◆ Verification Statement ◆ Verification Statement ◆ Verification Statement ◆

VERIFICATION STATEMENT

GLOBE Performance Solutions

Verifies the performance of

Kraken® Membrane Filtration System

Developed by Bio Clean Environmental Inc., a Forterra Company
Carlsbad, CA, USA

Registration: GPS-ETV_V2019-03-15

In accordance with

ISO 14034:2016

Environmental Management —
Environmental Technology Verification (ETV)

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Verification Overview

This Environmental Technology Verification (ETV) of the Kraken™ Filter is the first part of a two-part verification process and entails the verification of performance claims based on laboratory testing in accordance with the New Jersey Department of Environmental Protection (NJDEP) *Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (January 2013)*. This verification complements the subsequent verification of field testing data, collected in accordance with The Washington State Department of Ecology emerging stormwater treatment technologies, in accordance with guidelines identified by Ecology (2011) in the Technology Assessment Protocol – Ecology (TAPE).

Technology description and application

The Kraken® Membrane Filtration System ("Kraken® Filter") is an engineered storm water quality treatment device utilizing a reusable membrane filter designed to remove high levels of TSS, hydrocarbons, particulate metals and nutrients found in contaminated storm water. Each filter contains a large surface area which is designed to deal with high TSS and particulate concentrations. The large surface area of each filter allows it to operate at a loading rate from one fifth to one twentieth the loading rate of other media filtration devices to improve longevity. The Kraken® Filter is different from other membrane filters in that it has separation chambers that are utilized as a form of pre-treatment for floatables, oils, coarser sediments and other suspended particulates. By filtering out the coarser material prior to reaching the membrane filters, the efficiency of the unit is increased and maintenance requirements reduced.

Once the water exits the pre-treatment chamber, it passes through the filter chamber orifices and into the filtration chambers where the membrane filters are located. The membrane filters are used to filter out finer micron sediments and associated contaminants. The Kraken® Filter is a unique design in that the filter's efficiency is controlled by an internal riser tube so the filters will only begin to process and discharge once the water level has reached to the top of the filter column, close to the maximum hydraulic grade line (HGL) in the filtration chamber. The riser tubes also control the flow rate to a level substantially less than the flow capacity of the membrane filters. This creates a built-in safety factor to insure longevity of the system's treatment capacity. It also helps to guard against clogging by ensuring the sediment loading is evenly distributed along the full height of the cartridge. Each filter chamber also includes one drain down cartridge which has an additional small drain orifice at the bottom of the tube to allow the chambers to drain dry after each storm event.

Since the standard cartridges have risers, there is no positive pressure on the influent side of the filter membrane during the drain down period, thereby allowing sediment which has accumulated on the surface of the membrane to be flushed off. This prevents biofouling of the filter material by eliminating the anaerobic environment associated with bacteria growth that can occur on the material.

Figures 1 and 2 show cut-away views of the system's pre-treatment, filtration and discharge chambers. The pre-treatment chamber is portioned into a primary and secondary separation chambers divided by a baffle wall. The second separation chamber contains a floatables/oil baffle wall that extends upward. This wall directs water to pass underneath it, thereby trapping floatables and free floating hydrocarbons. After water passes under the floatables/oil baffle walls, it travels upward to the filter chamber orifices and enters the filter chambers.

The Kraken® Filter also offers an optional internal bypass weir. The bypass weir is located at the effluent end of the secondary pre-treatment chamber and allows runoff to pass directly from pre-treatment chamber to discharge chamber without passing through the filtration chambers. Water will pass over the weir once incoming flow exceeds the system's treatment capacity. This prevents scouring of fine sediment

captured in the filtration chambers. The Kraken® Filter can also be used without the internal bypass feature in a traditional set up using an external flow splitter/diversion weir structure. In this configuration the internal bypass weir is not present in the system.

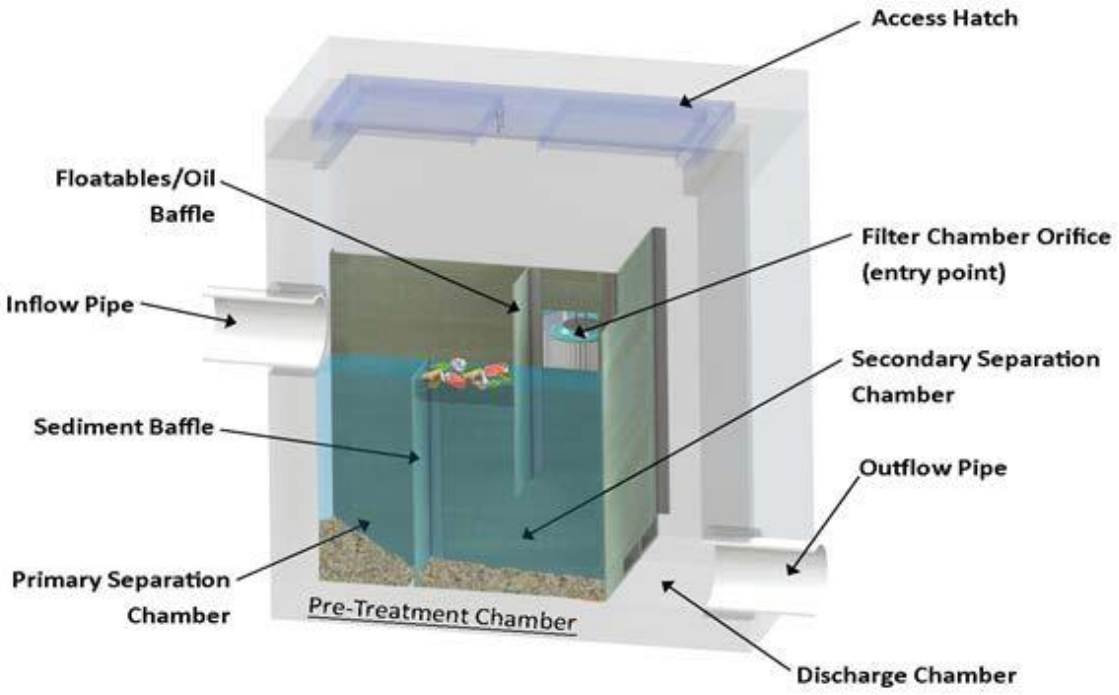

Figure 1: Kraken® Design

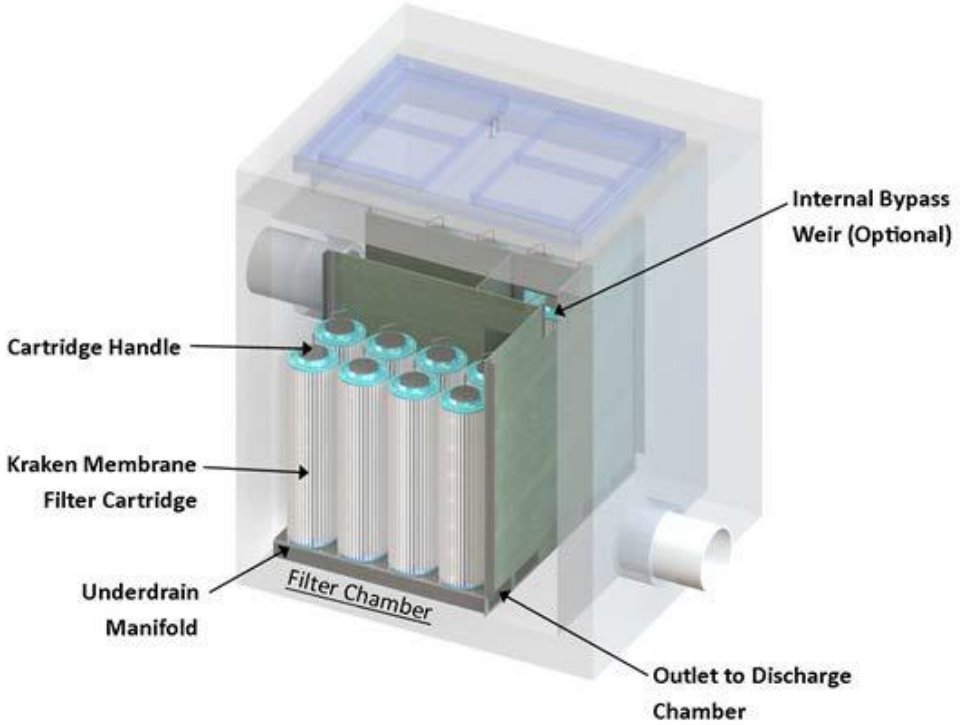

Figure 2: Kraken® Design

Performance conditions

The data and results published were obtained by a laboratory testing program conducted on a Kraken® Filter Model KF-4. The test program was conducted by Good Harbour Laboratories, an independent water technology testing lab, at their site in Mississauga, Ontario. The testing was conducted under the *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device (January, 2013)*. Prior to starting the performance testing program, a quality assurance project plan (QAPP) was submitted to and approved by the New Jersey Corporation for Advanced Technology (NJCAT).

Performance claim(s)

Performance Claim 1 (NJCAT)

During the performance (removal efficiency) test, which is composed of 16 test runs, under the NJDEP Filter Protocol, the Kraken® Filter at a constant influent test sediment concentration of 200 mg/L, removed 83% of influent sediment at a loading rate of 0.05 gpm/sq ft media surface area (8.5 gpm/ cartridge). This performance claim was verified statistically at a 95% level of confidence.

Performance Claim 2 (NJCAT)

During the load testing (mass sediment load capacity), which is composed of 16 test plus an additional 17 runs, under the NJDEP Filter Protocol, the Kraken® Filter at a constant influent test sediment concentration of 200 mg/L for the first 16 runs and 400 mg/L for the additional 17 runs, removed 89% of influent sediment at a loading rate of 0.05 gpm/sq ft media surface area (8.5 gpm/cartridge) without any loss in treatment flow rate. This performance claim was verified statistically at a 95% level of confidence.

Performance Claim 3 (NJCAT)

During the load testing (mass sediment load capacity), which composed of 16 test plus an additional 17 runs, under the NJDEP Filter Protocol, the Kraken® Filter maintained a driving head across the filter of less than 3 inches up to a cumulative mass sediment load of 434 pounds which equates to 27.125 pounds per standard size cartridge. This performance claim was verified statistically at a 95% level of confidence.

Performance Claim 4 (NJCAT)

During supplemental load testing (mass sediment load capacity) after the primary load testing was completed, which composed of 6 additional runs at sediment concentrations of 200, 400, and 600 mg/L, under the NJDEP Filter Protocol, the Kraken® Filter did not go into bypass, continued to provide TSS removal efficiencies averaging 89% and was loaded up to 600 pounds which equates to 37.5 pounds per standard size cartridge without any loss in treatment flow rate. This performance claim was verified statistically at a 95% level of confidence.

Performance Claim 5 (NJCAT)

During the scour testing (high flow bypass), under the NJDEP Filter Protocol, the Kraken® Filter when preloaded with 644.4 lbs of sediments in the pre-treatment and filter chambers, tested at a flow rate equal to 200% of its peak treatment flow rate, passed the protocol requirements for not scouring previously captured sediments with the average adjusted effluent concentration of 17 mg/L. This performance claim was verified statistically at a 95% level of confidence.

Performance results

Performance Claim 1 (NJCAT):

Removal Efficiency at 200 mg/L Influent Sediment Concentration (16 Runs)

	Suspended Sediment Concentration (mg/L)															
Run #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Average Influent	203.5	199.3	207.0	203.6	204.9	196.8	199.0	197.1	202.3	204.2	200.4	197.4	201.5	195.5	203.5	200.8
Background	4.0	10.0	0.5	0.5	0.5	0.5	0.5	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Adjusted Effluent	39.0	34.2	42.3	38.1	38.1	40.3	49.1	33.4	33.3	37.7	30.3	31.3	27.7	25.5	21.5	17.9

Average Adjusted Influent Sediment Concentration 201.1 mg/L **Removal Efficiency 83%**

Performance Claim 2 (NJCAT):

Removal Efficiency at 200 mg/L Influent Sediment Concentration (16 Runs) and 400 mg/L (additional 17 Runs)

Suspended Sediment Concentration (mg/L)

Run #	Average Influent	Background	Adjusted Effluent
1	203.5	0.5	39
2	199.3	0.5	34
3	207.0	0.5	42
4	203.6	0.5	38
5	204.9	0.5	38
6	196.8	0.5	40
7	199.0	0.5	49
8	197.1	0.5	33
9	202.3	0.5	33
10	204.2	0.5	38
11	200.4	0.5	30
12	197.4	0.5	31
13	201.5	0.5	28
14	195.5	0.5	26
15	203.5	0.5	22
16	200.8	0.5	18
17	395.8	0.5	48
18	400.8	0.5	42
19	396.5	0.5	36
20	387.4	0.5	49
21	407.5	0.5	30
22	394.6	0.5	32
23	394.7	0.5	33
24	392.8	0.5	21
25	394.3	0.5	20
26	392.3	0.5	15
27	387.5	0.5	26
28	404.2	0.5	12
29	393.8	0.5	12
30	398.9	0.5	14
31	416.2	0.5	15
32	406.0	0.5	8
33	412.3	0.5	9

Average Adjusted Influent Sediment Concentration 201.1 mg/L (Runs 1-16)
Average Adjusted Influent Sediment Concentration 398.6 mg/L (Runs 17-33)
Overall Average Removal Efficiency 89%

Performance Claim 3 (NJCAT):
Maintained a driving head across the filter of less than 3 inches up to a cumulative mass sediment load of 434 pounds.

	Water Level at End of Run (inches)		Cumulative Sediment Load
Run #	Measured	Increase	lbs
1	27.0	0	8
2	27.0	0	16
3	27.0	0	23
4	27.0	0	31
5	27.3	0.25	39
6	27.3	0.25	47
7	27.3	0.25	54
8	27.4	0.38	62
9	27.4	0.38	70
10	27.5	0.50	78
11	27.5	0.50	86
12	28.0	1.00	94
13	28.3	1.25	102
14	28.4	1.38	110
15	28.5	1.50	119
16	29.0	2.00	127
17	29.5	2.50	144
18	29.4	2.38	162
19	29.5	2.50	179
20	29.4	2.38	195
21	29.4	2.38	214
22	29.5	2.50	231
23	29.5	2.50	249
24	29.6	2.63	267
25	29.6	2.63	285
26	29.5	2.50	303
27	29.6	2.63	320
28	29.6	2.63	339
29	29.6	2.63	357
30	29.5	2.50	376
31	29.6	2.63	395
32	29.5	2.50	415
33	29.5	2.50	434

Cumulative Mass Sediment Load 434 lbs
Maintained Driving Head < 3 inches

Performance Claim 4 (NJCAT):

Suspended Sediment Concentration (mg/L)

Run #	34	35	36	37	Loading Run 1	Loading Run 2
Average Influent	405.9	199.3	201.2	203.6	621.6	605.9
Background	1.6	0.8	1.0	0.5	0.0	0.5
Adjusted Effluent	16.4	32.2	22.5	38.1	8.0	7.2

Average Adjusted Influent Sediment Concentration 372.9 mg/L

Removal Efficiency 89%

Performance Claim 5 (NJCAT):

Adjusted Effluent Sediment Concentration mg/L

Run Time (Minutes)	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35
Background	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.8	1.0	0.8	0.5	0.8	1.0	1.0
Adjusted Effluent	33.5	28.5	25.5	23.5	20.5	18.5	17.5	15.5	14.3	12.0	11.3	10.5	9.3	9.0	8.0

Average Adjusted Effluent Concentration 17 mg/L

Verification

The verification was completed by the Verification Expert, the Centre for Advancement of Water and Wastewater Technologies ("CAWT"), contracted by GLOBE Performance Solutions, applying the International Standard ***ISO 14034:2016 Environmental management -- Environmental technology verification (ETV)***. Data and information provided by Bio Clean Environmental to support the performance claim included the following: Performance test report prepared by Good Harbour Laboratories of Mississauga, Ontario, and dated August, 2015 for (Claims 1-4), January 2016 (Claim 5). This report is based on testing completed in accordance with the *New Jersey Department of Environmental Protection* (NJDEP) *Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (January 2013)* and in compliance with the requirements of ISO/IEC 17025.

What is ISO14034:2016 Environmental management – Environmental technology verification (ETV)?

ISO 14034:2016 specifies principles, procedures and requirements for environmental technology verification (ETV), and was developed and published by the *International Organization for Standardization (ISO)*. The objective of ETV is to provide credible, reliable and independent verification of the performance of environmental technologies. An environmental technology is a technology that either results in an environmental added value or measures parameters that indicate an environmental impact. Such technologies have an increasingly important role in addressing environmental challenges and achieving sustainable development.

For more information on the Kraken® Membrane Filtration System please contact:

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