Technical Abstract

Downstream Defender® - Sizing For Different Sediment Distributions

NJCAT Verified Sediment Removal for Particle Sizes Down To: 250 µm, 150 µm, 75 µm & 50 µm.

Abstract

The performance of hydrodynamic stormwater separators are usually quoted for 80% removal of Total Suspended Solids (TSS). As stormwater regulations have evolved to account for both water quality treatment and water quantity volume control, so has the use of treatment train systems incorporating multiple processes such as storage, flow control, TSS removal, and infiltration. The treatment for TSS may then be part of a progressive solution with options as to how much TSS to remove and whether to target finer or coarser sediments, depending on the water quality required before for final discharge or infiltration.

To support this approach Hydro International has undertaken to provide an increased range of removal data for differing TSS blends for the Downstream Defender using industry accepted protocols and verified by New Jersey Corporation for Advanced Technology (NJCAT).

Downstream Defender

The Downstream Defender is an advanced vortex separator designed to utilize the principles of swirl-enhanced gravity separation to remove TSS, trash and hydrocarbons from stormwater runoff. It is installed underground as a permanent part of the storm drain line to reduce the overall load of oils, solids and floatables conveyed through the storm drain to receiving waters.

Flow modifying internal components (Fig. 1) differentiate the Downstream Defender from conventional gravity-based and other vortex separators. The Downstream Defender has a tangential inlet to introduce a rotational flow path to the precast treatment chamber while flow-modifying internal components stabilize the swirling flow path to reduce turbulence and enhance sediment, oil, and trash removal, while preventing washout of previously captured material.

Capable of providing high pollutant removals for a wide range of flow rates with minimal head loss, the Downstream Defender is an economical solution for constrained sites. Its proven efficiency ensures the longevity and simplifies the maintenance of subsurface storage, infiltration and filtration practices.

Fine Sediment Removal Test Material

The feed sediment used for the removal efficiency testing was high purity silica (SiO_2 99.8%) supplied by two different commercial silica suppliers, blended in the proportions to produce a wide range of particle sizes distributed from less than 10 µm to over 1000 µm, with a D_{50} = 63 µm. This provides a loading bias towards finer particle sizes and produces more conservative results. In the presence of the independent observer, composited samples were sealed, signed, and packaged for independent transport to the outside laboratory for analysis.

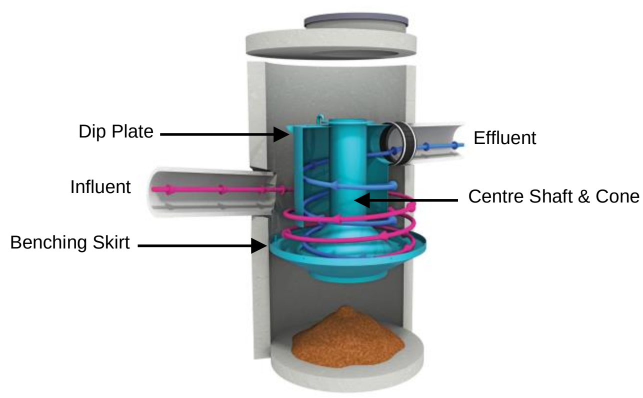

Fig.1 The unique internal components of the Downstream Defender enhanced pollutant removal performance and prevent washout

The independent laboratory, GeoTesting Express, analyzed the test sand particle size distribution (PSD) of each of the samples using ASTM D 422-63. The samples were then averaged to produce an overall measure of the test sediment. Because the goal was to verify the removal rate of the Downstream Defender for various PSD ranges, the test sand was also graded into subset PSD ranges are expressed as in Fig. 2. Each subset is expressed as a separate PSD "Down To" the smallest particle size in that subset, as a fraction of subset's total mass.

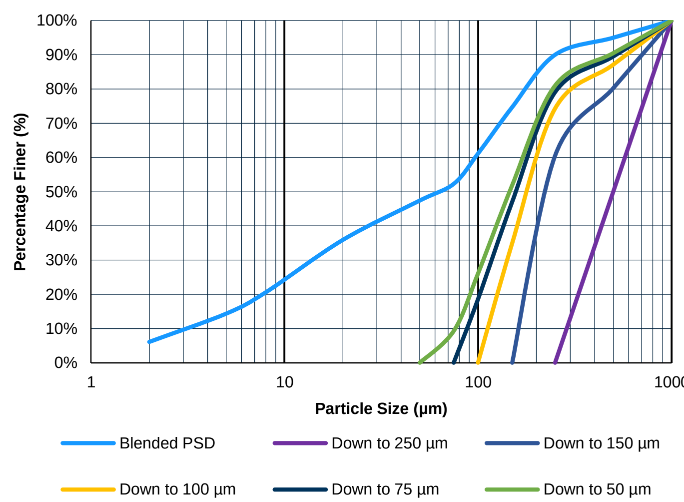

Fig.2 Particle Size Distribution of Test Sediment and Subset PSD Blends

Downstream Defender®

Laboratory Testing Arrangement

The laboratory setup consisted of a recirculating closed loop system with an 8-inch (200 mm) submersible Flygt pump that conveyed water from a 23,000 gal (87,064 L) reservoir through a PVC pipe network to the 4-ft (1.2m) Downstream Defender (Fig.3). The flow rate of the pump was controlled by a GE Fuji Electric AF-300 P11 Adjustable Frequency Drive and measured by an EMCO Flow Systems 4411e Electromagnetic Flow Transmitter.

The Downstream Defender sump measures 18 inches (457 mm) in height from the bottom of the internal components. It was fitted with a false bottom positioned 9 inches (229 mm) from the true sump bottom to simulate a 50% full condition to ensure a conservative test result.

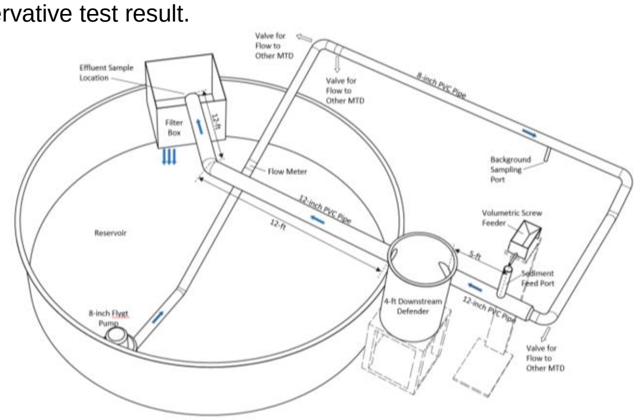

Fig.3 Set-up of the Portland, Maine hydraulic testing facility

Performance Test Procedures and Targets

Removal efficiency testing was conducted in accordance with standard laboratory protocols for hydrodynamic separators. Captured sediment was removed from the sump between each flow rate trial. These results are summarized below and the full report can be viewed at: http://www.njcat.org/uploads/newDocs/DDVerificationReportFinal.pdf

A total of five flow rates were tested: 0.27 cfs (7.7 L/s), 0.54 cfs (15.3 L/s), 0.82 cfs (23.2 L/s), 1.07 cfs (30.3 L/s), and 1.38 cfs (39.2 L/s).

Up to the maximum tested flow rate of 1.38 cfs (39.1 L/s), the target treatment goals were to remove at least:

- 95% of all test sediment down to 250 µm
- 94% of all test sediment down to 150 µm
- 90% of all test sediment down to 100 µm
- 85% of all test sediment down to 75 µm
- 81% of all test sediment down to 50 µm

Performance Results

The Downstream Defender performed well under the full range of tested flows with over 95% removal of all test sediment subsets at the low flow test of 0.27 cfs (7.6 L/s), and over 80% removal of all subsets at the high flow limit of 1.38 cfs (39.1 L/s).

The results for all tests were plotted on a flow vs. removal efficiency graph and a best fit curve produced (Fig. 4). These results confirm the efficiency of the Downstream Defender for pollutant capture over a wide range of tested flow rates.

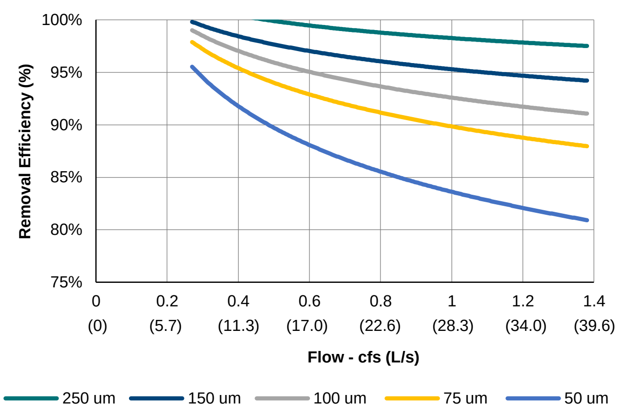

Fig.4 Removal Efficiency Results of the 4-ft Downstream Defender "Down To Particle Size"

Downstream Defender Sizing for 80% TSS

Table 1 gives the treatment flow rates for different sized Downstream Defender units based on surface load rate scaling of the test unit, for a minimum 80% TSS removal down to the particle size listed.

For design purposes the selected model's Treatment Flow Rate must be equal or greater to the site's required Water Quality Flow Rate for the site in question.

The peak flow rate and maximum pipe size must be considered to determine whether an online or offline configuration is appropriate. Refer to the Downstream Defender product information brochure for visit www.hydro-int.com/us for more information.

Down To Particle Size (µm) – Treatment Flow Rate										
Model	**50 µm**		**75 µm(1)**		**100 µm(1)**		**150 µm(1)**		**250 µm(1)**	
ft. (m)	(cfs)	(L/s)	(cfs)	(L/s)	(cfs)	(L/s)	(cfs)	(L/s)	(cfs)	(L/s)
4 (1.2)	**1.38**	**39.1**	**2.20**	**62.4**	**2.85**	**80.7**	**3.00**	**85.0**	**3.00**	**85.0**
6 (1.8)	**3.11**	**88.0**	**4.96**	**140.3**	**6.41**	**181.6**	**8.00**	**226.5**	**8.00**	**226.5**
8 (2.4)	**5.52**	**156.2**	**8.82**	**249.6**	**11.40**	**322.9**	**15.00**	**424.8**	**15.00**	**424.8**
10 (3.0)	**8.62**	**244.1**	**13.73**	**388.8**	**17.73**	**502.1**	**25.00**	**707.9**	**25.00**	**707.9**
12 (3.6)	**12.42**	**351.7**	**19.98**	**565.8**	**25.79**	**730.3**	**38.00**	**1076.0**	**38.00**	**1076.0**

Table 1. Downstream Defender flow rates for Min. 80% removal for the PSD range down to the listed minimum particle size, using linear regression and surface load rate scaling.

(1) Maximum hydraulic capacity of the Downstream Defender is reached for all PSDs over 50 µm with greater than 80% TSS removal.