THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

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

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**STORMWATER TREATMENT TECHNOLOGY**	
APPLICATION:	**SUSPENDED SOLIDS TREATMENT**	
TECHNOLOGY NAME:	**TERRE KLEEN™ 09**	
TEST LOCATION:	**HARRISBURG, PENNSYLVANIA**	
COMPANY:	**TERRE HILL CONCRETE PRODUCTS**	
ADDRESS:	**485 Weaverland Valley Road** **Terre Hill, Pennsylvania 17581**	PHONE: **(800) 242-1509** FAX: **(717) 445-3108**
WEB SITE:	**http://www.terrehill.com**	
EMAIL:	**precastsales@terrehill.com**	

NSF International (NSF), in cooperation with the U.S. Environmental Protection Agency (EPA), operates the Water Quality Protection Center (WQPC), one of five active centers under the Environmental Technology Verification (ETV) Program. The WQPC recently evaluated the performance of the Terre Kleen™ 09 (Terre Kleen™), manufactured by Terre Hill Silo Company, Inc. T/D/B/A Terre Hill Concrete Products (THCP). The Terre Kleen™ device was installed at the Department of Public Works (DPW) facility in Harrisburg, Pennsylvania. The testing organization (TO) for the evaluation was headed by a faculty member from the Environmental Engineering Department of The Pennsylvania State University – Harrisburg (PSH) in Middletown, Pennsylvania.

EPA created ETV 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. ETV 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 Terre Kleen™ was provided by the vendor and does not represent verified information.

The Terre Kleen™ device combines primary and secondary chambers, baffles, a screen, and inclined sedimentation, as well as oil, litter and debris/sediment storage chambers, into a self-contained concrete structure. The primary benefit of the Terre Kleen™ device is its ability to efficiently settle solids in the inclined cells (lamella plates) located in the secondary chamber using hydrodynamic principles. The design of the unit provides for underground installation as an in-line treatment device, where it may be applied at a critical source area, or a larger unit may be installed in a storm sewer main to provide treatment for larger flows. Installation can be performed using conventional construction techniques. Terre Kleen™ units can be designed to provide specific removal efficiencies based on the size characteristics of the suspended solids and flow rate of storm water to the device.

The Terre Kleen™ device addresses the concern of being space-effective, providing high particle removal efficiency given the device's relatively small footprint. The ability to install the device below grade allows for the use of the above-ground space, and makes it easier for the device to be retrofitted into a pre-existing storm sewer system. The design allows for some treatment of all water that enters the primary settling chamber of the device, even if the flows exceed the capacity of the secondary (lamella inclined plate) chamber. The treated and bypassed water recombine prior to discharge from the device. Re-suspension of captured material below the inclined plates is minimized because the stormwater enters the inclined cells sideways instead of scouring the top of the sediment.

The vendor claims that the Terre Kleen™ device installed for the verification test will remove 100% of particles 200 microns (µm) and larger in stormwater when the device is operating at the design storm flow of 3.49 cubic feet per second (cfs), which is based on the 25-year storm for Harrisburg. THCP also claims that at lower flows, removals of particles smaller than 200 µm will also be achieved.

VERIFICATION TESTING DESCRIPTION

Methods and Procedures

The test methods and procedures used during the evaluation are described in the *Environmental Technology Verification Test Plan for Terre Hill Concrete Products: The Terre Kleen™, City of Harrisburg, Pennsylvania.* (November 2004). The Terre Kleen™ device was installed at the downstream end of the stormwater collection system at the City of Harrisburg Department of Public Works facility. The drainage area is part of the city's maintenance yard occupied by the Bureau of Sanitation, and includes runoff from buildings and paved and unpaved parking areas having a 90 to 95% impervious drainage area initially estimated at approximately 1.27 acres, but was later estimated to be approximately 2.5 to 3 acres after topographic maps with finer contours were made available.

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 samplers and flow monitoring devices were installed and programmed to collect composite samples from the inlet and outlet, and to measure the stormwater flow into and out of the device. In addition to the flow and analytical data, operation and maintenance data were recorded. Samples were analyzed for total suspended solids (TSS) and suspended sediment concentration (SSC). The samples were also analyzed to quantify the mass of particles greater than 250 µm in size and to determine the particle size distribution for particles ranging in size from 0.8 to 240 µm.

VERIFICATION OF PERFORMANCE

The performance verification of the Terre Kleen™ device consisted of an evaluation of flow, sediment reduction, and operations and maintenance data collected during 15 qualified storm events over a period of approximately 11 months.

Test Results

The precipitation data for the rain events are summarized in Table 1.

Table 1. Rainfall Data Summary

Event Number	Date	Start Time	Rainfall Amount (in.)	Rainfall Duration (hr:min)	Peak Flow Rate (cfs) [1]	Runoff Volume (ft^3) [1]
1	6/29/05	12:00	0.31	2:00	0.83	750
2	7/7/05	18:40	1.68	15:00	0.82	7,900
3	8/16/05	09:35	0.43	11:10	0.029	210
4	8/27/05	19:05	0.68	14:00	0.76	1,800
5	9/16/05	18:55	1.22	5:40	2.0	4,900
6	10/13/05	05:20	0.63	21:55	0.50	960
7	10/21/05	22:45	1.17	24:15	0.80	3,800
8	11/16/05	10:30	0.20	14:40	0.013	110
9	11/22/05	23:20	0.52	9:45	0.37	1,300
10	11/29/05	04:55	1.04	19:05	1.2	6,500
11	12/25/05	11:50	0.45	8:40	0.26	580
12	1/2/06	10:45	0.99	25:40	0.14	940
13	1/11/06	12:50	0.42	11:05	0.20	480
14	4/3/06	14:40	0.75	7:50	0.36	1,500
15	5/13/06	16:20	0.71	54:10	0.089	660

1. Runoff volume and peak discharge rate measured at the outlet monitoring point, with the exception of event 14, which was measured at the inlet monitoring point. See the verification report for further details.

The flow monitoring and analytical results were evaluated using event mean concentration (EMC) and sum of loads (SOL) comparisons. The EMC evaluates treatment efficiency on a percentage basis, with the calculation being made 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 runoff volume) for all storm events. The calculation is made by subtracting the quotient of the total outlet load divided by the total inlet load from one, and multiplying the difference by 100. SOL results can be summarized on an overall basis since the load calculation takes into account both the concentration and volume of runoff from each event. The SOL calculation was also conducted for TSS and SSC samples with sediment particles greater than 250 µm. 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	Inlet Range (mg/L)	Outlet Range (mg/L)	EMC Range (%)	SOL Reduction (%)	SOL Reduction Particle Size >250 µm (%)	SOL Reduction Particle Size <250 µm (%)
TSS	58 – 6,900	35 – 980	-88 – 86	44	85	35
SSC	75 – 7,000	35 – 1,500	-11 – 87	63	98	32

Both the TSS and SSC analytical parameters measure sediment concentrations in water. However, the TSS analysis uses an aliquot drawn by the analyst from the sample container, while the SSC analysis uses the entire contents of the sample container. Heavier solids may not be picked up in the drawn aliquot for the TSS analysis, such that the TSS will tend to be more representative of the lighter solids concentrations.

The particle size distribution data showed that the Terre Kleen™ was approximately 98% effective in removing particles 200 µm or larger. When the particle size distribution data is combined with the hydrologic data, it shows that the performance of the device generally removed all of the particles 200 µm or larger when treating flows of 2.0 cfs or lower. The rated flow capacity (3.49 cfs) of the Terre Kleen™ was not exceeded during any of the 15 storm events. This device is designed to treat the entire entering flow (bypass over the plates was monitored after the primary chamber and at no time during the testing were the plates bypassed).

System Operation

The Terre Kleen™ was installed in February 2005, with no major issues noted. The Terre Kleen™ device was cleaned prior to the start of testing in March 2005, and was inspected frequently during verification. A review of the storm event records in January 2006 showed that two late January storms had substantial negative removals. Therefore, the decision was made to clean the device at the end of January 2006. Sediment depths prior to pump-out were between 50% and 75% of the maximum design sediment depth, measured at several points in the device. This maintenance activity consisted of using a sewer vactor truck from the City of Harrisburg to dewater and remove sediment from the device. A sample of the sediment was analyzed for Toxicity Characteristic Leachate Procedure (TCLP) metals and the concentrations were lower than the hazardous waste limits of 40 CFR Section 261.42.

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 quality assurance (QA) and quality control audits performed by NSF, EPA personnel conducted an audit of NSF's QA Management Program.

Note for this Revision

The original verification statement was signed in September 2006 but revised in July 2008 to reflect a change in the method the drainage area size and the runoff volume and peak runoff intensity were calculated. See Sections 3.2 and 5.1.1 of the verification report for information on the revised drainage area size and runoff calculations, respectively.

Original signed by		*Original signed by*	
Sally Gutierrez	*October 14, 2007*	*Robert Ferguson*	*October 3, 2007*
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 test plan, the verification statement, and the verification report (NSF Report Number 06/29/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.