# Collaboration between Academic Institutions & Nonprofits:

## A Case Study on the Musconetcong River

Nancy Roberts-Lawler, Musconetcong Watershed Association

Meiyin Wu, Montclair State University

# Nancy Roberts-Lawler

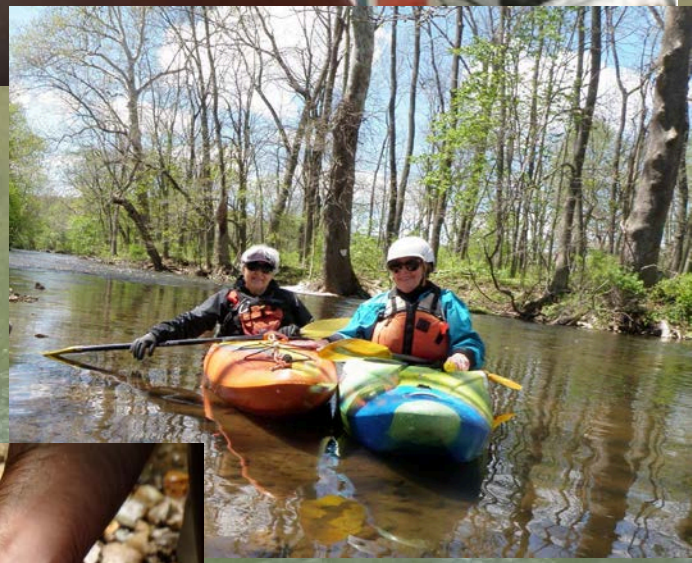
- MWA Water Quality Programs-2009
  - Non-ambient monitoring
    - Aquatic connectivity
    - Non point source pollution
  - River Watcher-volunteer program
- Advocate for 20 years
  - Use non-agency data for regulatory use
    - South Branch WA
    - NJDEP-E2/WQDE

# Musconetcong Watershed Association

- 501(c)3 Non-profit
- Mission on the Musconetcong
  - Protect & enhance River
    - Natural resources
    - Local cultural resources
  - Build community awareness
  - Foster protection & stewardship
- Philosophy: People
  - Protect natural resources
  - when they understand their value

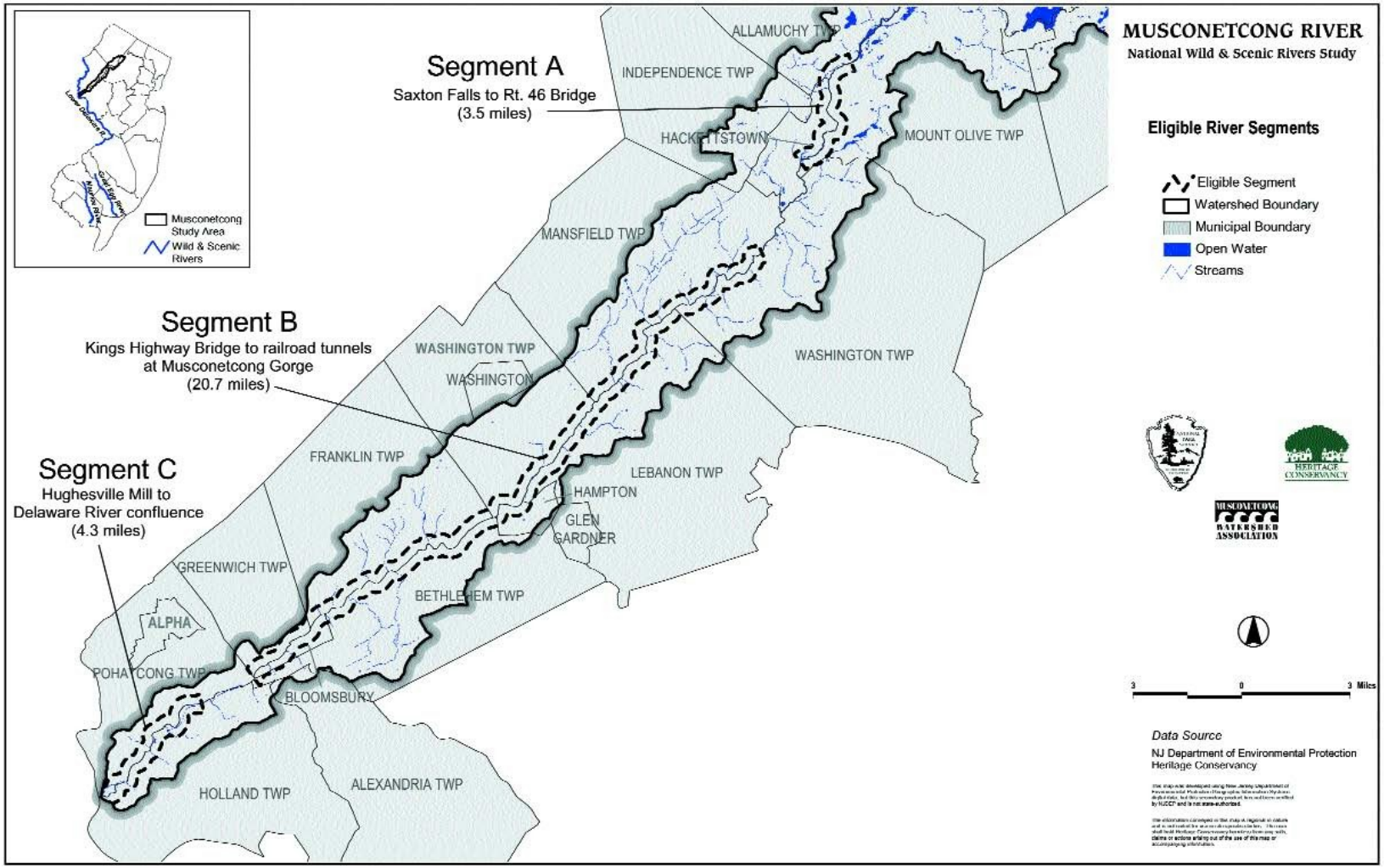
# Musconetcong River Watershed

- Outstanding Resource Values
  - Historical
  - Cultural
  - Natural
- Federal Wild & Scenic River
- C-1 protections
  - Fishing and Boating
- Impacts
  - Dams
  - NPSP from Land use
- Targeted for restoration



John Parke

# Musconetcong:
# A National Wild and Scenic River



# Musconetcong:
# High quality, still has problems

- NJDEP identified impairment
  - River segment on 303(d) list
  - High fecal coliforms
- Set restoration plan (TMDL)
  - Requires a 93% reduction
  - Identifies Primary sources
    - agriculture
    - failing septic systems
    - …and maybe geese

Cows in West Portal Brook with MWA staff

# TMDL recommendations

## 10.2. Segment Specific Recommendations

### 10.2.1. Watershed Management Area 1

**Musconetcong River at Reigelsville (Site ID #01457400) and near Bloomsbury (Site ID #01457000)**

Land use in the area is predominantly agriculture, with urban, including some older development on septic systems, and forest. Potential sources of fecal coliform include: livestock; land application of manure; older septic systems in Warren Glen and Finesville area.; geese; and beaver in the river between Finesville and the Delaware River. Strategies: prioritize for EQIP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

LAND USE analysis

# Local nonprofits: Stronger together

**Combine funding to address Nonpoint Source Pollution**

North Jersey Resource Conservation & Development
Dedicated to Community Needs, Through Conservation.

Applies and received 319 (h) funding to work with landowners and farmers

NEW JERSEY AUDUBON
www.njaudubon.org

NRCS funding that supports conservation of ground nesting birds

MUSCONETCONG WATERSHED ASSOCIATION

Bring local knowledge and connections with local residents, municipalities supported by NPS

# 319 (h) Timeline

- **North Jersey Resource Conservation & Development**
- **Collect data-Rutgers 2007-2009**
- **Musconetcong Watershed Restoration Plan 2010**
- **Execute plan 2011-2018**

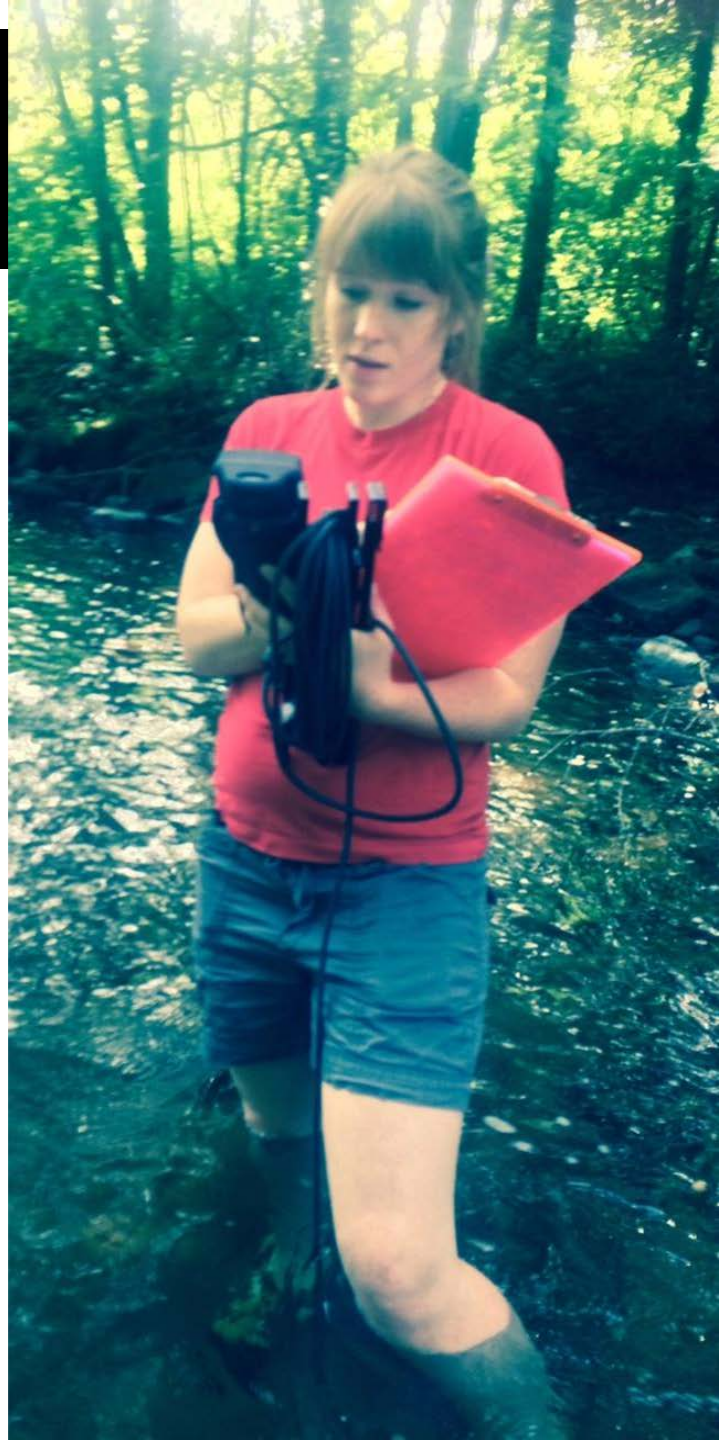
# Rutgers Study: 2007-2009

**10 Sites**

- Nutrients, Environmental indicators
- Bacteria-Some Microbial Source Tracking
- Basic Hydrology

**Results**

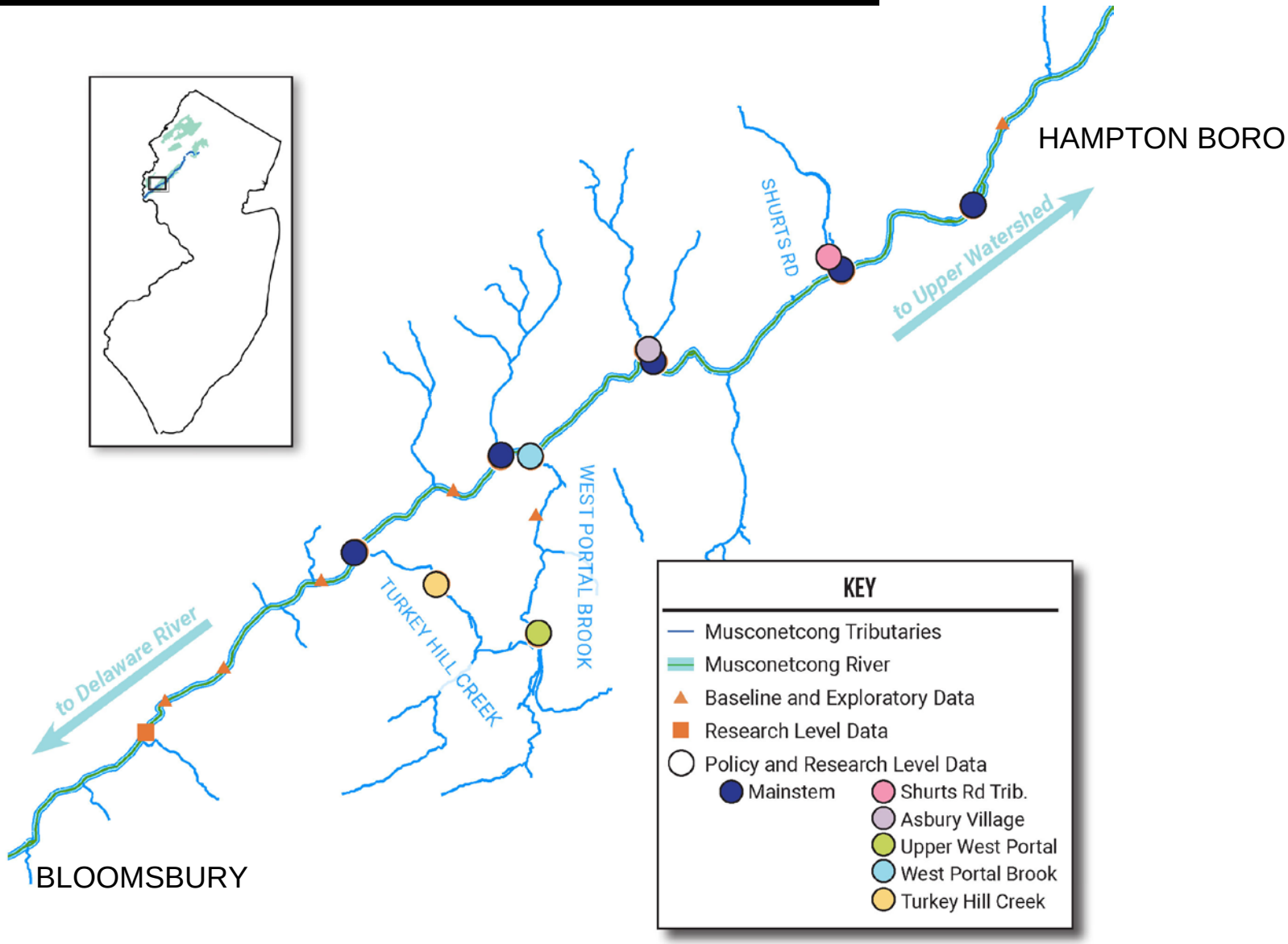
- Elevated water temperature
- Violations of the pH minimum criterion
- Violations of TP criterion
- High % of samples exceeding *E. coli* criteria



# Rutgers 2007 Study

- **Concluded River quality was clearly compromised.**
- **Recommended watershed restoration & management actions**

# Impaired Area is identified: Hampton to Bloomsbury



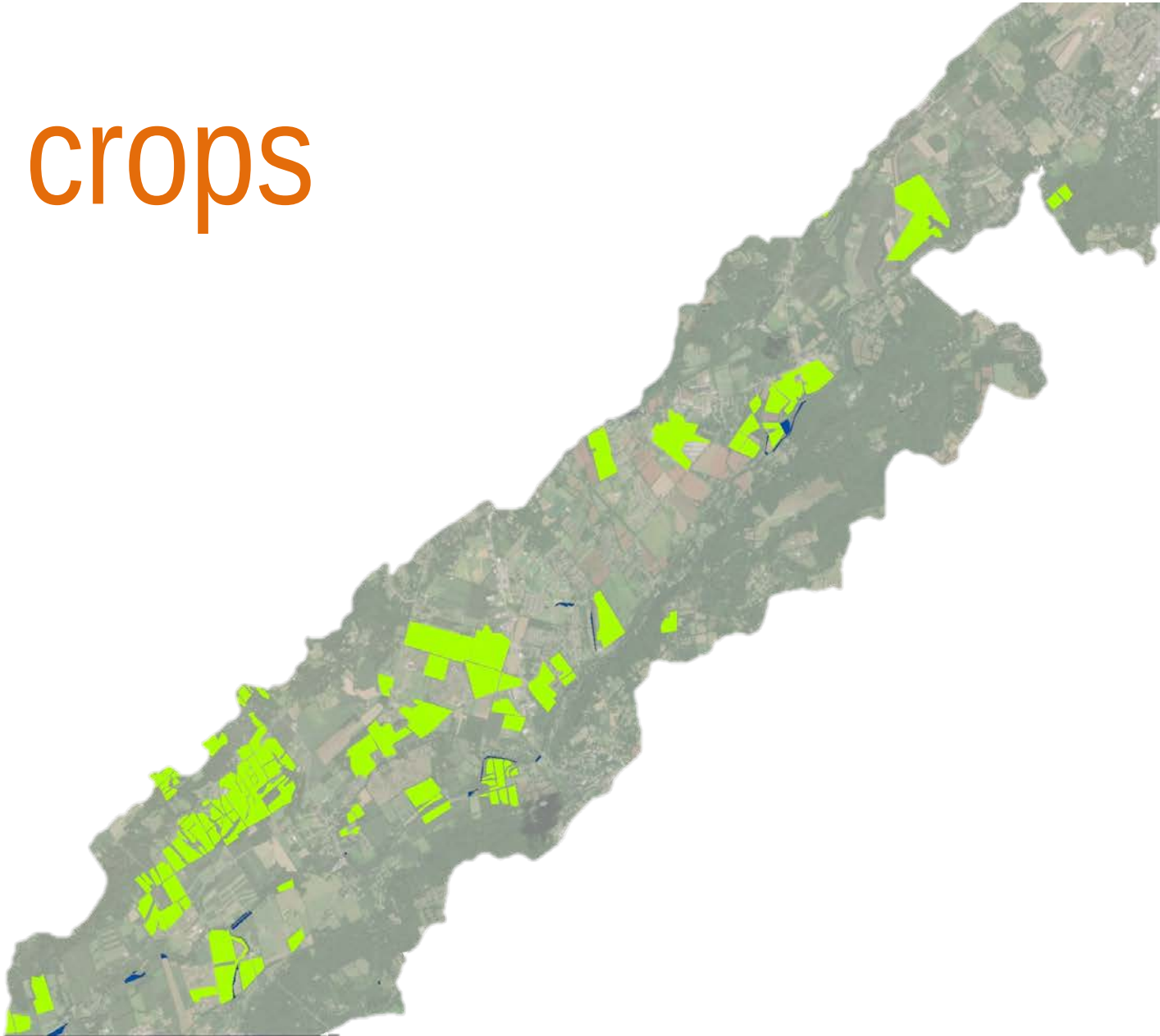
# Plan to Action 2007-2018 Restoration/Management Projects

**Limit sources of fecal contamination**

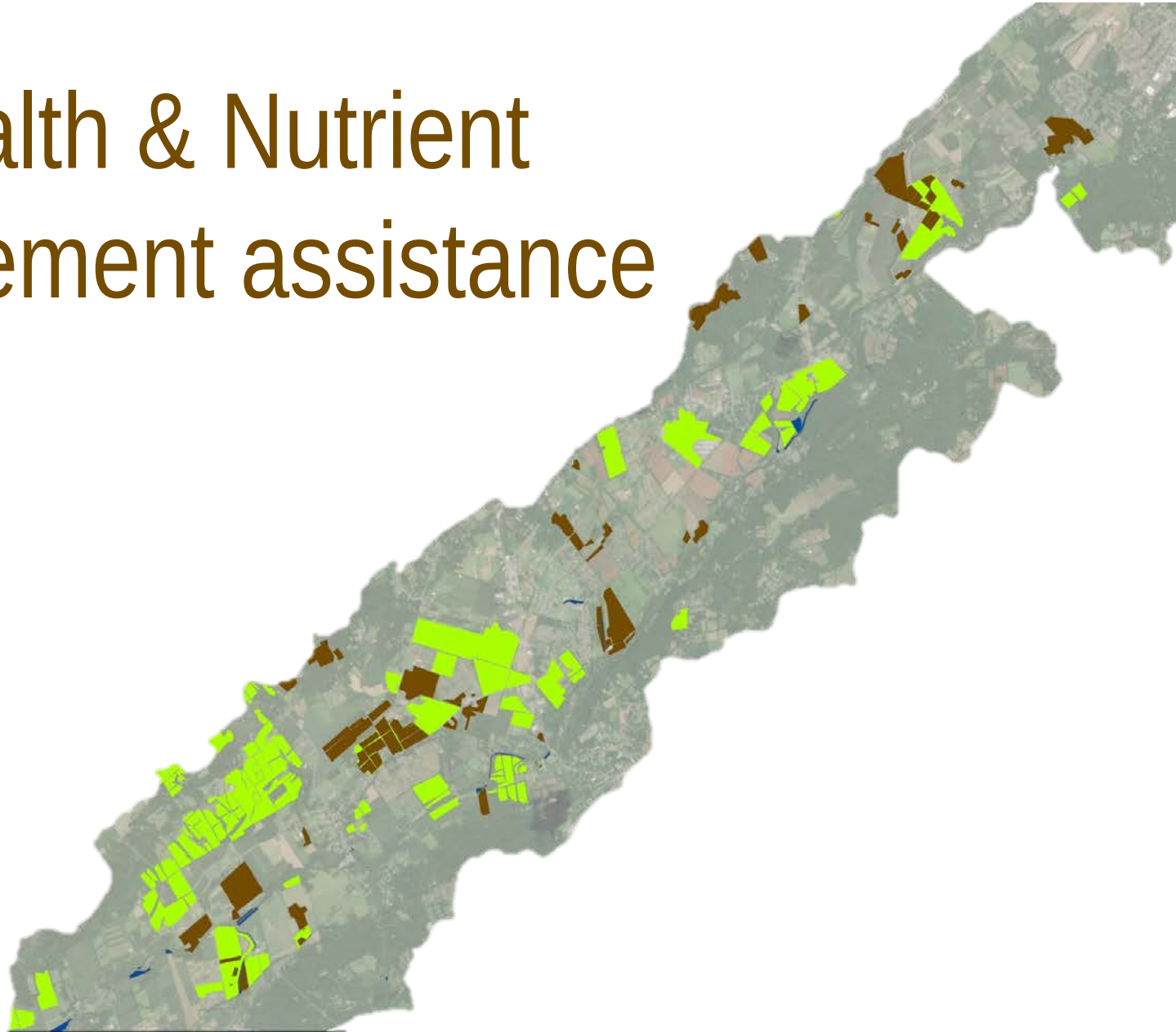
- Limit cow access to stream
  - armored stream crossing
  - Fencing
  - Riparian & Instream restoration
- Beef
  - Convert grain to grass feed
  - Reduce herd
- Cover crop
- Septic pumping incentive program
- 319(h)Work completed 2018

# In-stream and Riparian Restoration

# Cover crops

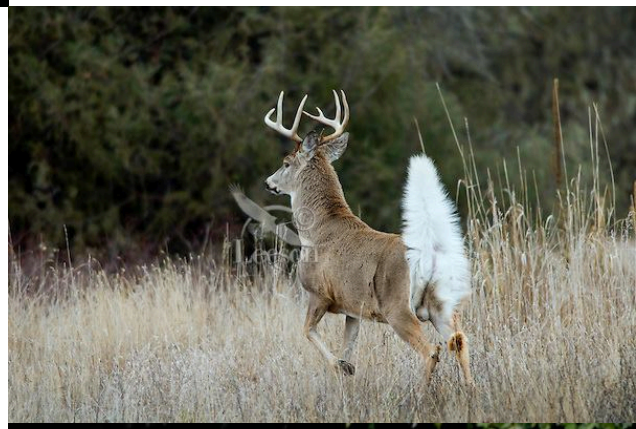


# Soil health & Nutrient management assistance



# How to track progress in improving water quality?

- Is there a reduction in
  - Fecal bacteria?
  - Erosion?
- Is bacteria from cow/human>wildlife?
- Data will allow us to provide feedback to
  - Landowners, municipalities to encourage continued efforts
  - NJDEP, EPA USDA to support future efforts
- We need a partner with expertise in Microbial Source Tracking



MONTCLAIR STATE UNIVERSITY

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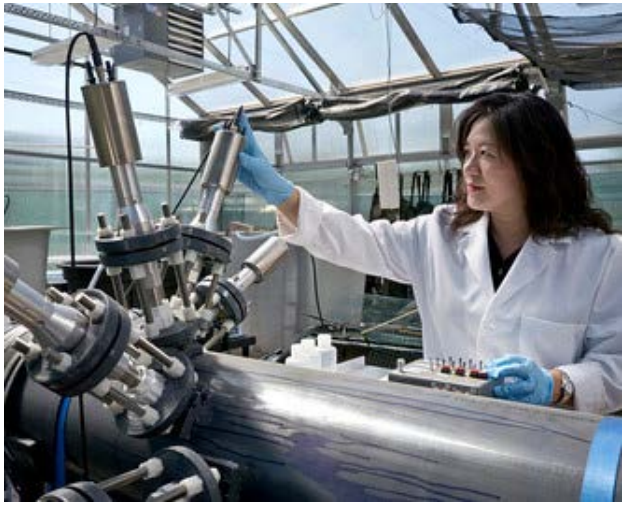
Director, Passaic River Institute

Director, Water Analysis Laboratory (NJDEP # 07105)

Professor, Department of Biology

Doctoral Faculty, Environmental Science & Management Program

Science Advisory Board, NJDEP



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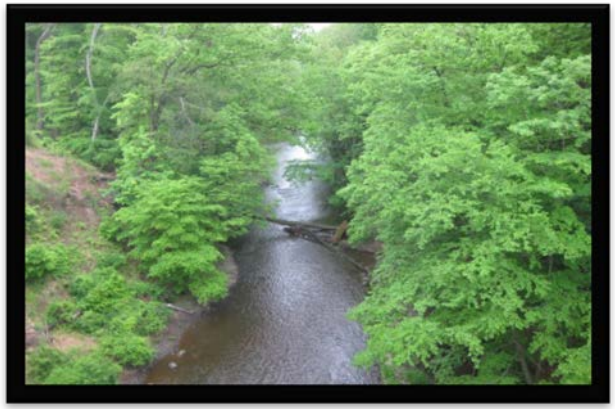
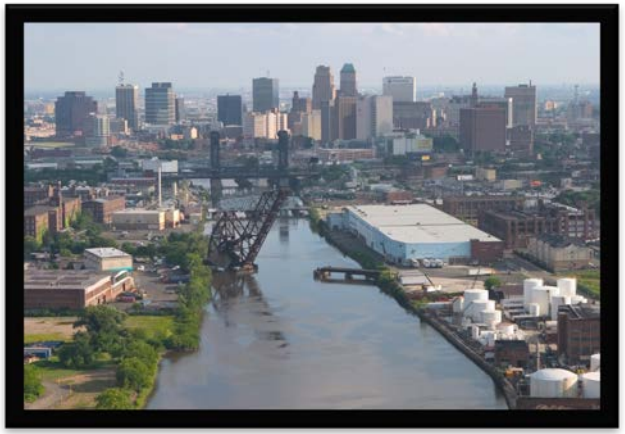
# New Jersey Center for
# Water Science and Technology

- Water quality and quantity
- Drinking and Recreation Safety
- Seafood consumption safety
- Urban environment
- Biodiversity
- Habitat connectivity
- Pollution transport & control
- Flood risk reduction





# Water Quality & Pollution Control

- Water quality assessment
- Plastic free water
- Non-point source pollution & control
- Microbial Source Tracking



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# New Jersey Center for Water Science and Technology

## Certified Analysis

- pH
- Turbidity
- Total suspended solids
- Conductivity
- Salinity
- Temperature
- Dissolved Oxygen
- Total Coliform
- *E. coli*
- *Enterococcus*

## Other Analysis

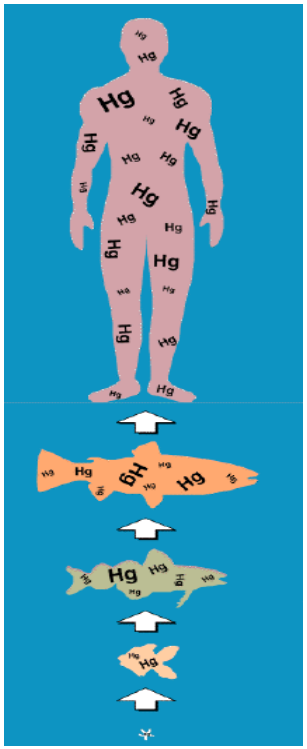
- Total Phosphorus
- Orthophosphate
- Total Nitrogen
- Ammonia
- Nitrite
- Nitrate
- Microbial Source Tracking
- Cyanotoxins
- Phytoplankton/cyanobacteria
- Benthic macroinvertebrate

# Harmful Algal Blooms (HABs)


- R&D detection & control of HABs & Cyanotoxins
- Identifying environmental variables triggering HABs
- Investigating human health risks related to cyanotoxins exposure
- Preserving biodiversity of freshwater phytoplankton

# Seafood Consumption Safety

- Bioaccumulation & biomagnification of contaminants
- Human consumption safety
- Consumption advisory



# Biodiversity & Habitat Connectivity

Restore Fragmented Habitats

Remove Habitat Barriers

Preserve Biodiversity

Prevent Flooding

**Montclair State University**

# New Jersey Center for
# Water Science and Technology

## Environmental Education

- To empower residents
- To promote environmental awareness & stewardships
- K-12 classroom visits/Science Fairs/Club and Community events

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# New Jersey Center for
# Water Science and Technology

Facilitate Communications
Sponsor conference, workshops & informational meetings

## Montclair State University

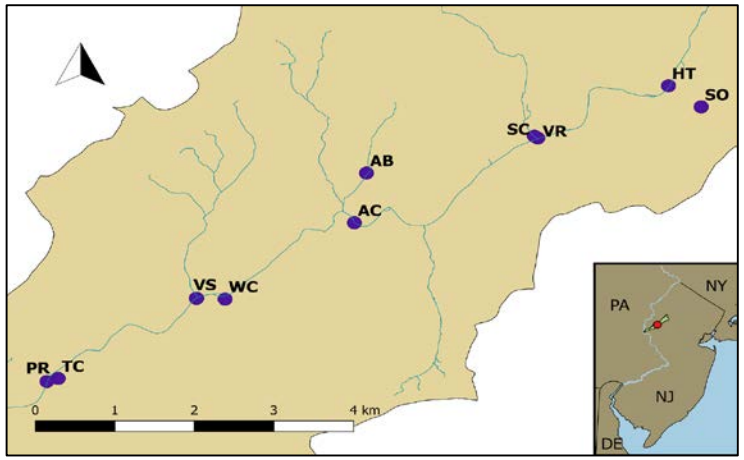
# New Jersey Center for
# Water Science and Technology

Environmental Outreach: Provide technical assistance & support for area municipalities, environmental groups & residents.

Water quality assessment at Bonsal Wildlife Preserve

Sediment chemistry assessment at Lake Hopatcong.

# Revisiting the Musconetcong after 10 Years




## 1. Water Quality & Quantity Monitoring

- Duplicate the 2007 Study & assess water quality and quantity from May to October 2018.
- Understand the trends in water quality and quantity of the Musconetcong River between 2007 and 2018

## 2. Microbial Source Tracking

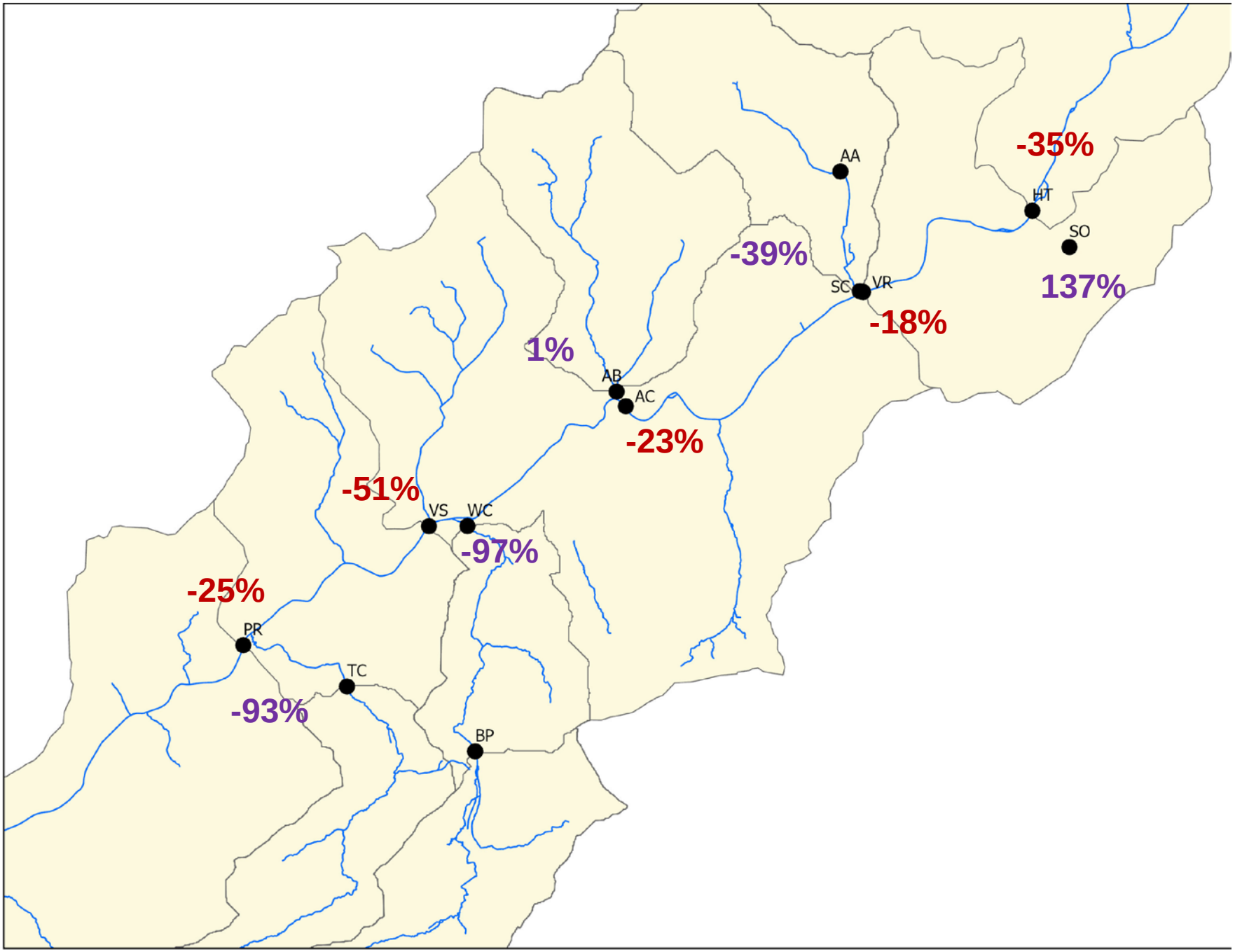
- To determine the origins of fecal contamination.
- Examine changes in origins of fecal contaminations between 2007 and 2018.

# 2007 vs. 2018

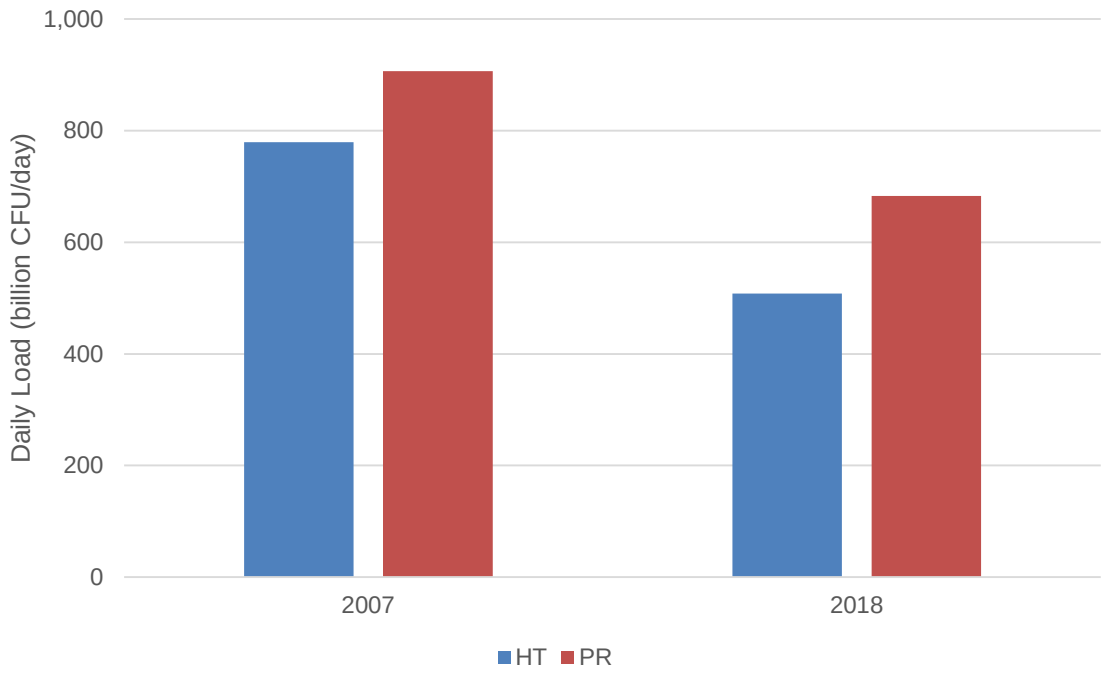
| Parameter | Significant (Y/N) | *p-value* | (+ or -) for the 2018-2007 |
|---|---|---|---|
| Discharge | N | 0.0762 | |
| pH | Y | <.0001 | + |
| water T | N | | |
| DO | N | | |
| *E. coli* conc. | Y | <.0001 | - |
| *E. coli* loads | Y | <.0001 | - |
| TSS conc. | Y | <.0001 | + |
| TSS loads | Y | 0.0032 | + |
| TP conc. | Y | <.0001 | - |
| TP loads | N | | |
| $NO_3$ | Y | 0.001 | - |

2007 to 2018

1. Higher pH
2. Lower *E. coli* counts and loads
3. Higher TSS concentration and loads
4. Lower TP and $NO_3$ concentrations
5. No significant difference in discharge, water temperature, DO or TP loads.


-35%
AA
HT
SO
-39%
SC
VR
137%
-18%
1%
AB
AC
-23%
-51%
VS
WC
-97%
-25%
PR
TC
-93%
BP

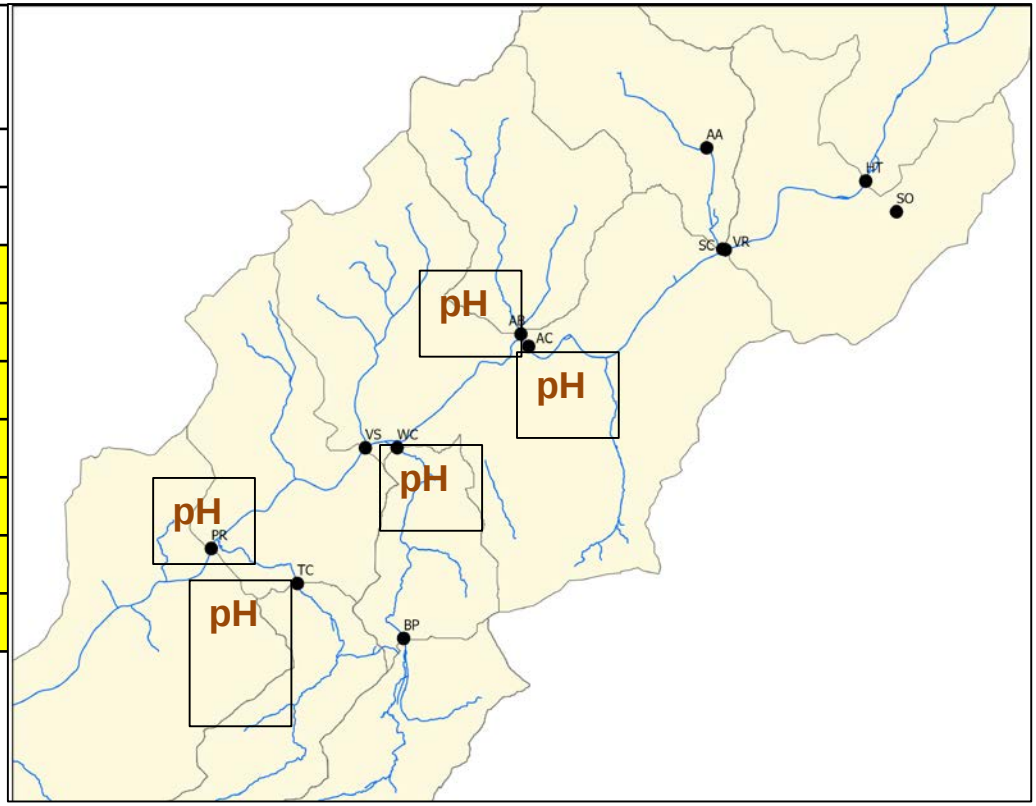
# Changes in *E. coli* Loads--Mainstem

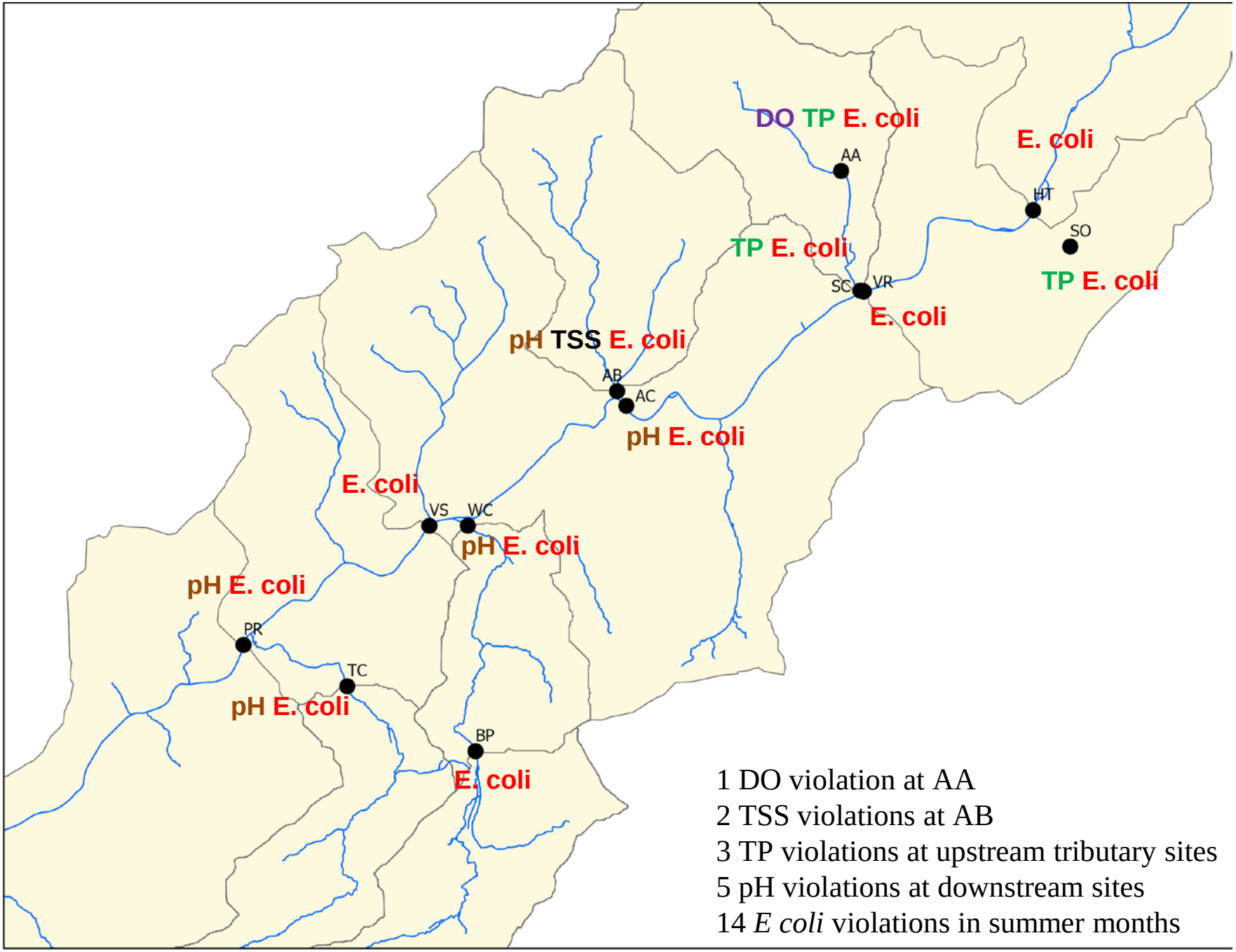



- In 2007, daily load was 779 billion CFU at HT, 906 billion CFU at PR
- Additional 127 billion CFU ; 16% increase in 2007
- In 2018, daily load was 508 billion CFU at HT, 683 billion CFU at PR
- Additional 175 billion CFU; 34% increase in 2018

# pH 2007 vs. 2018

| Site ID | Significant (Y/N) | *p-value* | (+ or -) for the 2018-2007 |
|---|---|---|---|
| HT | N | | |
| VR | N | | |
| AC | Y | 0.0001 | + |
| VS | Y | 0.0001 | + |
| PR | Y | <0.0001 | + |
| SC | Y | <0.0001 | + |
| AB | Y | 0.0001 | + |
| WC | Y | <0.0001 | + |
| TC | Y | <0.0001 | + |




DO TP E. coli
E. coli
AA
HT
SO
TP E. coli
TP E. coli
SC
VR
E. coli
pH TSS E. coli
AB
AC
pH E. coli
E. coli
VS
WC
pH E. coli
pH E. coli
PR
TC
pH E. coli
BP
E. coli
1 DO violation at AA
2 TSS violations at AB
3 TP violations at upstream tributary sites
5 pH violations at downstream sites
14 *E coli* violations in summer months

# Mainstem Sites 2007 vs. 2018

| Parameter | HT | VR | AC | VS | PR |
|---|---|---|---|---|---|
| Discharge | + | + | + | + | + |
| **pH** | | | **+** | **+** | **+** |
| water T | | | | | |
| **DO** | **-** | **-** | | | |
| *E. coli* conc. | - | - | - | - | - |
| *E. coli* loads | | | | | |
| TSS conc. | + | + | + | + | + |
| TSS loads | + | + | + | + | + |
| TP conc. | - | - | - | - | - |
| TP loads | | | | | |
| **$NO_3$** | | | **-** | **-** | **-** |

PR 2007 to 2018

1. Elevated discharge and TSS, both concentration and loads
2. Lower *E. coli* and nutrient concentrations, but not loads.

# 2018 MST-Human

| Log copy/mL-Sample | HT | SO | VR | SC | AA | AC | AB | VS | WC | BP | TC | PR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5/8/2018 | 2.872 | NA | 3.041 | 1.301 | NA | 2.267 | 2.086 | 2.952 | 1.663 | 2.049 | <1 | 2.828 |
| 5/22/2018 | 2.743 | NA | 2.818 | 2.513 | NA | 2.796 | 2.765 | 2.646 | 2.879 | 2.371 | 3.006 | 2.747 |
| 6/5/2018 | 2.999 | NA | 3.092 | 1.114 | NA | 2.854 | 2.576 | 3.066 | 1.556 | <1 | 1.342 | 2.884 |
| 6/19/2018 | 3.161 | NA | 3.169 | 1.146 | NA | 3.099 | 2.207 | 2.778 | 3.465 | 2.301 | 3.009 | 2.890 |
| 7/3/2018 | 3.111 | NA | 3.683 | 2.534 | NA | 3.322 | 2.534 | 3.012 | 3.552 | 2.188 | 3.044 | 3.217 |
| 7/24/2018 | 2.611 | NA | 2.680 | 2.215 | NA | 2.676 | 2.616 | 2.825 | 2.600 | 2.243 | 3.237 | 2.754 |
| 8/14/2018 | 2.529 | NA | 2.663 | 1.886 | NA | 3.086 | 2.648 | 2.942 | 2.318 | 1.996 | 3.080 | 2.896 |
| 8/28/2018 | 3.017 | NA | 3.002 | 2.061 | NA | 2.524 | 2.441 | 3.040 | 4.304 | 1.940 | 3.393 | 2.498 |
| 9/4/2018 | 3.052 | NA | 2.688 | 2.152 | NA | 2.473 | 3.041 | 2.837 | 3.267 | 1.204 | 1.544 | 2.696 |
| 9/18/2018 | 3.104 | 3.716 | 3.351 | 5.072 | 5.281 | 3.597 | 3.080 | 3.570 | 3.415 | 2.916 | 3.563 | 3.553 |
| 10/2/2018 | 2.822 | 2.755 | 2.822 | 1.491 | NA | 2.605 | 2.258 | 2.696 | 2.369 | 1.991 | 2.316 | 2.505 |
| 10/16/2018 | 2.516 | 2.093 | 2.565 | 1.672 | NA | 2.877 | 2.017 | 2.609 | 2.297 | 1.833 | 1.431 | 2.739 |

| | Criteria |
|---|---|
| NA | Not sampled |
| ND | Log Copy Number less than 1 |
| Very LOW | Log Copy Number in between 1 and 2 |
| LOW | Log Copy Number in between 2 and 3 |
| HIGH | Log Copy Number in between 3 and 4 |
| Very HIGH | Log Copy Number greater than 4 |

# 2018 MST-Horse

| Log copy/mL-Sample | HT | SO | VR | SC | AA | AC | AB | VS | WC | BP | TC | PR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5/8/2018 | <1 | NA | 1.114 | 1.380 | NA | 1.398 | 1.204 | 1.000 | 1.322 | 1.431 | 1.398 | 1.079 |
| 5/22/2018 | 1.041 | NA | 1.000 | 1.000 | NA | 1.176 | 1.204 | 1.301 | 1.079 | 1.230 | <1 | 1.230 |
| 6/5/2018 | 1.146 | NA | 1.362 | 1.255 | NA | 1.415 | 1.613 | 1.114 | 1.230 | 1.505 | 1.322 | 1.204 |
| 6/19/2018 | 1.146 | NA | 1.230 | 1.079 | NA | 1.301 | 1.724 | 1.000 | 1.079 | <1 | 1.398 | 1.176 |
| 7/3/2018 | <1 | NA | <1 | 1.146 | NA | 1.114 | <1 | 1.079 | 1.041 | <1 | 1.000 | <1 |
| 7/24/2018 | <1 | NA | <1 | 1.204 | NA | <1 | 1.041 | <1 | 1.000 | <1 | <1 | <1 |
| 8/14/2018 | 1.079 | NA | <1 | <1 | NA | 1.114 | 1.114 | <1 | 1.176 | 1.114 | 1.079 | 1.230 |
| 8/28/2018 | <1 | NA | 1.146 | <1 | NA | 1.204 | 1.146 | <1 | 1.279 | 1.146 | <1 | 1.000 |
| 9/4/2018 | 1.176 | NA | 1.301 | <1 | NA | 1.398 | 1.447 | 1.591 | 1.255 | 1.663 | 1.580 | 1.362 |
| 9/18/2018 | 1.079 | 1.431 | 1.556 | 1.447 | 1.255 | 1.491 | 1.230 | 1.255 | 1.079 | 1.447 | 1.380 | 1.477 |
| 10/2/2018 | 1.380 | 1.415 | 1.380 | 1.362 | NA | 1.447 | 1.519 | 1.415 | 1.491 | 1.491 | 1.415 | 1.519 |
| 10/16/2018 | 1.415 | 1.362 | 1.398 | 1.580 | NA | 1.041 | 1.653 | 1.568 | 1.415 | 1.732 | 1.462 | 1.380 |

| | Criteria |
|---|---|
| NA | Not sampled |
| ND | Log Copy Number less than 1 |
| Very LOW | Log Copy Number in between 1 and 2 |
| LOW | Log Copy Number in between 2 and 3 |
| HIGH | Log Copy Number in between 3 and 4 |
| Very HIGH | Log Copy Number greater than 4 |

# 2018 MST-Cow

| Log copy/mL-Sample | HT | SO | VR | SC | AA | AC | AB | VS | WC | BP | TC | PR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5/8/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 5/22/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | 2.013 | <1 | 2.033 | <1 |
| 6/5/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 6/19/2018 | 1.041 | NA | 1.041 | <1 | NA | <1 | <1 | <1 | 2.624 | <1 | 2.053 | <1 |
| 7/3/2018 | 1.079 | NA | 1.398 | <1 | NA | <1 | <1 | 1.633 | 2.865 | <1 | 1.857 | <1 |
| 7/24/2018 | <1 | NA | <1 | 1.342 | NA | <1 | <1 | <1 | 1.591 | <1 | 2.493 | <1 |
| 8/14/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | 1.342 | 1.000 | <1 | 2.332 | <1 |
| 8/28/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | 2.104 | 3.706 | <1 | 2.859 | <1 |
| 9/4/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | 2.292 | <1 | <1 | <1 |
| 9/18/2018 | 1.146 | <1 | 1.519 | 3.415 | 3.075 | 2.420 | <1 | 2.243 | 2.217 | <1 | 2.480 | 2.371 |
| 10/2/2018 | <1 | <1 | <1 | <1 | NA | <1 | <1 | <1 | 1.079 | <1 | 1.613 | <1 |
| 10/16/2018 | <1 | <1 | <1 | <1 | NA | <1 | <1 | <1 | 1.505 | <1 | <1 | <1 |

| | Criteria |
|---|---|
| NA | Not sampled |
| ND | Log Copy Number less than 1 |
| Very LOW | Log Copy Number in between 1 and 2 |
| LOW | Log Copy Number in between 2 and 3 |
| HIGH | Log Copy Number in between 3 and 4 |
| Very HIGH | Log Copy Number greater than 4 |

# 2018 MST-Geese

| Log copy/mL-Sample | HT | SO | VR | SC | AA | AC | AB | VS | WC | BP | TC | PR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5/8/2018 | <1 | NA | 1.380 | <1 | NA | 1.740 | <1 | <1 | <1 | <1 | <1 | <1 |
| 5/22/2018 | <1 | NA | 1.301 | <1 | NA | <1 | 1.602 | <1 | <1 | <1 | <1 | <1 |
| 6/5/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 6/19/2018 | 1.740 | NA | 1.716 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 7/3/2018 | 1.826 | NA | 1.633 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 7/24/2018 | <1 | NA | 1.079 | <1 | NA | 1.204 | <1 | <1 | <1 | <1 | 1.505 | <1 |
| 8/14/2018 | <1 | NA | 1.415 | 1.740 | NA | 1.415 | <1 | 1.398 | 2.037 | <1 | <1 | <1 |
| 8/28/2018 | 1.699 | NA | 1.556 | <1 | NA | 1.322 | <1 | <1 | <1 | <1 | <1 | <1 |
| 9/4/2018 | 1.255 | NA | <1 | <1 | NA | <1 | <1 | 1.491 | <1 | <1 | <1 | <1 |
| 9/18/2018 | <1 | <1 | 1.301 | <1 | <1 | 1.000 | <1 | <1 | <1 | <1 | <1 | <1 |
| 10/2/2018 | 1.146 | <1 | 1.301 | <1 | NA | 1.146 | <1 | 1.255 | <1 | <1 | <1 | <1 |
| 10/16/2018 | 1.301 | <1 | 1.716 | <1 | NA | <1 | <1 | 1.255 | <1 | <1 | <1 | <1 |

| | Criteria |
|---|---|
| NA | Not sampled |
| ND | Log Copy Number less than 1 |
| Very LOW | Log Copy Number in between 1 and 2 |
| LOW | Log Copy Number in between 2 and 3 |
| HIGH | Log Copy Number in between 3 and 4 |
| Very HIGH | Log Copy Number greater than 4 |

# 2018 MST-Chicken

| Log copy/mL-Sample | HT | SO | VR | SC | AA | AC | AB | VS | WC | BP | TC | PR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5/8/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 5/22/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 6/5/2018 | <1 | NA | <1 | <1 | NA | 1.041 | <1 | <1 | <1 | <1 | <1 | <1 |
| 6/19/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 7/3/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 7/24/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | 1.041 | <1 | <1 | <1 |
| 8/14/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | <1 | <1 | 1.279 | <1 |
| 8/28/2018 | <1 | NA | 1.342 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 9/4/2018 | <1 | NA | <1 | <1 | NA | 1.000 | <1 | <1 | <1 | <1 | <1 | <1 |
| 9/18/2018 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 10/2/2018 | <1 | <1 | <1 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 10/16/2018 | 1.114 | <1 | <1 | <1 | NA | <1 | 1.114 | <1 | <1 | <1 | <1 | <1 |

| | Criteria |
|---|---|
| NA | Not sampled |
| ND | Log Copy Number less than 1 |
| Very LOW | Log Copy Number in between 1 and 2 |
| LOW | Log Copy Number in between 2 and 3 |
| HIGH | Log Copy Number in between 3 and 4 |
| Very HIGH | Log Copy Number greater than 4 |

# 2018 MST-Deer

| Log copy/mL-Sample | HT | SO | VR | SC | AA | AC | AB | VS | WC | BP | TC | PR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5/8/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 5/22/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 6/5/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 6/19/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 7/3/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 7/24/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 8/14/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 8/28/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 9/4/2018 | <1 | NA | <1 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 9/18/2018 | <1 | 1.591 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 10/2/2018 | <1 | 1.146 | <1 | <1 | NA | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 10/16/2018 | <1 | 1.114 | <1 | 2.481 | NA | <1 | <1 | 1.079 | 2.751 | <1 | <1 | <1 |

| | Criteria |
|---|---|
| NA | Not sampled |
| ND | Log Copy Number less than 1 |
| Very LOW | Log Copy Number in between 1 and 2 |
| LOW | Log Copy Number in between 2 and 3 |
| HIGH | Log Copy Number in between 3 and 4 |
| Very HIGH | Log Copy Number greater than 4 |

# 2018 MST

| Mainstem Sites | HT | VR | AC | VS | PR |
|---|---|---|---|---|---|
| Fecal Contributions | **Human**, Horse, Geese | **Human**, Horse, Geese | **Human**, Cow, Horse, Geese | **Human**, Cow, Horse | **Human**, Cow, Horse |

| Tributary Sites | SO | SC | AA | AB | BP | WC | TC |
|---|---|---|---|---|---|---|---|
| Fecal Contributions | **Human**, Deer, Horse | **Human**, Cow, Deer, Horse | Human, Cow, Horse | **Human**, Horse | **Human**, Horse | **Human**, **Cow**, Deer, Geese, Horse | **Human**, **Cow**, Horse |

Listed criteria: > 50% detected or high copy number found ; > 50% high copy number (**bold**)

# Land Use Land Cover Change (%)

| Site | AGRICULTURE | BARREN LAND | FOREST | URBAN | WATER | WETLANDS |
|---|---|---|---|---|---|---|
| AA | -0.01 | 0.13 | -0.84 | 0.76 | 0.00 | -0.04 |
| AB | -1.33 | NA | 1.18 | 0.16 | 0.00 | -0.01 |
| AC | -0.48 | -0.09 | -0.20 | 0.77 | 0.03 | -0.05 |
| BP | -0.61 | NA | -0.15 | 0.75 | 0.00 | 0.00 |
| HT | -0.44 | -0.10 | -0.24 | 0.78 | 0.03 | -0.05 |
| PR | -0.48 | -0.10 | -0.16 | 0.75 | 0.03 | -0.04 |
| SC | 0.18 | 0.11 | -0.97 | 0.70 | 0.01 | -0.03 |
| SO | -4.18 | NA | 5.46 | -0.82 | 0.00 | 0.00 |
| TC | -0.43 | NA | 0.01 | 0.42 | 0.00 | 0.00 |
| VR | -0.45 | -0.10 | -0.22 | 0.78 | 0.03 | -0.05 |
| VS | -0.48 | -0.09 | -0.16 | 0.76 | 0.03 | -0.04 |
| WC | -0.71 | NA | 0.05 | 0.66 | -0.01 | 0.00 |

# Restoration Activity by Watersheds

| SITE | Agricultural Chemical Storage Facility | Conservation Cover | Cover Crop | Forest Stewardship | Forested Riparian Buffer | Grassed Waterway and Diversion | Heavy Use Area Protection | Other | Prescribed Grazing | Rain Garden | Sinkhole Repair | Stream Crossing | Streambed Restoration | Warm Season Grass Conversion | Wetland Restoration | TotalRestoration | TotalWatersheds | % Restoration Area |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AA | NA | NA | 83.8 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 83.8 | 1003.4 | 8.4 |
| AB | NA | NA | 225.7 | NA | NA | NA | NA | 0.1 | NA | NA | NA | NA | NA | NA | NA | 225.8 | 1276.7 | 17.7 |
| AC | NA | 4.0 | 1479.1 | 54.5 | 13.2 | 5.8 | 2.3 | NA | 15.6 | 0.3 | NA | NA | 10.3 | 122.2 | 8.1 | 1715.5 | 82677.7 | 2.1 |
| HT | NA | 4.0 | 1018.1 | 42.1 | 10.1 | 3.9 | NA | NA | NA | NA | NA | NA | 6.7 | 86.1 | 7.6 | 1178.7 | 77879.8 | 1.5 |
| PR | 2.1 | 64.5 | 2470.2 | 186.2 | 33.3 | 17.1 | 2.3 | 0.1 | 129.0 | 0.4 | 2.1 | 0.1 | 12.0 | 172.0 | 8.5 | 3099.8 | 90344.4 | 3.4 |
| SC | NA | NA | 181.6 | NA | NA | NA | 2.3 | NA | NA | NA | NA | NA | NA | NA | NA | 183.9 | 1182.6 | 15.6 |
| TC | NA | NA | 13.4 | NA | NA | 1.4 | NA | NA | NA | NA | NA | NA | NA | NA | NA | 14.8 | 911.6 | 1.6 |
| VR | NA | 4.0 | 1228.6 | 42.1 | 12.9 | 5.8 | NA | NA | NA | NA | NA | NA | 10.3 | 86.1 | 7.6 | 1397.5 | 79590.3 | 1.8 |
| VS | 2.1 | 4.0 | 2285.9 | 98.0 | 25.6 | 12.5 | 2.3 | 0.1 | 129.0 | 0.4 | NA | 0.1 | 12.0 | 168.9 | 8.1 | 2748.8 | 87953.9 | 3.1 |
| WC | NA | NA | 112.0 | NA | 6.6 | NA | NA | NA | NA | 0.1 | NA | 0.1 | 0.9 | NA | NA | 119.7 | 1776.9 | 6.7 |

(Unit in acres unless otherwise noted)

# Revisiting the Musconetcong after 10 Years

3. Evaluate the effectiveness of various BMPs

4. Conduct interviews to understand the motivations and limitations for focus groups to take part in BMPs

5. Stakeholder Engagement: involve stakeholders to develop restoration/management plans & elicit feedback for TMDL revision

# Opportunities & Considerations: Nonprofit View

## OPPORTUNITY…they have

- Grant officer to help file complicated grant
- University has experts in diverse fields
- Own laboratory facilities
- Opportunity to publish papers
- Graduates students!
- Undergraduate students!
- Diversity—introduce new people to your "world"!

## CONSIDERATIONS…Will they

- Anticipate your resource limitations?
- Know your locale?
- Play well with other partners?
- Understand your jargon?
- Be culturally different?

# Opportunities & Considerations: Academic Institution View

**OPPORTUNITY…They have**

- Deep understanding of the study area
- Memory of area conservation history
- Better sense of project feasibility
- Connection to the local residents and offices
- Access to study sites
- Convenience of being nearby (i.e. sample holding time, rapid response, etc.)

**CONSIDERATIONS…Will they**

- Align project goals
- Have the same expectations
- Follow the same SOPs
- Tolerate the “system”
- Move at different paces
- Work with inexperienced students

# To build a successful collaboration

- Communication. Communication. Communication…….
- ***We are a team!***
- ***It Takes Time!***
- Understand each other's priorities and limitations
- Utilize technology (i.e. Dropbox, Google Drive, Zoom)
- Schedule side meetings