May 2019

CONDITIONAL USE LEVEL DESIGNATION FOR BASIC (TSS) AND PHOSPHORUS

For

Rotondo Environmental Solutions, LLC’s
StormGarden Modular Stormwater Bio-filtration System
Standard Box Filter

Ecology’s Decision:

Based on Rotondo Environmental Solutions, LLC application submissions for the StormGarden Modular Stormwater Bio-filtration System (StormGarden System) standard box filter, Ecology hereby issues the following use level designation:

1. Conditional Use Level Designation (CULD) for Basic and Phosphorus Treatment
   • Sized at a hydraulic loading rate of 1.45 gallon per minute (gpm) per square foot (sq ft) of media surface area for Basic Treatment and 1.0 gpm/sq ft for Phosphorus Treatment.
   • Constructed with a minimum media thickness of 21-inches (1.75-feet).

2. Ecology approves the StormGarden System at the hydraulic loading rates listed above, to achieve the maximum water quality design flow rate. The water quality design flow rates are calculated using the following procedures:
   • Western Washington: For treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute flow rate as calculated using the latest version of the Western Washington Hydrology Model or other Ecology-approved continuous runoff model.
   • Eastern Washington: For treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute flow rate as calculated using one of the three methods described in Chapter 2.2.5 of the Stormwater Management Manual for Eastern Washington (SWMMEW) or local manual.
   • Entire State: For treatment installed downstream of detention, the water quality design flow rate is the full 2-year release rate of the detention facility.
3. The use level designation expires on July 1, 2021 unless extended by Ecology, and is subject to the conditions specified below.

Ecology’s Conditions of Use:

The StormGarden System shall comply with these conditions:

1) Rotondo Environmental Solutions, LLC shall design, assemble, install, operate, and maintain the StormGarden System installations in accordance with Rotondo Environmental Solutions, LLC’s applicable manuals and the Ecology Decision.

2) Install the StormGarden System in such a manner that you bypass flows exceeding the maximum operating rate and you will not resuspend captured sediment.

3) Evaluate site characterization and suitability, as outlined in the Stormwater Management Manual for Western Washington Volume III or Stormwater Management Manual for Eastern Washington Chapter 6, before installing any StormGarden Systems that infiltrate a portion or all of the treated flow.

4) Rotondo Environmental Solutions, LLC commits to submitting a QAPP for Ecology approval by October 1, 2016 that meets the TAPE requirements for attaining a GULD for Basic Treatment at a hydraulic loading rate of 140 inches/hour.

5) Rotondo Environmental Solutions, LLC shall complete all required testing and submit a TER for Ecology review by February 1, 2019.

6) Rotondo Environmental Solutions, LLC may request Ecology to grant deadline or expiration date extensions, upon showing cause for such extensions.

7) Discharges from the StormGarden System shall not cause or contribute to water quality standards violations in receiving waters.

Applicant: Rotondo Environmental Solutions, LLC

Applicant’s Address: 2560 Huntington Ave, Suite 303
Alexandria, VA 22303
Application Documents:

Application for Pilot Use Level Designation, BioPod High-Flow Media Bioretention System, Rotondo Environmental Solutions, LLC, January 2016


Addendum #1 BioPod Pollutant Removal Efficiency Test, Rotondo Environmental Solutions, LLC, May 2016

Application for Conditional Use Level Designation, StormGarden™ Biofilter System Performance Certification Project, Rotondo Environmental Solutions, LLC, May 2018

Applicant’s Use Level Request:

- Conditional Use Designation as a Basic and Phosphorus Treatment device in accordance with Ecology’s Stormwater Management Manual for Western Washington

Applicant’s Performance Claims:

- Based on field-testing with an average TSS influent concentration of 42 mg/L, the StormGarden can achieve an LCL95 TSS removal efficiency of 85% and an UCL95 effluent concentration of 5.5 mg/L at an infiltration rate of 140 inches per hour.
- Based on field-testing with an average total phosphorus concentration of 0.092 mg/L, the StormGarden can achieve an LCL95 total phosphorus removal efficiency of 53.8% at an infiltration rate of 95 inches per hour.
- Based on laboratory testing, at a hydraulic loading rate of 46 inches per hour, the StormGarden System has an average total suspended solids (TSS) removal efficiency of: 93% at an influent concentration of 20 mg/L; 94% at an influent concentration of 100 mg/L; and 98% at an influent concentration of 200 mg/L. These results were achieved using Sil-co-sil 106 (D₅₀ of 22 µm).
- Based on laboratory testing at a hydraulic loading rate of 140 inches per hours, the StormGarden System has an average TSS removal efficiency of 89.6% at an influent concentration of 130 mg/L. These results were achieved using Sil-co-sil 106 (D₅₀ of 22 µm).
- Based on laboratory testing at a hydraulic loading rate of 200 inches per hours, the StormGarden System has an average TSS removal efficiency of 80.6% at an influent concentration of 130 mg/L. These results were achieved using Sil-co-sil 106 (D₅₀ of 22 µm).
Ecology’s Recommendations:

Ecology finds that:

- Rotondo Environmental Solutions, LLC qualifies for the opportunity to demonstrate, through field-testing in the Pacific Northwest, whether the StormGarden System can attain Ecology’s Basic and Phosphorus Treatment goals.

Findings of Fact:

Field Testing

1. Herrera Environmental Consultants conducted field-testing between May 2017 – February 2018 at the Lake Union Ship Canal Test Facility in Seattle, WA. Herrera tested a 4’x6’ unit with a treatment flow rate of 0.078 cfs (35 gpm). The unit contained the standard StormGarden System media composition: a 3-inch layer of shredded wooden mulch; 21-inches of specially engineered soil media; and a 6-inch layer of bridging gravel.

- The $D_{50}$ of the influent PSD ranged from 3 microns to 111 microns, with an average $D_{50}$ of 33 microns.
- TSS removal efficiency was evaluated over 15 qualifying storm events. Influent TSS concentrations during these events ranged from 20 mg/L to 98 mg/L with a mean concentration of 42 mg/L. The bootstrap estimate of the lower 95 percent confidence limit (LCL95) of the mean TSS reduction was 84.9% and the bootstrap estimate of the upper 95 percent confidence limit (UCL95) of the mean TSS effluent concentration was 5.5 mg/L. A regression analysis of sampled flow rate versus TSS removal indicated the system can achieve ≥80 percent removal at the design flow rate of 35 gallons per minute (140 inches per hour).
- Total phosphorus removal efficiency was evaluated over 18 qualifying storm events. Influent total phosphorus concentrations during these events ranged from 0.054 mg/L to 0.252 mg/L, with a mean concentration of 0.092 mg/L. The bootstrap estimate of the LCL95 of the mean total phosphorus reduction was 53.7%. A regression analysis of sampled flow rate versus phosphorus removal indicated the system can achieve ≥50 percent removal up to 23.8 gallons per minute (95 inches per hour).
- The system experienced rapid clogging and needed to have the mulch replaced 3 times during the 9-month monitoring period. The longest maintenance cycle lasted 2.75 months, or 20% of the water year. Monitoring personnel observed similar clogging issues with other systems evaluated at the Lake Union Ship Canal Test Facility. The runoff from the Test Facility may induce this rapid clogging, and maintenance requirements of systems installed at the Test Facility may not be indicative of maintenance requirements for all sites.

Laboratory Testing

1. MicroBAC Laboratories of Baltimore Maryland conducted laboratory testing in September 2015. The laboratory tested four 6-inch diameter columns at an infiltration rate of 46 inches per hour. The columns contained the same media composition as the StormGarden Modular Stormwater Bio-filtration System Standard Box Filter: a 3-inch surface layer of shredded
hardwood mulch; 21-inches of Rotondo Environmental Solutions StormGarden High Flow Media; and a 6-inch bed of AASHTO No. 8 stone. Based on the lab test results:

- The StormGarden System was evaluated using Sil-co-sil 106, which is shown to be a silt-sized material with a median (D50) diameter of about 22 μm.
- Removal efficiency was evaluated over 10 events using influent TSS concentration of 20 mg/L, 10 events at 100 mg/L, and 10 events at 200 mg/L. At these influent concentrations, the results showed an average removal efficiency of 93 percent, 94 percent, and 98 percent of TSS, respectively.
- The StormGarden System was also evaluated for total phosphorus, total copper, and total zinc using synthetic runoff solutions. Ecology does not allow the use of synthetic stormwater in pursuit of a ULD for phosphorus or metals, so the PULD is limited to Basic Treatment.
  - Liquid phosphorus (Inorganic Ventures inorganic ion chromatography solution – ICPP041 – Lot No. J2-POX01109), prepared using ammonium dihydrogen phosphate (NH₄H₂PO₄) at a concentration of 1,000 μg/ml (certified 997±3 μg/ml) was used to produce synthetic runoff with a total phosphorus concentration of 0.5 mg/L. Results from 10 events showed an average phosphorus removal efficiency of 17.6 percent.
  - Liquid copper (SCP Science AA standard solution – 140-001-291 – Lot no. S150225013), prepared using elemental copper HNO₃ to formulate copper solution of 1,000 μg/ml (certified 1002±3 μg/ml), was used to produce synthetic runoff with a total copper concentration of 0.02 mg/L. Results from 10 events showed an average copper removal efficiency of 75 percent.
  - Liquid zinc (SCP Science AA standard solution – 140-001-301 – Lot No. S150126014), prepared using elemental zinc and HNO₃ to formulate a zinc solution of 1,000 μg/ml (certified 996±3 μg/ml), was used to produce synthetic runoff with a total zinc concentration of 0.3 mg/L. Results from 10 events showed an average zinc removal efficiency of 93 percent.

2. MicroBAC Laboratories of Baltimore Maryland conducted laboratory testing in April and May 2016. The laboratory tested a 6-inch diameter column at infiltration rates of 140 inches per hour and 200 inches per hour. For both tests, the column contained the same media composition as the StormGarden Modular Stormwater Bio-filtration System Standard Box Filter: a 3-inch surface layer of shredded hardwood mulch; 21-inches of Rotondo Environmental Solutions StormGarden High Flow Media; and a 6-inch bed of AASHTO No. 8 stone. Based on the lab test results:

- The system was evaluated using Sil-co-sil 106, which is shown to be a silt-sized material with a median (D50) diameter of about 22 μm.
- Removal efficiency was evaluated over 10 events at an infiltration rate of 140 inches per hour and 10 events at an infiltration rate of 200 inches per hour.
  - During the 10 events evaluated during the 140 inches per hour infiltration rate influent TSS concentration ranged from 86 to 180 mg/L (average of 130 mg/L). Results showed an average TSS removal efficiency of 89.6 percent (LCL95 of 85.3 percent).
  - During the 10 events evaluated during the 200 inches per infiltration rate influent TSS concentration ranged from 41 to 160 mg/L (average of 130 mg/L). Results showed an average TSS removal efficiency of 80.6 percent (LCL95 of 75.1 percent).
The StormGarden System was also evaluated for dissolved phosphorus, total copper, and total zinc using synthetic runoff solutions. Ecology does not allow the use of synthetic stormwater in pursuit of a ULD for phosphorus or metals, so the PULD is limited to Basic Treatment.

- Liquid phosphorus (Inorganic Ventures inorganic ion chromatography solution – ICPP041 – Lot No. J2-POX01109), prepared using ammonium dihydrogen phosphate (NH₄H₂PO₄) at a concentration of 1,000 µg/ml (certified 997±3 µg/ml), was used to produce synthetic stormwater runoff. The StormGarden System showed an average dissolved phosphorus removal efficiency of 6.2 percent (LCL95 2.1 percent) at an average influent concentration of 1.10 mg/L and an infiltration rate of 140 inches per hour. The StormGarden System showed an average dissolved phosphorus removal efficiency of 5.4 percent (LCL95 3.6 percent) at an average influent concentration of 0.78 mg/L and an infiltration rate of 200 inches per hour.

- Liquid copper (SCP Science AA standard solution – 140-001-291 – Lot no. S150225013), prepared using elemental copper HNO₃ to formulate copper solution of 1,000 µg/ml (certified 1002±3 µg/ml) was used to produce synthetic stormwater runoff. The StormGarden System showed an average total copper removal efficiency of 93.2 percent (LCL95 90.3 percent) at an average influent concentration of 0.90 mg/L and an infiltration rate of 140 inches per hour. The StormGarden System showed an average total copper removal efficiency of 85.1 percent (LCL95 84.1 percent) at an average influent concentration of 0.11 mg/L and an infiltration rate of 200 inches per hour.

- Liquid zinc (SCP Science AA standard solution – 140-001-301 – Lot No. S150126014), prepared using elemental zinc and HNO₃ to formulate a zinc solution of 1,000 µg/ml (certified 996±3 µg/ml), was used to produce synthetic runoff. The StormGarden System showed an average total zinc removal efficiency of 70.7 percent (LCL95 62.4 percent) at an average influent concentration of 0.95 mg/L and an infiltration rate of 140 inches per hour. The StormGarden System showed an average total zinc removal efficiency of 63.6 percent (LCL95 62.6 percent) at an average influent concentration of 0.29 mg/L and an infiltration rate of 200 inches per hour.

Other StormGarden System Related Issues to be Addressed By the Company:

1. Conduct field-testing at an additional site deemed more “representative” than the Lake Union Ship Canal Test Facility. The details of this testing will be negotiated with Ecology during the GULD process.

2. Ecology recommends conducting loading tests on the media to determine maximum treatment life of the system.
Technology Description: Download at http://www.rotondo-es.com/

Contact Information:

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Revision History

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<tr>
<td>June 2016</td>
<td>PULD Granted</td>
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<tr>
<td>August 2017</td>
<td>Changed Device Name from BioPod to StormGarden</td>
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<tr>
<td>July 2018</td>
<td>CULD Granted</td>
</tr>
<tr>
<td>December 2018</td>
<td>Added minimum media thickness requirement</td>
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<tr>
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