

# **NJCAT TECHNOLOGY VERIFICATION**

## **Modular Wetlands® Linear Stormwater Treatment Device**

**Bio Clean Environmental Services Inc.  
a Forterra Company**

**May 2022**

## Table of Contents

List of Figures.....	ii
List of Tables.....	iii
1. Description of Technology.....	1
2. Laboratory Testing.....	4
2.1 Test Setup.....	5
2.2 Test Sediment.....	8
2.3 Removal Efficiency Testing Procedure.....	11
2.4 Scour Testing Procedure.....	11
3. Performance Claims.....	12
4. Supporting Documentation.....	13
4.1 Removal Efficiency and Mass Load Capacity Results.....	13
4.2 Water Surface Levels and Retention Times.....	21
4.3 QA/QC.....	24
4.4 Scour Results.....	30
5. Design Limitations.....	32
6. Maintenance Plans.....	34
7. Statements.....	39
8. References.....	44
Verification Appendix.....	46

## **List of Figures**

Figure 1 Isometric and End Views.....	1
Figure 2 Operational Diagram – Top View.....	2
Figure 3 Operational Diagram – Side View.....	3
Figure 4 Operational Diagram – Bypass Flows (High Flow).....	3
Figure 5 Test Unit.....	5
Figure 6a Test Flow Apparatus - Sediment Removal Testing.....	6
Figure 6b Test Flow Apparatus - Scour Testing.....	6
Figure 7 Background Sampling Point.....	8
Figure 8 Effluent Sampling Point.....	8
Figure 9 Sediment Addition Point.....	9
Figure 10 Average Particle Size Distribution of Removal Efficiency Test Sediment.....	10
Figure 11 Water Levels.....	23
Figure 12 Removal Efficiencies vs. Cumulative Mass Loading.....	24
Figure 13 Water Flow – Scour Test.....	31

## **List of Tables**

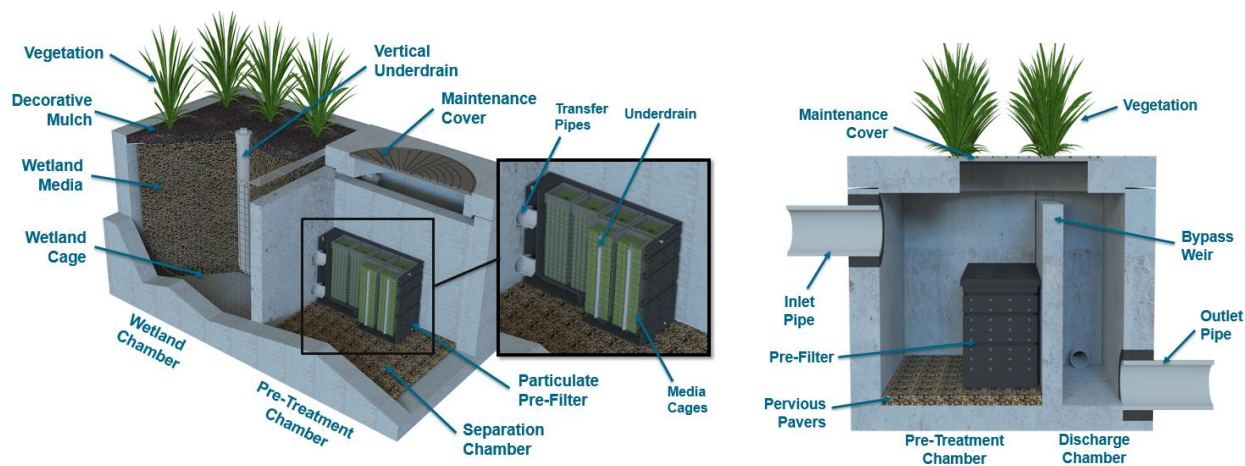
Table 1 Modular Wetland Linear Model MW-L-4-8 Dimensions.....	5
Table 2 PSD of Removal Efficiency Test Sediment.....	10
Table 3 Removal Efficiency and Sediment Mass Capacity Sampling Schedule.....	16
Table 4 Removal Efficiency Results.....	16
Table 5 Mass Load Capacity Results.....	17
Table 6 Individual Run Data – Removal Efficiency Testing.....	19
Table 7 Individual Run Data – Mass Load Capacity Testing.....	19
Table 8 Removal Efficiency Detention Times and Water Levels.....	21
Table 9 Sediment Mass Capacity Detention Times and Water Levels.....	22
Table 10 Summary of Removal Efficiency Flow Rates and Temperature.....	25
Table 11 Summary of Sediment Mass Loading Flow Rates and Temperature.....	26
Table 12 Summary of Removal Efficiency Feed Rate and Concentration.....	28
Table 13 Summary of Sediment Mass Load Feed Rate and Concentration.....	29
Table 14 Scour Test Sampling Frequency.....	30
Table 15 Water Flow and Temperature – Scour Test.....	31
Table 16 Suspended Sediment Concentrations for Scour Testing.....	32
Table A-1 MTFRs and Sediment Removal Intervals for Modular Wetlands Linear Models.....	48

## 1. Description of Technology

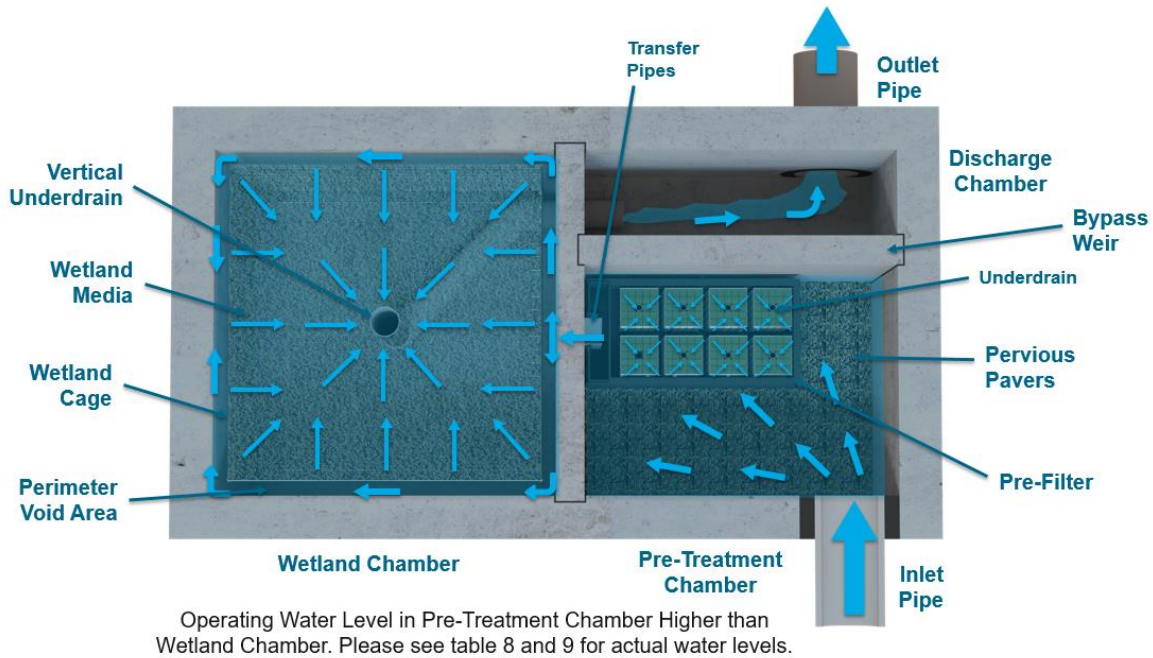
The Modular Wetlands® Linear is a biofiltration system designed by Bio Clean Environmental Services, Inc. a Forterra company. The Modular Wetlands® Linear system captures a high level of sediments, including total suspended solids at various micron ranges and mimics the treatment processes found in a traditional sub-surface flow wetland using a biofiltration type media which includes an organic element along with advanced pre-treatment to prolong maintenance intervals. The system is commercially available with plants in the biofiltration chamber or without. The Modular Wetlands® Linear system was tested without plants.

The Modular Wetlands® Linear (MW-L) is designed to optimize the treatment of entering stormwater utilizing a combination of filtration processes and filter media. The system has no moving parts and operates utilizing the principles of gravity separation and filtration.

Runoff is directed into the system via an inflow pipe (or curb opening) into the pre-treatment chamber, as illustrated in **Figure 1**. Within the pre-treatment chamber, water flows over a separation area where larger sediments, trash, and debris are captured. From the separation area, water flows toward the pre-filter(s) located along the wall dividing the pre-treatment chamber from the wetland chamber. Water enters the pre-filter(s) via a series of dozens of  $\frac{3}{4}$  inch diameter openings on the perimeter of the filter housing. Each pre-filter has multiple individual horizontal flow media cages made of plastic-coated metal mesh containing a granular filter material called BioMediaGREEN, which the stormwater flows through. Particulates and other pollutants are captured in this media. Treated water travels into and down a vertical slotted underdrain into the effluent cavity where it exits via two stacked transfer pipes. These pipes pass through the wall of the pre-treatment chamber into the perimeter void area of the wetland chamber as shown in **Figure 2**. Additionally, the floor of the pre-treatment chamber is covered with a layer of two-inch pervious pavers to allow for an optional drain down line (not tested) and to assist with cleaning of the chamber via a vacuum truck.

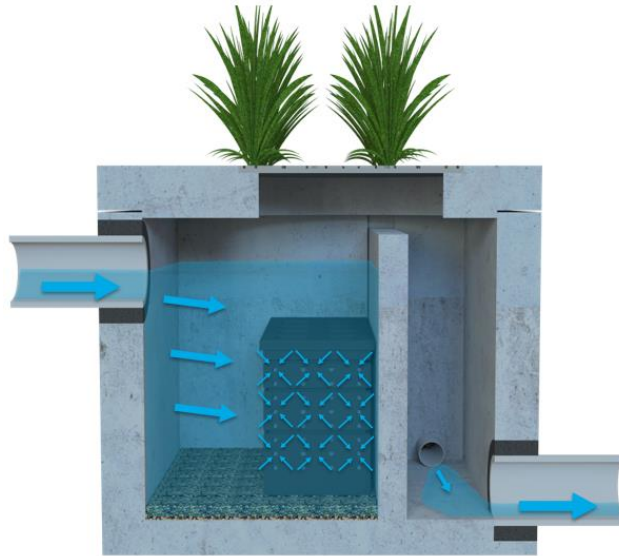


**Figure 1 Isometric and End Views**



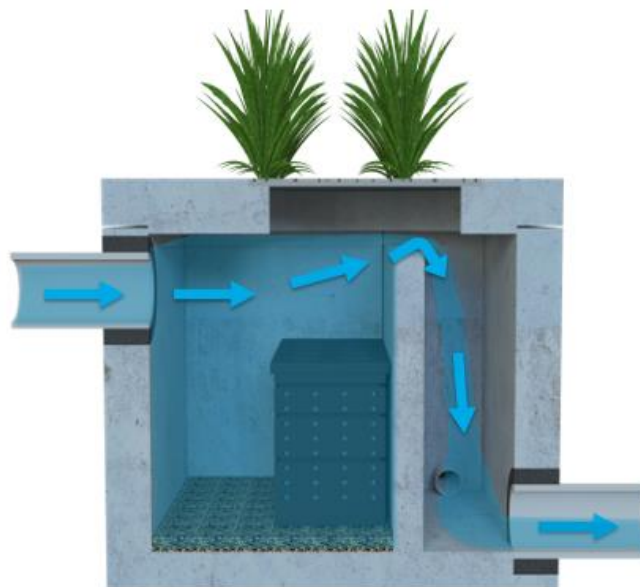
**Figure 2 Operational Diagram – Top View**

As water enters the wetland chamber it is allowed to free flow around the chamber perimeter via the peripheral void area that extends vertically from the floor on all sides of the chamber, thus providing maximum Wetland Media surface area. The Wetland Media is housed in a stainless-steel mesh cage backed by a high strength netting. This spaces the media away from the chamber walls approximately two inches on all four sides. The water flows from the void area inward through the wetland media horizontally toward the center vertical slotted underdrain. The media surface area is based on the active water level within the chamber. The active peak water level before bypass is 2.9 ft. The media thickness from the wetland cage to the vertical underdrain is 20 inches at a minimum from the center of a side to the vertical underdrain; the distance increases at the corners where sides intersect. The wetland cage is square on this model with a width/length of 44.4 inches and a height of 2.9 ft. From the vertical underdrain, the treated water travels to the discharge chamber via a horizontal pipe on the floor of the wetland chamber.



**Figure 3 Operational Diagram – Side View**

The horizontal pipe connects to the discharge chamber via an underdrain, as shown in **Figure 2** and **Figure 3**. The discharge chamber is adjacent to both the wetland chamber and the pre-treatment chamber allowing for internal bypass. When the influent flow rate exceeds the capacity of the system, water bypasses internally directly from the pre-treatment chamber to the discharge chamber over a weir as shown in **Figure 4**. This feature prevents any disturbances and related high velocities to pass through the wetland chamber during storm event periods that exceed the system's MTR.



**Figure 4 Operational Diagram – Bypass Flows (High Flow)**

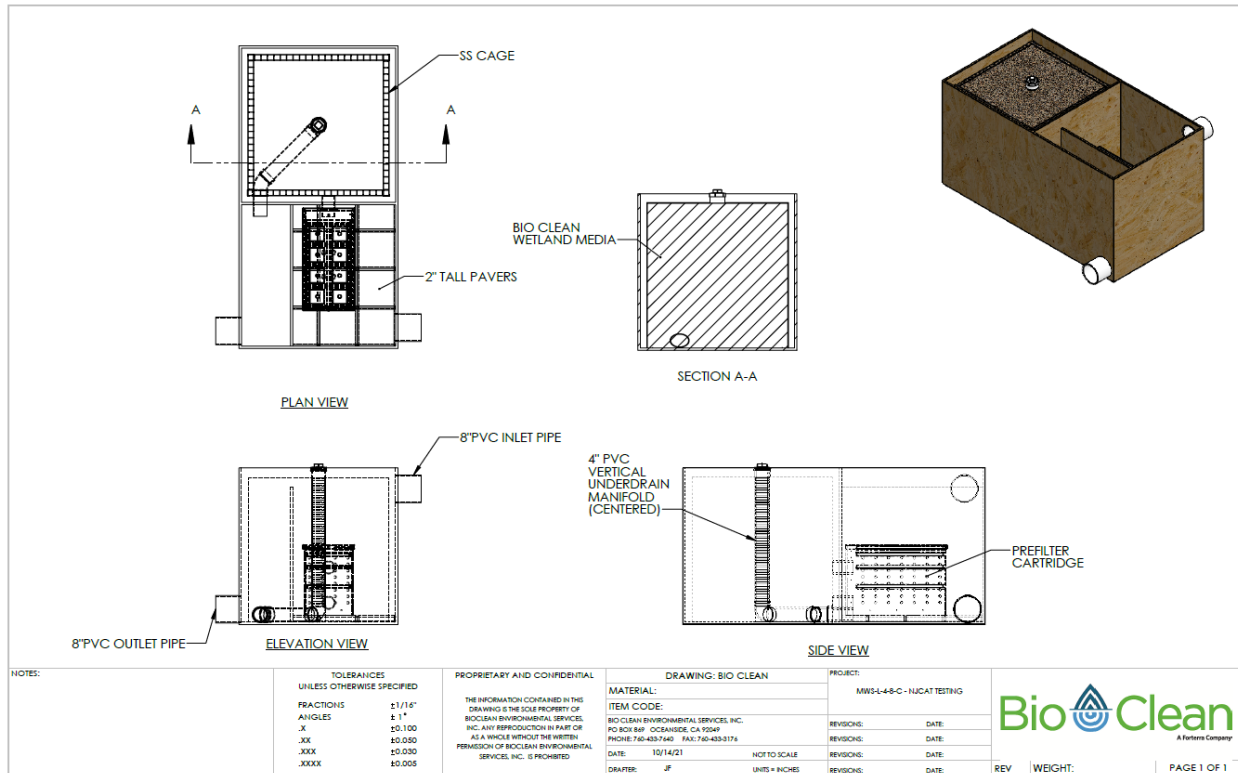
## 2. Laboratory Testing

Testing was performed to determine:

- The hydraulic characterization of the test unit.
- The sediment removal efficiency (80% cumulative target) using the grab sample test method.
- The sediment mass load capacity (until >10% reduction in flow capacity) or a reduction in cumulative sediment removal efficiency below 80%; and
- Potential for sediment scour with system's pre-treatment chamber pre-loaded with greater than 50% manufacturers recommended maximum storage volume (at the maximum intended conveyance flow rate).

Bio Clean Laboratories, a state-of-the-art water technology testing laboratory based in Oceanside, California, was commissioned by Bio Clean Environmental Services, Inc. to test the Modular Wetlands® Linear 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 (January 25, 2013)*. Note: Bio Clean laboratories is wholly owned by Bio Clean Environmental Services, Inc, but operates as an independent division. Independent third-party observation was provided by Michael Kimberlain, P.E. of KimberWerks, Inc. Mr. Kimberlain has extensive background in water quality. Mr. Kimberlain has no conflict of interest that would disqualify him from serving as the independent third-party observer during this testing process.

The test unit is a 4-foot by 8-foot Modular Wetlands® Linear (Model MW-L-4-8) unit consisting of commercially supplied internal components housed in a wooden structure as shown in **Figure 5**. In commercial systems, the internal components are typically housed in a concrete, plastic, or fiberglass structure. The wooden structure of the test unit is equivalent to commercial structures in all key dimensions. The Bio Clean Laboratory has limited lifting capacity and available space, so a lightweight structure was necessary.



**Figure 5 Test Unit**

## 2.1 Test Setup

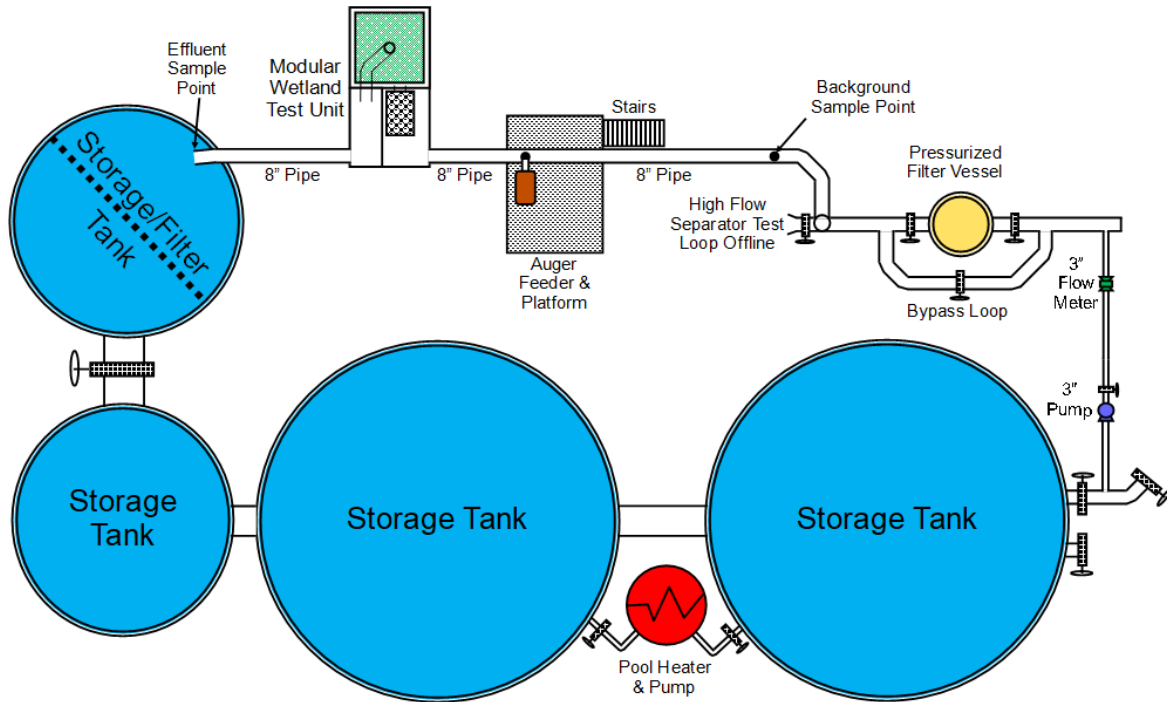
The design specifications of the MW-L are provided in **Table 1**. The test unit had a total treatment area of 42.9 ft<sup>2</sup> and a maximum treatment flow rate (MTFR) of 0.28 cfs (125 gpm).

**Table 1 Modular Wetland Linear MW-L-4-8 Dimensions**

MTFR		Length (ft)	Width (ft)	Height (ft)	Wetland Chamber Media Surface Area (sq ft) <sup>1</sup>	Loading Rate (gpm/ft <sup>2</sup> )
(cfs)	(gpm)					
0.28	125	8	4	3.5	42.92	2.91

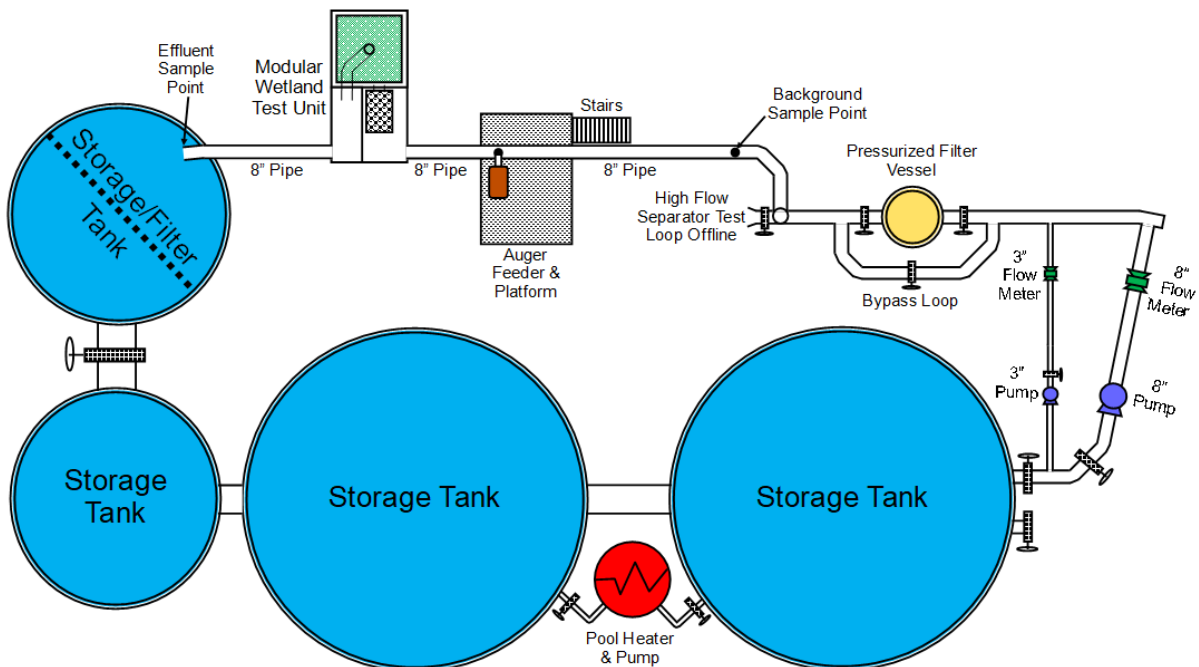
<sup>1</sup> Based on a height of 2.9 feet and a perimeter of 14.8 feet (sum of all four sides).

The laboratory test set-up is a recirculating water flow loop, capable of moving water at a rate of several cubic feet per second (cfs). The test loop, illustrated in **Figure 6a**, is comprised of water reservoirs, pumps, sediment filter, receiving tank and flow meters. The configuration for performance and mass load testing used the 3-inch pump and flow through a pressurized filter vessel.



**Figure 6a Test Flow Apparatus – Sediment Removal Testing**

The configuration for scour testing (**Figure 6b**) was modified to allow higher flow rates. The scour flow rate is higher than the capacity of the 3-inch pump (smallest pump) so the 8-inch pump was run during this testing.



**Figure 6b Test Flow Apparatus – Scour Testing**

### *Water Flow and Measurement*

From the water supply tanks, water was pumped using one Xylem AC e-1500, 3x3x9.5C 5 HP (10 - 200 gpm) centrifugal pump during efficiency and load testing. Water was pumped using one Xylem AC e-1500, 8x8x9.5 20 HP (250 - 2000 gpm) centrifugal pump during scour testing. The pumps were controlled by one Aquavar IPC AVA20200B0F0x0x1 VFD and one Aquavar IPC AVA20050B0F0X0X1 VFD. Flow measurement was done using one Toshiba LF654 Flanged Mount Magmeter (combined type) with 8" flanges and one Toshiba LF654 Flanged Mount Magmeter (combined type) with 3" flanges, electromagnetic type flow meters with an accuracy of  $\pm 0.5\%$  of reading. The data logger was a MadgeTech CurrentX4 30MA, 4-Channel Current type and related software, configured to record a flow measurement once every 5 seconds.

The water in the flow loop was circulated through a filter housing containing high-efficiency, high-surface area pleated paper filters with a 0.5 micron ( $\mu\text{m}$ ) absolute rating. The influent pipe was 8 inches in diameter with a slope of 1.1%. Sediment addition was done through a port at the crown of the influent pipe, directly upstream of the Modular Wetlands<sup>®</sup> Linear. The sediment feeder was an Acrison Model 105X volumetric screw feeder with a spout attachment and motor controller. The feeder has a 1 cubic foot hopper at the upper end of the auger to provide a constant supply of sediment.

Water flow exited the Modular Wetlands<sup>®</sup> Linear and terminated with a free-fall into the receiving tank to complete the flow loop. The length of the 8-inch diameter outlet pipe is 108 inches with a slope of 1.2%. Observations documented that no sediment was deposited in either the inlet or outlet pipe during any of the test runs.

### *Sample Collection*

Background water samples were grabbed by hand in a 1 L bottle from a sampling port located upstream of the auger feeder. The sampling port was controlled manually by a ball valve (**Figure 7**) that was opened approximately 0.5 seconds prior to sampling to purge any collected sediment.

Effluent samples were also grabbed by hand. The effluent pipe discharged freely into the receiving tank and the effluent samples were taken at that point (**Figure 8**). The sampling technique used was to take the grab sample by sweeping a wide-mouth 1 L bottle through the stream of effluent flow such that the jar was full after a single pass.



**Figure 7 Background Sampling Point**



**Figure 8 Effluent Sampling Point**

### *Other Instrumentation and Measurement*

Water temperature was taken inside the pre-treatment chamber using an Elitech RC-5+ PDF USB Temperature Data Logger that automatically logs the temperature in 1-minute intervals. The maximum temperature from each run is presented in **Table 10** and **Table 11**.

A water surface level (WSL) reading was recorded manually at the beginning and end of each run within the pre-treatment chamber. A yardstick mounted to the inside of the wall of the pre-treatment chamber was visually observed to record the levels. Water surface level was also recorded automatically inside the wetland chamber's peripheral void area using a liquid level sensor, model #TL232. The liquid level sensor was connected to the MadgeTech CurrentX4 30MA, 4-Channel Current data logger. The ending water levels in both chambers were used to time the two drain down samples based on two-thirds and one-third of the volume during that run.

Run and sampling times were measured using a Thomas Scientific NIST traceable stopwatch, manufactured by Control Company Model 8788V77.

The sediment feed samples that were taken during each run were collected in 500 mL jars and weighed on a precision balance (Mettler Toledo, MS1003TS/00). The mass sediment at the beginning and at the end of each run was taken and weighed on a balance (Mettler Toledo, PBA655-B60 US).

## **2.2 Test Sediment**

The test sediment was fed through an opening in the crown of the influent pipe, 43 inches upstream of the Modular Wetlands® Linear. A 5-inch diameter hole was used to direct the sediment into the pipe (**Figure 9**). The test sediment purchased and used for the removal efficiency study was custom blended by GHL (Good Harbours Laboratories, Mississauga, Ontario, Canada) using

various commercially available silica sands; this particular batch was GHL lot #A028-095. GHL sent out three samples of sediment for particle size analysis using the methodology of ASTM method D422-63. The samples were composite samples created by taking samples throughout the blending process and in various positions within the blending drum. The testing laboratory was Bureau Veritas, an independent test laboratory also located in Mississauga, Ontario, Canada. Bio Clean received three sealed drums from GHL.

Each drum was opened, and security seals were removed for this sampling. Representative samples were taken from each drum (at the top, middle and bottom of the drum) and were composited into three separate five-gallon buckets. When all drums were sampled and composites placed into the buckets, the buckets were thoroughly mixed, and a single sample taken from each bucket to be sent for analysis. Samples of approximately 500 grams were placed into glass jars, which were then sealed, labelled, and packaged for transport to the testing laboratory for analysis. Sample jars were immediately packaged and shipped to Apex Labs in Tigard, Oregon. Chain of Custody (COC) paperwork was provided to Apex requesting analysis per ASTM D422-63 (2007). Drum numbers one, two, and three (drum serial #2371511, 2371513, and 2371512) were used during Modular Wetlands® Linear testing. All opening and closing of the drum and removal and replacement of security tags was done in the presence of the third-party observer. The PSD results are summarized in **Table 2** and shown graphically in **Figure 10**.



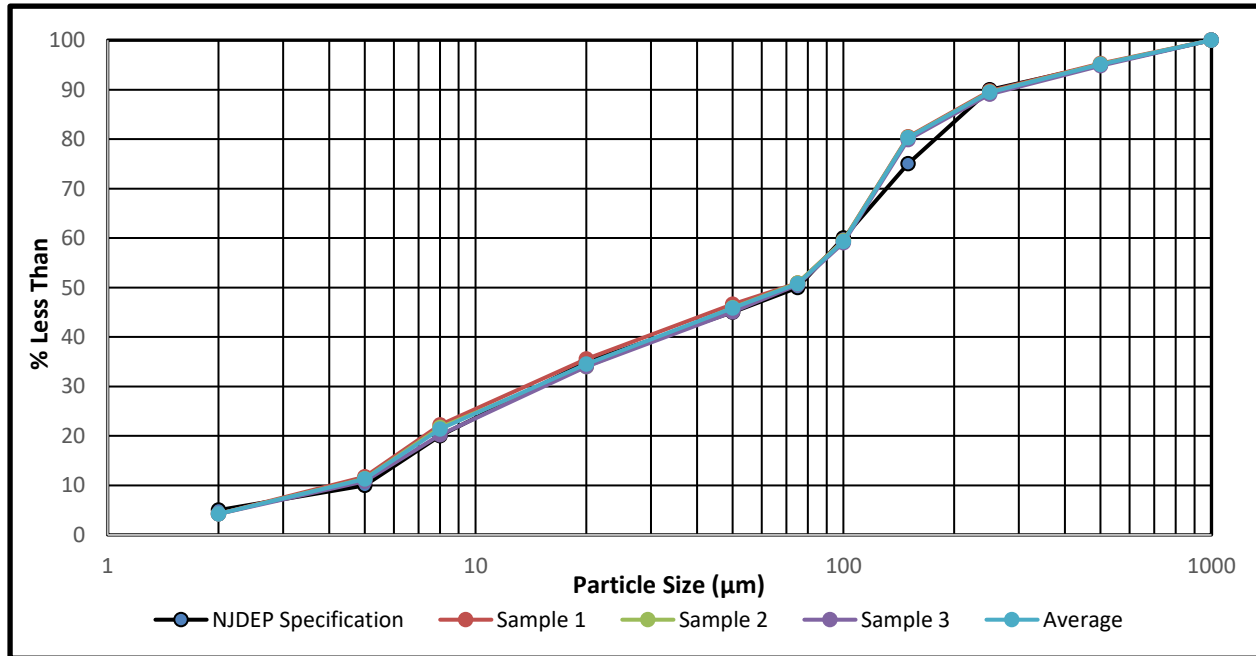
**Figure 9 Sediment Addition Point**

**Table 2 PSD of Removal Efficiency Test Sediment**

Particle Size (Microns)	Test Sediment Particle Size (% Less Than) <sup>1</sup>				Specification <sup>2</sup> (Minimum % Less Than)	QA/QC
	Sample 1	Sample 2	Sample 3	Average		
1000	100	100	100	100	100	PASS
500	95.29	95.18	94.84	95.10	95	PASS
250	89.72	89.53	89.08	89.44	90	PASS
150	80.48	80.34	79.90	80.24	75	PASS
100	59.50	59.43	59.02	59.31	60	PASS
75	50.87	50.87	50.54	50.76	50	PASS
50	46.65	45.89	45.05	45.86	45	PASS
20	35.50	34.03	34.02	34.53	35	PASS
8	22.26	21.27	20.23	21.26	20	PASS
5	11.75	11.44	10.87	11.32	10	PASS
2	4.24	4.24	4.24	4.24	5	PASS
d <sub>50</sub>	71 µm	71 µm	72 µm	71 µm	≤ 75 µm	PASS

<sup>1</sup> Where required, particle size data has been interpolated to allow for comparison to the required NJDEP particle size specification.

<sup>2</sup> Per NJDEP, a measured value (three sample average) may be lower than a target minimum % less than value by up to two percentage points provided that the measured d<sub>50</sub> value does not exceed 75 microns.



**Figure 10 Average Particle Size Distribution of Removal Efficiency Test Sediment**

### **2.3 Removal Efficiency Testing Procedure**

Removal testing was conducted on a clean unit. Removal efficiency testing was performed as specified in Section 5 of the NJDEP Laboratory Protocol for Filtration MTDs. While the protocol only requires 10 runs for removal efficiency testing additional runs were done in case of any unforeseen QC issues with specific runs.

The test sediment feed was sampled three times per run to confirm the sediment feed rate. Each sediment feed sample was collected in a 500-mL bottle over an interval timed to the nearest hundreds of a second and was a minimum 0.1 liter or the collection interval did not exceed one minute, whichever came first. Feed samples were started the precise moment the effluent sample collection was completed (passed through flow stream) when occurring at the same time intervals.

Effluent grab sampling began following more than three MTD detention times after the initial sediment feed sample was taken. The time interval between sequential samples was 2 minutes, however, when the test sediment feed was interrupted for measurement, the next effluent sample was collected following more than three MTD detention times from the time the sediment feed was re-established. A total of 6 effluent samples were taken during each run.

Two evenly spaced volume paced drawdown samples were taken at one-third and two-thirds of the drawdown volume after the flow was cut off at the end of each run. The ending water levels during that run in both the pre-treatment and wetland chamber were used to establish the water levels that each of the two samples should be taken. As the ending water level increased over the course of the testing, the levels when the samples were taken changed proportionally. Prior to testing, calculations were performed to find the drawdown volume and these calculations were performed by filling the unit with clean water and quantifying the volume. The drawdown mass was calculated using Equation 6.

Background water samples were taken with the odd-numbered effluent samples. Alpha Analytical Laboratories, Inc. of Carlsbad, California performed analysis of all background, drawdown, and effluent samples under test method ASTM D3977-97 (2019) “Standard Test Methods for Determining Sediment Concentrations in Water Samples”. It was discovered post-testing by the 3<sup>rd</sup> party observer that Alpha utilized a sample volume measurement calculation versus the weight to volume calculation outlined in ASTM D3977-97. As such, adjustments were made to the resulting concentrations using effluent and background sample weights measured in-house by Bio Clean on a calibrated and certified analytical balance and under 3<sup>rd</sup> party observation prior to shipping to the independent lab. These adjustments reduced the overall cumulative performance of the system down about 0.5% to 82.46% after 64 runs.

### **2.4 Scour Testing Procedure**

Following removal efficiency testing, the Modular Wetlands® Linear sat undisturbed and allowed to dry out until the sediment scour testing was ready to begin. The unit sat for 23 hours between the last removal efficiency testing run and the beginning of the scour testing. Up until the time of scour testing a total of 754 lbs of sediment was injected into the test unit. Based upon removal efficiency results, the total sediment retained in the system prior to scour testing was 622 lbs. The levels of sediment inside the various sections of the pre-treatment chamber and peripheral void

area of the wetland were recorded by the third-party observer. Nothing was disturbed between removal efficiency testing and scour testing.

The scour test was conducted at a target flow rate of 260 gpm (actual average was 259 gpm) greater than two times the MTFR.

During the scour test, the water flow rate was recorded using a MadgeTech CurrentX4 30MA, 4-Channel Current type data logger and related software, configured to record a flow measurement once every five seconds. The MadgeTech software was calibrated to the Toshiba Flow meters. Water temperature was taken using an Elitech RC-5+ PDF USB Temperature Data Logger that automatically logs the temperature in 1-minute intervals. The Temperature Data Logger was suspended inside the Modular Wetlands® Linear pre-treatment chamber. The maximum temperature recorded is used in the run summary data below.

Run and sampling times were measured using a Thomas Scientific NIST traceable stopwatch, manufactured by Control Company Model 8788V77.

Testing commenced by gradually increasing the water flow into the system until the target flow rate of greater than 200% of the MTFR was achieved (within five minutes of commencing the test). Effluent and background grab samples were taken once every two minutes, starting after achieving the target flow rate, until a total of 15 effluent samples were taken. A total of 15 background water samples were collected at evenly spaced intervals throughout the scour test at the same time effluent samples were collected.

### **3. Performance Claims**

#### *Total Suspended Solids (TSS) Removal Rate*

The Modular Wetlands® Linear exceeded the NJDEP required total suspended solids (TSS) removal rate of 80% at an MTFR of 125 gpm. A removal efficiency of 94.57% was determined based on 10 runs 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 (MTFR).*

The Modular Wetlands® Linear unit demonstrated a maximum treatment flow rate (MTFR) of 0.28 cfs (125 gpm). This corresponds to a hydraulic loading rate of 2.91 gpm/ft<sup>2</sup> of effective wetland media surface area and 4.88 gpm/ft<sup>2</sup> of effective pre-filter media surface area.

#### *Effective Filtration Treatment Area (EFTA)*

The 4 ft x 8 ft Modular Wetlands® Linear has an effective wetland media surface area of 42.9 ft<sup>2</sup>. The full-size pre-filter used during testing in the pre-treatment chamber has a media surface area of 25.6 ft<sup>2</sup>.

#### *Effective Sedimentation Treatment Area (ESTA).*

The 4 ft x 8 ft Modular Wetlands® Linear tested has a pre-treatment sedimentation area, which is 2.94 ft wide by 3.67 ft long. Total area is 10.79 sq ft.

#### *Sediment Mass Load Capacity*

The 4 ft x 8 ft Modular Wetlands® Linear tested has a mass load capacity of 754 lbs and a mass load capture capacity of 622 lbs, or 14.5 lbs/ft<sup>2</sup> of effective wetland media surface area.

#### *Maximum Allowable Inflow Drainage Area*

The 4 ft x 8 ft Modular Wetlands® Linear can treat 1.04 acres based on the sediment mass capture of 622 lbs.

#### *Detention Time and Volume*

The maximum operational wet volume of 58.24 ft<sup>3</sup> for a 4 ft x 8 ft Modular Wetlands® Linear produces a detention time of 4.08 minutes at 125 gpm. The associated water levels for this maximum operational wet volume were not experienced during the testing. The water levels for all 64 runs were below this level and therefore the detention time used was greater and more conservative.

#### *Online/Offline Installation*

Based on the scour testing results shown in Section 4.3 the Modular Wetlands® Linear qualifies for online installation.

## **4. Supporting Documentation**

To support the performance claims, 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. were made available to NJCAT for review. It was agreed that as long as such documentation could be made available upon request that it would not be prudent or necessary to include all this information in this verification report. All supporting documentation will be retained securely by Bio Clean Laboratories and has been provided to NJCAT and is available upon request.

### **4.1 Removal Efficiency and Mass Load Capacity Results**

A total of 15 removal efficiency testing runs were completed in accordance with the NJDEP Filtration protocol. The target flow rate was 100% MTR and the target influent sediment concentration was 200 mg/L. The removal efficiency from the first 10 runs was 94.57%, qualifying the Modular Wetlands® Linear for an 80% TSS removal efficiency certification. In addition, an additional 49 runs were completed for sediment mass capacity testing, at the same target flow rate and an influent sediment concentration of 400 mg/L. A total of 64 runs were

completed altogether. Equations 7 and 8 were used to calculate the individual run efficiency and overall cumulative run efficiency.

The total water volume and average flow rate per run were calculated from the data collected by the flow data logger, one reading every 5 seconds. The average influent sediment concentration for each test flow was determined by mass balance using Equation 2. The amount of sediment fed into the auger feeder during dosing, and the amount remaining at the end of a run, was used to determine the amount of sediment fed during a run. The sediment mass was corrected for the mass of the three feed rate samples taken during the run. The mass of the sediment fed was divided by the volume of water that flowed through the Modular Wetlands® Linear during dosing to determine the average influent sediment concentration for each run using Equation 3. The total cumulative sediment mass injected and retained were calculated using Equations 9 and 10.

Three feed rate samples were collected, at evenly spaced time intervals, during the run to ensure the rate was stable. The COV (coefficient of variance) of the samples had to be  $\leq 0.10$  per the NJDEP protocol. Feed rate was calculated using Equation 1. The feed rate samples were also used to calculate an influent concentration to double-check the concentration calculated by mass balance.

The average effluent sediment concentration was adjusted for the background sediment concentration using Equation 4. In cases where the reported background sediment concentration was less than 1.0 mg/L (the method quantitation limit), 0.5 mg/L was used in calculating the adjusted effluent concentration.

Removal efficiencies, drawdown adjustments, and mass load capacities for each test run were computed using the following equations:

$$\text{Feed Rate (g/min)} = \left( \frac{\text{Mass}_{\text{sample+bottle (g)}} - \text{Mass}_{\text{bottle (g)}}}{\text{Time collection (s)} \times \left( \frac{\text{min}}{60 \text{ s}} \right)} \right) \times (1 - \text{Sediment Moisture Content})$$

**(Equation 1)**

$$\begin{aligned} \text{Influent Mass (kg)} &= (1 - \text{Sediment Moisture Content}) \times [\text{Mass}_{\text{pre test (kg)}} - \text{Mass}_{\text{post test (kg)}}] \\ &\quad - \sum \text{Mass}_{\text{feed sample (g)}} \times \left( \frac{\text{kg}}{1\text{E}3 \text{ g}} \right) \end{aligned}$$

**(Equation 2)**

$$\begin{aligned} \text{Average Influent Concentration (mg/L)} &= \left( \frac{\text{Influent Mass (kg)} \times \left( \frac{1\text{E}6 \text{ mg}}{\text{kg}} \right)}{\text{Avg. Flow Rate} \left( \frac{\text{ft}^3}{\text{s}} \right) \times \left( \frac{28.3168 \text{ L}}{\text{ft}^3} \right) \times \left( \frac{60 \text{ s}}{\text{min}} \right) \times \text{Time}_{\text{sediment injection (min)}}} \right) \end{aligned}$$

**(Equation 3)**

$$\begin{aligned}
& \textbf{Average Adjusted Effluent SSC Concentration (mg/L)} \\
& = \text{Avg. Effluent Concentration (mg/L)} - \text{Avg. Background Concentration (mg/L)}
\end{aligned}
\tag{Equation 4}$$

$$\begin{aligned}
& \textbf{Effluent Mass (mg)} \\
& = \text{Avg. Adjusted Effluent SSC (mg/L)} \times ((\text{Time}_{\text{sediment injection}} (\text{min}) \times \text{Average Flow Rate (gpm)}) \\
& - \text{Drain Down Volume (gal)}) \times 3.78541
\end{aligned}
\tag{Equation 5}$$

$$\begin{aligned}
& \textbf{Drawdown Flow Mass (mg)} \\
& = (\text{Avg. Drawdown Effluent SSC (mg/L)} \\
& - \text{Avg. Background SSC (mg/L)}) \times \text{Drawdown Flow Volume (L)}
\end{aligned}
\tag{Equation 6}$$

$$\textbf{Removal Efficiency (\%)} = \left( \frac{\text{Influent Mass (mg)} - \text{Effluent Mass (mg)} - \text{Drawdown Mass (mg)}}{\text{Influent Mass (mg)}} \right) \times 100
\tag{Equation 7}$$

$$\textbf{Cumulative Removal Efficiency (\%)} = \left( \frac{\sum \text{Influent Mass (mg)} - \sum \text{Effluent Mass (mg)} - \sum \text{Drawdown Mass (mg)}}{\sum \text{Influent Mass (mg)}} \right) \times 100
\tag{Equation 8}$$

$$\textbf{Cumulative Mass Load (lbs)} = \frac{\sum \text{Influent Mass (mg)}}{\frac{453,592 \text{ mg}}{\text{lb}}}
\tag{Equation 9}$$

$$\textbf{Cumulative Mass Load Capacity (lb)} = \left( \frac{\sum \text{Influent Mass (mg)} - \sum \text{Effluent Mass (mg)} - \sum \text{Drawdown Mass (mg)}}{\frac{453,592 \text{ mg}}{\text{lb}}} \right)
\tag{Equation 10}$$

NOTE: it was found that the moisture content was negligible and therefore no correction was required. Table 2 of the sediment report titled “Particle Size Characterization of GHL Silica Blend Lot A028-095 for use in Hydrodynamic Separator Removal Efficiency Testing” shows that the percentage moisture was below the detectable limit of 0.3% for all three samples.

The data collected for all removal efficiency runs is presented below:

**Table 3 Removal Efficiency and Sediment Mass Capacity Sampling Schedule**

Elapsed Time	Feed Rate Sample	Effluent Sample	Background Sample <sup>1</sup>
0:00:00	1		
0:13:15		1	1
0:15:15		2	
0:17:15	2	3	2
0:30:30		4	
0:32:30		5	
0:34:30	3	6	3
1/3 Drawdown		7	
2/3 Drawdown		8	

<sup>1</sup>Background sample was pulled right after the effluent sample with less than a second delay.

**Table 4 Removal Efficiency Results**

PERFORMANCE SUMMARY – Removal Efficiency Testing											
Run #	Total Water Volume (gal)	Sediment Mass Injected - (lb)	Influent TSS Based on Mass Injected (mg/L)	Average Adjusted Effluent TSS (mg/L)	Effluent Mass (lb)	Average Adjusted Draw-down TSS (mg/L)	Draw-down Volume (gal)	Draw-down Mass (lb)	Cumulative Mass Captured (lb)	Removal Efficiency (%)	Cumulative Removal Efficiency <sup>1</sup> (%)
1	4067	6.75	199.3	0.3	0.009	0.0	367	0.000	6.741	99.86%	99.86%
2	4064	6.61	194.8	1.3	0.040	1.0	375	0.003	13.308	99.35%	99.61%
3	4067	6.83	201.3	10.3	0.318	1.3	372	0.004	19.816	95.29%	98.15%
4	4067	6.83	201.2	17.2	0.530	1.2	375	0.004	26.112	92.19%	96.64%
5	4061	6.77	199.7	7.8	0.240	0.4	380	0.001	32.641	96.44%	96.60%
6	4067	7.06	207.9	5.7	0.176	0.5	375	0.001	39.524	97.49%	96.75%
7	4065	6.95	205.0	7.2	0.221	0.2	379	0.001	46.252	96.80%	96.76%
8	4062	6.87	202.7	22.6	0.696	6.0	371	0.019	52.408	89.60%	95.86%
9	4065	6.62	195.1	23.2	0.715	7.0	372	0.022	58.291	88.87%	95.11%
10	4065	6.69	197.1	21.8	0.671	7.1	375	0.022	64.287	89.63%	94.57%
11	4069	6.77	199.3	21.2	0.655	8.6	375	0.027	70.376	89.93%	94.15%
12	4065	6.72	198.2	17.1	0.527	5.3	374	0.017	76.553	91.91%	93.96%
13	4062	6.93	204.4	24.1	0.742	12.5	375	0.039	82.702	88.74%	93.55%
14	4061	6.95	205.0	25.4	0.781	10.5	375	0.033	88.838	88.28%	93.17%
15	4064	6.94	204.6	25.3	0.779	12.6	376	0.040	94.959	88.21%	92.83%

**Table 5 Mass Load Capacity Results**

PERFORMANCE SUMMARY – Sediment Mass Capacity Testing											
Run #	Total Water Volume (gal)	Sediment Mass Injected - (lb)	Influent TSS Based on Mass Injected (mg/L)	Average Adjusted Effluent TSS <sup>1</sup> (mg/L)	Effluent Mass (lb)	Average Adjusted Draw-down TSS (mg/L)	Draw-down Volume (gal)	Draw-down Mass (lb)	Cumulative Mass Captured (lb)	Removal Efficiency (%)	Cumulative Removal Efficiency (%)
16	4068	13.59	400.3	52.8	1.627	24.5	374	0.076	106.846	87.47%	92.20%
17	4065	13.82	407.5	61.0	1.876	29.4	380	0.093	118.697	85.75%	91.52%
18	4063	13.79	406.7	67.0	2.062	30.3	375	0.095	130.330	84.36%	90.83%
19	4068	14.13	416.1	67.5	2.077	26.6	383	0.085	142.298	84.70%	90.28%
20	4065	13.78	406.2	69.3	2.134	30.3	375	0.095	153.849	83.83%	89.76%
21	4065	13.73	404.7	69.9	2.150	40.4	379	0.128	165.301	83.41%	89.29%
22	4065	13.58	400.2	71.1	2.187	32.1	380	0.102	176.593	83.15%	88.87%
23	4062	13.59	400.9	75.4	2.319	39.5	377	0.124	187.740	82.02%	88.43%
24	4062	13.79	406.7	77.4	2.377	41.8	382	0.133	199.020	81.80%	88.03%
25	4062	13.83	407.8	80.9	2.485	36.5	381	0.116	210.248	81.19%	87.63%
26	4069	13.74	404.8	78.4	2.410	39.5	385	0.127	221.451	81.53%	87.30%
27	4065	13.53	398.7	74.2	2.279	51.0	384	0.164	232.538	81.95%	87.03%
28	4075	13.71	403.2	78.5	2.423	55.0	376	0.173	243.653	81.07%	86.74%
29	4059	13.72	404.9	79.0	2.429	59.1	375	0.185	254.759	80.95%	86.47%
30	4069	13.57	399.5	95.6	2.943	52.3	381	0.166	265.220	77.09%	86.06%
31	4065	13.72	404.5	83.9	2.581	49.8	379	0.158	276.202	80.04%	85.80%
32	4069	13.58	400.0	75.0	2.301	36.2	392	0.119	287.362	82.18%	85.65%
33	4068	13.84	407.7	82.0	2.514	41.5	395	0.137	298.552	80.85%	85.46%
34	4065	13.86	408.6	85.4	2.614	36.4	398	0.121	309.677	80.27%	85.27%
35	4064	13.79	406.7	86.3	2.643	48.9	394	0.161	320.664	79.67%	85.06%
36	4072	14.02	412.5	89.4	2.747	56.5	390	0.184	331.753	79.10%	84.85%
37	4065	13.78	406.1	88.2	2.707	55.6	387	0.179	342.646	79.05%	84.65%
38	4072	13.71	403.6	74.9	2.304	39.9	387	0.129	353.924	82.26%	84.57%
39	4066	13.73	404.7	72.9	2.240	31.1	384	0.100	365.314	82.96%	84.52%
40	4079	13.93	409.1	77.2	2.378	46.8	387	0.151	376.714	81.84%	84.44%
41	4069	13.87	408.4	75.9	2.333	42.8	386	0.138	388.113	82.19%	84.37%
42	4072	13.90	409.0	66.3	2.038	40.2	389	0.131	399.845	84.40%	84.37%
43	4069	13.87	408.4	83.5	2.564	51.2	390	0.167	410.984	80.31%	84.25%
44	4063	14.00	413.0	93.5	2.871	58.7	383	0.188	421.925	78.15%	84.08%
45	4059	14.02	414.0	90.6	2.779	62.1	384	0.199	432.968	78.76%	83.94%
46	4059	14.02	413.8	80.8	2.478	71.3	384	0.229	444.281	80.70%	83.85%
47	3659	12.41	406.4	65.9	1.814	69.8	361	0.210	454.667	83.69%	83.85%
48	3656	12.34	404.5	85.3	2.347	69.3	359	0.208	464.453	79.30%	83.75%
49	3656	12.24	401.3	85.4	2.348	69.5	360	0.209	474.136	79.11%	83.65%

PERFORMANCE SUMMARY CON'T – Sediment Mass Capacity Testing											
Run #	Total Water Volume (gal)	Sediment Mass Injected - (lb)	Influent TSS Based on Mass Injected (mg/L)	Average Adjusted Effluent TSS (mg/L)	Effluent Mass (lb)	Average Adjusted Draw-down TSS (mg/L)	Draw-down Volume (gal)	Draw-down Mass (lb)	Cumulative Mass Captured (lb)	Removal Efficiency (%)	Cumulative Removal Efficiency (%)
50	3659	12.44	407.4	89.4	2.462	62.8	359	0.188	483.926	78.70%	83.54%
51	3653	12.42	407.5	76.3	2.097	49.6	360	0.149	494.100	81.92%	83.51%
52	3666	12.28	401.5	75.7	2.082	59.5	370	0.184	504.114	81.55%	83.47%
53	3653	12.43	407.6	87.0	2.386	55.1	367	0.169	513.989	79.45%	83.39%
54	3660	12.38	405.5	86.5	2.378	62.6	365	0.191	523.800	79.25%	83.31%
55	3656	12.35	404.8	86.4	2.372	67.8	367	0.208	533.570	79.11%	83.22%
56	3663	12.12	396.5	87.8	2.414	74.2	370	0.229	543.047	78.19%	83.13%
57	3659	12.16	398.3	90.9	2.496	65.6	370	0.202	552.509	77.81%	83.03%
58	3656	12.31	403.6	88.5	2.429	79.9	367	0.245	562.145	78.28%	82.95%
59	3653	12.87	422.1	97.8	2.678	78.4	371	0.243	572.093	77.30%	82.84%
60	3659	12.77	418.2	92.5	2.535	62.9	374	0.196	582.132	78.61%	82.77%
61	3656	12.79	419.3	98.1	2.689	81.7	371	0.253	591.980	77.00%	82.66%
62	3656	12.77	418.9	90.0	2.467	71.1	372	0.220	602.062	78.96%	82.60%
63	3656	12.53	410.8	93.1	2.554	79.7	370	0.246	611.793	77.66%	82.51%
64	3656	12.68	415.7	86.7	2.376	72.6	372	0.225	621.872	79.48%	82.46%

**Table 6 Individual Run Data – Removal Efficiency Testing**

<b>PERFORMANCE CONCENTRATIONS – Removal Efficiency Testing</b>											
<b>Run #</b>	<b>Effluent 1 (mg/L)</b>	<b>Effluent 2 (mg/L)</b>	<b>Effluent 3 (mg/L)</b>	<b>Effluent 4 (mg/L)</b>	<b>Effluent 5 (mg/L)</b>	<b>Effluent 6 (mg/L)</b>	<b>Draw-down 1 (mg/L)</b>	<b>Draw-down 2 (mg/L)</b>	<b>Back-ground 1 (mg/L)</b>	<b>Back-ground 2 (mg/L)</b>	<b>Back-ground 3 (mg/L)</b>
1	0.8	0.5	0.5	1.1	0.8	1.3	0.5	0.6	0.5	0.5	0.5
2	1.5	1.6	2.5	1.7	2.2	1.3	1.3	1.7	0.5	0.5	0.5
3	8.8	4.0	6.9	15.7	16.1	14.3	2.2	1.6	0.8	0.5	0.6
4	14.9	15.1	17.1	19.2	19.9	20.0	1.8	1.8	0.6	0.5	0.5
5	8.8	5.6	9.7	8.5	10.3	6.8	1.2	0.7	0.5	0.5	0.5
6	5.8	5.6	5.3	8.5	5.7	6.3	0.5	1.6	0.5	0.5	0.5
7	8.7	7.0	7.1	7.4	8.7	7.6	0.5	0.9	0.5	0.5	0.5
8	21.7	21.6	23.1	24.5	23.2	24.8	5.3	7.7	0.5	0.5	0.5
9	23.4	23.2	23.4	23.1	23.8	25.0	5.9	9.1	0.5	0.5	0.5
10	21.4	24.6	20.9	20.7	23.0	22.9	3.3	11.8	0.5	0.5	0.5
11	20.7	22.2	19.7	26.1	20.6	21.1	9.8	8.5	0.5	0.5	0.5
12	15.0	16.1	20.2	18.2	17.0	19.2	4.8	6.7	0.5	0.5	0.5
13	21.1	22.3	24.7	22.3	28.6	28.8	8.4	17.5	0.5	0.5	0.5
14	24.9	29.3	20.6	26.2	29.5	24.9	7.9	14.0	0.5	0.5	0.5
15	25.7	19.9	28.5	31.1	28.7	21.1	9.0	17.3	0.5	0.5	0.5

**Table 7 Individual Run Data – Mass Load Capacity Testing**

<b>PERFORMANCE CONCENTRATIONS – Mass Load Testing</b>											
<b>Run #</b>	<b>Effluent 1 (mg/L)</b>	<b>Effluent 2 (mg/L)</b>	<b>Effluent 3 (mg/L)</b>	<b>Effluent 4 (mg/L)</b>	<b>Effluent 5 (mg/L)</b>	<b>Effluent 6 (mg/L)</b>	<b>Draw-down 1 (mg/L)</b>	<b>Draw-down 2 (mg/L)</b>	<b>Back-ground 1 (mg/L)</b>	<b>Back-ground 2 (mg/L)</b>	<b>Back-ground 3 (mg/L)</b>
16	49.3	59.0	52.2	51.0	52.0	56.1	19.9	30.2	0.5	0.5	0.5
17	59.2	60.2	61.2	62.5	60.6	65.1	28.3	31.6	0.5	0.5	0.5
18	64.6	63.7	64.3	78.2	64.5	69.4	26.9	34.8	0.5	0.5	0.5
19	65.6	68.8	66.4	71.7	62.9	72.5	19.1	35.1	0.5	0.5	0.5
20	66.8	69.0	68.4	71.1	71.5	72.0	21.0	40.6	0.5	0.5	0.5
21	67.5	68.0	69.1	72.3	73.3	72.0	34.0	47.7	0.5	0.5	0.5
22	60.5	71.1	69.2	79.7	70.7	78.4	17.6	47.7	0.5	0.5	0.5
23	73.2	74.6	74.2	73.6	83.2	76.9	31.0	49.0	0.5	0.5	0.5
24	73.1	74.9	78.6	77.9 <sup>1</sup>	83.2	80.0	34.4	50.1	0.5	0.5	0.5
25	78.7	77.8	80.2	82.1	84.9	84.6	21.4	52.5	0.5	0.5	0.5
26	79.8	80.1	81.1	77.8	78.9	75.9	27.3	52.7	0.5	0.5	0.5
27	68.7	69.4	73.1	77.8	79.9	79.2	40.2	62.8	0.5	0.5	0.5
28	80.5	77.8	74.2	82.2	81.8	77.3	65.2	45.8	0.5	0.5	0.5
29	76.3	75.1	77.7	81.3	84.0	82.8	50.8	68.3	0.5	0.5	0.5
30	64.0	71.4	68.8	208.4	81.5	82.6	43.8	61.7	0.5	0.5	0.5

PERFORMANCE CONCENTRATIONS – Mass Load Testing											
Run #	Effluent 1 (mg/L)	Effluent 2 (mg/L)	Effluent 3 (mg/L)	Effluent 4 (mg/L)	Effluent 5 (mg/L)	Effluent 6 (mg/L)	Draw-down 1 (mg/L)	Draw-down 2 (mg/L)	Back-ground 1 (mg/L)	Back-ground 2 (mg/L)	Back-ground 3 (mg/L)
31	82.4	78.7	82.8	91.7	84.8	85.9	40.0	60.6	0.5	0.5	0.5
32	65.7	74.3	74.4	78.6	79.3	80.4	30.2	43.2	0.5	0.5	0.5
33	78.3	81.4	84.2	81.6	85.7	84.1	35.4	48.6	0.5	0.5	0.5
34	85.4	84.7	87.3	89.2	83.8	85.1	28.9	44.9	0.5	0.5	0.5
35	85.0	84.7	85.4	86.1	90.9	88.7	40.2	58.5	0.5	0.5	0.5
36	87.5	86.5	87.8	94.2	92.0	91.4	48.7	65.3	0.5	0.5	0.5
37	86.7	88.7	85.1	91.5	89.7	90.4	46.1	66.0	0.5	0.5	0.5
38	83.1	69.6	71.4	82.3	74.9	70.8	27.7	53.0	0.5	0.5	0.5
39	68.9	76.2	70.5	71.4	78.5	74.9	24.9	38.3	0.5	0.5	0.5
40	70.9	73.4	77.8	78.0	84.7	81.5	33.4	61.2	0.5	0.5	0.5
41	69.0	72.7	74.9	82.5	79.3	79.8	37.6	49.1	0.5	0.5	0.5
42	67.1	65.7	67.5	85.7	75.7	39.4	29.7	51.7	0.5	0.5	0.5
43	83.1	80.4	76.4	88.8	92.3	86.7	46.5	57.7	0.5	0.5	1.86
44	90.1	93.8	94.1	93.4	95.2	97.7	52.8	65.6	0.5	0.5	0.5
45	89.2	81.0	97.3	93.6	93.5	92.1	50.2	75.1	0.5	0.5	0.5
46	74.7	90.7	76.8	83.5	79.6	82.3	61.7	81.8	0.5	0.5	0.5
47	60.9	62.3	67.6	70.8	71.9	64.6	61.0	79.6	0.5	0.5	0.5
48	81.5	80.2	84.9	89.9	89.1	89.2	59.8	79.8	0.5	0.5	0.5
49	81.3	83.4	85.7	86.6	89.9	88.2	65.4	74.6	0.5	0.5	0.5
50	87.3	88.9	89.0	91.5	91.1	91.9	63.2	63.5	0.5	0.5	0.5
51	84.5	77.1	66.7	73.8	77.8	81.8	42.5	57.8	0.5	0.5	0.5
52	74.8	71.7	76.9	74.4	85.2	74.3	56.1	64.0	0.5	0.5	0.5
53	80.2	83.3	90.0	88.2	93.3	90.0	55.6	55.6	0.5	0.5	0.5
54	84.1	84.7	86.5	88.8	90.6	87.0 <sup>2</sup>	61.0	65.2	0.5	0.5	0.5
55	78.8	89.0	86.1	85.1	87.2	95.4	65.5	71.0	0.5	0.5	0.5
56	83.8	87.8	86.0	92.0	90.1	90.3	70.6	78.7	0.5	0.5	0.5
57	84.9	85.6	91.4 <sup>3</sup>	98.4	93.4	94.8	56.9	75.3	0.5	0.5	0.5
58	84.1	86.8	93.2	87.2	92.5	90.3	75.1	85.6	0.5	0.5	0.5
59	92.1	98.4	97.6	101.5	97.3	102.9	75.6	82.2	0.5	0.5	0.5
60	92.4	90.3	86.5	99.6	103.3	85.8	54.8	72.1	0.5	0.5	0.5
61	102.1	95.3	95.2	101.3	103.0	94.7	82.1	82.3	0.5	0.5	0.5
62	85.2	89.1	84.9	100.6	91.8	91.3	60.7	82.5	0.5	0.5	0.5
63	84.4	93.8	89.8	98.7	97.7	97.3	91.1	69.3	0.5	0.5	0.5
64	91.8	93.7	83.3	77.8	91.3	85.4	55.4	90.9	0.5	0.5	0.5

<sup>1</sup>Effluent sample 4 on run 24 has a 0.5 mg/L value. It is assumed this was an error by the lab during processing. An average of the other 5 effluent samples was used as a substitute.

<sup>2</sup>Effluent sample 6 on run 54 has a 0.5 mg/L value. It is assumed this was an error by the lab during processing. An average of the other 5 effluent samples was used as a substitute.

<sup>3</sup>Effluent sample 3 on run 57 has a 20.9 mg/L value. It is assumed this was an error by the lab during processing. An average of the other 5 effluent samples was used as a substitute.

## 4.2 Water Surface Levels and Retention Times

The water levels were monitored in both the pre-treatment and wetland chambers of the Modular Wetlands® Linear during each test run. Water levels slowly increased over the course of the testing until the flow rate was reduced to 90% of the MTFR. As shown in **Table 8** and **Table 9** the observed water levels were less than the maximum water levels used prior to official testing and used to calculate the retention time. Thus, retention times were longer than required by the protocol and provided a safety factor.

**Table 8 Removal Efficiency Detention Times and Water Levels**

DETENTION TIME AND WATER LEVELS – Removal Efficiency Testing								
Run #	Average Inflow Rate (gpm) ( $\pm 10\%$ )	Pre-Treatment Chamber Water Level (in)	Wetland Chamber Water Level (in)	Active Wet Volume (cu ft)	Retention Time (min)	3X Retention Time (min)	Time Used In Sampling Schedule (min)	Detention Time Compliant?
1	125.2	32.5	25.8	48.79	2.91	8.74	12.25	YES
2	125.1	32.875	26.8	49.89	2.98	8.95	12.25	YES
3	125.2	33.0	26.2	49.54	2.96	8.88	12.25	YES
4	125.2	33.0	26.7	49.93	2.98	8.95	12.25	YES
5	125.0	32.875	27.6	50.51	3.02	9.07	12.25	YES
6	125.2	32.75	26.9	49.86	2.98	8.94	12.25	YES
7	125.1	32.625	27.8	50.44	3.02	9.05	12.25	YES
8	125.0	33.0	26.6	49.85	2.98	8.95	12.25	YES
9	125.1	33.0	26.3	49.62	2.97	8.90	12.25	YES
10	125.1	33.0	26.6	49.85	2.98	8.94	12.25	YES
11	125.2	32.875	26.9	49.97	2.99	8.96	12.25	YES
12	125.1	33.0	26.7	49.93	2.99	8.96	12.25	YES
13	125.0	33.0	26.7	49.93	2.99	8.96	12.25	YES
14	125.0	33.0	26.6	49.85	2.98	8.95	12.25	YES
15	125.1	33.0	26.9	50.08	2.99	8.98	12.25	YES

**Table 9 Sediment Mass Capacity Detention Times and Water Levels**

<b>DETENTION TIME AND WATER LEVELS – Sediment Mass Capacity Testing</b>								
<b>Run #</b>	<b>Average Inflow Rate (gpm) (<math>\pm 10\%</math>)</b>	<b>Pre-Treatment Chamber Water Level (in)</b>	<b>Wetland Chamber Water Level (in)</b>	<b>Active Wet Volume (cu ft)</b>	<b>Retention Time (min)</b>	<b>3X Retention Time (min)</b>	<b>Time Used In Sampling Schedule (min)</b>	<b>Detention Time Compliant?</b>
16	125.2	32.75	26.7	49.71	2.97	8.91	12.25	YES
17	125.1	33.5	27.0	50.61	3.03	9.08	12.25	YES
18	125.1	33.25	26.4	49.92	2.98	8.95	12.25	YES
19	125.2	33.25	27.8	51.00	3.05	9.14	12.25	YES
20	125.1	33.25	26.9	50.31	3.01	9.02	12.25	YES
21	124.9	33.0	27.3	50.39	3.02	9.05	12.25	YES
22	125.1	33.5	27.5	50.99	3.05	9.15	12.25	YES
23	125.1	33.5	27.7	51.14	3.06	9.17	12.25	YES
24	125.0	33.5	27.0	50.61	3.03	9.08	12.25	YES
25	125.0	33.25	27.4	50.69	3.03	9.10	12.25	YES
26	125.2	33.25	28.1	51.23	3.06	9.18	12.25	YES
27	125.1	33.25	27.9	51.08	3.05	9.16	12.25	YES
28	125.4	33.375	26.8	50.29	3.00	9.00	12.25	YES
29	124.9	33.25	26.6	50.07	3.00	9.00	12.25	YES
30	125.2	33.375	27.2	50.65	3.03	9.08	12.25	YES
31	125.1	33.5	27.2	50.76	3.03	9.10	12.25	YES
32	125.2	34.75	28.2	52.64	3.15	9.44	12.25	YES
33	125.2	34.75	28.1	52.56	3.14	9.42	12.25	YES
34	125.1	34.75	28.6	52.95	3.17	9.50	12.25	YES
35	125.1	34.75	28.4	52.80	3.16	9.47	12.25	YES
36	125.3	34.5	28.2	52.42	3.13	9.39	12.25	YES
37	125.1	34.375	27.9	52.08	3.11	9.34	12.25	YES
38	125.3	34.375	27.1	51.46	3.07	9.22	12.25	YES
39	125.1	34.0	27.0	51.05	3.05	9.16	12.25	YES
40	125.5	34.5	27.3	51.73	3.08	9.25	12.25	YES
41	125.2	34.25	27.2	51.43	3.07	9.22	12.25	YES
42	125.3	34.5	27.4	51.80	3.09	9.28	12.25	YES
43	125.2	34.375	27.8	52.00	3.11	9.32	12.25	YES
44	125.0	34.375	27.4	51.69	3.09	9.28	12.25	YES
45	124.9	34.25	26.8	51.12	3.06	9.18	12.25	YES
46	124.9	34.25	28.3	52.27	3.13	9.39	12.25	YES
47	112.6	31.5	25.9	47.98	3.19	9.56	12.25	YES
48	112.5	31.875	25.3	47.85	3.18	9.54	12.25	YES
49	112.5	31.75	25.6	47.97	3.19	9.57	12.25	YES
50	112.6	31.75	25.3	47.74	3.17	9.51	12.25	YES
51	112.4	31.75	25.6	47.97	3.19	9.58	12.25	YES

DETENTION TIME AND WATER LEVELS CON'T – Sediment Mass Capacity Testing								
Run #	Average Inflow Rate (gpm) ( $\pm 10\%$ )	Pre-Treatment Chamber Water Level (in)	Wetland Chamber Water Level (in)	Active Wet Volume (cu ft)	Retention Time (min)	3X Retention Time (min)	Time Used In Sampling Schedule (min)	Detention Time Compliant?
52	112.8	32.5	26.5	49.33	3.27	9.81	12.25	YES
53	112.4	32.5	26.3	49.18	3.27	9.82	12.25	YES
54	112.6	32.375	25.7	48.60	3.23	9.69	12.25	YES
55	112.5	32.25	26.2	48.88	3.25	9.75	12.25	YES
56	112.7	32.25	26.6	49.18	3.26	9.79	12.25	YES
57	112.6	32.25	26.6	49.18	3.27	9.80	12.25	YES
58	112.5	32.5	26.8	49.56	3.30	9.89	12.25	YES
59	112.4	32.375	26.7	49.37	3.29	9.86	12.25	YES
60	112.6	32.5	27.1	49.79	3.31	9.92	12.25	YES
61	112.5	32.375	26.7	49.37	3.28	9.85	12.25	YES
62	112.5	32.375	26.8	49.45	3.29	9.86	12.25	YES
63	112.5	32.5	26.3	49.18	3.27	9.81	12.25	YES
64	112.5	32.75	26.4	49.48	3.29	9.87	12.25	YES

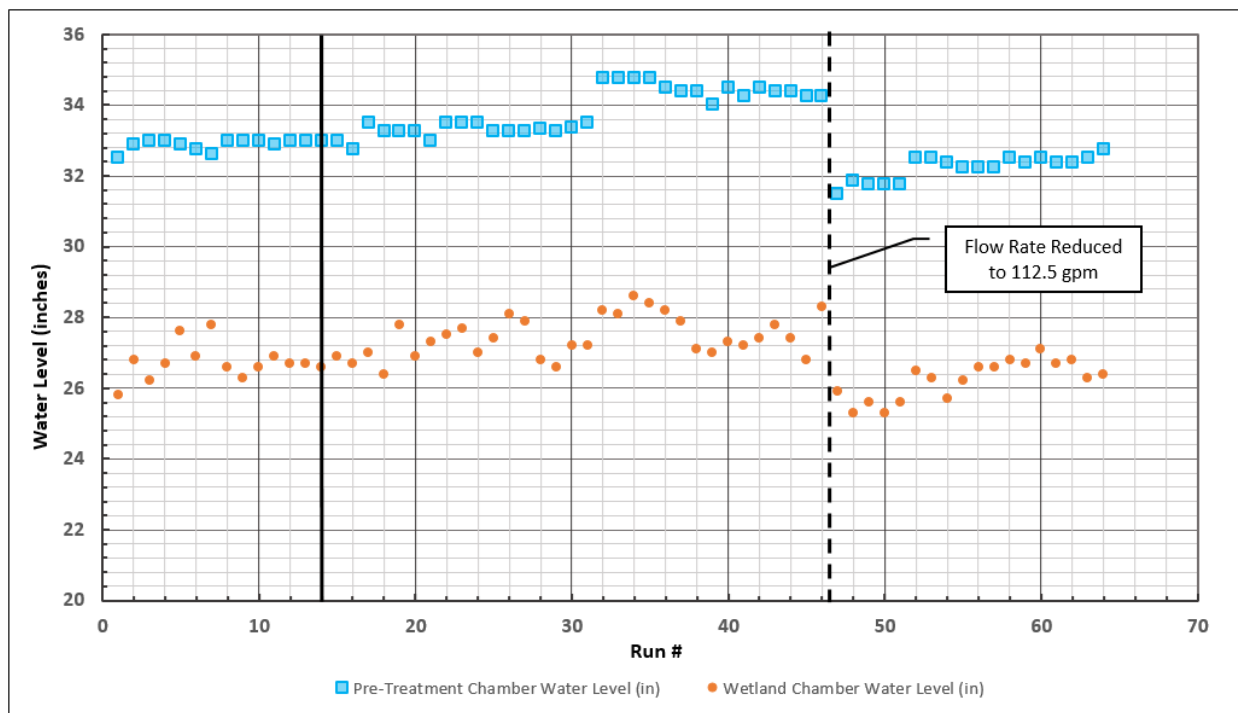
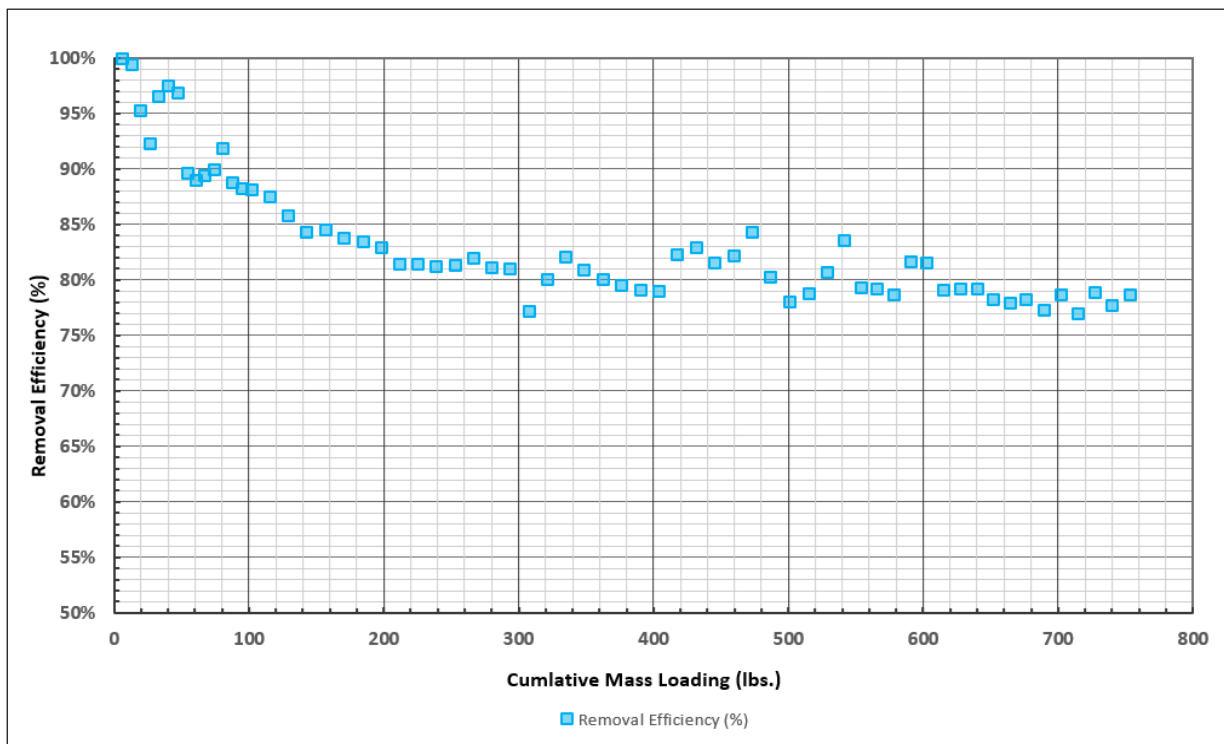


Figure 11 Water Levels



**Figure 12 Removal Efficiencies vs. Cumulative Mass Loading**

### 4.3 QA/QC

The average inflow rate was within 10% variation from the target flow rate for each of the 64 total runs as shown in **Table 10** and **Table 11**. The associated COV was also within compliance of the NJDEP protocol. All runs had temperatures less than 80° F. Each background and effluent sample was weighed (subtracting out the weight of the empty bottle) after the test run and recorded. As shown in **Table 12** and **Table 13** all samples were greater than the 0.5 L minimum requirement in the protocol.

**Table 10 Summary of Removal Efficiency Flow Rates and Temperature**

<b>FLOW RATE AND WATER TEMPERATURE – Removal Efficiency Testing</b>					
<b>Run #</b>	<b>QAQC PASS/FAIL</b>	<b>Target Inflow Rate (gpm)</b>	<b>Average Inflow Rate (gpm) (<math>\pm 10\%</math>)</b>	<b>Inflow Rate COV (<math>\leq 0.03</math>)</b>	<b>Maximum Water Temperature (°F) (<math>\leq 80</math> ° F)</b>
1	PASS	125.0	125.2	0.003	75.2 <sup>1</sup>
2	PASS	125.0	125.1	0.003	75.3
3	PASS	125.0	125.2	0.002	75.0
4	PASS	125.0	125.2	0.002	75.0
5	PASS	125.0	125.0	0.004	75.0
6	PASS	125.0	125.2	0.003	Datalogger Error - Manual Reading of 75.0 <sup>2</sup>
7	PASS	125.0	125.1	0.005	75.3
8	PASS	125.0	125.0	0.003	75.0
9	PASS	125.0	125.1	0.003	75.0
10	PASS	125.0	125.1	0.003	75.2 <sup>3</sup>
11	PASS	125.0	125.2	0.005	75.5 <sup>4</sup>
12	PASS	125.0	125.1	0.003	75.5
13	PASS	125.0	125.0	0.002	75.2
14	PASS	125.0	125.0	0.003	75.2 <sup>5</sup>
15	PASS	125.0	125.1	0.004	75.2

<sup>1</sup>The max temperature from single data point during run due to operator error with temperature sensor. Temperature confirmed by the 3<sup>rd</sup> party observer as the maximum temperature for this run.

<sup>2</sup>No automatically recorded temperature sensor data was available. Manual readings were recorded during the test run and confirmed by the 3<sup>rd</sup> party observer as the maximum temperature for this run.

<sup>3</sup>Temperatures were recorded for the initial portion of the run prior to the error occurring. Manual readings were recorded and confirmed by the 3<sup>rd</sup> party observer as the maximum temperature for this run.

<sup>4</sup>Some erroneous temperature readings were recorded for approximately 80 seconds during the test run. Manual readings were recorded during the test run and confirmed by the 3<sup>rd</sup> party observer.

<sup>5</sup>Temperatures were recorded for the initial portion of the run prior to the error occurring. Manual readings were recorded and confirmed by the 3<sup>rd</sup> party observer as the maximum temperature for this run.

**Table 11 Summary of Sediment Mass Loading Flow Rates and Temperature**

<b>FLOW RATE AND WATER TEMPERATURE – Sediment Mass Capacity</b>					
<b>Run #</b>	<b>QAQC PASS/FAIL</b>	<b>Target Inflow Rate (gpm)</b>	<b>Average Inflow Rate (gpm) (<math>\pm 10\%</math>)</b>	<b>Inflow Rate COV (<math>\leq 0.03</math>)</b>	<b>Maximum Water Temperature (<math>^{\circ}\text{F}</math>) (<math>\leq 80^{\circ}\text{F}</math>)</b>
16	PASS	125.0	125.2	0.002	75.7
17	PASS	125.0	125.1	0.002	74.6 <sup>1</sup>
18	PASS	125.0	125.1	0.002	74.6 <sup>2</sup>
19	PASS	125.0	125.2	0.003	74.4
20	PASS	125.0	125.1	0.003	74.6
21	PASS	125.0	124.9	0.003	74.6
22	PASS	125.0	125.1	0.002	74.6
23	PASS	125.0	125.1	0.004	74.6 <sup>3</sup>
24	PASS	125.0	125.0	0.004	74.6
25	PASS	125.0	125.0	0.003	74.6 <sup>3</sup>
26	PASS	125.0	125.2	0.004	74.8
27	PASS	125.0	125.1	0.002	75.5
28	PASS	125.0	125.4	0.003	76.4
29	PASS	125.0	124.9	0.004	77.0
30	PASS	125.0	125.2	0.002	75.9 <sup>4</sup>
31	PASS	125.0	125.1	0.003	74.6
32	PASS	125.0	125.2	0.003	74.6
33	PASS	125.0	125.2	0.003	74.6
34	PASS	125.0	125.1	0.004	74.6
35	PASS	125.0	125.1	0.003	74.6
36	PASS	125.0	125.3	0.003	74.6
37	PASS	125.0	125.1	0.003	74.4
38	PASS	125.0	125.3	0.003	74.4
39	PASS	125.0	125.1	0.004	74.3
40	PASS	125.0	125.5	0.004	74.4
41	PASS	125.0	125.2	0.003	74.4
42	PASS	125.0	125.3	0.003	74.4
43	PASS	125.0	125.2	0.003	74.3
44	PASS	125.0	125.0	0.003	74.1
45	PASS	125.0	124.9	0.004	74.1
46	PASS	125.0	124.9	0.003	74.1
47	PASS	112.5	112.6	0.003	74.3
48	PASS	112.5	112.5	0.003	73.9
49	PASS	112.5	112.5	0.002	73.7
50	PASS	112.5	112.6	0.002	75.2
51	PASS	112.5	112.4	0.002	77.0
52	PASS	112.5	112.8	0.007	74.6

FLOW RATE AND WATER TEMPERATURE CON'T – Sediment Mass Capacity					
Run #	QAQC PASS/FAIL	Target Inflow Rate (gpm)	Average Inflow Rate (gpm) ( $\pm 10\%$ )	Inflow Rate COV ( $\leq 0.03$ )	Maximum Water Temperature (°F) ( $\leq 80^\circ \text{F}$ )
53	PASS	112.5	112.4	0.003	75.2
54	PASS	112.5	112.6	0.003	75.7
55	PASS	112.5	112.5	0.003	76.6
56	PASS	112.5	112.7	0.003	78.4
57	PASS	112.5	112.6	0.003	78.6
58	PASS	112.5	112.5	0.002	77.0
59	PASS	112.5	112.4	0.003	77.0
60	PASS	112.5	112.6	0.002	77.0
61	PASS	112.5	112.5	0.005	78.2
62	PASS	112.5	112.5	0.002	79.7
63	PASS	112.5	112.5	0.002	77.1
64	PASS	112.5	112.5	0.004	77.1

<sup>1</sup>Temperatures were recorded for the full duration of the test run but intermittent errors occurred with sensor. Manual readings were recorded and confirmed by the 3<sup>rd</sup> party observer as the maximum for the run.

<sup>2</sup>Erroneous temperature readings were recorded for approximately 40 seconds during the test run. Manual readings were recorded and confirmed by the 3<sup>rd</sup> party observer as the maximum for this run.

<sup>3</sup>Manual temperature readings were recorded during the test run and confirmed by the 3<sup>rd</sup> party observer as the maximum for this run.

<sup>4</sup>Erroneous temperature readings were recorded for the last three minutes of this test run. Manual readings were recorded and been confirmed by the 3<sup>rd</sup> party observer as the maximum for this run.

**Table 12 Summary of Removal Efficiency Feed Rate and Concentration**

<b>FEED RATE AND CONCENTRATIONS - Removal Efficiency Testing</b>									
<b>Run #</b>	<b>QAQC PASS/FAIL</b>	<b>Target Influent SCC (mg/L)</b>	<b>Average Influent SSC (mg/L) (±10%)</b>	<b>Feed Rate (g/min)</b>			<b>Feed Rate COV (≤0.10)</b>	<b>Average Background SSC (≤20 mg/L)</b>	<b>Minimum SSC Sample Volume (≥0.5 L)</b>
1	PASS	200	199.3	94.125	94.139	94.466	0.002	0.5	0.850
2	PASS	200	194.8	94.165	91.553	90.807	0.019	0.5	0.800
3	PASS	200	201.3	95.248	94.841	97.659	0.016	0.5	0.850
4	PASS	200	201.2	92.943	94.626	97.104	0.022	0.5	0.860
5	PASS	200	199.7	93.688	96.088	95.581	0.013	0.5	0.840
6	PASS	200	207.9	94.152	97.685	98.240	0.023	0.5	0.840
7	PASS	200	205.0	93.963	98.045	96.786	0.021	0.5	0.830
8	PASS	200	202.7	93.726	98.208	96.617	0.024	0.5	0.770
9	PASS	200	195.1	92.039	91.222	93.914	0.015	0.5	0.850
10	PASS	200	197.1	95.376	95.593	96.022	0.003	0.5	0.830
11	PASS	200	199.3	90.603	96.640	95.489	0.034	0.5	0.850
12	PASS	200	198.2	92.554	95.065	95.224	0.016	0.5	0.870
13	PASS	200	204.4	95.386	98.217	97.186	0.015	0.5	0.850
14	PASS	200	205.0	92.930	98.957	98.839	0.036	0.5	0.830
15	PASS	200	204.6	98.109	96.440	100.064	0.018	0.5	0.860

**Table 13 Summary of Sediment Mass Load Feed Rate and Concentration**

<b>FEED RATE AND CONCENTRATIONS - Sediment Mass Capacity</b>									
<b>Run #</b>	<b>QAQC PASS/FAIL</b>	<b>Target Influent SCC (mg/L)</b>	<b>Average Influent SSC (mg/L) (±10%)</b>	<b>Feed Rate (g/min)</b>			<b>Feed Rate COV (≤0.10)</b>	<b>Average Background SSC (≤20 mg/L)</b>	<b>Minimum SSC Sample Volume (≥0.5 L)</b>
16	PASS	400	400.3	182.429	186.353	196.206	0.038	0.5	0.840
17	PASS	400	407.5	186.820	190.328	191.534	0.013	0.5	0.810
18	PASS	400	406.7	189.789	193.175	188.548	0.013	0.5	0.740
19	PASS	400	416.1	189.397	196.614	199.813	0.027	0.5	0.840
20	PASS	400	406.2	192.779	192.128	186.120	0.019	0.5	0.820
21	PASS	400	404.7	190.479	188.778	196.449	0.021	0.5	0.810
22	PASS	400	400.2	192.675	194.084	194.884	0.006	0.5	0.840
23	PASS	400	400.9	192.453	184.701	188.699	0.021	0.5	0.740
24	PASS	400	406.7	189.320	189.135	188.992	0.001	0.5	0.780
25	PASS	400	407.8	192.327	194.317	191.151	0.008	0.5	0.740
26	PASS	400	404.8	189.840	194.222	189.932	0.013	0.5	0.790
27	PASS	400	398.7	189.037	185.134	193.284	0.022	0.5	0.800
28	PASS	400	403.2	190.275	195.917	188.839	0.020	0.5	0.870
29	PASS	400	404.9	188.681	197.187	191.382	0.023	0.5	0.850
30	PASS	400	399.5	186.706	187.264	185.320	0.005	0.5	0.820
31	PASS	400	404.5	188.211	192.569	197.202	0.023	0.5	0.770
32	PASS	400	400.0	186.240	190.634	188.125	0.012	0.5	0.810
33	PASS	400	407.7	192.361	195.453	195.714	0.010	0.5	0.800
34	PASS	400	408.6	195.833	191.666	191.519	0.013	0.5	0.790
35	PASS	400	406.7	190.222	193.673	188.540	0.014	0.5	0.800
36	PASS	400	412.5	196.204	199.451	195.051	0.012	0.5	0.790
37	PASS	400	406.1	189.914	189.163	197.418	0.024	0.5	0.800
38	PASS	400	403.6	192.272	191.819	193.509	0.005	0.5	0.800
39	PASS	400	404.7	197.044	195.838	191.447	0.015	0.5	0.840
40	PASS	400	409.1	193.096	193.647	190.863	0.008	0.5	0.860
41	PASS	400	408.4	199.100	192.888	193.235	0.018	0.5	0.810
42	PASS	400	409.0	189.579	196.022	194.595	0.017	0.5	0.830
43	PASS	400	408.4	193.033	196.497	192.096	0.012	1.0	0.840
44	PASS	400	413.0	190.932	193.383	190.887	0.007	0.5	0.810
45	PASS	400	414.0	197.105	196.800	198.912	0.006	0.5	0.790
46	PASS	400	413.8	195.748	199.368	195.318	0.011	0.5	0.840
47	PASS	400	406.4	173.808	176.871	174.494	0.009	0.5	0.810
48	PASS	400	404.5	172.406	167.727	171.619	0.015	0.5	0.860
49	PASS	400	401.3	174.032	171.209	169.444	0.013	0.5	0.840
50	PASS	400	407.4	169.058	171.026	171.920	0.009	0.5	0.790

FEED RATE AND CONCENTRATIONS CON'T - Sediment Mass Capacity									
Run #	QAQC PASS/FAIL	Target Influent SCC (mg/L)	Average Influent SSC (mg/L) (+10%)	Feed Rate (g/min)			Feed Rate COV (≤0.10)	Average Background SSC (≤20 mg/L)	Minimum SSC Sample Volume (≥0.5 L)
51	PASS	400	407.5	170.931	169.403	175.262	0.018	0.5	0.810
52	PASS	400	401.5	172.113	180.826	171.834	0.029	0.5	0.830
53	PASS	400	407.6	176.333	175.094	171.425	0.015	0.5	0.790
54	PASS	400	405.5	174.706	172.061	168.777	0.017	0.5	0.830
55	PASS	400	404.8	174.509	171.706	170.334	0.012	0.5	0.810
56	PASS	400	396.5	170.264	171.816	170.616	0.005	0.5	0.800
57	PASS	400	398.3	171.722	170.177	173.517	0.010	0.5	0.820
58	PASS	400	403.6	166.650	169.302	170.240	0.011	0.5	0.820
59	PASS	400	422.1	172.118	178.679	188.677	0.046	0.5	0.830
60	PASS	400	418.2	180.049	176.022	177.645	0.011	0.5	0.850
61	PASS	400	419.3	180.288	177.383	175.228	0.014	0.5	0.800
62	PASS	400	418.9	180.119	181.328	181.241	0.004	0.5	0.880
63	PASS	400	410.8	173.899	173.298	176.626	0.010	0.5	0.850
64	PASS	400	415.7	175.850	181.841	175.339	0.020	0.5	0.830

#### 4.4 Scour Results

Scour testing was conducted in accordance with Section 4 of the NJDEP Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration MTD. Testing was conducted at a target flow rate of 260 gpm, more than 200% (250 gpm) of the maximum treatment flow rate (MTFR).

Scour testing began by gradually increasing the flow rate to the target flow within a five-minute period. Effluent and background samples were taken from the same locations as for the removal efficiency test, starting 2 minutes after target flow rate was sustained and the ramp up period had ended. The sampling frequency is summarized in **Table 14**.

**Table 14 Scour Test Sampling Frequency**

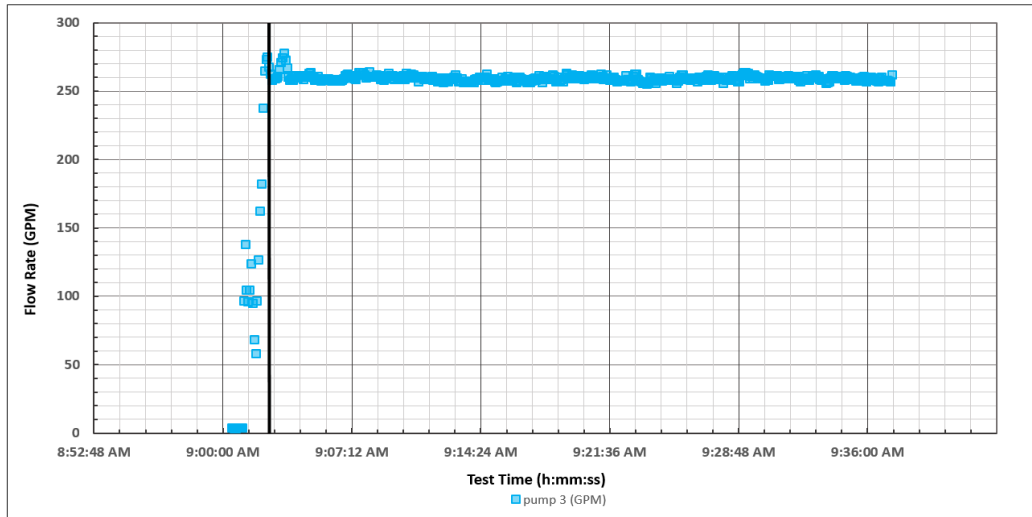
Sample/ Measurement Taken	Run Time (min.)															
	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
Effluent		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Background		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Note: The Run Time of 0 minutes was the end of the 5-minute flow ramp up period.

Water temperature was below the 80-degree maximum allowable as shown in **Table 15**. The water flow rate is shown in **Table 15** and on **Figure 13**.

**Table 15 Water Flow and Temperature - Scour Test**

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	260	259.3	-0.28 %	0.007	
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS



**Figure 13 Water Flow - Scour Test**

The effluent and background SSC results are reported in **Table 16**. The adjusted effluent concentration was calculated as:

$$\begin{aligned}
 \text{Adjusted Effluent Concentration } \left( \frac{\text{mg}}{\text{L}} \right) \\
 = \text{Measured Effluent Concentration } \left( \frac{\text{mg}}{\text{L}} \right) - \text{Background Concentration } \left( \frac{\text{mg}}{\text{L}} \right)
 \end{aligned}
 \quad (\text{Equation 11})$$

The TSS method reporting limit was 1.0 mg/L. Any results below this value were reported as 0.5 mg/L for calculation purposes. A total of 15 samples were collected for both effluent and background concentrations to have matching pairs and eliminate the need for interpolation. The average adjusted effluent concentration was 4.0 mg/L. Therefore, when operated up to 202% of the MTR, the Modular Wetlands® Linear can be used for online conveyance.

**Table 16 Suspended Sediment Concentrations for Scour Test**

	Scour Suspended Sediment Concentration (mg/L)															
Sample #	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Effluent		14.7	6.5	6.7	5.6	5.1	4.8	4.3	4.0	3.2	3.0	3.3	3.2	1.0	2.8	2.1
Background		0.5	0.5	0.5	0.5	3.7	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Adjusted Effluent		14.2	6.0	6.2	5.1	1.4	4.3	3.8	3.5	2.7	2.5	2.8	2.7	0.5	2.3	1.6
Average Adjusted Effluent Concentration							4.0 mg/L									

## 5. Design Limitations

Bio Clean Environmental Services, Inc. provides engineering support to clients on all projects. Each system prior to submittal is evaluated and professionally designed/sized to meet site-specific conditions including treatment and bypass flow rates, load rating requirements, and pipe depth/inlet design details. All site and design constraints will be addressed during the design and manufacturing process.

### *Required Soil Characteristics*

The Modular Wetlands® Linear is delivered to the job site as a pre-assembled unit housed in a concrete structure designed to meet site-specific soil conditions, corrosiveness, and groundwater. Note: Some project specific conditions may warrant the need to deliver systems not fully assembled and may require some filter assembly. Plastic or fiberglass housing may also be available. The system can be used in most soil types provided the structure is properly designed to deal with project specific loading, ground water, and corrosive soil conditions. A copy of the geotechnical report along with surface loading requirements will be reviewed and verified for each project if provided.

### *Slope*

In general, it is not recommended that the pipe slope into the system neither exceed 5% nor be less than 0.5%. Slopes higher than 5% will cause increased velocities, which could affect the performance. Slopes less than 0.5% could cause sediment to accumulate in the bottom of the inflow pipe and affect its hydraulic capacity.

The Modular Wetlands® Linear is usually not affected by variations in slope of the finish surface if the unit is buried underground. Risers of various heights can be used to bring access to the system up to the finish surface. For units installed at surface with an open vegetated planter the slope of the finish surface may require custom designed top slabs and installation procedures that should be addressed during the design process. In these configurations finish surface slope is more constrained and will require design review to ensure appropriate configuration.

### *Maximum Treatment Flow Rate*

Maximum treatment flow rate is dependent on model size. The Modular Wetlands® Linear is sized based upon the NJDEP tested hydraulic loading rate of 2.91 gallons per minute per square foot of wetland media surface area and 4.88 gallons per minute per square foot of pre-filter media surface area. Section 6 includes details pertaining to inspection and maintenance of the Modular Wetlands® Linear.

### *Maintenance Requirements*

Requirements pertaining to maintenance of the Modular Wetlands® Linear will vary depending on pollutant loading and individual site conditions. It is recommended that the system be inspected at least twice during the first year to determine loading conditions for each site. These first-year inspections can be used to establish inspection and maintenance frequency for subsequent years.

### *Driving Head*

Driving head required is 2.9 feet for the Modular Wetlands® Linear. Design support is provided for all projects including site-specific drawings/cut sheets, which show elevations of pipes, flow line (curb inlet style) and finish surface. Peak and treatment flow rates will also be evaluated to ensure the system is correctly designed from a hydraulic standpoint.

### *Installation Limitations*

With each installation, Bio Clean Environmental provides contractors with instructions prior to delivery. Contractors can request onsite assistance from an installation technician during delivery and installation. Pick weights and lifting details are also provided prior to delivery so the contractor can have appropriate equipment onsite to set the unit.

### *Configurations*

The Modular Wetlands® Linear can be installed online or offline. The Modular Wetlands® Linear has an internal bypass, which allows for it to be installed online without the need for any external high flow diversion structure up to 202% MTFR conveyance.

### *Structural Load Limitations*

The Modular Wetlands® Linear is housed in a pre-cast concrete structure. Most standard structures are designed to handle indirect traffic loads with open planter configurations. For deeper installation, or installation requiring direct traffic rating or higher, the structure will be designed and modified with potentially thicker tops, bottoms and/or walls to handle the additional loading. Various access hatch options are available for parkway, indirect traffic, direct traffic, and other higher loading requirements such as airports or loading docks.

### *Pre-treatment Requirements*

The Modular Wetlands® Linear has no additional pre-treatment requirements.

### *Limitations in Tailwater*

Site-specific tailwater conditions must be assessed on each individual project. Tailwater conditions increase the amount of driving head required for optimal system operation. The manufacturer's internal protocols require that these conditions are discussed with the engineer of record and that

a solution be implemented to adjust for any design variations caused by tailwater conditions at both treatment and bypass flow rates.

#### *Depth to Seasonal High-Water Table*

High groundwater conditions will not affect the operation of the Modular Wetlands® Linear, as it is a closed system. In conditions where high groundwater is present, various measures are employed by Bio Clean Environmental Services' engineering department to ensure that there are no negative consequences caused by the high groundwater. Various measures can be employed such as waterproofing the inside and outside of the structure with an approved coating. A footing can also be added to the bottom of the structure to increase its footprint and offset any buoyancy concerns.

## **6. Maintenance Plans**

As with all stormwater BMPs, inspection and maintenance on the Modular Wetlands® Linear is necessary. Stormwater regulations require that all BMPs be inspected and maintained to ensure they are operating as designed to allow for effective pollutant removal and provide protection to receiving water bodies. It is recommended that inspections be performed multiple times during the first year to assess site specific loading conditions. This is recommended because pollutant loading can vary greatly from site to site. Variables such as nearby soil erosion or construction sites, winter sanding of roads, amount of daily traffic and land use can increase pollutant loading on the system. The first year of inspections can be used to set inspection and maintenance intervals for subsequent years. Without appropriate maintenance, a BMP can exceed its storage capacity, which can negatively affect its continued performance in removing and retaining captured pollutants. The Modular Wetlands® Linear Operation and Maintenance Manual is available at: <https://biocleanenvironmental.com/wp-content/uploads/2022/04/Modular-Wetlands-Operation-Maintenance-Manual-4-20-22.pdf>

#### *Inspection Equipment*

Following is a list of equipment to allow for simple and effective inspection of the Modular Wetlands® Linear:

- Flashlight
- Maintenance cover hook or appropriate tools to remove access hatches and covers.
- Appropriate traffic control signage and procedures.
- Measuring pole and/or tape measure.
- Protective clothing and eye protection.
- 7/16" open or closed ended wrench.
- Large permanent black marker (initial inspections only – first year).
- Note: Entering a confined space requires appropriate safety and certification. It is generally not required for routine inspections of the system.

### *Inspection Steps*

The core to any successful stormwater BMP maintenance program is routine inspections. The inspection steps required on the Modular Wetlands® Linear are quick and easy. As mentioned above the first year should be seen as the maintenance interval establishment phase. During the first year, more frequent inspections should occur in order to gather loading data and maintenance requirements for that specific site. This information can be used to establish a base for long-term inspection and maintenance interval requirements.

The Modular Wetlands® Linear can be inspected through visual observation without entry into the system. All necessary pre-inspection steps must be carried out before inspection occurs, especially traffic control and other safety measures to protect the inspector and nearby pedestrians from any dangers associated with an open access hatch or manhole. Once these access covers have been safely opened, the inspection process can proceed:

- Prepare the inspection form by writing in the necessary information including project name, location, date and time, unit number and other info (see inspection form).
- Observe the inside of the system through the access hatches. If minimal light is available and vision into the unit is impaired utilize a flashlight to see inside the system and all of its chambers.
- Look for any out of the ordinary obstructions in the inflow pipe, pre-treatment chamber, biofiltration/wetland chamber, discharge chamber or outflow pipe. Write down any observations on the inspection form.
- Through observation and/or digital photographs estimate the amount of trash, debris and sediment accumulated in the pre-treatment chamber. Utilizing a tape measure or measuring stick estimate the amount of trash, debris, organics and sediment in this chamber. Record this depth on the inspection form.
- Through visual observation, inspect the condition of the pre-filters. Look for excessive build-up of sediments on the pre-filter sides and top, and/or evidence of hole clogging. Record this information on the inspection form. The pre-filters can further be inspected by removing the top and assessing the color of the filter cubes (requires entry into pre-treatment chamber – see notes above regarding confined space entry). Record the color of the material. New material is a light green in color. As the media becomes clogged it will turn darker in color, eventually becoming dark brown or black. Using the maintenance inspection color indicator described below, record the percentage of media exhausted.
- The biofiltration/wetland chamber is generally maintenance free due to the system's advanced pre-treatment chamber. For units, which have open planters with vegetation, it is recommended the vegetation be inspected and maintained. Look for any plants that are dead or showing signs of disease or other negative stressors. Record the general health of the plants on the inspection form and indicate through visual observation or digital photographs if trimming of the vegetation is needed.
- The discharge chamber is connected to the outflow pipe and allows for internal bypass around the biofiltration/wetland chamber. Generally, the discharge chamber will be clean and free of debris. Inspect the watermarks on the sidewalls. If possible, inspect

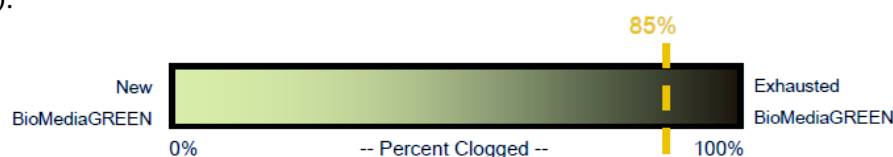
the discharge chamber during a rain event to assess the amount of flow leaving the system while it is at 100% capacity (pre-treatment chamber water level at peak hydraulic grade line or HGL). The water level of the flowing water should be compared to the watermark level on the sidewalls, which is an indicator of the highest discharge rate the system achieved when initially installed. Record on the form if there is any difference in level from watermark in inches.

- Water level in the discharge chamber is a function of flow rate and pipe size. Observation of water level during the first few months of operation can be used as a benchmark level for future inspections. The initial mark and all future observations shall be made when the system is at 100% capacity (water level at maximum level in pre-treatment chamber). If future water levels are below this mark when system is at 100% capacity this is an indicator that maintenance to the pre-filter(s) may be needed.
- Finalize the inspection report for analysis by the maintenance manager to determine if maintenance is required.

### *Maintenance Indicators*

Based upon observations made during inspection, maintenance of the system may be required based on the following indicators:

- Missing or damaged internal components or pre-treatment filter housing.
- Obstructions in the system or its inlet or outlet.
- Excessive accumulation of floatables in the pre-treatment chamber in which the length and width of the chamber is fully impacted more than 18 inches.
- Excessive accumulation of sediment in the pre-treatment chamber of more than 6 inches in depth.
- Excessive accumulation of sediment on the pre-filter media housed within the pre-filter. When the media is more than 85% clogged, replacement is required. The media will turn from a light green color to a dark brown or black color (see maintenance manual).



- Overgrown vegetation.
- Little to no water exiting the wetland chamber into the discharge chamber. Only applicable during rain event inspections.

### *Inspection Notes*

- Following maintenance and/or inspection, it is recommended that the maintenance operator prepare a maintenance/inspection record. The record should include any maintenance activities performed, amount and description of debris collected, and condition of the system and its various filter mechanisms.

- The owner should keep maintenance/inspection record(s) for a minimum of five years from the date of maintenance. These records should be made available to the governing municipality for inspection upon request at any time.
- Transport all debris, trash, organics, and sediments to an approved facility for disposal in accordance with local and state requirements.
- Entry into the chambers may require confined space training requirements.
- No fertilizer shall be used in the biofiltration/wetland chamber during maintenance.
- Irrigation should be provided as recommended by the manufacturer and/or landscape architect. The amount of irrigation required is dependent on plant species. Some plants may not require irrigation after initial establishment.

### *Maintenance Equipment*

It is recommended that a vacuum truck be utilized to minimize the time required to maintain the Modular Wetlands® Linear. Following is a list of equipment to allow for an efficient and effective maintenance of the Modular Wetlands® Linear:

- Modular Wetland Maintenance Form.
- Manhole hook or appropriate tools to access hatches and covers.
- Protective clothing, flashlight, and eye protection.
- 7/16" open or closed ended wrench.
- Vacuum assisted truck with pressure washer.
- Replacement BioMediaGREEN for Pre-Filter Cartridges if required (order from manufacturer or outside supplier).

### *Maintenance Procedures*

1. Pre-treatment Chamber (bottom of chamber)
  - A. Remove access hatch or manhole cover over pre-treatment chamber and position vacuum truck accordingly.
  - B. With a pressure washer spray down pollutants accumulated on walls and pre-filter cartridges.
  - C. Vacuum out Pre-Treatment Chamber and remove all accumulated pollutants including trash, debris, organics and sediments. Be sure to vacuum the floor until pervious pavers are visible and clean.
  - D. If Pre-Filter Cartridges require media replacement move onto step 2. If not, replace access hatch or manhole cover.
2. Pre-Filter Housing and Media Cages (attached to wall of pre-treatment chamber)
  - A. After finishing step 1 enter pre-treatment chamber.
  - B. Unscrew the two bolts holding the lid on each pre-filter housing and remove lid.
  - C. Place the vacuum hose over each individual media filter cage to remove spent media.

- D. Once filter media has been vacuumed, use a pressure washer to spray down inside of the pre-filter housing and its containing media cages. Remove cleaned media cages and place to the side. Once removed the vacuum hose can be inserted into the cartridge to vacuum out any remaining material near the bottom of the housing.
  - E. Reinstall media cages and fill with new media from manufacturer or outside supplier. Manufacturer will provide specification of media and sources. Only BioMediaGREEN material should be used that meets strict specifications provided by the manufacturer. Other materials are not acceptable and cannot be used. Utilize the manufacturer provided refilling tray and place on top of cartridge. Fill tray with new bulk media and shake down into place. Using your hands, slightly compact media into each filter cage. Once cages are full, remove refilling tray and replace housing top by ensuring bolts are properly tightened.
  - F. Exit pre-treatment chamber. Replace access hatch or manhole cover.
3. Biofiltration/Wetland Chamber (optionally vegetated)
- A. In general, the biofiltration chamber is maintenance free with the exception of maintaining the vegetation. Using standard gardening tools properly trim back the vegetation to healthy levels. The Modular Wetlands® Linear utilizes vegetation similar to surrounding landscape areas; therefore, trim vegetation to match surrounding vegetation. If any plants have died, replace plants with new ones.
  - B. Over time, sediment will accumulate in the perimeter void area and will need to be vacuumed out. The media surface may also require power washing if it becomes occluded with sediment. In addition, the wetland media will eventually need to be replaced after 10 plus years of service. A vacuum truck is recommended to fully remove all wetland media. Once old media is removed the entire chamber, media cage, and netting should be power washed. The netting may require replacement before installing new media. New wetland media should be purchased directly from the manufacture. It can be delivered either in bulk or in super sacks for easy installation.

### *Inspection Notes*

- Following maintenance and/or inspection, it is recommended the maintenance operator prepare a maintenance/inspection record. The record should include any maintenance activities performed, amount and description of debris collected, and condition of the system and its various filter mechanisms.
- The owner should keep maintenance/inspection record(s) for a minimum of five years from the date of maintenance. These records should be made available to the governing municipality for inspection upon request at any time.
- Transport all debris, trash, organics, and sediments to an approved facility for disposal in accordance with local and state requirements.
- Irrigation (if necessary) should be noted.

## **7. Statements**

The following attached pages are signed statements from the manufacturer (Bio Clean Environmental Services Inc.), the third-party observer (Mike Kimberlain of KimberWerks, LLC), and NJCAT. These statements are a requirement of the verification process.

In addition, it should be noted that this report has been subjected to public review (e.g., stormwater industry) and all comments and concerns have been satisfactorily addressed.



Date: 2/21/2022

To Whom It May Concern,

We are providing this letter as our statement certifying that the protocol titled "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) has been strictly followed. Testing performed at Bio Clean Laboratories, in Oceanside, CA on the Modular Wetlands® Linear in September of 2021 under the strict supervision of Mike Kimberlain, of KimberWerks, was conducted in full compliance with protocol requirements. All required documentation, data, and calculations have been provided in addition to the accompanying report.

We certify that all requirements and criteria were met and/or exceeded during testing of the Modular Wetlands® Linear.

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

Sincerely,

Zachariha J. Kent  
VP of Product Management  
Bio Clean, a Forterra Company.

Signature:  Date: 2/21/2022

**KimberWerks, Inc.**  
**P.O. Box 7198**  
**Rancho Santa Fe, California 92067**  
**(858) 381-6209**

---

February 24, 2022

Richard S. Magee Sc.D., P.E., BCEE  
Executive Director  
New Jersey Corporation for Advanced Technology  
Center for Environmental Systems  
Stevens Institute of Technology  
Castle Point on Hudson  
Hoboken, NJ 07030  
973-879-3056 (M)  
[rsmagee@rcn.com](mailto:rsmagee@rcn.com)

**Re: Third-Party Observer Statement of Disclosure / Disclosure Record**

Dr. Magee,

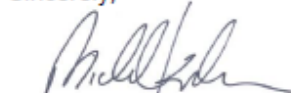
In accordance with the *Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology (January 25, 2013), Section 4. B Conflict of Interest*, KimberWerks, Inc. would like to inform NJCAT that we have no disclosures that would represent a conflict of interest. KimberWerks, Inc. has no personal, professional, or financial interest in the outcome of the Performance Verification Testing performed by Bio Clean, and has no personal, professional, or financial interest in Bio Clean.

KimberWerks, Inc. is a privately owned Engineering Consulting company that regularly performs work in the areas of Civil Engineering, Storm Water, Wastewater, and Potable Water and as such has in the past Engaged with various Storm Water MTD Manufacturers including but not limited to: AbTech, Industries, Inc., Prinsco, Hydro International, Advanced Drainage Systems, Forterra Building Products, Bio Clean, Old Castle Stormwater Solutions, Lane Enterprises, AquaShield, Precon, Triton SWS, and Jensen Stormwater Systems. None of these engagements present a personal, professional, or financial conflict of interest as the engagements did not include:

- having an ownership stake in any of the companies;
- receiving commission for selling a MTD for a manufacturer;
- having a licensing agreement with the manufacturer; or
- receiving funding or grants not associated with a testing program from the manufacturer.

Please let me know should you have any questions or need any clarification to these statements.

Sincerely,



Michael Kimberlain, P.E., CPSWQ  
[mkimberlain@kimberwerks.com](mailto:mkimberlain@kimberwerks.com)  
(858) 381-6209

**KimberWerks, Inc.**  
**P.O. Box 7198**  
**Rancho Santa Fe, California 92067**  
**(858) 381-6209**

---

February 24, 2022

Richard S. Magee Sc.D., P.E., BCEE  
Executive Director  
New Jersey Corporation for Advanced Technology  
Center for Environmental Systems  
Stevens Institute of Technology  
Castle Point on Hudson  
Hoboken, NJ 07030  
973-879-3056 (M)  
[rsmagee@rcn.com](mailto:rsmagee@rcn.com)

**Re: Statement of Third-Party Observer**

Performance Verification of the Bio Clean Modular Wetland Linear Model MW-L-4-8

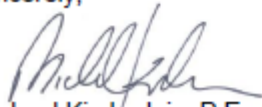
Dr. Magee,

KimberWerks, Inc. has been Engaged by Bio Clean to act as the third-party observer for the Performance Verification Testing of their Modular Wetland Linear Model MW-L-4-8. Performance Verification testing was performed by Bio Clean personnel under the direction of Mr. Zach Kent, Managing Director, and began on August 24<sup>th</sup>, 2021, and was completed on September 24<sup>th</sup>, 2021. The Performance Verification was performed at Bio Clean Laboratories located at 398 Via El Centro, Oceanside, California 92008.

I was personally on site to observe the testing and I remained on site while testing was in process to observe the testing for its full duration. The flow rates and frequency of sampling reported for the performance tests were observed and reported accurately. Grain size analysis and sediment concentration in water samples analysis was performed offsite by third party laboratories. The sampling occurred under my observation and the samples were transported under my direction and control to the laboratories. Sediment concentration analysis deviated from the method standard, but in-house data was combined with and compared to the laboratory data and a determination made that the combined sediment concentration data is representative. The verification testing used applicable protocol, as outlined in the Quality Assurance Project Plan (QAPP). I have personally reviewed the data sets and calculations in the Report by Bio Clean dated February 2022 and hereby state they conform to my observations while acting as third-party observer.

Please let me know should you have any questions or need any clarification to these statements.

Sincerely,

  
Michael Kimberlain, P.E., CPSWQ  
[mkimberlain@kimberwerks.com](mailto:mkimberlain@kimberwerks.com)  
(858) 381-6209



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

March 7, 2022

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 a full-scale, commercially available Modular Wetlands® Linear (MW-L-4-8) at the Bio Clean Laboratories, based in Oceanside, California, 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 consistent with the NJDEP Approval Process. Independent third-party observation was provided by Michael Kimberlain, P.E. of KimberWerks, Inc. Specifically:

*Test Sediment Feed*

The test sediment purchased and used for the removal efficiency study was custom blended by GHL (Good Harbours Laboratories, Ontario, Canada) using various commercially available silica sands. GHL sent out three samples of sediment for particle size analysis using the methodology of ASTM method D422-63. The samples were composite samples created by taking samples throughout the blending process and in various positions within the blending drum. The testing lab was Bureau Veritas, an independent test lab also located in Ontario, Canada. Bio Clean received three sealed drums from GHL.

Each drum was sampled and composites placed into three separate five-gallon buckets, the buckets thoroughly mixed, and a single sample taken from each bucket and sent for analysis to Apex Labs in Tigard, Oregon. The test sediment PSD exceeded the NJDEP specifications and had a  $d_{50}$  of  $71\mu\text{m}$  less than the  $<75\mu\text{m}$  requirement.

### *Scour Test Sediment*

The same sediment was used for scour testing.

### *Removal Efficiency Testing*

Removal efficiency testing followed the effluent grab sampling test method outlined in Section 5 of the NJDEP Protocol. The sediment removal efficiency of the Modular Wetlands® Linear (MW-L-4-8) at the MTFR (125 gpm, 0.28 cfs) was 94.57% after 10 runs, qualifying the Modular Wetlands® Linear for an 80% TSS removal efficiency certification. An additional five runs were conducted to ensure that 10 qualifying removal efficiency runs were obtained.

### *Sediment Mass Loading Capacity*

The Sediment Mass Loading Capacity study was a continuation of the Removal Efficiency study. All aspects of the testing remained the same, except that the target feed concentration was increased to 400 mg/L, up from the 200 mg/L used for the Removal Efficiency test. An additional 49 runs were completed for sediment mass capacity testing. The feed rate COV  $\leq 0.10$  and the flow rate COV  $\leq 0.03$  both were within protocol requirements.

The total mass of sediment captured for the 64 runs was 622 lbs. and the cumulative mass removal efficiency was 82.46%.

### *Scour Testing*

Scour testing of the Modular Wetlands® Linear (MW-L-4-8) was conducted in accordance with Section 4 of the NJDEP Protocol at a target flow rate greater than 200% of the MW-L-4-8 MTFR to qualify the MTD for online conveyance installation. The test flow rate was 202% of the 0.28 cfs MTFR. The average adjusted effluent concentration for this test was 4.0 mg/L, which is less than the 20 mg/L limit, qualifying the Modular Wetlands® Linear for online conveyance installation up to 202% MTFR.

Sincerely,



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

## **8. References**

1. NJDEP 2013. New Jersey Department of Environmental Protection Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology. January 25, 2013.
2. NJDEP 2013. New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device. January 25, 2013.

## **VERIFICATION APPENDIX**

## ***Introduction***

- Manufacturer – Bio Clean Environmental Services Inc., 398 Via El Centro, Oceanside, CA 92058. Website: <http://www.biocleanenvironmental.com> Phone: 760-433-7640.
- Modular Wetlands® Linear MTD – Bio Clean Modular Wetlands® Linear verified models are shown in **Table A-1**.
- TSS Removal Rate – 80%
- Online conveyance installation up to 202% MTFR

## ***Detailed Specification***

- NJDEP sizing tables and physical dimensions of the Bio Clean Modular Wetlands® Linear verified models are attached (**Table A-1**).
- New Jersey requires that the peak flow rate of the NJWQ Design Storm event of 1.25 inch in 2 hours shall be used to determine the appropriate size for the MTD. The Modular Wetlands® Linear MW-L-4-8 model has a maximum treatment flow rate (MTFR) of 0.28 cfs (125 gpm), which corresponds to a wetland media surface loading rate of 2.91 gpm/ft<sup>2</sup>.
- Pick weights and installation procedures vary slightly with model size. Design support is given by Bio Clean for each project and pick weights and installation procedures will be provided prior to delivery.
- Maximum recommended pre-treatment chamber sediment depth prior to cleanout is 9 inches for all model sizes.
- Operations and Maintenance Guide is at: [https://biocleanenvironmental.com/wp-content/uploads/2022/04/Modular-Wetlands-Operation-Maintenance-Manual\\_4-20-22.pdf](https://biocleanenvironmental.com/wp-content/uploads/2022/04/Modular-Wetlands-Operation-Maintenance-Manual_4-20-22.pdf)
- Under N.J.A.C. 7:8-5.5, NJDEP stormwater design requirements do not allow a biofiltration device such as the Modular Wetlands® Linear to be used in series with another biofiltration device to achieve an enhanced TSS removal rate.

**Table A-1 MTFRs and Sediment Removal Intervals for Modular Wetlands Linear Models**

<b>Model #</b>	<b>Wetland Media Surface Area (EFTA) (sq ft)</b>	<b>Treatment Flow Rate<sup>1</sup> (cfs)</b>	<b>Maximum Allowable Drainage Area<sup>2</sup> (acres)</b>	<b>Number of Pre-Filter Cartridges</b>	<b>Pre-Filter Surface Loading<sup>3</sup> (gpm/sq ft)</b>	<b>Pre-Treatment Chamber Sedimentation Area (ESTA) (sq ft)</b>	<b>ESTA/EFTA Ratio<sup>4</sup></b>	<b>Perimeter Void Area ESTA/EFTA Ratio<sup>5</sup></b>
MW-L-4-4	19.43	0.13	0.47	0.5	4.42	5.34	0.27	0.06
MW-L-4-6.5	26.97	0.17	0.65	1	3.07	7.56	0.28	0.06
MW-L-4-8	42.92	0.28	1.04	1	4.88	10.79	<b>0.25</b>	<b>0.06</b>
MW-L-6-8	54.52	0.35	1.32	1.5	4.13	15.30	0.28	0.06
MW-L-8-8	85.84	0.56	2.07	2	4.88	21.10	0.25	0.06
MW-L-8-12	128.76	0.83	3.11	3	4.88	32.11	0.25	0.06
MW-L-8-16	171.68	1.11	4.15	4	4.88	42.83	0.25	0.06
MW-L-8-20	214.60	1.39	5.19	5	4.88	53.22	0.25	0.06
<ol style="list-style-type: none"> <li>1. Based on a verified loading rate of 2.91 gpm/ft<sup>2</sup> for test sediment with a mean particle size of 71 µm and TSS removal of at least 80% using the methodology in the NJDEP Filter protocol.</li> <li>2. Based on the NJDEP 600 lbs per acre per year loading requirement. Calculated based upon the tested sediment load capacity of 14.5 lbs per sq ft of media surface area.</li> <li>3. The pre-filter loading rate must be equal to or less than the tested loading rate of 4.88 gpm/sq ft to comply with the approval. Each full-size pre-filter contains eight individual media filters, each with a surface area of 3.2 square feet for a total of 25.6 square feet per full size pre-filter. Top of media in the pre-filter is 21.2 inches from the chamber floor.</li> <li>4. The tested unit had an ESTA/EFTA ratio of 0.25. All other models have a ratio equal to or greater than the tested unit.</li> <li>5. Measures the ratio of perimeter void area sedimentation area to media surface area. Secondary sedimentation area downstream of the pre-filter. It measures 2 inches in width multiplied by the perimeter length of the wetland media.</li> </ol>								