NJCAT TECHNOLOGY VERIFICATION

Environment 21 StormPro Stormwater Treatment Device

Environment 21, LLC

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TABLE OF CONTENTS

List of Figures

Page

List of Tables

Page

1. Description of Technology

The Environment 21 StormPro system, as shown in Figure 1, is designed to remove suspended sediment and floatable waste (e.g., hydrocarbons, trash, etc.) from stormwater runoff. It is composed of a singular precast concrete structure with a sump depth that varies to accommodate collection of sediment while preventing scour of previously captured sediment. It is divided into two chambers by a baffle wall, with the first chamber for removal of sediment and floatables and the second chamber for recombining the treatment flow and bypass flow before exiting the structure at the outlet. The first chamber has a separation slab that extends the width of the chamber and for approximately 85% of the length of the first chamber. The StormPro includes an internal bypass pipe that begins in the first chamber and ends in the second chamber downstream of the baffle wall (water-lock). The internal bypass pipe allows a portion of inflowing water to travel directly to the outflow pipe as discharge rates exceed the Manufacturer's Treatment Flow Rate (MTFR). The material composition of the separation slab and baffle wall is usually precast concrete; however, other rigid materials, approved by Environment 21, LLC, may be used. The inlet pipe is mounted perpendicular to the wall of the structure and joined, in the first chamber, to the internal bypass. The second chamber has an anti-scour vane in it to decrease turbulence, thus enhancing sediment removal and limit scour of captured sediment. The outlet pipe is located downstream of the baffle wall.

The material composition of the internal bypass pipe is usually a rigid plastic (e.g., Polyvinyl Chloride – PVC, High-density Polyethylene – HDEP, etc.) or other rigid materials, approved by Environment 21, LLC. The internal bypass pipe has engineered openings sized geometrically for the various model sizes. The openings are located both upstream and downstream of the baffle wall.

Operation

Flow enters the first chamber of the Environment 21 StormPro through an inlet pipe. Suspended sediment removal primarily occurs within this chamber; however, some sediment removal also occurs in the second chamber. Flow rates below the MTFR pass into the first chamber via the openings in the internal bypass pipe.

During flows less than the MTFR, all of the water must travel through the first chamber, by the separation slab in the first chamber, and the flow-control opening in the baffle wall before it leaves through the outflow pipe. As flows exceed the MTFR, the flow of water splits with most traveling the path through the first chamber and the rest going through the internal bypass pipe. The greater the flow rate exceeding the MTFR, the greater the percentage of flow that passes through the bypass pipe - avoiding the first chamber. The baffle wall is intended to trap sediment and floatable material in the first chamber and allow it to be removed during the scheduled cleanout of the device.

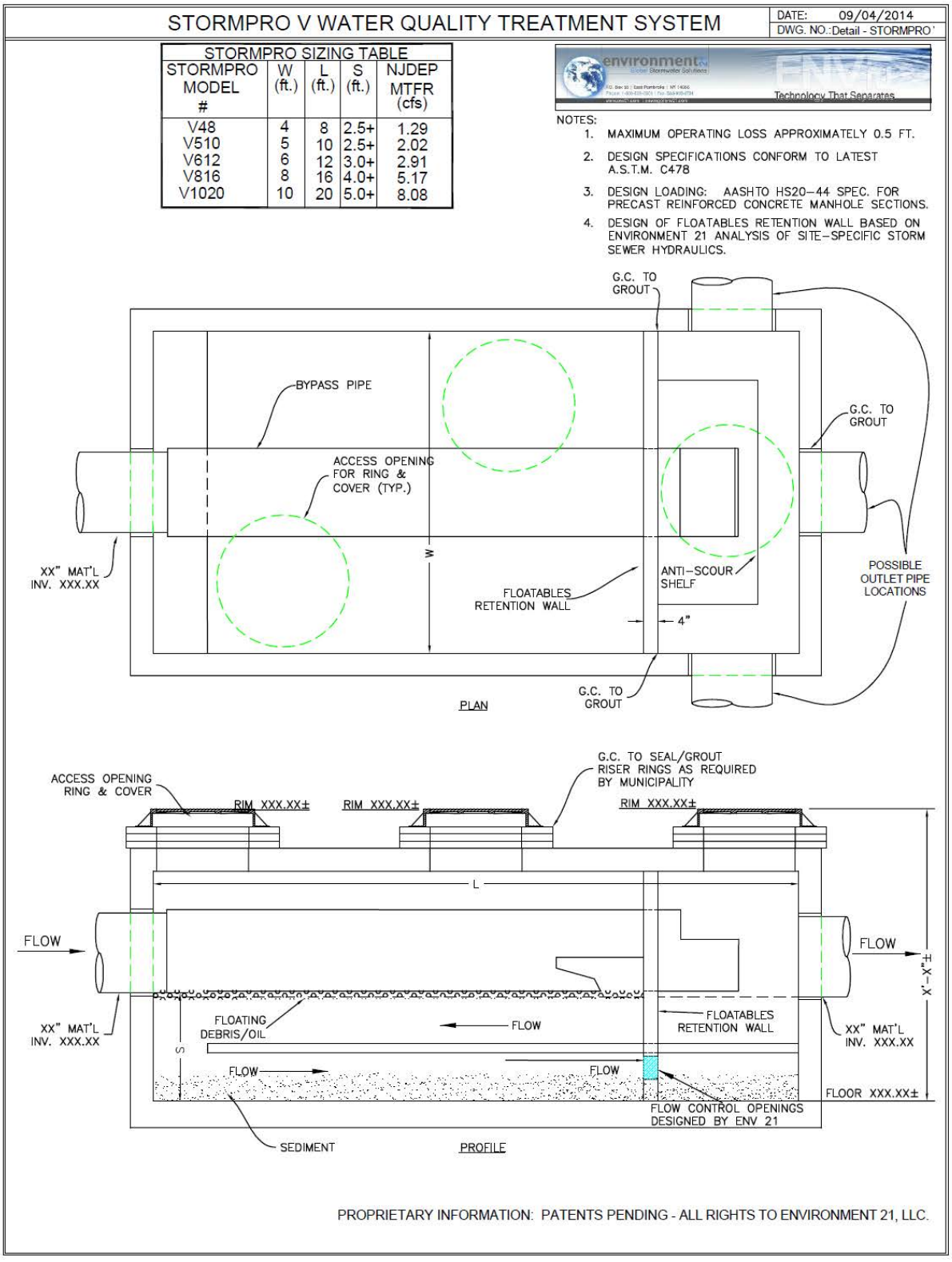

Figure 1 Schematic of the Environment 21 StormPro Test Unit

2. Laboratory Testing

The test site is located in Western New York and the testing was performed in an outdoor laboratory setting under the direction of Barr Engineering Company as the independent third party observer. Barr Engineering Company is headquartered in Minneapolis/St. Paul, Minnesota and has extensive experience in testing and analyzing stormwater structures, especially hydrodynamic separators. They also developed the SHSAM program (sediment removal efficiency predictor) based on the testing done at St. Anthony Falls Laboratory by two of the current employees of Barr Engineering Company. Barr Engineering Company was retained to provide third-party test observation and communication of the test results.

ALS Environmental and SJB Services, Inc. completed the laboratory analyses of samples collected during the testing. ALS Environmental has offices throughout the world including one in Rochester, NY. They are qualified for ASTM D3977-97 (reapproved 2007) sediment concentration analysis and ASTM D422-63 (reapproved 2007) particle size analysis (PSD). SJB Services is an independent laboratory with locations throughout Western New York. Their Henrietta, NY facility, is qualified for ASTM D3977-97 (reapproved 2007) sediment concentration analysis and ASTM D422-63 (reapproved 2007) particle size analysis (PSD). ALS Environmental completed all sediment concentration analyses for the efficiency and scour testing and the PSD for the StormPro scour test. SJB completed the PSD analysis for the StormPro removal efficiency tests.

2.1 Test Setup

An Environment 21 StormPro Model V510 unit was tested in accordance with the NJDEP HDS Protocol (NJDEP 2013a). A graphic of the StormPro Model V510 unit is shown in Figure 2. The Model V510 is a commercially available unit that is 5-feet wide, 10-feet long, and has a 2.5-foot sump (inlet invert to floor). The test setup utilized two ponds with an elevation difference of approximately 22-feet. The upper pond (supply pond) is spring-fed. It is approximately 125-feet east of the lower pond (catch pond for the test water). The water supplied from the upper pond was not recycled through the system. The upper pond has a 12-inch drain line that empties the upper pond into the lower pond. The east end of the 12-inch drain line is submerged and located horizontally at the center of the pond and approximately 4-foot vertically from the bottom of the pond. There is a concrete valve pit on the west shore of the upper pond. In the concrete valve pit there is a 12-inch butterfly valve in the 12-inch drain line to control the flow from the upper pond to the lower pond. The west end of the 12-inch drain line is at the shoreline of the lower pond and approximately 2-feet above the normal (dry weather) level of the lower pond; there is a 12-inch metering valve in this line.

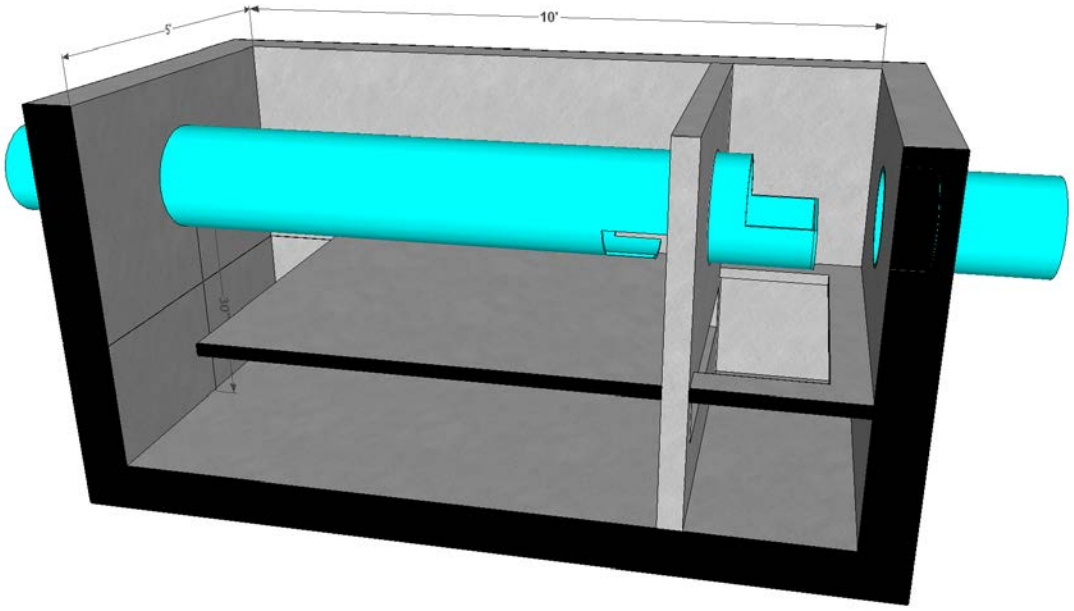

Figure 2 Graphic of StormPro Model V510 Test Unit

Technicians calibrated the metering valve by monitoring the rate at which the test unit filled with water at various valve openings. Based on this calibration, a chart showing the degrees of valve opening versus discharge was determined. For each test, the valve calibration was used to get close to the required discharge, and then a digital flow meter was used to further refine the valve setting. Downstream of the metering valve is a 12-inch 90° elbow. The 90° elbow is connected to a flexible, reinforced 10-foot length of 12-inch pipe to divert the direction of flow to the test unit. Attached to the flexible pipe was a 10-foot length of 15-inch carbon steel pipe that was the inlet to the test unit. There was also a 10-foot length of 15-inch steel pipe at the outlet from the test unit. See Figure 3 for the schematic of the laboratory setup. The entire test setup (including ancillary equipment) was under a shelter to protect the study from the elements (Photo-Figure 4).

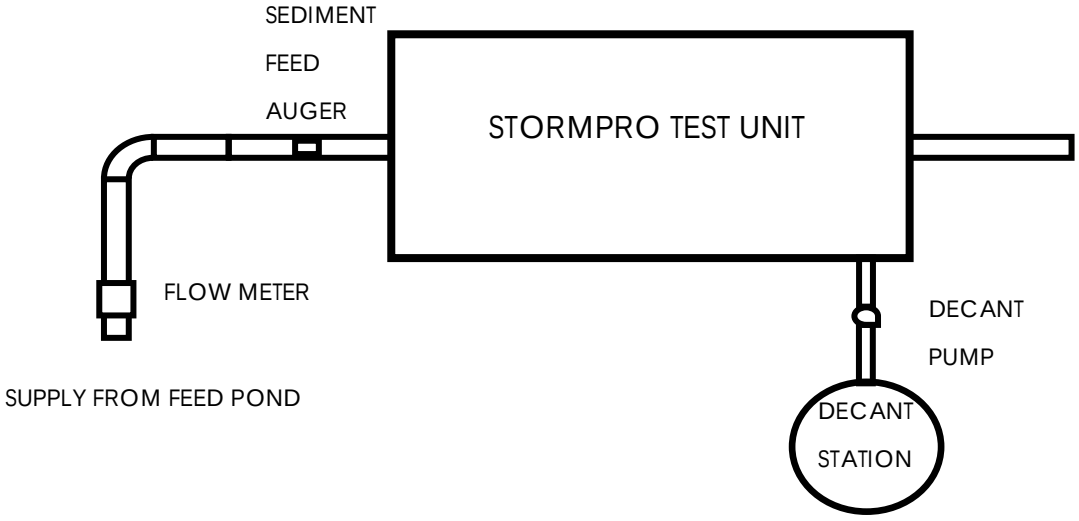

Figure 3 Schematic of Laboratory Setup

Figure 4 Photo of the Environment 21 StormPro Test Setup

Total Suspended Solids Removal Efficiency Laboratory Setup

A false floor was installed at the midlevel (6-in) of the 12-inch maintenance level of the Environment 21 StormPro V510 (24-in from the invert of the inlet pipe and 16.5-inch below the separation slab). This floor elevation remained constant during all of the tests. The StormPro V510 was tested using a once-through configuration. None of the test water was recirculated for any tests and the background sediment level of the inlet water was always less than 2 mg/L; therefore, no filtering of the water was required.

Sediment was fed at the crown of the inlet pipe via an auger system, located three pipe diameters upstream of the Environment 21 StormPro. Water exits the StormPro V510 through the 15" outlet pipe and goes to the downstream receiving pond.

The water flow to the StormPro V510 is controlled by the calibrated 12-inch metering valve, upstream of the StormPro V510. The water flow was verified and recorded by a Panametrics PT878 digital flow meter. The data was downloaded from the Panametrics to a Lenovo laptop.

Scour Test Laboratory Setup

The Environment 21 StormPro V510 used for the removal efficiency testing was also used for the scour testing. The false floor was kept the same for the scour testing as for the removal efficiency testing. Sediment was placed in the Environment 21 StormPro covering the false floor to a levelled depth of four (4) inches in the first chamber. This is 83% of the maintenance level and is conservative as it exceeds the 50% maximum level required by the NJDEP HDS Protocol. NOTE: Minor sediment accumulation occurs on the separation slab in the first chamber; since it is in the treatment area and credit was taken for accumulations during the efficiency testing, Environment 21 opted to cover it to a 4" depth also. The second chamber of the StormPro collects minimal, if any, sediment during operation and; therefore, should not be required to be loaded for the scour testing. However, in order to avoid the potential for challenges, Environment 21, LLC opted to load the second chamber to the same level (4") as the first chamber thus including substantial sediment in the second chamber in the washout testing. No noticeable sediment collects in the bypass pipe or on the anti-scour vane in the second chamber and, since removal efficiency credit was not taken for any potential sediment deposits in the bypass pipe or on the anti-scour vane during the efficiency testing, no material was placed in or on either for the scour test. Effluent samples were obtained by grab sample. The scour test commenced within 4 hours of the completion of the sump loading.

2.2 Test Sediment

Test Sediment Feed for Suspended Solids Removal Efficiency Testing

Environment 21 procured hard, firm, inorganic material with a specific gravity of 2.65 to be used for solids removal efficiency testing. Environment 21 prepared numerous blends of materials in an effort to achieve a mix that closely resembled the NJDEP gradation. The blends were numbered sequentially to maintain traceability with the analytical lab and to avoid confusing blends. Environment 21 technicians mixed and sampled (three samples per batch) a batch of test sediment for use during the removal efficiency testing. Sampling of the batch used for the suspended solids removal efficiency testing was witnessed by Barr Engineering Company. The sample was identified as "Mix 7". Mix 7 was chosen as the most ideal blend for the suspended solids removal efficiency testing that is outlined in this report. SJB Services, Inc. analyzed the three samples of the batch (Mix 7) using ASTM D422-63 (reapproved 2007). The mean of the three PSD samples was calculated and plotted as a single PSD curve representing the batch of material (Figure 5). The average specific gravity of the test sediment was measured by SJB Services, Inc. to be 2.65.

Scour Test Sediment

Environment 21 procured hard, firm, inorganic material to blend to be used for scour testing. The scour test sample was identified as "Scour 14", representing "Scour Mix 2014". Environment 21 technicians mixed and sampled (three samples) of Scour Mix 14; sampling was witnessed by Barr Engineering Company. ALS Environmental analyzed the three samples of the batch using ASTM D422-63 (reapproved 2007). The mean of the three PSD samples was calculated and plotted as a single PSD curve representing the batch of material (Figure 6).

2.3 Removal Efficiency Testing Procedure

Barr Engineering Company provided third party oversight for the duration of all testing. Removal efficiency testing utilized the "Mass Balance Test Method" approach outlined in Section 5C of the NJDEP HDS protocol. This requires that the sediment fed to the V510 and the sediment collected in the V510 are accurately known. The V510's sump was cleaned prior to the start of each test. The flow rate for each test was started and steadied for a time before the start of each test. After the flow rate was established, the test was started with the introduction of the test sediment. For the removal efficiency tests, a Merrick volumetric sediment feeder Model 25-07 was utilized to feed sediment upstream of the device. The sediment feeder was operated at variable rates in order to ensure the required target feed rate of 200 mg/L ($\pm$ 10%) was maintained for each test. The target sediment concentration for each test was maintained by adjusting the sediment feeder rate to the water rate. Flow of water (L/min) x 200 mg/L = sediment feed rate (mg/min). Required samples were taken as follows. The background samples for each test were taken at the beginning, midway, and at the end of each test. The sediment samples were taken at equally spaced intervals throughout each test dependent on the test duration. The weight of the sediment samples for each test was deducted from the total weight fed during the corresponding test. After each test, the material in the sump was collected, dried per ASTM D4959-07, and weighed per the protocol.

The test procedure was repeated for each flow rate corresponding to 25%, 50%, 75%, 100% and 125% of the target MTFR.

2.4 Scour Testing Procedure

Based on past testing of the StormPro Stormwater Treatment device, Environment 21 felt that the unit would qualify for online installation and conducted scour testing at over 200% of the MTFR, with the intent of demonstrating such. Barr Engineering Company provided third party oversight for the duration of all scour testing.

After all required horizontal surfaces were covered to a 4" depth with the proper scour sediment, the bed was lowered (~1-in) on the separation slab along the baffle wall to match the deposition observed during the removal efficiency tests, as specified in Section 4A of the NJDEP HDS Protocol. Next, the StormPro was filled with clear water to its normal, dry weather operating depth. Testing began within four hours of loading the sediment into the StormPro. Clear water was conveyed through the Environment 21 StormPro until just below the inlet and outlet inverts. Clear water was then immediately conveyed at increasing flow rates until the target scour flow rate was reached and stabilized. The sampling began less than 5 minutes after initiating the clear water flow rate and every two minutes after that. Grab samples were taken at the end of the discharge pipe per the NJDEP HDS Protocol. A total of sixteen – time/date stamped effluent samples were obtained at two-minute intervals. Eight influent background samples were also obtained corresponding to odd-numbered effluent samples. Sample bottles were collected during the scour test and were independently identified with appropriate labels, date, time of collection, sampler's initials, and sequential bottle number of the test. In addition, flow rates and temperature readings were recorded during the test. All samples obtained during the washout testing were analyzed by ALS Environmental per ASTM D3977-97 (reapproved 2007).

3. Performance Claims

Per the NJDEP verification procedure document (NJDEP, 2013b), the following are the performance claims made by Environment 21 and/or established via the laboratory testing conducted.

Total Suspended Solids Removal Rate

Based on the laboratory testing conducted, the Environment 21 StormPro Stormwater Treatment Device achieved greater than 50% removal efficiency of suspended solids. In accordance with the NJDEP procedure for obtaining verification of a stormwater manufactured treatment device from NJCAT (NJDEP 2013b) the TSS removal efficiency is rounded down to 50%.

Maximum Treatment Flow Rate (MTFR)

For all of the commercially available geometrically similar model sizes, the hydraulic loading rate used to calculate the MTFR is 18.1 gpm/ft^2. This surface loading rate will be used as the scaling factor to size other StormPro models (see the Specification Appendix).

Maximum sediment storage depth and volume

The maximum sediment storage depth for the StormPro model series is 1 ft. The available volume is dependent on the size of the model. The V510 tested (5'x10') with a sediment storage depth of 1 ft. has 50 cubic feet of available storage volume. The sediment storage depth may be increased to accommodate more sediment storage by increasing the distance below the separation slab by lowering the sump bottom.

Effective treatment area

The effective treatment area is equal to the surface area of all chambers. The effective treatment area is dependent on the StormPro model and will change accordingly.

Detention time and volume

The detention times vary based on the sump requirements of the model size. The detention time of the StormPro V510 is 104 seconds. The volumes will vary according to the model size. The volume of the StormPro V510 is 125 ft^3.

Effective sedimentation area

The effective sedimentation area and effective treatment area for the Environment 21 StormPro Stormwater Treatment Device are the same.

Online installation

Based on the testing results shown in Section 4.4 the Environment 21 StormPro Stormwater Treatment Device qualifies for online installation.

4. Supporting Documentation

The NJDEP Procedure (NJDEP, 2013b) for obtaining verification of a stormwater manufactured treatment device (MTD) from the New Jersey Corporation for Advanced Technology (NJCAT) requires that "copies of the laboratory test reports, including all collected and measured data; all data from performance evaluation test runs; spreadsheets containing original data from all performance test runs; all pertinent calculations; etc." be included in this section. This was discussed with NJDEP and it was agreed that as long as such documentation could be made available by NJCAT upon request that it would not be prudent or necessary to include all this information in this verification report.

4.1 Test Sediment PSD Analysis – Removal Efficiency Testing

Three samples were obtained at different locations in the mix prepared by Environment 21 technicians and the three samples were sent to and analyzed by SJB Services, Inc. Results of the three PSD analyses on the mix are provided in Table 1.

Table 1 Removal Efficiency Sediment Particle Size Distribution Analysis

Particle Size µm	Removal Efficiency Test Mix (Percent Finer)			
	Sample 1	Sample 2	Sample 3	Mean
1000	100	100	100	**100**
500	99	99	99	**99**
250	90	87	92	**90**
150	81	75	84	**80**
100	70	62	78	**70**
75	61	53	70	**61**
50	49	43	53	**48**
20	34	34	34	**34**
8	19	18	20	**19**
5	13	13	17	**14**
2	4	4	7	**5**

The mean PSD for the 3 samples in the mix was also calculated and presented in Table 1. As described in the NJDEP HDS Protocol the mean PSD serves as the PSD of the batch of test sediment.

The mean PSD of Environment 21's test sediment complies with the PSD criteria established by the NJDEP HDS protocol. Figure 5 plots the Environment 21 PSD against the NJDEP PSD specification for the mix. The median particle size of the Environment 21 gradation is less than 60 microns; the NJDEP HDS protocol requires a maximum d_{50} particle size of 75 microns.

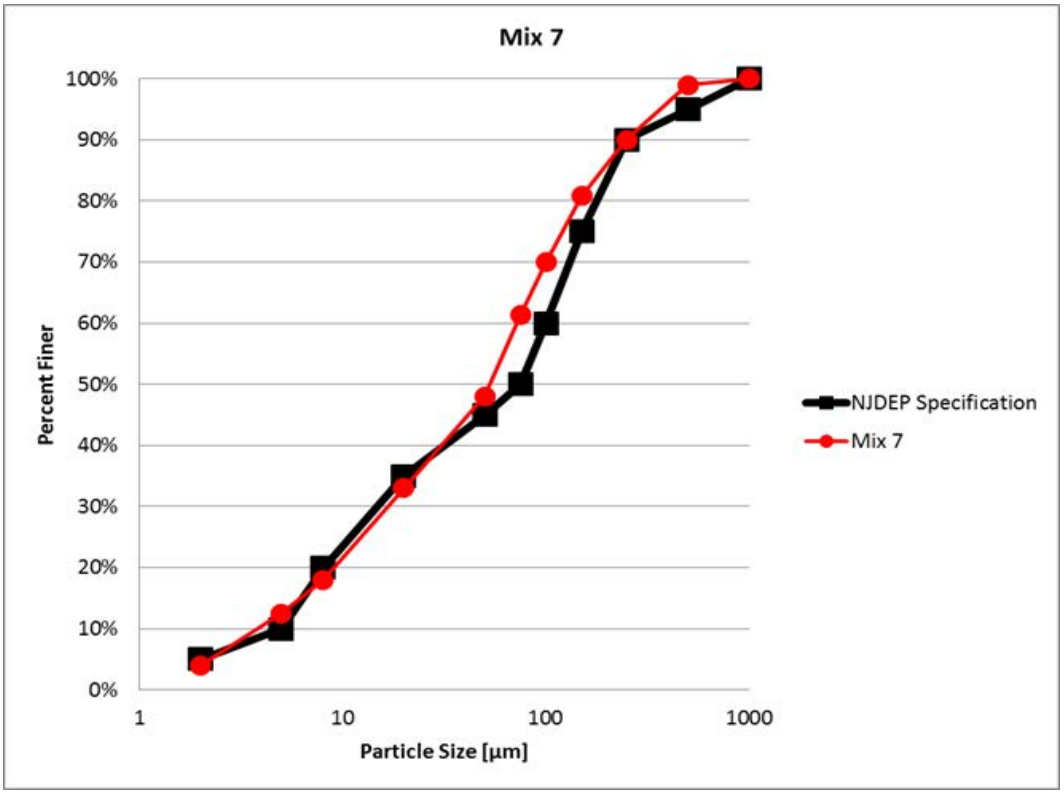

Figure 5 Comparison of the Environment 21 Test Sediment PSD to the NJDEP Removal Efficiency Test Sediment PSD Specification

4.2 Removal Efficiency Testing

In accordance with the NJDEP HDS Protocol, removal efficiency testing was executed on the StormPro V510 in order to establish the ability of the test unit to remove the specified test sediment at 25%, 50%, 75%, 100% and 125% of the target MTFR. Prior to the start of testing Environment 21 reviewed existing data and decided to utilize a target MTFR of 2.02 cfs. This target was chosen based on the ultimate goal of demonstrating greater than 50% annualized weighted solids removal as defined in the NJDEP HDS Protocol. The Mean Influent Concentration was calculated from the mean feed rate and the mean flow rate. Mass balance methodology was used to determine removal efficiencies. Three background samples were taken for each test. The water temperature was constant at 75F for all runs.

25% MTFR Results

A target flow rate of 0.505 cfs was used for the 25% MTFR removal test. Table 2 provides an overview of the StormPro V510 test conditions and a summary of the results for the 25% MTFR test. The feed rate calibration sample results are provided in Table 3. The influent background concentration averaged 1.35 mg/L. The total mass introduced into the StormPro V510 was 11,774 grams and the total mass collected in the system was 7,192 grams yielding a removal efficiency of 61.1% for the 25% MTFR test.

Table 2 Summary of StormPro V510 25% MTFR Laboratory Test

Test Date	% MTFR	Target Water Flow Rate (cfs)	Actual Mean Water Flow Rate (cfs)	Water Flow Rate COV	Target sediment Feed Rate Conc. (mg/L)	Actual Sediment Feed Rate Conc. (mg/L)	Sediment Feed rate COV	Test Duration (min.)	Removal Efficency (%)
8282014	25	0.505	0.492	0.006	200	217	0.063	65	61.1

Table 3 StormPro V510 25% MTFR Feed Rate Calibration Sample Results

Sample Time (sec)	Sample (g)						COV
	1	2	3	4	5	6	
51	211	223	225	231	193	221	0.063

50% MTFR Results

A target flow rate of 1.010 cfs was used for the 50% MTFR removal test. Table 4 provides an overview of the StormPro V510 test conditions and a summary of the results for the 50% MTFR test. The feed rate calibration sample results are provided in Table 5. The influent background concentration was <1 mg/L. The total mass introduced into the StormPro V510 was 11,756 grams and the total mass collected in the system was 6,328 grams yielding a removal efficiency of 53.8% for the 50% MTFR test.

Table 4 Summary of StormPro V510 50% MTFR Laboratory Test

Test Date	% MTFR	Target Water Flow Rate (cfs)	Actual Mean Water Flow Rate (cfs)	Water Flow Rate COV	Target sediment Feed Rate Conc. (mg/L)	Actual Sediment Feed Rate Conc. (mg/L)	Sediment Feed rate COV	Test Duration (min.)	Removal Efficency (%)
8282014	50	1.010	0.993	0.005	200	215	0.058	37	53.8

Table 5 StormPro V510 50% MTFR Feed Rate Calibration Sample Results

Sample Time (sec)	Sample (g)						COV
	1	2	3	4	5	6	
26	228	216	219	217	220	191	0.058

75% MTFR Results

A target flow rate of 1.515 cfs was used for the 75% MTFR removal test. Table 6 provides an overview of the StormPro V510 test conditions and a summary of the results for the 75% MTFR test. The feed rate calibration sample results are provided in Table 7. The influent background concentration averaged 1.53 mg/L. The total mass introduced into the StormPro V510 was 11,795 grams and the total mass collected in the system was 5,818 grams yielding a removal efficiency of 49.3% for the 75% MTFR test.

Table 6 Summary of StormPro V510 75% MTFR Laboratory Test

Test Date	% MTFR	Target Water Flow Rate (cfs)	Actual Mean Water Flow Rate (cfs)	Water Flow Rate COV	Target sediment Feed Rate Conc. (mg/L)	Actual Sediment Feed Rate Conc. (mg/L)	Sediment Feed rate COV	Test Duration (min.)	Removal Efficency (%)
8272014	75	1.515	1.472	0.015	200	201	0.040	28	49.3

Table 7 StormPro V510 75% MTFR Feed Rate Calibration Sample Results

Sample Time (sec)	Sample (g)						COV
	1	2	3	4	5	6	
18	208	213	193	196	195	202	0.040

100% MTFR Results

A target flow rate of 2.020 cfs was used for the 100% MTFR removal test. Table 8 provides an overview of the StormPro V510 test conditions and a summary of the results for the 100% MTFR test. The feed rate calibration sample results are provided in Table 9. The influent background concentration averaged 1.35 mg/L. The total mass introduced into the StormPro V510 was 11,840 grams and the total mass collected in the system was 5,144 grams yielding a removal efficiency of 43.4% for the 100% MTFR test.

Table 8 Summary of StormPro V510 100% MTFR Laboratory Test

Test Date	% MTFR	Target Water Flow Rate (cfs)	Actual Mean Water Flow Rate (cfs)	Water Flow Rate COV	Target sediment Feed Rate Conc. (mg/L)	Actual Sediment Feed Rate Conc. (mg/L)	Sediment Feed rate COV	Test Duration (min.)	Removal Efficency (%)
8272014	100	2.020	2.019	0.006	200	194	0.070	21	43.4

Table 9 StormPro V510 100% MTFR Feed Rate Calibration Sample Results

Sample Time (sec)	Sample (g)						COV
	1	2	3	4	5	6	
13	193	169	204	203	204	190	0.070

125% MTFR Results

A target flow rate of 2.525 cfs was used for the 125% MTFR removal test. Table 10 provides an overview of the StormPro V510 test conditions and a summary of the results for the 125% MTFR test. The feed rate calibration sample results are provided in Table 11. The influent background concentration averaged 1.57 mg/L. The total mass introduced into the StormPro V510 was 11,797 grams and the total mass collected in the system was 4,701 grams yielding a removal efficiency of 39.8% for the 125% MTFR test.

Table 10 Summary of StormPro V510 125% MTFR Laboratory Test

Test Date	% MTFR	Target Water Flow Rate (cfs)	Actual Mean Water Flow Rate (cfs)	Water Flow Rate COV	Target sediment Feed Rate Conc. (mg/L)	Actual Sediment Feed Rate Conc. (mg/L)	Sediment Feed rate COV	Test Duration (min.)	Removal Efficency (%)
8282014	125	2.525	2.520	0.003	200	211	0.043	16	39.8

Table 11 StormPro V510 125% MTFR Feed Rate Calibration Sample Results

Sample Time (sec)	Sample (g)						COV
	1	2	3	4	5	6	
10	198	204	211	218	223	212	0.043

Excluded Data/Results

The NJDEP HDS Protocol requires that any data collected as part of the testing process that is ultimately excluded from the reported results be discussed during the reporting process. No data were excluded from the datasets that make up each of the 5-qualifying test trials reported herein and ultimately used to determine the annualized weighted TSS Removal Efficiency.

Annualized Weighted TSS Removal Efficiency

The results of TSS removal efficiency testing at 25%, 50%, 75%, 100% and 125% of a target MTFR of 2.02 cfs and reported herein were entered into the NJDEP specified annualized weighted TSS removal efficiency calculation. The results are presented in Table 12.

Table 12 Annualized Weighted TSS Removal of the StormPro V510 Tested in Accordance with the NJDEP HDS Protocol at a MTFR of 2.02 cfs.

Percent of MTFR	Test Average Removal Efficiency	NJDEP Weighting Factor	Annualized TSS Removal Efficiency (Eff. X Weighting)
25%	61.1	0.25	15.28
50%	53.8	0.30	16.14
75%	49.3	0.20	9.86
100%	43.4	0.15	6.51
125%	39.8	0.10	3.98
NJDEP Removal Rated Efficiency			**51.77%**

Testing in accordance with the provisions detailed in the NJDEP HDS Protocol demonstrate that the StormPro V510 achieved a 51.77% annualized weighted TSS removal at an MTFR of 2.02 cfs (18.1 gpm/ft^2). This testing demonstrates that the StormPro V510 exceeds the NJDEP requirement for HDS devices of demonstrating greater than 50% weighted annualized TSS Removal Efficiency at the chosen MTFR.

4.3 Test Sediment PSD Analysis - Scour Testing

Three samples were obtained at different locations in the scour sediment mix prepared by Environment 21 technicians and the samples were sent to and analyzed by ALS Environmental. Results of the three PSD analyses are provided in Table 13. The mean particle size of the Environment 21 gradation is approximately 160 microns; the NJDEP HDS protocol requires a mean particle size of less than 205 microns.

Table 13 Results of Scour Testing Sediment Particle Size Distribution Analysis

Particle Size µm	Percent Finer			
	Sample 1	Sample 2	Sample 3	Mean
1000	100	100	100	**100**
500	91	91	91	**91**
250	72	70	75	**72**
150	46	48	50	**48**
100	24	26	25	**25**
75	10	10	10	**10**

The mean PSD of Environment 21's scour test sediment complies with the PSD criteria established by the NJDEP HDS protocol. Figure 6 is a plot of the Environment 21 PSD against the NJDEP PSD specification for the scour test sediment. The Environment 21 sediment gradation is equivalent to or finer than the NJDEP gradation.

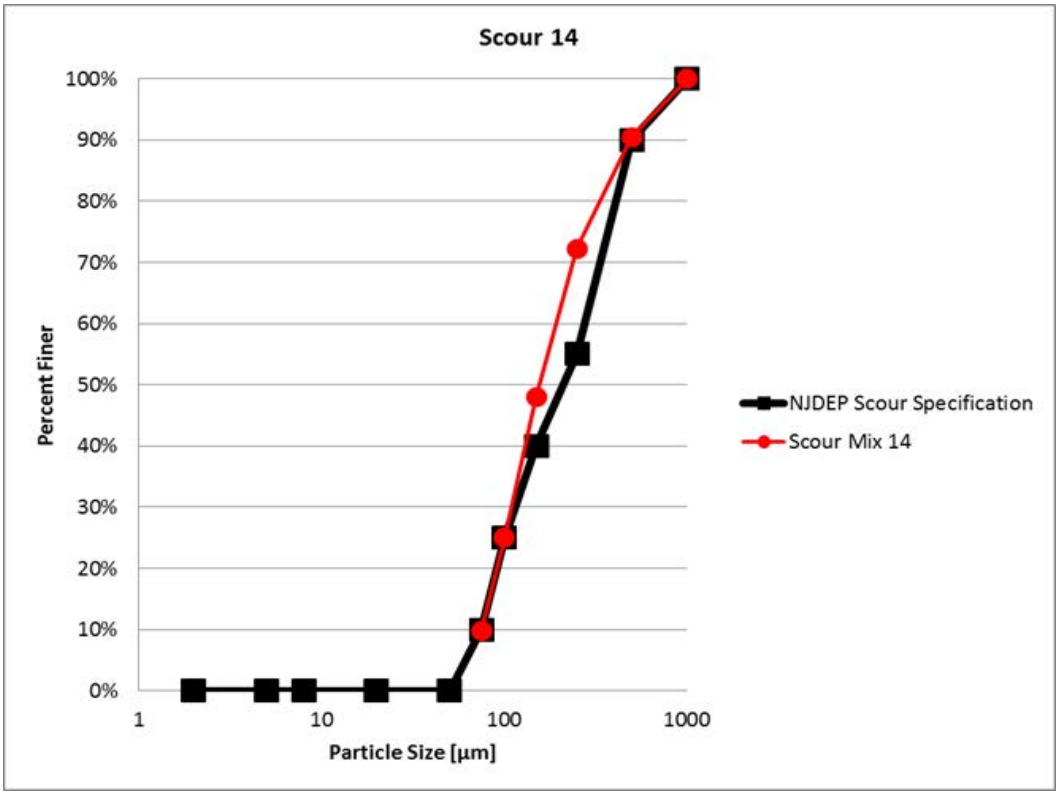

Figure 6 Comparison of the Environment 21 Scour Test Sediment PSD to NJDEP Scour Sediment PSD Specification

4.4 Scour Testing for Online Installation

In order to demonstrate the ability of the Environment 21 StormPro V510 to be used as an online treatment device, scour testing was conducted at greater than 200% of the MTFR in accordance

with the NJDEP HDS Protocol. The average flow rate during the online scour test was 4.42 cfs, which is equivalent to 219% of the MTFR (MTFR = 2.02 cfs). The results from the scour test are reported in Tables 14 and 15 and show that the StormPro V510 had an overall test effluent concentration of 1.50 mg/L (Average Effluent Concentration – Average Background Concentration) at 219% of the MTFR confirming that the StormPro V510 meets the NJDEP criteria of less than 20 mg/L for online use.

Table 14 Scour Test Background Samples

Time (24 hr.)	Water Flow Rate (cfs)	Background Concentration (mg/L)
1143	4.39	2.1
1147	4.46	2.1
1151	4.40	1.6
1155	4.41	1.6
1159	4.44	1.6
1203	4.39	2.1
1207	4.38	1.7
1211	4.41	1.9
Average Concentration		**1.84**

Table 15 Scour Test Effluent Sample Concentrations

Time (hr.)	Water Flow Rate (cfs)	Effluent Concentration (mg/L)
1141	4.42	5.2
1143	4.39	5.8
1145	4.45	4.3
1147	4.46	4.2
1149	4.47	3.2
1151	4.40	3.5
1153	4.38	1.8
1155	4.41	1.6
1157	4.42	2.6
1159	4.44	1.9
1201	4.40	3.3
1203	4.39	3.6
1205	4.41	3.4
1207	4.38	2.8
1209	4.40	3.2
1211	4.41	3.1
Average Concentration		**3.34**

5. Design Limitations

The Environment 21, LLC engineering staff works with the project design engineer and generates a design submittal for each project. Therefore, any possible design limitation is evaluated and corrected so that the StormPro installation will perform as intended.

Required Soil Characteristics

The StormPro is constructed out of precast concrete with the interior sealed off from the exterior. Therefore, the StormPro may be installed in all soil types without impact from the existing soil conditions.

Slope

Environment 21 recommends that the StormPro be installed on slopes less than 10%. Environment 21 engineers will investigate viability of installation on slopes greater than 10% on a case-by-case basis.

Maximum Flow Rate

The maximum treatment flow rate is dependent on the StormPro model. The surface loading for all models is 18.1 gpm/ft^2.

Maintenance Requirements

Environment 21, LLC recommends a bimonthly inspection of the StormPro for the first two years to establish a sediment-loading baseline. After the baseline is established, quarterly inspections are adequate. The site characteristics will determine the need for maintenance. Maintenance (also discussed in Section 6) should be performed, **when required**, for optimal performance of the StormPro.

Driving Head

The driving head could vary from project to project based on the site characteristics. Environment 21, LLC performs a backwater analysis for each project so any problem with the hydraulic grade line from the structure upstream to the structure downstream of the StormPro would be identified.

Installation limitations

The Environment 21, LLC affiliates (pre-casters) supply the contractors with pick weights and installation instructions (most referenced from NPCA). In addition, Environment 21, LLC engineers are available to answer installation questions.

Configurations

The StormPro can be installed online or offline. It can also accommodate other than 180° pipe configurations.

Structural Load Limitations

The StormPro is typically designed to AASHTO HS20-44 loading; however, it can be designed for additional loading as needed.

Pretreatment Requirements

There are no pre-treatment requirements for the StormPro Stormwater Treatment System.

Limitations in Tailwater

Environment 21, LLC performs a backwater analysis for each project; therefore, any limitation from tail water is identified and correction recommendations are made.

Depth to Seasonal High Water Table

The StormPro is a concrete structure and not easily affected by high groundwater. If at any time high groundwater is expected on a project, the Environment 21 engineering staff will work with the project design engineer, pre-caster, and contractor to address the high water and thus circumvent possible buoyancy issues.

6. Maintenance Plans

Environment 21, LLC recommends a bimonthly inspection of the StormPro for the first two years to establish a sediment-loading baseline. After the baseline is established, quarterly inspections are adequate. The site characteristics and site maintenance (e.g., lot sweeping, winter road sand, etc.) will determine the need for maintenance. Maintenance should be performed, **when required**, for optimal performance of the StormPro.

Inspection

Inspection of the StormPro (or any stormwater structure) is very important as it identifies the need for maintenance, off-normal conditions, and establishes a baseline for maintenance. The inspection of the StormPro is visual and does not require a personnel entry into the StormPro. Safety is still a priority as visual access to the StormPro is required and involves removing covers. Open access to any stormwater structure has the potential for personal injury.

The visual inspection is performed with readily available tools (e.g., flashlight, tape measure, etc.). The inspection includes measuring the hydrocarbon/floatable trash depth, measuring the depth of the sediment pile in the sump, integrity inspection of the structure, noting anomalies (e.g., blockages), and determining the need for maintenance (pump-out). Environment 21, LLC recommends pump-out of the StormPro when the sediment depth is at 50% of the maximum.

This is conservative and meant to prevent exceeding the maximum sediment storage depth. In addition, an excess depth of hydrocarbons and floatable trash (approximately 6") should be pumped out even if the sediment depth has not reached one foot. Detailed inspection instructions for the StormPro are in the StormPro Operation and Maintenance Manual and may be obtained at http://www.env21.com/media/docs/StormPro/drawings/StormPro%20System%20Maintenance.pdf.

Maintenance Cleanout

Environment 21 recommends a yearly cleanout of the StormPro or when the sediment depth is at 50% of the maximum, whichever occurs first. Cleanout is accomplished with standard pump-out trucks and equipment. Cleanout should be done during a day without inclement weather. As in the inspection, covers must be removed in order to access the StormPro for cleanout. The waste removed during cleanout should be segregated (e.g., hydrocarbons, sediment, floatable debris) and disposed of per local, state, and federal regulations. If the water removed from the StormPro can be segregated from the waste, it may be put back into the StormPro in order to minimize the disposal volume. Detailed cleanout instructions for the StormPro are in the StormPro Operation and Maintenance Manual.

7. Statements

The following signed statements from the manufacturer, third-party observer and NJCAT are required to complete the NJCAT verification process. In addition, it should be noted that this report has been subjected to public review (e.g. stormwater industry) and all comments and concerns have been satisfactorily addressed.

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engineering and environmental consultants

BARR

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

Date: September 18, 2014

Subject: NJCAT Verification of Environment 21 StormPro Stormwater Treatment System

Dr. Magee,

We are submitting this letter as required per the "Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology" dated January 25, 2013.

Barr Engineering Company, having previously received Third-Party Observer approval from you, meets the required qualifications and had no conflict of interests in performing the function of Third-Party Observer during testing of the Environment 21 StormPro.

Our representative observed all phases of the StormPro testing.Based on this observation, we verify that Environment 21 exercised thoroughness in following the "New Jersey Department of Environmental Protection Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device" in the testing of the StormPro and were compliant with all requirements of said document.

If you have any questions or comments regarding the evaluation of this testing device please contact us.

Sincerely,

Omid Mohseni

Adam Howard

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Technology That Separates

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

Date: September 29, 2014

Subject: NJCAT Verification of Environment 21 StormPro Stormwater Treatment System

Dr. Magee,

This letter is submitted as a signed statement asserting that the requirements of the applicable testing protocol, "New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device", were met or exceeded for the retest of the Environment 21 StormPro Stormwater Treatment System.

Dino Pezzimenti
Science & Government
Environment 21, LLC

environment 21
Global Stormwater Solutions

Center for Environmental Systems
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Castle Point on Hudson
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October 8, 2014

Lisa Schaefer
Environmental Engineer 2
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Dino Pezzimenti
Environment 21, LLC
8713 Read Road
East Pembroke, NY 14056-0055

To all,

Based on my review, evaluation and assessment of the testing conducted on the Environment 21 StormPro V510 and observed by Barr Environmental Co., the test protocol requirements contained in the "New Jersey Laboratory Testing Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device" (NJDEP HDS Protocol) were met or exceeded. Specifically:

Test Sediment Feed

The PSD of Environment 21's test sediment complies with the PSD criteria established by the NJDEP HDS protocol (Figure 5). The median particle size of the Environment 21 gradation is less than 60 microns; the NJDEP HDS protocol requires a mean particle size of 75 microns.

Removal Efficiency Testing

In accordance with the NJDEP HDS Protocol, removal efficiency testing was executed on the Environment 21 StormPro V510 in order to establish the ability of the unit to remove the specified test sediment at 25%, 50%, 75%, 100% and 125% of the target MTFR. Prior to the start of testing, Environment 21 reviewed existing data and decided to utilize a target MTFR of 2.02 cfs. This target was chosen based on the ultimate goal of demonstrating greater than 50% annualized weighted solids removal as defined in the NJDEP HDS Protocol. The flow rates, feed rates and influent concentration met the Test Protocol's requirements and the background concentration for all five test runs never exceeded 1.6 mg/L. The water flow rate COVs were all below the NJDEP protocol requirement of < 0.03; the feed rate calibration samples COVs were 0.070 or less, meeting the NJDEP protocol requirement of ≤0.10.

Scour Testing

In order to demonstrate the ability of the StormPro V510 to be used as an online treatment device, scour testing was conducted at greater than 200% of the MTFR in accordance with the NJDEP HDS Protocol. The average flow rate during the online scour test was 4.42 cfs, which is 219% of the MTFR (MTFR = 2.02 cfs). Sediment loading was 83% of the recommended maintenance level and exceeded the 50% protocol requirement. The maximum background sample was 2.1 mg/L and the maximum effluent sample was 5.8 mg/L. These results confirm that the StormPro V510 did not scour at 219% MTFR and meets the criteria for online use.

Maintenance Frequency

The predicted maintenance frequency for all models is slightly more than 14 years.

Sincerely,

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

8. References

ASTM D422-63. “Standard Test Method for Particle-size Analysis of Soils”

ASTM D3977-97. “Standard Test Methods for Determining Concentrations in Water Samples”

ASTM D4959-07. “Standard Test Method for Determination of Water (Moisture) Content of Soil by Direct Heating”

Environment 21 (2014). *Environment 21 StormPro Testing Report.* Prepared by Environment 21, LLC. September 21014.

NJDEP (2013a). “New Jersey Department of Environment Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device”. Trenton, NJ.

NJDEP (2013b). “New Jersey Department of Environment Protection Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology”. Trenton, NJ.

QAPP (2013). “Quality Assurance Project Plan for the Environment 21 High Efficiency V2B1® StormPro Stormwater Treatment System”. Document No. 2013-StormPro-2001. E. Pembroke, NY.

VERIFICATION APPENDIX

Introduction

- Manufacturer – Environment 21, LLC, 8713 Read Road, East Pembroke, NY 14056-0055. *General Phone*: 800-809-2801. *Website*: http://www.env21.com/

- MTD – Environment 21 StormPro Stormwater Treatment Device Model numbers verified are shown in Table A-1.

- TSS Removal Rate – 50%

- On-line installation

Detailed Specification

- NJDEP sizing tables attached (Table A-1 and Table A-2).

- Environment 21, LLC affiliates (pre-casters) supply contractors with pick weights and installation instructions (most referenced from NPCA). Environment 21, LLC engineers are available to answer installation questions.

- Maximum sediment depth prior to cleaning is 12 inches

- See Environment 21 StormPro Operation and Maintenance Manual for maintenance plan. http://www.env21.com/media/docs/StormPro/drawings/StormPro%20System%20Maintenance.pdf.

- A hydrodynamic separator, such as the StormPro, cannot be used in series with another hydrodynamic separator to achieve an enhanced removal rate for total suspended solids (TSS) removal under N.J.A.C. 7:8-5.5.

Table A-1 MTFRs and Required Sediment Removal Intervals for Verified StormPro Models

StormPro Model	Size		Maximum Treatment Flow Rate (cfs)	Effective Treatment Area (ft2)	Hydraulic Loading Rate (gpm/ft2)	50% Maximum Sediment Storage Volume (ft3)**	Required Sediment Removal Interval (years)*
	Width (ft.)	Length (ft.)					
V48	4	8	1.29	32	18.1	16	14.2
V510	5	10	2.02	50	18.1	25	14.2
V612	6	12	2.91	72	18.1	36	14.2
V816	8	16	5.17	128	18.1	64	14.2
V1020	10	20	8.08	200	18.1	100	14.2

***Sediment removal interval calculated using "yearly" calculation in Section B, Appendix A of the NJDEP HDS protocol**

****50% sediment storage capacity is equal to effective treatment area x 0.5 ft. of sediment depth. Verified StormPro Models have a minimum of 2.5 ft. sump depth.**

Table A-2 Dimensional Overview for Verified StormPro Models

StormPro Model	Dimensions			Hydraulic Loading Rate (gpm/ft2)	Aspect Ratios		
	Width (ft.) W	Length (ft.) L	Sump Depth (ft.) D		L/W	W/D	L/D
V48	4	8	2.5	18.1	2	1.6*	3.2*
V510	5	10	2.5	18.1	2	2	4
V612	6	12	3.0	18.1	2	2	4
V816	8	16	4.0	18.1	2	2	4
V1020	10	20	5.0	18.1	2	2	4

***An Aspect Ratio <2.0 and <4.0 indicates a sump depth greater than necessary for scaling**