THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency **NSF International**

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**STORMWATER TREATMENT TECHNOLOGY**	
APPLICATION:	**SUSPENDED SOLIDS AND ROADWAY POLLUTANT TREATMENT**	
TECHNOLOGY NAME:	**VORTECHS® SYSTEM, MODEL 1000**	
TEST LOCATION:	**MILWAUKEE, WISCONSIN**	
COMPANY:	**VORTECHNICS, INC.**	
ADDRESS:	**200 Enterprise Drive** **Scarborough, Maine 04074**	PHONE: **(877) 907-8676** FAX: **(207) 878-2735**
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NSF International (NSF), in cooperation with the U.S. Environmental Protection Agency (EPA), operates the Water Quality Protection Center (WQPC), one of six centers under the Environmental Technology Verification (ETV) Program. The WQPC recently evaluated the performance of the Vortechs® System, Model 1000 (Vortechs), manufactured by Vortechnics, Inc. (Vortechnics). The Vortechs was installed at the "Riverwalk" site in Milwaukee, Wisconsin. Earth Tech, Inc. and the United States Geologic Survey (USGS) performed the testing.

The ETV Program was created to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The ETV program's goal is to further environmental protection by accelerating the acceptance and use of improved and more cost-effective technologies. ETV seeks to achieve this goal by providing high quality, peer-reviewed data on technology performance to those involved in the design, distribution, permitting, purchase, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations; stakeholder groups, which consist of buyers, vendor organizations, and permitters; and with the full participation of individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests (as appropriate), collecting and analyzing data, and preparing peer-reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

TECHNOLOGY DESCRIPTION

The following description of the Vortechs was provided by the vendor and does not represent verified information.

The Vortechs is designed to remove settable and floatable pollutants from stormwater runoff. Based on the size of the grit chamber, the Vortechs Model 1000 maximum operating flow rate is 1.6 cfs (720 gpm).

Untreated stormwater enters the Vortechs through an inlet pipe that is tangential to the grit chamber. This creates a swirling motion that directs settleable solids into a pile towards the center of the grit chamber. Floating pollutants are trapped upstream of an underflow baffle. The Vortechs contains two flow controls in the last chamber of the system. The first control is designed to allow nearly-free discharge at very low flows so that very fine particles do not settle in the inlet pipe. This control begins to create a significant backwater at operating rates in excess of 5 gpm/ft^2 of grit chamber surface area such that the inlet pipe becomes submerged at an operating rate of 20 gpm/ft^2 of grit chamber surface area. This backwater creates a low-velocity entry into the grit chamber, which encourages stratification of pollutants in the inlet pipe. Under low flow rates, a small amount of material may settle out in the inlet pipe, but at higher flow rates, these relatively large particles will be transported into the grit chamber. Additional hydraulic capacity is provided over the top of the flow control wall so that the system does not cause upstream flooding at flow rates exceeding the maximum recommended operating rate of 100 gpm/ft^2 of grit chamber surface area.

The vendor claims that the Vortechs will provide a net annual removal efficiency of total suspended solids (TSS) that are typically encountered in runoff from urban environments in excess of 80%. According to the vendor's product literature, Vortechnics typically selects a system size that will provide an 80% annual TSS load reduction based on laboratory-generated performance curves for 50-µm sediment particles.

VERIFICATION TESTING DESCRIPTION

Methods and Procedures

The test methods and procedures used during the study are described in the *Final Test Plan for the Verification of Vortechs® Model 1000 Stormwater Treatment System, "Riverwalk Site," Milwaukee, Wisconsin.* (March 2004). The Vortechs was installed to treat runoff collected from a 0.25-acre portion of the westbound highway surface of Interstate 794. Milwaukee receives an average annual precipitation of nearly 33 in., approximately 31% of which occurs during the summer months. Sampling was not conducted during winter months. Street sweeping occurred monthly during summer months.

Verification testing consisted of collecting data during a minimum of 15 qualified events that met the following criteria:

- The total rainfall depth for the event, measured at the site, was 0.2 in. (5 mm) or greater;
- Flow through the treatment device was successfully measured and recorded over the duration of the runoff period;
- A flow-proportional composite sample was successfully collected for both the inlet and the outlet over the duration of the runoff event;
- Each composite sample was comprised of a minimum of five aliquots, including at least two aliquots on the rising limb of the runoff hydrograph, at least one aliquot near the peak, and at least two aliquots on the falling limb of the runoff hydrograph; and
- There was a minimum of six hours between qualified sampling events.

Automated sample monitoring and collection devices were installed and programmed to collect composite samples from the inlet and outlet during qualified flow events. In addition to the flow and analytical data, operation and maintenance (O&M) data were recorded. Samples were analyzed for:

Sediments
- TSS
- total dissolved solids (TDS)
- suspended sediment concentration (SSC)
- particle size analysis

Metals
- total and dissolved copper and zinc

Nutrients
- total and dissolved phosphorus

Water Quality Parameters
- chemical oxygen demand (COD)
- total calcium and magnesium

VERIFICATION OF PERFORMANCE

Verification testing of the Vortechs lasted approximately 16 months, and coincided with testing conducted by USGS and the Wisconsin Department of Natural Resources. Conditions during certain storm events prevented sampling for some parameters. However, samples were successfully taken and analyzed for all parameters for at least 15 of the 18 total storm events.

In addition to the vendor's claim for sediment removal (TSS), the verification test plan included measurements for other water quality parameters. These verification factors were developed by a participating stakeholder group and technology panel, and provide ancillary performance data which is considered by many municipalities in addition to primary vendor claims when purchasing stormwater treatment technology.

Environmental conditions and other factors which may have impacted TSS removal are addressed in Chapter 5 of the full report.

Test Results

Table 1. Rainfall Data Summary

Event Number	Date	Start Time	Rainfall Amount (in.)	Rainfall Duration (hr:min)	Runoff Volume (ft^3)[1]	Peak Flow Rate (cfs) [1]
1	4/30/03	22:24	1.1	3:30	847	0.352
2	5/4/03	21:34	0.72	4:05	795	0.059
3	5/9/03	0:42	0.87	4:27	717	0.084
4	5/30/03	19:07	0.54	4:07	665	0.164
5	6/8/03	3:34	0.62	11:09	847	0.466
6	6/27/03	17:35	0.57	17:25	518	0.101
7	9/12/03	15:42	0.30	3:49	156	0.039
8	9/14/03	6:09	0.47	6:35	588	2.02
9	10/14/03	1:19	0.27	2:53	268	0.057
10	10/14/03	8:54	0.23	0:39	138	0.055
11	10/24/03	17:41	0.71	5:31	613	0.138
12	3/25/04	23:08	0.85	4:57	311	0.023
13	3/28/04	15:30	0.87	4:49	216	0.025
14	4/17/04	3:29	0.24	1:18	69	0.026
15	5/12/04	18:33	0.55	9:05	311	0.076
16	5/20/04	16:39	0.24	1:02	259	1.26
17	8/3/04	20:25	1.8	3:43	2,510	2.45
18	8/24/04	20:40	0.85	3:32	449	1.02

1. Runoff volume and peak discharge rate measured at the inlet monitoring point. See the verification report for further details.
2. Peak flow rates exceeded the rated treatment capacity of the Vortechs unit indicating the unit may be undersized for the drainage area.

The monitoring results were evaluated using event mean concentration (EMC) and sum of loads (SOL) comparisons. The EMC evaluates treatment efficiency on a percentage basis by dividing the outlet concentration by the inlet concentration and multiplying the quotient by 100. The EMC was calculated for each analytical parameter and each individual storm event. The SOL comparison evaluates the treatment efficiency on a percentage basis by comparing the sum of the inlet and outlet loads (the parameter concentration multiplied by the precipitation volume) for all storm events. The calculation is made by subtracting from one the quotient of the total outlet load divided by the total inlet load, and multiplying by 100. SOL results can be summarized on an overall basis since the loading calculation takes into account both the concentration and volume of runoff from each event. The analytical data ranges, EMC range, and SOL reduction values are shown in Table 2.

Table 2. Analytical Data, EMC Range, and SOL Reduction Results

Parameter	Units	Inlet range	Outlet range	EMC range (%)	SOL reduction all events (%)	SOL reduction all events except 8 & 17 (%)[1]
TSS	mg/L	46 – 310	28 – 150	-170 – 70	18	35
SSC	mg/L	50 – 820	26 – 150	-90 – 90	58	61
TDS	mg/L	<50 – 290	<50 – 1,400	-1,100 – 25	-120	-110
Total phosphorus	mg/L as P	0.062 – 0.68	0.041 – 0.48	-82 – 52	9.3	21
Dissolved phosphorus	mg/L as P	0.014 – 0.24	0.007 – 0.15	-200 – 68	0	26
Total copper	µg/L	21 – 280	13 – 120	-83 – 70	25	33
Dissolved copper	µg/L	5.4 – 75	5.4 – 43	-250 – 52	-10	-12
Total zinc	µg/L	100 – 920	84 – 520	-80 – 58	16	24
Dissolved zinc	µg/L	17 – 350	33 – 330	-380 – 31	-24	-21
Total magnesium	mg/L	3.7 – 23	2.3 – 10	-96 – 78	42	47
Total calcium	mg/L	9.5 – 48	9.3 – 43	-120 – 65	21	22
COD[2]	mg/L	27 – 310	25 – 220	-170 – 57	-15	0

1. The SOL was recalculated excluding events 8 and 17, since the peak runoff intensity for these events exceeded the rated flow capacity of the Vortechs. Refer to the verification report for further details.
2. The outlet COD concentration for event 4 was 1,400 mg/L but considered an outlier and was not used in EMC or SOL calculations.

The calculated SOL reduction for TSS, SSC, total and dissolved phosphorus, COD, and total metals improved when omitting the two events where the peak runoff intensity exceeded the rated flow capacity of the Vortechs (shown in the last column of Table 2). The high negative TDS removals were likely influenced by road salting operations. Dissolved-phase constituents, other than dissolved phosphorous, showed relatively little change when excluding events 8 and 17. The data suggest that scouring or resuspension may have occurred as a result of the high peak flow rates encountered during events 8 and 17.

A particle size distribution procedure known as "sand-silt split" was conducted on samples as part of the SSC analysis. The sand-silt split procedure quantifies the percentage (by weight) of particles greater than 62.5 µm (defined as sand) and less than 62.5 µm (defined as silt). The percentage of sand in the inlet ranged from 2% to 58%, while the percentage of sand in the outlet ranged from 0% to 19%. This data was incorporated into the SOL calculation, revealing the reduction in the SSC sand fraction was 94% and the reduction in the SSC silt fraction was 21%.

System Operation

The Vortechs was installed in December 2001, prior to verification, so verification of installation procedures on the system was not documented. The installed system cleaned and was inspected immediately prior to and during verification. Seven inspections of the unit were also performed during the test period. Upon completing the verification testing, the sediment chamber was cleaned out and contained sediment at depths ranging from 0 to 5.75 in., and approximately 120 lb (dry weight) of sediment was removed from the sediment chamber.

Quality Assurance/Quality Control

NSF personnel completed a technical systems audit during testing to ensure that the testing was in compliance with the test plan. NSF also completed a data quality audit of at least 10% of the test data to ensure that the reported data represented the data generated during testing. In addition to QA/QC audits performed by NSF, EPA personnel conducted an audit of NSF's QA Management Program.

Original signed by Sally Gutierrez	*10/3/05*	*Original signed by Robert Ferguson*	*10/5/05*
Sally Gutierrez	Date	Robert Ferguson	Date
Director		Vice President	
National Risk Management Research Laboratory		Water Systems	
Office of Research and Development		NSF International	
United States Environmental Protection Agency			

Availability of Supporting Documents

Copies of the *ETV Verification Protocol, Stormwater Source Area Treatment Technologies Draft 4.1, March 2002,* the verification statement, and the verification report (NSF Report Number 05/24/WQPC-WWF) are available from:

ETV Water Quality Protection Center Program Manager (hard copy)
NSF International
P.O. Box 130140
Ann Arbor, Michigan 48113-0140

NSF website: http://www.nsf.org/etv (electronic copy)
EPA website: http://www.epa.gov/etv (electronic copy)
Appendices are not included in the verification report, but are available from NSF upon request.