Impacts of Combined Sewer Overflow (CSO) remediation on water quality and mosquito abundance

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Georgia Mosquito Control Association
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Outline

- CSOs, mosquitoes and West Nile virus
- Overview of CSOs
- Objectives of Current Study
- Methods
- Results
- Conclusions

Am. J. Trop. Med. Hyg., 77(3), 2007, pp. 478–484

Combined Sewage Overflows (CSO) Are Major Urban Breeding Sites for *Culex quinquefasciatus* in Atlanta, Georgia

Lisa M. Calhoun, Melissa Avery, LeeAnn Jones, Karina Gunarto, Raymond King, Jacquelin Roberts, and Thomas R. Burkot*
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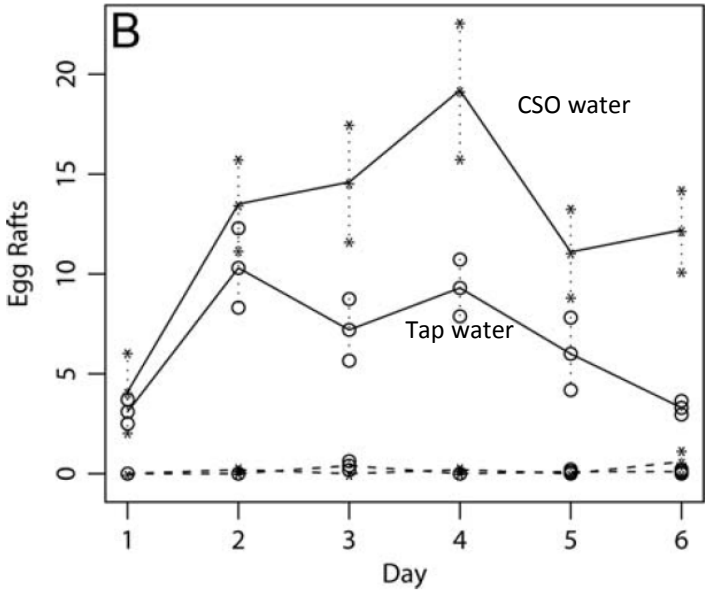
- CSO streams suitable breeding habitats for *Culex spp*.
- Nutrient-enriched water – optimal mosquito habitat
  - Food source (bacteria)
  - Fewer predators
- Enhance oviposition of *Culex spp*
- Predominantly in pools with stagnant water and sandy bottom.



J. Med. Entomol. 46(2): 220–226 (2009)

Research

ehp ENVIRONMENTAL HEALTH PERSPECTIVES OPEN ACCESS

The Risk of West Nile Virus Infection Is Associated with Combined Sewer Overflow Streams in Urban Atlanta, Georgia, USA

Gonzalo M. Vazquez-Prokopec,[1] Jodi L. Vanden Eng,[2] Rosmarie Kelly,[3] Daniel G. Mead,[4] Priti Kolhe,[5] James Howgate,[5] Uriel Kitron,[1,6] and Thomas R. Burkot[2]

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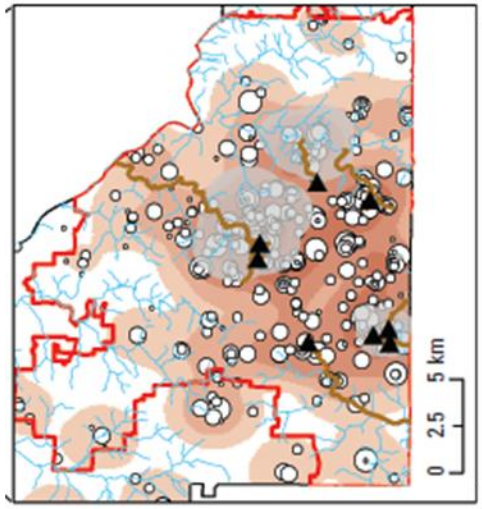
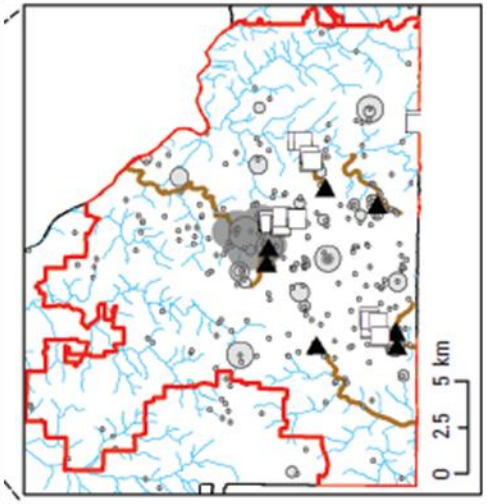
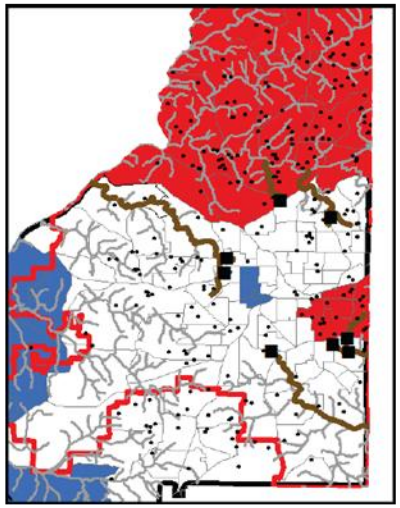
Cx. quinquefasciatus **abundance**



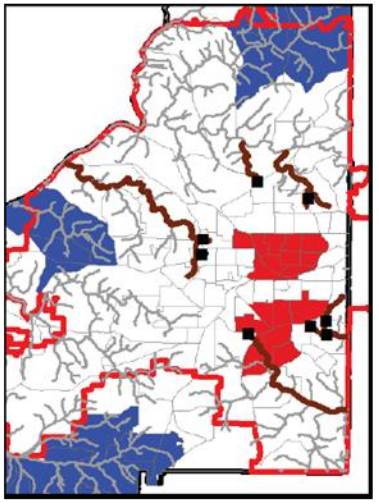
WNV infection in *Cx. quinquefasciatus*



WNV infection in dead corvids

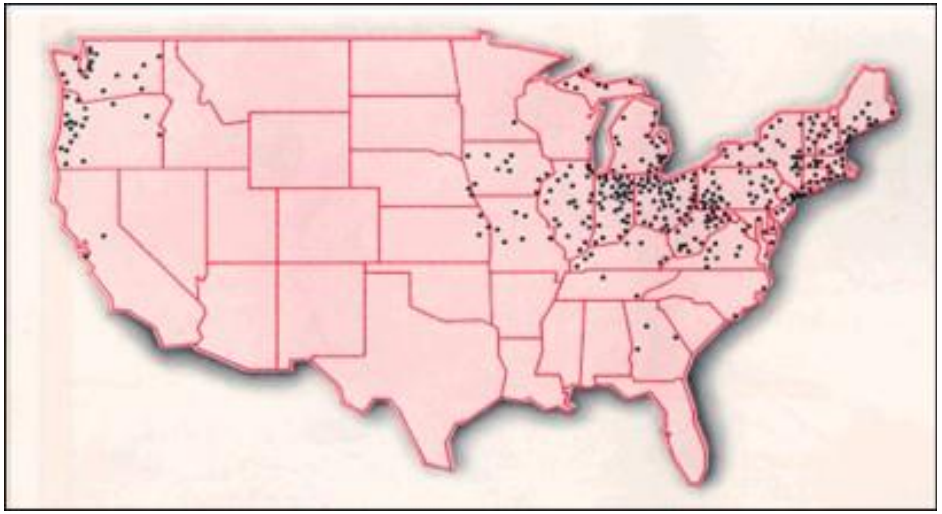


WNV infection in humans

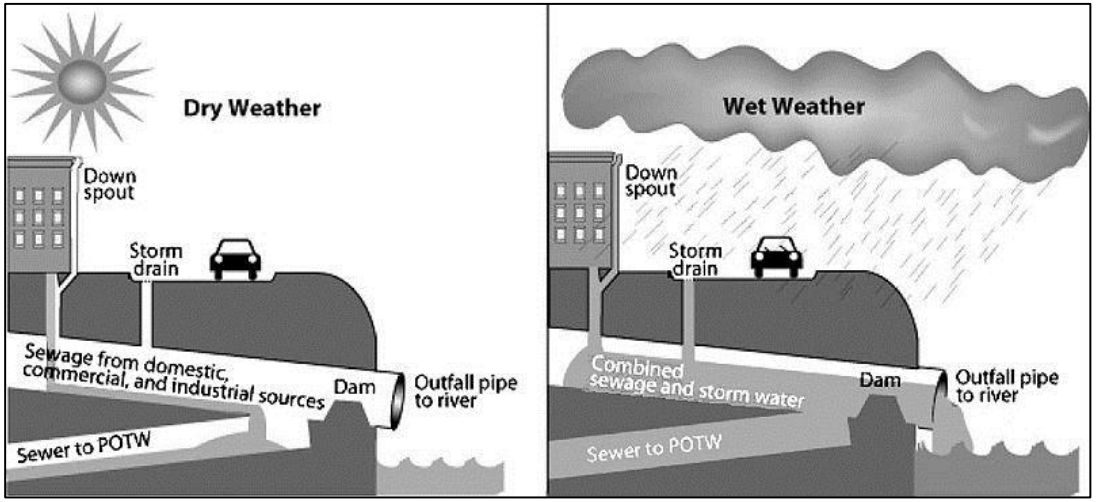


- Distance to CSO stream most important predictor of Cx. quinquefasciatus abundance
- WNV infection in mosquitoes, birds and humans clustered around CSO streams

Combined Sewer Systems



- 19th century origins
- 772 U.S. cities
- 40 million people affected
- Major source of pollution and pathogens



CSOs in Atlanta

- 1999 Consent Decree
- Seven CSS facilities
  - Sewer separation
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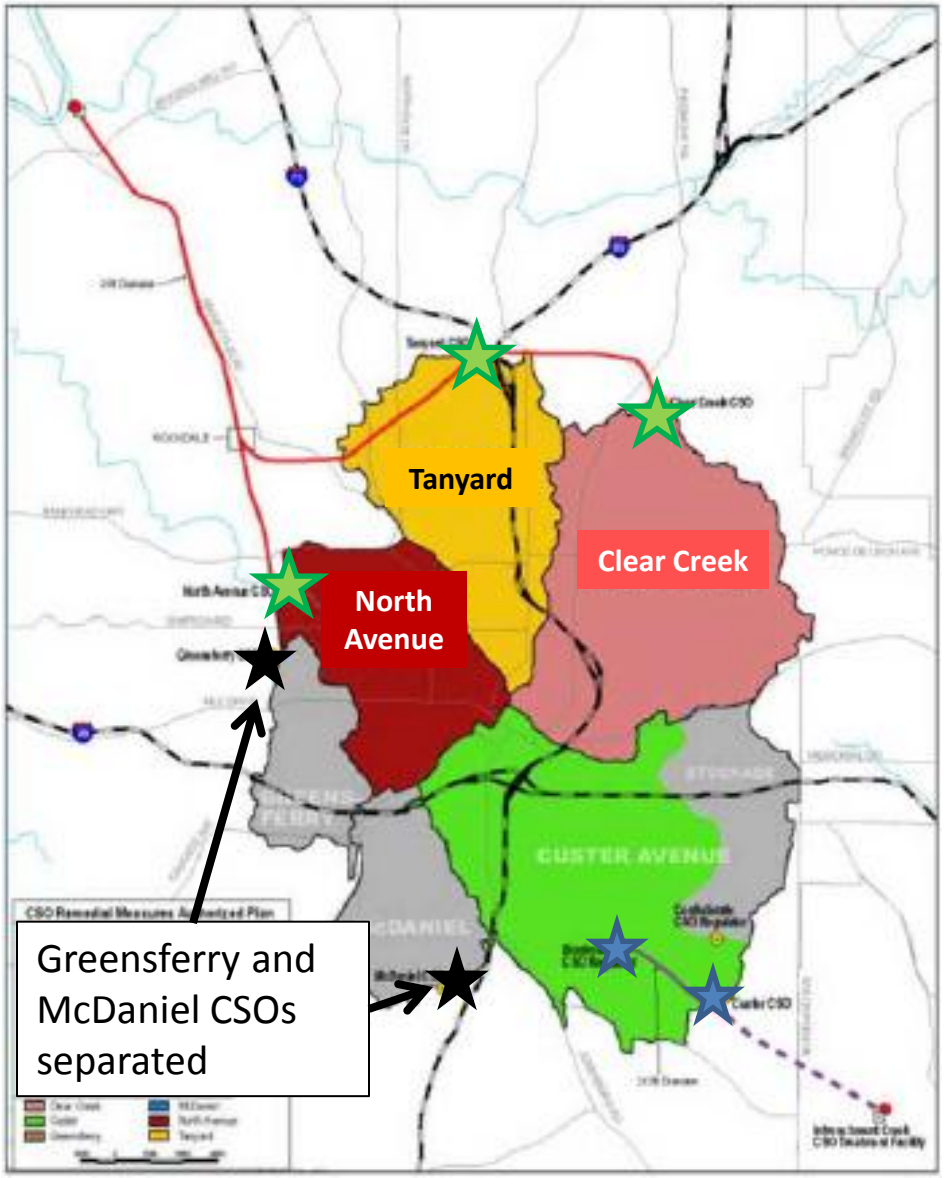
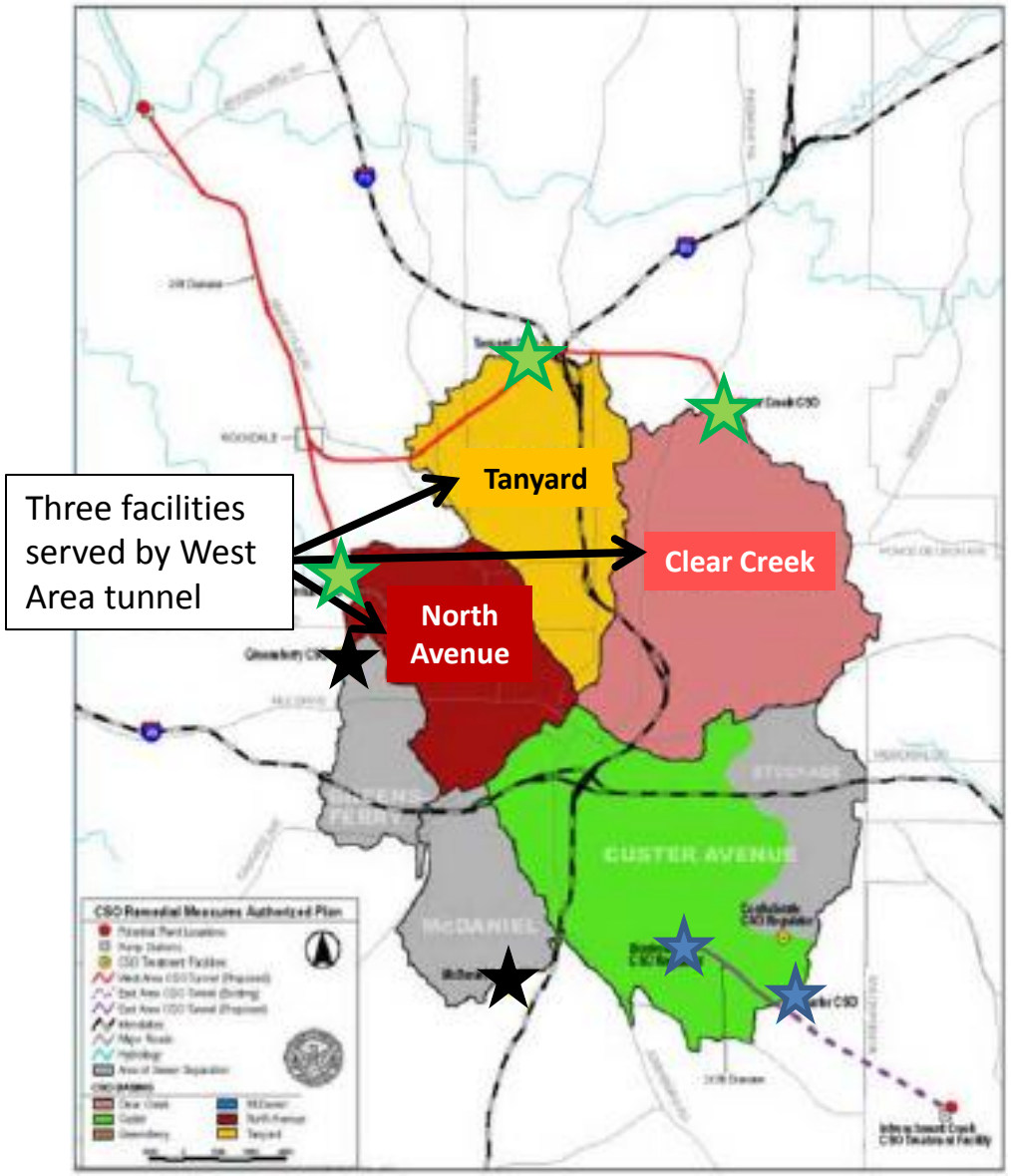
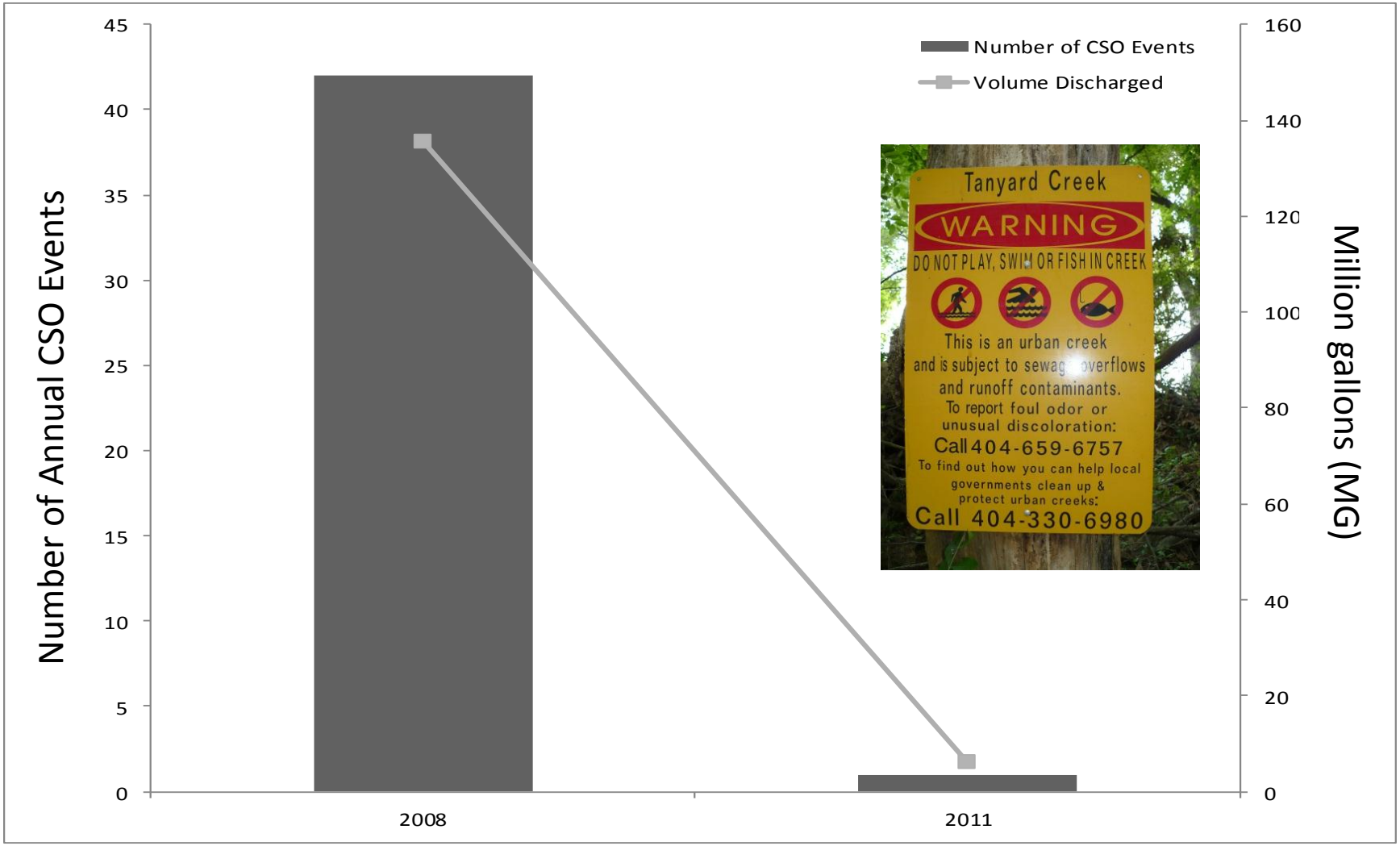


CSOs in Atlanta

- 1999 Consent Decree
- Seven CSS facilities
  - Sewer separation
  - Deep storage tunnels
- West Area CSO tunnel
  - Serving three CSO facilities
  - Increased storage capacity
  - Completed Nov. 2008
- Tanyard Creek
  - Most CSO-polluted urban creek.



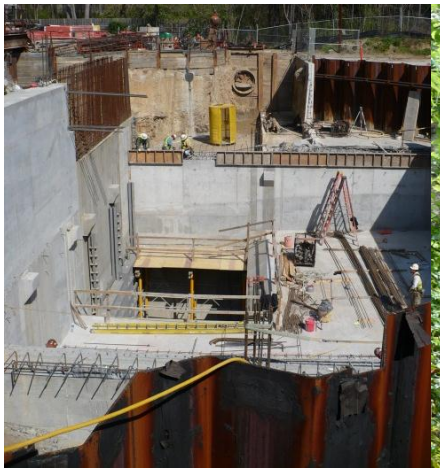
CSO discharges into Tanyard Creek



Source: Atlanta Department of Watershed Management

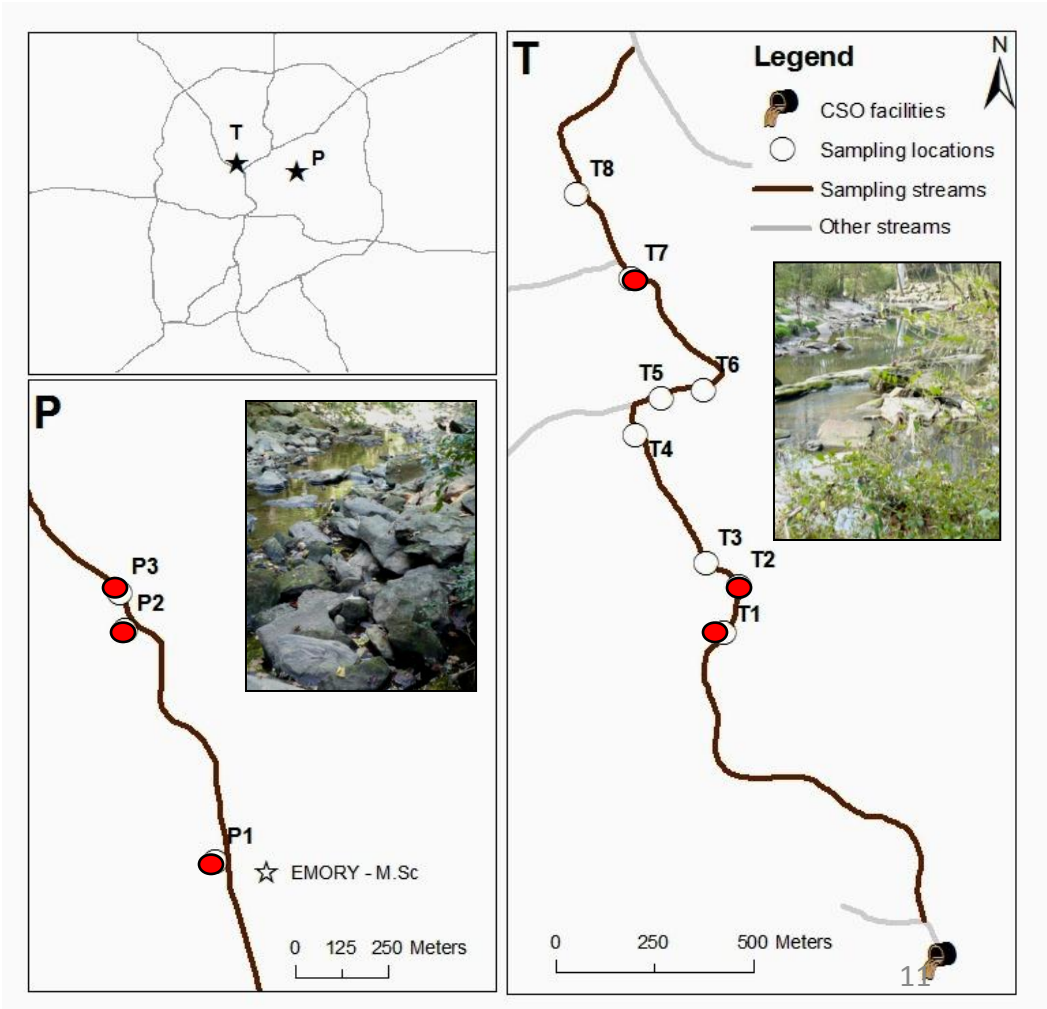
Study Objectives

- What impact will the new West Area tunnel have on streams receiving CSO discharges?
  - Mosquito abundance
  - Water quality – nutrient concentrations
- Document changes in a CSO-affected stream and compare to a stream unaffected by CSOs




Study Design

- June 2008 – October 2011
- Tanyard and Peavine (non-CSO) Creeks
- Biweekly data collection
  - Immature mosquitoes
    - 5 dips at each pool
  - Water samples
    - Ammonia, nitrate, phosphate, pH and dissolved oxygen
  - Aspiration for adult mosquitoes (~5m from pool)
- Statistical modeling



Mosquito Collections

Year	All Larvae	Pupae	Adult Female	Adult Male
2008	7778	2520	457	484
2009	448	173	213	96
2010	423	134	210	150
2011	48	56	253	167
Total	8697	2883	1133	897

Collected in 2008 pre-remediation:

- 89% of larvae
- 87% of pupae
- 46% of adults

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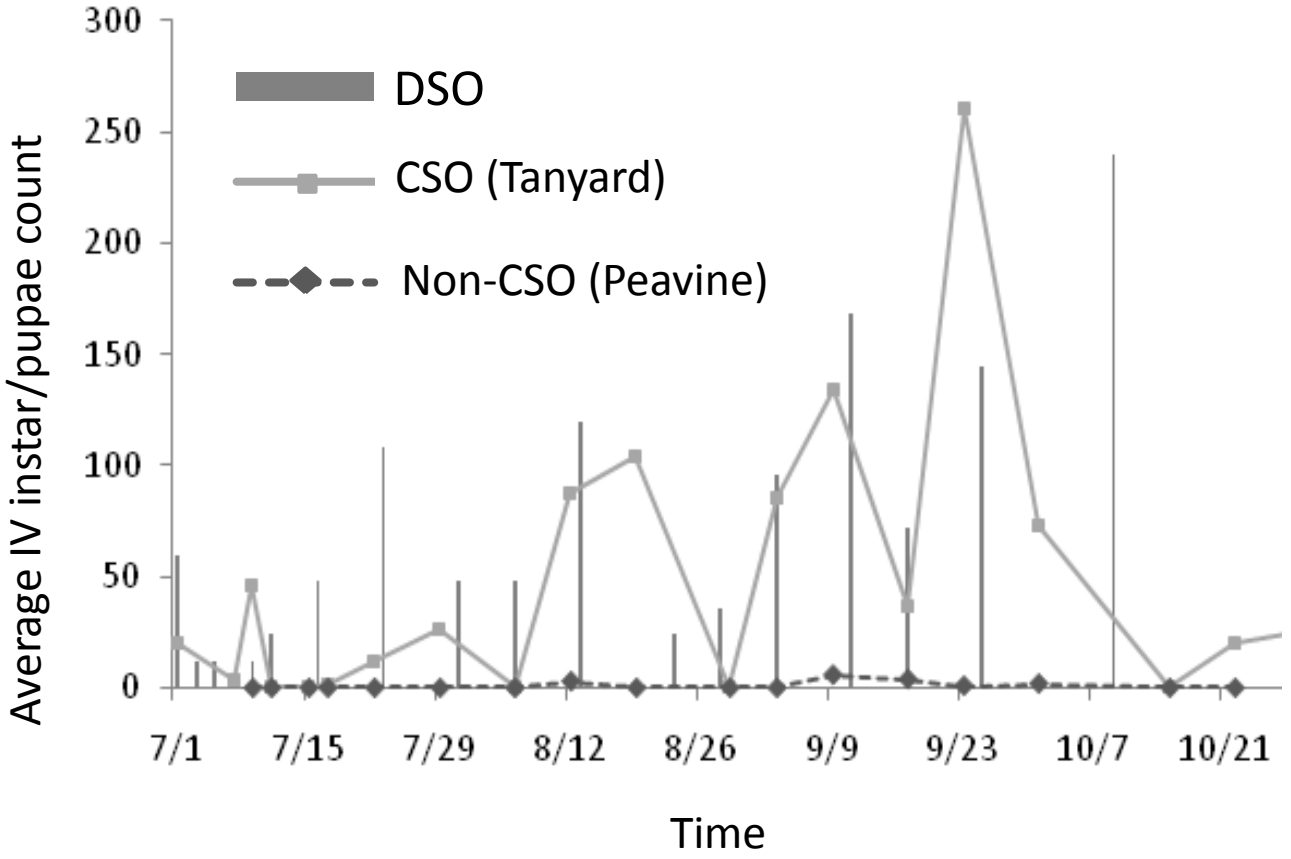
1 Determinants of high productivity pre-remediation

2 Long-term trends in productivity and water quality

Immature productivity Pre-remediation

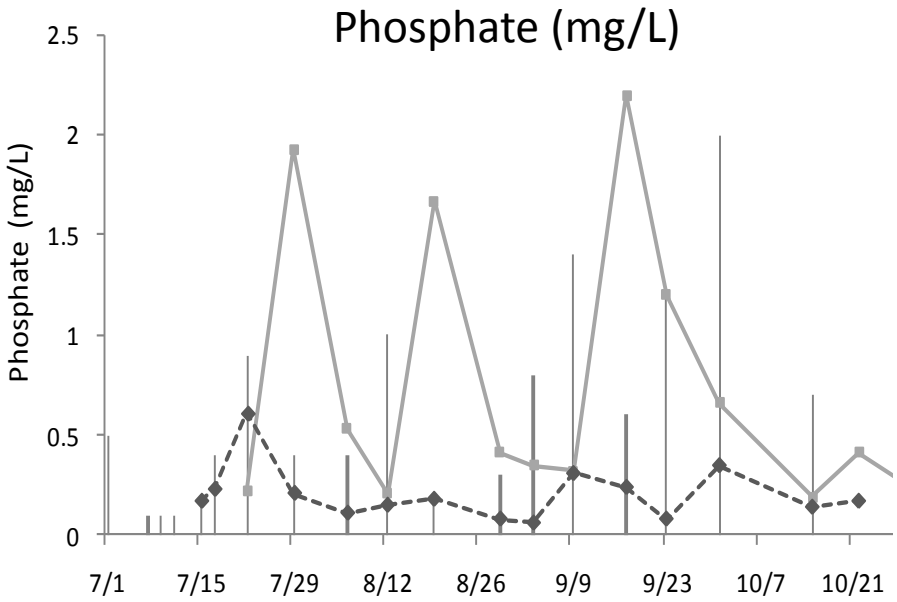
Productivity up to 260 pupae/dip on CSO creek.

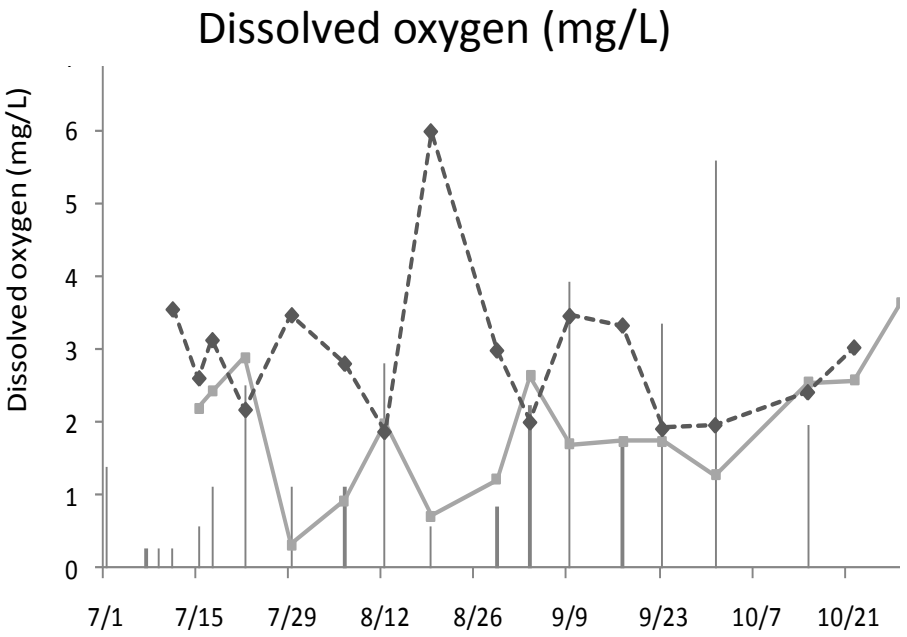
Non-CSO creeks are not suitable habitats for *Cx. spp.* mosquitoes

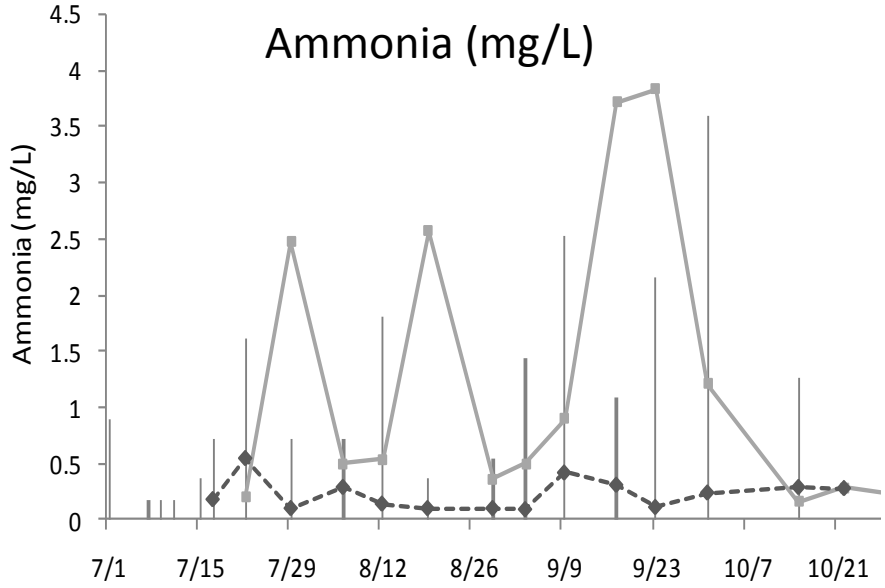


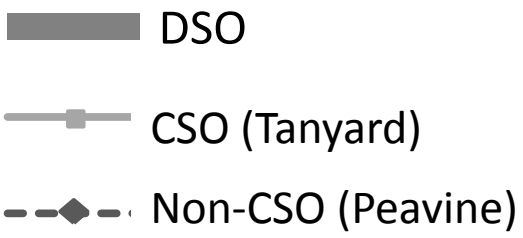
Factors that determine such difference in productivity?

Water Quality estimations





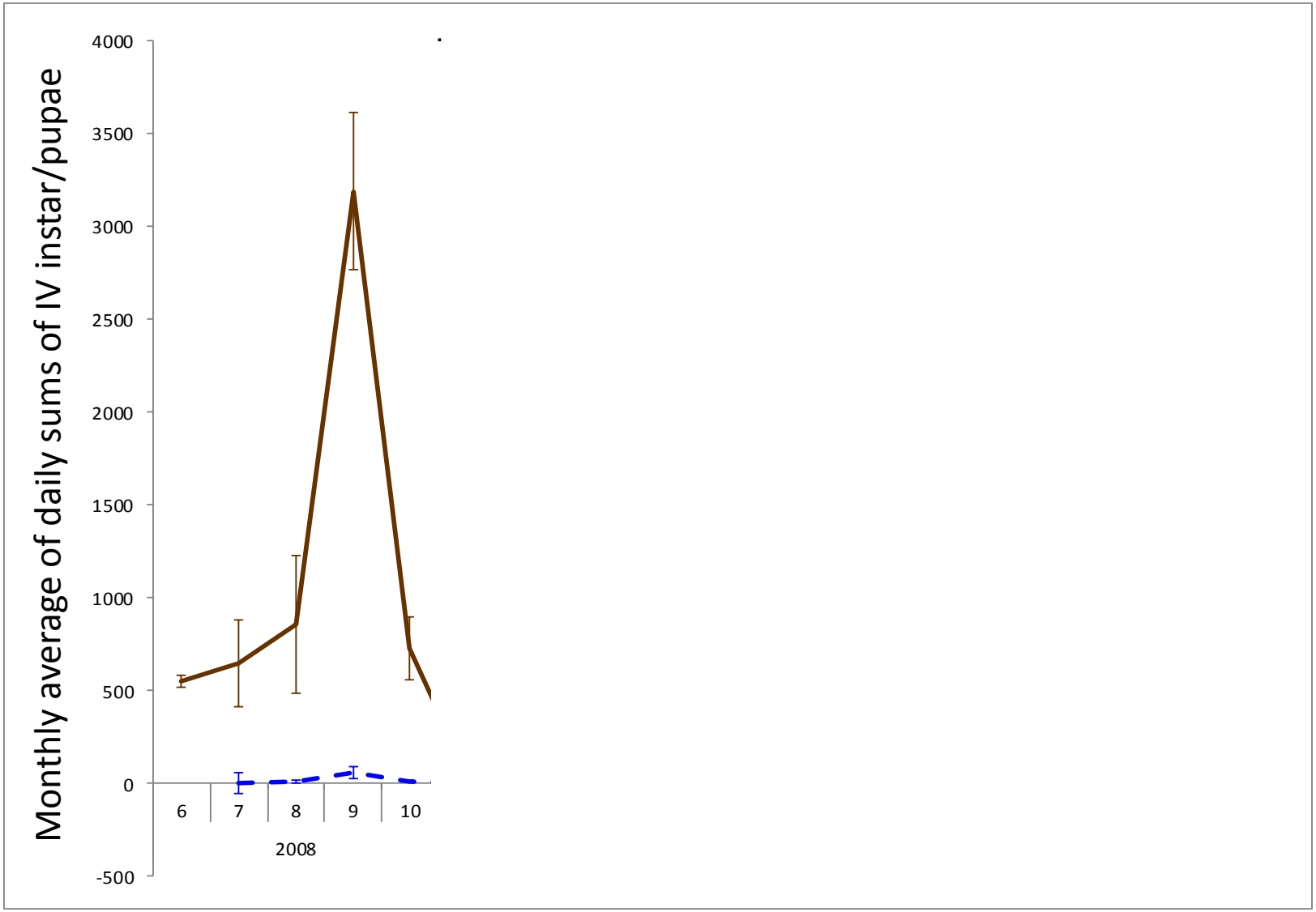




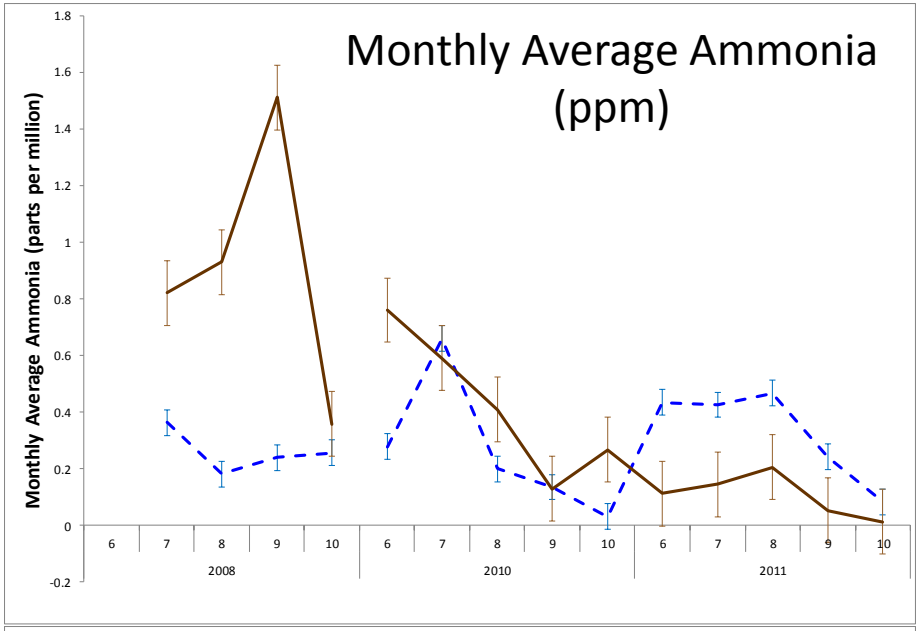
Differences between creeks Pre-remediation

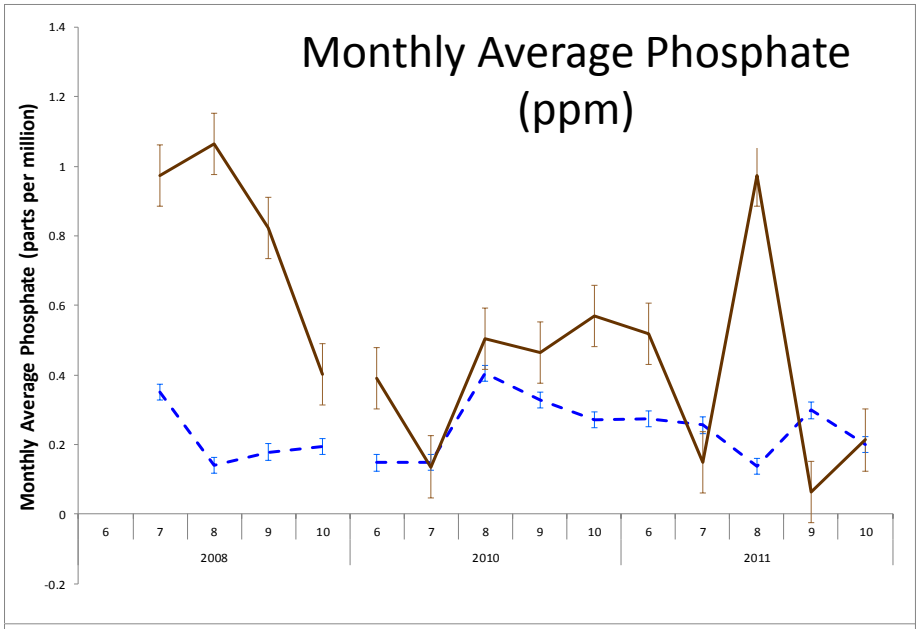
- High productivity at CSO creek explained by:
  - High Ammonia
  - High phosphate
  - Low dissolved oxygen
  - Although not quantified, very low abundance of natural predators of mosquito larvae.

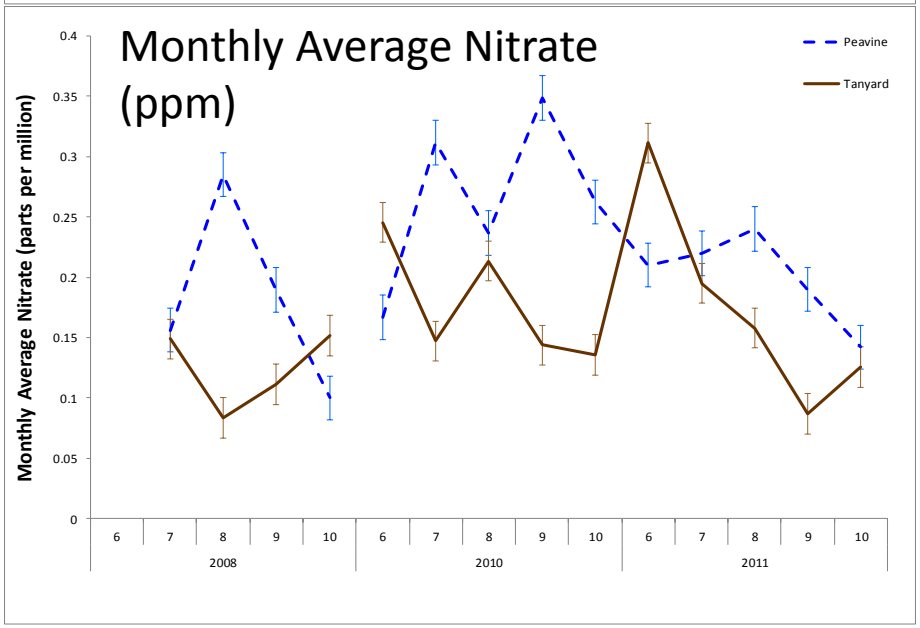
Post-remediation: *Cx. spp.* productivity

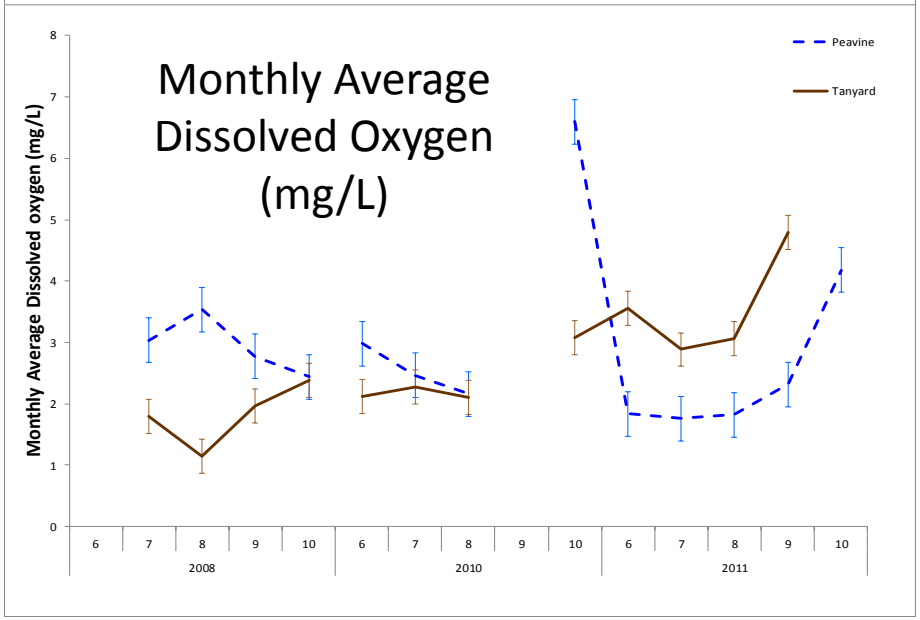


Water Quality Indicators









Modeling Mosquito Abundance

What are the determinants of the temporal trend in mosquito productivity?

- Time-series regression (Generalized estimating equations)
  - Dependent variable: IV instar+pupae counts
- Multi-model Selection Approach
  - Selected best model among 10 different combinations of variables

Best-fitting Model (QIC = -1831.90)		
Parameter	Estimate	P-value
Intercept	**6.3827**	**<.0001**
Time	**0.1278**	**<.0001**
Water Temperature	**-0.2451**	**<.0001**
Rainfall	**-86.803**	**<.0001**
pH	**0.7264**	**<.0001**
Ammonia	-0.5474	0.0667
Nitrate	**-6.9318**	**0.0006**
DO	**-1.1896**	**0.0408**
DO x Temperature	**0.0807**	**0.0138**
Ammonia x Time	**-0.2666**	**0.0037**
DO x Time	**-0.0804**	**<.0001**

Conclusions

- CSO streams – significant source of Cx. spp mosquitoes.
- Remediation of Tanyard CSO facility led to:
  - Significant reduction in Cx. spp productivity
  - Reductions in frequency and quantity of discharges
  - Changes in water quality (mainly…)
  - Increases in natural predators of mosquito larvae
- Minimizing CSO discharges has significant impacts of mosquitoes, but..

Will this change translate in proportional reductions in WNV transmission risk?

Acknowledgements

- Emory University for funding
- The Vazquez-Prokopec/Kitron labs
  - Bex Levine, Donal Bisanzio, Frances Kim, Carrie Keough, Andy Nguyen, Alex VanNostrand, Gouthami Rao, Parisa Nourani, Bryant Jones, Kevin Lanza, Helen Hill, Ryan Huang, Naeemah Munir, Greg Decker, Will Galvin, Miho Yoshioka, Nelle Couret, Sarah Guagliardo, Emma Accorsi, Whitney Pennington, An Nguyen.