Attachment - A

WASHINGTON STATE DEPARTMENT OF ECOLOGY

August 2019

GENERAL 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. **General Use Level Designation (GULD) 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.**
   - **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 GULD has no expiration date, but may be amended or revoked by Ecology.

<u>Ecology's Conditions of Use:</u>

The StormGarden System shall comply with these conditions:

1) **Applicants shall design, assemble, install, operate, and maintain the StormGarden System in accordance with Rotondo Environmental Solutions, LLC's applicable manuals and the Ecology Decision.**
2) **The minimum size filter surface-area for use in Washington is determined by using the design water quality flow rate (as determined in Ecology Decision, Item 3, above) and the Infiltration Rate (as identified in Ecology Decision, Item 1, above). Calculate the required area by dividing the water quality design flow rate (cu-ft/sec) by the Infiltration Rate (converted to ft/sec) to obtain required surface area (sq ft) of the StormTree unit.**
3) **Applicants must 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) **StormGarden media shall conform to the specifications submitted to and approved by Ecology.**
5) **Maintenance: The required inspection/maintenance interval for stormwater treatment devices is often dependent on the efficiency of the device and the degree of pollutant loading from a particular drainage basin. Therefor Ecology does not endorse or recommend a "one size fits all" maintenance cycle for a particular model/size of manufactured filter treatment device.**
    - **The StormGarden is designed for a target maintenance interval of 6- to 12-months. Maintenance includes inspecting the unit structure and media, removing trash, and silt from the filter surface, replacing the surface mulch layer, and assessing the health of the vegetation.**
    - **A StormGarden System tested at the Lake Union Ship Canal Test Facility in Seattle, WA required maintenance after 2.75 months or 20% of a water year. Monitoring personnel observed similar cases of early blinding with other systems evaluated at the Test Facility. The runoff from the Test Facility may be unusual and service needs of the systems installed at the Test Facility may not be indicative of other, more typical, sites.**
    - **Owners/operators must inspect StormGarden systems for a minimum of twelve months from the start of post-construction operation to determine site-specific inspection/maintenance schedules and requirements. Owners/operators must conduct inspections monthly during the wet season, and every other month during the dry season. (According to the SWMMWW, the wet season in western Washington is October 1 to April 30. According to the SWMMEW, the set season for eastern Washington is October 1 to June 30.) After the first year of operation, owners/operators must conduct inspections based on the findings during the first year of inspections.**

- **Conduct inspections by qualified personnel, follow manufacturer's guidelines, use methods capable of determining either a decrease in treated effluent flow rate and/or a decrease in pollutant removal ability.**

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

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: 4950-C Eisenhower Avenue
Alexandria, VA 22304

Application Documents:

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

Emerging Stormwater Treatment Technologies Application for Certification: StornGarden (BioPod) Modular Stormwater Bio-filtration System, Rotondo Environmental Solutions, LLC, January 2016

Quality Assurance Project Plan, StormGarden (BioPod) Modular Stormwater Bio-Filtration System Performance Certification Project, Rotondo Environmental Solutions, LLC, March 2016

Addendum #1 StormGarden (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

Technical Evaluation Report, StormGarden™ BioFilter System Performance Certification Project, Rotondo Environmental Solutions, LLC, June 2019

Applicant's Use Level Request:

- General Use Level 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 results from laboratory and field-testing, the applicant claims the StormGarden System operating at a hydraulic loading rate of 140 inches per hour is able to remove:

- 80% of Total Suspended Solids (TSS) for influent concentrations greater than 100 mg/L and achieve a 20 mg/L effluent for influent concentrations less than 100 mg/L
- 50% or greater total phosphorus for influent concentrations 0.1 to 0.5 mg/L.

Ecology's Recommendations:
Ecology finds that:

- Rotondo Environmental Solutions, LLC has shown Ecology, through laboratory and field testing, that 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 – November 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 289 mg/L with a mean concentration of 55 mg/L. The bootstrap estimate of the lower 95 percent confidence limit (LCL95) of the mean TSS reduction was 85.1% and the bootstrap estimate of the upper 95 percent confidence limit (UCL95) of the mean TSS effluent concentration was 5.4 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 19 qualifying storm events. Influent total phosphorus concentrations during these events ranged from 0.03 mg/L to 0.346 mg/L, with a mean concentration of 0.099 mg/L. The bootstrap estimate of the LCL95 of the mean total phosphorus reduction was 53.4%. A regression analysis of sampled flow rate versus phosphorus removal indicated the system can achieve ≥50 percent removal at the design flow rate of 35 gallons per minute (140 inches per hour).
    - The system needed to have the mulch replaced 5 times during the 19-month monitoring period. The longest maintenance cycle lasted 2.75 months, or 20% of the water year. Monitoring personnel observed similar sediment loading and blinding issues with other systems evaluated at the Lake Union Ship Canal Test Facility. The runoff from the Test Facility may induce this early blinding, 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 (D_{50}) 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 ($NH_4H_2PO_4$) 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 HNO_3 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 HNO_3 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 ($NH_4H_2PO_4$) 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 HNO_3 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 HNO_3 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 hydraulic testing to obtain information about maintenance requirements on a site with runoff that is more typical of the Pacific Northwest.

Technology Description: Download at http://www.rotondo-es.com/

Contact Information:

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Ecology web link: http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html

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Revision History

Date	Revision
June 2016	PULD Granted
August 2017	Changed Device Name from BioPod to StormGarden
July 2018	CULD Granted
July 2019	GULD Granted
August 2019	Added sizing guidance based on infiltration rate and water quality design flow rate.
August 2019	Added requirement for installations that infiltrate all or part of the treated flow.