NJCAT TECHNOLOGY VERIFICATION

Nutrient Separating Baffle Box with Hydro-Variant Technology

Suntree Technologies Inc.

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1. Description of Technology

The Nutrient Separating Baffle Box with Hydro-Variant Technology (NSBB-HVT) is a subsurface rectangular vault MTD that is placed on-line in the stormwater collection system (**Figure 1**). The NSBB-HVT is engineered to be able to remove solids from stormwater flowing through stormwater pipes and other types of stormwater conveyances. NSBB-HVT treatment removes suspended sediment as well as larger floatable solids including foliage, detritus, and liter.

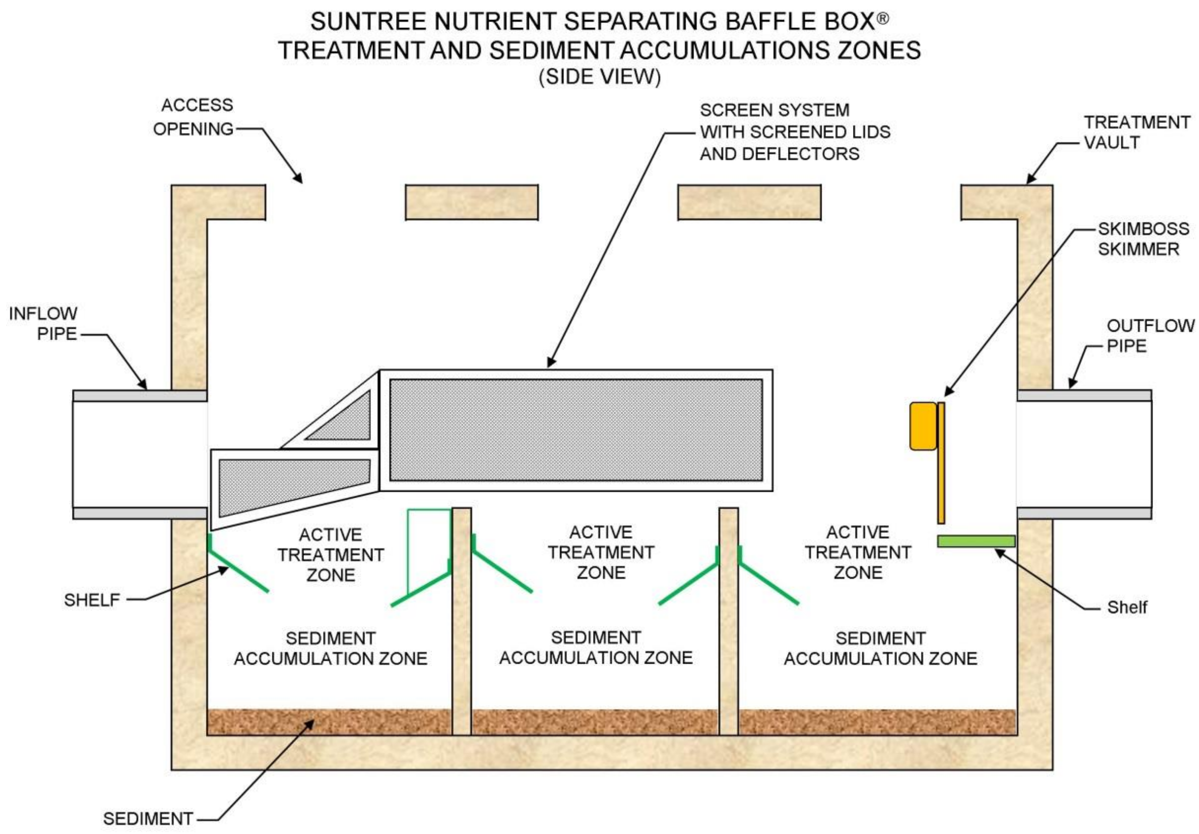


Figure 1 Nutrient Separating Baffle Box Schematic

The NSBB-HVT vault is subdivided into a series of chambers by vertical partitions that extend at an equal distance from the bottom of the vault, supplemented with engineering baffling to influence hydrodynamics and capture suspended particles by sedimentation (**Figure 1**). The water column in each chamber is divided into an upper and a lower zone by shelves that extend from the fore and aft walls. The upper zone of each chamber is the *active treatment zone*, while the *sediment accumulation zone* lies beneath the shelves (**Figure 1**). As water enters the NSBB-HVT the width of flow increases and the linear velocity decreases, making conditions more favorable for particle sedimentation.

Multiple internal components are contained within the NSBB-HVT vault, with a primary objective of calming the water and enabling finer solids to settle out of the flow and accumulate in the sediment accumulation zone of the chambers. The shelves in the NSBB-HVT chambers are strategically arranged and uniquely designed to capture finer particles within the settling chambers, while preventing their resuspension from the underlying sediment accumulation zone during high flow storm events. The shelves create a horizontal vortex at the top of the first and second settling chambers, located above the shelves and below the bottom of the screen system (**Figure 2**). This hydrodynamic characteristic assists in the ability of gravity to act on particles, enhancing their retention within the settling chambers. In addition, the shelves isolate the sediments captured in the underlying sediment accumulation zone from turbulence that could otherwise result in re-suspension. Scaling of the NSBB-HVT is based on the depth of the active treatment zone, as measured by the vertical elevation from the top of the chamber partition to the bottom of the lowest shelf component.

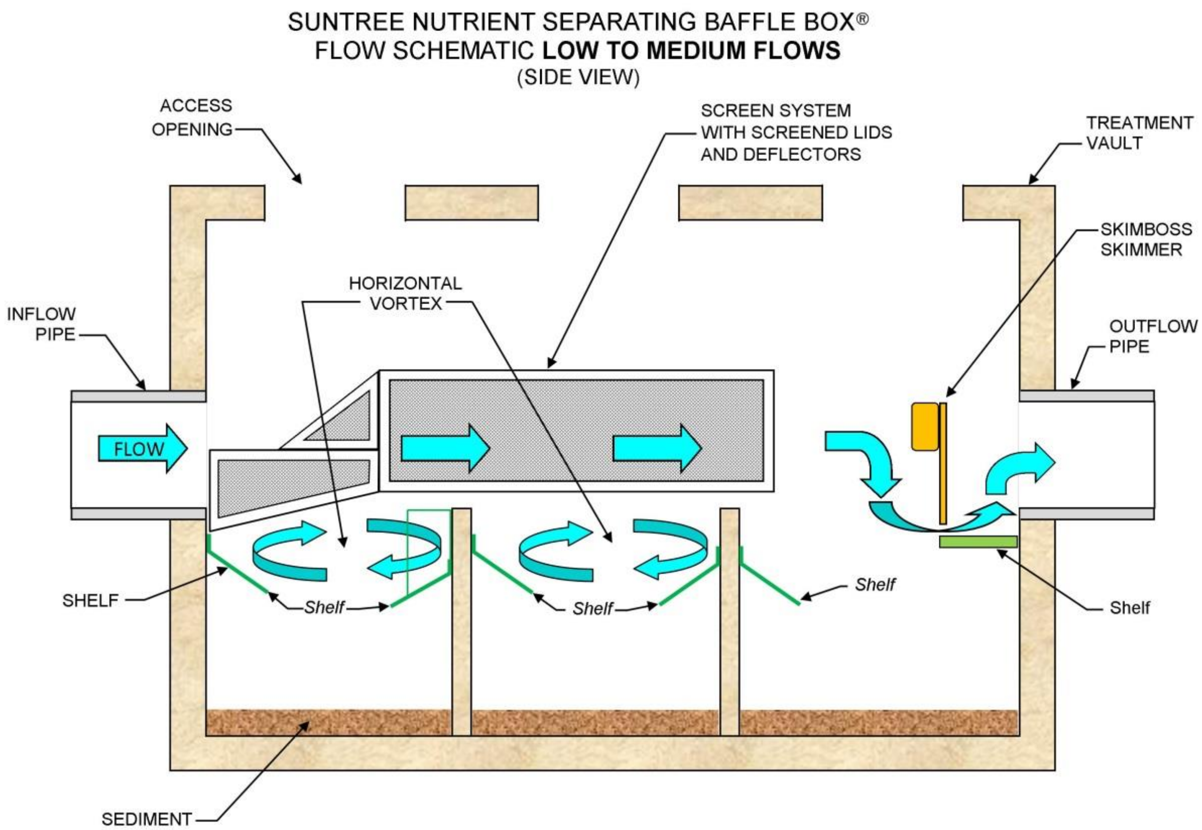


Figure 2 NSBB-HVT Operation at Low to Medium Flows

The NSBB-HVT also incorporates an internal basket screen that is located above the top of the chamber partitions (**Figure 1**). The objective of the screen is to collect and retain floatables including foliage, liter and detritus. As flow rate declines at the tail end of a storm event, the water level in the NSBB-HVT decreases to its static level (i.e. at the top of the partitions). The materials captured in the screen system remain above and out of the water column during non-flow periods, reducing leaching.

The unique hydraulic design of the NSBB-HVT provides *upper level conveyance* of flow in the region that lies above the chamber partitions. The horizontal cross sectional area available for flow conveyance around the outside of the screen system is always sized to be equal to or greater than the conveyance area of the inflow and the outflow pipes. It is not necessary for upper layer stormwater flow to pass through the screen system; it can flow around the screen in order to pass through the NSBB-HVT vault. During high flows, when the water level may be higher than the top of the screen system, screened lids across the top of the screen system prevent large floatables captured by the screen system from escaping through overtopping and washout. These unique hydraulic features enable the NSBB-HVT to be easily retrofitted to existing storm pipes with only minimal headloss impact and without compromising the hydrology of the water shed.

The NSBB-HVT is an evolution of the fixed-skimmer NSBB that contains a performance-enhancing feature trade named SkimBoss® MAX (**Figures 2 and 3**).

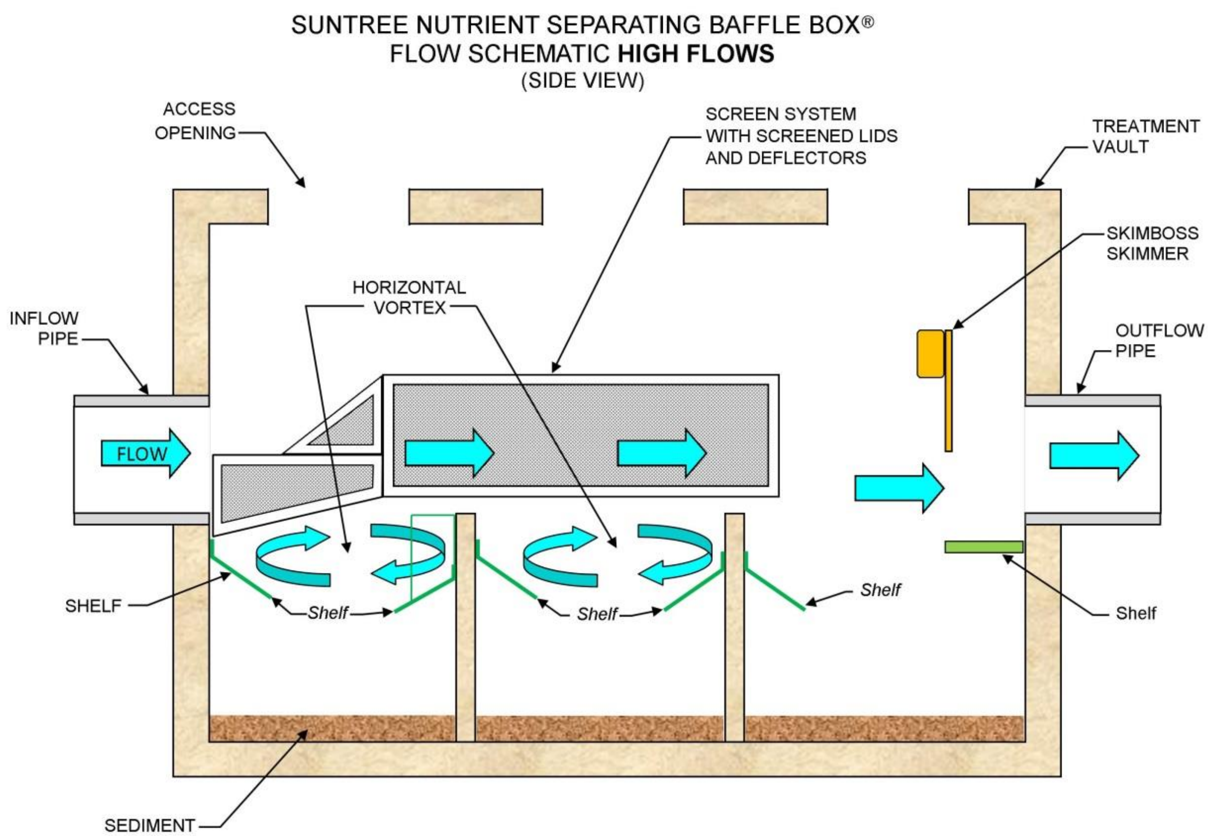


Figure 3 NSBB-HVT Operation at High Flows

SkimBoss® MAX is *a hydro-variant* skimmer that is located adjacent to the vault outflow. The SkimBoss® MAX system automatically adjusts its level in response to stormwater flow and water level, providing a variant level hydraulic conveyance feature. During low to medium flows, the SkimBoss® Max is at its lower level, which optimizes water detention time and reduces turbulence in order to maximize the removal efficiency of finer particles (**Figure 2**). During high flows, when flooding may be a concern, SkimBoss® MAX rises vertically to reduce the headloss of the treatment system and provide the higher conveyance that is needed (**Figure 3**). The SkimBoss®

MAX adjusts its height automatically with flow rate and water level; operator attention is not required.

2. Laboratory Testing

This testing was conducted to independently verify NSBB-HVT performance such that it could be certified by the New Jersey Department of Environmental Protection (NJDEP) as a 50% Total Suspended Solids removal device.

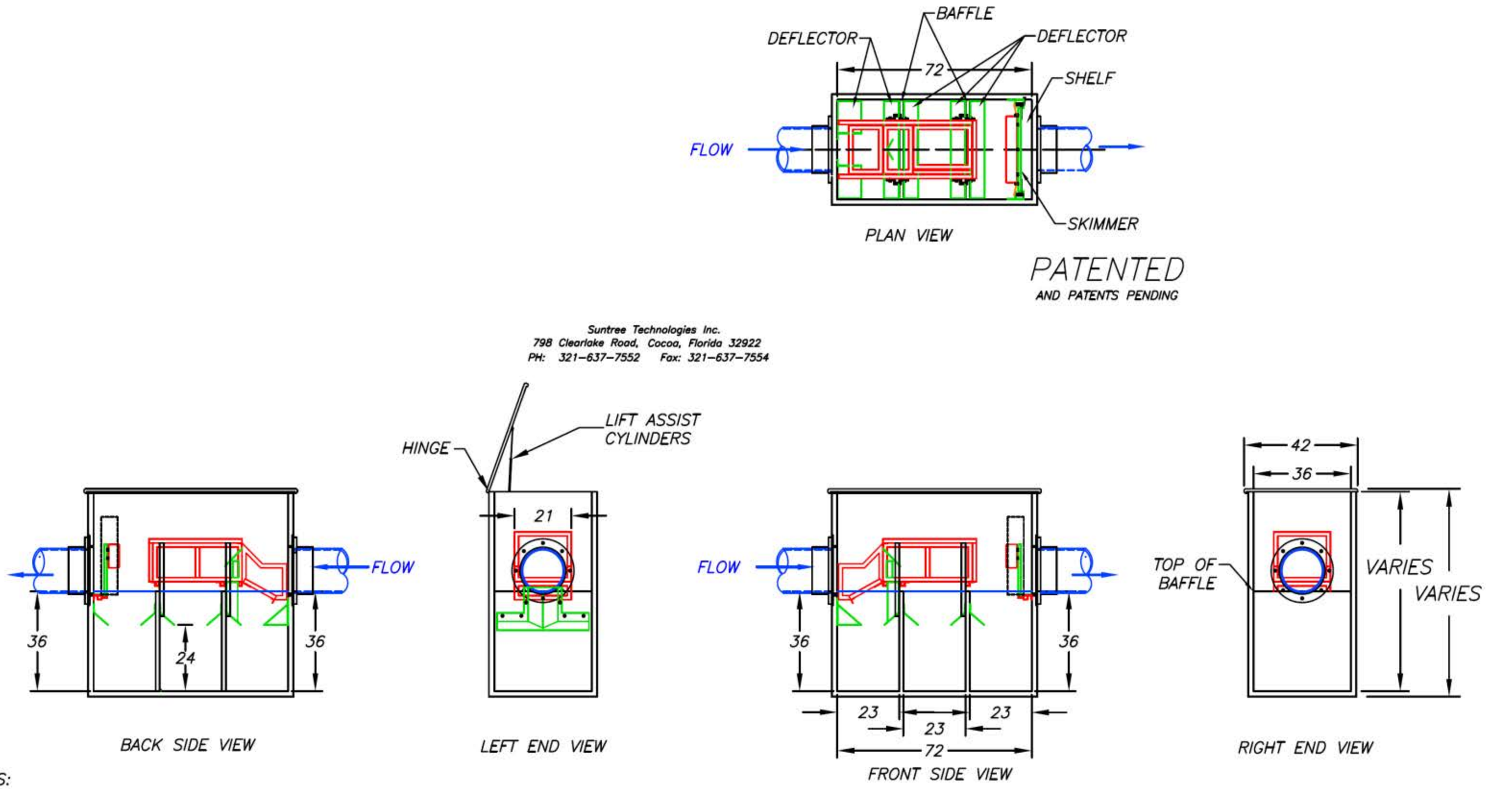
The NSBB-HVT was tested to the "New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device" (NJDEP 2013b). The testing was conducted at the Applied Environmental Technology Test Facility (AET-TF) in Hillsborough County, Florida. AET-TF is located on a 4-acre site that is dedicated to the evaluation of water treatment technologies, with electric power, water supply, shop and pilot support facilities, and an analytical laboratory. Dr Daniel Smith, President of AET, an environmental and water resources engineer with over thirty years' experience in water quality, treatment and modelling conducted the NSBB-HVT performance testing.

The particle size distribution of the removal efficiency test sediment samples and the scour testing test sediment samples were analyzed by the independent analytical laboratory BTL Engineering, Inc., Tampa, FL. All water quality samples for both the removal efficiency testing and the washout testing were collected and analyzed by AET.

2.1 Test Unit

The test unit was a full-scale commercially available 3 ft wide x 6 ft long Nutrient Separating Baffle Box with Hydro-Variant Technology (NSBB-HVT 3-6). A drawing of the NSBB-HVT 3-6 is shown in **Figure 4**. There are three (3) bottom chambers. The depths of the active treatment zone and the sediment accumulation zone are 12 and 24 inch, respectively. The depth of the Maintenance Sediment Storage Volume (MSSV) in the NSBB-HVT 3-6 was established as 50% of the depth of the sediment accumulation zone, or 12 inch.

SUNTREE TECHNOLOGIES INC. NUTRIENT SEPARATING BAFFLE BOX®
MODEL NO: NSBB-HVT-3-6



NOTES:

1. VAULT SUPPORTS PEDESTRIAN LOADING.
2. ALL WALLS, TOP, AND BOTTOM ARE LAMINATED FIBERGLASS
3. INFLOW AND OUTFLOW PIPES CAN NOT INTRUDE INTO THE VAULT.
4. TOP OF VAULT TO BE HINGED WITH STAINLESS STEEL PIANO HINGE ALONG ONE LONG SIDE OF THE VAULT.
5. LIFT SUPPORT CYLINDER TO INCORPORATED TO HELP WITH HOLDING UP THE TOP COVER OF THE VAULT.
6. PYLON AND PIVOTING PANEL TO BE INCORPORATED AS SHOWN INTO THE BODY OF THE SCREEN SYSTEM.
7. TURBULENCE DEFLECTORS TO BE INCOPORATED AS SHOW TO REDUCE TURBULENCE INSIDE SETTLING CHAMBERS.
8. RECOMMENDED PIPE SIZE TO RANGE FROM 12" TO 18".
9. THE TRADE NAME FOR HVT IS SKIMBOSS MAX

SUNTREE TECHNOLOGIES, INC. 798 CLEARLAKE RD. SUITE #2 COCOA, FL. 32922		PROJECT: GENERIC DRAWING	
		DRAWING #: 2-01-03-30-16	
NUTRIENT SEPARATING BAFFLE BOX® MODEL NO: NSBB-HVT-3-6		FILE NAME: NSBB-3-6-72	
DATE: 03/30/16	SCALE: = 57.6	REVISIONS:	DATE:
DRAFTER: T.H.H.	UNITS =INCHES	REVISIONS:	DATE:

2.2 Test Setup

The configuration of the experimental system is shown in **Figure 5**. The test system consists of a NSBB-HVT 3-6 and Water Supply Recycle Reservoir (WSRR), connected by an influent pump (IP) that recycled water from the WSSR to the NSBB-HVT (**Figure 5**). The WSRR was pre-charged with AET-TF groundwater which is of circumneutral pH and virtually completely free of suspended sediment. Water was aerated and equilibrated prior to testing. A valve for fine flow rate control was located downstream of the influent pump inline flow meter. This arrangement enabled a single operator to iteratively adjust flow rate in order to maintain flows close to target values. Water pumped from the WSRR was treated in a pre-filter chamber to reduce background SSC prior to background SSC sampling and sediment dosing. Effluent from the pre-filter chamber entered the feed channel to the NSBB-HVT 3-6. The feed channel was an 18 in. diameter pipe with upper openings for background sampling, sediment dosing, discharge sampling, and visual observation.

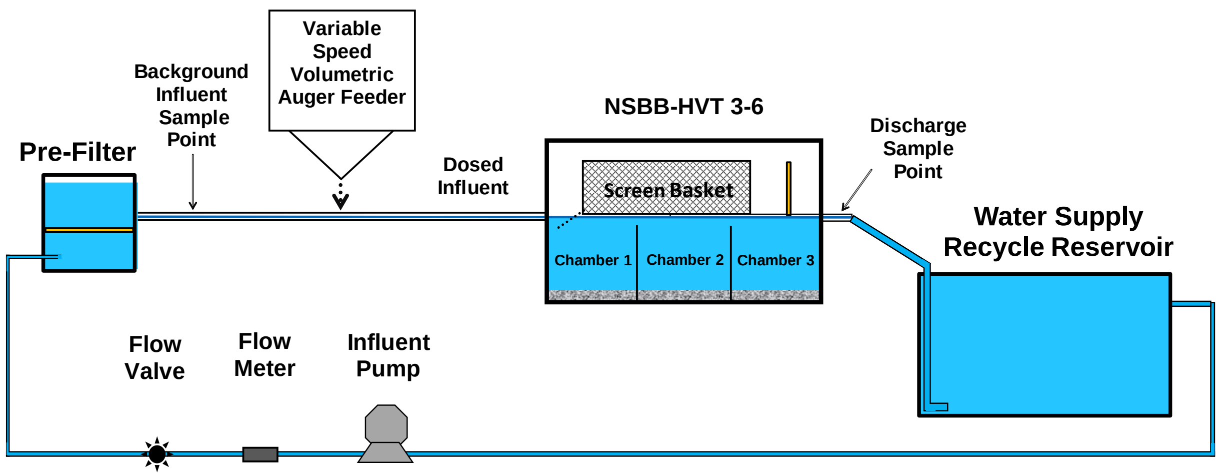


Figure 5 Schematic of Experimental System

The WSRR had a working volume of at ca. 13,500 gallon and served to settle and remove suspended solids prior to recycling. Solids removal was aided by bottom horizontal entry of discharge from the NSBB-HVT 3-6 and tangential withdrawal, which created a circular flow regime, augmented by upper level withdrawal from a baffled WSRR sub-chamber. Flow to the experimental system was provided by John Deere diesel powered vacuum well point pumps (Thompson Pump Co., Sarasota, FL). Pumps were connected by 6 or 8 inch pipes to a PVC withdrawal manifold in the Water Recycle Reservoir that extended ca. 8 in. below the water surface. Pumps had a variable speed control to adjust the flow rate. Removal efficiency testing employed one pump, while two pumps in parallel were employed for the high flow rate resuspension testing. For tests that used a single pump, pump flow was routed through a 6 inch pipe and adjusted with a 6-inch knife gate valve (Thompson Pump Co., Sarasota, FL). Where two pumps were used, pump flows were combined and routed through an 8 inch pipe and adjusted with an 8-inch knife gate valve (Thompson Pump Co., Sarasota, FL). Flow rate was measured with a Portaflow PTFM 1.0 Inline Portable Transit Time Flow Meter, which uses clamp-on ultrasonic sensors and has measurement accuracy within 1% (Greyline Instruments Inc., Massena, N.Y.). Flow rate was recorded at a frequency of one minute during removal efficiency and resuspension testing. The Pre-Filter Chamber (4 ft. by 8 ft. inner plan dimensions) contained a coarse screen followed filter media to remove suspended sediment not captured in the WSRR or which inadvertently enters the experimental system. Water was pumped from the WSRR to the upstream end of the Pre-Filter Chamber, with all flow passing through screens prior to entering the channel leading to the NSBB-HVT. Background influent SSC samples were collected directly from the influent pipe prior to the point of sediment dosing and discharge SSC samples were collected directly from the discharge pipe (**Figure 5**).

Total Suspended Solids Removal Efficiency Laboratory Test Setup

For the removal efficiency test runs, test sediment was dosed into the feed channel using a variable speed volumetric feed that dispensed dry materials from a hopper at a selected feed rate (Model VF-2, IPM Systems, Lee's Summit, MO). The VF-2 employs a direct drive auger delivery system to provide feed rates that are accurate to within 2%. The point of sediment dosing was 68 inches upstream from the entrance wall of the NSBB-HVT 3-6.

For removal efficiency testing, a false floor was installed at the 50% MSSV depth (6 in. from chamber bottom). In line with the protocol requirements, it was fitted with a false bottom positioned 6 inches from the true sump bottom to simulate a 50% full condition.

Scour Test Laboratory Setup

To simulate the 50% full condition for the scour test, the false bottom was set 2 inches above the sump floor over all three chambers and 4 inches of the scour test sediment blend was pre-loaded on top of the false bottom, bringing the level of sump contents to 6 inches from the sump bottom.

2.3 Test Sediment

Test Sediment Feed for Suspended Solids Removal Efficiency Testing

Removal efficiency tests employed high purity silica (99.8%) that conformed to the NJDEP PSD specification. Test sediment was a mixture of high purity silica components. The sediment mixture was prepared by placing a known mass of each sediment component in a five gallon container, sealing the container, and blending by container rotation for five minutes. Fifteen containers of the sediment mixture were prepared, each with the same ratio of sediment component masses. The PSD of test sediment was determined as follows. The sediment containers were numbered 1 through 15. A composite sediment was prepared by collecting an equal mass subsample from five randomly selected sediment containers and thoroughly blending (Composite 1). Two other composites samples were prepared using five randomly and independently selected sediment containers (Composites 2 and 3). PSD analyses of each sediment composite were conducted by BTL Engineering, Inc., Tampa, Florida according to ASTM D422-63 (reapproved 2007). The PSD of test sediment was calculated as the mean of the PSD of the three composites.

Scour Test Sediment

The resuspension test sediment consisted of a mixture of multiple high pursity silica (99.8%) sand components. Fifteen containers of the sediment mixture were prepared. The sediment mixture was prepared by placing a known mass of each component in a five gallon container, sealing the container, and blending container contents by rotation for five minutes. Fifteen containers of the sediment mixture were prepared, each with the same ratio of sediment component masses. The PSD of scour test sediments were determined as follows. Sediment containers were numbered 1 through 15. A composite sediment was prepared by collecting an equal mass subsample from five randomly and independently selected sediment containers and thoroughly blending (Composite 1). Two other composites samples were similarly prepared (Composites 2 and 3). PSD analyses of Composites 1, 2 and 3 were conducted by BTL Engineering, Inc., Tampa, Florida according to ASTM D422-63 (reapproved 2007). PSDs of test sediments were calculated as the mean of the PSD of Composites 1, 2 and 3.

2.4 Removal Efficiency Testing Procedure

Removal efficiency testing was conducted in accordance with Section 5 of the NJDEP Laboratory Protocol for HDS MTDs. A total of five flow rates were tested: the 25%, 50%, 75%, 100% and 125% Maximum Treatment Flow Rate (MTFR). The NSBB-HVT, Screening Chamber, and piping were completely cleaned prior to testing to remove sediment. Captured sediment was removed from the sump between each flow rate trial. Cleaning of the Water Supply Recycle Reservoir was determined by experimental needs.

The test sediment mass was fed into the flow stream at a known rate using the variable speed volumetric feed that dispensed dry materials from the hopper. Sediment was introduced at a rate within 10% of the targeted value of 200 mg/L influent concentration throughout the duration of the testing.

Six calibration samples were taken from the injection point. The calibration samples were timed at evenly spaced intervals over the total duration of the test for each tested flow rate. Each calibration sample was collected over 60 seconds timed to the nearest second. These samples were weighed to the nearest hundredth gram. The average influent TSS concentration was calculated using the total mass of the test sediment added during dosing divided by the volume of water that flowed through the MTD during dosing (**Equation 1**). The mass extracted for calibration samples was subtracted from the total mass introduced to the system when removal efficiency was subsequently calculated. The volume of water that flows through the MTD was calculated by multiplying the average flow rate by the time of sediment injection only.

$$\textbf{Average Influent Concentration} = \frac{\text{Total mass added}}{\text{Total volume of water flowing through the MTD during addition of test sediment}}$$

Equation 1 Calculation for Average Influent Concentration

Field data sheets were prepared for preparation of test sediment, temperature monitoring, flow rate target and monitoring, sediment dosing rate monitoring, total sediment dosing time, background and discharge suspended sediment concentration sample collection times, Suspended Sediment Concentration (SSC) laboratory analysis, and laboratory blank and laboratory control samples for SSC analysis. Data sheets specified and recorded time of sediment dosing initiation, time of sediment dosing termination, time of all sample events, and time of other observations.

The flow meter was powered on and allowed to electronically stablilize. The pump was started and brought to initial speed estimated to produce the target flow rate. When flow readings could be discerned, the pump speed was adjusted if necessary and the flow rate adjusted with the flow control valve until stable flow was achieved that was centered around the target flow rate. The pump was run for several minutes of stable flow at the target flow rate before sediment dosing was initiated. Flow rate adjustments were made as needed through out the experiments using the flow rate control valve. Flow rate was recorded on data sheets at 1 minute intervals throughout the experiments.

Shortly after the pump was started the dosing auger was started with the sediment from the auger collected in a container. After several minutes of stable flow at the target flow rate, sediment dosing was initiated by removing the container. The time of initiation of sediment dosing was the start of the sediment dosing period and was carefully recorded. The sediment dosing time ended when sediment dosing was terminated. The time of the start of the sediment dosing was the zero time point of the experiment and the basis of the time stamp for all sampling and all measurements. Sediment dosing was terminated by depowering the auger after the last samples were collected.

Samples containers were prepared for at least eight background influent SSC samples, fifteen discharge SSC samples, and six sediment dosing samples. All containers had sealable tops. Containers and tops were rinsed at least three times with tap water and drained. SSC containers were one half gallon PETE canisters with round 4 in. diameter open mouths. SSC containers were numbered and deployed in order of increasing number with experimental time. Influent background and discharge sampling were conducted by loosening but not removing the threaded cap on the sample container, immersing the container into the water with the opening facing directly into the direction of water flow at pipe centerline, removing the cap for a short time to allow water ingress, placing the cap over the opening, quickly removing the cannister from the water, and screwing the top closed. Sediment dose containers were 6 x 6 in. open top containers of 2.75 in. depth, cleaned by repeated wipings with clean paper towels. They were lettered A though F and deployed progressively with experimental time.

Eight background influent samples were collected at evenly spaced intervals through the sediment dosing time. The sample location was in the pipe leading to the NSBB-HVT, before the sediment dosing point (**Figure 5**). Fifteen effluent samples were collected at evenly spaced intervals throughout the sediment dosing time. The effluent sample location was at the NSBB-HVT discharge (**Figure 5**). Following sediment dose samples collection, effluent sampling was not conducted until after at least three hydraulic residence times of flow had passed though the NSBB-HVT.

The background data were plotted on a curve for use in adjusting the effluent samples for background concentration. The NSBB-HVT 3-6 removal efficiency for each tested flow rate was calculated as per **Equation 2**.

$$\textbf{Removal Efficiency (\%)} = \frac{\left(\begin{array}{c}\text{Average Influent}\\ \text{Concentration}\end{array} - \begin{array}{c}\text{Adjusted}\\ \text{Average Effluent*}\\ \text{Concentration}\end{array}\right)}{\text{Average Influent Concentration}} \times 100$$

* Adjusted for background concentration

Equation 2 Equation for Calculating Removal Efficiency

Water temperature was verified to between 79 and 80F during the tests using a NIST traceable thermometer (Traceable Calibration Control Company 281-482-1714).

Analysis of Suspended Sediment Concentration (SSC) analysis was conducted according to the AET SSC protocol. A 2 hour drying time was verified to produce constant weight for rinsed filters and filtered samples. Method Blanks were less than the established Reporting Limit of 2.07 mg/L for all analyses events. For all analyses events, Lab Control Sample recoveries were within the established tolerances of 15% for high range samples (100 mg/L) and 30% for low range samples (20 mg/L). Initial Demonstration of Capability samples in the high and low SSC range were all within the 15% and 30% Recovery Criteria, respectively.

Data sheets were assembled and a complete file maintained at AET for each experiment. All data was placed in electronic format by entering into Excel spreadsheets.

2.5 Scour Testing Procedure

To simulate a 50% full sump condition, the NSBB-HVT sump false bottom was set to a height of 2 inches and then topped with 4 inches of scour test sediment. The sediment was leveled, then the NSBB-HVT was filled with clear water at a slow rate as to not disturb the sediment prior to the beginning of testing. The scour testing was begun within 24 hours of sediment placement, less than the 96 hours allowed by the protocol. The scour test was conducted at a water temperature of 79 to 80 F.

The test was initiated by starting the water pump. Full scour flow rate was reached within 5 minutes of test initiation and maintained at constant flow rate through duration of the test. Flow rate was recorded at one minute intervals from initiation to the end of test. The first discharge and the first background sample were each collected after the steady test flow rate was reached. Thereafter, discharge samples were collected at 2 minute intervals (3, 5, 7…) for a total of fifteen samples. After the first background sample, background samples were collected at 4 minute intervals (3, 5, 7…) for a total of fifteen samples. Background and discharge sampling was conducted by the same procedures employed in the removal efficiency tests. Sample collection, SSC analyses, analytical, quality control and data management methods were the same as those used in the removal efficiency tests.

3. Performance Claims

In line with the NJDEP verification procedure (NJDEP 2013a), NSBB-HVT performance claims are outlined below.

Total Suspended Solids Removal Rate

The TSS removal rate of the NBSS-HVT is dependent upon flow rate, particle density and particle size. For the particle size distribution and weighted calculation method required by the NJDEP HDS MTD protocol, the NSBB-HVT 3-6 at a MTFR of 1.40 cfs will demonstrate at least 50% TSS removal efficiency.

Maximum Treatment Flow Rate

The MTFR for the NSBB-HVT 3-6 was demonstrated to be 628 gpm (1.40 cfs), which corresponds to a surface loading rate of 34.9 gpm/sf.

Sediment Storage Depth and Volume

The maximum sediment storage depth of the NSBB-HVT 3-6 is 12 inches. The available sediment storage volume of the NSBB-HVT 3-6 is 0.61 cubic yards. Available sediment storage volume varies with each NSBB-HVT model, as NSBB-HVT model dimensions increase in plan area and depth.

Effective Treatment Area and Effective Sedimentation Area

The effective treatment and sedimentation area of the NSBB-HVT varies with model size, and equals the plan surface area of the NSBB-HVT model. The tested NSBB-HVT 3-6 has a treatment surface area of 18.0 square feet.

Detention Time and Volume

The detention time of the NSBB-HVT depends on flow rate and model size. The nominal detention time is calculated by dividing the treatment zone volume by the flow rate. The volume of the treatment zone is defined as the volume between the top of partition and the top of the underlying sediment accumulation zone. For the tested NSBB-HVT 3-6 model at the MTFR of 1.40 cfs, the nominal detention time was 12.9 seconds.

Online or Offline Installation

Based on the results of the Scour Testing documented in Section 4.4, the NSBB-HVT qualifies for online installation.

4. Supporting Documentation

The NJDEP Procedure (NJDEP 2013a) 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

The test sediment for the removal efficiency testing was prepared and blended as described in **Section 2.3**. PSD analysis on three blends was conducted by BTL Engineering, Inc., Tampa, Florida according to ASTM D422-63 (reapproved 2007). The test sediment was found to be slightly finer than the protocol specified sediment blend. The results and the comparison to the protocol specification are shown in **Table 1** and **Figure 6.**

Table 1 - Particle Size Distribution Results of Test Sediment Samples

Particle Size	% Finer					Difference from Protocol %
µm	Protocol	Sample 1	Sample 2	Sample 3	Test Sediment Average	
1000	100	100.0	100.0	100.0	100.0	0.0
500	95	99.9	99.9	99.9	99.9	-4.9
250	90	96.6	96.8	96.8	96.7	-6.7
150	75	77.1	77.7	77.6	77.5	-2.5
100	60	61.4	61.1	61.3	61.3	-1.3
75	50	58.9	58.1	58.4	58.5	-8.5
50	45	50.4	49.8	51.3	49.3	-4.3
20	35	34.9	35.4	35.4	35.2	-0.2
8	20	20.9	20.3	20.8	20.7	-0.7
5	10	14.4	15.1	15.0	14.8	-4.8
2	5	9.0	8.5	9.0	8.8	-3.8

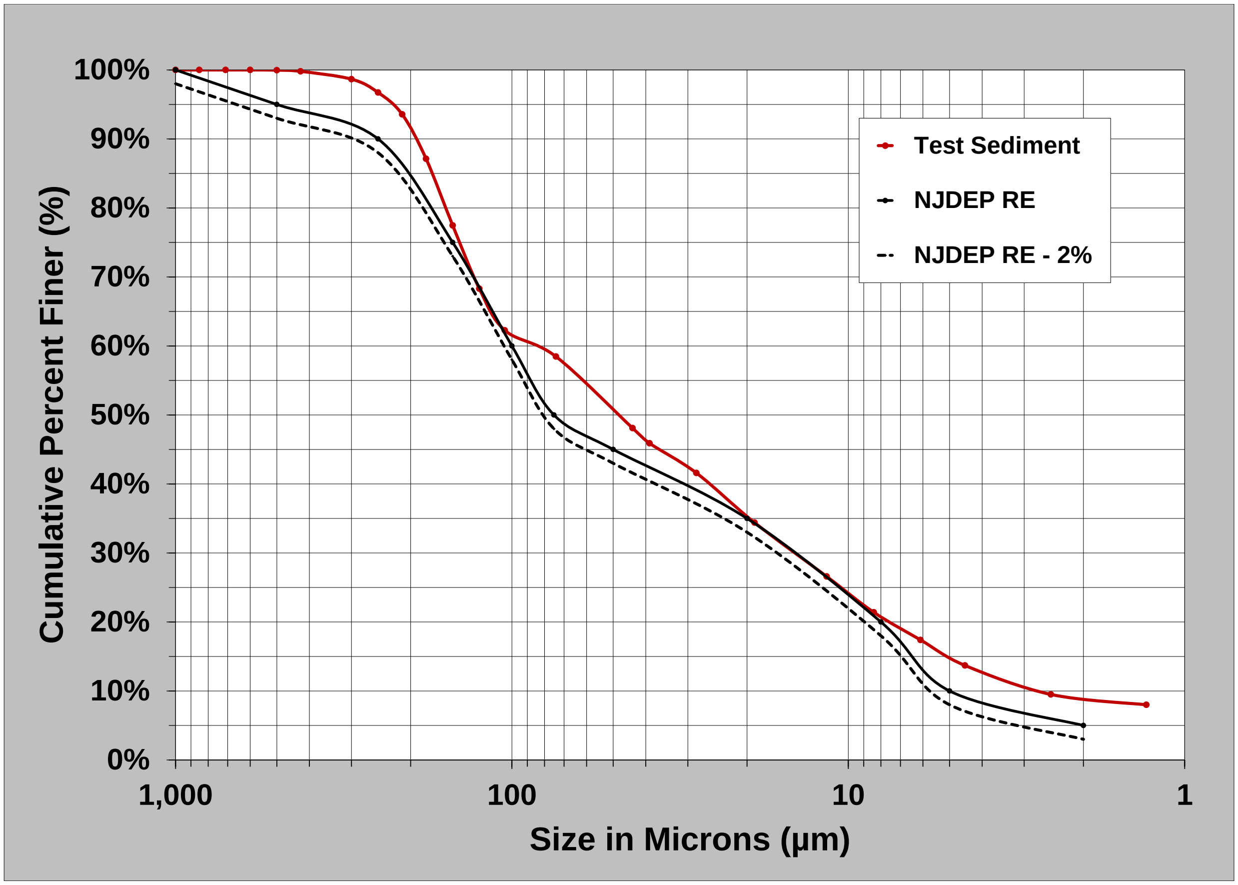


Figure 6 Average Test Sediment PSD vs Protocol Specification

4.2 Removal Efficiency Testing

In accordance with the NJDEP HDS Protocol, removal efficiency testing was executed on the NSBB-HVT 3-6 unit in order to establish the ability of the NSBB-HVT to remove the specified test sediment at 25%, 50%, 75%, 100% and 125% of the target MTFR. The target MTFR was 628 gpm (1.40 cfs). This target was chosen based on the ultimate goal of demonstrating greater than 50% annualized weighted solids removal as defined in the Protocol.

All results reported in this section were derived from test runs that fully complied with the terms of the protocol. None of the collection intervals of the calibration samples exceeded one minute in duration for any of the reported tests. The inlet feed concentration coefficient of variance (COV) did not exceed 0.10 for any flow rate trials.

The mean influent concentration was calculated using Equation 1 from *Section 2.4 Removal Efficiency Test Procedure.* The mean effluent concentration was adjusted by subtracting the measured background concentrations. No background TSS concentrations exceeded the 20 mg/L maximum allowed by the protocol. At no point did the water temperature exceed 80 F.

25% MTFR Results

The NSBB-HVT 3-6 25% MTFR test was conducted in accordance with the NJDEP HDS Protocol at a target flow rate of 0.35 cfs (157 gpm). A summary of test readings, measurements and calculations are shown in **Table 2**. Feed calibration results are shown in **Table 3**. Background and effluent sampling measurements are shown in **Table 4**.

The NSBB-HVT removed 67.9% of the test sediment at a flow rate of 0.35 cfs. **Table 5** shows that the QA/QC results for flow rate, feed rate and influent and effluent background concentrations were within the allowable parameters specified by the protocol.

Table 2 - Summary of NSBB-HVT 3-6 25% MTFR Test

Trial Date	Target Flow (cfs)/(gpm)	Detention Time (sec)	Target Sediment Concentration (mg/L)	Target Feed Rate (mg/min)	Test Duration (Min)
1/07/2016	0.35 /157.1	51	200	118,910	82
Measured Values					
Mean Flow Rate (cfs)/(gpm)	**Mean Influent Concentration [1] (mg/L)**	**Max. Water Temperature °C / °F**	**Mean Adjusted Effluent Concentration (mg/L)**	**Average Removal Efficiency**	**QA/QC Compliance**
0.35 /158.1	192.6	26.7 / 80	61.8	67.9%	YES

[1] The mean influent concentration reported is calculated by dividing the entire mass of test sediment injected into the flow stream over the duration of the test divided by the total flow during the injection of test sediment.

Table 3 – NSBB-HVT 3-6 25% MTFR Test Calibration Results

Target Concentration	200 mg/L	Target Feed Rate		119,664 mg/min	
Sample ID	**Sample Time (min)**	**Sample Mass (g)**	**Sample Duration (sec)**	**Feed Rate (mg/min)**	**Calculated Influent Concentration (mg/L)**
Feed Rate 1	1	113.26	60	113,260	189
Feed Rate 2	17	113.03	60	113,030	189
Feed Rate 3	33	115.83	60	115,830	194
Feed Rate 4	49	115.12	60	115,120	192
Feed Rate 5	65	116.48	60	116,480	195
Feed Rate 6	81	117.78	60	117,780	197
			Mean	115,250	**193**

Table 4 – NSBB-HVT 3-6 25% MTFR Background and Effluent Measurements

Sample ID	Time (min)	Concentration (mg/L)		
Background 1	10	MDL		
Background 2	16	<MDL		
Background 3	29	<MDL		
Background 4	42	<MDL		
Background 5	48	<MDL		
Background 6	61	<MDL		
Background 7	74	<MDL		
Background 8	80	<MDL		
Sample ID	**Time (min)**	**Concentration (mg/L)**	**Associated Background Concentration (mg/L)**	**Adjusted Concentration (mg/L)**
Effluent 1	10	59.4	1	58.4
Effluent 2	13	60.2	1	59.2
Effluent 3	16	61.8	1	60.8
Effluent 4	26	53.3	1	52.3
Effluent 5	29	59.9	1	58.9
Effluent 6	32	60.9	1	59.9
Effluent 7	42	61.7	1	60.7
Effluent 8	45	63.2	1	62.2
Effluent 9	48	64.7	1	63.7
Effluent 10	58	65.1	1	64.1
Effluent 11	61	65.6	1	64.6
Effluent 12	64	67.4	1	66.4
Effluent 13	74	64.3	1	63.3
Effluent 14	77	66.2	1	65.2
Effluent 15	80	68.1	1	67.1
	Mean	**62.8**	**1.0**	**61.8**

MDL – 2.1 mg/L

Table 5 – NSBB-HVT 3-6 25% MTFR Trial QA/QC Results

Flow Rate			
Target (cfs / gpm)	Mean (cfs / gpm)	Coef. Of Variance	Acceptable Parameters Coef. Of Variance
0.35 / 157.1	0.35 / 158.1	0.022	<0.03
Feed Rate			
Target (mg/min)	Mean (mg/min)	Coef. Of Variance	Acceptable Parameters Coef. Of Variance
119,664	115,250	0.016	<0.1
Influent Concentration			
Target (mg/L)	Mean (mg/L)	Coef. Of Variance	Acceptable Parameters Coef. Of Variance
200	192.6	0.016	<0.1
Background Concentration			
Low (mg/L)	High (mg/L)	Mean (mg/L)	Acceptable Threshold (mg/L)
<MDL	MDL	1.0 (1/2 MDL)	<20

50% MTFR Results

The NSBB-HVT 3-6 50% MTFR test was conducted in accordance with the NJDEP HDS Protocol at a target flow rate of 0.70 cfs (314 gpm). A summary of test readings, measurements and calculations are shown in **Table 6**. Feed calibration results are shown in **Table 7**. Background and effluent sampling results are shown in **Table 8**.

The NBSS-HVT 3-6 removed 65.8% of the test sediment at a flow rate of 0.70 cfs. **Table 9** shows that the QA/QC results for flow rate, feed rate and influent and effluent background concentrations were within the allowable parameters specified by the protocol.

Table 6 – Summary of NSBB-HVT 3-6 50% MTFR Test

Trial Date	Target Flow (cfs) / (gpm)	Detention Time (sec)	Target Sediment Concentration (mg/L)	Target Feed Rate (mg/min)	Test Duration (Min)
1/07/2016	0.70 / 314.2	26	200	237,840	62
Measured Values					
Mean Flow Rate (cfs) / (gpm)	**Mean Influent Concentration [1] (mg/L)**	**Max. Water Temperature °C / °F**	**Mean Adjusted Effluent Concentration (mg/L)**	**Average Removal Efficiency**	**QA/QC Compliance**
0.70 / 312.5	196.1	26.7 / 80	67.0	65.8%	YES

[1] The mean influent concentration reported is calculated by dividing the entire mass of test sediment injected into the flow stream over the duration of the test divided by the total flow during the injection of test sediment.

Table 7 – NSBB-HVT 3-6 50% MTFR Test Calibration Results

Target Concentration	200 mg/L	Target Feed Rate		237,840 mg/min	
Sample ID	**Sample Time (min)**	**Sample Mass (g)**	**Sample Duration (sec)**	**Feed Rate (mg/min)**	**Calculated Influent Concentration (mg/L)**
Feed Rate 1	1	224.62	60	224,620	190
Feed Rate 2	13	226.53	60	226,530	192
Feed Rate 3	25	234.25	60	234,250	198
Feed Rate 4	37	233.62	60	233,620	198
Feed Rate 5	49	232.71	60	232,710	197
Feed Rate 6	61	239.70	60	239,700	203
			Mean	**231,905**	**196**

Table 8 – NSBB-HVT 3-6 50% MTFR Background and Effluent Measurements

Sample ID	Time (min)	Concentration (mg/L)
Background 1	6	<MDL
Background 2	12	<MDL
Background 3	21	<MDL
Background 4	30	<MDL
Background 5	36	<MDL
Background 6	45	2.5
Background 7	54	<MDL
Background 8	60	2.3

Sample ID	Time (min)	Concentration (mg/L)	Associated Background Concentration (mg/L)	Adjusted Concentration (mg/L)
Effluent 1	6	66.6	1	65.6
Effluent 2	9	68.2	1	67.2
Effluent 3	12	69.8	1	68.8
Effluent 4	18	68.4	1	67.4
Effluent 5	21	71.1	1	70.1
Effluent 6	24	72.8	1	71.8
Effluent 7	30	72.9	1	71.9
Effluent 8	33	68.4	1	67.4
Effluent 9	36	69.2	1	68.2
Effluent 10	42	71.5	1	70.5
Effluent 11	45	70.3	2	68.3
Effluent 12	48	61.4	2	59.4
Effluent 13	54	51.6	2	49.6
Effluent 14	57	73.2	2	71.2
Effluent 15	60	69.3	2	67.3
	Mean	**68.3**	**1.3**	**67.0**

MDL – 2.1 mg/L

Table 9 – 4-ft FDHC 50% MTFR Trial QA/QC Results

Flow Rate			
Target (cfs / gpm)	Mean (cfs / gpm)	Coef. Of Variance	Acceptable Parameters Coef. Of Variance
0.70 / 314.2	0.70 / 312.5	0.013	<0.03
Feed Rate			
Target (mg/min)	Mean (mg/min)	Coef. Of Variance	Acceptable Parameters Coef. Of Variance
237,840	231,905	0.024	<0.1
Influent Concentration			
Target (mg/L)	Mean (mg/L)	Coef. Of Variance	Acceptable Parameters Coef. Of Variance
200	196.1	0.024	<0.1
Background Concentration			
Low (mg/L)	High (mg/L)	Mean (mg/L)	Acceptable Threshold (mg/L)
>MDL	2.5	1.3	<20

75% MTFR Results

The NSBB-HVT 3-6 75% MTFR test was conducted in accordance with the NJDEP HDS Protocol at a target flow rate of 1.05 cfs (471 gpm). A summary of test readings, measurements and calculations are shown in **Table 10**. Feed calibration results are shown in **Table 11**. Background and effluent sampling results are shown in **Table 12**.

The NBSS-HVT 3-6 removed 63.1% of the test sediment at a flow rate of 1.05 cfs. **Table 13** shows that the QA/QC results for flow rate, feed rate and influent and effluent background concentrations were within the allowable parameters specified by the protocol.

Table 10 – Summary of NSBB-HVT 3-6 75% MTFR Test

Trial Date	Target Flow (cfs) / (gpm)	Detention Time (sec)	Target Sediment Concentration (mg/L)	Target Feed Rate (mg/min)	Test Duration (Min)
1/06/2016	1.05 / 471.3	17	200	356,790	57
Measured Values					
Mean Flow Rate (cfs / gpm)	**Mean Influent Concentration[1] (mg/L)**	**Max. Water Temperature °C / °F**	**Mean Adjusted Effluent Concentration (mg/L)**	**Average Removal Efficiency**	**QA/QC Compliance**
1.05 / 471.9	199.1	26.7 / 80	73.4	63.1%	YES

[1] The mean influent concentration reported is calculated by dividing the entire mass of test sediment injected into the flow stream over the duration of the test divided by the total flow during the injection of test sediment.

Table 11 – NSBB-HVT 3-6 75% MTFR Test Calibration Results

Target Concentration	200 mg/L	Target Feed Rate		356,790 mg/min	
Sample ID	**Sample Time (min)**	**Sample Mass (g)**	**Sample Duration (sec)**	**Feed Rate (mg/min)**	**Calculated Influent Concentration (mg/L)**
Feed Rate 1	1	352.26	60	352,260	197
Feed Rate 2	12	355.89	60	355,890	199
Feed Rate 3	23	358.64	60	358,640	201
Feed Rate 4	34	354.16	60	354,160	198
Feed Rate 5	45	361.42	60	361,420	202
Feed Rate 6	56	351.82	60	351,820	197
			Mean	**355,698**	**199**

Table 12 – NSBB-HVT 3-6 75% MTFR Background and Effluent Measurements

Sample ID	Time (min)	Concentration (mg/L)
Background 1	5	3.2
Background 2	11	3.6
Background 3	19	3.2
Background 4	27	<MDL
Background 5	33	5.5
Background 6	41	4.4
Background 7	49	7.1
Background 8	55	8.9

Sample ID	Time (min)	Concentration (mg/L)	Associated Background Concentration (mg/L)	Adjusted Concentration (mg/L)
Effluent 1	5	72.7	3.2	69.5
Effluent 2	7	79.0	3.4	75.6
Effluent 3	11	80.0	3.6	76.4
Effluent 4	16	76.3	3.4	72.9
Effluent 5	19	69.3	3.2	66.1
Effluent 6	22	85.1	2.1	83.0
Effluent 7	27	129.0	1.0	128.0
Effluent 8	30	86.3	3.3	83.0
Effluent 9	33	84.0	5.5	78.5
Effluent 10	38	80.0	5.0	75.0
Effluent 11	41	83.2	4.4	78.8
Effluent 12	44	49.4	5.8	43.6
Effluent 13	49	70.1	7.1	63.0
Effluent 14	52	59.3	8.0	51.3
Effluent 15	55	65.5	8.9	56.6
	Mean	**77.9**	**4.5**	**73.4**

MDL – 2.1 mg/L

Table 13 – NSBB-HVT 3-6 75% MTFR Trial QA/QC Results

Flow Rate			
Target (cfs / gpm)	Mean (cfs / gpm)	Coef. Of Variance	Acceptable Parameters Coef. Of Variance
1.05 / 471.3	1.05 / 471.9	0.011	<0.03
Feed Rate			
Target (mg/min)	Mean (mg/min)	Coef. Of Variance	Acceptable Parameters Coef. Of Variance
356,790	355,698	0.011	<0.1
Influent Concentration			
Target (mg/L)	Mean (mg/L)	Coef. Of Variance	Acceptable Parameters Coef. Of Variance
200	199.1	0.011	<0.1
Background Concentration			
Low (mg/L)	High (mg/L)	Mean (mg/L)	Acceptable Threshold (mg/L)
<MDL	8.9	4.5	<20

100% MTFR Results

The NSBB-HVT 3-6 100% MTFR test was conducted in accordance with the NJDEP HDS Protocol at a target flow rate of 1.40 cfs (628 gpm). A summary of test readings, measurements and calculations are shown in **Table 14**. Feed calibration results are shown in **Table 15**. Background and effluent sampling results are shown in **Table 16**.

The NBSS-HVT 3-6 removed 56.4% of the test sediment at a flow rate of 1.40 cfs. **Table 17** shows that the QA/QC results for flow rate, feed rate and influent and effluent background concentrations were within the allowable parameters specified by the protocol.

Table 14 – Summary of NSBB-HVT 3-6 100% MTFR Test

Trial Date	Target Flow (cfs) / (gpm)	Detention Time (sec)	Target Sediment Concentration (mg/L)	Target Feed Rate (mg/min)	Test Duration (Min)
1/08/2015	1.40 / 628.4	12.9	200	475,680	42
Measured Values					
Mean Flow Rate (cfs / gpm)	**Mean Influent Concentration (mg/L)[1]**	**Max. Water Temperature °C / °F**	**Mean Adjusted Effluent Concentration (mg/L)**	**Average Removal Efficiency**	**QA/QC Compliance**
1.40 / 629.3	198.3	26.7 / 80	86.5	56.4%	YES

[1] The mean influent concentration reported is calculated by dividing the entire mass of test sediment injected into the flow stream over the duration of the test divided by the total flow during the injection of test sediment.

Table 15 – NSBB-HVT 3-6 100% MTFR Test Calibration Results

Target Concentration	200 mg/L	Target Feed Rate		475,680 mg/min	
Sample ID	**Sample Time (min)**	**Sample Mass (g)**	**Sample Duration (sec)**	**Feed Rate (mg/min)**	**Calculated Influent Concentration (mg/L)**
Feed Rate 1	1	462.66	60	462,660	194
Feed Rate 2	9	470.75	60	470,750	198
Feed Rate 3	17	467.25	60	467,250	196
Feed Rate 4	25	474.72	60	474,720	199
Feed Rate 5	33	480.77	60	480,770	202
Feed Rate 6	41	477.39	60	477,390	200
			Mean	**472,257**	**198**

Table 16 – NSBB-HVT 3-6 100% MTFR Background and Effluent Measurements

Sample ID	Time (min)	Concentration (mg/L)		
Background 1	4	<MDL		
Background 2	8	<MDL		
Background 3	14	<MDL		
Background 4	20	3.7		
Background 5	24	3.2		
Background 6	30	5.1		
Background 7	36	6.7		
Background 8	40	10.9		
Sample ID	**Time (min)**	**Concentration (mg/L)**	**Associated Background Concentration (mg/L)**	**Adjusted Concentration (mg/L)**
Effluent 1	4	77.4	1.0	76.4
Effluent 2	6	88.9	1.0	87.9
Effluent 3	8	70.4	1.0	69.4
Effluent 4	12	99.5	1.0	98.5
Effluent 5	14	101.3	1.0	100.3
Effluent 6	16	83.7	2.4	81.3
Effluent 7	20	98.0	3.7	94.3
Effluent 8	22	100.6	3.5	97.1
Effluent 9	24	96.2	3.2	93.0
Effluent 10	28	62.5	4.2	58.3
Effluent 11	30	88.4	5.1	83.3
Effluent 12	32	101.7	5.9	95.8
Effluent 13	36	91.2	6.7	84.5
Effluent 14	38	96.9	8.8	88.1
Effluent 15	40	100.7	10.9	89.8
	Mean	**90.5**	**4.0**	**86.5**

MDL – 2.1 mg/L

Table 17 – NSBB-HVT 3-6 100% MTFR Trial QA/QC Results

Flow Rate			
Target (cfs / gpm)	Mean (cfs / gpm)	Coef. Of Variance	Acceptable Parameters Coef. Of Variance
1.40 / 628.4	1.40 / 629.3	0.009	<0.03
Feed Rate			
Target (mg/min)	Mean (mg/min)	Coef. Of Variance	Acceptable Parameters Coef. Of Variance
475,680	472,257	0.014	<0.1
Influent Concentration			
Target (mg/L)	Mean (mg/L)	Coef. Of Variance	Acceptable Parameters Coef. Of Variance
200	198.3	0.014	<0.1
Background Concentration			
Low (mg/L)	High (mg/L)	Mean (mg/L)	Acceptable Threshold (mg/L)
>MDL	10.9	4.0	<20

125% MTFR Results

The NSBB-HVT 3-6 125% MTFR test was conducted in accordance with the NJDEP HDS Protocol at a target flow rate of 1.75 cfs (785 gpm). A summary of test readings, measurements and calculations are shown in **Table 18**. Feed calibration results are shown in **Table 19**. Background and effluent sampling results are shown in **Table 20**.

The NBSS-HVT 3-6 removed 50.6% of the test sediment at a flow rate of 1.75 cfs. **Table 21** shows that the QA/QC results for flow rate, feed rate and influent and effluent background concentrations were within the allowable parameters specified by the protocol.

Table 18 – Summary of NSBB-HVT 3-6 125% MTFR Test

Trial Date	Target Flow (cfs / gpm)	Detention Time (sec)	Target Sediment Concentration (mg/L)	Target Feed Rate (mg/min)	Test Duration (Min)
1/13/2016	1.75 / 785.5	10	200	594,600	32
Measured Values					
Mean Flow Rate (cfs / gpm)	**Mean Influent Concentration[1] (mg/L)**	**Max. Water Temperature °C / °F**	**Mean Adjusted Effluent Concentration (mg/L)**	**Average Removal Efficiency**	**QA/QC Compliance**
1.75 / 785.8	201.9	26.7 / 80	99.7	50.6%	YES

[1] The mean influent concentration reported is calculated by dividing the entire mass of test sediment injected into the flow stream over the duration of the test divided by the total flow during the injection of test sediment.

Table 19 – NSBB-HVT 3-6 125% MTFR Test Calibration Results

Target Concentration	200 mg/L	Target Feed Rate		594,600 mg/min	
Sample ID	**Sample Time (min)**	**Sample Mass (g)**	**Sample Duration (sec)**	**Feed Rate (mg/min)**	**Calculated Influent Concentration (mg/L)**
Feed Rate 1	1	587.90	60	587,900	198
Feed Rate 2	7	599.93	60	599,930	202
Feed Rate 3	13	600.58	60	600,580	202
Feed Rate 4	19	600.27	60	600,270	202
Feed Rate 5	25	606.54	60	606,540	204
Feed Rate 6	31	606.94	60	606,940	204
			Mean	**600,360**	**202**

Table 20 – NSBB-HVT 3-6 125% MTFR Background and Effluent Measurements

Sample ID	Time (min)	Concentration (mg/L)		
Background 1	4	<MDL		
Background 2	6	<MDL		
Background 3	11	<MDL		
Background 4	16	<MDL		
Background 5	18	<MDL		
Background 6	23	<MDL		
Background 7	28	2.1		
Background 8	30	3.2		
Sample ID	**Time (min)**	**Concentration (mg/L)**	**Associated Background Concentration (mg/L)**	**Adjusted Concentration (mg/L)**
Effluent 1	4	98.7	1.0	97.7
Effluent 2	5	92.7	1.0	92.7
Effluent 3	6	104.4	1.0	103.4
Effluent 4	10	82.2	1.0	81.2
Effluent 5	11	112.7	1.0	111.7
Effluent 6	12	130.3	1.0	129.3
Effluent 7	16	105.2	1.0	104.2
Effluent 8	17	111.2	1.0	110.2
Effluent 9	18	98.8	1.0	97.8
Effluent 10	22	96.9	1.0	95.9
Effluent 11	23	107.6	1.0	106.6
Effluent 12	24	110.1	1.0	109.1
Effluent 13	28	92.1	2.1	91.1
Effluent 14	29	79.7	2.6	78.7
Effluent 15	30	93.1	3.2	92.1
	Mean	**101**	**1.3**	**99.7**

MDL – 2.1 mg/L

Table 21 – NSBB-HVT 3-6 125% MTFR Trial QA/QC Results

Flow Rate			
Target (cfs / gpm)	Mean (cfs / gpm)	Coef. Of Variance	Acceptable Parameters Coef. Of Variance
1.75 / 785.5	1.75 / 785.8	0.009	<0.03
Feed Rate			
Target (mg/min)	Mean (mg/min)	Coef. Of Variance	Acceptable Parameters Coef. Of Variance
594,600	600,360	0.011	<0.1
Influent Concentration			
Target (mg/L)	Mean (mg/L)	Coef. Of Variance	Acceptable Parameters Coef. Of Variance
200	201.9	0.011	<0.1
Background Concentration			
Low (mg/L)	High (mg/L)	Mean (mg/L)	Acceptable Threshold (mg/L)
>MDL	3.2	>MDL	<20

Excluded Data/Results

Section 5.D, *Verification Report Requirements: Supporting Documentation* of the NJDEP Process document requires that all data from performance evaluation test runs excluded from the computation of the removal rate or verification analysis be disclosed. Results from one removal efficiency test run conducted at 1.75 cfs on January 9, 2016 were not reported since it was determined that background SSC exceeded 20 mg/L.

Annualized Weighted TSS Removal Efficiency

The NJDEP-specified annual weighted TSS removal efficiency calculation is shown in **Table 22** using the results from the removal efficiency testing.

Testing in accordance with the provisions detailed in the NJDEP HDS Protocol demonstrate that the NSBB-HVT 3-6 achieved a 62.86% annualized weighted TSS removal at an MTFR of 1.40 cfs (34.9 gpm/sf). This testing demonstrates that the NSBB-HVT 3-6 exceeds the NJDEP requirement that HDS devices demonstrate at least 50% weighted annualized TSS removal efficiency at the MTFR.

Table 22 – Annualized Weighted TSS Removal of the NSBB-HVT 3-6

% MTFR	Mean Flow Rate Tested (cfs)	Actual % MTFR	Measured Removal Efficiency	Annual Weighting Factor	Weighted Removal Efficiency
25	0.35	25.2	67.9%	0.25	16.98%
50	0.70	49.7	65.8%	0.3	19.74%
75	1.05	75.1	63.1%	0.2	12.62%
100	1.40	100.2	56.4%	0.15	8.46%
125	1.75	125.1	50.6%	0.1	5.06%
Weighted Annualized TSS Removal Efficiency					**62.86%**

4.3 Test Sediment PSD Analysis - Scour Testing

The scour test sediment, as described in Section 2.3 *Test Sediment,* was a mixture of multiple high pursity silica (99.8%), blended as described in Section 2.3. Three composite samples were prepared as described in Section 2.3 and analyzed by BTL Engineering Inc., Tampa, Florida.

The results showed that the average test sediment significantly exceeded the particle size distribution specified by the protocol (**Table 23**). A comparison of the PSD specified by the protocol, the average PSD of the scour sediment, and the removal efficiency PSD are shown in **Figure 7**.

Table 23 – Scour Test Sediment Particle Size Distribution Comparison

Particle Size (µm)	% Finer					% Difference from Spec
	NJDEP Spec	Sample 1	Sample 2	Sample 3	Averag e	
1000	100	100.0	100.0	100.0	100.0	0.0
500	90	99.9	99.0	99.9	99.9	-9.9
250	55	97.1	96.9	96.7	96.9	-41.9
150	40	78.5	78.1	76.8	77.8	-37.8
100	25	60.2	59.8	58.9	59.6	-34.6
75	10	53.8	53.5	52.0	53.1	-43.1
50	0	48.9	48.0	47.5	48.1	-48.1

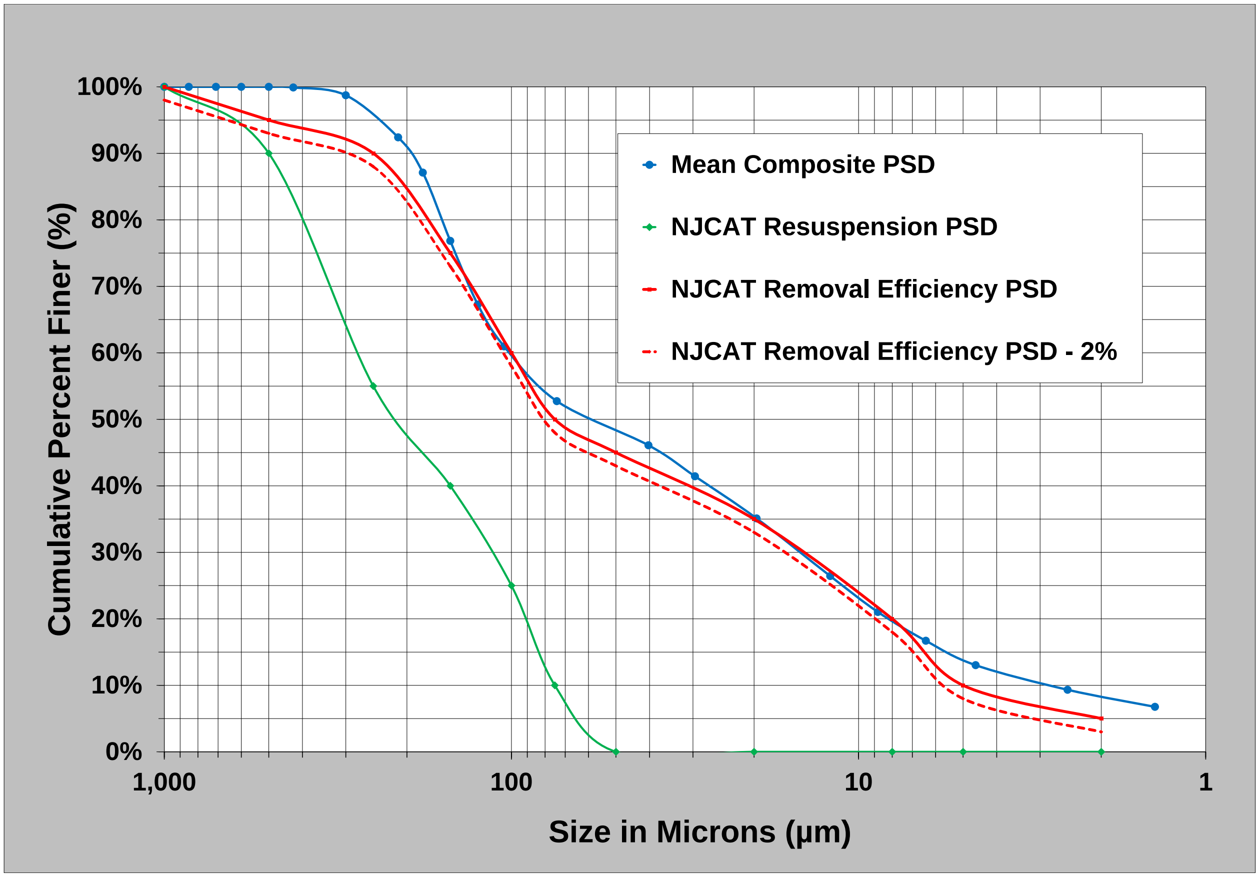


Figure 7 Scour Test Sediment PSD vs Protocol Specification

4.4 Scour Testing for Online Installation

The NSBB-HVT 3-6 underwent scour testing in line with Section 4 of the NJDEP HDS protocol at a flow rate greater than 200% of its MTFR in order to verify its suitability for online use. For the NSBB-HVT 3-6 with an MTFR of 1.40 cfs (628 gpm) the average scour test flow rate had to be at least 2.8 cfs (1,256 gpm). The average flow rate for the scour test was 5.84 cfs (2621 gpm), which represents 417% of the MTFR. The target flow rate was reached within 4 minutes and the first samples taken one minute later. The maximum water temperature during testing was 79.4°F. The flow rate COV was 0.015. Background concentrations measured 2.5 mg/L – 8.6 mg/L, which complies with the 20 mg/L maximum background concentration specified by the test protocol. Flow and background concentration measurements are shown in **Table 24**. The unadjusted and adjusted effluent concentrations are shown in **Table 25**.

Table 24 – Flow and Background Concentrations for NSBB-HVT 3-6 Scour Testing

Trial Date		2/25/2016	Average Flow Rate =	5.84 cfs
Mean Temperature		26.3 C / 79.4 F	Flow Rate COV	0.015
Sample ID	**Time (min)**	**Concentration (mg/L)**		
Background 1	1	2.5		
Background 2	5	8.0		
Background 3	9	5.5		
Background 4	13	8.6		
Background 5	17	6.3		
Background 6	21	5.8		
Background 7	25	6.1		
Background 8	29	3.8		

Table 25 – Effluent Concentrations for NSBB-HVT 3-6 Scour Test at 417% MTFR

Sample ID	Time (min)	Effluent Concentration with Background Concentrations (mg/L)	Background Concentration (mg/L)	Adjusted Effluent Concentration (mg/L)
Effluent 1	1	6.3	2.5	3.8
Effluent 2	3	8.3	5.2	3.1
Effluent 3	5	9.0	8.0	1.0
Effluent 4	7	8.1	6.8	2.3
Effluent 5	9	9.6	5.5	4.1
Effluent 6	11	6.5	7.0	-0.5
Effluent 7	13	7.1	8.6	-1.5
Effluent 8	15	6.9	7.5	-0.6
Effluent 9	17	7.1	6.3	0.8
Effluent 10	19	6.0	6.0	0.0
Effluent 11	21	6.0	5.8	0.2
Effluent 12	23	5.9	6.0	-0.1
Effluent 13	25	5.4	6.1	-0.7
Effluent 14	27	6.3	5.0	1.3
Effluent 15	29	6.7	3.8	2.9
	Mean	**7.0**	**6.0**	**1.1**

Excluded Data/Results

The protocol requires the disclosure and discussion of any data collected as a part of the testing process that is excluded from the reported results. Several scour tests were conducted at lower flow rates to assess scour performance. These were superseded by subsequent resuspension testing at the final scour test run (5.84 cfs).

5. Design Limitations

The NSBB-HVT is an engineered system for which Suntree Technologies Inc. engineers work with site designers to generate a detailed engineering submittal package for each installation. Design limitations are identified and managed during the design process. Design limitations are discussed in general terms below.

Required Soil Characteristics

The NSBB-HVT is a flow-through system contained within a water tight enclosure. The NSBB-HVT can be installed and function as intended in all soil types.

Slope of Drainage Pipe

Suntree Technologies Inc. recommends contacting our design engineers when the NSBB-HVT is going to be installed on a drainage line with a slope greater than 15%.

Maximum Flow Rate

The maximum treatment flow rate (MTFR) of the NSBB-HVT is dependent upon model size. The recommended maximum peak flow rate is dependent on NSBB-HVT model size and other design and performance specifications. Suntree Technologies Inc. recommends contacting their engineering staff with questions about managing high peak flow rates at specific locations.

Maintenance Requirements

The NSBB-HVT should be inspected and maintained with guidelines set forth in the *Operation, Maintenance, Inspection and Cleaning Manual Nutrient Separating Baffle Box at:* http://www.suntreetech.com/files/Documents/Products/Nutrient-Separating-Baffle-Box/O&M%20Manual%20_%20New%20Jersey%20(3).pdf

The sediment accumulation rate within the NSBB-HVT is dependent on site-specific characteristics such as land use in the contributing drainage and topography, and it is recommended to develop a site specific maintenance interval for each unit.

Driving Head

Testing shows that the headloss across the NSBB-HVT is a function of flow rate and pipe velocities. Generally, the NSBB-HVT headloss is estimated using the energy equation:

$$\Delta H = \left(H_U - \frac{V_U^2}{2g} \right) - \left(H_D - \frac{V_D^2}{2g} \right)$$

where ΔH is the headloss across the NSBB-HVT, H_U is the inlet water elevation, V_U is the average flow velocity at the inlet, H_D is the outlet water elevation, V_D is the average flow velocity at the outlet, and g is the gravitational constant (32.2 ft./sec^2).

Installation Limitations

Pick weights and installation procedures vary slightly with model size. Suntree Technologies Inc. provides contractors with project-specific unit pick weights and installation instructions prior to delivery.

Configurations

The NSBB-HVT is designed for online applications in which the inlet and outlet are tied directly into the main drainage line. In some cases multiple inlet lines can be accommodated. Contact Suntree Technologies Inc. engineering staff when multiple inlet pipes must be accommodated.

Load Limitations

Standard NSBB-HVT units may be designed for HS-20 loading. Contact Suntree Technologies Inc. engineering staff for load ratings analysis.

Pretreatment Requirements

The NSBB-HVT has no pre-treatment requirements.

Limitations on Tail Water

The NSBB-HVT does not have tail water limitations.

Depth to Seasonal High Water Table

Although the functionality of the NSBB-HVT is not impacted by high groundwater levels, Suntree Technologies Inc. recommends consulting their engineering staff to determine whether the addition of anti-flotation collars to the base of the NSBB-HVT chamber is necessary to counterbalance buoyant forces.

Pipe Sizes

Inlet and pipe sizes are evaluated by Suntree Technologies Inc. engineering team for each installation.

6. Maintenance Plans

To maintain proper NSBB-HVT operation, maintenance of these units is important. Suntree Technologies has prepared an *Operations, Maintenance, Inspection and Cleaning Manual* that provides typical inspection and maintenance procedures that should be followed to ensure that the

NSBB-HVT maintains optimal pollutant removal performance. The Manual can be accessed at: http://www.suntreetech.com/files/Documents/Products/Nutrient-Separating-Baffle-Box/O&M%20Manual%20_%20New%20Jersey%20(3).pdf

Inspection

Suntree Technologies recommends the following inspection guidelines:

- After installation and the site has stabilized, inspections should be conducted after every runoff event for the first thirty (30) days.
- Subsequent inspections of sediment accumulation should be conducted a minimum of four (4) times per year.
- When sediment accumulation equals or exceeds 50% of the Minimum Sediment Storage Volume then all accumulated sediment must be removed.
- All inspections must be document. The Manual provides typical inspection procedures, for example, visually inspect for broken or missing parts, and an Inspection Checklist form.

Maintenance

Maintenance activities include the removal of captured sediment and debris. Maintenance can be performed from outside the NSBB-HVT through access points such as manhole covers or hatches installed in the vault surface above the sediment chambers. The screen system may have either SunGlide® Sliding Top Doors or SunGlide® Hinged Doors. These top doors open to give access to the debris captured by the screen system. The screen system also has bottom doors that open to give access to the sediment collected in the settling chambers. A vacuum truck is required for debris and sediment removal. Typical service procedures are listed in the O&M Manual.

7. Statements

The following signed statements from the manufacturer (Suntree Technologies), the independent testing laboratory (Applied Environmental Technology) 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.

Suntree® Technologies Inc.
798 Clearlake RD, Cocoa, FL 32922, Ph: 321-637-7552 FAX: 321-637-7554, www.suntreetech.com

April 12, 2016

Dr. Richard Magee, Sc.D., P.E., BCEE
Technical Director
New Jersey Corporation for Advanced Technology
Center for Environmental Systems
Stevens Institute of Technology
One Castle Point
Hoboken, NJ 07030

Re: Nutrient Separating Baffle Box® with Hydro-Variant Technology

Dear Dr. Magee,

The Suntree Technologies Nutrient Separating Baffle Box® with Hydro-Variant Technology, which is a hydro dynamic separator for applications of stormwater treatment, recently underwent verification testing according to the NJDEP HDS laboratory testing protocol. The model number NSBB-HVT-3-6, a full size commercially available treatment system, was tested for removal efficiency and scour by the qualified third party entity Applied Environmental Technologies under the direct supervision of Dr. Daniel Smith, Ph.D., P.E., DEE. Testing was conducted according to New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device, dated January 25, 2013. Testing was performed at the testing facility of Applied Environmental Technology located in Tampa, FL. As required by the "Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation of Advanced Technology", this letter serves as Suntree's statement that all procedures and requirements identified in the aforementioned test protocol and process document were met or exceeded.

Sincerely,

Tom Happel

Tom Happel
President

Applied Environmental Technology

10809 Cedar Cove Drive Thonotosassa Florida 33592-2250 813 716 2262

March 25, 2016

Dr. Richard Magee
New Jersey Corporation for Advanced Technology (NJCAT)

RE: Hydrodynamic Protocol Evaluation
Nutrient Separating Baffle Box with Hydrovariant Technology
Suntree Technologies Inc.

Dr. Magee:

Verification testing has been conducted for the Nutrient Separating Baffle Box with Hydrovariant Technology according to the *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device,* January 25, 2013.

Manufacturer

Suntree Technologies, Inc.
798 Clear Lake Road
Cocoa, Florida 32922
Phone: 321-637-7552

Mr. Tom Happel, President
Phone: 321-537-9069

Laboratory Testing Location

Applied Environmental Technology Test Facility
10809 Cedar Cove Drive
Thonotosassa, Florida 33592-2250

Dr. Daniel P. Smith, P.E., DEE, President
Applied Environmental Technology
10809 Cedar Cove Drive
Thonotosassa, Florida 33592-2250
Phone: 813-716-2262

Dr. Daniel P. Smith provided the test facility, conducted all testing and acted as third party observer for all testing. Dr. Smith observed or directly supervised all activities over the full duration including:

- test sediment preparation and sampling
- sediment submittal to laboratories for PSD analyses
- design of removal efficiency and resuspension tests including pump operation, sediment dosing, and background and discharge sampling schedules
- all temperature measurements
- all flow rate measurements
- collection methods for sediment dosing rate
- collection method for background and discharge SSC sampling
- all laboratory SSC analyses including QA/QC
- all data and records management
- all data assessment calculations
- reporting

The laboratory testing fully met or exceeded the requirements of *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device,* January 25, 2013.

Dr. Daniel Smith (AET) has no financial conflict of interest regarding the test results. Dr. Smith has provided services for Suntree Technologies Inc. for two previous NJCAT verification tests and for other technical evaluations, reviews and assessments. Dr. Smith (AET) has no direct financial interest in Suntree Technologies, Inc. Dr. Smith (AET) has no previous or current personal relationships Suntree Technologies, Inc.

Maintenance that was conducted on the experimental system during the testing program consisted of between-test cleanings of the NSBB-HVT chambers, pre-filter chamber, water supply recycle reservoir, and piping; replacing media in the pre-filter, and pump maintenance.

Please contact me if you require additional information.

Sincerely,

Daniel P. Smith

Daniel P. Smith, Ph.D., P.E., BCEES

Florida PE #58388 ▪ New Jersey PE #24GE03765900

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

April 18, 2016

Titus Magnanao
NJDEP
Division of Water Quality
Bureau of Non-Point Pollution Control
401-02B
PO Box 420
Trenton, NJ 08625-0420

Dear Mr. Magnanao,

Based on my review, evaluation and assessment of the testing conducted on Suntree Technologies Inc.'s Nutrient Separating Baffle Box with Hydro-Variant Technology by Applied Environmental Technology (AET), 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 mean PSD of the AET test sediments comply with the PSD criteria established by the NJDEP HDS protocol. The AET removal efficiency test sediment PSD analysis was plotted against the NJDEP removal efficiency test PSD specification. The test sediment was shown to be slightly finer than the sediment blend specified by the protocol. The AET scour test sediment PSD analysis was plotted against the NJDEP removal efficiency test PSD specification and shown to be significantly finer than specified by the protocol.

Removal Efficiency Testing

In accordance with the NJDEP HDS Protocol, removal efficiency testing was executed on the NSBB-HVT 3-6 in order to establish the ability of the NSBB-HVT to remove the specified test sediment at 25%, 50%, 75%, 100% and 125% of the target MTFR. A target MTFR of 628 gpm (1.40 cfs) 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 all met the NJDEP HDS test protocol's coefficient of variance requirements and the background concentration for all five test runs never exceeded 20 mg/L.

Scour Testing

In order to demonstrate the ability of the NBSS-HVT 3-6 to be used as an online treatment device scour testing was conducted at greater than 200% of MTFR in accordance with the NJDEP HDS Protocol. The average flow rate during the online scour test was 5.84 cfs, which represents 417% of the MTFR (MTFR = 1.40 cfs). Background concentrations were less than 8.6 mg/L throughout the scour testing, which complies with the 20 mg/L maximum background concentration specified by the test protocol. Unadjusted effluent concentrations ranged from 5.4 mg/L to 9.0 mg/L with a mean of 7.0 mg/L. When adjusted for background concentrations, the effluent concentrations range from -1.5 to 4.1 mg/L with a mean of 1.1 mg/L. These results confirm that the NBSS-HVT 3-6 did not scour at 417% MTFR and meets the criteria for online use.

Maintenance Frequency

The predicted maintenance frequency for all models is >30 months.

Sincerely,

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

8. References

ASTM D422-63 (Reapproved 2007). *Standard Test Method for Particle-Size Analysis of Soils.* ASTM, Philadelphia, PA.

ASTM D3977-97 (Reapproved 2007). *Standard Test Methods for Determining Concentrations in Water Samples*. ASTM, Philadelphia, PA.

NJDEP 2013a. *New Jersey Department of Environmental Protection Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology.* Trenton, NJ. January 25, 2013.

NJDEP 2013b. *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device.* Trenton, NJ. January 25, 2013.

Smith, D. (2016). *Nutrient Separating Baffle Box with Hydro-Variant Technology*. Submitted to New Jersey Corporation for Advanced Technology, Hoboken, New Jersey. March, 2016.

VERIFICATION APPENDIX

Introduction

- Manufacturer – Suntree Technologies Inc., 798 Clearlake Road, Suite 2, Cocoa, FL 32922. *General Phone: (321)637-7552. Website:* www.suntreetech.com

- MTD – Nutrient Separating Baffle Box with Hydro-Variant Technology (NSBB-HVT) verified models are shown in **Table A-1.**

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- TSS Removal Rate – 50%

- Online installation

Detailed Specification

- NJDEP sizing tables and physical dimensions for the NSBB-HVT verified models are attached (**Table A-1** and **Table A-2**).

- 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 in New Jersey.

- Pick weights and installation procedures vary slightly with model size. Suntree Technologies provides contractors with project-specific unit pick weights and installation instructions prior to delivery.

- Maximum recommended sediment depth prior to cleanout is 4-13 inches (50% of the maximum sediment storage depth) for various model sizes (**Table A-1)**.

- For a reference maintenance plan, download the NSBB-HVT O&M Manual at: http://www.suntreetech.com/files/Documents/Products/Nutrient-Separating-Baffle-Box/O&M%20Manual%20_%20New%20Jersey%20(3).pdf

- Under N.J.A.C. 7:8-5.5, NJDEP stormwater design requirements do not allow a hydrodynamic separator such as the NSBB-HVT to be used in series with another hydrodynamic separator to achieve an enhanced total suspended solids (TSS) removal rate.

Table A-1 NSBB-HVT Model MTFRs and Required Sediment Removal Intervals

NSBB-HVT Model No.	Inside Length (L), ft	Inside Width (W), ft	Depth Below Invert (DBI)[1], ft.	Maximum Treatment Flow Rate (MTFR)[2], cfs	Partition Height (PH)[3], ft	Partition Thickness (PT), in	Floor Area (FA)[4], ft^2	50% Maximum Sediment Storage Volume, ft^3	Sediment Removal Interval (SRI)[5], months
2-4	4.00	2.00	2.70	0.62	2.70	0.75	7.75	3.88	44.5
3-6	6.00	3.00	3.00	1.40	3.00	1.50	17.25	8.63	44.0
3-8	8.00	3.00	3.00	1.87	3.00	1.50	23.25	11.6	44.5
4-8	8.00	4.00	3.00	2.49	3.00	3.00	30.00	15.0	43.0
5-10	10.00	5.00	4.10	3.89	4.10	3.00	47.50	23.8	43.6
6-12	12.00	6.00	4.80	5.60	4.80	3.50	68.50	34.3	43.7
6-13.75	13.75	6.00	5.40	6.42	5.40	3.50	79.00	39.5	44.0
7-14	14.00	7.00	5.50	7.62	5.50	4.00	93.33	46.7	43.7
7-15	15.00	7.00	5.90	8.17	5.90	4.00	100.33	50.2	43.9
8-14	14.00	8.00	6.20	8.71	6.20	4.00	106.67	53.3	43.7
8-16	16.00	8.00	6.20	9.96	6.20	4.00	122.67	61.3	44.0
9-18	18.00	9.00	6.90	12.60	6.90	6.00	153.00	76.5	43.4
10-17	17.00	10.00	7.60	13.22	7.60	6.00	160.00	80.0	43.2
10-20	20.00	10.00	7.60	15.56	7.60	6.00	190.00	95.0	43.6
12-21	21.00	12.00	9.00	19.60	9.00	6.00	240.00	120	43.7
12-24	24.00	12.00	9.00	22.40	9.00	6.00	276.00	138	44.0

[1]DBI = depth from invert of inlet pipe to bottom of unit

[2]MTFR scaling based on 1.40/18 = 0.07778 cfs/ft^2

[3]PH=DBI

[4]FA = W x (L-2xPT)

[5]SRI calculated from NJDEP HDS Protocol 2013 Appendix A (50% TSS Removal Efficiency)

Table A-2 NSBB-HVT Model Scaling Ratios

				(SD/SD)		(L/W)		(SD/L)		(SD/W)	
NSBB-HVT Model No.	Inside Length (L), ft	Inside Width (W), ft	Scaling Depth (SD)[1], ft	SD/SD[2]	SD within 15% of NSBB-HVT 3-6?	L/W	L/W within 15% of NSBB-HVT 3-6?	SD/L	SD/L within 15% of NSBB-HVT 3-6?	SD/W	SD/W within 15% of NSBB-HVT 3-6?
Test Unit											
3-6	6.00	3.00	2.50			2.00		0.417		0.833	
MTFR < 250% of Test Unit											
2-4	4.00	2.00	2.20	0.88	YES						
3-8	8.00	3.00	2.50	1.00	YES						
4-8	8.00	4.00	2.50	1.00	YES						
MTFR > 250% of Test Unit											
5-10	10.00	5.00	3.60			2.00	YES	0.360	YES	0.720	YES
6-12	12.00	6.00	4.30			2.00	YES	0.358	YES	0.717	YES
6-13.75	13.75	6.00	4.90			2.29	YES	0.356	YES	0.817	YES
7-14	14.00	7.00	5.00			2.00	YES	0.357	YES	0.714	YES
7-15	15.00	7.00	5.40			2.14	YES	0.360	YES	0.771	YES
8-14	14.00	8.00	5.70			1.75	YES	0.407	YES	0.713	YES
8-16	16.00	8.00	5.70			2.00	YES	0.356	YES	0.713	YES
9-18	18.00	9.00	6.40			2.00	YES	0.356	YES	0.711	YES
10-17	17.00	10.00	7.10			1.70	YES	0.418	YES	0.710	YES
10-20	20.00	10.00	7.10			2.00	YES	0.355	YES	0.710	YES
12-21	21.00	12.00	8.50			1.75	YES	0.405	YES	0.708	YES
12-24	24.00	12.00	8.50			2.00	YES	0.354	YES	0.708	YES

[1]SD = Depth of invert of inlet pipe to bottom of unit (DBI) minus 0.5 ft (location of false floor for tested unit).
[2]SD/SD = Ratio of scaling depth of the NSBB-HVT model to the test unit scaling depth.