Canadian ETV Verification Report

Performance Testing
of
Catch Basin Shield Technology

FINAL – STRICTLY CONFIDENTIAL

Date: 17 October 2016

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Verification Report Outline for CB Shield Inc.

Catch Basin Shield Technology

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Disclaimer

The Toronto and Region Conservation Authority ("TRCA") including its employees and Directors, (the "Verifier") has participated in the Canadian Environmental Technology Verification (ETV) Program verification of the CB Shield (the "Vendor") Catch Basin Shield Technology.

Any reference to the "Technology" refers to the Vendor's Catch Basin Shield Technology.

The Verifier is in no way affiliated with the Vendor.

The Vendor shall not edit or modify the report in any way or make any attempt to misrepresent data to the benefit of the Vendor. Selectively using sections of the report in order to change or misrepresent its overall meaning is also prohibited.

Claim verification by the Verifier does not represent any guarantee of the performance or safety of the Technology.

The Verifier shall not be liable in any way in the event that the Technology fails to perform as advertised by the Vendor and/or CB Shield Technology does not meet government-mandated health and safety standards.

To the extent permitted by law, the Verifier denies all liability to the Vendor or to any other person or entity for any loss, damage, costs, expenses and/or other compensation, arising directly or indirectly from the use of the report (in whole or on part) and/or any information contained therein.

The Vendor is wholly responsible for ensuring that the Technology complies with all applicable legislation, regulations, and other authorities.

Executive Summary

The CB Shield Technology was subjected to verification in accordance with the Canadian ETV Program General Verification Protocol, and taking into account the current draft of the proposed FDIS ISO 14034.

The verification process was mutually agreed upon by GLOBE Performance Solutions, the Verification Body, and Toronto and Region Conservation Authority ("TRCA"), the subcontracted Verification Expert. The purpose of this verification is to provide objective and quality-assured performance data on environmental technologies, so that users, developers, regulators, and consultants can make informed decisions about purchasing and applying these technologies.

This report, prepared by TRCA according to the criteria and guidelines set out in the Canadian ETV Program General Verification Protocol (GVP) of June 2012, is an official audit of the testing report generated through the performance testing of the CB Shield technology. The report is based on the Canadian ETV Program.

In addition, through guidance provided by GPS, the TRCA completed its verification of the CB Shield technology performance taking into account the principles and requirements of FDIS ISO 14034.

Performance testing for this verification took place at Good Harbour Laboratories in Mississauga, Ontario, Canada. Good Harbour Laboratories conducted the testing and followed the test sediment particle size distribution and many of the methods outlined in the *Procedure for Laboratory Testing of Oil-Grit Separators* developed by Toronto and Region Conservation Authority for the Canadian ETV Program.

CB Shield Technology is based on established scientific and technical principles in the field of fluid dynamics, sedimentation/settling, hydrology and sediment transport.

The technology incorporates an insert for catchbasins that aims to deflect and reduce the energy of inflows and thereby increase capture and reduce scour of sediment found in stormwater runoff.

After examination and audit of the test report and based on the test data submitted, the TRCA has concluded that _the CB Shield insert provides an environmental benefit related to capture and scour prevention of suspended sediments in stormwater runoff.

Accordingly, the TRCA recommends that the performance claims be worded as follows:

1. During the sediment capture test, for a catch basin with a false floor set to 50% of the manufacturer's recommended maximum sediment storage depth and a constant influent sediment concentration of 200 mg/L, the catch basin with a CB Shield insert removed 64, 59.9, 52.4, 42.6, 25.2, and 26.7 percent of influent sediment by mass at inflow rates of 0.24, 0.48, 1.20, 2.40, 6.00, and 8.40 L/s, respectively.

2. For a catchbasin filled to three quarters of the manufacturer's recommended maximum sediment storage depth, with the CB Shield™ insert, scouring of test sediment is at most 8% of the control catchbasin during a continuous 30 minute scour test run with 5 minute duration inflows of 1.2, 4.8, 8.4, 12.0, and 15.6 L/s.

1. Introduction

GLOBE Performance Solutions (GPS) which operates the Canadian ETV Program on behalf of Environment Canada has engaged the Toronto and Region Conservation Authority ("TRCA") to verify the performance of CB Shield Technology within the framework of a subcontracted agreement. The CB Shield technology is a technology for capturing sediment from storm water runoff when inserted inside street drains (catchbasins) and retaining sediment by preventing scour and re-suspension.

GLOBE Performance Solutions, in collaboration with the TRCA, has further agreed to prepare a verification report and verification statement that will meet the requirements of the Canadian ETV Program.

This verification report, prepared by the TRCA (the Verifier), in its capacity as a Canadian ETV Program Verification Expert (VE), constitutes a review of the application of the CB Shield technology based on the Canadian ETV Program General Verification Protocol (GVP) and taking into account the principles and requirements of FDIS ISO 14034.

The verification report is a summary record of the audit undertaken by the TRCA to verify the Vendor's technology performance claim.

CB Shield applied for technology verification through GLOBE Performance Solutions. Testing was carried out by the Good Harbour Laboratories in accordance with ISO 17025 requirements. TRCA examined the test report and prepared the verification report.

The CB Shield Technology is based on established scientific and technical principles in the field of _fluid dynamics, sedimentation/settling, hydrology and sediment transport. The technology incorporates an insert for catchbasins that deflects incoming water to the sidewalls dissipating its energy and passing it over a grate where velocity is decreased and residence time is increased allowing sediments to drop out of suspension and be captured. The dissipation of influent water energy also reduces scouring of already captured sediment during subsequent storms.

CB Shield's performance claims as submitted were:

1. For a catch basin containing sediment up to 150mm below the outlet invert, use of a CB Shield™ reduces scour of ETV sediment by a factor of at least 20 for stormwater inflows from 1.2-15.6L/s.
2. In addition use of CB Shield™ increases capture of ETV test sediment in all cases and by at least 370% to 490% respectively for flows of 2.4L/s and 8.4L/s.

Results showed that the initial claim for capture test could not be verified for individual flow rates as independence between samples of different flow rates could not be maintained since the captured sediment was not removed between the tests of different flow rates. A re-test was requested for the capture test. The re-test was done on a catchbasin with CB Shield insert without reference to a control catch basin. Results showed removal efficiencies ranging from 64.0 - 26.7% for inflow rates ranging from 0.24 - 8.40 L/s respectively.

The scour test was evaluated as a continuous test. Comparing the CB Shield to the Control treatment indicated that the CB Shield scoured much less than the control catch basin at 5 minute duration inflow rates of 1.2, 4.8, 8.4, 12.0, and 15.6 L/s.

1.1 Objectives

The objective of this report is to verify the performance claim made by CB Shield for the Catch Basin Shield Technology. This report summarizes the findings of the Canadian ETV Program Verification Expert, the TRCA, based on information and data contained in the Formal Application submitted by CB Shield to GLOBE Performance Solutions.

1.2 Scope

This verification was conducted by the TRCA using the June 2012 Canadian ETV Program General Verification Protocol and the most recent version (June 2015) of the international ETV standard (FDIS ISO 14034).

2. Review of the Application

2.1 Introduction

This section provides a summary of the information provided by the applicant included with the pre-screening application and formal application forms submitted to GLOBE Performance Solutions and reviewed by the TRCA pursuant to the Canadian ETV Program and the new international ETV standard (FDIS ISO 14034).

2.2 Applicant Organization

CB Shield Inc.
233 Cross Avenue, Suite 302
Oakville, ON L6J 2W9

Canada

2.3 Documents Reviewed

The technology and all information provided by the Applicant with the Formal Application, the formal application binder and all subsequent transmittals to the Verification Expert were reviewed. The results of this Application Review are summarized in the Application Review Checklist (Table 1) below.

Table 1: Application Review Checklist – Mandatory Information

Ref.	Criteria		Yes	No	Verifier Comments
1.1	Signed Formal Application.		☑	☐	
1.2	Signed Declaration Regarding Codes & Standards submitted with signed formal application.		☑	☐	
1.3	Technology provides an environmental benefit.		☑	☐	When installed in storm water catch basin, the device reduces souring and re-suspension of retained sediment, thereby reducing discharge of sediment into the environment.
1.4	A copy of "Claim to be Verified" for each performance claim to be verified included with the Formal Application.		☑	☐	"Claim to be Verified" submitted with application.
1.5	Performance Claim composed in a way that satisfies "Criteria for Specifying Claims":		☐	☐	
	1.5.1	Include Technology name (and model number)	☑	☐	CB Shield™
	1.5.2	Include application of the technology	☑	☐	Applied as an insert into catchbasins to improve capture and reduce scour of stormwater runoff sediment.
	1.5.3	Include specific operating conditions during testing	☑	☐	Test sediment: ETV test sediment Capture (Claim 1): Constant influent concentration of 200 mg/L. False floor set to 50% of the manufacturer's recommended maximum sediment storage (300 mm below the outlet invert) Inflow rates of 0.24, 0.48, 1.20, 2.40, 6.00 and 8.40 L/s. Scour (Claim 2): Catchbasin filled to ¾ of the manufacturer's recommended maximum sediment storage depth Claim based on continuous 30 minute test with 5 minute duration inflows of 1.2, 4.8, 8.4, 12.0, and 15.6 L/s.
	1.5.4	Does it meet the minimum requirement for the majority of Canadian Standards / Guidelines?	☑	☐	Signed Declaration Regarding Codes & Standards submitted with signed formal
	1.5.5	Does it specify the performance achievable by the technology?	☑	☐	Capture: Removal efficiencies of 64, 59.9, 52.4, 42.6, 25.2, and 26.7 for inflow rates of 0.24, 0.48, 1.20, 2.40, 6.00, and 8.40 L/s respectively with a constant influent sediment concentration of 200 mg/L. Scour: Scouring is at most 8% of the control catchbasin during a continuous 30 minute scour test run with 5 minute duration inflows of 1.2, 4.8, 8.4, 12.0, and 15.6 L/s.

	1.5.6	Is the performance measurable?	☑	☐	Capture: To measure the capture performance at each flow rate, a modified mass balance calculation is required, which can be done using mass of the sediment added to the sediment feeder, mass of sediment remaining in the feeder, and mass of captured sediment. Scour: To compare scouring potential for the continuous test between the control and CB Shield treatments the total effluent load is calculated for the entire duration of the test based on flow rate, duration, and sediment concentration of individual samples.
1.6	Standard operating practices and a description of operating conditions for each individual performance claim specified.		☑	☐	Tests are done in a lab on a simulated street scape with catchbasins clean of litter/debris. In the field, on average there are 5 catch basins per hectare. Therefore, the results from the maximum flow rate (15.6L/s) during the scour test will be meaningful for runoff flows up to 78 L/s per hectare. The range of flows tested is anticipated to match the range of flows expected at most installations. ETV test sediment: AGSCO 1-1000 micron silica sediment blend. Background samples are taken to account for all sources of sediment input. Capture Test (Claim 1) Background samples taken at least three times per run to account for all sources of sediment input Influent sediment concentration is constant at 200 mg/L (+/- 25mg/L) Tested flows: 0.24, 0.48, 1.2, 2.4, 6, and 8.4 L/s. These flow rates comply with surface loading rates specified in the CETV OGS testing procedures (40, 80, 200, 400, 1000, and 1400 L/min/m^2), based on the effective treatment area (0.36m^2) of the device. The specified loading rate of 600 L/min/m^2 was not tested. Conducted with a false bottom set at 300 mm below the outlet invert. Effluent was not recirculated; single pass through. Sediment injected 16.5 mm away from the inlet Scour Test (Claim 2) Tested flows: 1.2, 4.8, 8.4, 12, and 15.6 L/s. These flow rates comply with surface loading rates specified in the CETV OGS testing procedures (200, 800, 1400, 2000, and 2600 L/min/m^2), based on the effective treatment area (0.36m^2) of the device. Conducted with a false bottom set at 254 mm below the invert and preloaded with sediment up to 152 mm below the outlet invert. Water is filled to the effluent pipe and allowed to settle for 12-24 hours. Initial start time and flow rate transition times shall not exceed 1 minute. Effluent filtered using a 10µm filter before recirculation.

1.7	The proponent has supplied significant references describing or supporting scientific and engineering principles of the technology.	☐	☐	Proponent claimed that scientific principles underlying the CB Shield are based on widely accepted knowledge of fluid dynamics, sedimentation/settling, hydrology and sediment transport. Link to EPA paper was broken.
1.8	Two or more names and contact information of independent experts (with no vested interest in the technology), qualified (backgrounds of experts are needed) to review the scientific and engineering principles on which the technology is based. These experts must be willing to be contacted by the VE.	☑	☐	Greg Williams (Ph.D., P.Eng), Jenn Drake (Ph.D)
1.9	Brief summary of significant human or environmental health and safety issues associated with the technology. (Note: this criterion complements but does not replace the obligation for the applicant to submit a duly signed "Declaration Regarding Codes and Standards")	☑	☐	Brief descriptions given about health and safety issues associated with the working environment during installation, removal, the cleanout of catchbasins (considering they are confined spaces), and sediment disposal. Persons involved with installing, removing, and or maintaining CB Shield inserts need to be trained in accordance with requirements for servicing regular catchbasins.
1.10	Brief summary of training requirements needed for safe, effective operation of technology, and a list of available documents describing these requirements. (Note: this criterion complements but does not replace the obligation for the applicant to submit a duly signed "Declaration Regarding Codes and Standards")	☑	☐	Link to video instructions that guides installation and removal of the CB Shield is provided; a list of general practices is also given.
1.11	Process flow diagram(s), design drawings, photographs, equipment specification sheets (including response parameters and operating conditions), and/or other information identifying the unit processes or specific operating steps in the technology. If feasible, a site visit to inspect the process should be part of the technology assessment.	☑	☐	Photographs of lab setup, flow diagrams of water flow through the simulated streetscape, and links to videos showing test runs and sampling methods were provided.
1.12	Supplemental materials (optional) have been supplied which offer additional insight into the technology application integrity and performance, including one or more of the following:	☐	☑	
	A copy of patent(s) for the technology, patent pending or submitted.	☐	☑	
	User manual(s).	☐	☑	
	Maintenance manuals.	☐	☑	
	Operator manuals.	☐	☑	
	Quality assurance procedures.	☐	☑	
	Sensor/monitor calibration program.	☐	☑	
	Certification for ISO 9001, ISO 14000, or similar.	☐	☑	
	Material Safety Data Sheet (MSDS) information.	☐	☑	
	Workplace Hazardous Materials Information System (WHMIS) information.	☐	☑	
	Health and Safety plan.	☐	☑	
	Emergency response plan.	☐	☑	
	Protective equipment identified.	☐	☑	
	Technical brochures.	☑	☐	Website link provided with technical drawings and information.
1.13	The applicant provided adequate documentation and data. There is sufficient information on the technology and performance claim for the verification. [Note: The Verifier should communicate with the Canadian ETV Program, through GPS, to request copies of the necessary documentation and required data that are available to support the claims.]	☑	☐	Adequate documentation given for reviewing testing protocol. All collected data including laboratory work book were submitted. Methodology for testing was clearly outlined in application. Videos of testing protocol, and installation/removal of CB Shield were also provided.

3. Review of the Technology

3.1 Technology Review Criteria

The results of the Technology Review are summarized in the Technology Review Criteria Checklist (Table 2) below.

Table 2: Technology Review Criteria Checklist

Ref	Criteria	Yes	No	Verifier Comments
2.1	The technology is based on scientific and technical principles. (Note: It will be necessary for the Verifier to read the key articles and citations listed in the Formal Application. It may also be necessary to contact the independent experts listed in the Formal Application to obtain additional information)	☑	☐	The technology is a flow deflection device that dissipates the energy of inflows, preventing scour and increasing capture. The scientific principles underlying the technology are based on well-known areas of fluid dynamics, sedimentation/settling, hydrology and sediment transport.
2.2	The technology is supported by peer review technical literature or references. (Note: Peer review literature and texts must be supplied with the Formal Application as well as relevant regulations and standards that are pertinent to the performance claim)	☐	☐	Currently the link to peer review article is inaccessible.
2.3	The technology is designed, manufactured, and/or operated reliably. (Note: Historical data from the applicant, not conforming to all data criteria, may be useful for the Verifier to review to assess the viability of the technology not for verification, but for insight purposes)	☑	☐	CB Shield is said to be constructed in Canada using quality fiberglass. No details from long term studies to comment on long term reliability.
2.4	The technology is designed to provide an environmental benefit and not create an alternative environmental issue. (e.g., It does not create a more hazardous and/ or unmanaged byproduct and it does not result in the transfer of an environmental problem from one media to another media without appropriate management of the subsequent contaminated media)	☑	☐	The technology provides an environmental benefit of controlling sediment washoff at upstream locations by capturing and retaining sediment from stormwater runoff within the catchbasin. However, long term reliability specifically about the clogging of grate opening by debris which would decrease its hydraulic capacity requires further attention.
2.5	The technology conforms to standards for health and safety of workers and the public. (Note: The vendor must submit a signed "Declaration Regarding Codes & Standards", with the Formal Application. The Verifier should ensure that this signed document is included with the information that is reviewed for the performance claim verification)	☑	☐	Signed Declaration Regarding Codes and Standards was submitted.
Environmental Standards				
2.6	Technology achieves federal, provincial, and/or municipal regulations or guidelines for management of contaminated and/or treated soils, sediments, sludges, or other solid-phase materials.	☑	☐	
2.7	Technology achieves federal, provincial, and/or municipal regulations or guidelines for all (contaminated and or treated) aqueous discharges as determined by the applicant's information.	☑	☐	
2.8	Technology achieves federal, provincial, and/or municipal regulations or guidelines for all (direct or indirect) air emissions. If the environmental technology results in the transfer of contaminants directly or indirectly to the atmosphere, then, where required, all regulations or guidelines (at any level of government) relating to the management of air emissions must be satisfied by the applicant's information.	☑	☐	
Commercial Readiness				
2.9	Technology and all components (apparatus, processes, products) is full-scale, commercially-available, or alternatively see 2.10 or 2.11, and, data supplied to the Verifier is from the use or demonstration of a commercial unit.	☑	☐	Technology and components used for testing are full-scale and commercially available. At the time of this verification, the vendor has the capacity to produce many hundred units per month.

2.10	Technology is a final prototype design prior to manufacture or supply of commercial units, or alternatively see 2.11. (Note: Verification of the performance claim for the technology is valid if based on a prototype unit, if that prototype is the final design and represents a pre- commercial unit. The verification will apply to any subsequent commercial unit that is based on the prototype unit design. The verification will not be valid for any commercial unit that includes any technology design change from the prototype unit used to generate the supporting data for the verification.	☐	☐	NA
2.11	Technology is a pilot scale unit used to provide data which when used with demonstrated scale up factors, proves that the commercial unit satisfies the performance claim.	☐	☐	NA
Operating Conditions				
2.12	All operating conditions affecting technology performance and the performance claim have been identified.	☑	☐	Operating conditions affecting technology performance were identified. Please see Ref. 1.6.
2.13	The relationships among operating conditions and their impacts on technology performance have been identified. (Note: It is the responsibility of the Verifier to understand the relationship between the operating conditions and the performance of the technology, and to ensure that the impacts of the operating conditions and the responses of the technology are compatible)	☑	☐	Background concentration – needs to be < 20 mg/L to allow for accurate assessment of performance in the laboratory Water temperature – needs to be <25 °C; higher water temperatures have reduced viscosity allowing suspended sediments to settle quicker. However, water temperature has a negligible impact on settling velocity. Standardized test sediment - ensures comparability between units and a fair assessment of performance based on range of sediment sizes. Flow rates - lower flow rates should allow higher percentage of capture and retention. False floor (used storage capacity) – higher false floor will lower capture and retention performance as sediment will be held closer to the outlet invert <u>Capture test</u> Influent sediment concentration - held constant at 200 mg/L; studies have shown this to be a reasonable average sediment concentration in stormwater runoff from paved surfaces. Higher or lower influent concentrations may change the removal efficiencies
2.14	Technology designed to respond predictably when operated at normal conditions (i.e. conditions given in 2.12), and/or alternatively see 2.15. (Note: The Verifier must be satisfied that these data do not demonstrate a performance that is different than the performance indicated in the Performance Claim to be validated)	☑	☐	Based on the test results, the technology does respond predictably when operated at normal conditions. The discrepancy with the S5 run result during the control treatment of the scour test showing the second lowest scour rate for the highest flow rate is likely the result of a lack of finer sediments in the sump to scour.
2.15	Effects of variable operating conditions, including start up and shut down, are important to the performance of the technology and have been described completely as a qualifier to the performance claim under assessment.	☑	☐	A range of inflow rates were tested and the samples taken when changing from one flow rate to the next were clearly distinguished.
Throughput Parameters				

2.16	Effects of variable contaminant loading or throughput rate must be assessed and input/output limits established for the technology. Note: If the application of the technology is to a variable waste source or expected (designed) variable operating conditions, then it will be necessary to establish acceptable upper and lower ranges for the operating conditions, applications and/or technology responses. Sufficient, quality data must be supplied to validate the performance of the technology at the upper and lower ranges for the operating conditions, applications and or technology responses detailed in the performance claim.	☑	☐	Scour: The tested flow rates were between 1.2 and 15.6 L/s. The catch basins with and without CB Shield were pre-loaded with test sediment. Influent was clean water. Testing was continuous from one flow rate to the next with 1 minute transition periods. Capture: The tested lower and upper throughput rates are 0.24 and 8.40 L/s. Contaminant loading rates were controlled to have a constant inflow sediment concentration of 200mg/L.
Other Relevant Parameters/Variables/Operating Conditions Note: The Verifier is expected to understand the technology and identify and record all relevant criteria, parameters, variables or operating conditions that potentially can or will affect the performance of the technology under assessment. It is practical to include all of these variables in Table 2 (i.e., from 2.17 to …).		☑	☐	Parameters mentioned from 2.12 to 2.16 will also affect field performance accordingly (e.g., the false floor represents the accumulated amount of sediment). Additionally, in the field, debris may accumulate and affect performance which was not evaluated in the lab setting but can be evaluated in a field case study.
2.17				
2.18				

4. Review of Test Plan, Test Execution and Data

4.1 Review of Test Plan and Execution of Test Plan

The results of the Test Plan Review are summarized in the Test Plan Design Assessment Criteria Checklist (Table 3) below.

Table 3: Test Plan Design Assessment Criteria Checklist

Ref.	Criteria			Verifier Comments
3.1	Was a statistician, or an expert with specialized capabilities in the design of experiments, consulted prior to the completion of the test program, and if so please provide the contact details	☑	☐	Greg Williams 416-624-2007 gwilliams@goodharbourlabs.com
3.2	Is a statistically testable hypothesis or hypotheses provided? (such that an objective, specific test is possible)	☑	☐	The testable hypothesis is that a catchbasin with the CB Shield insert will retain more sediment in stormwater runoff than a catch basin without the insert. The hypothesis can be tested by a capture and comparative scour test as follows: Capture test: The OGS testing protocol requires the total amount of sediment to be accounted for by means of a modified mass balance. As a result, statistics will not be required since the whole "population" is taken into account instead of taking samples. Scour test: The scour test is a continuous test where samples taken within and between flow rates are not independent of each other. Since the assumption of independence fails, a mix model approach is required to compare the means between the control and CB shield catchbasin and confirm a significance difference. A measure of difference can be calculated between the two treatments by finding the quotient of their total effluent loads.
3.3a-c	Does the performance test generate data suitable for testing the hypothesis being postulated? Namely:	☑	☐	

3.3a	Does the test measure the parameters used in the performance claim hypothesis?	☑	☐	<u>Capture test:</u> Total amount of sediment added into the feeder is measured as well as the total amount captured after each flow rate test. A modified mass balance is undertaken to calculate exactly how much sediment was fed through the feeder as influent into the catchbasin and what percentage was retained for both treatments. <u>Scour test:</u> Performance test measures effluent concentrations of control and CB Shield treatments.
3.3b	Does the performance test control for extraneous variability?	☑	☐	The test was conducted under controlled laboratory conditions, following well defined procedures, thereby limiting extraneous variability. More specifically, influent flow was sampled to account for any background concentrations that would add to the controlled influent sediment feed. Inflow concentration was measured for each flow rate to ensure auger feed rates were synced to influent flow rate to achieve target influent concentrations. When concentrations of samples were analyzed, a blank, 20 mg/L standard, and 100 mg/L standard were also tested to account for instrumental or systematic errors. For sediment re-suspension test, pre-loaded sediment is allowed to settle for 12-24 hours before tests are started. Water temperature were monitored to not exceed 25°C as higher temperature can decrease water viscosity and thereby increase sediment settling velocity.
3.3c	Does the performance test include only those effects attributable to the technology being evaluated?	☑	☐	To ensure effects are attributable to the technology evaluated, the catchbasin with a CB shield insert is evaluated against a catchbasin without the insert (control) as part of the scour test.
3.4	Does the performance test generate data suitable for analysis using the SAWs? (Note: It is preferable that tests are designed with the SAWS in mind before test plans are written)	☐	☑	The mixed model approach required to compare control and CB Shield catchbasin scour test results requires a test outside of recommended SAWs (the R statistical program was used)
3.5	Does the performance test generate data suitable for analysis using other generic experimental designs? (Note: Performance testing and verification studies should be designed with the final data analysis in mind to facilitate interpretation and reduce costs)	☑	☐	<u>Capture</u> and <u>scour</u> tests generally followed the experimental design proposed by the OGS testing protocol which do not require statistical analysis. However, scour test claim compares control and CB Shield catchbasin which requires further analysis (mixed model) to prove significance difference between control and CB Shield catchbasin.
3.6	Are the appropriate parameters, specific to the technology and performance claim, measured? (Note: It is essential that the Verifier and the technology developer ensure that all parameters – e.g. temperature, etc - that could affect the performance evaluation are either restricted to pre-specified operating conditions or are measured)	☑	☐	Water temperature, influent flow rate, background concentration <u>Capture test:</u> Influent concentration, total influent mass, total captured mass <u>Scour test:</u> influent flow rate, preloaded sediment mass, effluent concentration
3.7a-d	Are samples representative of process characteristics at specified locations? Namely:	☑	☐	

3.7a	Are samples collected in a manner representative of typical process characteristics at the sampling locations? (e.g., the samples are collected from the source stream fully mixed, etc.)	☑	☐	Capture test: Sampling done according to OGS test Procedure. Upon completion of test, the remaining water from the catchbasin is decanted over a period of less than 30hrs. The total sediment captured is removed, dried and weighed. Mass of sediment remaining in the feeder is weighed and subtracted from total mass of sediment added at the beginning of the test to establish actual amount fed. Scour test: Effluent grab samples are taken at the catch basin outlet which will reflect effluent concentrations. A minimum of 500 ml samples was taken in 1000 mL jars that were attempted to be held under the whole effluent stream or passed under the stream such that the sample collection would be complete with a single pass.
3.7b	Is data representative of the current technology?	☑	☐	The data reflects the effect of a CB shield inserted into a normal catchbasin without any other alterations to the catchbasin. The inserted CB Shield is the unit that is currently commercially available.
3.7c	Have samples been collected after a sufficient period of time for the process to stabilize?	☑	☐	Samples were collected according to OGS testing procedure, which was developed based on scientific principles to ensure, among other things, sampling is conducted in a representative and replicable manner. Capture test: Sediment is only fed once target flows are reached and stabilized. A maximum of 30hrs is given to decant remaining water after a test run before captured sediment is removed, dried and weighed. Scour: Once sediment is pre-loaded, the device is filled up with water to the invert and allowed to sit for 12-24 hours before starting the tests. Changes in flow rates were done within 60s and an effluent sample was taken at approximately 30s to determine if additional scouring was taking place while flow rates were stabilizing.
3.7d	Have samples been collected over a sufficient period of time to ensure that the samples are representative of process performance?	☑	☐	Capture test: Total captured sediment is collected at the end of each flow run. The test duration for tested flow rates of 0.24, 0.48, 1.20, 2.40, 6.00, and 8.40 L/s are 420, 420, 360, 180, 70, and 50 mins respectively. Scour test: Effluent samples were taken every 1 minute for test durations of 5 minutes for flow rates of 1.2, 4.8, 8.4, 12.0, and 15.6 L/s. Transition samples were taken within 30 seconds of switching to a new flow rate. The system was shut down between flow rates of 8.4 and 12.0 L/s and between 12.0 and 15.6 L/s due to standpipe overflow.

3.8	Are samples representative of operating conditions? (Note: A time lag occurs between establishing steady state conditions and stabilization of the observed process performance. This time lag depends in part on the time scale of the process)	☑	☐	Long term operating conditions need to be evaluated. The effect of debris accumulation in an in situ field setting needs to be considered as affecting the performance. <u>Capture test:</u> Flow rates are monitored and influent sediment is only added once each target flow is stabilized in order to match performance to specific flow rates that cover the expected range of catchbasin inflow. Performance is representative of catchbasin that has used up 50% of the manufacture recommended Maximum Sediment Storage Depth and a constant inflow concentration of 200 mg/L. Because the sediment is collected at the end of each run, it accounts for the performance of the unit during start up and shut down as well. <u>Scour test:</u> Samples are representative for a specific operating condition of having the catch basin ¾ full of sediment. Scouring results are from a continuous test where scouring from a previous flow will affect subsequent scouring rates. After pre-loading the sediment time is given for agitated sediments to settle over a period of 12-24 hours. Flow changes are done within 1 minute and a sample is taken at approximately 30s to capture the scouring potential when altering flow rates.
3.9	Are samples representative of known, measured and appropriate operating conditions? (Note: This includes technologies that operate on short cycles and so have start and stop cycles which affects the operation of the technology. If the operating conditions are not vital but are recommended, then the reviewer must evaluate operating conditions)	☑	☐	The device is a passive device working to deflect and reduce the energy of stormwater inflow, which increases capture and reduces scour. The data were collected under controlled laboratory conditions using a test sediment that includes clay, silt and sand sized particles characteristic of stormwater runoff. The effects of debris on performance were not evaluated.
3.10	Were samples and data prepared or provided by a third party? (Note: In some cases, where the expertise rests with the applicant, an independent unbiased third party should witness and audit the collection of information and data about the technology. The witness auditor must not have any vested interest in the technology.)	☑	☐	Data samples were analyzed and prepared by a third party laboratory (Good Harbour Laboratories). Good Harbour Laboratories 2596 Dunwin Drive, Mississauga ON, L5L 1J5 905 696 7276 goodharbourlabs.com
3.11a-c	Performance Test Design is Acceptable - Namely:	☑	☐	
3.11a	The samples have been collected when the technology was operated under controlled and monitored conditions.	☑	☐	<u>Capture test:</u> flow rate, and influent concentrations were monitored and adjusted as required <u>Scour test:</u> flow rates were monitored and adjusted as required
3.11b	The test plan design should have been established prior to testing to ensure that the data were collected using a systematic and rational approach	☑	☐	Test plan design generally satisfied the OGS testing protocol.

3.11c	The test plan design should have defined the acceptable values or ranges of values for key operating conditions, and the data collection and analysis methodology	☑	☐	Operating conditions: Flows tested (operating conditions) are the expected general range of flows through a catchbasin: capture test (0.24-8.4L/s), scour test: (1.2-15.6 L/s). Water temperature needs to be below 25°C. Unit tested having 50% of its maximum storage capacity filled. Data collection and analysis: follows the OGS testing protocol. However, the scour test is run additionally with a control catch basin for comparison.

4.3 Data Validity Checklist

The results of the Data Validity Review are summarized in the Data Validity Checklist (Table 4) below.

Table 4: Data Validity Checklist

Ref.	Criteria	Yes	No	Verifier Comments
4.1	Were appropriate sample collection methods used (e.g. random, judgmental, systematic etc)? For example: simple grab samples are appropriate if the process characteristics at a sampling location remain constant over time. Composites of aliquots instead may be suitable for flows with fluctuating process characteristics at a sampling location. (Note: Sampling methods appropriate for specific processes may sometimes be described in federal, provincial or local monitoring regulations)	☑	☐	Capture test: The mass of sediments fed into the catchbasin and captured is measured in order to carry out a modified mass balance. Scour test: Multiple effluent grab samples are appropriate to evaluate the effluent concentrations and thereby the scouring potential at each flow rate.
4.2	Were apparatus and/or facilities for the test(s) adequate for generation of relevant data? (i.e. testing was performed at a location and under operating conditions and environmental conditions for which the performance claim has been defined)	☑	☐	Facility/apparatus sufficiently simulated a streetscape with a catchbasin with and without a CB Shield insert. Slurry feeder was calibrated and the auger feed rate was monitored. The facility had the capacity to manage the large amounts of water required for testing.
4.3	Were operating conditions during the test monitored and documented and provided?	☑	☐	Monitored/ documented operating conditions: background concentration, water temperature, PSD of test sediment Capture test: False floor height, flow rates, influent sediment concentration, amount of sediment injected Scour test: False floor height, flow rates, time limits, sampling frequency
4.4	Has the information and/or data on operating conditions and measuring equipment measurements and calibrations been supplied to the Verifier?	☑	☐	Measurements of monitored flow, water temperature and concentrations of sediment added were provided. Calibration of flow meter and PSD of sediment used were also provided.

4.5	Were acceptable protocols used for sample collection, preservation and transport? (Note: Acceptable protocols include those developed by a recognized authority in environmental testing such as a provincial regulatory body, ASTM, USEPA, Standard Methods)	☑	☐	
4.6	Were Quality Assurance/Quality Control (QA/QC) (e.g. use of field blanks, standards, replicates, spikes etc) procedures followed during sample collection? A formal QA/QC program, although highly desirable, is not essential, if it has been demonstrated by the vendor's information that quality assurance has been applied to the data generation and collection.	☑	☐	Replicates were taken and kept for 7 days (refrigerated) for each sample. Blank, 20 mg/L standard, and 100 mg/L standard run during sample analysis.
4.7	Were samples analyzed using approved analytical protocols? (e.g. samples analyzed using a protocol recognized by an authority in environmental testing such as Standard Methods, EPA. ASTM etc. Were the chemical analyses at the site in conformance with the SOPs (Standard Operating Procedures)?	☑	☐	The SSC samples were analyzed by GHL as detailed in ASTM D3977-97 (2013), Standard Test Methods for Determining Sediment Concentration in Water Samples.
4.8	Were samples analysed within recommended analysis times (especially for time sensitive analysis such as bacteria)	☑	☐	Recommended storage time is 7 days but samples were analyzed within 2.
4.9 a-e	Were QA/QC procedures followed during sample analysis? Namely:	☐	☐	
4.9a	Maintaining control charts	☑	☐	QA/QC (e.g., flow rates monitored to not vary more than expected COV (<0.04)
4.9b	Establishing minimum detection limits	☑	☐	MDL is 1.26 mg/L.
4.9c	Establishing recovery values	☐	☑	
4.9d	Determining precision for analytical results	☐	☑	
4.9e	Determining accuracy for analytical results	☐	☑	
4.10 a-c	Was a chain-of-custody (full tracing of the sample from collection to analysis) methodology used for sample handling and analysis - Namely:	☐	☐	
4.10a	Are completed and signed chain-of-custody forms used for each sample submitted from the field to the analytical lab provided for inspection by the Verifier?	☑	☐	Chain of custody provided for ETV test sediment analysis. Sampling and analyzing were done by GHL in their laboratory.
4.10b	Are completed and easily readable field logbooks available for the Verifier to inspect?	☑	☐	Field logbook from GHL was made available to the verifier.
4.10c	Are there other chain-of-custody methodology actions and documentation recorded/available (e.g. sample labels, sample seals, sample submission sheet, sample receipt log and assignment for analysis)?	☑	☐	GHL provided certificate of analysis for effluent concentration of the scour test.
4.11	Experimental Data Set is Acceptable (i.e., the quality of the data submitted is established using the best professional judgment of the Verifier)	☑	☐	The Verifier believes that the experimental data quality set is acceptable as overseen by Good Harbour Laboratories.

4.5 Data Analysis Checklist

The intent of the data analysis checklist is to ensure that the appropriate statistical tools can be used in a rigorous, defensible manner (Environment Canada 2012). The checklist also emphasizes that an initial performance claim may be rewritten and updated to better reflect what the data support, using the expertise of the Verifier and other pertinent resources. In this case, the performance claims were modified and restated by the Verifier. The updated performance claims are presented in the conclusion of this report.

Table 5: Data Analysis Checklist

Ref.	Criteria	Yes	No	Verifier Comments

5.1	Does the analysis test the performance claim being postulated? (Note: When conducting performance evaluations, under the Canadian ETV program, the alternative hypothesis of a "significant difference" without stating the direction of the expected difference will usually be unacceptable)	☑	☐	Capture test: analysis not required since modified mass balance will be done. Scour test: mixed model is used to evaluate whether there is a significant difference in effluent concentrations between CB shield and Control treatments. A confidence interval for the quotient of means between the control and CB Shield treatment will be calculated for comparison. The standard error of the distributions that is required to calculate the confidence intervals is calculated using a bootstrap method in R statistical program. This method is less stringent on the assumption of normality which the data set does not fully satisfy.
5.2	Does the analysis fit into a generic verification study design? For example, many other "generic" designs exist that are not explicitly covered by the Canadian ETV Program (e.g. ANOVA, ANCOVA, regression, etc.) that are potentially useful.	☑	☐	Capture test: Since there are no replications, results of the tests are presented as they are. Scour test: Mixed model analysis is carried to determine if there is a significant difference, a type of comparison of means taking into account non-independence. The quotient between the Control and the CB Shield treatments are used to compare the treatments.
5.2 a-c	Are the assumptions of the analysis met? Namely: (Note: A negative response means the Verifier needs to request further information)	☑	☐	Scour test: assumptions for a linear model include: 1. Linearity –dependent variable is the result of a linear combination of independent variable(s) 2. Absence of collinearity – fixed effects should not be collinear to each other 3. Homoskedasticity – variance of your data should be approximately equal across the range of predicted values 4. Normality or residuals (least important) – residuals of the regression need to be normally distributed 5. Absence of influential data points 6. Independence – most important for a linear model. Samples need to be independent. Since this assumption is not satisfied, a mixed model is used in place of a linear model. The mixed model allows for non-independent samples.
5.2.a	Did the data analyst check the assumptions of the statistical test used?	☑	☐	
5.2.b	Are the tests of assumptions presented?	☑	☐	
5.2.c	Do the tests of the assumptions validate the use of the test and hence the validity of the inferences?	☑	☐	
5.3	Data Analysis is Acceptable The data analysis is acceptable if the statistical test employed tests the hypothesis being postulated by the technology developer, the assumptions of the statistical test is met and the test is performed correctly.	☑	☐	Data analysis is acceptable.

4.7 Data Interpretation Checklist

The intent of the data interpretation checklist is to ensure that the data analyses results are reviewed in a manner that emphasizes the applicability to the specific performance claim and the statistical power of the performance test.

Table 6: Data Interpretation Checklist

Ref	Criteria	Yes	No	Verifier Comments

6.1a	Are the results statistically or operationally significant? Did the performance test result in a statistically significant test of hypothesis?	☑	☐	Capture test: Results are operationally significant. Removal efficiencies ranged from 64 to 26.7% for flow rates of 0.24 – 8.40 L/s. Scour test: results reflect comparison between control and CB Shield for a continuous scour test of different flow rates (0.24-8.4L/s) at 5 minute intervals. Under a mixed model analysis that takes into account non-independence between samples (since it is a continuous test, the previous sample will affect subsequent sample) it was shown that the treatment (control vs. CB Shield) had a significant effect on scouring.
6.1b	To be operationally significant, does the technology meet regulatory guidelines and applicable laws?	☑	☐	Declaration regarding codes & standards have been signed.
6.2	Does the performance test have sufficient power to support the claim being made? Note: For performance test designs where acceptance of the null hypothesis results in a performance claim being met, the statistical power of the test must be determined (Note: A statistical power of at least 0.8 is the target. If the power of the verification experiment is less than this value, the Verifier should contact the Canadian ETV Program to discuss an appropriate course of action)	☑	☐	Capture test: No statistical tests were conducted. Instead, a mass balance approach was used, which is regarded as a direct and robust and scientifically valid means of evaluating capture in stormwater sedimentation devices. Scour test: No suitable method of testing the power of a mixed model statistical test was available. However, the differences between the control catch basin and CB shield catch basin were very significant, and the number of effluent samples collected was suitable for the selected statistical method of evaluation.
6.3	Is the interpretation phrased in a defensible manner? Note: The final performance claim should reflect any changes to the claim made during the course of the analyses, variations or restrictions on operating conditions, etc. that changed the scope of the performance claim. The initial performance claim should be viewed as a tentative claim that is subject to modification as the verification progresses. A thoughtful open-minded verification will in the end, prove to be of greatest benefit to the technology developer.	☑	☐	Both claims were revised Capture test: Results for the capture test cannot undergo a statistical test due to a lack of replicates. However, since the analysis was performed in a control laboratory setting, it is assumed that results would be replicable and therefore interpreted as results for a given set of testing conditions. Scour test: Since the scour test was run as a continuous test, comparison between specific flow rates cannot be made, but rather on the entire series. Using mixed models to account for non-independence between samples, a significant difference was found between the two treatments. The interpretation is specific to testing conditions, but can be generalized to state the CB Shield scours much less than the control catchbasin.
6.4	Data Interpretation is Acceptable The data interpretation is acceptable if the data analyses results are reviewed in a manner that emphasizes the applicability to the specific performance claim and the statistical power of the verification experiment.	☑	☐	In general, the data interpretation is acceptable.

5. Statistical Evaluation of Claims

The statistical evaluation of the claims put forward by the Vendor was carried out using the R statistical software based on some of the principles presented in Statistical Analysis Worksheets (SAWs) provided by GPS (as per Environment Canada 2012). The first claim (capture test) does not require a statistical evaluation since the entire "population" is sampled (total mass of influent and captured sediments are accounted for) and n = 1 for each flow rate. The capture test follows the OGS protocol published by CETV and the analysis of which specifies a modified mass balance approach.

The data set resulting from the scour test does not satisfy the assumption of independence. Therefore, the second claim (scour test) cannot be evaluated statistically using the provided standard SAWs that require normality. A mixed model approach is taken to confirm significant difference between results of control catchbasin and one with a CB Shield. A bootstrap simulation method is used in R to calculate the standard deviation from which confidence intervals for their quotient is derived to make estimates of the minimum performance limit.

5.1 Statistical Evaluation of Claim #1: Capture test

A modified mass balance approach is taken to analyze the treatment performance of capturing suspended sediments at various loading rates. Each flow rate is run only once due to feasibility related to testing duration and cost, but the total influent sediment and total captured sediment is weighed and accounted for. Since there are no repeated tests, statistical analysis is not carried out but rather the results of the modified mass balance is given as is.

5.1.1 Raw Data

The raw data provided by the Vendor is presented in Appendix D of the formal application.

5.1.2 Assessing Normality

This procedure is used to determine if the data variable is normally distributed or log-normally distributed. This is important as the assumption of normality is often invoked in subsequent calculations.

– Not applicable

Assumptions:
- Not applicable

5.1.3 Testing if the Mean is Equal to Specified Value

This test is used to determine at a level of 95% confidence that the mean is not equal to some pre-specified value, μ_o. The value μ_o will often be the performance that a technology is claiming to achieve.
$H_0 : \mu_1 = \mu_o$

– Not applicable

Assumptions:
- Not applicable

Inferences:
No statistical inferences are made. Based on the modified mass balance approach, under specified operating conditions of a false floor set to 50% of the manufacturer's recommended maximum sediment storage depth and a constant influent sediment concentration of 200 mg/L, the catch basin with a CB Shield insert removed 64, 59.9, 52.4, 42.6, 25.2, and 26.7 percent of influent sediment by mass at inflow rates of 0.24, 0.48, 1.20, 2.40, 6.00, and 8.40 L/s, respectively.

Table Z1: Summary of Acceptable Data Sets for Verification

Acceptable Data Set(s) Identification	SAWs Used	Supports Claim (Y/N)
Table 9. Removal efficiency based on mass balance (from Performance testing of the CB Shield for the enhancement of catch basin sediment capture – 24 Aug 2016)	Not applicable	Yes

5.2 Statistical Evaluation of Claim #2: Scour Test

5.2.1 Raw Data

The raw data provided by the Vendor is presented in Appendix D of the formal application.

5.2.2 Mixed model analysis: Testing for significant difference between scour test effluent loads of control and CB Shield treatment using

The scour test is run continuously with test sediment of a specified PSD preloaded and having flow rates altered at 5 minute intervals (1.2, 4.8, 8.4, 12.0, and 15.6 L/s). Effluent loads of the two treatments cannot be compared separately at each flow rate since preceding flow rates affect the amount of sediment left to scour during subsequent flow rates. As a result, for each treatment all collected effluent concentrations are treated as part of a single dataset. However, conventional statistics used for comparison of means analysis (i.e., t-test) requires each sample to be independent of each other, put forth as the assumption of independence. Since data from the scour test fails to meet this assumption, a mixed model approach is taken.

A mix model is a linear model that includes a “mix” of fixed and random effects. Effects that are constant for each sample are fixed effects (i.e., the treatment) while effects that are variable for each sample(run/flow rate) are random effects and in part treated as a random error term. A “full” model is created with all fixed and random effects along with a “null” model that excludes the fixed effect that is in question of having a significant effect. The treatment effect (CB Shield vs. control) will be excluded in the null model. An ANOVA is used to compare the two models which if determined to be significantly different from each other identifies the fixed effect in question (i.e., treatment) to be a significant effect.

Assumptions:

- Linearity: The dependent variable has to be a result of a linear combination of the independent variables. A residual plot can be used as an indicator. Residuals should not exhibit a recognizable pattern (e.g., exhibit an increase or decrease or a curved relationship)

- Homoscedasticity: Variance of the data should be approximately equal across the range of predicted values. Residuals on a residual plot should be approximately equal distance from the Y=0 line.

- Absence of collinearity: Fixed effects should not be collinear (very closely related) to each other so that it would not be difficult to distinguish between their effects.

- Normality of residuals: Linear model are relatively robust against violations of normality assumption so this is the least important assumption to satisfy. Normality of residuals can be checked using a q-q plot.

- Absence of influential data points

5.2.3 Calculating the 95% confidence interval for the effluent load mean quotient of the two treatments

To make a claim on the effluent load performance of the CB Shield relative to the control treatment, the quotient of the mean effluent loads is calculated and expressed as a percentage. The 95% confidence interval of the quotient of means is calculated and the lower limit is used in the claim to reference the minimum performance as required by CETV instead of the mean performance.

A bootstrap simulation method is used in R to calculate the standard deviation of the distribution of effluent loads of the two treatments as an effective means of correcting for non-normal distribution. The calculated standard deviation is used with GraphPad’s web application (http://www.graphpad.com/quickcalcs/errorProp1/) to estimate the 95% confidence intervals of the quotient. The application assumes normal distributions for the datasets, which although not satisfied, the robust bootstrapping method used to calculate the standard deviations is believed to give very good estimates of the minimum performance without introducing complications of transforming and retransforming variables.

Assumptions:

- Data set is normally distributed: although not satisfied, the robust bootstrapping method used to calculate the standard deviations is believed to give good estimates of the calculated minimum performance without introducing abstractions of transforming and retransforming variables.

Inferences:
Based upon the above inferences, it can be concluded that for a catchbasin filled to three quarters of the manufacturer's recommended maximum sediment storage depth, with the CB Shield™ insert, scouring of test sediment is at most 8% of the control catchbasin during a continuous 30 minute scour test run with 5 minute duration inflows of 1.2, 4.8, 8.4, 12.0, and 15.6 L/s.

Table Z2: Summary of Acceptable Data Sets for Verification

Acceptable Data Set(s) Identification	Analysis Used	Supports Claim (Y/N)
Table 2. Scour test results for CB Shield protected and control catch basins (from Environmental Technology Verification (ETV): Supporting documentation for Canadian ETV program formal application – October 2015)	Mixed model regression is used (R statistical package)	Y
Table 2. Scour test results for CB Shield protected and control catch basins (from Environmental Technology Verification (ETV): Supporting documentation for Canadian ETV program formal application – October 2015)	Bootstrap simulation is run in R to find the standard error for the mean percent change (between scour results of the control and CB Shield treatments)	Y

Table 2. Scour test results for CB Shield protected and control catch basins (from Environmental Technology Verification (ETV): Supporting documentation for Canadian ETV program formal application – October 2015)	GraphPad web application is used to calculate 95% confidence interval of the quotient of mean effluent loads of the two treatments.	Y

6. Audit Trail

The items in Table 8 are useful in determining reasons for data discrepancies.

Table 8: Key documents

Raw data sheets and summary data	Yes
Signature pages	Yes
Signed Formal Application	Yes
Declaration Regarding Codes & Standards	Yes
Patent(s)	NA (Patent Pending)
Sample security: e.g. chain of custody sheets for each sample	Chain of custody for sediment, not for effluent sample since collected and analyzed by same lab.
Operation and maintenance manual	Operation and maintenance videos.
Field notebooks	Provided
Certificate of accreditation of laboratories	GHL not accredited but allowed by the verifier since an internal verification documented in the validation report TR-AA20120409-01.

7. Conclusion

CB Shield's technology performance claims have been verified as follows:

1. Capture test:

   During the sediment capture test, for a catch basin with a false floor set to 50% of the manufacturer's recommended maximum sediment storage depth and a constant influent sediment concentration of 200 mg/L, the catch basin with a CB Shield insert removed 64, 59.9, 52.4, 42.6, 25.2, and 26.7 percent of influent sediment by mass at inflow rates of 0.24, 0.48, 1.20, 2.40, 6.00, and 8.40 L/s, respectively.

2. Scour Test:

   For a catchbasin filled to three quarters of the manufacturer's recommended maximum sediment storage depth, with the CB Shield™ insert, scouring of test sediment is lowered by at least 81% compared to a control catchbasin during a continuous 30 minute scour test run with 5 minute duration inflows of 1.2, 4.8, 8.4, 12.0, and 15.6 L/s.

The verified claims concur with the verification report.

8. References

Environment Canada. 2012. Environmental Technology Verification – General Verification Protocol (GVP). Review of Application & Assessment of Technology. [online] http://etvcanada.ca/wp-content/uploads/2013/05/General-Verification-Protocol_Canadian-ETV-Program_June2012-May2013.pdf [accessed June 2016]. Environment Canada, Science and Technology Programs, Science and Technologies Strategies Directorate, Science and Technology Branch, Gatineau, QC.

ISO/FDIS 14034:2015, Environmental management – Environmental technology verification (ETV)

ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories

Appendices

Appendix A. Statistical Analysis

Appendix A contains the detailed worksheets of the statistical analysis undertaken to confirm the CB Shield Technology performance claims.

A.1 Claim 1: Capture Test

No statistical analysis performed. It is not feasible to do repeated tests for the capture test. Instead, a modified mass balance is calculated by weighing the mass of all influent and captured materials to arrive at removal efficiencies.

A.2 Claim 2: Scour Test

A.2.1 Mixed model analysis: Testing for significant difference between scour test effluent loads of control and CB Shield treatment using

A "linear mixed model" approach is taken to compare the effluent loads of the CB Shield and Control treatment.

The scour test is run continuously with test sediment of a specified PSD preloaded and having flow rates altered at 5 minute intervals (1.2, 4.8, 8.4, 12.0, and 15.6 L/s). Effluent loads of the two treatments cannot be compared separately at each flow rate since preceding flow rates affect the amount of sediment left to scour during subsequent flow rates. As a result, for each treatment all collected effluent concentrations are treated as part of a single dataset. However, conventional statics used for comparison of means analysis (i.e., t-test) requires each sample to be independent of each other, put forth as the assumption of independence. Since data from the scour test fails to meet this assumption, a mixed model approach is taken.

A mixed model can represent a "mix" of fixed and random variables. In our study, treatment will be a fixed effect while each run (different flow rate) will be treated as a random effect. More specifically, we account for the interaction of the treatment and run factor as the random effect. The analysis is carried out in "R" statistical software using the "lmer" function of the "lme4" package. To assess if the fixed factor "treatment" (CB Shield, Control) has a significant effect on the model, both a "full" model and a "null" model are created, with and without the fixed effect of "treatment" respectively. An ANOVA is run to compare the "full" and "null" model and a significant difference between the two models indicates that the fixed factor "treatment" is a significant effect. This indicates a significant difference in the responses (effluent loads) of the two treatments.

There are 6 assumptions for linear models:

1. Linearity: The dependent variable has to be a result of a linear combination of the independent variables. A residual plot can be used as an indicator. Residuals should not exhibit a recognizable pattern (e.g., exhibit an increase or decrease or a curved relationship)

2. Homoscedasticity: Variance of the data should be approximately equal across the range of predicted values. Residuals on a residual plot should be approximately equal distance from the Y=0 line.

3. Absence of collinearity: Fixed effects should not be collinear (very closely related) to each other so that it would not be difficult to distinguish between them.

4. Normality of residuals: Linear model are relatively robust against violations of normality assumption so this is the least important assumption to satisfy. Normality of residuals can be check using a q-q plot.

5. Absence of influential data points: Influential data points can change interpretation of results. The "influence" and "dfbetas" function for the "influence.ME" package can be used in R to check for this.

6. Independence: This is the most important assumption for a linear model. If the assumption is not satisfied, and linear "mixed model" is used.

The "full" and "null" models are built using the following codes. Notice that loads is the response variable, treatment is the fixed effect (constant for samples) and the interaction of the treatment and run variables is the random effect (varies for each sample) .

```
Code [
model_full = lmer(loads_g ~ treatment + (treatment|run), data=test.data, REML=FALSE)
model_null = lmer(loads_g ~ (1|run), data=test.data, REML=FALSE)
]
```

<u>Assumptions 1 and 2: Linearity and homoscedasticity</u>
Both assumption 1 and 2 can be checked using a residual plot.

```
Code [
```

plot(fitted(model_full), residuals(model_full))
]

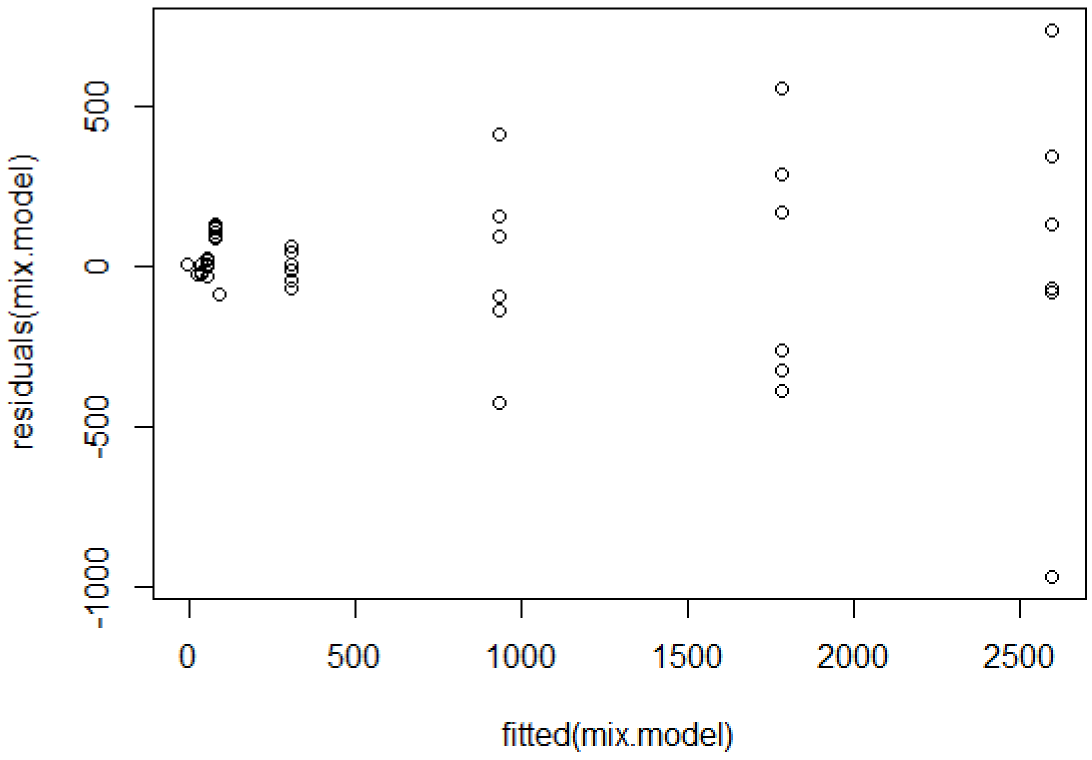

Figure A1. Residual vs. fitted model.

There seems to be a pattern where the residuals of this model are increasingly dispersed. As a result, the response variable (loads) is transformed logarithmically and the assumptions are re-tested.

```
Code [
model_full = lmer(loads_g_log ~ treatment + (treatment|run), data=test.data, REML=FALSE)
model_null = lmer(loads_g_log ~ (1|run), data=test.data, REML=FALSE)

plot(fitted(model_full), residuals(model_full))
]
```

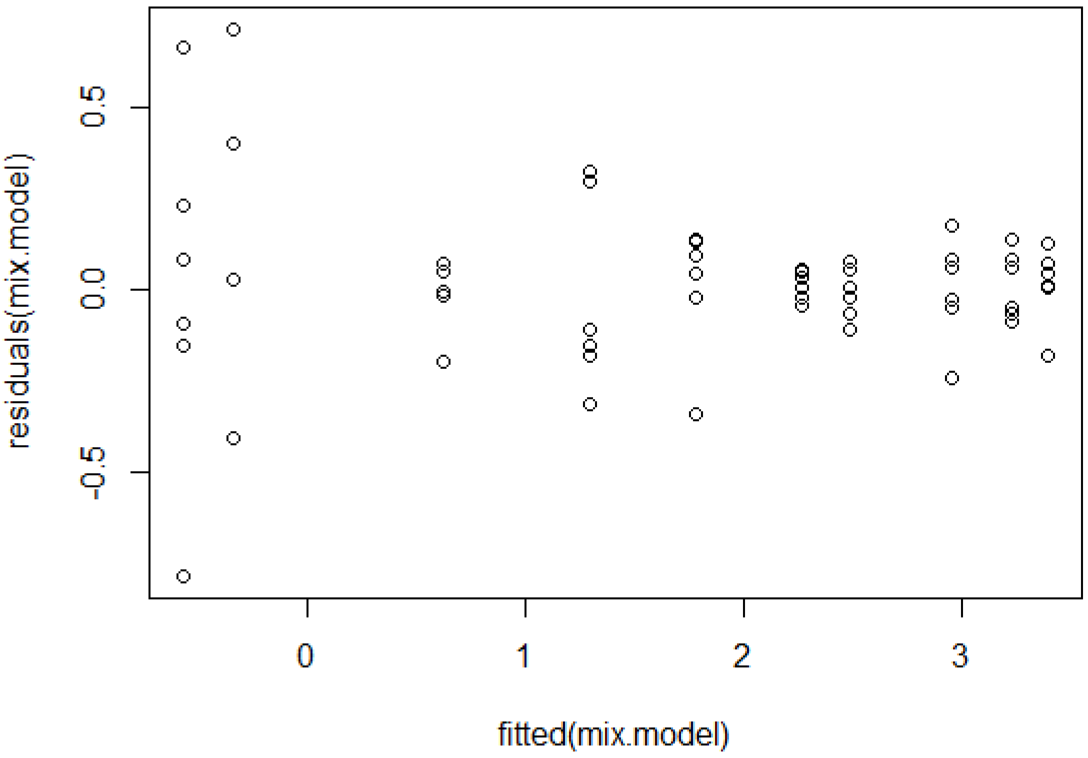

Figure A2. Residual vs. fitted model with log transformed response variable.

This model satisfactorily meets the assumptions 1 and 2. Residuals do not exhibit a clear recognizable pattern and are relatively equidistant from the Y=0 line.

Assumption 3: Absence of collinearity
This assumption is satisfied as the model only identifies one fixed effect with no other closely related variables.

Assumption 4: Normality of residuals

```
Code[
# LOAD LIBRARY
library(fitdistrplus)

# PLOT THE FITTED MODEL AGAINST THE NORMAL DISTRIBUTION
fit.norm <- fitdist(residuals(model_full), "norm")
```

plot(fit.norm)
]

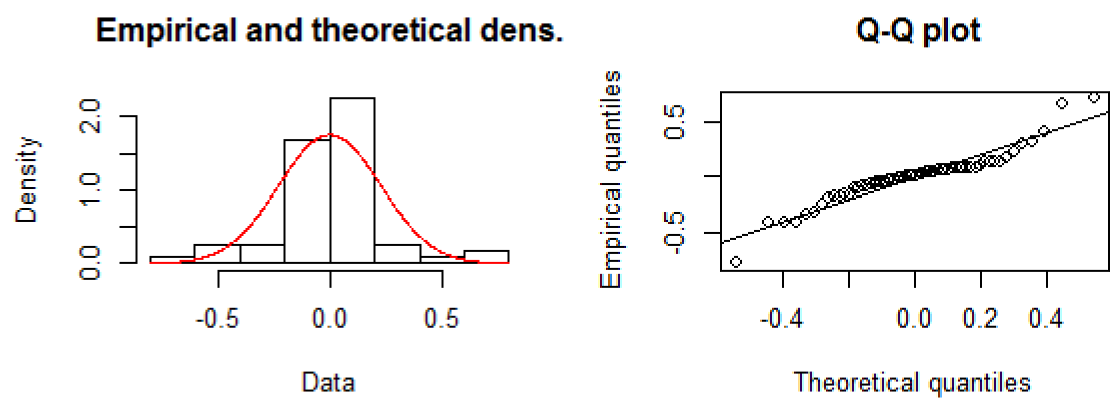

Figure A3. Histogram and Q-Q plot of residuals

Based on figure A3, the model satisfies assumption 4.

Assumption 5: Absence of influential data points

```
Code[
#LOAD LIBRARY
library(influence.ME)

# DFBETA VALUES SHOULD NOT BE MORE THAN 2/sqrt of n;  "n" BEING NUMBER OF VALUES
FOR THE GROUPING FACTOR (THERE ARE 5 RUNS/FLOW RATES)
2/(sqrt(5)) # equals 0.8944272

estex.mix.model <- influence(mix.model, "run")
dfbetas(estex.mix.model, parameter =c(0))
]
```

Table A1. DFBETAS values fixed factor by runs.

Run/flow rates	Intercept	treatmentControl
S1	-0.64651330	-0.02705247
S2	-0.50157391	0.88798512
S3	-0.05102875	0.34856408
S4	0.45949187	-0.29719975
S5	0.81812841	-0.93360428

All DFBETA values are less than 2/sqrt of n (2/(sqrt(5)) = 0.8944272); "n" being number of values for the grouping factor (there are 5 runs/flow rates). Assumption 5 is also satisfied.

ANOVA comparing the full and null model, with and without the fixed factor of treatment respectively

```
Code[
anova(model_full, model_null)
]
```

Table A2. Results for ANOVA comparing the full and null model with and without the fixed factor of treatment, respectively.

Model	Df	AIC	BIC	logLik	Deviance	Chisq	Pr(>Chisq)
Model_null	3	206.187	212.470	-100.094	200.187		
Model_full	6	59.523	72.089	-23.761	47.523	152.66	<2.2e-16

Based on table A2, there is significant difference between the models with and without the fixed factor of treatment. It can be inferred that the treatment has a significant effect, and therefore a significant difference can be claimed between the effluent loads from the CB Shield and Control treatments.

A.2.2 Calculating the 95% confidence interval for the effluent load mean quotient of the two treatments

Table A3. Calculated total/mean loads, bootstrapped standard error, standard deviation, and variance for the scour test results.

	N	Total load (g)	Mean load (g)	Bootstrap standard error[a]	Standard deviation	Variance
CB Shield	30	1564.42	52.11	12.69	69.52	4832.47
Control	30	33957.38	1131.91	176.50	966.75	934597.15

[a]Since datasets are not well suited to satisfy a normal distribution, a bootstrap method was used to calculate standard errors in the R statistical program. The bootstrap method is less stringent on satisfying the normality assumption for calculation of standard errors.

Ratio of mean effluent loads between the control and CB Shield treatments:

Mean of CB Shield/ Mean of Control
= 52.150/1131.910
=0.046
= The mean effluent load of the CB Shield treatment is 5% of the Control treatment.

Confidence Interval:
Using the standard deviation calculated in Table A1, the following GraphPad web application was used to find the confidence interval:
http://www.graphpad.com/quickcalcs/errorProp1/

CI of a sum, difference, quotient or product
Mean of CB Shield **divided by** Mean of Control = 0.046

Table A2. Confidence intervals calculated using bootstrapped standard error at the 90, 95, and 99 percentile (using GraphPad web application)

90% CI:	0.026	to	0.073
95% CI:	**0.023**	**to**	**0.080**
99% CI:	0.016	to	0.096

"These results assume that both variables follow a Gaussian distribution and that the measurements of CB Shield are not paired or matched to measurements of Control. Although the datasets are not entirely normally distributed, the standard error used to calculate the standard deviation was derived using a bootstrap method which is assumed to decrease the stringency on the requirement of normality.

Results computed by the method of EC Fieller, Suppl to J.R.Statist.Soc, 7,1-64 summarized here. "

Based on the calculated confidence interval, the effluent load of the CB Shield during the scour test is at most 8% of that of the Control treatment.

Appendix B. Supplemental Verification Checklist Pursuant to ISO/FDIS 14034:2015

Appendix B provides a supplemental verification checklist pursuant to ISO/FDIS 14034:2015. It may be useful for the verifier to include this completed Appendix in the final Verification Report.

ISO/FDIS 14034:2015 Checklist Principles, procedures and requirements for ETV		
Reference	Requirements (Criteria)	Verifier Comments
1. Applicant Information	1.1 Applicant name(s), address(es) and physical location(s)	Applicant names and addresses provided.
2. Technology Description	2.1 A unique identifier for the technology (e.g., a commercial name, an identification number or applicable version)	The technology is uniquely identified as CB Shield™.
3. Information about the intended application of the technology NOTE: More than one technology purpose, type of material and measurable property can be provided.	3.1 Purpose of the technology	The technology is a flow deflection device that when inserted into catchbasins dissipates the energy of inflows by deflecting flows to the side walls which prevents scour and increases capture of sediments within storm water runoff by increasing its residence time inside the catchbasin.
	3.2 Type of material for which the technology is intended	The technology is intended to catch suspended sediments from stormwater runoff.
	3.3 Measurable property that is affected by the technology and the way in which it is affected	The effluent sediment concentration of stormwater catchbasins is reduced by the technology.
	3.4 Information sufficient to understand the operation and performance of the technology	Applicant has provided sufficient information to understand the operation (i.e., videos and written instructions) and performance of the technology (lab test results).
	3.5 Development status of the	Technology is ready for the market. Production

	technology proposed for verification and its readiness for market (Note: Technology proposed for verification shall be either already available on the market or available at least at a stage where no substantial change affecting its performance will be implemented before market entry)	line is set up to make 100s at a time.
	3.6 Information on relevant alternatives of the technology, including relevant performance and environmental impacts	Current alternatives are in some form of fine mesh either as a guard surrounding the catchbasin inlet or as a pouch directly under the inlet through which all inflow passes through. More similar alternatives to the CB shield include OGS units, but are more expensive to install or retrofit while the CB Shield can be simply inserted into an existing catch basin.
	3.7 Information on significant environmental impacts of the technology proposed for verification and its environmental added value, if applicable.	Yes, the technology will reduce downstream transport of suspended sediment within stormwater runoff received in the catchbasin.
	3.8 Does the technology fulfil the definition of environmental technology?	Definition: "technology that either results in an environmental added value or measures parameters that indicate an environmental impact". The CB Shield inserted into a catchbasin results in an environmental added value of decreased effluent suspended sediment concentration from catchbasins.
4. Operational aspects	4.1 Are the Installation and operating requirements and conditions described?	Yes, installation, operating requirements, and conditions are detailed within the application in addition to links for videos that show installation and lab testing.
	4.2 Are the service and maintenance requirements described?	Yes, service and maintenance would be that required by normal catchbasins in terms of cleanout. The technology is manufactured with strong fiberglass material making it very durable.
	4.3 Is information provided on the expected length of time for which the technology functions under normal operating conditions?	The applicant expects the technology to operate normally given its durability combined with a regular cleanout cycle of less than 2 years; no specific life expectancy is provided.
5. Legal and regulatory context	5.1 Is information provided on the relevant legal requirements and/or standards related to the technology and its use?	Yes.
	5.2 Does the technology adhere to applicable regulatory requirements?	Yes it adheres to requirements for technologies fitted into a catchbasin.
6.Health and Safety	6.1 Are there any applicable health and safety requirements and considerations?	Health and safety requirements follow those set out for cleaning and maintaining regular catchbasins.
7. Performance claim(s) and parameters	7.1 Do the performance claims for the intended application of the technology address the needs of the interested parties?	Yes, the performance claim addresses typical flows that can be expected for a catchbasin and the performance as a result of the CB Shield insert.
	7.2 Is the information on the technology sufficient to review the performance claim(s)?	Yes, the technology is a fairly straight forward flow deflection device and information provided is sufficient to review performance claims.
	7.3 Do the performance claim(s) to be verified include proposed performance parameters and numerical values?	Yes.

	7.4 Are the performance parameters relevant and sufficient for verification of the performance of the environmental technology, and the environmental added value, if applicable?	Yes, the performance parameters indicate the improvement to sediment capture and retention.
	7.5 Can the performance claims be quantitatively verified through testing?	For the claim regarding removal efficiencies determined through the capture test, the results will be simply stated in the form of a claim. For the scour analysis, a significance difference between control and CB shield catchbasin can be verified and the absolute difference stated.
	7.6 Can their numerical values be verified under set operating conditions, using existing verification plans and relevant technical references, including standardized testing methods, preferably based on international standards?	Their numerical values and analysis for the performance claims were attained by 3rd party Good Harbour Laboratory under set operating conditions following for the greater part the OGS testing protocol published by TRCA.
8. Test data	8.1 Are relevant test data and the methods for acquiring these data provided to support the performance claim?	Testing methodology, videos taken during testing, and relevant test data were provided to support the performance claims.
	8.2 Are specifications of the requirements for the test data provided, including quality and quantity and testing conditions?	Specific testing conditions were listed in report regarding flow rates, time for each run, height of the sump (false floor), and amount of sediment added to list a few.
	8.3 Is a description provided of the methods for the assessment of the test data and their quality?	Description of the methods used to assess test data and its quality were provided.
	8.4 Are the data at a quality level generally accepted by the scientific community for the technology and/or the industrial sector concerned?	Yes.
	8.5 Are the data of sufficient quality in terms of reproducibility, repeatability, ranges of confidence, accuracy, and uncertainties?	Yes for the most part. There were a few discrepancies related to the filter of recycled effluent flow not working optimally which increased the background sediment concentration and not having enough sediment left over for scour in the control catchbasin for the final flow rate.
	8.6 Are other relevant technical references included, such as other existing verification plans, applicable legislation, standardized test methods and international standards?	Yes, applicant refrenced OGS testing protocol upon which much of the testing for the CB Shield was based on.
	8.7 Was information provided to explain deviations from the test plan?	Yes deviations from the OGS testing protocol were evident in the testing methodology.
9. Verification	9.1 Were the test data assessed against the performance specified in the verification plan?	Yes.

	9.2 Do the test data confirm the performance of the technology, achieved under the same conditions, constraints and limitations as those specified?	Yes. Few requests made for proof of analysis and for alteration of claim composition were satisfied.
	9.3 Are the performance claims verified as originally stated?	No.
	9.4 If the performance claims are not verified as originally stated, how should they be modified?	<u>Capture test:</u> During the sediment capture test, for a catch basin with a false floor set to 50% of the manufacturer's recommended maximum sediment storage depth and a constant influent sediment concentration of 200 mg/L, the catch basin with a CB Shield insert removed 64, 59.9, 52.4, 42.6, 25.2, and 26.7 percent of influent test sediment by mass at inflow rates of 0.24, 0.48, 1.20, 2.40, 6.00, and 8.40 L/s, respectively. <u>Scour test:</u> For a catchbasin filled to three quarters of the manufacturer's recommended maximum sediment storage depth, with the CB Shield™ insert, scouring of test sediment is at most 8% of the control catchbasin during a continuous 30 minute scour test run with 5 minute duration inflows of 1.2, 4.8, 8.4, 12.0, and 15.6 L/s.

Appendix C. Verification Guidance Pursuant to ISO/FDIS 14034:2015

Appendix C provides guidance on performance testing and verification of technologies pursuant to ISO/FDIS 14034:2015

1. Definition of Roles:

Verifier - Organization that performs environmental technology verification

Test body - Organization that performs testing, test-implementation and reporting on the testing of an environmental technology

Applicant – Organization proposing a technology for which performance will be verified through environmental technology verification

2. Terminology

2.1 Terms related to verification

Verification - Confirmation through the provision of objective evidence

Verification Plan - Detailed planning document for implementation of the environmental technology verification

Verification Report - Document detailing the environmental technology verification and its results

Verification Statement - Document summarizing the results of the environmental technology verification

Test Plan - Detailed planning document specifying the principles, testing methods, conditions and procedures, required to carry out testing and to produce test data

Data Quality - Characteristics of data that relate to their ability to satisfy stated requirements [SOURCE: ISO 14040:2006]

Test Report - Document describing conditions and results of testing

2.2 Terms related to technology

Technology - Application of scientific knowledge, tools, techniques, crafts, or systems in order to solve a problem or achieve an objective, which can result in a product or process

Product - Any goods or service [SOURCE: ISO 14050:2009]

Process - Set of interrelated or interacting activities that transforms inputs into outputs [SOURCE: ISO 14001]

Environmental Technology - Technology that either results in an environmental added value or measures parameters that indicate an environmental impact

Environmental Technology Verification - Verification of the performance of an environmental technology by a verifier

Environmental Impact - Change to the environment, whether adverse or beneficial, wholly or partially resulting from material acquisition, design, production, use, or end-of-use of a technology [SOURCE: adapted from ISO 14001]

Environmental Added Value - More beneficial or less adverse environmental impact of a technology with respect to the relevant alternative

Relevant Alternative - Technology applied currently in similar situation as the environmental technology for which performance will be verified through environmental technology verification

2.3 Terms related to performance

Performance - Measurable result; Performance relates to measurable results supported by numerical quantitative findings. [SOURCE: adapted from ISO 14001]

Performance Claim - Statement of the performance of the environmental technology declared by the applicant

Performance Parameter - Numerical or other measurable factor of the performance of a technology

3. General principles and requirements

3.1 Principles

General - The purpose of environmental technology verification is to provide a credible and impartial account of the performance of environmental technologies. Environmental technology verification is based on a number of principles to ensure that verifications are performed and reported accurately, clearly, unambiguously and objectively.

Factual approach - Verification statements are based on factual and relevant evidence collected through an objective confirmation of the performance of environmental technologies.

Sustainability - Environmental technology verification is a tool in support of sustainability, by providing credible information on the performance of environmental technologies.

Transparency and credibility - Environmental technology verification is based on reliable test results and robust procedures. The process is facilitated such that, to the greatest extent feasible, methods and data are fully disclosed and reports are clear, complete, objective and useful to the interested parties.

Flexibility - Environmental technology verification allows for flexibility in the specification of performance parameters and test methods. This is achieved through dialogue among the applicant, verifier and interested parties to maximize utility of environmental technology verification.

3.2 Requirements

When verifying performance of environmental technologies, the requirements of ISO/FDIS 14034 and the current version of ISO/IEC 17020 Conformity assessment – requirements for the operation of various types of bodies performing inspection - shall be applied and demonstrated.

4. Application review

4.1 Administrative review

Administrative review shall ensure that all information requested for the application has been provided in accordance with the requirements specified.

4.2 Technical review

Technical review shall ensure that:
a) The technology fulfils the definition of environmental technology
b) The performance claim for the intended application of the technology addresses the needs of the interested parties
c) The information on the technology is sufficient to review the performance claim.

4.3 Feedback to Applicant

Any issues related to the acceptance or rejection of the application that may arise from the administrative or the technical review shall be resolved prior to the verification. Acceptance or rejection of the application shall be communicated to the applicant with justification.

5. Pre-verification

5.1 Specification of performance to be verified

Performance to be verified shall be specified in consultation with the applicant prior to the establishment of the verification plan.

Performance parameters shall be specified considering that:
a) They are relevant and sufficient for the verification of the performance of the environmental technology, and the environmental added value, if applicable;
b) They correspond in full to the needs of the interested parties;
c) They can be quantitatively verified through testing;
d) Their numerical values can be verified under set operating conditions, using existing verification plans and relevant technical references, including standardized testing methods, preferably based on international standards.

5.2 Verification plan

The verification plan shall detail the verification procedure specific to the technology and the performance to be verified. The testing conditions specified in the verification plan shall be identical to the operational conditions of the technology defined. The verification plan shall include at a minimum:
a) Identification of the verifier;

b) Identification of the applicant;
c) Unique identification of the verification plan and date of issue;
d) Description of the technology;
e) A list of performance parameters and their assigned numerical values and the description of how they will be verified;
f) Technical and operational details of the planned verification;
g) Specification of the requirements for the test data, including quality and quantity and testing conditions;
h) Description of methods for the assessment of the test data and their quality.

NOTE:
- Requirements on data and data quality should refer to the quality level (e.g. regarding reproducibility, repeatability, ranges of confidence, accuracy, uncertainties,) generally accepted by the scientific community for the technology or (by default) in the industrial sector concerned.
- Other existing verification plans, similar relevant technical references including applicable legislation and standardized test methods, preferably international standards, should be used or referred to wherever available.

6. Verification

The verification of the performance shall be organized as follows: i) acceptance of existing test data; ii) generation of additional test data if needed and iii) confirmation of the performance based on the results of test data assessment.

6.1 Acceptance of existing test data

Test data provided by the applicant which were generated prior to verification may be accepted for the verification if they meet the following requirements:
a) They are relevant for the performance to be verified;
b) They are produced and reported according to the requirements of ISO/IEC 17025;
c) They meet the requirements specified in the verification plan.

If the existing test data do not meet the above requirements then additional test data shall be generated. This shall be communicated to the applicant.

6.2 Generation of additional test data

If any additional test data is required, they shall be produced meeting the requirements specified. This shall be communicated to the applicant.

6.3 Confirmation of performance

Existing test data, that is accepted and additional test data that is generated shall be assessed against the performance specified in the verification plan. The result of the assessment shall be a confirmation of the performance of the technology, achieved under the same conditions, constraints and limitations as those specified for the generation of the test data used for verification.

7. Reporting

7.1 Verification report

A verification report shall be developed. It shall adhere to the verification plan and shall include at a minimum:
a) Identification of the verifier;
b) Identification of the applicant;
c) Unique identification of the report and date of issue;
d) Date of verification;
e) Description of the technology;
f) Test results;
g) Verification results including the verified performance, test conditions, constraints and limitations under which they are met;
h) Description on how the requirements for the verification of the performance and for the test data, as specified in the verification plan, were met, including reporting of any deviations;
i) Signature or other indication of approval by verifier;

If it is necessary to include, information not verified under the environmental technology verification, this shall be clearly stated and explained. The report shall be submitted to the applicant for review and comment. The comments may be incorporated as deemed appropriate.

7.2 Verification statement

A short document summarizing the verification report shall be developed. It shall include at a minimum:

a) Identification of the verifier;
b) Identification of the applicant;
c) Unique identification of the statement and date of issue;
d) A summary description of the technology;
e) A summary description on how the requirements specified in the verification plan were met;
f) Verification results including the verified performance;
g) Description on how the requirements of the verification specified in the verification plan were met including reporting of any deviations
h) A summary of the verification results including the verified performance, test conditions, constraints and limitations under which they are met;
i) A statement that the verification plan has been addressed,
j) Any other information necessary to understand and use the verification statement
k) Signature or other indication of approval by the verifier.

If it is necessary to include, information not verified under the environmental technology verification this shall be clearly stated and explained. The statement shall be submitted to the applicant for review and comment. The comments may be incorporated as deemed appropriate.

8. Post-verification

8.1 Publication

At a minimum, the verification statement should be made available publicly. The publication shall be included in a publicly available directory (e.g. website).

The applicant shall make the statement available to interested parties in full and shall not use parts of the statement for any purpose.

8.2 Validity of the verification report / verification statement

The applicant shall:
a) Ensure that the technology which performance has been verified is conforming to the conditions as per its verification, published verification statement and report, if relevant;
b) Inform the verifier, in writing, of any changes that are made to the technology.

Based on the information provided by the applicant, the verifier shall determine the impact of any changes on the verified performance of the technology to the verification conditions, and therefore the validity of the verification statement and the verification report.

If it is determined that the verification statement and verification report are no longer valid, it shall be communicated to the applicant and made publicly available

8.3 Expiration

An expiration date may be established on the verification statement. After the defined time period, upon demonstration that no changes affecting the verified performance have occurred in the technology, the validity of the verification statement could be extended under the same conditions.

9. References

ISO/IEC 14001, Environmental management systems - Requirements with guidance for use

ISO/IEC 14025, Environmental labels and declarations – Type III environmental declarations – Principles and procedures

ISO/IEC 14040, Environmental management — Life cycle assessment — Principles and framework

ISO/IEC 14050, Environmental management — Vocabulary

ISO/IEC 17020, General criteria for the operation of various types of bodies performing inspection

ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories

ISO Guide 82, Guidelines for addressing sustainability in standards

Appendix D. Raw data

Capture test raw data

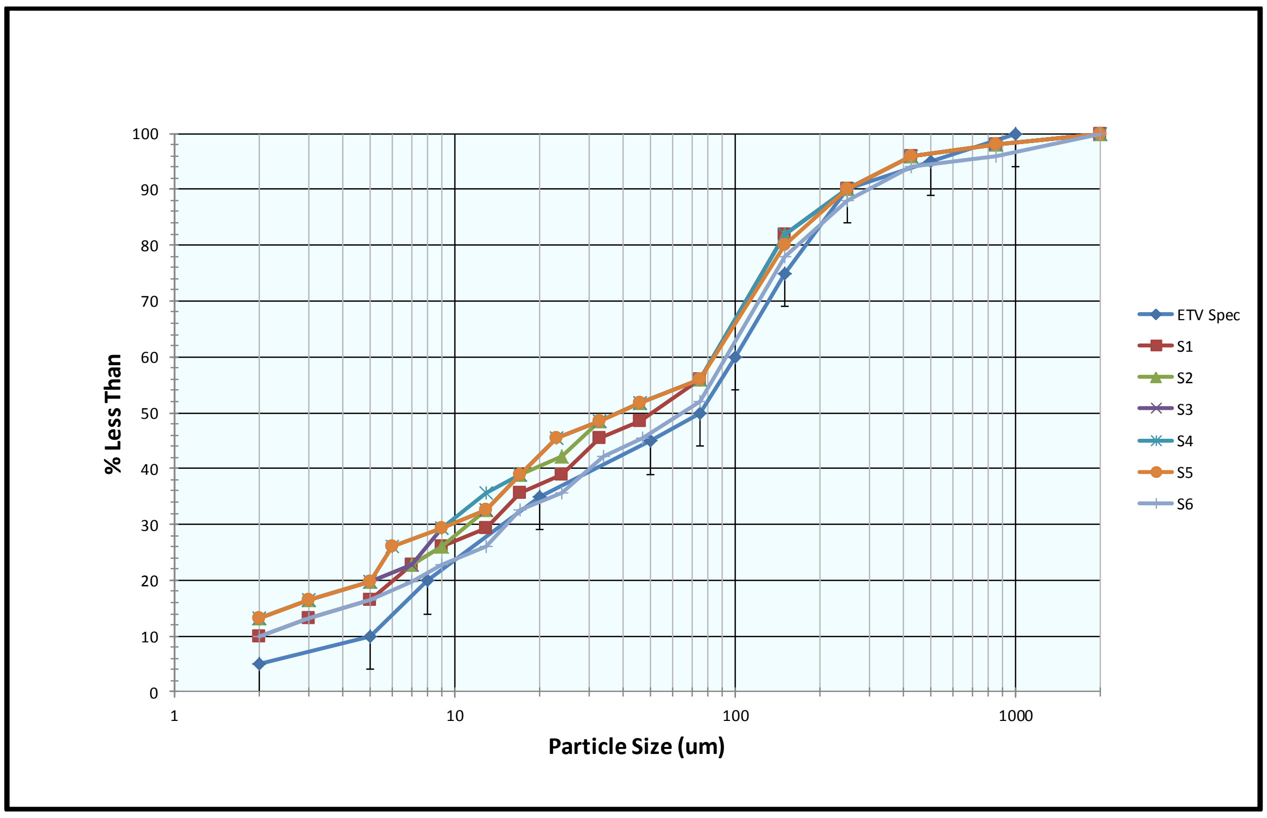

Figure D1. Feed sediment particle size distribution.

Table D1. Removal efficiency based on mass balance.

Run		S1	S2	S3	S4	S5	S6
Target Flow Rate	**(L/s)**	0.24	0.48	1.2	2.4	6.0	8.4
	(gpm)	3.8	7.7	19.0	38.0	95.1	133
Sediment Mass Added	**(kg)**	1.217	2.302	5.072	5.150	4.921	4.812
Sediment Captured in Catch Basin	**(kg)**	0.765	1.368	2.643	2.184	1.238	1.287
Sediment Captured on FCS and Grate	**(kg)**	0.013	0.010	0.016	0.012	0	0
Total Mass Captured	**(kg)**	0.778	1.378	2.659	2.196	1.238	1.287
Removal Efficiency	**(%)**	64.0	59.9	52.4	42.6	25.2	26.7

Scour test raw data

Run Summary for CB Shield – Simulated Streetscape

- Control (No CB Shield Installed)

Run Date: March 6th, 2015

Sediment Pre-load:

- The test sediment was the AGSCO silica sand (1-1000 micron)
- Sediment was pre-loaded on March 5th
- The total sediment load was 53 kg
- Following the preload, the sump was filled with water and allowed to sit overnight

Water Temperature:

Temperature at 1:00 minutes into run: 18.1 °C
Temperature at 7:00 minutes into run: 12.3 °C
Temperature at 13:00 minutes into run: 11.7 °C
Temperature at 52:30 minutes into run: 12.5 °C

Run Data:

Target Flow Rate	Run Time	Flow Rate
1.2 L/S (19 GPM)	0:00	19.3[1]
	0:30	19.7[1]
	1:00	19.8
	1:30	19.9
	2:00	19.9
	2:30	19.9
	3:00	19.9
	3:30	19.9
	4:00	19.8
	4:30	19.9
	5:00	19.9
	5:30	20.0
	6:00	22.3
Average Flow Rate (US GPM):		20.1
4.8 L/S (76 GPM)	6:30	74.2[1]
	7:00	76.3
	7:30	76.3
	8:00	76.3
	8:30	76.2
	9:00	76.2
	9:30	76.2
	10:00	76.0
	10:30	76.2
	11:00	76.1

	11:30	76.0
	12:00	80.7
Average Flow Rate (US GPM):		76.6

[1] Transition flow rate, not included in the average

Target Flow Rate	Run Time	Flow Rate
8.4 L/S (133 GPM)	12:30	134.6[1]
	13:00	132.6
	13:30	132.9
	14:00	132.4
	14:30	132.5
	15:00	132.9
	15:30	132.8
	16:00	132.5
	16:30	132.7
	17:00	132.4
	17:30	132.6
	18:00	132.4
Average Flow Rate (US GPM):		132.6
12.0 L/S [2] (190 GPM)	25:00	185.2[1]
	25:30	188.7
	26:00	189.3
	26:30	189.5
	27:00	191.0
	27:30	191.0
	28:00	190.8
	28:30	190.8
	29:00	190.6
	29:30	191.0
	30:00	190.7
	30:30	191.2
Average Flow Rate (US GPM):		190.4
15.6 L/S [3] (247 GPM)	52:00	245.7[1]
	52:30	249.1
	53:00	248.2
	53:30	248.6
	54:00	248.0
	54:30	247.9
	55:00	247.9
	55:30	247.7
	56:00	248.1
	56:30	247.9
	57:00	247.8
	57:30	247.7
Average Flow Rate (US GPM):		248.1

[1] Transition flow rate, not included in the average

[2] The system was shut down between flow 8.4 L/s and flow 12.0 L/s due to standpipe overflow

[3] The system was shut down between flow 12.0 L/s and flow 15.6 L/s due to standpipe overflow

Effluent Analysis:

Run Time (minutes)	Sample ID	Sample Description	SSC (mg/L)	
			Measured	Corrected[4]
0:00	Background 1-1	Background sample taken at 1.2 L/s	< MDL	-
0:30	Effluent 1-1	1.2 L/s transition sample #1	94.3	94.3
1:00	Effluent 2-1	1st sample taken at 1.2 L/s	129.2	129.2
2:00	Effluent 3-1	2nd sample taken at 1.2 L/s	185.3	185.3
3:00	Effluent 4-1	3rd sample taken at 1.2 L/s	206.0	206.0
4:00	Effluent 5-1	4th sample taken at 1.2 L/s	176.0	176.0
5:00	Effluent 6-1	5th sample taken at 1.2 L/s	523.6	523.6
6:00	Effluent 7-1	6th sample taken at 1.2 L/s	495.7	495.7
7:00	Background 2-1	Background sample taken at 4.8 L/s	< MDL	-
6:30	Effluent 8-1	4.8 L/s transition sample #1	6420	6420
7:00	Effluent 9-1	1st sample taken at 4.8 L/s	7164	7164
8:00	Effluent 10-1	2nd sample taken at 4.8 L/s	8094	8094
9:00	Effluent 11-1	3rd sample taken at 4.8 L/s	6762	6762
10:00	Effluent 12-1	4th sample taken at 4.8 L/s	4842	4842
11:00	Effluent 13-1	5th sample taken at 4.8 L/s	5266	5266
12:00	Effluent 14-1	6th sample taken at 4.8 L/s	4768	4768
13:00	Background 3-1	Background sample taken at 8.4 L/s	1.8	-
12:30	Effluent 15-1	8.4 L/s transition sample #1	6665	6663
13:00	Effluent 16-1	1st sample taken at 8.4 L/s	5431	5429
14:00	Effluent 17-1	2nd sample taken at 8.4 L/s	6649	6648
15:00	Effluent 18-1	3rd sample taken at 8.4 L/s	5027	5025
16:00	Effluent 19-1	4th sample taken at 8.4 L/s	5861	5859
17:00	Effluent 20-1	5th sample taken at 8.4 L/s	5021	5019
18:00	Effluent 21-1	6th sample taken at 8.4 L/s	3251	3249
The system was shut down due to standpipe overflow				
25:30	Background 4-1	Background sample taken at 12.0 L/s	41.2	-
25:00	Effluent 22-1	12.0 L/s transition sample #1	1569	1528
25:30	Effluent 23-1	1st sample taken at 12.0 L/s	1927	1886
26:30	Effluent 24-1	2nd sample taken at 12.0 L/s	1474	1432
27:30	Effluent 25-1	3rd sample taken at 12.0 L/s	1208	1167
28:30	Effluent 26-1	4th sample taken at 12.0 L/s	1550	1508
29:30	Effluent 27-1	5th sample taken at 12.0 L/s	1141	1100
30:30	Effluent 28-1	6th sample taken at 12.0 L/s	749.5	708
The system was shut down due to standpipe overflow				
52:00	Effluent 29-1	15.6 L/s transition sample #1	Not tested	
52:30	Background 5-1	1st Background sample taken at 15.6 L/s	145.6	-
52:30	Effluent 30-1	1st effluent sample taken at 15.6 L/s	532.5	386.9
53:30	Background 6-1	2nd Background sample taken at 15.6 L/s	179.2	-
53:30	Effluent 31-1	2nd effluent sample taken at 15.6 L/s	432.0	252.7
54:30	Background 7-1	3rd Background sample taken at 15.6 L/s	182.4	-
54:30	Effluent 32-1	3rd effluent sample taken at 15.6 L/s	554.9	372.5
55:30	Background 8-1	4th Background sample taken at 15.6 L/s	198.2	-
55:30	Effluent 33-1	4th effluent sample taken at 15.6 L/s	530.6	332.4

56:30	Background 9-1	5th Background sample taken at 15.6 L/s	200.3	-
56:30	Effluent 34-1	5th effluent sample taken at 15.6 L/s	480.1	279.8
57:30	Background 10-1	6th Background sample taken at 15.6 L/s	210.0	-
57:30	Effluent 35-1	6th effluent sample taken at 15.6 L/s	520.2	310.2

MDL – Method detection limit

[4] $SSC_{corrected} = SSC_{measured} - SSC_{background}$

Run Summary for CB Shield Scour Testing

– Simulated Streetscape - With CB Shield Insert

Run Date: March 13th, 2015

Sediment Pre-load:

- The test sediment was the AGSCO silica sand (1-1000 micron)
- Sediment was pre-loaded on March 12th
- The total sediment load was 53 kg
- Following the preload, the sump was filled with water and allowed to sit overnight

Water Temperature:

Temperature at 1:00 minutes into run: 17.1 °C
Temperature at 7:00 minutes into run: 10.6 °C
Temperature at 13:00 minutes into run: 10.0 °C
Temperature at 19:00 minutes into run: 10.4 °C
Temperature at 25:00 minutes into run: 10.7 °C

Run Data:

Target Flow Rate	Run Time	Flow Rate
1.2 L/S (19 GPM)	0:00	17.7[1]
	0:30	18.8[1]
	1:00	18.8
	1:30	18.9
	2:00	18.9
	2:30	19.0
	3:00	18.9
	3:30	19.0
	4:00	18.9
	4:30	18.9
	5:00	18.9
	5:30	18.9
	6:00	18.9
Average Flow Rate (US GPM):		18.9
4.8 L/S (76 GPM)	6:30	50.9[1]
	7:00	76.6
	7:30	76.5
	8:00	76.2
	8:30	76.0
	9:00	75.8
	9:30	76.0
	10:00	76.0
	10:30	75.8

	11:00	75.8
	11:30	76.0
	12:00	75.9
Average Flow Rate (US GPM):		76.1
[1] Transition flow rate, not included in the average		
Target Flow Rate	Run Time	Flow Rate
8.4 L/S (133 GPM)	12:30	131.0[1]
	13:00	132.6
	13:30	132.5
	14:00	132.8
	14:30	132.7
	15:00	132.6
	15:30	133.0
	16:00	132.8
	16:30	132.8
	17:00	132.8
	17:30	132.8
	18:00	132.6
Average Flow Rate (US GPM):		132.7
12.0 L/S (190 GPM)	25:00	181.9[1]
	25:30	187.6
	26:00	188.5
	26:30	189.8
	27:00	189.4
	27:30	189.2
	28:00	190.0
	28:30	189.4
	29:00	189.6
	29:30	190.0
	30:00	189.9
	30:30	189.9
Average Flow Rate (US GPM):		189.4
15.6 L/S (247 GPM)	52:00	247.5[1]
	52:30	248.0
	53:00	247.8
	53:30	247.6
	54:00	247.5
	54:30	247.6
	55:00	247.7
	55:30	247.6
	56:00	247.6
	56:30	247.7
	57:00	247.6
	57:30	247.5
Average Flow Rate (US GPM):		247.7

[1] Transition flow rate, not included in the average

Effluent Analysis:

Run Time (minutes)	Sample ID	Sample Description	SSC (mg/L)	
			Measured	Corrected[2]
0:00	Background 1-1	Background sample taken at 1.2 L/s	< MDL	-
0:30	Effluent 1-1	1.2 L/s transition sample #1	31.5	31.5
1:00	Effluent 2-1	1st sample taken at 1.2 L/s	17.7	17.7
2:00	Effluent 3-1	2nd sample taken at 1.2 L/s	6.5	6.5
3:00	Effluent 4-1	3rd sample taken at 1.2 L/s	2.7	2.7
4:00	Effluent 5-1	4th sample taken at 1.2 L/s	3.1	3.1
5:00	Effluent 6-1	5th sample taken at 1.2 L/s	4.6	4.6
6:00	Effluent 7-1	6th sample taken at 1.2 L/s	< MDL	< MDL
7:00	Background 2-1	Background sample taken at 4.8 L/s	< MDL	-
6:30	Effluent 8-1	4.8 L/s transition sample #1	3.0	3.0
7:00	Effluent 9-1	1st sample taken at 4.8 L/s	8.2	8.2
8:00	Effluent 10-1	2nd sample taken at 4.8 L/s	4.0	4.0
9:00	Effluent 11-1	3rd sample taken at 4.8 L/s	< MDL	< MDL
10:00	Effluent 12-1	4th sample taken at 4.8 L/s	< MDL	< MDL
11:00	Effluent 13-1	5th sample taken at 4.8 L/s	1.7	1.7
12:00	Effluent 14-1	6th sample taken at 4.8 L/s	< MDL	< MDL
13:00	Background 3-1	Background sample taken at 8.4 L/s	< MDL	-
12:30	Effluent 15-1	8.4 L/s transition sample #1	2.5	2.5
13:00	Effluent 16-1	1st sample taken at 8.4 L/s	5.4	5.4
14:00	Effluent 17-1	2nd sample taken at 8.4 L/s	10	10
15:00	Effluent 18-1	3rd sample taken at 8.4 L/s	9.5	9.5
16:00	Effluent 19-1	4th sample taken at 8.4 L/s	10	10
17:00	Effluent 20-1	5th sample taken at 8.4 L/s	8.4	8.4
18:00	Effluent 21-1	6th sample taken at 8.4 L/s	8.2	8.2
19:00	Background 4-1	Background sample taken at 12.0 L/s	1.6	-
18:30	Effluent 22-1	12.0 L/s transition sample #1	21.1	19.5
19:00	Effluent 23-1	1st sample taken at 12.0 L/s	40.0	38.4
20:00	Effluent 24-1	2nd sample taken at 12.0 L/s	81.0	79.4
21:00	Effluent 25-1	3rd sample taken at 12.0 L/s	115	113
22:00	Effluent 26-1	4th sample taken at 12.0 L/s	104	103
23:00	Effluent 27-1	5th sample taken at 12.0 L/s	116	114
24:00	Effluent 28-1	6th sample taken at 12.0 L/s	93.9	92.3
25:00	Background 5-1	1st Background sample taken at 15.6 L/s	2.0	-
24:30	Effluent 29-1	15.6 L/s transition sample #1	131.3	128.0
25:00	Effluent 30-1	1st sample taken at 15.6 L/s	180.8	177.4
26:00	Effluent 31-1	2nd sample taken at 15.6 L/s	214.9	211.6
27:00	Effluent 32-1	3rd sample taken at 15.6 L/s	223.7	220.3

28:00	Effluent 33-1	4th sample taken at 15.6 L/s	191.1	187.8
29:00	Effluent 34-1	5th sample taken at 15.6 L/s	227.7	224.4
30:00	Effluent 35-1	6th sample taken at 15.6 L/s	202.5	199.2
30:00	Background 6-1	2nd Background sample taken at 15.6 L/s	4.6	-

MDL – Method detection limit

[2] $SSC_{corrected} = SSC_{measured} - SSC_{background}$

For additional datasets please request for vendor's CETV formal application.