

Bioretention Media Blends to Improve Stormwater Treatment: Final Phase

King County and Herrera with Ecology, Redmond, Kitsap County, Seattle, Thurston
County, Tacoma, UW, and WSU

November 13, 2019





Purpose of This Study

- Provide 2nd BSM option that:
 - Meets Ecology's basic treatment objectives (TSS removal).
 - Meets Ecology's enhanced treatment objectives (Copper and zinc removal).
 - Meets Ecology phosphorus treatment objectives.
- ...and also:
 - Is affordable and locally available.
 - Supports plant growth.
 - Does not release phosphorus/other pollutants or cause toxicity.
- This is Final Phase of 2-Phase study.
 - Phase 1 – Initial testing of components (Finishes June 2017).
 - Phase 2 – Final testing of components + complete testing of mixes + provide science-based specifications for BSM to Ecology and the region.

Problem and Question

Problem:

Use of default sand/compost BSM can result in increased nutrients and some metals in effluent; therefore, does not meet enhanced or phosphorus treatment criteria.

Question:

Is there a BSM that meets Ecology's treatment objectives without potentially releasing contaminants (e.g., Cu, Zn, N and P)?

Study Design

- Test individual media components for leaching potential (EPA Method 1312).
- Test media blends for flushing potential (1 Seattle water year with DI water).
- Dose media blends for pollutant capture capabilities (25% of a Seattle water year with actual stormwater).
- Balance performance with cost.

Study Design

- HWY 520 stormwater for rigorous test and consistency.
- Large columns.
- Media depth = 46 cm.
- Drainage/polishing layer = 30.5 cm.

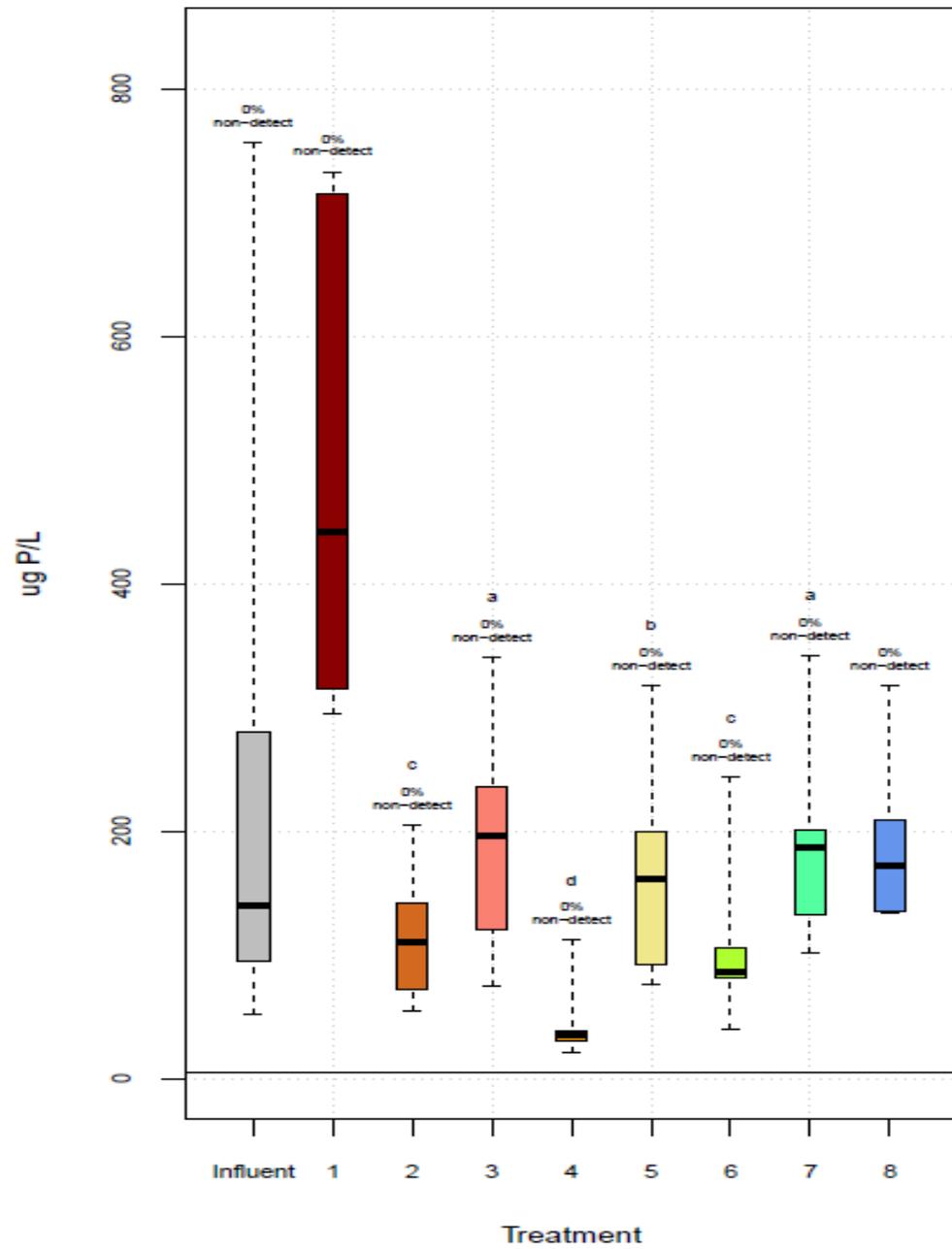


Treatment Number	BSM Blend Abbreviations	Primary BSM Blend	Polishing Layer	Notes
1	60/40	60% ecology sand/40%compost	none	Compare 60/40 with and without polishing layer
2	60/40/aafep-layer	60% ecology sand/40%compost	90% state sand/7% coarse activated alumina (14x28 mesh)/3% iron aggregate	
3	70vs/20cp/10ash/compmulch	70% volcanic sand/20% coco coir/10% high carbon wood ash/2-inch compost mulch	None	Compare different BSM blends below compost mulch (compost mulch provides improved plant growth)
4	70vs/20cp/10ash/compmulch/aafep-layer	70% volcanic sand/20% coco coir/10% high carbon wood ash/2-inch compost mulch	90% state sand/7% coarse activated alumina/3% iron aggregate	
5	70vs/20cp/10ash	70% volcanic sand/20% coco coir/10% high carbon wood ash	None	Evaluate treatment performance of high Ksat vs higher Ksat
6	70ss/20cp/10ash	70% state sand/20% coco coir/10% high carbon wood ash	None	
7	70ls/20cp/10ash	70% lava sand/20% coco coir/10% high carbon wood ash	None	Same high Ksat blends with no orifice vs orifice control
8	70ls/20cp/10ash/orifice	70% lava sand/20% coco coir/10% high carbon wood ash (orifice control)	None	

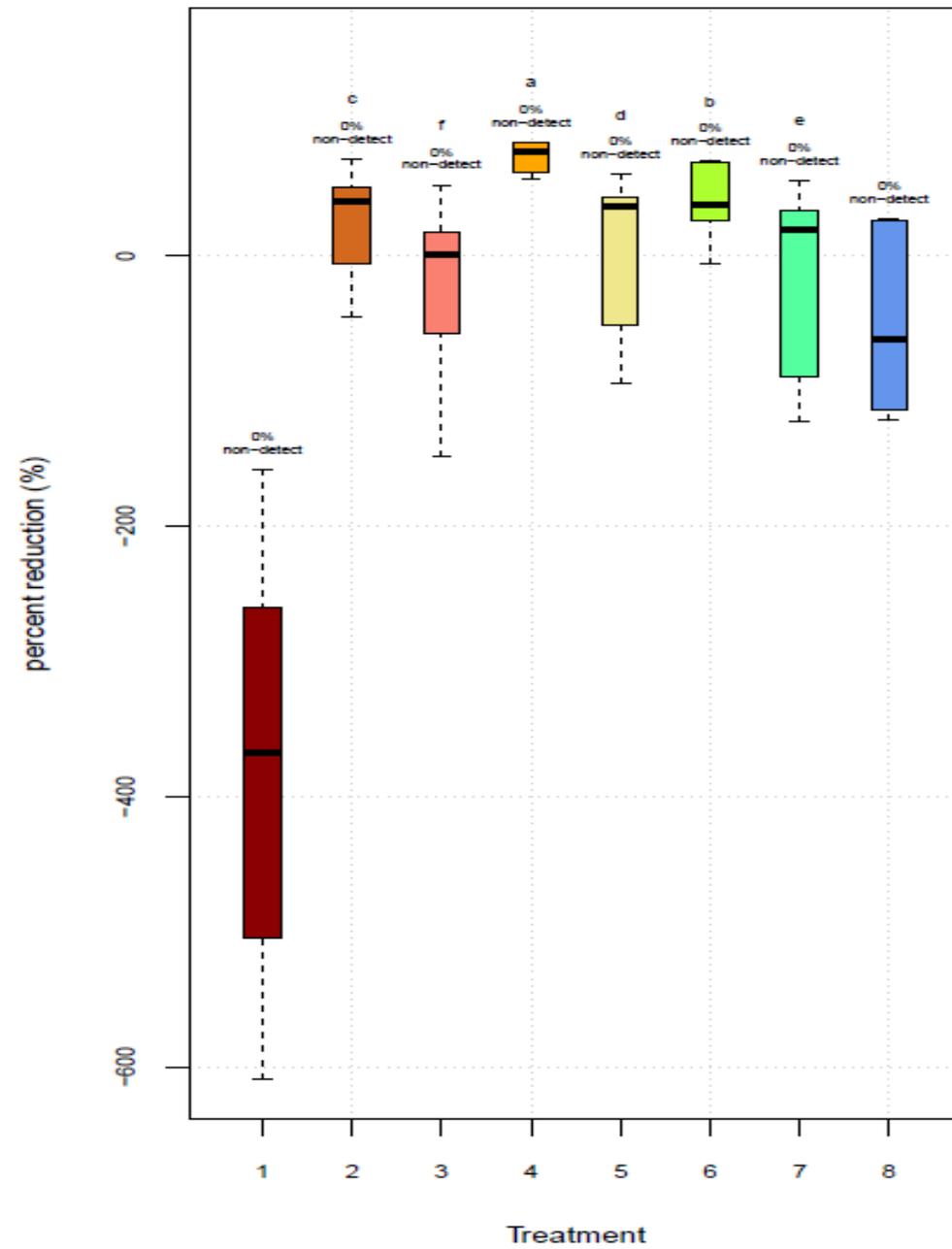
Influent 1

Influent 2

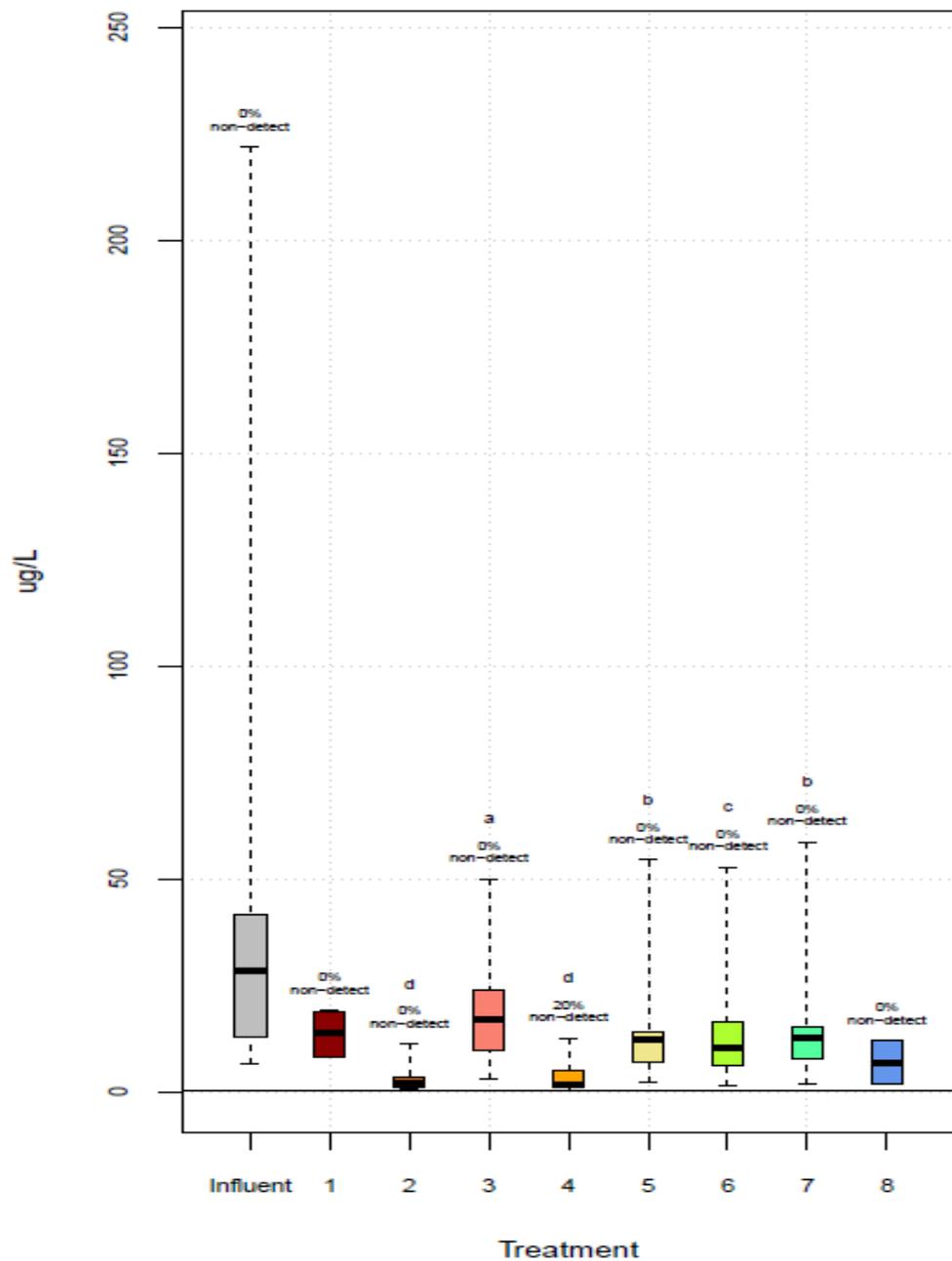
Parameter: TP



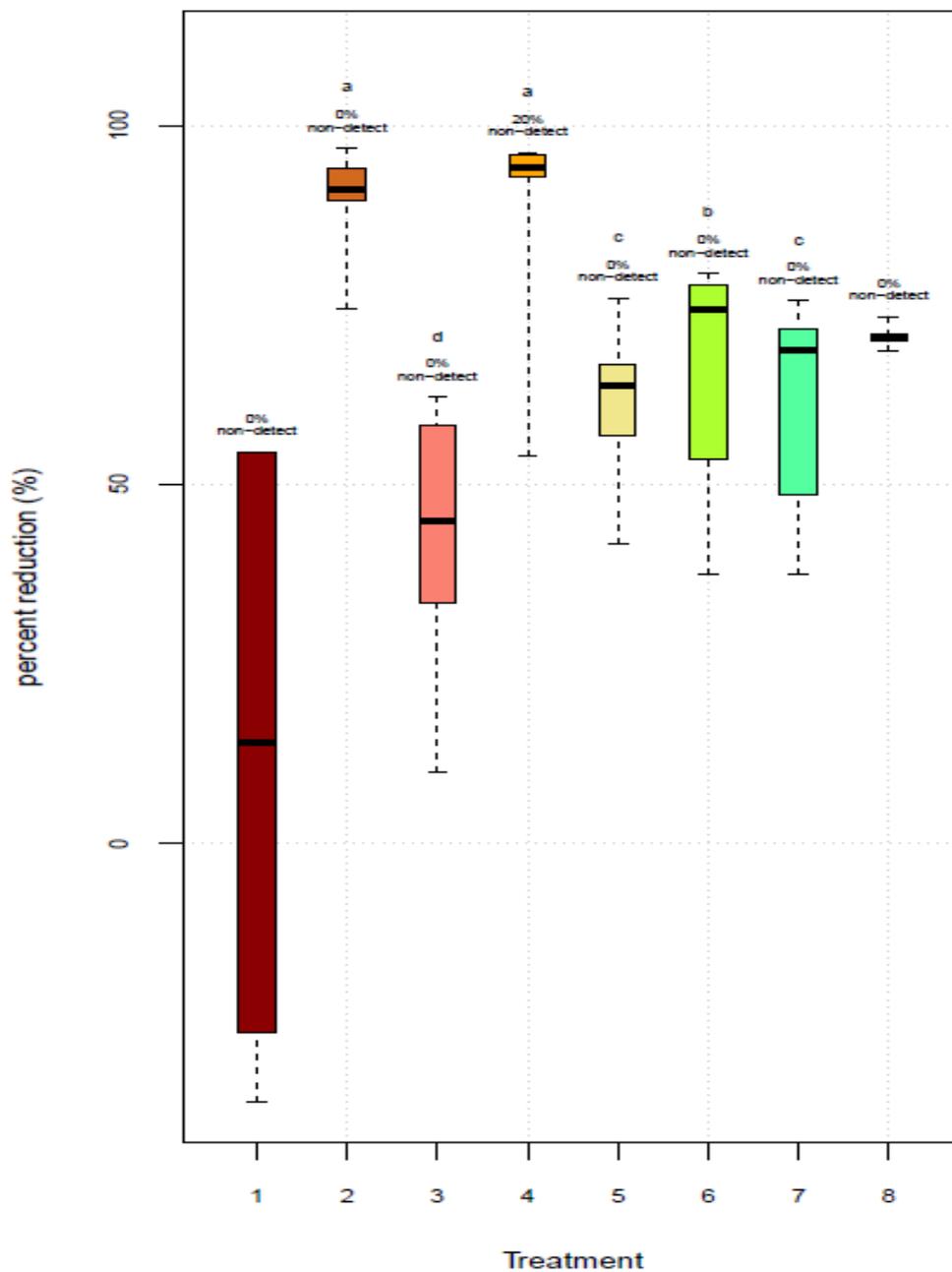
Percent Reduction

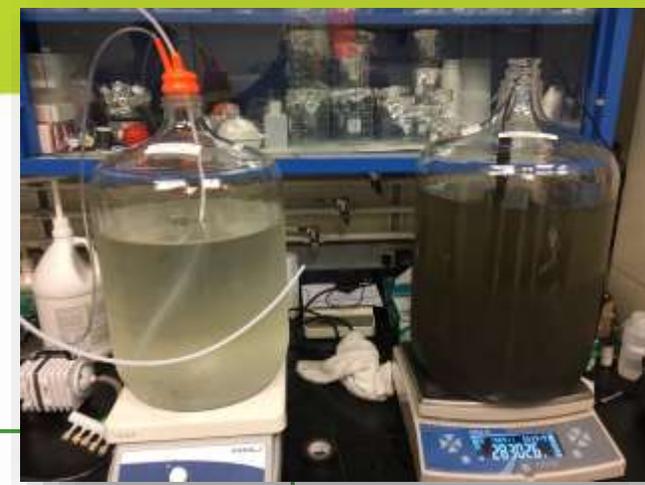


Parameter: Copper, Dissolved



Percent Reduction





Findings: Water Quality Treatment

Bootstrapped Lower 95 Percent Confidence Interval Around the Mean Removal Efficiency (%)

Parameter	Treatment 4 Primary Layer	Treatment 4 Primary Layer plus Polishing Layer	TAPE Guideline
Total Suspended Solids	83	90	80
Total Phosphorus	- 1	73	50
Dissolved Copper	62	91	30
Dissolved Zinc	89	96	60

Recommendations: BSM Specification

Components and Application of New Washington Bioretention Media.				
	Basic Treatment	Enhanced Treatment	Phosphorus Treatment	Expanded Plant Palette and Robust Plant Growth
Primary layer	X	X		
Primary plus polishing layer	X	X	X	
Primary plus polishing layer plus compost mulch	X	X	X	X

Toxicological Analyses

Phase 2 of the project:

- Do the new blends protect targeted aquatic organisms (biological effectiveness)?
- Do the BSM blends reduce or eliminate toxicity in aquatic animals exposed to urban stormwater runoff?
- Toxicity tests on *Ceriodaphnia dubia* and Zebrafish embryo (*Danio rerio*)

Toxicological Analyses

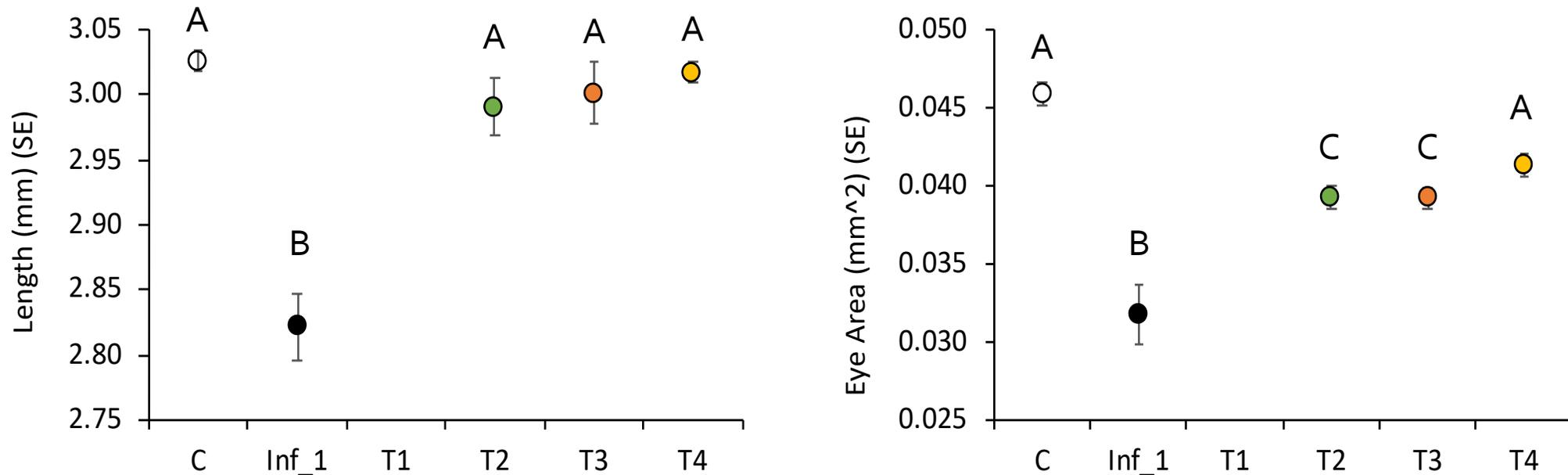
Phase 2 of the project:

- Do the new blends protect targeted aquatic organisms (biological effectiveness)?
- Do the BSM blends reduce or eliminate toxicity in aquatic animals exposed to urban stormwater runoff?
- Toxicity tests on *Ceriodaphnia dubia* and Zebrafish embryo (*Danio rerio*)

Toxicological Analyses

		Influent Decreased Survival		Influent Decreased Reproduction		Influent did not affect reproduction	
Influent	Effluent	Influent decreased survival	Treatment prevented mortality	Reproduction Decreased in Influent	Treatment prevented toxicity	Reproduction Not Affected by Influent	Reproduction Decreased in Effluent
Day 1	T1	1/2	1/1	2/2	2/2	0/2	NA
	T2	2/5	1/2	3/5	2/3	2/5	0/2
	T3		1/2		3/3		0/2
	T4		1/2		3/3		1/2
Day 2	T5	1/5	0/1	1/5	0/1	4/5	1/4
	T6		0/1		0/1		1/4
	T7		0/1		0/1		1/4
	T8	0/2	NA	1/2	0/1	2/2	0/2
TOTAL		10 cases	4 cases	15 cases	10 cases	20 cases	4 cases

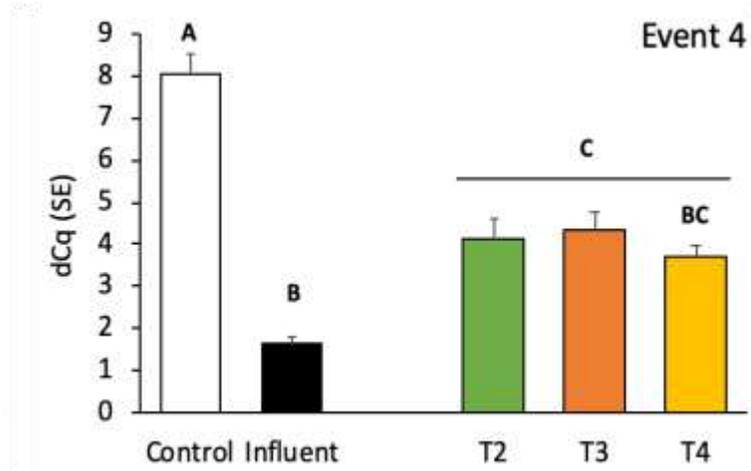
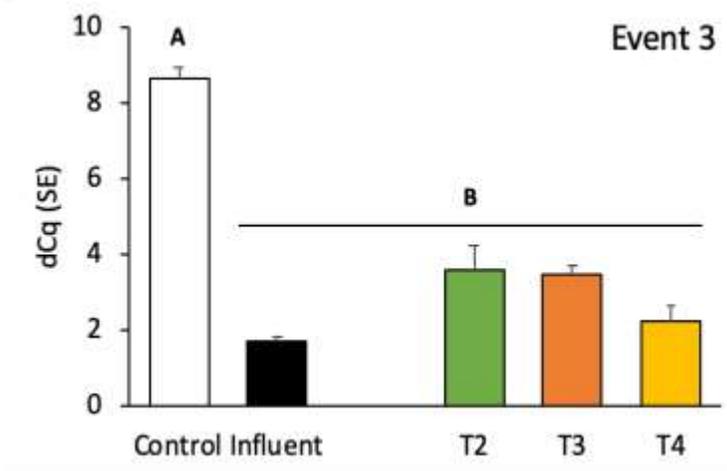
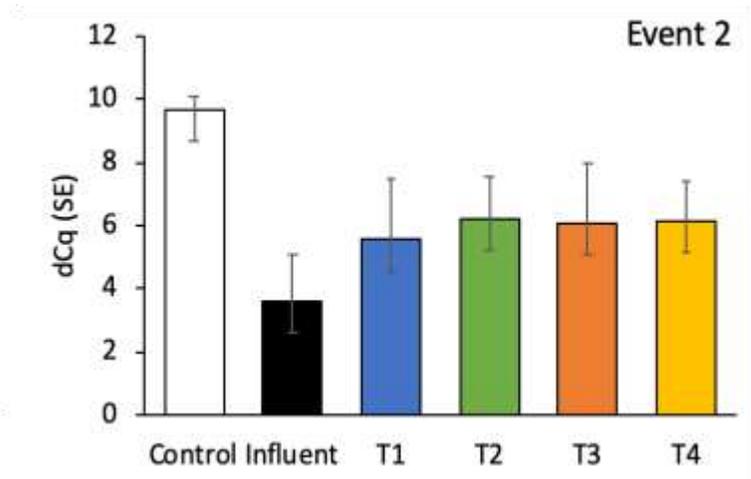
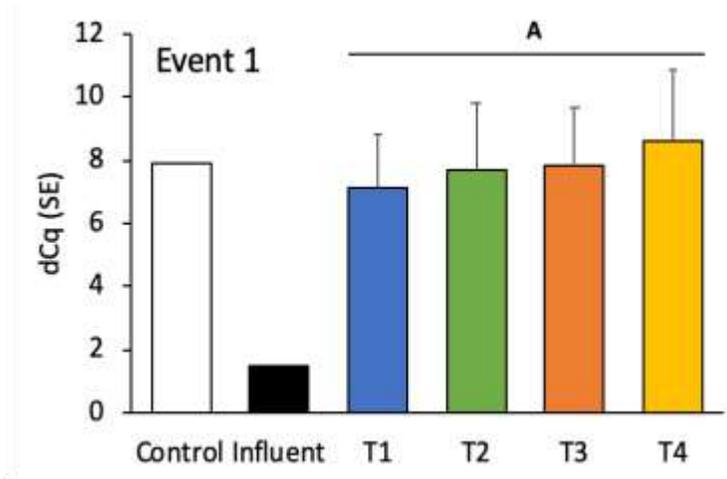
Toxicological Analyses: *D. rerio* Conclusions (partial results)



Analysis complete for length and eye area for Events 1-4 (Day 1 only)

- Influent toxic only for Event 4
- All treatments (T2-T4) prevented impact on length
- Impact on eye area prevented only for T4

Toxicological Analyses: *D. rerio* Conclusions



cyp1a induced to metabolize aromatic hydrocarbons like PAHs

Events 1-4 (Day 1 only)

- Influent significantly induced *cyp1a* for Events 1, 3, 4
- Event 1: Induction prevented by all treatments
- Event 3: No treatments prevented induction
- Event 4: Some prevention of induction (T2,3)

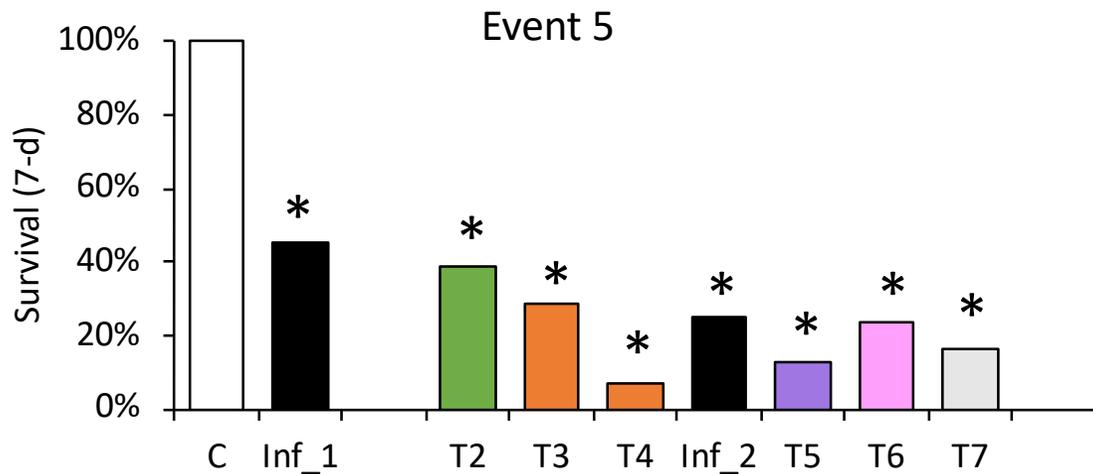


Final Report – end of year

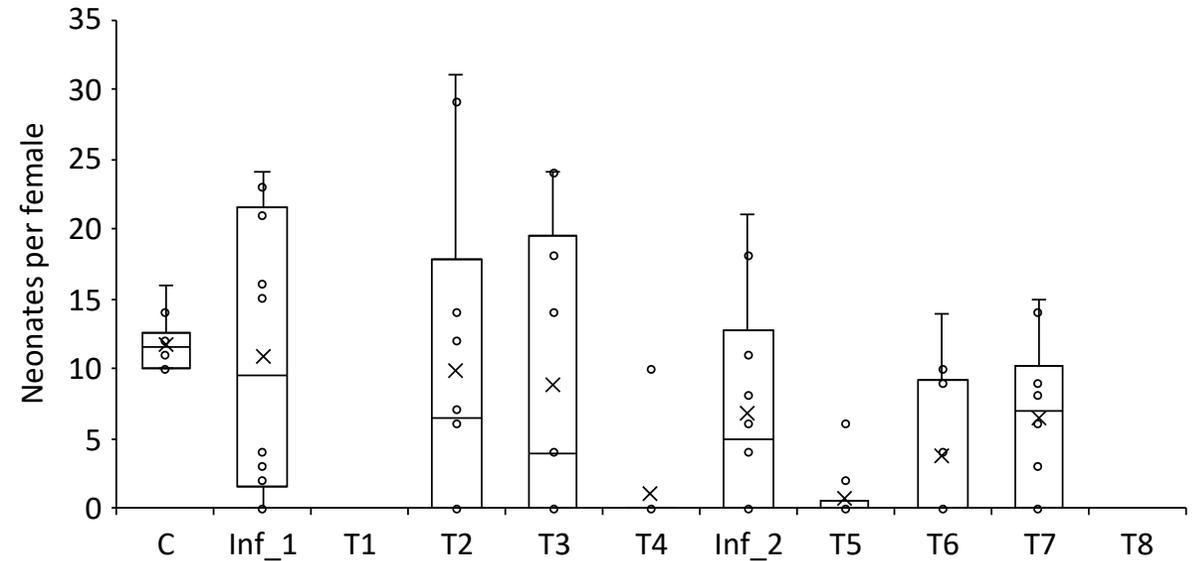
Thanks to: Brandi Lubliner, Doug Howie,
Marcus Flury, Chris May, Dana DeLeon, Shanti
Colwell, Doug Hutchinson, Andy Rheaume,
Mark Maurer

Toxicological Analyses: Event 5, *C. dubia*

Survival of founders



Reproduction



Poor treatment for most media = Artifact of laboratory testing?