ISO 14034:2016 Verification Report

Performance Testing of Hydroworks® HS 4 Stormwater Treatment System / Hydroworks, LLC

FINAL – STRICTLY CONFIDENTIAL

Date: May 22, 2018

Prepared For:
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Authentication

Dated: May 22, 2018
Approved by:

Name: Tim Van Seters
Title/Position: Senior Manager
Department: Sustainable Technologies
Organization: Toronto and Region Conservation Authority

ISO 14034:2016 Verification Report for Hydroworks, LLC

Technology Name: HydroStorm® (HS) 4 Separator

Contents

Disclaimer

The Toronto and Region Conservation Authority ("TRCA") including its employees and Directors, (the "Verifier") has participated in the ISO 14034:2016 Environmental Technology Verification (ETV) of the Hydroworks, LLC (the "Vendor") Hydroworks® HS 4 Stormwater Treatment System technology.

Any reference to the "Technology" refers to the Vendor's Hydroworks® HydroStorm (HS) 4 Separator.

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 Hydroworks® HydroStorm (HS) 4 Separator 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.

The claim can be applied to other units smaller or larger than the tested unit as long as the scaling rule specified in the Procedure for Laboratory of Testing of Oil Grit Separators (Version 3.0, June 2014) has been met.

Executive Summary

The Hydroworks® HydroStorm (HS) 4 Separator was subjected to verification using the International Standard ISO 14034:2016 and also taking into account the Canadian ETV Program General Verification Protocol.

The verification process was mutually agreed upon by GLOBE Performance Solutions ("GPS"), 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 the TRCA according to the criteria and guidelines set out in the International Standard ISO 14034:2016, is an official audit of the testing report generated through the performance testing of the Hydroworks® HydroStorm (HS) 4 Separator.

In addition, through guidance provided by GPS, the TRCA completed its verification of the HS-4 performance taking into account the principles and requirements of the Canadian ETV Program General Verification Protocol of June 2012.

Performance testing for this verification took place at Alden Research Laboratory, Inc. , Holden, Massachusetts, USA. Alden Research Laboratory conducted the testing and employed the *Procedure of Laboratory Testing of Oil-Grit Separators, 2014.*

HS-4 is based on established scientific and technical principles in the field of hydrodynamics.

The HydroStorm Separator is a concrete cylindrical device with an annular pretreatment channel, an inner chamber, and lower collection sump. A schematic of the HS 4 test unit is shown in Figure 1. The pretreatment channel extends below the outlet pipe invert and contains three intermediate low-flow weirs (flush with the outlet invert), and two downstream higher bypass weirs that extend above the outlet invert. The higher weirs bypass high flows to prevent oil and solids from being scoured out of the separator.

As water enters the unit through one or more inlets, coarser solids immediately start to settle below a horizontal grate extending from the inlet to two sets of lower weirs near the outlet pipe. The grating is positioned over the pretreatment channel to help displace the inflow turbulence and protect the captured sediment from scour. Openings are located on the horizontal plate upstream of each weir to allow the flow to be conveyed into the inner chamber and lower sump. The weirs are positioned to create a counter clockwise rotation of water in the inner chamber to minimize turbulence and maximize settling. After water spirals down the inner chamber to the main settling chamber towards the floor of the separator where it deposits suspended sediments, it flows upwards between the wall of the unit and the outer edge of the disk extended from the inner chamber and through an arced opening at the bottom of the pretreatment disk, downstream of the bypass weirs, where it is conveyed into the outlet pipe. An annular secondary horizontal plate with 32% of open-perforations is located within the lower sump to protect the collected sediment from scour. Oil and light liquids are channeled by the vortex suction into the inner chamber through the holes reaching the bottom of the pretreatment area and rise to the water level surface where they are trapped.

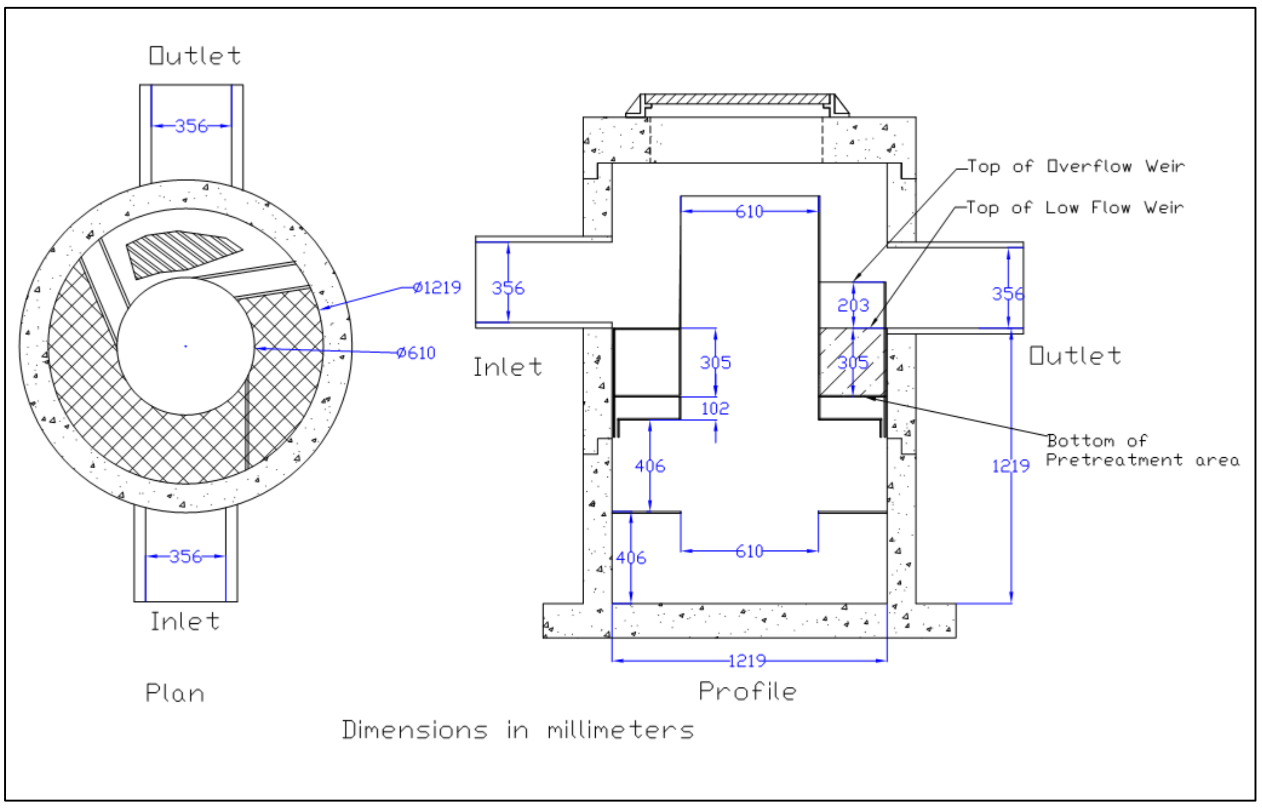

Figure 1: Schematic of the Hydroworks® HS4 Hydrodynamic Separator treatment unit tested as part of this verification.

After examination and audit of the test report and based on the test data submitted, the TRCA has concluded that under the context of OGS testing protocol conditions Hydroworks, LLC's Hydroworks® HydroStorm (HS) 4 Separator provides an environmental benefit of capturing suspended sediments, preventing scour of captured sediment, and preventing re-entrainment of light liquids from stormwater runoff.

Accordingly, the TRCA recommends that the performance claim(s) be worded as follows:

Performance Claim(s)

Capture test:

During the capture test, the Hydroworks HydroStorm OGS device, with a false floor set to 50% of the manufacturer's recommended maximum sediment storage depth and a constant influent test sediment concentration of 200 mg/L, removes 69, 64, 60, 56, 46, 41, and 36 percent of influent sediment by mass at surface loading rates of 40, 80, 200, 400, 600, 1000, and 1400 L/min/m^2, respectively.

Scour test:

During the scour test, the Hydroworks HydroStorm OGS device, with 10.2 cm (4 inches) of test sediment pre-loaded onto a false floor reaching 50% of the manufacturer's recommended maximum sediment sump storage depth and onto the pre-treatment channel emulating depositional pattern of the 40 L/min/m^2 capture test, generate corrected effluent concentrations of 22.4, 28.5, 20.0, 19.1, and 24.4 mg/L at 5-minute duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m^2, respectively.

Light liquid re-entrainment test:

During the light liquid re-entrainment test, the Hydroworks HS OGS device with surrogate low-density polyethylene beads preloaded within the lower chamber oil collection zone, representing a floating light liquid volume equal to a depth of 50.8 mm over the sedimentation area, retains 100, 99.9, 95.4, 95.7, and 97.5 percent of loaded beads by mass during the 5-minute duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m^2, respectively.

1. Introduction

GLOBE Performance Solutions ("GPS") has engaged the Toronto and Region Conservation Authority ("TRCA") to verify the performance of Hydroworks® HS 4 Stormwater Treatment System within the framework of a subcontracted agreement. The Hydroworks® HS 4 Stormwater Treatment System is a technology for treating stormwater as an oil and grit separator. Both oil and grit are captured by the unit and what is captured is prevented from being re-entrained or scoured by subsequent stormwater passing through the unit.

GLOBE Performance Solutions, in collaboration with the TRCA, has further agreed to prepare a verification report and verification statement using the International Standard ISO 14034:2016..

This verification report, prepared by the TRCA (the Verifier), in its capacity as a ETV Verification Expert (VE), constitutes a review of the application of the Hydroworks® HS 4 Stormwater Treatment System based on the International Standard ISO 14034:2016 and taking into account the principles and requirements of the Canadian ETV Program General Verification Protocol (GVP).

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

Hydroworks, LLC applied for technology verification through GLOBE Performance Solutions. Testing was carried out by ALDEN Research Laboratory in accordance with ISO 17025 requirements. TRCA examined the test report and prepared the first draft of the verification report.

The Hydroworks® HS 4 Separator is based on established scientific and technical principles in the field of hydrodynamics.

Hydroworks, LLC's performance claims as submitted were:

Capture test:

During the capture test, the Hydroworks HydroStorm OGS device, with a false floor set to 50% of the manufacturer's recommended maximum sediment storage depth and a constant influent test sediment concentration of 200 mg/L, removes 69, 64, 60, 56, 46, 41, and 36 percent of influent sediment by mass at surface loading rates of 40, 80, 200, 400, 600, 1000, and 1400 L/min/m^2, respectively.

Scour test:

During the scour test, the Hydroworks HydroStorm OGS device, with 10.2 cm (4 inches) of test sediment pre-loaded onto a false floor reaching 50% of the manufacturer's recommended maximum sediment sump storage depth and onto the pre-treatment channel emulating depositional pattern of the 40 L/min/m^2 capture test, generate corrected effluent concentrations of 22.4, 28.5, 20.0, 19.1, and 24.4 mg/L at 5-minute duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m^2, respectively.

Light liquid re-entrainment test:

During the light liquid re-entrainment test, the Hydroworks HS OGS device with surrogate low-density polyethylene beads preloaded within the lower chamber oil collection zone, representing a floating light liquid volume equal to a depth of 50.8 mm over the sedimentation area, retains 100, 99.9, 95.4, 95.7, and 97.5 percent of loaded beads by mass during the 5-minute duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m^2, respectively.

1.1 Objectives

The objective of this report is to verify the performance claim made by Hydroworks, LLC, for the Hydroworks® HS 4 Separator. This report summarizes the findings of the ETV Verification Expert, the TRCA, based on information and data contained in the Formal Application submitted by Hydroworks, LLC, to GLOBE Performance Solutions.

1.2 Scope

This verification was conducted by the TRCA using the International Standard ISO 14034:2016 and taking into account the principles and requirements of the Canadian ETV Program General Verification Protocol (GVP).

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 International Standard ISO 14034:2016 and the General Verification Protocol of the Canadian ETV Program.

2.2 Applicant Organization

Hydroworks, LLC
136 Central Ave., 2nd FL Clark, NJ
07066
USA

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 series of checklists (tables) below:

Table 1. Checklist Pursuant to ISO 14034:2016 Principles, procedures and requirements for ETV

Reference	Requirements (Criteria)	Verifier Comments
1.1Applicant Information	1.1 Applicant name(s), address(es) and physical location(s)	Applicant name: Hydroworks, LCC Address: 136 Central Ave., 2nd FL Clark, NJ 07066 USA
1.2 Technology Description	1.2 A unique identifier for the technology (e.g., a commercial name, an identification number or applicable version)	The tested technology is uniquely identified as HydroStorm (HS) 4 Separator
1.3 Information about the intended application of the technology NOTE: More than one technology purpose, type of material and measurable property can be provided.	1.3.1 Purpose of the technology	The technology separates suspended sediments and free floating light liquids from stormwater and snowmelt by gravity and prevents scour and re-entrainment of captured sediment and light liquids.
	1.3.2 Type of material for which the technology is intended	The technology is intended to treat suspended sediments and light liquids in stormwater and snowmelt runoff.
	1.3.3 Measurable property that is affected by the technology and the way in which it is affected	The mass of sediment captured in the sump, the effluent concentration of scoured sediment and the effluent concentration of light liquid (using surrogate plastic beads) can be measured in a controlled laboratory testing to understand the suspended sediment removal efficiency and potential of the unit to scour captured sediment and re-entrain light liquids.
	1.3.4 Information sufficient to understand the operation and performance of the technology	Applicant has provided sufficient descriptions, diagrams, and photographs to illustrate the technology's operation and performance testing.
	1.3.5 Development status of the technology proposed for verification and its readiness for market (Note: Technology proposed for	The technology is market ready.

	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)	
	1.3.6 Information on relevant alternatives of the technology, including relevant performance and environmental impacts.	Information on relevant alternatives and their performances was not provided, but the ETV factsheet for this product will be published alongside previously verified oil and grit separators. Interested parties may compare and contrast performances between units.
	1.3.7 Information on significant environmental impacts of the technology proposed for verification and its environmental added value, if applicable.	The technology will reduce downstream transport of suspended sediments and light liquid pollutants found in stormwater and snowmelt runoff.
	1.3.8 Does the technology fulfil the definition of environmental technology?	Yes. Definition: "technology that either results in an environmental added value or measures parameters that indicate an environmental impact". The HydroStorm provides an environmental added value of decreased effluent concentration of suspended sediments and free light liquid pollutants of treated stormwater and snowmelt runoff.
1.4 Operational aspects	1.4.1 Are the Installation and operating requirements and conditions described?	Yes, installation and operating requirements are detailed within the technology's technical manual v 2.5.
	1.4.2 Are the service and maintenance requirements described?	Maintenance requirements and procedures are outlined in the technology's technical manual v 2.5.
	1.4.3 Is information provided on the expected length of time for which the technology functions under normal operating conditions?	Inspection of the unit is prescribed once every 2 weeks during the construction phase and once every year for a stabilized site. As such, the technology is expected to function for a year under normal operation conditions before it requires maintenance.
1.5 Legal and regulatory context	1.5.1 Is information provided on the relevant legal requirements and/or standards related to the technology and its use?	The technology abides by all applicable standards related to construction and operation of municipal drainage structures.
	1.5.2 Does the technology adhere to applicable regulatory requirements?	In the "declaration regarding codes and standards" an authorized officer has stated that the unit abides by all applicable codes and standards for the construction and operation of a municipal drainage structure.
1.6 Health and Safety	1.6 Are there any applicable health and safety requirements and considerations?	None provided. Since maintenance can be done without entering the unit, health and safety requirements are likely minimal.
1.7 Performance claim(s) and parameters	1.7.1 Do the performance claims for the intended application of the technology address the needs of the interested parties?	Yes, having stormwater treatment as the intended application, the performance claims address the ability of the technology to effectively treat stormwater for suspended sediments and free floating light liquids at various surface loading rates.

	1.7.2 Is the information on the technology sufficient to review the performance claim(s)?	Yes, information provided on how the technology functions, the testing procedure, and collected data is sufficient to review the performance claim. Requests for clarifications and additional information were communicated through Globe Performance Solutions and were provided to the verifier's satisfaction.
	1.7.3 Do the performance claim(s) to be verified include proposed performance parameters and numerical values?	Yes, performance claims include numerical laboratory test results for sediment removal efficiencies, sediment effluent concentration and surrogate light liquid effluent concentrations.
	1.7.4 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 are relevant and sufficient to analyze the unit's removal efficiency for suspended sediments, and potential for scouring and re-entrainment for sediments and free floating oils, respectively.
	1.7.5 Can the performance claims be quantitatively verified through testing?	Yes. Performance claims were based on testing done on the unit in a laboratory using the "Procedure for Laboratory Testing of Oil-Grit Separators". The claims can be verified by re-testing the unit under the same conditions and constraints.
	1.7.6 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?	Yes.
1.8 Test data	1.8.1 Are relevant test data and the methods for acquiring these data provided to support the performance claim?	Yes, summary datasets were provided. Full data sets available upon request.
	1.8.2 Are specifications of the requirements for the test data provided, including quality and quantity and testing conditions?	Yes, specifications regarding testing conditions and adherence to standards set out by the "Procedure for Laboratory Testing of Oil-Grit Separators" protocol have been provided.
	1.8.3 Is a description provided of the methods for the assessment of the test data and their quality?	Yes, below are few means of providing Quality Assurance for the test data: 1. Particle size distribution of test sediment is required to be within 6% of the ETV test sediment specifications without the median particle size exceeding 75um. Three sample composites are used for the assessment. 2. Flow rates are required to be measured at no longer than 30 second intervals and cannot vary by more than +/- 10% while having Coefficient of Variation (COV) of less than 0.04.

		3. Background sediment concentrations are monitored for scour and removal tests. 4. Internationally standardized procedures are followed in the laboratory for sediment analysis. See protocol for additional specific controls.
	1.8.4 Are the data at a quality level generally accepted by the scientific community for the technology and/or the industrial sector concerned?	Yes. Test data is produced from a standardized testing protocol.
	1.8.5 Are the data of sufficient quality in terms of reproducibility, repeatability, ranges of confidence, accuracy, and uncertainties?	Yes, the protocol was followed with minor exceptions that are not viewed to have an impact on results or reproducibility.
	1.8.6 Are other relevant technical references included, such as other existing verification plans, applicable legislation, standardized test methods and international standards?	Yes. 1. ASTM D3977-97(2013), Standard test methods for determining sediment concentration in water samples. 2. ASTM D422-63, Standard test method for particle-size analysis of soils; reapproved 2007. 3. ASTM D4959-07, Standard test method for determination of water (moisture) content of soil by direct heating. 4. ISO 13320:2009, Particle size analysis – laser diffraction methods. 5. Canadian environmental technology verification program (CETV) Procedure for laboratory testing of oil-grit separators, June 6, 2014 – version 3.0. 6. ASTM D792-13, Standard test methods for density and specific gravity of plastics by displacement.
	1.8.7 Was information provided to explain deviations from the test plan?	Yes. <u>Scour test:</u> It was necessary to change flow meters during the sediment scour and light liquid re-entrainment test, as the required flows exceeded the minimum and/or maximum range of any single meter. When the flow capacity of the selected meter was reached, the flow was shut down over a period of approximately 10 seconds and all flow data saved. The next data acquisition file was executed and flow increased at a rate that corresponded to reaching each previous target flow after a period of 1-minute. This procedure was approved by CETV prior to testing, in recognition that most particles susceptible to scour at low flows would not be in the sump at higher flows. Similarly, re-entrainment of the oil beads was not expected to be significantly affected by the flow meter change. <u>Sediment removal test:</u> Sediment injection is required to occur at a distance from the inlet of the unit that is the lesser of 3 m or 5 pipe diameters (1.75 m).

		However, sediment injection occurred at 4 pipe diameters (1.4 m) upstream of the inlet, which was considered to yield more conservative results. Background concentrations did exceed 20 mg/L (from 0.2 -28.4) during the 60 L/min/m2 capture test with the perforated secondary plate, but this was deemed to have negligible effect on results.
1.9 Verification	1.9.1 Were the test data assessed against the performance specified in the verification plan?	Yes.
	1.9.2 Do the test data confirm the performance of the technology, achieved under the same conditions, constraints and limitations as those specified?	Yes. Test data confirms the performance of the technology achieved during testing under conditions and constraints outlined by the "Procedure for Laboratory Testing of Oil-Grit Separators".
	1.9.3 Are the performance claims verified as originally stated?	The HydroStorm has a treatment rate of 1400 L/min/m^2 prior to bypass. HydroStorm provides a minimum of 60% TSS removal at 200 L/min/m2 and 35% TSS removal at 1400 L/min/m^2 for the ETV TSS particle size distribution. The scour in HydroStorm is less than 25 mg/l at 2600 L/min/m^2 based on preloading the sump of the separator as well as the pretreatment area. HydroStorm provides a minimum of 95% retention of floatables at any given flow rate.

	1.9.4 If the performance claims are not verified as originally stated, how should they be modified?	<u>Capture test[1]:</u> During the capture test, the Hydroworks® HS4 Hydrodynamic Separator, with a false floor set to 50% of the manufacturer's recommended maximum sediment storage depth and a constant influent test sediment concentration of 200 mg/L, removes 69, 64, 60, 56, 46, 41, and 36 percent of influent sediment by mass at surface loading rates of 40, 80, 200, 400, 600, 1000, and 1400 L/min/m^2, respectively. <u>Scour test[2]:</u> During the scour test, the Hydroworks® HS4 Hydrodynamic Separator, with 10.2 cm (4 inches) of test sediment pre-loaded onto a false floor reaching 50% of the manufacturer's recommended maximum sediment sump storage depth and sediment loaded onto the pre-treatment channel emulating depositional pattern of the 40 L/min/m^2 capture test, generate corrected effluent concentrations of 22.4, 28.5, 20.0, 19.1, and 24.4 mg/L at 5-minute duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m^2, respectively.

[1] The claim can be applied to other units smaller or larger than the tested unit as long as the untested units meet the scaling rule specified in the Procedure for Laboratory of Testing of Oil Grit Separators (Version 3.0, June 2014)

		Light liquid re-entrainment test[2]: During the light liquid re-entrainment test, the Hydroworks® HS4 Hydrodynamic Separator with surrogate low-density polyethylene beads preloaded within the inner chamber, representing a floating light liquid volume equal to a depth of 50.8 mm over the sedimentation area, retains 100, 99.9, 95.4, 95.7, and 97.5 percent of loaded beads by mass during the 5-minute duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m², respectively.

Table 2. Application Review Checklist

Ref.	Criteria		Yes	No	Verifier Comments
2.1	Signed Formal Application.		☑	☐	
2.2	Signed Declaration Regarding Codes & Standards submitted with signed formal application.		☑	☐	
2.3	Technology provides an environmental benefit.		☑	☐	The technology separates suspended sediments and free floating light liquids from stormwater and snowmelt by gravity and prevents scour and re-entrainment of captured sediment and free floating light liquids respectively.
2.4	A copy of "Claim to be Verified" for each performance claim to be verified included with the Formal Application.		☑	☐	
2.5	Performance Claim composed in a way that satisfies "Criteria for Specifying Claims":		☐	☐	
	2.5.1	Include Technology name (and model number)	☐	☐	HydroStorm 4
	2.5.2	Include application of the technology	☐	☐	Sediment removal – removes certain percentage of influent sediment by mass depending on the loading rate Sediment scour – prevents scour of already captured sediment for surface loading rates ranging from 200-2600 L/min/m² Light liquid re-entrainment – prevents re-entrainment of captured free floating light liquids

2.5.3	Include specific operating conditions during testing	☑	☐	Sediment removal – false floor set to 50% of the manufacturer's recommended maximum sediment storage depth, influent test sediment concentration of 200 mg/L, and loading rates of 40, 80, 200, 400, 600, 1000, and 1400 L/min/m^2. Sediment scour – test sediment reaching 50% of the manufacturer's recommended maximum sediment storage depth with approximately continuous 5 minute duration surface loading rates of 200, 800, 1400, 2000, 2600 L/min/m^2. Light liquid re-entrainment – surrogate low-density polyethylene beads preloaded within the oil collection skirt as a surrogate for free floating liquid with a volume equal to a depth of 50.8 mm over the sedimentation area, with continuous 5 minute duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m^2).
2.5.4	Does it meet the minimum requirement for the majority of Canadian Standards / Guidelines?	☑	☐	
2.5.5	Does it specify the performance achievable by the technology?	☐	☐	Sediment removal–69, 64, 60, 56, 46, 41 and 36 percent removal of influent sediment by mass at surface loading rates of 40, 80, 200, 400, 600, 1000, and 1400 L/min/m^2. Sediment scour – effluent concentrations of 22.4, 28.5, 20.0, 19.1, and 24.4 mg/L during continuous 5 minute duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m^2 through the unit with sediment preloaded to 50% of the manufacturer's recommended maximum sediment storage depth. Light liquid re-entrainment – retains 100, 99.9, 95.4, 95.7, and 97.5% of pre-loaded bead mass during continuous 5-minute duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m^2 respectively.
2.5.6	Is the performance measurable?	☑	☐	Sediment removal: The performance of the device during the capture test is measured by weighing the total captured sediment mass and comparing it to the influent sediment mass. Sediment scour: The performance of the device during the scour test is measured by taking effluent samples at 1 minute intervals for each loading rate and analyzing the sediment concentration of each sample. Light liquid re-entrainment: The performance of the device during the light liquid test is measured by capturing re-entrained beads by use of a screen and comparing the amount to

2.6	Standard operating practices and a description of operating conditions for each individual performance claim specified.	☑	☐	Background concentrations are accounted for in all sources of sediment input - temperatures are kept below 25°C to control the viscosity of water - the 3 sample average of test sediment PSD is within 6% difference of ETV specified sediment PSD -the test sediment was adjusted by Alden to meet the specifications - moisture content/weight of test sediment accounted for Sediment removal: - test sediment from AGSCO Corp. (ETV specified PSD); the material was adjusted by Alden to meet the specifications - surface loading rates tested: 40, 80, 200, 400, 600, 1000, and 1400 L/min/m^2 - false floor: at 50% of the manufacturer's recommended maximum sediment storage depth - minimum of 11.3kg fed at each loading rate - flow rates did not vary more than +/- 10% and have a COV of less than 0.04. - influent sediment concentration is constant at 200 mg/L (+/- 25 mg/L) Scour test: - test sediment from AGSCO Corp. (ETV specified PSD); the material was adjusted by Alden to meet the specifications - loading rates tested at 5 minute intervals: 200, 800, 1400, 2000, 2600 L/min/m^2. - The unit was preloaded to the 50% storage capacity with test sediment reaching a height of 4" off the false floor - the unit is filled with water and test was started within 96 hours - flow rates should not vary more than by +/- 10% and have a COV of less than 0.04. Light liquid test: - test sediment: low density polyethylene beads (Dow Chemical Dowlex 2517) - surface loading rates tested at 5 minute intervals: 200, 800, 1400, 2000, 2600 L/min/m^2. - false floor set at 50% of maximum sediment storage; - beads were into the inner chamber that was filled by water - flow rates should not vary more than by +/- 10% and have a COV of less than 0.04.
2.7	The proponent has supplied significant references describing or supporting scientific and engineering principles of the technology.	☑	☐	The proponent has submitted 9 peer reviewed articles and manuals in relation to hydrodynamic separators.

2.8	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.	☑	☐	Jim Mailloux Alden Research Laboratory, Holden, MA Alden Research Laboratory, Inc. 30 Shrewsbury St., Holden, MA 01520-1843 Phone (508) 829-6000 ext. 6446 jmailloux@aldenlab.com Richard Magee New Jersey Corporation for Advanced Technology Stevens Institute of Technology Center for Environmental Systems Hoboken, NJ 07030 Phone (973)-879-3056 rsmagee@rcn.com
2.9	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")	☑	☐	Health and safety issues regarding the Hydroworks Hydroguard separator relate to confined space entry requirements for installation of the internal inserts in the field. There are no hazardous materials being used in the construction of the separator. Material Safety Data Sheets are provided on the CD for the caulking that is used.
2.10	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")	☑	☐	There is no general training required to install the Hydroguard since Hydroworks, or one of its affiliates installs the internal components in the separator, and the separator itself is installed similar to any drainage manhole structure. Typically personnel from Hydroworks, or its affiliate, will either be onsite to install the internal components or review the installation of separator to ensure it functions as designed. An owner's manual is provided to the owner's consultant or municipality such that the owner is aware of the need for maintenance of the separator. This manual provides instructions on how to inspect and clean the separator and a list of conditions or triggers that would indicate that maintenance is required.
2.11	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.	☑	☐	
2.12	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.	☑	☐	The submitted patent reference number: 2669-2 P
	User manual(s).	☑	☐	
	Maintenance manuals.	☑	☐	

	Operator manuals.	☑	☐	
	Quality assurance procedures.	☑	☐	The test plan consisted of following the standard Procedure for laboratory testing of oil-grit separators (TRCA, 2014).
	Sensor/monitor calibration program.	☐	☑	
	Certification for ISO 9001, ISO 14000, or similar.	☐	☑	
	Material Safety Data Sheet (MSDS) information.	☑	☐	MSDS provided for the co-polymer polypropylene "Versadur PP-C570"used for the internal baffles.
	Workplace Hazardous Materials Information System (WHMIS) information.	☐	☑	
	Health and Safety plan.	☐	☑	NA
	Emergency response plan.	☐	☑	NA
	Protective equipment identified.	☐	☑	NA
	Technical brochures.	☑	☐	
2.13	The applicant provided adequate documentation and data. There is sufficient information on the technology and performance claim for the verification.	☑	☐	

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 3. Technology Review Criteria Checklist

Ref	Criteria	Yes	No	Verifier Comments
3.1	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 functions passively based on the gravity settling of sediments and centrifugal forces. The technology's configuration leads influent water in a circular path generating centrifugal forces that pushes water in an outward direction while forming a negative pressure towards the center of the water column that draw in particulate matter. Sediment deposit at the bottom of the sump. A 30% perforated plate helps to reduce scour of captured sediment.
3.2	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)	☑	☐	9 peer reviewed articles and manuals in relation to hydrodynamic separators were submitted.

3.3	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)	☐	☑	The HydroStorm is a new model design that does not have extensive historical field data to evaluate its reliability.
3.4	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)	☑	☐	See Ref# 2.3.
3.5	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 submitted.
Environmental Standards				
3.6	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.	☑	☐	As per the "declaration regarding codes and standards" an authorized officer has stated that the unit abides by all applicable codes and standards for the construction and operation of a municipal drainage structure.
3.7	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.	☑	☐	See Ref# 3.6
3.8	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.	☐	☐	NA
Commercial Readiness				
3.9	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.	☑	☐	
3.10	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	☐	☐	NA
3.11	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				
3.12	All operating conditions affecting technology performance and the performance claim have been identified.	☑	☐	See Ref# 2.6.
3.13	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 technology 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. Capture test 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.
3.14	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)	☑	☐	
3.15	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.	☑	☐	Variability in surface loading rates has been tested. Sediment removal: 8 steady state surface loading rates : 40, 80, 200, 400, 600, 1000, and 1400 L/min/m^2. Sediment scour/ light liquid re-entrainment test: 5 steady state surface loading rates: 200, 800, 1400, 2000, 2600 L/min/m^2. The device being verified is a passive device that is not turned on or off. Effect of variation is only measured for steady state loading rates and not during transition periods.

Throughput Parameters				
3.16	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.	☑	☐	A standardized range of variable surface loading rates are given by the OGS testing Procedure that are estimated to span the range of expected loading rates. Contaminant loading was kept constant to assess effect of variable surface loading rate. <u>Capture test:</u> Tested range: 40-1400 L/min/m^2. <u>Scour/light liquid re-entrainment test:</u> Tested range: 200-2600 L/min/m^2
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 3.17 to …).		☐	☐	
3.17				
3.18				

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 4. Test Plan Design Assessment Criteria Checklist

Ref.	Criteria			Verifier Comments
4.1	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	☑	☐	The design of the experiment was based on CETV's OGS testing Procedure.
4.2	Is a statistically testable hypothesis or hypotheses provided? (such that an objective, specific test is possible)	☐	☐	N/A. Not required by the OGS testing procedure. Standardized test performance is established by comparing the removal efficiencies determined by a modified mass balance approach, measuring effluent concentrations during a scour test and the volume and mass of re-entrained surrogate beads during light liquid re-entrainment test. The modified mass balance test involves measuring all of the sediment entering and retained by the unit, and is therefore regarded as a 'true value' of performance at a given flow rate. The capture, scour, and light liquid re-entrainment tests are objective, repeatable and verifiable.
4.3a-c	Does the performance test generate data suitable for testing the hypothesis being postulated? Namely:	☑	☐	
4.3a	Does the test measure the parameters used in the performance claim hypothesis?	☑	☐	Test measures parameters in performance claim, namely amount of sediment captured by the unit (removal efficiency) during the capture test, effluent concentrations during the scour test, and volume/mass of surrogate light liquid beads that are re-entrained into the effluent during the light liquid re-entrainment test.

4.3b	Does the performance test control for extraneous variability?	☑	☐	Water temperature is monitored to not increase above 25°C. Surface loading rates are monitored and kept constant with calibrated equipment. Samples are taken to ensure background concentrations do not exceed 20 mg/L. The test sediment to be used is specified in the testing protocol and its PSD has to be within 6% of the specified distribution.
4.3c	Does the performance test include only those effects attributable to the technology being evaluated?	☑	☐	
4.4	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)	☐	☐	N/A <u>Capture test:</u> Statistics are not necessary since the entire population is measured (e.g., weighing total sediment added and captured for each loading rate). This follows the modified mass balance approach. <u>Scour/ Light liquid re-entrainment test:</u> SAWs cannot be used since the sediment scour test continuously runs from one flow rate to the next and therefore samples collected are not independent from one other. Determination of scour is based on the effluent concentrations, with 25 mg/L being widely recognized in the literature as having limited impacts on downstream aquatic life.
4.5	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)	☐	☑	The limitations of performance testing don't allow for statistical evaluation but the standardized testing protocol allows for relative comparison between units.
4.6	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)	☑	☐	Following parameters were appropriately measured: temperature, surface loading rate, background concentration of source water <u>Capture test:</u> Sediment feed rate, influent sediment amount, captured sediment amount, moisture content of test sediment and retained sediment <u>Scour test:</u> Effluent concentrations <u>Light liquid re-entrainment test:</u> Mass and volume of surrogate beads found in effluent flow.
4.7a-d	Are samples representative of process characteristics at specified locations? Namely:	☑	☐	

4.7a	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: For each surface loading rate tested, total influent and captured mass were weighed. Water was decanted over period of 24 hours after each loading rate tested and captured sediments throughout the unit were extracted and oven dried before weighing. Scour test: For each flow rate, effluent sediment concentration was measured at the outlet. The samples were taken in 1 liter bottles, held under the middle of the effluent stream for the amount of time required to fill up the bottle. Concentration was corrected to not include particle sizes below the lower 5th percentile of captured sediment PSD for the 40 L/min/m^2 capture test and the background concentration. Light liquid re-entrainment test: Screens are used to capture surrogate beads that are re-entrained into the effluent.
4.7b	Is data representative of the current technology?	☑	☐	The full scale commercial HS4 unit was tested.
4.7c	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 have stabilized. Water was decanted over a period of 24 hours (not exceeding 30hrs) after a test run before captured sediment is removed, dried and weighed. Scour test: 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. Samples were taken once loading were are stabilized. Light liquid re-entrainment test: Surrogate pellets were pre-loaded giving sufficient time for stabilization prior to onset of test.
4.7d	Have samples been collected over a sufficient period of time to ensure that the samples are representative of process performance?	☑	☐	Capture test: The total mass captured is collected at the end of each flow rate from the device. A minimum of 11.3kg of sediment is passed through the unit at each loading rate to ensure processes have stabilized. Scour test: The scour test is a continuous flow test and following the OGS testing procedure, each surface loading rate is run for 5 minutes and effluent concentration is sampled once every minute before transitioning into the next loading rate. A total of five rates are tested. Light liquid re-entrainment test: The test is a continuous flow test and following the OGS testing procedure, each surface loading rate is run for 5 minutes for each of the 5 rates tested. Flow designated nets are used to capture re-entrained pellets for each flow rate.

4.8	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)	☑	☐	In order to ensure samples are representative of operating conditions the following has been monitored and controlled: surface loading rates, water temperature and influent sediment (sediment concentration for capture test and amount of sediment preloaded). The following additional considerations have also been taken: <u>Capture test:</u> Sediment is only fed into the water flow stream once the flow rate becomes steady, which ensures that sediment concentration matches target concentration. 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 of a device that is approximately 50% full. 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. <u>Light liquid re-entrainment test:</u> The test measures the ability of the unit to retain the captured light liquids under various loading rates including those that trigger internal bypass.
4.9	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)	☑	☐	Samples are representative of the controlled conditions of the test mentioned in Ref# 2.6. and we believe that these conditions cover the range of average conditions the device is likely to undergo in the field. The unit itself is a passive device and therefore performance is dependent on these aforementioned conditions.
4.10	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	☑	☐	Samples and data were prepared by the third party laboratory: Alden Research Laboratory, Inc.
4.11a-c	Performance Test Design is Acceptable - Namely:	☑	☐	
4.11a	The samples have been collected when the technology was operated under controlled and monitored conditions.	☑	☐	Samples were collected in a controlled monitored laboratory that maintained consistency in flow and feed rates using a control system in real time.
4.11b	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 follows the OGS testing procedure.
4.11c	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	☑	☐	Test plan specifies surface loading rates and their allowed margin of variation, water temperature (cannot exceed 25°C), placement of a false floor at 50% of maximum sediment storage, type PSD of test sediment used and margin of its allowed variation.

4.2 Data Validity Checklist

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

Table 5. Data Validity Checklist

Ref.	Criteria			Verifier Comments
5.1	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)	☑	☐	OGS Procedure was followed: Capture test: Total masses were weighed for modified mass balance Scour test: Effluent grab samples were taken at 1 minute intervals. Light liquid re-entrainment: Effluent for all tested loading rates were screened to capture any re-entrained surrogate beads.
5.2	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)	☑	☐	Lab was sufficiently equipped with electronic flow rate, pressure, and temperature sensors, volumetric screw feeder systems of various sizes with variable speed drive, calibrated scales, and automated data acquisition programs. The lab also had the infrastructure to support both low and high loading rates and effective recycling of water.
5.3	Were operating conditions during the test monitored and documented and provided?	☑	☐	See Ref# 4.8.
5.4	Has the information and/or data on operating conditions and measuring equipment measurements and calibrations been supplied to the Verifier?	☑	☐	All of the instruments mentioned in ref#4.2 were calibrated either externally or internally via operational procedures or accredited services.
5.5	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)	☑	☐	Moisture content/ drying of test sediment: ASTM D4959-07 PSD analysis of dry sediments: ASTM D422-63(2007)e1 Suspended solids concentration samples: ASTM D3977-97 (2013) Aqueous samples particle size analysis: ISO 13320-1 (2009) Density and specific gravity of plastics by displacement : ASTM D792-13
5.6	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.	☑	☐	The test plan was submitted to and accepted by the verifier. Flow meters and pressure cells were calibrated. A water manometer board and engineers rule were used to verify computer measurement of each flow meter. The sediment feed rate was verified using a digital stop watch and a calibrated digital scale. Sediment concentration samples were processed in accordance with the ASTM D3977-97. Analytical accuracy was verified by using two blind controls.
5.7	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)?	☑	☐	See Ref#5.5
5.8	Were samples analysed within recommended analysis times (especially for time sensitive analysis such as bacteria)	☐	☐	NA
5.9 a-e	Were QA/QC procedures followed during sample analysis? Namely:	☑	☐	A Test Plan outlining the testing methodologies and procedures used for conducting the verification tests was submitted to the Toronto and Region Conservation Authority and approved by Globe Performance Solutions. The Test Plan was followed throughout the testing. All instruments were calibrated prior to testing and periodically checked throughout the test program.
5.9a	Maintaining control charts	☐	☑	

5.9b	Establishing minimum detection limits	☑	☐	
5.9c	Establishing recovery values	☐	☑	
5.9d	Determining precision for analytical results	☐	☑	
5.9e	Determining accuracy for analytical results	☐	☑	
5.10 a-c	Was a chain-of-custody (full tracing of the sample from collection to analysis) methodology used for sample handling and analysis - Namely:	☑	☐	
5.10a	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?	☑	☐	
5.10b	Are completed and easily readable field logbooks available for the Verifier to inspect?	☑	☐	
5.10c	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)?	☑	☐	
5.11	Experimental Data Set is Acceptable (i.e., the quality of the data submitted is established using the best professional judgment of the Verifier)	☑	☐	

4.4 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 6.: Data Analysis Checklist

Ref.	Criteria			Verifier Comments
6.1	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)	☑	☐	It is impractical to test fully sized OGS units and collect sufficient data to run statistical analysis with adequate statistical power. As a result the following approaches are taken for analysis: <u>Capture test:</u> Modified mass balance is used to determine removal efficiencies for each surface loading rate. <u>Scour test:</u> The scour test is conducted at varying flow rates. Effluent concentrations are used to determine whether and when scour occurs based on the recognition that values below 25 mg/L are widely regarded in the literature as providing a high level of protection to downstream aquatic organisms. <u>Light liquid re-entrainment:</u> Mass of the beads remaining in the unit is expressed as a percent of the total mass of the beads loaded.
6.2	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?	☐	☐	N/A
6.2 a-c	Are the assumptions of the analysis met? Namely: (Note: A negative response means the Verifier needs to request further information)	☐	☐	N/A
6.2.a	Did the data analyst check the assumptions of the statistical test used?	☐	☐	N/A
6.2.b	Are the tests of assumptions presented?	☐	☐	N/A

6.2.c	Do the tests of the assumptions validate the use of the test and hence the validity of the inferences?	☐	☐	N/A
6.3	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.	☑	☐	Acknowledging the restraints placed on testing full sized OGS units in a controlled lab setting, the laboratory analysis provided based on what was outlined in the OGS test Procedure is acceptable.

4.5 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 7. Data Interpretation Checklist

Ref	Criteria			Verifier Comments
7.1a	Are the results statistically or operationally significant? Did the performance test result in a statistically significant test of hypothesis?	☑	☐	<u>Capture test:</u> Approximately 50% or more of the sediment is captured for loading rates of 400 L/min/m^2 or lower. <u>Scour test:</u> The effluent concentrations threshold of 25 mg/L was only surpassed on the 2nd of 5 continuous loading rates of 200, 800, 1400, 2000, and 2600 L/min/m^2. <u>Light liquid re-entrainment test:</u> The total mass of beads retained was at least 95% for each of the five loading rates tested: 200, 800, 1400, 2000, and 2600 L/min/m^2.
7.1b	To be operationally significant, does the technology meet regulatory guidelines and applicable laws?	☑	☐	As per the "declaration regarding codes and standards" an authorized officer from Hydroworks has stated that the unit abides by all applicable codes and standards for the construction and operation of a municipal drainage structure.
7.2	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)	☐	☐	NA
7.3	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.	☑	☐	
7.4	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.	☑	☐	Claim formulation suggested by the CETV verifier standardizes the interpretation of results from carrying out the OGS testing protocol.

5. Statistical Evaluation of Claims

The Statistical Analysis Worksheets were not used in this evaluation because there is a standard testing Procedure that provides a robust test of the technology based on mass balance principles and verifiable effluent sample testing. The Procedure was developed based on extensive peer review and comment by experts in the industry. As part of this verification, it was verified that the requirements of the Procedure were followed (see verification checklist in Appendix A).

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	Submitted
Signature pages	Submitted
Signed Formal Application	Submitted
Declaration Regarding Codes & Standards	Submitted
Patent(s)	Submitted
Sample security: e.g. chain of custody sheets for each sample	Submitted
Operation and maintenance manual	Submitted
Field notebooks	Available upon request
Certificate of accreditation of laboratories	Submitted

7. Conclusion

Hydroworks, LLC's technology performance claims have been verified as follows:

Capture test[2]:

During the capture test, the Hydroworks® HS4 Hydrodynamic Separator, with a false floor set to 50% of the manufacturer's recommended maximum sediment storage depth and a constant influent test sediment concentration of 200 mg/L, removes 69, 64, 60, 56, 46, 41, and 36 percent of influent sediment by mass at surface loading rates of 40, 80, 200, 400, 600, 1000, and 1400 L/min/m2, respectively.

Scour test[2]:

During the scour test, the Hydroworks® HS4 Hydrodynamic Separator, with 10.2 cm (4 inches) of test sediment pre-loaded onto a false floor reaching 50% of the manufacturer's recommended maximum sediment sump storage depth and sediment loaded onto the pre-treatment channel emulating depositional pattern of the 40 L/min/m2 capture test, generate corrected effluent concentrations of 22.4, 28.5, 20.0, 19.1, and 24.4 mg/L at 5-minute duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m2, respectively.

Light liquid re-entrainment test[2]:

During the light liquid re-entrainment test, the Hydroworks® HS4 Hydrodynamic Separator with surrogate low-density polyethylene beads preloaded within the inner chamber, representing a floating light liquid volume equal to a depth of 50.8 mm over the sedimentation area, retains 100, 99.9, 95.4, 95.7, and 97.5 percent of loaded beads by mass during the 5-minute duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m2, respectively.

The verified claims concur with the verification report.

[2] The claim can be applied to other units smaller or larger than the tested unit as long as the untested units meet the scaling rule specified in the Procedure for Laboratory of Testing of Oil Grit Separators (Version 3.0, June 2014)

6. References

ISO 14034:2016, Environmental management – Environmental technology verification (ETV)

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

Appendices

Appendix A. Verification Checklist for the *Procedure for Laboratory Testing of Oil Grit Separators.*

Ref.	Criteria	Meets Criteria		
		Yes	No	NA
3.0	**Sediment Removal Performance Test**	☐	☐	☐
3.0a	MTD is full scale, commercially available and same as the one used for an actual installation.	☑	☐	☐
3.1	**Test Sediment**			
3.1a	Comprised of inorganic ground silica with specific gravity of 2.65.	☑	☐	☐
3.1b	3 samples analyzed for PSD in accordance with *Standard Test Method for the Particle Size Analysis of Soils* ASTM D422 - 63(2007)e1 meets particle size distribution in Table 1 of "Procedure for Laboratory Testing of Oil-Grit Separators" (Percentages can vary by 6% as long as the median particle size does not exceed 75 µm).	☑	☐	☐
3.1c	One sample of the test sediment used for each flow rate is analyzed for PSD in accordance with ASTM D422-63(2007)e1 and meets the 6% allowance threshold - if not, removal efficiencies are reported by the three sample average PSD sample in addition to the individual flow test PSD samples.	☑	☐	☐
3.2	**Test Conditions**			
3.2a	The system is clean with no preloaded sediment, with clean water which has a background TSS concentration below 20 mg/L.	☑	☐	☐
3.2b	False floor is installed to simulate the sediment retention chamber being filled to 50% of manufacturer's recommended maximum sediment storage depth.	☑	☐	☐
3.2c	Manufacturer`s installation recommendations are followed.	☑	☐	☐
3.2d	Temperature of the water used does not exceed 25°C.	☑	☐	☐
3.3	**Test Parameters and Requirements**			
3.3.1	**Flow Rates and Hydraulic Characteristics**			
3.3.1a	A minimum of 7 steady state surface loading rates are tested: 40, 80, 200, 400, 600, 1000, and 1400 L/min/m^2 of Effective Treatment Area.	☑	☐	☐
3.3.1b	Instruments measuring flow rates are calibrated and calibration reports are submitted.	☑	☐	☐
3.3.1c	Flow rates are recorded at no longer than 30 second intervals.	☑	☐	☐
3.3.1d	Flow rates do not vary from target flow rate by more than +/- 10% and have a coefficient of variation (COV) of less than 0.04.	☑	☐	☐
3.3.1e	Head loss coefficients across the device are measured on a clean unit without sediment, over the full range of operational flow rates using calibrated instruments at appropriate locations.	☑	☐	☐
3.3.1f	Methodology for determining head loss is clearly described.	☑	☐	☐
3.3.2	**Test Duration**			
3.3.2a	The test is run for 25 minutes or for the time required for 8 complete volume exchanges in the primary sedimentation chamber (whichever is greater) to ensure stabilized flows and sediment fluxes.	☑	☐	☐
3.3.2b	A minimum of 11.3 kg of sediment is fed into the MTD to limit analytical errors associated with mass balance testing.	☑	☐	☐
3.3.3	**Influent Sediment Concentration**			
3.3.3a	Sediment feed system is calibrated to deliver a constant concentration of 200 mg/L (+/- 25mg/L) over the duration of the test.	☑	☐	☐
3.3.3b	Test sediment is injected into the flow stream at the lesser of 3 m or 5 pipe diameters upstream of the inlet to the MTD.	☐	☑	☐
3.3.3c	Sediment is injected only after a constant flow rate has been achieved.	☑	☐	☐
3.3.3d	Six calibration samples are taken from the injection point at evenly spaced intervals over the duration of the test to verify that the sediment is being injected at a constant rate.	☑	☐	☐

3.3.3e	Calibration samples are a minimum of 0.1 L or the collection interval is less than one minute, whichever comes first.	☑	☐	☐
3.3.3f	Samples are weighed to the nearest milligram and the concentration COV does not exceed 0.10.	☑	☐	☐
3.3.3g	Average influent concentration is determined using the mass injected divided by the volume of water flowing through the unit during the period of sediment injection.	☑	☐	☐
3.3.3h	The moisture content of the test sediment used for each flow rate is measured in accordance with *ASTM Method D 4959-07, Standard Test Method for Determination of Water (Mositure) Content of Soil By Direct Heating.*	☑	☐	☐
3.3.4	**Modified Mass Balance**			
3.3.4a	The influent sediment mass load (mass of the test sediment injected over the duration of the test) is measured for each flow rate.	☑	☐	☐
3.3.4b	At the end of the test, the water is decanted over a period not exceeding 30 hours and the remaining sediment in the MTD retention chamber is dried in a nonferrous tray and weighed following ASTM D 4959-07. A sample is analyzed for PSD in accordance with ASTM D422-63(2007)e1.	☑	☐	☐
3.3.5	**Background Samples**			
3.3.5a	A minimum of 5 aqueous background samples are taken over the entire testing period at regular increments, or taken on an hourly basis for tests longer than 5 hours.	☑	☐	☐
3.3.5b	Samples are analyzed by the SSC method (ASTM D3977-97(2013)), and TSS concentrations are less than 20 mg/L.	☑	☐	☐
3.4	**Sediment Removal Calculation**			
3.4a	Removal efficiency (%) is calculated as $\frac{Total\ Mass\ Retained}{Inlet\ Mass\ Injected}$*100 where the mass of the retained sediment includes sediment in the chamber and residual sediment accumulated in the inlet pipe. Residual sediment accumulated in the inlet pipe is measured and reported separately also.	☑	☐	☐
3.4b	Sediment removal results are reported as percentage of influent mass retained of the total mass and for each individual particle size fraction. At a minimum, size fractions include: <5um, 5um-8um, 8um-20um, 20um-50um, 50um-75um, 75um-100um, 100um - 150um, 150um-250um, 250um-500um, >500um.	☑	☐	☐
4.0	**Sediment Scour and Re-suspension Test**			
4.1	**Test Sediment**			
4.1a	The test sediment preloaded into the chamber is from the same batch as the test sediment used in the sediment removal test, such that the 3 sample average is representative of the preloaded test sediment.	☑	☐	☐
4.2	**Test Conditions**			
4.2a	Test is run with clean water at temperatures not exceeding 25°C.	☑	☐	☐
4.2b	If the false floor is used, it is set at 10.2cm below the 50% maximum sediment storage and filled to the 50% capacity with sediment; sediment is evenly distributed.	☑	☐	☐
4.2c	The MTD is filled with clear water (background concentration of TSS below 20mg/L) to a normal operating depth prior to initiating flows and the test is initiated within 96 hours of pre-loading.	☑	☐	☐
4.3	**Test Parameters and Requirements**			
4.3.1	**Flow Rates**			
4.3.1a	To determine the re-suspension and washout of sediments, five surface loading rates (200 to 800 to 1400 to 2000 to 2600 L/min/m^2) are used in 5 minute intervals, where the time to switch from one rate to the next does not exceed 1 minute; the duration of the total test for 5 loading rates does not exceed 30 minutes.	☑	☐	☐
4.3.1b	Additional flow rates (optional) lower than 2600 L/min/m^2 are tested separately.	☐	☐	☑
4.3.1c	Flow is measured with calibrated instruments, recorded at no longer than 30 second intervals, and maintained within +/- 10% of the target flow rate with a COV less than 0.04.	☑	☐	☐
4.3.2	**Sampling and Analysis**			
4.3.2a	Paired effluent samples are collected at 1 minute sampling intervals as soon as the target flow rate is achieved (within 1 minute of initializing a flow rate).	☑	☐	☐

4.3.2b	Only flows that have passed through the MTD treatment chamber(s) are sampled and the effluent concentration is determined using any of the three effluent sampling methods cited in the *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device*- January 25, 2013 (reproduced in Appendix B of *Procedure for Laboratory Testing of Oil-Grit Separators*).	☑	☐	☐
4.3.2c	The effluent samples are analyzed for TSS concentrations using the Suspended Solids Concentration (SSC) analytical method (ASTM D3977-97 (2013)).	☑	☐	☐
4.3.2d	The PSD of the samples are determined in accordance with ISO 13320 (2009).	☑	☐	☐
4.3.2e	PSD, suspended sediment loads, and scour test results are reported for each of the surface loading rates.	☑	☐	☐
4.3.2f	In addition to effluent samples, a minimum of 5 aqueous background samples are taken of the clear water (TSS concentration less than 20 mg/L) over the testing period at regular increments; if TSS concentration exceed 20mg/L the sample concentrations are adjusted accordingly.	☑	☐	☐
4.4	**Sediment Scour Test Analysis**			
4.4a	Scour effluent concentrations are adjusted such that the solid particles finer than those removed by the MTD during 40L/min/m^2 removal test are excluded from the scour results.	☑	☐	☐
4.4b	Report contains particle size fractions removed and scoured by the MTD, as well as the scour effluent concentration before and after adjustment of results.	☐	☑	☐
5.0	**Light Liquid Re-entrainment Simulation Test**			
5.0a	The light liquid re-entrainment simulation test is done on the same unit tested for sediment removal/scouring.	☑	☐	☐
5.1	**LDPE Plastic Beads Specification**			
5.1a	The test material used is the Dow Chemical Dowlex™ 2517 (specific gravity = 0.917), or if unavailable the Dow Chemical Dowlex™ 722 (specific gravity = 0.918); the density of the material is independently measured and reported by the technology performance testing laboratory.	☑	☐	☐
5.2	**Test Conditions**			
5.2a	The test is run with clean water (temperature does not exceed 25°C) with a false floor set at 50% of the maximum recommended sediment storage depth.	☑	☐	☐
5.2b	If additional oil capture features are added to the device, they are also made present during sediment removal performance tests.	☐	☐	☑
5.2c	MTD is preloaded with known volume and mass of plastic beads to a depth of 5 cm over an area equivalent to the MTD sedimentation area (Effective Treatment Area). If the MTD has a maximum light liquid storage depth of less than 5 cm, the sedimentation area is loaded with plastic beads to a depth equal to the maximum light liquid storage depth.	☑	☐	☐
5.3	**Test Parameters and Requirements**			
5.3.1	**Flow Rates**			
5.3.1a	To determine the potential for oil re-entrainment and washout, five surface loading rates (200 to 800 to 1400 to 2000 to 2600 L/min/m^2) are used in 5 minute intervals, where the time to switch from one rate to the next does not exceed 1 minute; the duration of the total test for 5 loading rates does not exceed 30 minutes.	☑	☐	☐
5.3.1b	Additional flow rates (optional) lower than 2600 L/min/m^2 are tested separately.	☐	☐	☑
5.3.1c	Flow is measured with calibrated instruments, recorded at no longer 30 second intervals, and maintained within +/- 10% of the target flow rate with a COV less than 0.04.	☑	☐	☐
5.3.2	**Effluent Screening and Analysis**			
5.3.2a	Appropriate screen mesh size is used such that all washed out plastic beads are retained on the screen.	☑	☐	☐
5.3.2b	Screening methodology provides the means for quantifying the volume, mass, and percentage of plastic beads washed out of the MTD for each surface loading rate.	☑	☐	☐
5.3.2c	Values are summed for the entire test duration to determine cumulative volume, mass, and percentage of plastic beads washed out.	☑	☐	☐
6.0	**Scaling**			
6.0a	If performance results of a tested MTD is scaled to other MTD models: 1) The claimed sediment removal efficiencies for the similar MTD is the same or lower than the test MTD at identical surface loading rates; **and** 2) The similar MTD is scaled geometrically proportional to the tested unit in all inside dimensions of length and width and has a minimum of 85%	☐	☐	☑

	proportionality in depth.			
6.0b	If the requirements for scaling are not met, three full scale commercially available MTDs of different sizes are tested to validate the alternative scaling methodology.	☐	☐	☑
7.0	**Analytical Methods**			
7.0a	Analytical laboratories performing sample analysis is accredited to ISO 17025 or equivalent.	☑	☐	☐
7.1	**Suspended Solids**			
7.1a	The SSC test method *Standard Test Methods for Determining Sediment Concentration in Water Samples ASTM D3977-97 (2013)e1*) is used on aqueous samples.	☑	☐	☐
7.2	**Particle Size Distribution**			
7.2a	Test sediment is analyzed in accordance with the *Standard Test Method for the Particle Size Analysis of Soils* ASTM D422 - 63(2007)e1.	☑	☐	☐
7.2b	Aqueous samples are analyzed for PSD using laser diffraction following ISO 13320:*2009 Particle Size Analysis-Laser Diffraction Methods*.	☑	☐	☐
7.3	**Sediment Drying**			
7.3a	Sediment drying procedures follow the ASTM Method D 4959-07, *Standard Test Method for Determination of Water (Moisture) Content of Soil By Direct Heating.*	☑	☐	☐

Comments:

3.3.3b. Sediment is injected 4 pipe-diameters upstream as opposed to 5. The shorter distance is analyzed to provide a shorter settling time and therefore will yield a conservative result.

3.4a. Removal efficiency was based on the combined sediment collected from the secondary plate and the pre-treatment channel in addition to the sediment sump and inlet pipe.

4.3.1a , 5.3.1a. It was necessary to change flow meters during the sediment scour and light liquid re-entrainment test, as the required flows exceeded the minimum and/or maximum range of any single meter. When the flow capacity of the selected meter was reached, the flow was shut down over a period of approximately 10 seconds and all flow data saved. The next data acquisition file was executed and flow increased at a rate that corresponded to reaching each previous target flow after a period of 1-minute. This procedure was approved by CETV prior to testing, in recognition that most particles susceptible to scour at low flows would not be in the sump at higher flows. Similarly, re-entrainment of the oil beads was not expected to be significantly affected by the flow meter change.

Appendix B. Verification Guidance Pursuant to ISO 14034:2016

Appendix B provides guidance on performance testing and verification of technologies pursuant to ISO 14034:2016.

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 C. Selected data sets from CETV testing report.

Table C1. PSD analysis of test batches

Particle size	40 l/m/m^2	80 l/m/m^2	200 l/m/m^2	400 l/m/m^2	600 l/m/m^2	1000 l/m/m^2	1400 l/m/m^2	Average	CETV	QA / QC Compliant
(micron)	%-Finer	%-Finer	%-Finer	%-Finer	%-Finer	%-Finer	%-Finer	%-Finer	%-Finer	
1000	100	100	100	100	100	100	100	**100**	**100**	Y
500	95	97	95	95	96	96	95	**96**	**95**	Y
250	91	93	90	90	92	92	90	**91**	**90**	Y
150	77	74	76	74	79	73	74	**75**	**75**	Y
110	65	63	64	63	65	63	63	**64**	**60**	Y
75	53	51	51	51	54	51	50	**52**	**50**	Y
53	47	47	47	45	47	47	45	**46**	**45**	Y
20	35	36	36	35	36	37	35	**36**	**35**	Y
8	22	20	22	20	18	21	21	**21**	**20**	Y
5	16	14	16	14	13	15	15	**15**	**10**	Y
2	7	6	7	7	4	6	6	**6**	**5**	Y
D50	64	69	69	71	62	69	75	**69**	**75**	Y

Table C2. Injected sediment summary for the capture test.

Target Flow		Target Concentration	Injector Wts. Concentration	Injector Measurements	Mass/Volume Concentration	Total Injected Mass	QA / QC Compliant
L/min/m^2	L/min	mg/L	mg/L	COV	mg/L	kg	
40	47	200	202	0.01	**203**	**11.7**	**Y**
80	94	200	203	0.02	**196**	**11.9**	**Y**
200	234	200	200	0.00	**201**	**11.9**	**Y**
400	468	200	201	0.01	**194**	**12.3**	**Y**
600	702	200	199	0.00	**199**	**12.2**	**Y**
1000	1170	200	200	0.00	**197**	**12.4**	**Y**
1400	1638	200	200	0.00	**194**	**12.6**	**Y**

Table C3. Removal efficiency by settling location for each sediment loading rate.

Flow	Tested Flow	Removal Efficiency	Inlet Pipe	Pretreatment Channel	Secondary Plate	Outlet Dispersion Plate	Collection Sump
L/min/m^2	L/min	%	%	%	%	%	%
40	**46**	**68.6**	**0.0**	**52.3**	**8.2**	**1.6**	**6.5**
80	**93**	**64.0**	**0.0**	**44.8**	**9.1**	**2.3**	**7.7**
200	**233**	**60.0**	**0.0**	**44.5**	**6.6**	**1.5**	**7.4**
400	**425**	**56.1**	**0.0**	**37.4**	**8.6**	**2.4**	**7.7**
600	**736**	**46.1**	**0.0**	**24.7**	**8.5**	**3.1**	**9.9**
1000	**1104**	**41.2**	**0.0**	**20.5**	**8.3**	**2.8**	**9.6**
1400	**1628**	**35.7**	**0.5**	**20.0**	**4.3**	**1.7**	**9.3**

Table C4. PSD summary of captured sediment for each tested loading rate.

Particle Range (µm)	Average Test Sediment	40 L/min/m^2	80 L/min/m^2	200 L/min/m^2	400 L/min/m^2	600 L/min/m^2	1000 L/min/m^2	1400 L/min/m^2
>1000	0%	0%	0%	0%	0%	0%	0%	0%
500-1000	4%	4%	6%	5%	3%	4%	4%	1%
250-500	4%	4%	5%	5%	3%	5%	4%	2%
150-250	16%	15%	14%	12%	12%	12%	11%	11%
105-150	12%	11%	12%	13%	13%	11%	10%	10%
75-105	12%	12%	9%	10%	11%	7%	7%	6%
53-75	5%	5%	6%	7%	7%	4%	3%	3%
20-53	11%	8%	6%	5%	4%	2%	1%	1%
8-20	15%	5%	4%	2%	1%	0%	0%	0%
5-8	6%	1%	0%	0%	0%	0%	0%	0%
2-5	8%	1%	0%	0%	0%	0%	0%	0%

Table C5. Scoured effluent concentration from the scour test with a solid secondary plate, adjusted by the background concentration and D5 correction.

Measured Concentration at Each surface Loading Rate					
Effluent Sample No.	200 L/min/m^2	800 L/min/m^2	1400 L/min/m^2	2000 L/min/m^2	2600 L/min/m^2
1	32.4	58.0	68.5	255.7	138.5
2	38.8	120.7	188.1	254.8	128.6
3	37.4	75.5	329.0	238.0	113.6
4	40.1	55.8	417.5	216.7	144.7
5	52.1	44.9	352.9	170.3	117.1
Average	**40.2**	**71.0**	**271.2**	**227.1**	**128.5**
D_5 Correction	**11.3**	**28.9**	**196.7**	**175.4**	**99.9**

Table C6. Scoured effluent concentration from the scour test with a perforated secondary plate, adjusted by the background concentration and D5 correction.

Measured Concentration at Each surface Loading Rate					
Effluent Sample No.	200 L/min/m^2	800 L/min/m^2	1400 L/min/m^2	2000 L/min/m^2	2600 L/min/m^2
1	50.6	18.2	14.7	17.3	30.5
2	49.4	59.1	27.4	34.6	35.2
3	38.6	43.0	36.3	28.4	33.1
4	27.4	39.0	24.1	21.6	24.8
5	19.9	26.0	18.1	18.5	25.5
Average	**37.2**	**37.1**	**24.1**	**24.1**	**29.8**
D_5 Correction	**22.4**	**28.5**	**20.0**	**19.1**	**24.4**

Table C7. Light liquid re-entrainment test results.

Light-liquid Re-Suspension Data				Starting Volume	(Liters) 58.3	Starting Mass	(grams) 33399	Hydroworks HG4	
						Measured		Calculated Percentages	
Action	Time Stamp (minutes)	Meter	Target Flow (L/min/m^2)	Recorded Flow (L/min/m^2)	COV	Collected Volume (Liters)	Collected Mass (grams)	Collected Volume (Liters)	Collected Mass (grams)
Start D.A. Recording	0.0								
Flow set	1.0	4"	200	**199**	0.021	0	0	**0.0%**	**0.0%**
Stop Collection	6.0			-0.6%					
Flow set	7.0	4"	800	**807**	0.005	0.1	49	**0.1%**	**0.1%**
Stop Collection	12.0			0.9%					
Flow set	13.0	8"	1400	**1408**	0.002	2.7	1523	**4.6%**	**4.6%**
Stop Collection	18.0			0.6%					
Flow set	19.0	8"	2000	**2014**	0.002	2.5	1445	**4.3%**	**4.3%**
Stop Collection	24.0			0.7%					
Flow set	25.0	8"	2600	**2608**	0.002	1.5	847	**2.5%**	**2.5%**
Stop Collection	30.0			0.3%					
				Interim Collection Net		0.1	39	**0.1%**	**0.1%**
				Total		**6.8**	**3902**	**11.7%**	**11.7%**
						Pellets Retained		**88.3%**	**88.3%**