NJCAT TECHNOLOGY VERIFICATION

HumeFilter® Universal Pollutant Trap (UPT) Stormwater Treatment Device

Holcim Australia Pty Ltd
(Trading as Humes)

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(Addendum for Scaling begins on page 35)

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1. Description of Technology

The HumeFilter® Universal Pollutant Trap (UPT) is a new Humes technology incorporating hydrodynamic processes and filtration into a compact, precast concrete package. The HumeFilter UPT is enclosed within a cylindrical, precast concrete chamber designed to be installed offline to the main drainage network in a triangular configuration, utilizing an upstream diversion pit and downstream collection pit. The hydrodynamic separation treatment chamber utilizes three zones as follows: upper (flow is dissipated, and floating matter withheld), middle (settling of solids/particulates) and lower (sump storage of settled material) as shown in **Figure 1**.

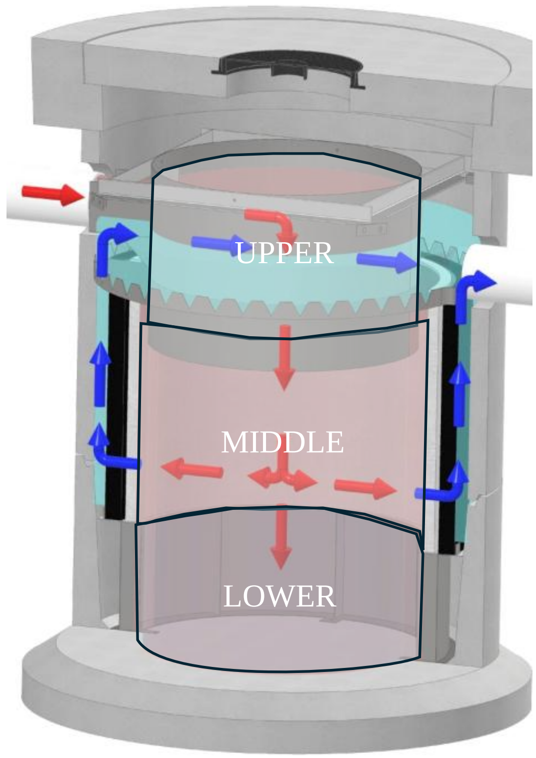

Figure 1 Schematic Section View of HumeFilter

The filter elements within the treatment chamber also consists of three main components (this arrangement can be changed depending on the target pollutant):

1. An inner litter basket consisting of 304 stainless steel perforated sheet with 1mm (0.039 inches) hole size. This layer physically removes the litter and other coarse pollutants.

2. An intermediate granular activated carbon (GAC) layer (2 – 3mm granules) (0.079 – 0.118 inches), within inner and outer baskets of 304 Stainless Steel perforated sheet with 1mm (0.039 inches) hole size. This layer physically removes some entrained particulates and chemically removes soluble pollutants. *It is acknowledged that this test is for total suspended solids (TSS) removal alone.* The GAC layer within the filter elements is interchangeable depending on the target pollutants, but for TSS removal alone there will be GAC only.

3. A pleated polyethylene terephthalate (PET) fabric cartridge filter designed for TSS removal efficiency of 99% at 40 microns. This is the final polishing stage of the filtration elements and physically removes particulates that pass through the previous layer.

A schematic diagram of the HumeFilter UPT including an internal view can be seen in **Figure 2**. Flow enters the center of the unit (red arrow) and then passes out via radial flow through the perforated Stainless Steel mesh➀, through the GAC cartridge➁, through the pleated filter cartridge➂, and then flows upwards to the v-notch weirs and exits the outlet. If the inflow, even in the offline configuration, exceeds the Maximum Treatment Flow Rate (MTFR), then the excess flow passes over the inlet channel bypass weirs➃ (yellow arrows) and into the return/bypass channel➄ to ensure the filter does not become damaged. If the filters become 100% blocked the water can rise within the HumeFilter UPT and spill over the inlet channel bypass weirs➃, down the bypass channel➄ (blue arrow) and discharged through the outlet.

A close up schematic section showing the perforated screen, GAC layer and pleated filter is shown in **Figure 3.**

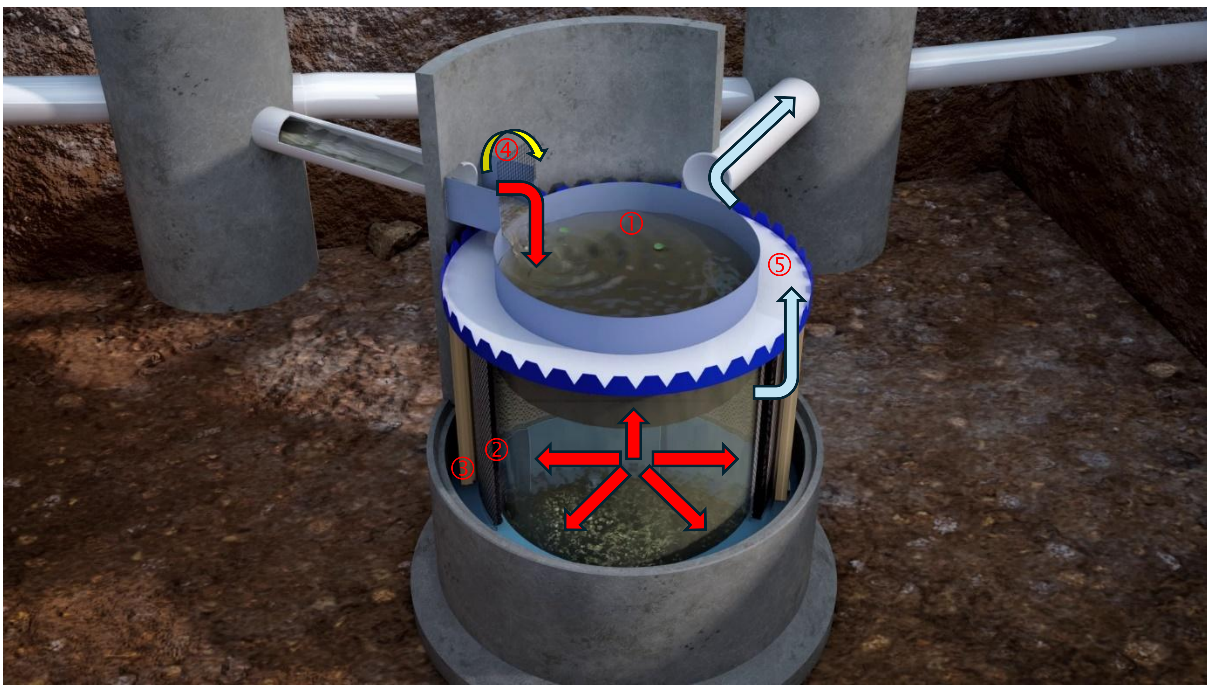

Figure 2 Schematic of HumeFilter UPT

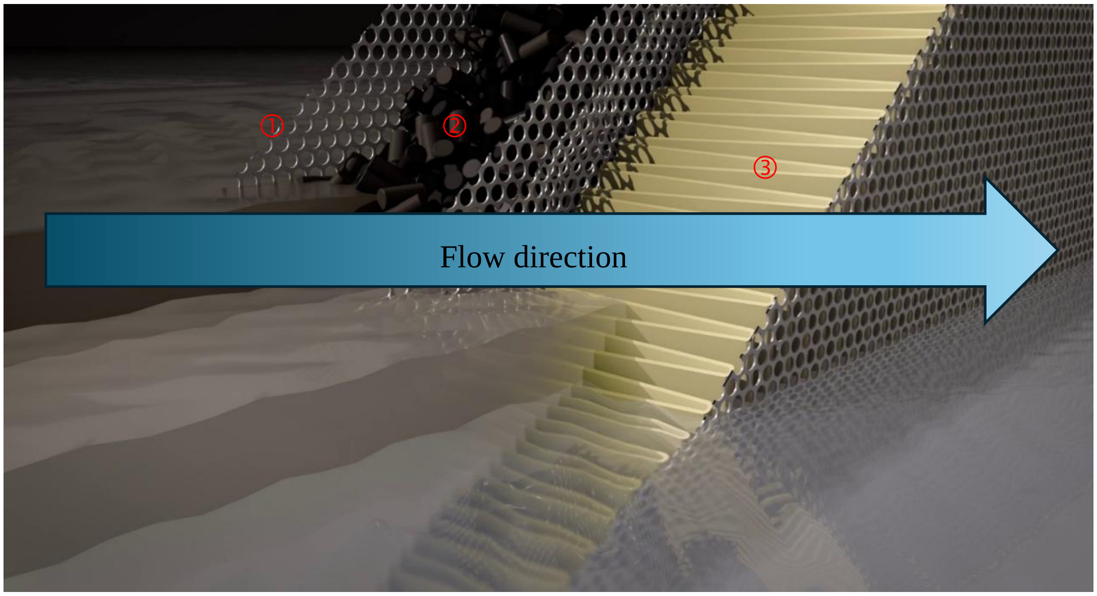

Figure 3 Schematic Section of Perforated Screen, GAC Cartridge and Pleated Filter

2. Laboratory Testing

The test program was conducted from August - September 2024 by Waterlabs Australia (WLA) at the company's full-scale hydraulic testing facility in Brisbane, Australia under the direction of Dr Darren Drapper. While testing was carried out by WLA, an independent party to Humes (Holcim Australia) and WLA, Associate-Professor Prasanna Egodawatta from Queensland University of Technology (QUT), Australia was also engaged to provide the New Jersey Department of Environmental Protection (NJDEP) protocol-compliant third-party oversight. Associate Professor Prasanna Egodawatta has no conflicts of interest that would prohibit him from providing independent third-party observation.

The particle size distribution (PSD) was independently verified by ALS Environmental (ALS) to demonstrate that the test sediment meets the specifications as detailed in Section 4 of the NJDEP Protocol. ALS Environmental is ISO/IEC 17025 (2017) accredited with the National Association of Testing Authorities (NATA) for PSD testing in accordance with Australian Standards AS1289 3.6.1 (sieve) and AS1289 3.6.3 (hydrometer). Water analysis of background and effluent samples was conducted by the Environmental Analysis Laboratory (EAL), Southern Cross University, also a ISO/IEC 17025 (2017) NATA accredited laboratory. EAL is accredited for suspended sediment concentration (SSC) analysis (APHA 2540D).

Laboratory testing was conducted in accordance with the NJDEP "Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device" January 14, 2022, updated April 25, 2023 (Filtration Protocol). Prior to starting the performance testing program, a quality assurance project plan (QAPP) was submitted to, and approved by, the New Jersey Corporation for Advanced Technology (NJCAT) as per the NJDEP procedure for obtaining verification of a stormwater MTD from NJCAT (August 4, 2021).

2.1 Test Setup

The laboratory setup is shown schematically in **Figure 4**. Descriptions of the key components are provided in the following text.

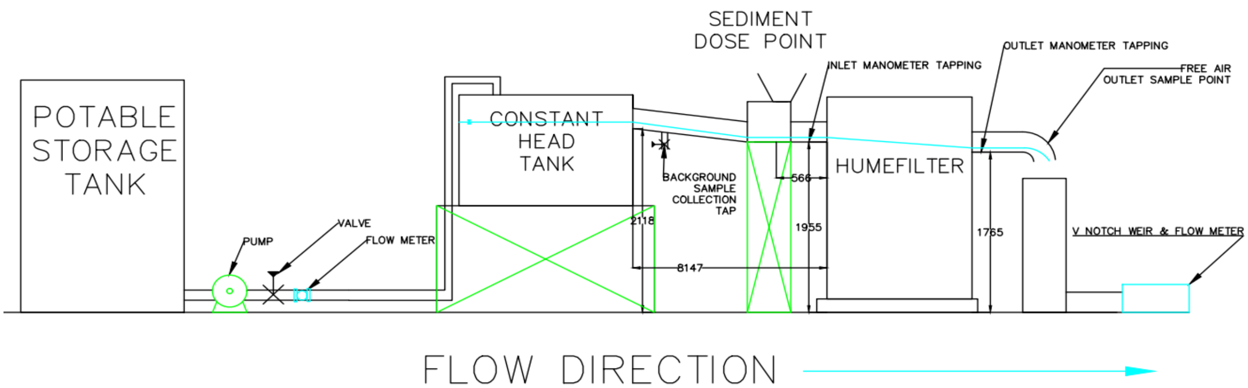

Figure 4 Laboratory Test Setup

Test Unit

A full-scale commercially available HumeFilter UPT1200 was tested (**Figure 5**). Relevant dimensions of the tested HumeFilter UPT1200 are provided in **Table 1**.

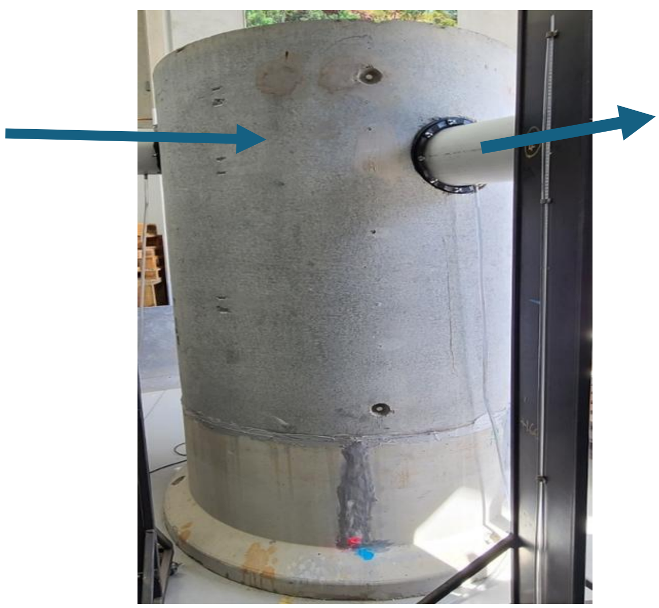

Figure 5 Photo of the Installed HumeFilter UPT1200

Table 1 Relevant Dimensions of the HumeFilter UPT1200

HumeFilter UPT1200	Dimensions (mm)
Inlet Pipe Diameter	225
Outlet Pipe Diameter	225
Inside Diameter	1219
GAC Filter ID	760
GAC Filter OD	860
GAC Bed Thickness	50
GAC Bed Height	1200
Pleated Filter ID	880
Pleated Filter OD	1000
Pleated Filter EFTA	109 m^2

Flow Measurement

Water was pumped to the constant head tank and flowrate monitored using a DN100 MagFlux 7200 ultrasonic flow meter (Serial no. 7015842, Part no. 887231-016-00).

Figure 6 Photo of the Installed Constant Head Tank

Pumping into a constant head tank allowed the water to naturally overflow from the tank as a free surface flow into a 225mm (8.86 inches) PVC pipe at >1% grade, simulating a stormwater pipe under typical flow conditions. The gradient on the 225mm (8.86 inches) PVC pipe from the header tank (**Figure 6**) is sufficient to prevent any tailwater conditions causing a head variation in the tank.

Calibration of the MagFlux was performed by the manufacturers in the factory. In-situ calibration is not required by the manufacturer. However, for the purposes of this testing, flow measurements and temperature were also taken from a downstream 45º V notch weir using a Starflow QSD ultrasonic sensor to provide water depth against the calibrated V notch (refer **Figure 4**). This also acts as a second flowrate check against the Magflux influent flow rate measurement.

All flow meter data was recorded by a Campbell Scientific datalogger at a maximum of 10 second intervals, with average flowrate calculated across a 60 second rolling window. The target flowrate was 12 L/s (190.204 gpm) with an acceptable variation of +/- 1.2 L/s (19.02 gpm) (±10%). The concentration coefficient of variance (COV) of the flow data was ≤ 0.03.

Head Measurements

Manometers were installed at the invert of the inlet and outlet pipes to the test unit to record the head level during the test (**Figure 7**).

Figure 7 Manometers Installed at the Invert of the Inlet and Outlet Pipes to the HumeFilter

The water level at both locations were recorded every minute during the test. The minimum tolerance of the manometer was ±1 mm (0.039 inches). These were used to determine the driving head as the filter occludes.

Test Sediment Dosing

A screw-auger (WAM Micro-batch Feeder, MBF042A) was used to deliver the appropriate target levels of test sediment to the potable water flow, at 566mm (less than the maximum of 1,000mm, <3 feet) upstream of the test device (**Figure 8**). The pipework upstream of the device was configured to provide appropriate turbulence to ensure a fully mixed influent prior to entering the device. The inlet and outlet pipes are 225mm (8.86 inches) PVC and have a minimum 1% slope. Photos of the dosing location and outlet sampling box can be seen in **Figures 9** and **10**, respectively. Any sediment settled in the inlet pipe was photographed, and removed, weighed and added to the balance of sediment not dosed to the test unit. A photo looking inside the installed HumeFilter UPT1200 can be seen in **Figure 11**.

Figure 8 Screw-Auger Dosing

Figure 9 Upstream Dosing Location

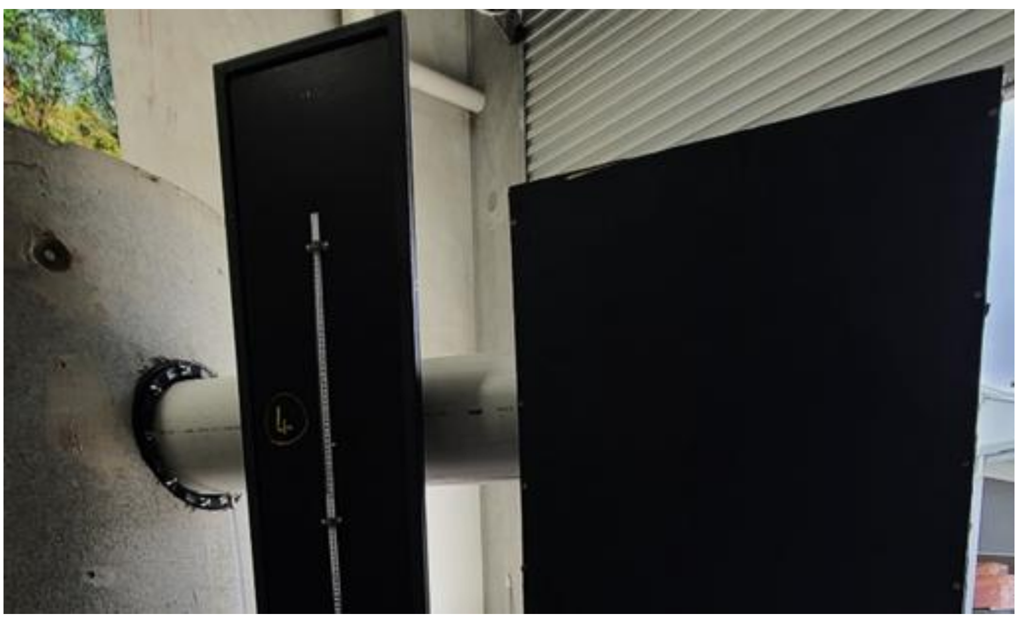

Figure 10 Outlet Sampling Box

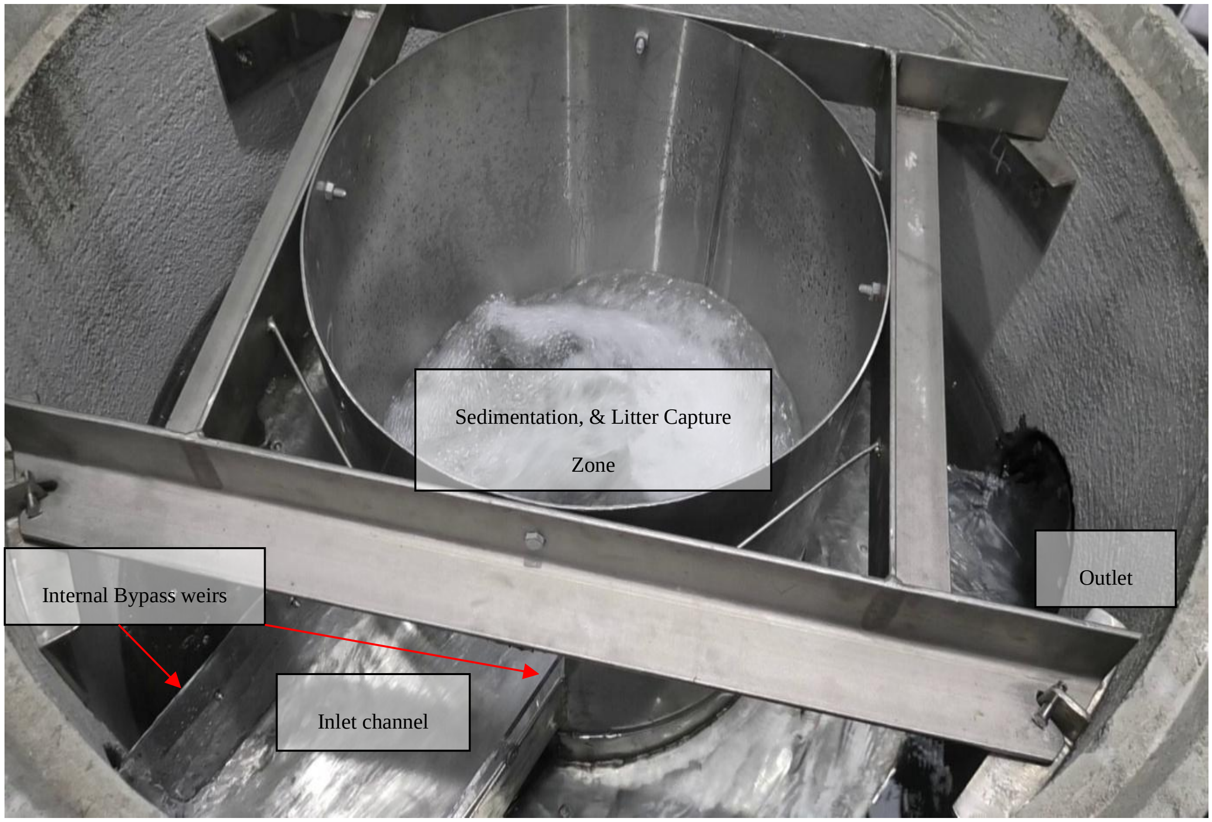

Figure 11 Photo Inside the HumeFilter UPT1200

2.2 Removal Efficiency and Mass Loading Capacity Testing

Sediment removal testing was conducted to determine the removal efficiency as well as the sediment mass loading capacity. All test runs were conducted with clean water containing a background suspended sediment concentration (SSC) of <20 mg/L.

The sediment testing was conducted on an initially clean system at the target 100% MTFR of 12 L/s (190 gpm) with an influent concentration of 200 mg/L (±10%). A minimum of ten 30-minute test runs were required to be conducted to meet the removal efficiency criterion of a cumulative removal efficiency >80%. The captured sediment was not removed from the system between test runs.

Ten (10) test runs were performed at an influent TSS concentration of 200 mg/L (±10%). For each of these tests, five effluent samples and three background samples were collected. Samples collected at the WLA hydraulics lab were forwarded to the EAL laboratory at Southern Cross University for SSC testing. Water samples were tested using the whole sample with washout, in accordance with ASTM D3977.

Prior to each sediment removal efficiency test, the auger was calibrated to ensure the appropriate amount of test sediment was injected +/- 10%. The mass of the dose sediment was determined prior to each test with a calibrated Ohaus Scout SPX123 balance to the nearest 0.01kg. This was deposited into the auger under the observation of the third-party observer. The sediment remaining in the auger was removed at completion of the test and weighed. The total influent mass dosed per test run was determined by correcting for moisture content, sediment retained in the inlet pipe and subtracting the mass collected for the dose rate samples.

The total mass injected into the system was quantified for each run by subtracting the mass remaining in the feeder and collected for the feed rate calibrations from the recorded starting mass. This value was used in calculating the influent mass/volume concentration.

The Sediment Mass Loading Capacity Testing was a continuation of the TSS Removal Efficiency study. Once 10 compliant test runs were completed, the Mass Loading Capacity testing was performed at a target influent concentration of 400 mg/L (±10%). In accordance with the NJDEP Protocol, testing continued until the cumulative TSS removal efficiency dropped below 80%, and/or the driving head exceeded the maximum driving head. Once this occurred, the test flowrate was reduced to 90% of the MTFR and testing recommenced until either the cumulative TSS removal efficiency once more dropped below 80%, and/or the driving head exceeded the maximum driving head.

From the data collected, the following graphs will be produced to show the life cycle performance of the HumeFilter UPT stormwater treatment device:

- Driving Head vs. Sediment Mass Loading
- Removal Efficiency vs. Sediment Mass Loading

The total mass captured in the system was quantified at the conclusion of the testing. This data is used for determination of the maximum inflow drainage area (acres) per the NJDEP protocol.

Sediment Sampling

During the test, sediment feed samples were collected at the injection point before, in the middle and just prior to the conclusion of each test run, into a clean 500mL plastic jar. A minimum volume of 0.1 liter was collected or a collection interval that did not exceed 1 minute, timed to the nearest second (whichever comes first). Samples were weighed to the nearest 0.01g with analysis revealing that the COV did not exceed 0.10. When sampling was interrupted to collect the sediment sample, three MTD detention times were waited before outlet sampling recommences.

Background and Effluent Sampling

The background and effluent samples were collected according to a predetermined schedule. The effluent grab samples were collected in clean plastic 1-L containers in a single sweeping motion across the full effluent flow profile.

Background grab samples were collected in clean plastic 2-L containers, taken from the inlet pipe, via a tap in the invert of the pipe, in correspondence with each odd-numbered effluent sample. The first effluent grab sample was collected following a minimum of three MTD detention times after flow rate was established and the first sediment sample was collected. The detention time was calculated to be 2min:03sec. Therefore, the first effluent sample was collected at 7min:09sec from the commencement of the test to account for the 1-minute sediment dose collection + 6min:09 sec for the three detention times.

Each subsequent sample was taken 6 minutes thereafter, until Sample 3, when the sediment feed sample 2 was taken. Then the next effluent sample was delayed by 7min:09sec (3 detention times + 1 minute sediment collection) to avoid being influenced by the interruption of the sediment dosing. Sample volumes were a minimum of 500 ml per the NJDEP Protocol requirements. Since the HumeFilter UPT1200 does not incorporate internal backwash or post-operation drawdown flow, flow measurement and samples of this function are not required. The sampling schedule used is shown in **Table 2**.

Table 2 Sampling Schedule

Elapsed Time (hh:mm:ss)	Effluent Sample	Sediment Feed Sample	Background TSS Sample
0:00:00		1	
0:07:09	1		1
0:13:09	2		
0:19:09	3	2	2
0:26:18	4		
0:32:18	5	3	3

2.3 Scour Testing

No scour testing was conducted since the HumeFilter UPT is designed for offline installation.

2.4 Quality Objectives and Criteria

Samples were collected in-house by Waterlabs personnel under supervision by an independent third party (Associate-Professor Prasanna Egodawatta from Queensland University of Technology (QUT) Australia). All collection bottles were labelled and organized prior to testing. Samples were sent to EAL as soon as possible after testing. A Chain of Custody (COC) form was used for each set of samples.

Sediment was stored in sealed crates, with desiccant parcels to minimize moisture content, and accessed immediately prior to the test to weigh the dose amount required for the test.

Other quality control measures that were performed during the tests were:

- Monitoring water temperature to ensure temperature did not exceed 80 degrees Fahrenheit (26.7^{o}C).
- Monitoring background water concentrations to ensure background TSS levels did not exceed 20 mg/L.
- Monitoring flowrate at the inlet and the outlet.

2.5 Laboratory Proficiency

To demonstrate laboratory proficiency in accordance with Section 3B of the Protocol, twelve water samples were spiked with known concentrations [6 @ 20 (±5) mg/L, 6 @ 50 (±5) mg/L] by WLA using the same sediment as that used for the performance testing. This exceeds the minimum Protocol requirement of 3 each. These samples were sent to EAL, the independent third party laboratory, for analysis against the APHA 2540D standard, adapted to apply the same requirements of ASTM D3977-97 including using the full 500mL sample volume, and rinsing the sample container. Two replicates were performed following Sample 6 of Replicate 1 returning a low result. Replicate 2 recorded one sample for 20 mg/L at 180% recovery, and one 50 mg/L sample at 120% recovery. When considered as an average of all results (n = 6 each), the SSC recovery is within the 85%-115% range specified by the Protocol. Results are shown in **Table 3**.

Table 3 Laboratory Proficiency SSC Results

Replicate	Sample ID	Measured Concentration (mg/L)	Reported Concentration (mg/L)	% recovery
Replicate 1	Sample 1	20.2	17	84%
	Sample 2	20.4	19	93%
	Sample 3	20.2	16	79%
Replicate 2	Sample 1	20.6	37	180%
	Sample 2	20.2	18	89%
	Sample 3	19.8	20	101%
	Average			**104%**
Replicate 1	Sample 4	48.2	37	77%
	Sample 5	48.6	38	78%
	Sample 6	48.2	25	52%
Replicate 2	Sample 4	49.8	44	88%
	Sample 5	49.6	46	93%
	Sample 6	51.0	61	120%
	Average			**85%**

3. Performance Claims

Per the NJDEP verification procedure and based on the laboratory testing conducted on the HumeFilter UPT1200, the following are the performance claims made by Humes.

Total Suspended Solids (TSS) Removal Efficiency

Based on the laboratory testing conducted, the tested HumeFilter UPT1200 achieved a 97.7% cumulative TSS removal efficiency rounded down to 80% per the NJDEP protocol.

Effective Filtration Treatment Area (EFTA)

The tested HumeFilter UPT1200 has an EFTA of 109 m^2 - (1173 ft^2).

Maximum Treatment Flow Rate (MTFR)

The tested HumeFilter UPT1200 has an MTFR of 190 gpm (12 L/s) – (190/1173 = 0.16 gpm/ft^2)

Sediment Load Capacity/Mass Load Capture Capacity

Based on laboratory testing results, the HumeFilter UPT1200 has a mass loading capacity of 188.0 lbs (85.3 kg) and a mass loading capture capacity of 183.7 lbs (83.34 kg).

Maximum Allowable Inflow Drainage Area

Per the NJDEP filter protocol, to calculate the maximum inflow drainage area, the total sediment load captured mass observed during the test (183.7lbs) is divided by 600 lbs/acre. Thus, the maximum inflow drainage area for the HumeFilter UPT1200 is 0.306 acres.

4. Supporting Documentation

The NJDEP procedure (NJDEP, 2021) for obtaining verification of a stormwater manufactured treatment device (MTD) from the New Jersey Corporation for Advanced Technology (NJCAT) requires that "copies of the laboratory test reports, including all collected and measured data; all data from performance evaluation test runs; spreadsheets containing original data from all performance test runs; all pertinent calculations; etc." be included in this section. This was discussed with NJDEP, and it was agreed that as long as such documentation could be made available by NJCAT upon request it would not be prudent or necessary to include all this information in this verification report. This information was provided to NJCAT and is available upon request.

4.1 Test Sediment PSD Analysis

The test sediment is a commercial brand of ground silica known as Sil-Co-Sil 106, blended with a sieved silica sand to simulate the NJDEP required particle size distribution. This material has a specific gravity of 2.65. The particle size distribution (PSD) was independently verified by ALS Environmental (ALS) to demonstrate that the test sediment meets the specifications as detailed in Section 4 of the NJDEP Protocol (**Table 4**). ALS Environmental is accredited with the National Association of Testing Authorities (NATA) for PSD testing in accordance with AS1289 3.6.1 (sieve) and AS1289 3.6.3 (hydrometer) analysis. Three (3) samples were tested using the above methods. Results of the particle size gradation testing are shown in **Table 5**. These results are graphed against the NJDEP required PSD in **Figure 12**.

Table 4 NJDEP Test Sediment PSD Requirements

Particle size (microns)	NJDEP Specification (% passing)
1000	100
500	95
250	90
150	75
100	60
75	50
50	45
20	35
8	20
5	10
2	5

Table 5 PSD of Test Sediment Samples

Particle diameter (microns)	Test sediment particle size (% less than)				NJDEP (-2%)
	Sediment 1	Sediment 2	Sediment 3	Test Sediment Average	PASS/FAIL
1000	100	100	100	100	PASS
500	98	98	98	98	PASS
250	87	87	90	88	PASS
150	77	77	82	79	PASS
100	61	63	68	64	PASS
75	53	56	61	57	PASS
50	49	51	55	52	PASS
20	32	32	34	33	PASS
8	19	18	20	19	PASS
5	14	14	15	14	PASS
2	9	11	11	10	PASS
d50(μm)	59	50	42	50	PASS

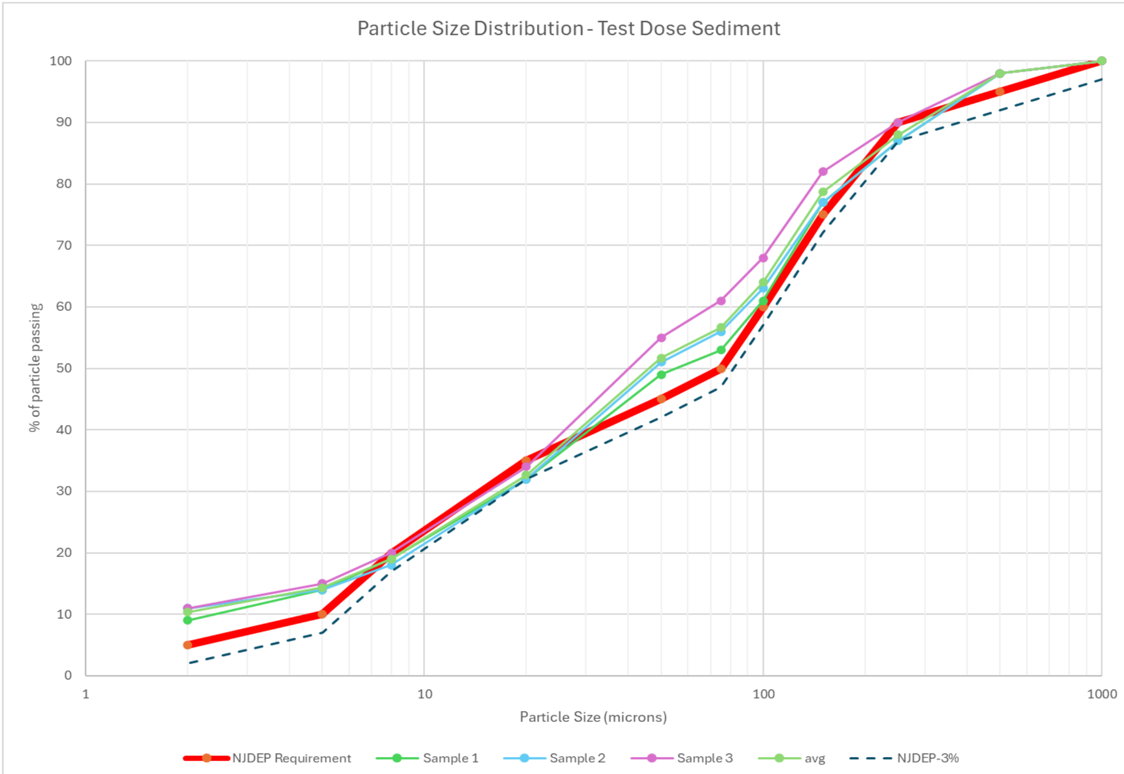

Figure 12 PSD Curves of 1-1000 Micron Test Sediment

4.2 Removal Efficiency and Mass Loading Testing

The influent mass was calculated from **Eqn. 1**:

$$\textit{Influent Mass (mg)} = (1\text{-Sediment Moisture Content}) \times [Mass_{pre\text{-}test\,(kg)} - Mass_{post\text{-}test\,(kg)} - Mass_{inlet\,pipe\,(kg)}] - \sum Mass_{dose\,samples} \times (1x10^6)$$

The average influent SSC was then calculated from **Eqn. 2**:

$$Average\ Influent\ SSC\ \left(\frac{mg}{L}\right) = \frac{Eqn\ 1.\ Influent\ Mass\ (mg)}{Average\ Flowrate\ \left(\frac{L}{min}\right) * Time_{dose\ injection}\ (\text{min})}$$

The individual run efficiency was calculated from **Eqn. 3**:

$$\text{Removal Efficiency} = \frac{\left(\begin{matrix} Avereage\ Influent \\ TSS\ Concentration\ X \\ Total\ Volume\ of\ Test\ Water \end{matrix}\right) - \left(\begin{matrix} Adjusted\ Effluent \\ TSS\ Concentrations\ X \\ Total\ Volume\ of\ Effluent\ Water \end{matrix}\right)}{Average\ Influent\ TSS\ Concentration\ X\ Total\ Volume\ of\ Test\ Water} \times 100$$

Testing Summary

A total of 10 removal efficiency test runs and 5 additional sediment mass loading capacity test runs were performed in accordance with the NJDEP Protocol. The target influent concentration was increased to 400 mg/L for the 5 sediment mass loading capacity test runs. The target removal efficiency tests were conducted at 12 L/s (190 gpm) as were the first 3 sediment mass loading capacity test. Once the driving head exceeded the maximum driving head (Run 13), the test flowrate was reduced to 90% of the MTFR and testing recommenced until the driving head exceeded the maximum driving head (Run 15). All tests met the requirements of the NJDEP protocol and the QA/QC parameters. **Table 6** (Flow Rate and Water Temperature) and **Table 7** (Feed Rate and Water Temperature) summarize the various QA/QC parameters recorded during the test runs.

Table 6 Summary of Flow Rate and Water Temperature

Test ID	QA/QC Pass/Fail	Target Inflow Rate (L/s)	Target Inflow Rate (gpm)	Average Inflow Rate (L/s)	Average Inflow Rate (gpm)	Inflow Rate COV (≤0.03)	Maximum Water Temperature (≤ 26.3 °C)	Maximum Water Temperature (≤ 80 °F)
1	PASS	12.	190.	12.152	192.608	0.0089	20.3	68.5
2	PASS	12.	190.	12.012	190.398	0.0007	20.8	69.4
3	PASS	12.	190.	12.131	192.274	0.0077	20.6	69.1
4	PASS	12.	190.	12.024	190.579	0.0014	20.6	69.1
5	PASS	12.0	190.	12.078	191.437	0.0046	23.3	73.9
6	PASS	12.0	190.	11.961	189.591	0.0023	20.8	69.4
7	PASS	12.0	190.	11.818	187.313	0.0108	22.0	71.6
8	PASS	12.0	190.	12.009	190.347	0.0005	22.3	72.1
9	PASS	12.0	190.	11.995	190.132	0.0003	22.3	72.1
10	PASS	12.0	190.	12.074	191.378	0.0044	22.8	73.0
SML-1	PASS	12.0	190.	11.876	188.236	0.0074	24.5	76.1
SML-2	PASS	12.0	190.	12.035	190.760	0.0021	23.0	73.4
SML-3	PASS	12.0	190.	12.077	191.418	0.0045	22.5	72.5
SML-4	PASS	10.8	171.2	10.710	169.751	0.0059	23.3	73.9
SML-5	PASS	10.8	171.2	10.730	170.079	0.0046	21.3	70.3

Table 7 Feed Rate and Concentration QA/QC Results

Test ID	QA/QC Pass/Fail	Target Inflow SSC (mg/L)	Average Influent SSC (mg/L) (±10%)	Dose Mass in Pipe & Auger (g)	Moisture Corrected Feed Rate (g/min)			Feed Rate COV (≤ 0.10)	Average Background SSC (mg/L)	Minimum SSC Sample Volume (mL) (>500 mL)
1	PASS	200	192.0	16	138.062	137.063	134.695	0.013	1.	503.3
2	PASS	200	199.4	15	146.136	143.849	136.951	0.034	0.5	562.4
3	PASS	200	197.8	16	146.493	140.569	129.770	0.061	1.	554.7
4	PASS	200	198.4	17	144.627	144.038	144.188	0.002	2.	543.0
5	PASS	200	198.1	16	145.060	143.232	142.293	0.010	1.2	559.3
6	PASS	200	196.4	14	143.129	142.830	140.433	0.010	1.	553.7
7	PASS	200	202.4	17	147.925	142.292	142.302	0.023	1.	565.6
8	PASS	200	200.0	17	145.155	148.292	142.168	0.021	1.	571.1
9	PASS	200	200.5	16	146.733	141.978	143.996	0.017	1.	547.1
10	PASS	200	196.4	15	147.418	142.733	137.629	0.034	1.	565.3
SML-1	PASS	400	401.7	16	287.658	283.884	285.547	0.007	1.	566.4
SML-2	PASS	400	400.7	15	291.654	290.105	288.316	0.006	0.8	559.0
SML-3	PASS	400	397.4	17	290.492	290.095	285.042	0.011	3.	562.0
SML-4	PASS	400	426.2	14	260.840	270.695	291.914	0.058	0.7	565.6
SML-5	PASS	400	421.6	2	256.709	262.167	246.600	0.031	0.7	556.1

Removal Efficiency Results

Results from the 10 removal efficiency tests are shown in **Table 8** (Background and Effluent Sediment Concentrations) and **Table 9** (Summary of Removal Efficiency Test Results). The cumulative sediment removal efficiency at Run 10 of 96.2% greatly exceeds the NJDEP protocol requirement of ≥80%.

Table 8 Background and Effluent Sediment Concentrations

Test ID		Individual Sample					Average
		1	2	3	4	5	
1	Background	1		1		1	1
	Effluent	18	19	21	19	19	19.2
2	Background	0.5		0.5		0.5	0.5
	Effluent	11	17	16	15	9	13.6
3	Background	1		1		1	1
	Effluent	2	6	5	3	6	4.4
4	Background	1		1		4	2
	Effluent	15	12	17	12	11	13.4
5	Background	0.5		2		1	1.2
	Effluent	11	9	12	11	12	11
6	Background	1		1		1	1
	Effluent	6	2	5	9	5	5.4
7	Background	1		1		1	1
	Effluent	4	1	4	3	6	3.6
8	Background	1		1		1	1
	Effluent	3	3	7	9	8	6
9	Background	1		1		1	1
	Effluent	8	7	5	5	7	6.4
10	Background	1		1		1	1
	Effluent	3	2	1	3	4	2.6

Table 9 Summary of Removal Test Results

Test ID	Dosing Water Volume (L)	Net Sediment Mass Injected (g)	Average Adjusted Effluent SSC (mg/L)	Effluent Mass (g)	Mass Captured (g)	Cumulative Mass Captured (kg)	Cumulative Mass Injected (kg)	Cumulative Removal Efficiency (%)
1	21448	4118	18.2	390	3728	3.728	4.118	**90.5**
2	21322	4252	13.1	279	3973	7.701	8.370	**92.0**
3	21592	4271	3.4	73	4198	11.899	12.641	**94.1**
4	21703	4306	11.4	247	4059	15.958	16.947	**94.2**
5	21740	4306	9.8	213	4093	20.051	21.253	**94.3**
6	21650	4252	4.4	95	4157	24.208	25.505	**94.9**
7	21390	4328	2.6	56	4272	28.480	29.833	**95.5**
8	21736	4348	5.0	109	4239	32.719	34.181	**95.7**
9	21652	4342	5.4	117	4225	36.944	38.523	**95.9**
10	21794	4280	1.6	35	4245	41.189	42.803	**96.2**

Sediment Mass Load Capacity Testing

After completion of the required 10 removal efficiency test runs, sediment feed rate, background and outlet samples were collected via grab sampling for a further 5 sediment mass loading capacity test runs. The target influent concentration for the sediment mass load capacity testing was increased to 400 mg/L. This was performed until the Hydraulic Grade Line (HGL) reached the maximum permitted level (137.5 mm), which occurred on the third SML test. Once this had occurred, the inflow rate was decreased by 10% and further test runs completed until the HGL once again exceeded 137.5 mm, or removal efficiency dropped below 80%. The HumeFilter achieved a cumulative mass removal efficiency of 80% for a total of 15 trials. The testing was suspended after 15 test runs. Shown in **Table 10** (Background and Effluent Sediment Concentrations) and **Table 11** (Summary of Sediment Mass Loading Test Results). **Figure 13** plots cumulative removal efficiency vs sediment mass load captured.

Table 10 Background and Effluent Sediment Concentrations

Test ID		Individual Sample					Average
		1	2	3	4	5	
SML-1	Background	1		1		1	1
	Effluent	4	6	5	6	4	5
SML-2	Background	0.5		1		1	0.8
	Effluent	4	8	3	9	3	5.4
SML-3	Background	2		2		5	3
	Effluent	9	6	6	8	8	7.4
SML-4	Background	1		0.5		0.5	0.7
	Effluent	1	4	1	4	1	2.2
SML-5	Background	0.5		0.5		1	0.7
	Effluent	1	0.5	6	5	0.5	2.6

Table 11 Summary of Sediment Mass Loading Test Results

Test ID	Dosing Water Volume (L)	Net Sediment Mass Injected (g)	Average Adjusted Effluent SSC (mg/L)	Effluent Mass (g)	Mass Captured (g)	Cumulative Mass Captured (kg)	Cumulative Mass Injected (kg)	Cumulative Removal Efficiency (%)
SML-1	21495	8635	4.0	86	8549	49.738	51.438	**96.7**
SML-2	21844	8753	4.6	100	8653	58.391	60.191	**97.0**
SML-3	21798	8662	4.4	96	8566	66.957	68.853	**97.2**
SML-4	19384	8261	1.5	29	8232	75.189	77.114	**97.5**
SML-5	19411	8184	1.9	37	8147	83.336	85.298	**97.7**

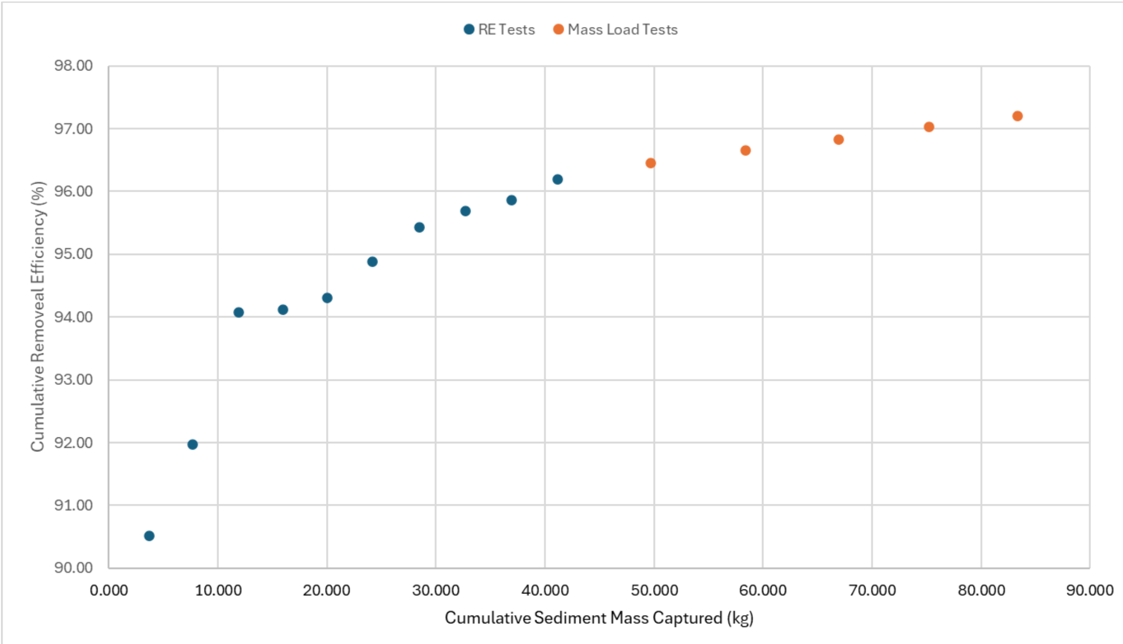

Figure 13 Cumulative Removal Efficiency vs Cumulative Sediment Mass Captured

4.3 Water Surface Level (Hydraulic Grade Line)

Hydraulic grade was monitored for every test. The maximum level permitted before the internal bypass occurs is at the manometer reading of 137.5 mm (5.41 inches), equivalent to 150 mm (5.91 inches) at the HumeFilter internal bypass weirs. This level was reached briefly in the final seconds of test 13, after recording the 32 minute reading. The flowrate was subsequently reduced by 10% and replicates continued. Two (2) further sediment capacity replicates were completed until the internal bypass level was once again reached. Test 15 commenced overflow internally during the 24th minute of the test, with a small proportion of the flow bubbling over the internal weirs due to the turbulence of the inflow. The majority of the flow continued to be treated through the filters. The upstream maximum water surface level (WSL) at the end of each run along with the cumulative mass captured is shown in **Table 12** and plotted in **Figure 14**.

Table 12 Maximum WSL vs Cumulative Mass Captured

Test ID	Upstream Maximum WSL (mm)	Cumulative Mass Captured (kg)
1	9	3.728
2	6	7.701
3	5	11.899
4	9	15.958
5	6	20.051
6	6	24.208
7	6	28.480
8	5	32.719
9	6	36.944
10	5	41.189
SML-1	6	49.738
SML-2	26	58.391
SML-3	126	66.957
SML-4	91	75.189
SML-5	150	83.336

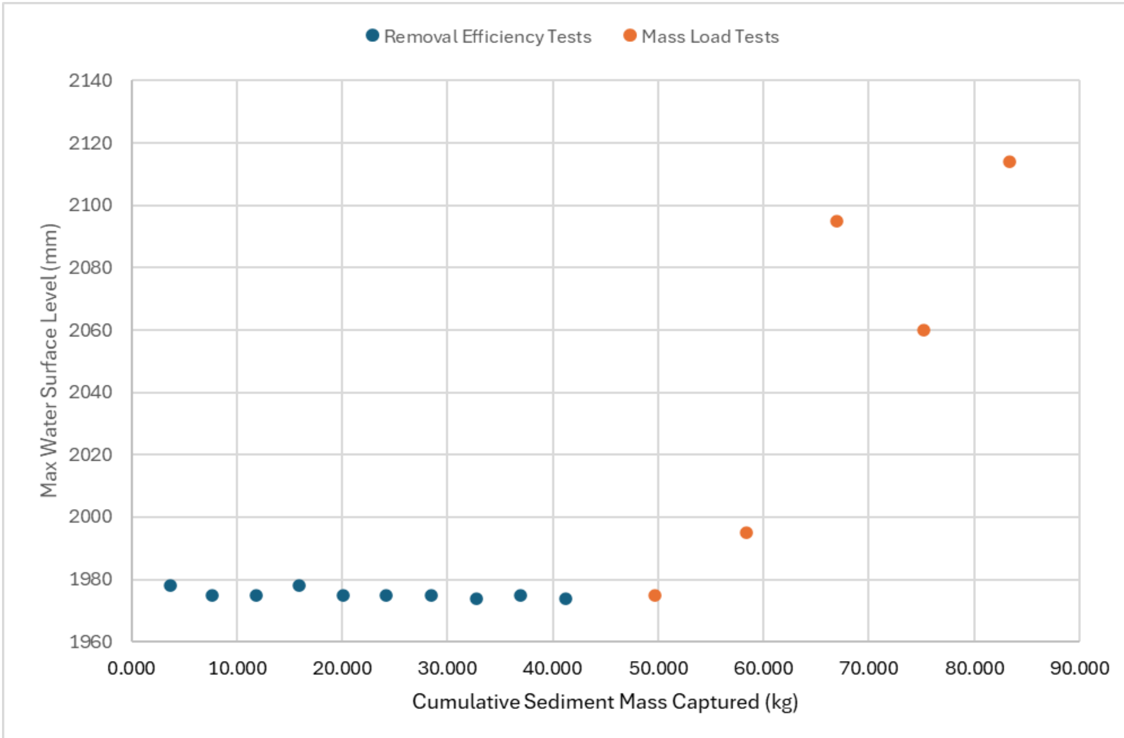

Figure 14 Maximum Water Surface Level vs Cumulative Sediment Mass Captured

5. Design Limitations

Required Soil Characteristics

The soil should be verified for its bearing capacity to ensure it is adequate for the required load prior to installation. The site shall be stabilized to achieve a non-erodible soil surface. Any topsoil removed during the excavation stage should be stockpiled and kept separate from subsoil or other materials. The HumeFilter UPT should not be installed on frozen ground.

Slope

The floor of the manhole should have a maximum slope of 6 mm (0.24 inches) across its width and a downstream slope of 25 mm (0.98 inches) per 3.7 m (12.14 ft) of length. Here, "length" refers to a line from the outlet invert through the center of the manhole, while "width" is perpendicular to this length.

Maximum Flow Rate

The maximum treatment flow rate of the HumeFilter is dependent upon model size and performance specifications. The model being tested is the UPT1200, which has a treatable flow rate of 12 L/s (190. gpm).

Driving Head

The maximum available driving head for a given HumeFilter UPT is 150 mm (~5.9 inches).

Installation Limitations

The HumeFilter UPT is supplied to site in separate, easily identifiable components. An installation guide is also provided. The device can be installed by a civil or plumbing contractor, with a Humes representative present if necessary. Component maximum weights and required lifting clutches information will be shared to the contractor prior to installation.

Configurations

The HumeFilter UPT is designed solely for offline installations to minimize maintenance requirements and for optimal performance.

Structural Load Limitations

The HumeFilter is assembled within a fully trafficable (HS-20), precast concrete chamber for underground installations on constrained sites, optimizing above land-use.

Pre-treatment Requirements

No pre-treatment is required for this device.

Depth to Seasonal High-Water Table

During installation, excavated areas with a high-water table should be continuously dewatered to ensure the site is stable and free of water.

6. Maintenance

The Humes HumeFilter unit must be maintained in accordance with all relevant health and safety requirements including the use of personal protective equipment (PPE) and fall protection where required. It is generally recommended that inspection of the unit be undertaken every three months for the first year of operation. The schedule may then be relaxed after a year, when confidence is gained regarding the actual pollutant load and run-off generated by the upstream catchment.

Maintenance

Yearly maintenance involves removing the contents of the sump with a vacuum truck and backwashing the filters with 2000L of clean water. The stainless-steel insert should also be rinsed. A filter exchange requirement will be triggered if the water level on the outside of the filters rises to the level of the return channel. If this requirement is not triggered, the filters may remain until the following inspection period.

Every second year, maintenance includes the above procedures as well as additional maintenance practices. This includes removing and rinsing the used GAC and pleated cartridge filters. The inside of the concrete chamber should be thoroughly rinsed, and the residual material and water vacuumed out. The filters should be replaced, and the old filters taken to the manufacturer for cleaning and replenishment.

Solids Disposal

Solids vacuumed from the device during maintenance including sediment, floatables, and gross pollutant debris can generally be disposed of at a local landfill in accordance with local regulations. The potential toxicity of the residues generated will vary based on the activities within the drainage area. If there is a possibility that the residues are hazardous, testing may be necessary. It is important to consult local regulatory authorities regarding proper disposal procedures in all instances.

Inspection / Maintenance
A detailed inspection procedure and maintenance overview can be found for the HumeFilter UPT at: https://www.humes.com.au/sites/humes/files/docs/humefilter_maintenance_guide.pdf

7. Statements

The following signed statements from the manufacturer (Holcim), independent testing laboratory (Waterlabs Australia), Prof. Egodawatta and NJCAT are required to complete the NJCAT verification process.

HOLCIM

Dr. Richard Magee
Executive Director
New Jersey Corporation for Advanced Technology
c/o Center for Environmental Systems
Stevens Institute of Technology
One Castle Point on Hudson
Hoboken, NJ 07030

Holcim Australia Pty Ltd (Trading as Humes)
18 Little Cribb St,
Milton QLD, 4064
Australia

Phone +61 429 791 386
charles.kelly@holcim.com

31 October 2024

RE: Verification of the HumeFilter Universal Pollutant Trap (UPT)

Dr. Richard Magee,

This correspondence is being sent to you in accordance with the "Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology" dated August 4, 2021.

Specifically, the process document requires that manufacturers submit a signed statement confirming that all of the procedures and requirements identified in the aforementioned process document and the "New Jersey Department of Environmental Protection (NJDEP) Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device" dated August 4, 2021 have been met.

We believe that the testing executed in Waterlabs Australia laboratory in Brisbane, QLD, Australia on the HumeFilter Universal Pollutant Trap during the spring of 2024 under the direct supervision of Dr. Darren Drapper, Principal Engineer from Waterlabs Australia, and overseen by Associate Professor Prasanna Egodawatta from Queensland University of Technology was conducted in full compliance with all applicable protocol and process criteria. Additionally, we believe that all the required documentation of the testing and resulting performance calculations has been provided within the submittal accompanying this correspondence.

Please do not hesitate to contact me with any additional questions related to this matter.

Yours sincerely,

C.A. Kelly

Dr. Charles Kelly
National Manager – Water Solutions
Holcim Australia Pty Ltd
Humes Concrete Products

Waterlabs Australia Pty Ltd
4/54 Quilton Place, Crestmead, QLD 4132
info@waterlabs.com.au

Your Ref:

Dr Richard Magee
Executive Director
New Jersey Corporation for Advanced Technology
c/o Center for Environmental Systems
Stevens Institute of Technology
One Castle Point on Hudson
Hoboken, NJ 07030

Verification of the Humefilter® UPT
Independent Test Facility Statement

Dear Dr Richard Magee,

This correspondence is being sent in accordance with the *Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology; for use in accordance with the Stormwater Management Rules*, N.J.A.C. 7:8, August 4, 2021.

Compliance

As an Independent Third Party conducting the laboratory testing on behalf of Holcim Australia Pty Ltd (trading as Humes concrete products), we can advise that all of the procedures and requirements identified in the aforementioned process document, and the *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Tota Suspended Solids Removal by a Filtration Manufactured Treatment Device*, April 25, 2023, and the approved Quality Assurance Project Plan (v5, dated 27th August 2024) have been met or exceeded. The testing executed in the Waterlabs Australia laboratory in Crestmead, QLD, Australia from August to September of 2024, under the supervision of Associate Professor Prasanna Egodawatta from QUT, was conducted in full compliance with all applicable protocol and process criteria. We confirm that all the required documentation from the testing, and performance calculations have been provided with the supporting information.

Holcim Australia representatives were present for some testing events, but were excluded from the sample collection, handling and processing.

All samples were tested by independent, external laboratories accredited under the National Association of Testing Authorities (NATA) scheme.

Conflicts of Interest

This letter also discloses that we, and our staff, have no conflicts of interest in performing the above testing. We have a consulting agreement with Holcim Australia for the Humefilter® laboratory testing, and have historically provided field testing for Holcim Australia on the Humefilter® for the Stormwater Australia, Stormwater Quality Improvement Device Evaluation Protocol (SQIDEP) process. We have no ownership stake, do not receive sales commissions, do not have licensing agreements and do not receive funds or grants beyond those associated with the testing program.

Waterlabs Australia has provided professional services to other manufacturers of stormwater products with no history of conflicts of interest, or ethical disputes. Our work with each client is protected through non-disclosure agreements and is independent of the work for Holcim Australia.

Should you have any further queries or concerns, please don't hesitate to contact me on 0431 299 875.

Kind Regards,

Dr Darren Drapper,
B.Eng(Env) Hons, PhD(EnvEng), MBA, Cert IV (WHS), MIEAust, CPEng, RPEQ.
Principal Engineer
Waterlabs Australia

Queensland University of Technology
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Third-Party Observation of NJCAT Testing for the HUMEFILTER UPT

To whom it may concern,

This letter confirms my participation as a third-party observer for the HUMEFILTER UPT testing undertaken by Waterlabs Australia. Based on the direct observations of the performance testing procedure, including the laboratory setup, equipment, and material used, I can confirm that all of the approved Quality Assurance Project Plan requirements for NJCAT testing have been met. I can also confirm that the verification report reflects the testing observed.

I, as a person, or QUT, as a reputed research organisation have no conflicts of interest that would bias my third-party observation of this testing for the HUMEFILTER UPT

Please do not hesitate to seek more information if required.

Prasanna Egodawatta

Prasanna Egodawatta | Associate Professor | Academic Lead Learning & Teaching
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Center for Environmental Systems
Stevens Institute of Technology
One Castle Point
Hoboken, NJ 07030-0000

November 15 , 2024

Gabriel Mahon, Chief
NJDEP
Bureau of Non-Point Pollution Control
Division of Water Quality
401 E. State Street
Mail Code 401-02B, PO Box 420
Trenton, NJ 08625-0420

Dear Mr. Mahon,

Based on my review, evaluation and assessment of the testing on the HumeFilter UPT1200 conducted by Waterlabs Australia (WLA) at the company's full-scale hydraulic testing facility in Brisbane, Australia under the direction of Dr Darren Drapper, the test protocol requirements contained in the *"New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device"* (NJDEP Filtration Protocol), dated January 14, 2022 (updated April 25, 2023) were met. Specifically:

Test Sediment Feed -The mean PSD (D_{50}) of the test sediment utilized for removal efficiency testing and mass loading capture capacity was 50 µm, less than the 75 µm as required by the protocol.

Removal Efficiency Testing – The tested UPT1200 achieved a 97.7% cumulative TSS removal efficiency rounded down to 80% per the NJDEP protocol and a mass loading capture capacity of 183.7 lbs. Per the NJDEP protocol, the maximum inflow drainage area for the HumeFilter UPT1200 is 0.306 acres.

Scour Testing – Hume decided to not conduct scour testing on a 50% loaded bed. The UPT1200 will be designated as an offline system.

All other criteria and requirements of the NJDEP HDS Protocol were met. These include flow rate measurements COV <0.03; test sediment influent concentration COV <0.10; test sediment influent concentration within 10% of the targeted value of 200 mg/L; influent background concentrations <20 mg/L; and water temperature <80 ^{o}F.

Sincerely,

Richard S. Magee, Sc.D., P.E., BCEE

8. References

NJDEP 2021. *New Jersey Department of Environmental Protection Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology.* Trenton, NJ. August 4, 2021.

NJDEP 2022. *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device.* Trenton, NJ. January 14, 2022 (Updated April 25, 2023).

VERIFICATION APPENDIX

Introduction

- Manufacturer of the HumeFilter® UPT1200–Holcim Australia Pty Ltd–Humes Concrete Products, 18 Little Cribb St, Milton, QLD, 4064, AUSTRALIA. Phone: +61 1300 361 601. www.humes.com.au

- MTD: HumeFilter® UPT1200. The HumeFilter UPT family of devices is scaled differently than the scaling principles outlined in Section 6 of the NJDEP Filtration Protocol. Consequently, additional testing is planned to validate Hume's alternate scaling methodology and extend this verification to encompass the entire HumeFilter UPT family.

- TSS Removal Rate: 80%

- The HumeFilter UPT1200 is qualified for offline installation for the New Jersey Water Quality Design Storm (NJWQDS).

Detailed Specification

- Additional HumeFilter UPT module types and sizing (MTFR and maximum drainage area per NJDEP sizing requirements) will be added to this report as an Addendum once the alternate scaling methodology has been validated.

- The HumeFilter UPT1200 has a mass loading capacity of 188.0 lbs (85.3 kg) and a mass loading capture capacity of 183.7 lbs (83.34 kg). The maximum inflow drainage area for the tested system is 0.306 acres.

- Prior to installation, Humes provides contractors with detailed installation and assembly instructions and is available to consult onsite during installation.

- The HumeFilter® UPT Inspection & Maintenance Guide may be found at: https://www.humes.com.au/sites/humes/files/docs/humefilter_maintenance_guide.pdf

- Under N.J.A.C. 7:8-5.5, NJDEP stormwater design requirements do not allow a hydrodynamic separator such as the HumeFilter UPT to be used in series with another hydrodynamic separator to achieve an enhanced total suspended solids (TSS) removal rate.

SCALING ADDENDUM

HumeFilter® Universal Pollutant Trap (UPT) Stormwater Treatment Device

Holcim Australia Pty Ltd
(Trading as Humes)

April 2025

Purpose

The HumeFilter® Universal Pollutant Trap (UPT) Stormwater Treatment Device is commercially available in 5 models (UPT1200, UPT1800, UPT2400, UPT3000, and UPT3600). The HumeFilter UPT1200 was tested to the New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device dated January 1, 2021 (Last updated April 25, 2023). Henceforth referred to as "the Protocol") and subsequently verified by the New Jersey Corporation for Advanced Technology (NJCAT) and certified by the New Jersey Department of Environmental Protection in March 2025. Based on the laboratory testing conducted, the tested HumeFilter UPT1200 achieved a 97.7% cumulative TSS removal efficiency rounded down to 80% per the NJDEP protocol. The purpose of this addendum is to propose a scaling methodology based on the results of the UPT1200 testing, that is consistent with NJDEP filtration protocol requirements, and numerous government and scientific references sizing GAC filters based on Empty Bed Contact Time (EBCT).

The HumeFilter® UPT consists of two separate concentric filters. The inner filter is a GAC filter that varies in depth (thickness) from 0.05m for the UPT1200 to 0.175m for the UTP3600. The outer filter is a pleated filter that has an EFTA of 109 m^2 for the UPT1200 and 1306 m^2 for the UPT3600.

The HumeFilter® UPT was designed to provide removal of TSS and additional stormwater pollutants including nutrients. It uses an internal GAC cartridge to remove the latter, however, nutrients were not the subject of this testing. The HumeFilter UPT family of devices are scaled differently than the scaling principles outlined in Section 6 of the NJDEP Filtration Protocol. After further analysis of this scaling methodology, it was determined that additional testing is not required to validate Hume's alternate scaling methodology and extend this verification to encompass the entire HumeFilter UPT family since the scaling methodology is already embedded in HumeFilter UPT1800 to UPT3600 designs (**Table A-1** and **Table A-2**).

Table A-1 demonstrates that the HumeFilter UPT scaling ratios meet the NJDEP protocol requirements for the pleated filter. Since scientific references and industry practice is to size GAC filters using EBCT, the four larger models UPT1800 to UPT3600 follow these guidelines and are designed with the same or longer EBCTs than the tested UPT1200 for the GAC filter cartridges. **Table A-2** demonstrates the scaling of the GAC cartridge based on EBCT.

Table A-1 HumeFilter UPT Model Design Specifications

Model	MFTR (L/s)	EFTA[1] (m^2)	ESTA[2] (m^2)	WV[3] (m^3)	MTFR:EFTA	ESTA:EFTA	WV:EFTA	Mass Load Captured[4] (lbs)	ACRES[5]
UPT1200	**12**	**109**	**0.453**	**1.705**	**0.11**	**0.0041**	**0.0156**	**184**	**0.307**
UPT1800	**27**	**246**	**1.483**	**4.087**	**0.11**	**0.0060**	**0.0166**	**415**	**0.692**
UPT 2400	**49**	**440**	**2.378**	**7.142**	**0.11**	**0.0054**	**0.0162**	**742**	**1.24**
UPT3000	**95**	**852**	**3.597**	**13.308**	**0.11**	**0.0042**	**0.0156**	**1436**	**2.39**
UPT3600	**138**	**1306**	**5.309**	**20.323**	**0.11**	**0.0041**	**0.0156**	**2201**	**3.67**

1. **ESTA – Effective Sedimentation Treatment Area –** The area inside the GAC cartridge.
2. **EFTA – Effective Filtration Treatment Area –** The pleated cartridge filter area. A product of the number of volume pleats (from the manufacturer) and the area of the pleats.
3. **WV – Wet Volume –** The maximum water volume in the MTD during a filtration run.
4. **Mass Load Captured –** Scaled from the HumeFilter UPT1200 test results: Mass Load/EFTA = 183.7/109
5. **ACRES –** The drainage area based on the equation in the NJDEP Filtration protocol wherein drainage area is calculated by dividing the pounds of mass captured by 600 lb/acre.

Table A-2 HumeFilter Model GAC Scaling Ratios

Model	MTFR (L/s)	GAC ID (m)	GAC OD (m)	GAC Bed Thickness (m)	GAC Cartridge Height (m)	GAC Vol-ume (m^3)	GAC Resi-dence Time - EBCT (sec)
UPT1200	**12**	**0.76**	**0.86**	**0.050**	**1.2**	**0.15**	**12.5**
UPT 1800	**27**	**1.374**	**1.51**	**0.068**	**1.2**	**0.37**	**13.7**
UPT2400	**49**	**1.74**	**1.934**	**0.097**	**1.2**	**0.67**	**13.7**
UPT3000	**95**	**2.14**	**2.42**	**0.140**	**1.2**	**1.20**	**12.6**
UPT3600	**138**	**2.60**	**2.95**	**0.175**	**1.2**	**1.83**	**13.3**