Brandywine-Christina Healthy Water Fund Model-based Prioritization

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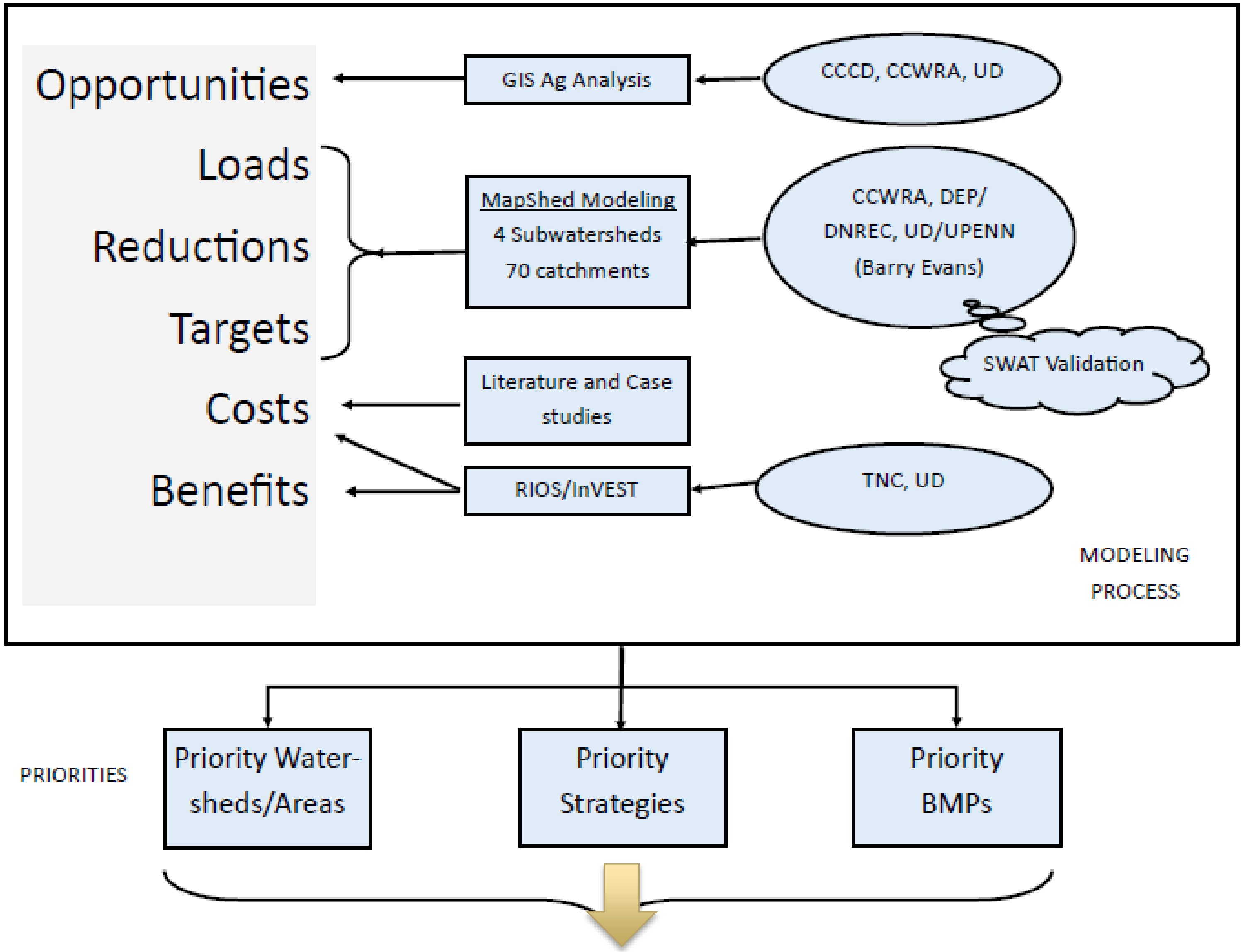
The big picture

- The Brandywine-Christina Healthy Water Fund seeks to develop sustainable funding to help restore waters (in 20 years)
  - Fishable
  - Swimmable
  - Potable
- Modeling is a key part of the process



[To the Brandywine Christina Healthy Water Fund]

Model what?

- On a watershed basis, determine
  - Environmental loads of constituents of concern
  - Effects of strategies (BMPs) to reduce impairments
  - Level of BMP implementation to meet WQ goals
  - Approximate costs to get these BMPs in the ground

Model why?

- Predict
  - The loads impacting streams
  - Reductions (and costs) expected from strategies
- Prioritize
  - Where should efforts focus
  - What types of strategies to employ
- Protect
  - Protect the water quality and quantity
  - Protect the process: **transparent, repeatable,** and **adaptive**

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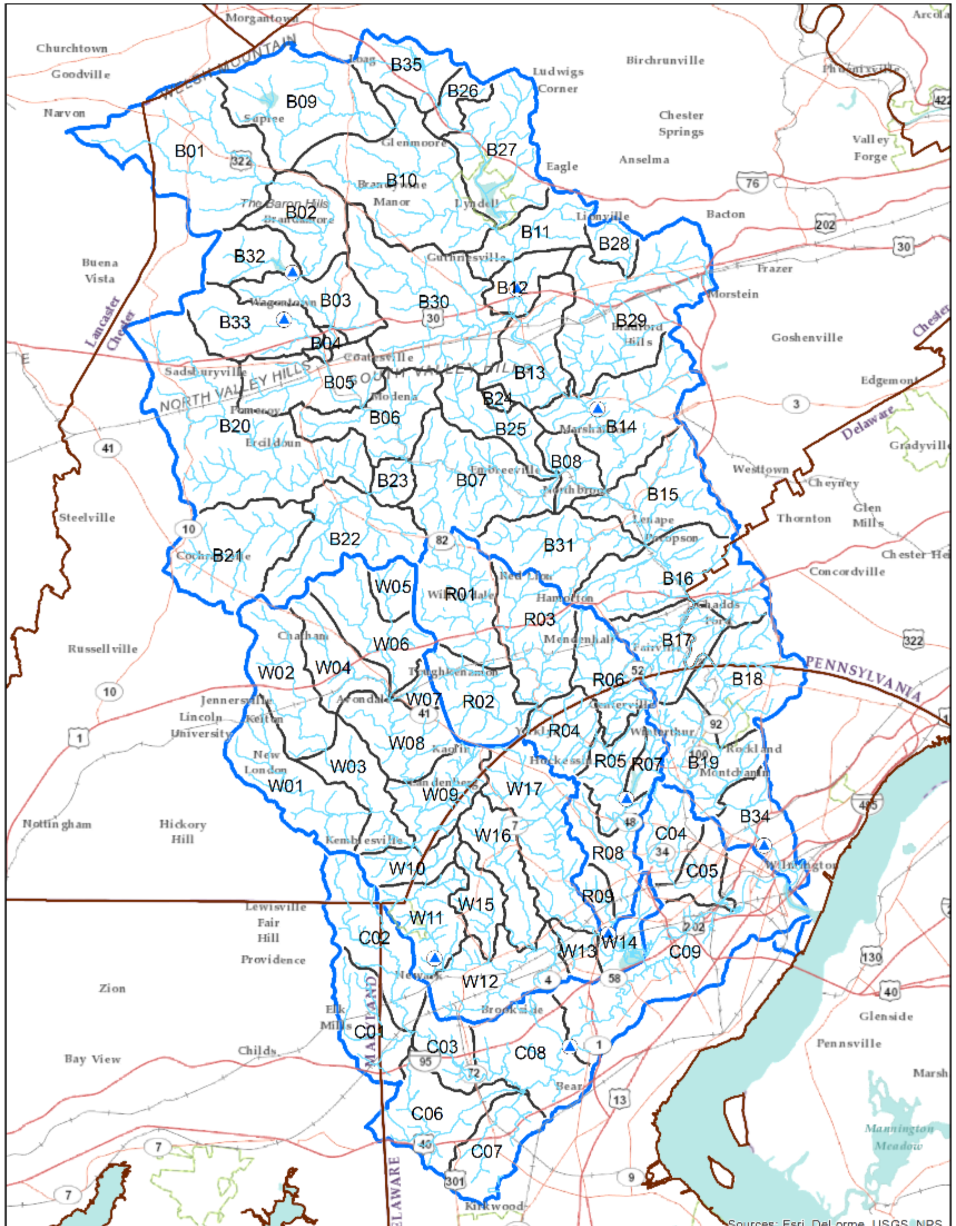
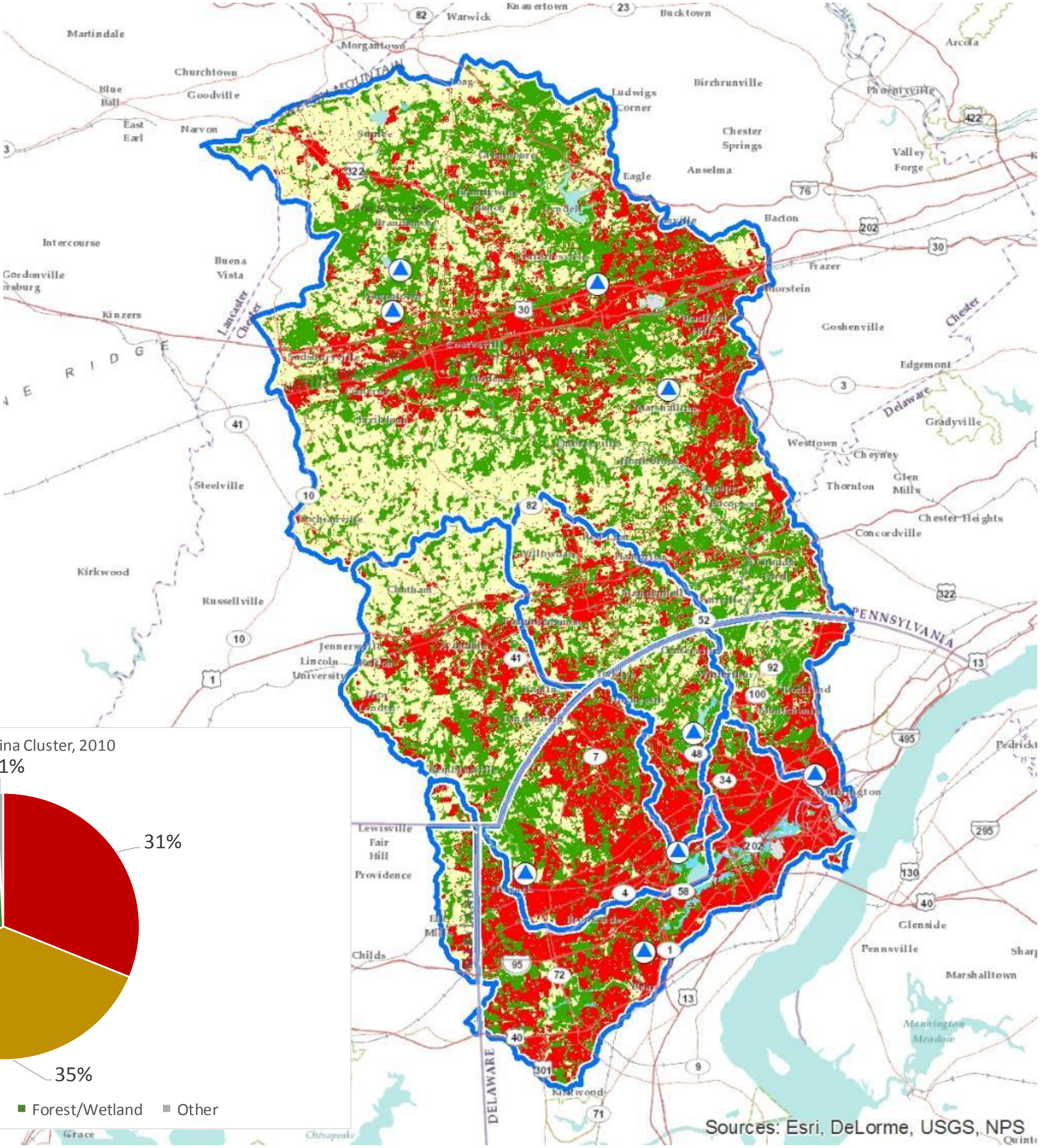
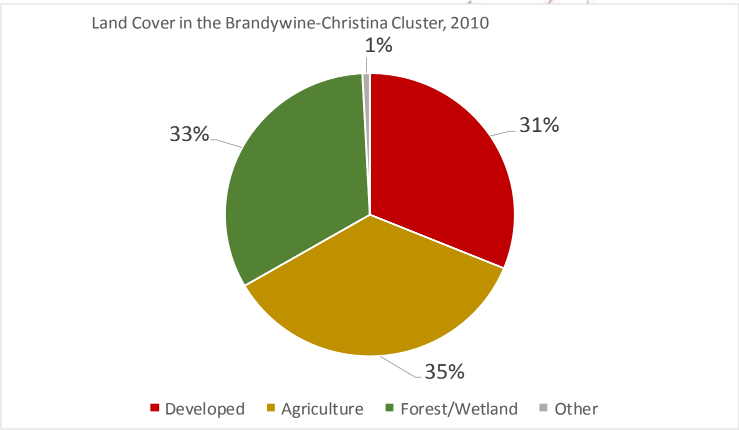
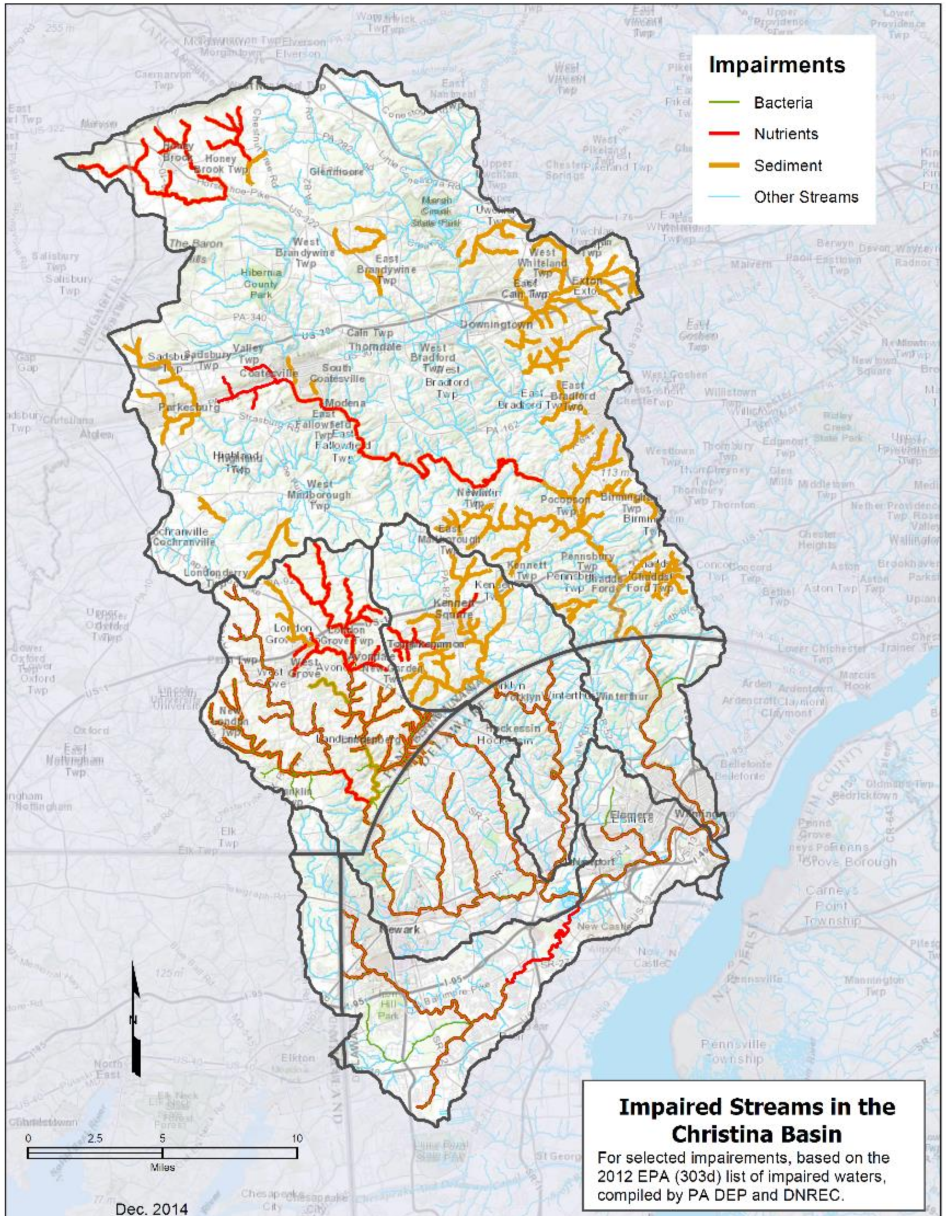
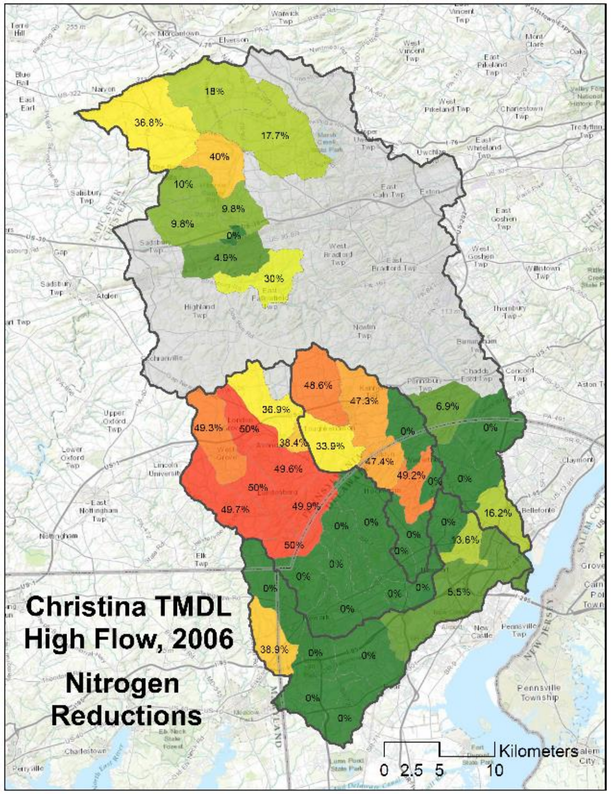


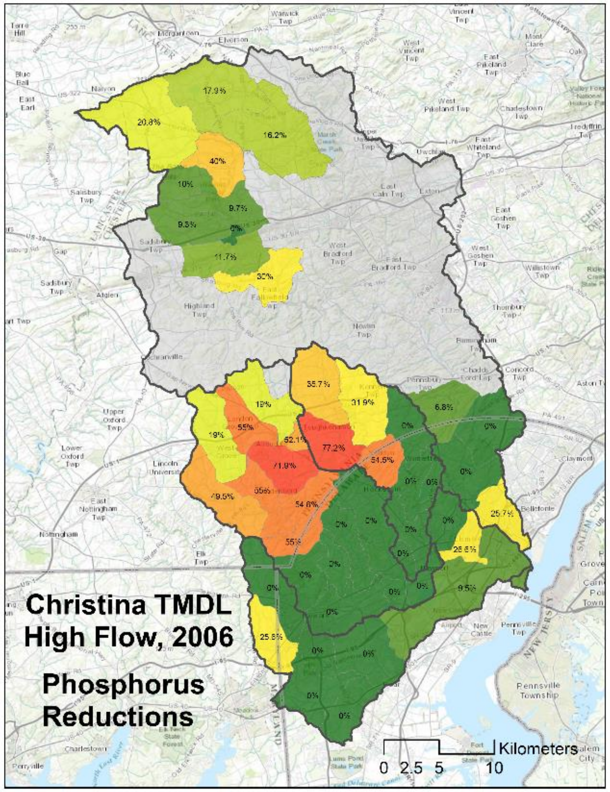

Warwick
Knauertown
Bucktown
Martindale
Morgantown
Churchtown
Goodville
Blue Ball
East Earl
Narvon
Birchrunville
Ludwigs Corner
Chester Springs
Anselma
Eagle
Arcola
Phoenixville
Valley Forge
Bacton
Frazer
Intercourse
Buena Vista
Gordonville
Kinzers
Goshenville
Edgemont
Gradyville
Westtown
Cheyney
Thornton
Glen Mills
Chester Heights
Concordville
Steelville
Kirkwood
Russellville
Jennersville
Lincoln University
PENNSYLVANIA
Lewisville
Fair Hill
Providence
Childs
Glenside
Pennsville
Marshalltown
Pedricktown
DELAWARE
Sources: Esri, DeLorme, USGS, NPS

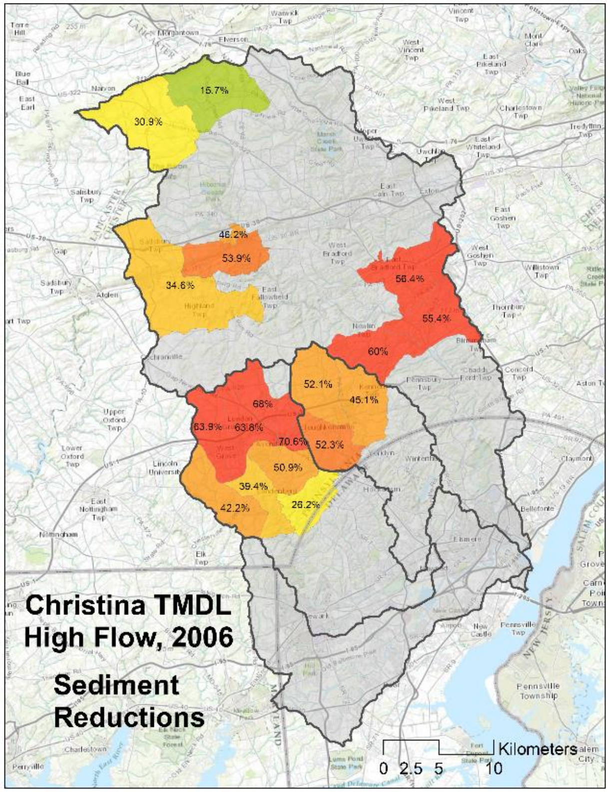

Land Cover in the Brandywine-Christina Cluster, 2010
1%
31%
33%
35%
Developed
Agriculture
Forest/Wetland
Other


Impairments
Bacteria
Nutrients
Sediment
Other Streams
Impaired Streams in the Christina Basin
For selected impairements, based on the 2012 EPA (303d) list of impaired waters, compiled by PA DEP and DNREC.
0 2.5 5 10
Miles
Dec. 2014

TMDLs


Christina TMDL
High Flow, 2006
Nitrogen
Reductions
Kilometers


Christina TMDL
High Flow, 2006
Phosphorus
Reductions
Kilometers

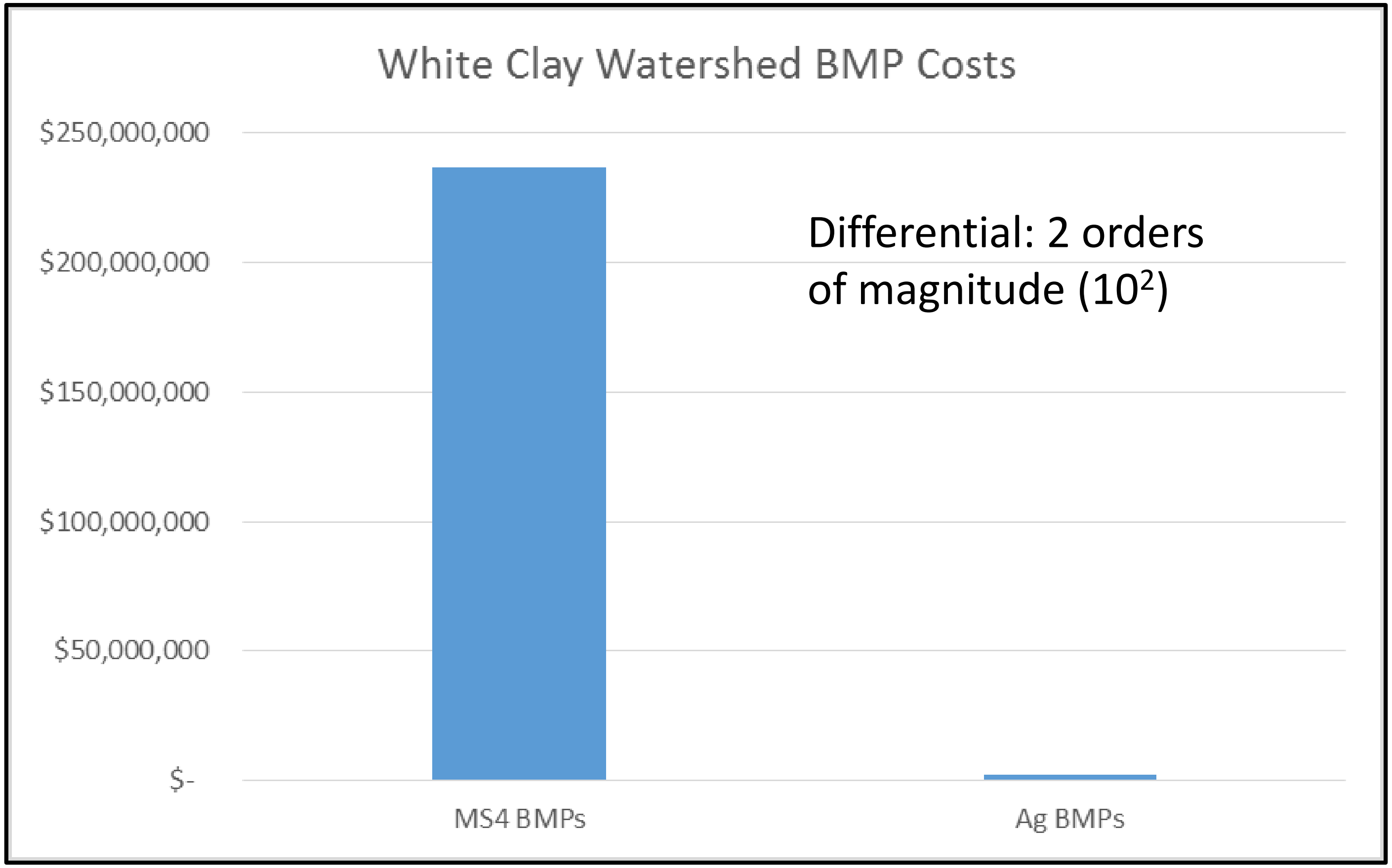

Christina TMDL
High Flow, 2006
Sediment
Reductions
Kilometers

The Water Fund

- Focus on agricultural sources
  - Nitrogen
  - Phosphorous
  - Sediment
- Focus on agricultural BMPs
  - Lower cost
  - Higher ROI

Pike Creek WQIP Example BMP implementation
Nitrogen Reductions

- $236,820,066 per year for MS4 urban stormwater BMPs
- ~$2,300,000 per year for agricultural BMPs (MapShed study)
- Differential: 2 orders of magnitude (10^2)



Potential annual MS4 BMP costs in the White Clay based on Pike Creek study

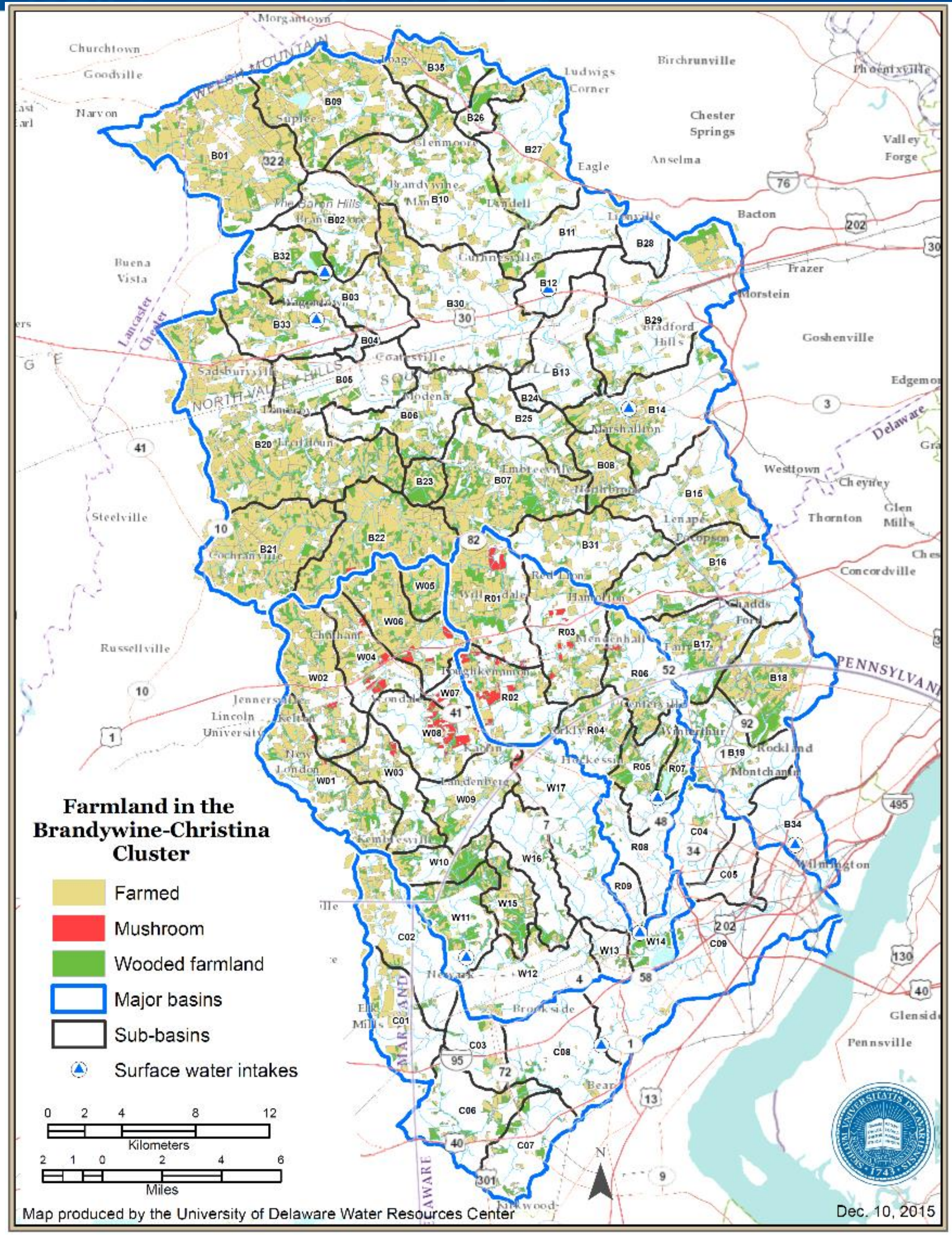
Pike Creek WQIP Example BMP implementation
Flow Reductions

Cost per acre-foot	Pike Creek acre-feet treated by BMPs	WCC sq.	WCC acres	Acre-feet in 2 inch rain event	Cost to capture 1% of runoff for 2 inch event	Cost to capture 0.1% of runoff for 2 inch event
$ 640,000	**5.5**	**107**	**68,480**	**11,413**	**$ 73,045,333**	**$ 7,304,533***

***Translates to**

- **over 55 miles of level lip spreaders,**
- **DEP grant funding for over 25 miles of stream restoration, or**
- **over 200 constructed wetland projects.**

Sources: Stroud WRC & BRC Red Streams Blue reports


Farmland in the Brandywine-Christina Cluster
Farmed
Mushroom
Wooded farmland
Major basins
Sub-basins
Surface water intakes
0 2 4 8 12
Kilometers
2 1 0 2 4 6
Miles
Map produced by the University of Delaware Water Resources Center
Dec. 10, 2015

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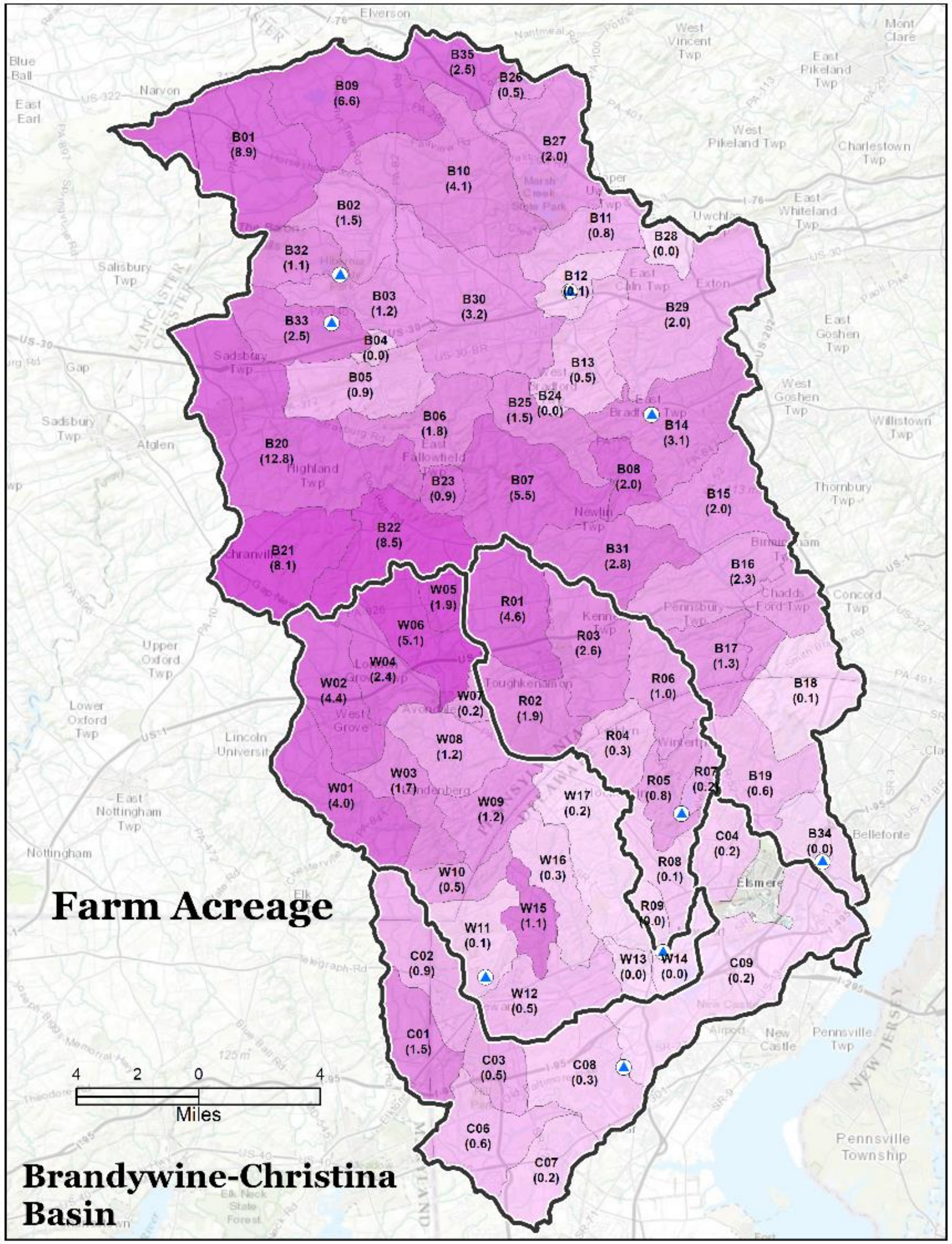

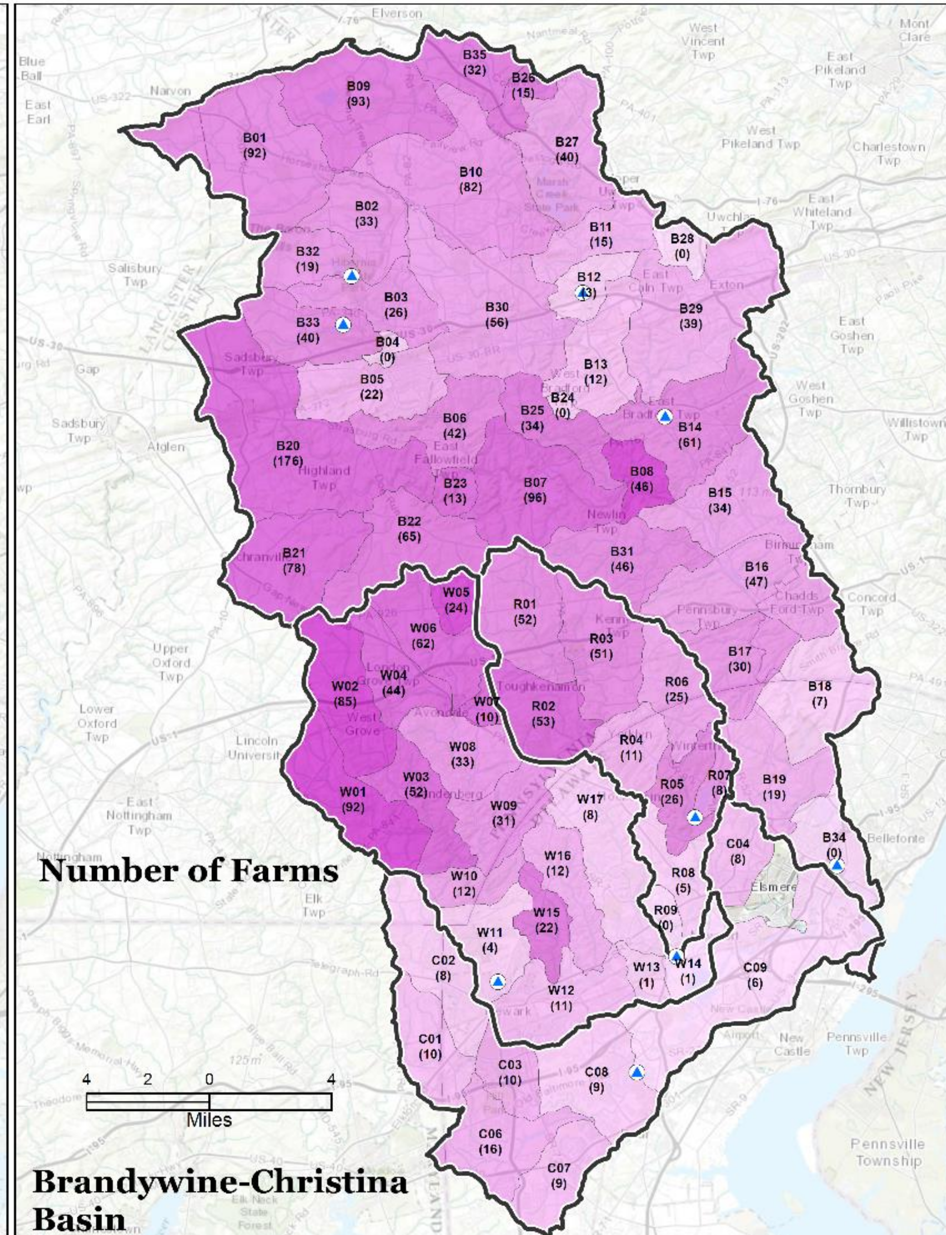

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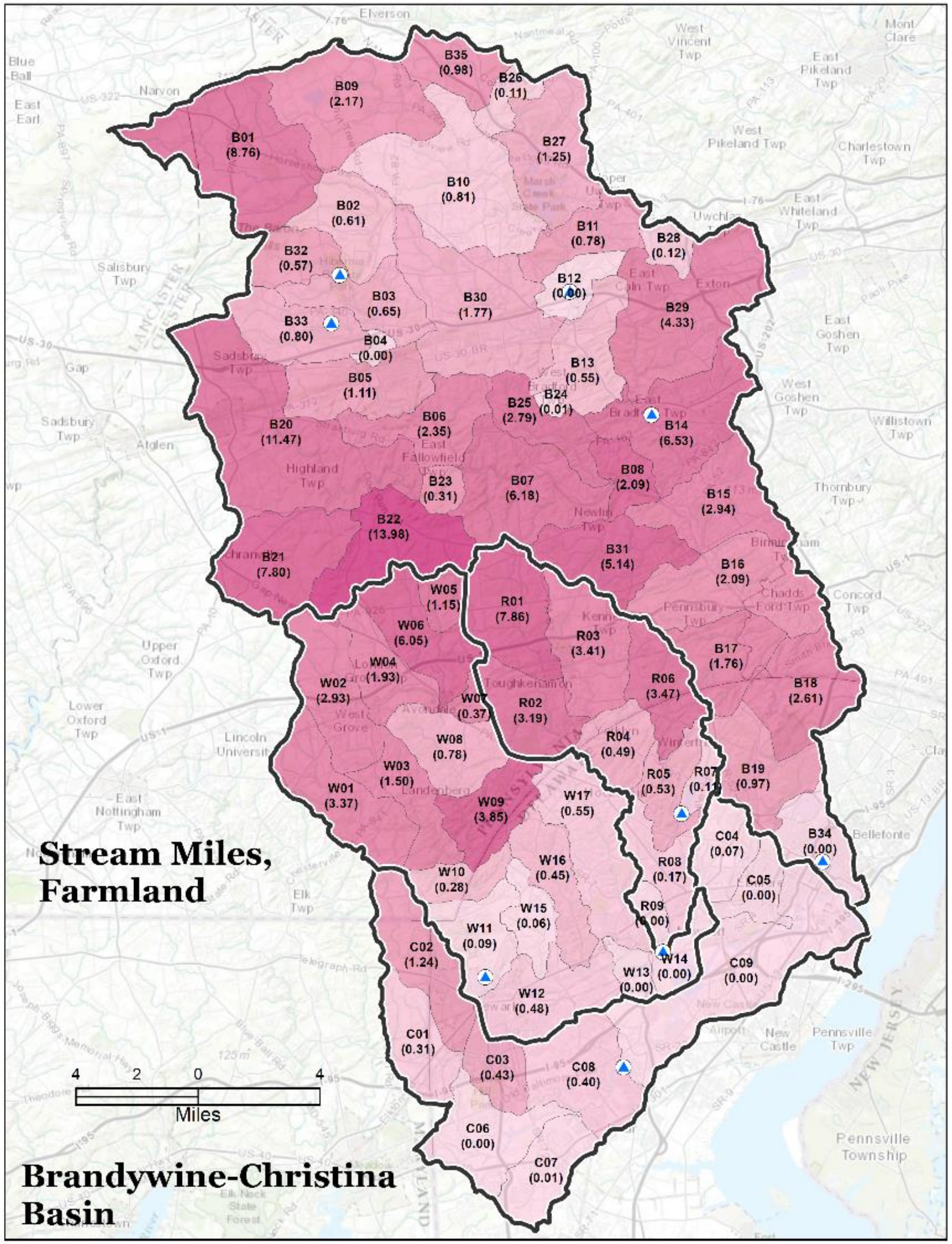
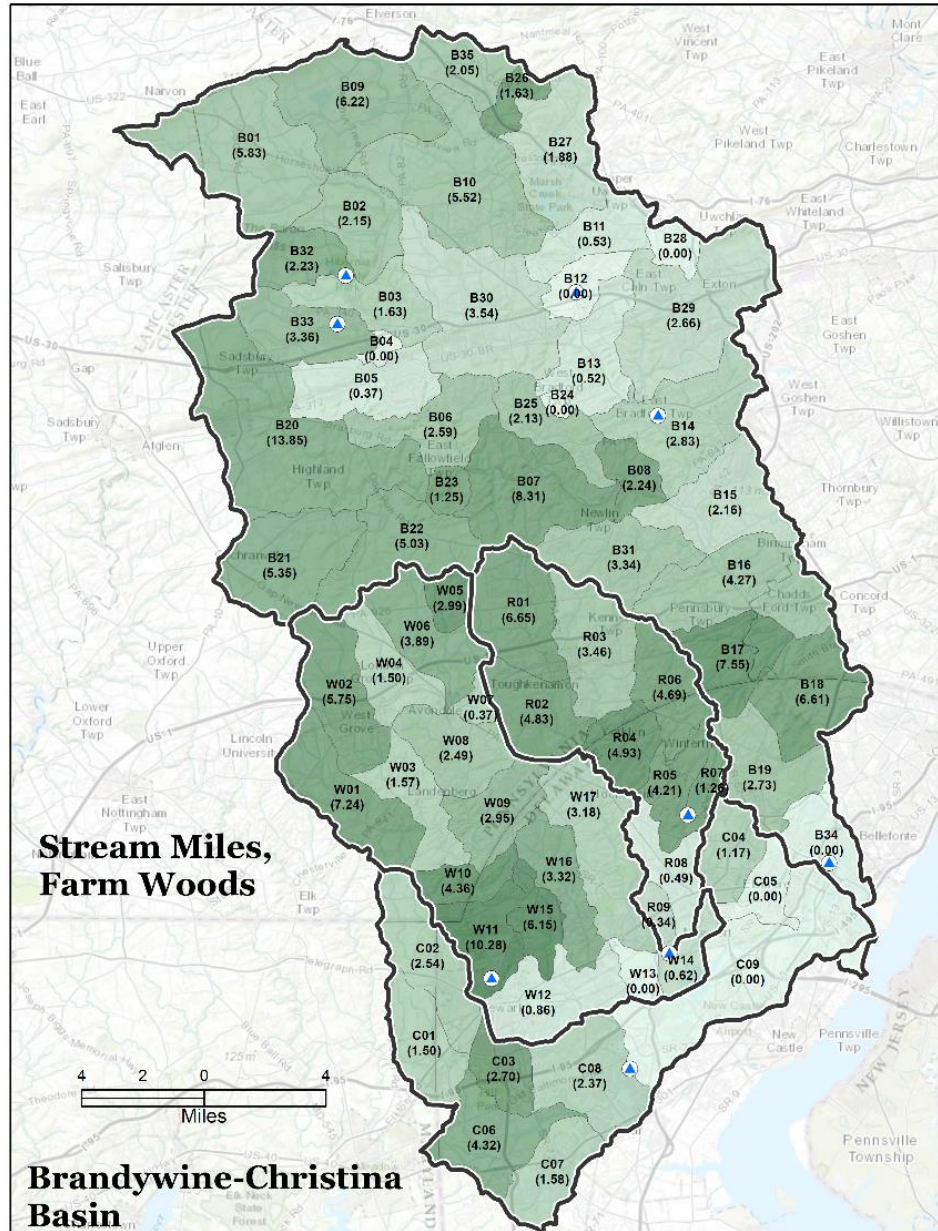
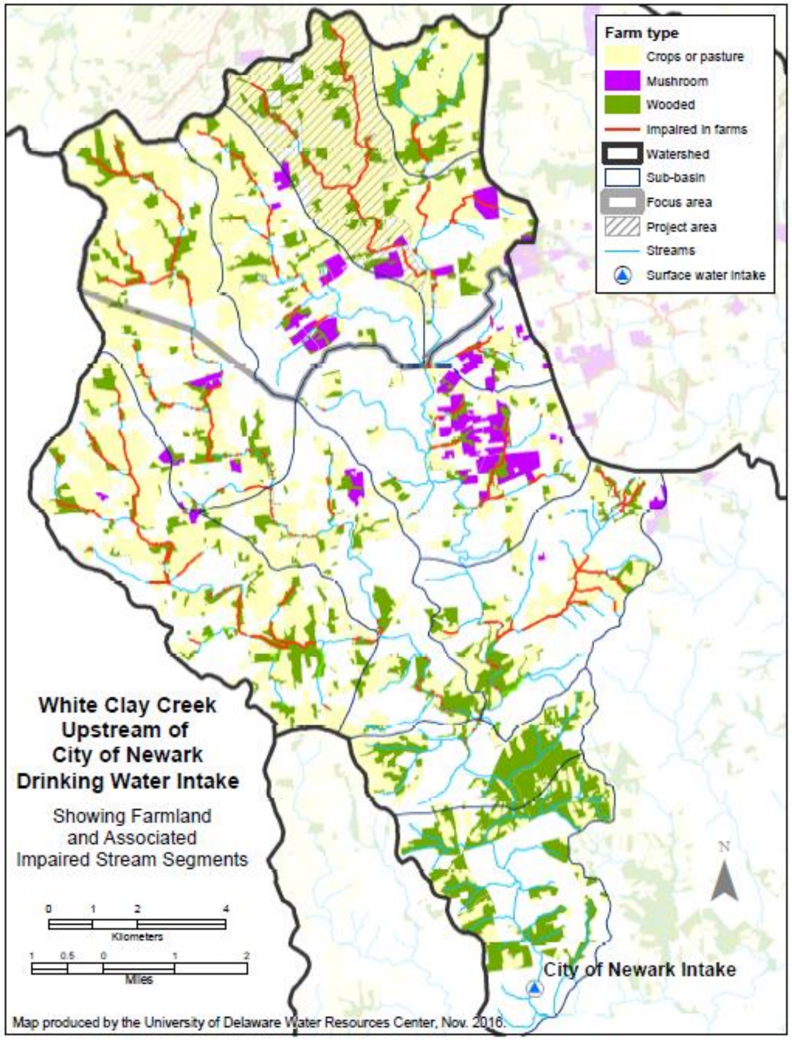
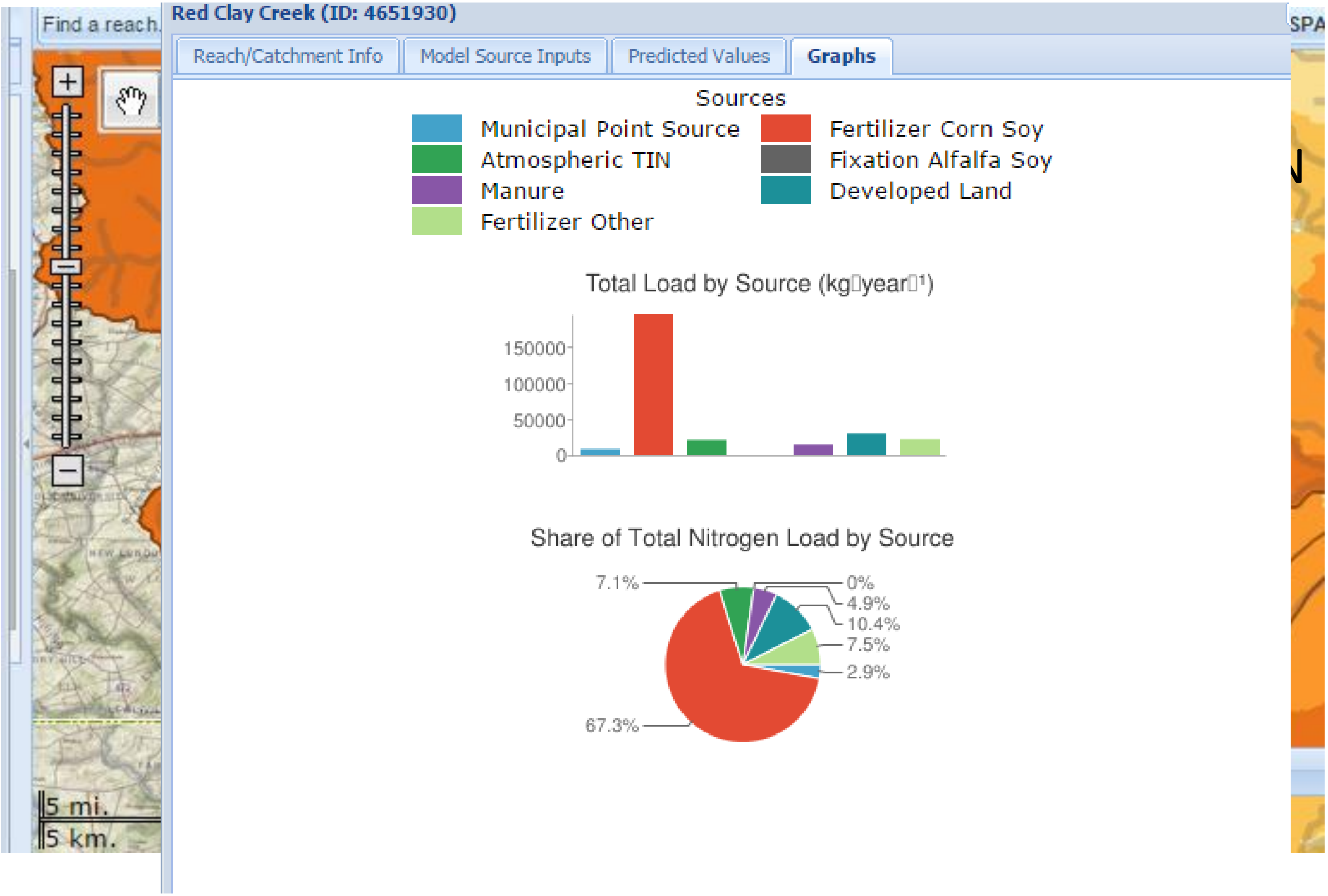


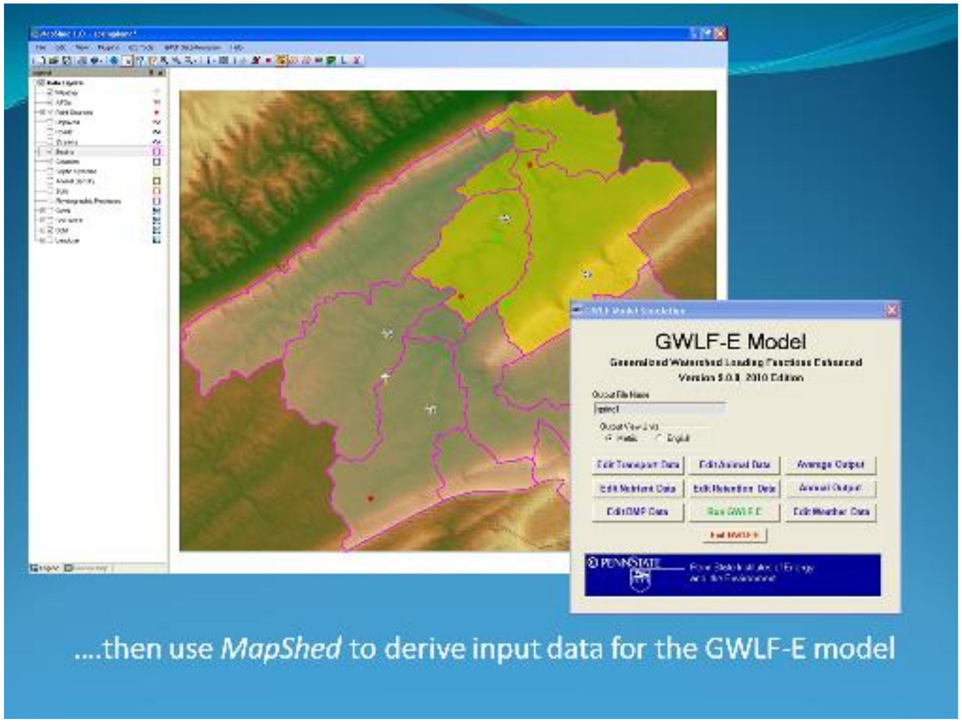




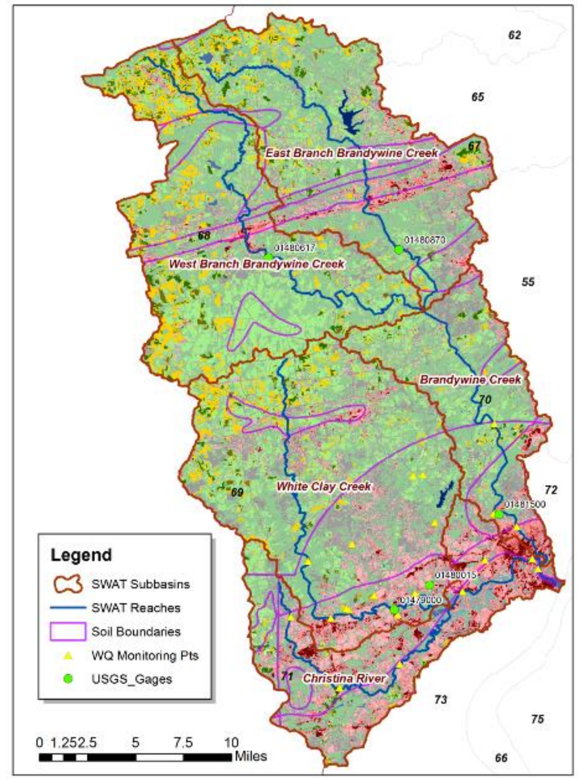
Farm type
Crops or pasture
Mushroom
Wooded
Impaired in farms
Watershed
Sub-basin
Focus area
Project area
Streams
Surface water intake
White Clay Creek
Upstream of
City of Newark
Drinking Water Intake
Showing Farmland
and Associated
Impaired Stream Segments
0 1 2 4
Kilometers
1 0.5 0 1 2
Miles
N
City of Newark Intake
Map produced by the University of Delaware Water Resources Center, Nov. 2016.



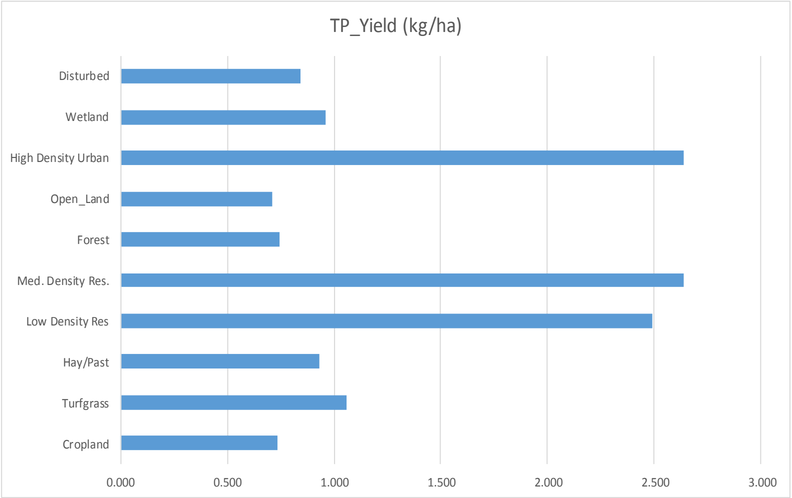
Find a reach
Red Clay Creek (ID: 4651930)
Reach/Catchment Info
Model Source Inputs
Predicted Values
Graphs
Sources
Municipal Point Source
Atmospheric TIN
Manure
Fertilizer Other
Fertilizer Corn Soy
Fixation Alfalfa Soy
Developed Land
Total Load by Source (kg year^{-1})
150000
100000
50000
0
Share of Total Nitrogen Load by Source
7.1%
0%
4.9%
10.4%
7.5%
2.9%
67.3%
5 mi.
5 km.
SPA

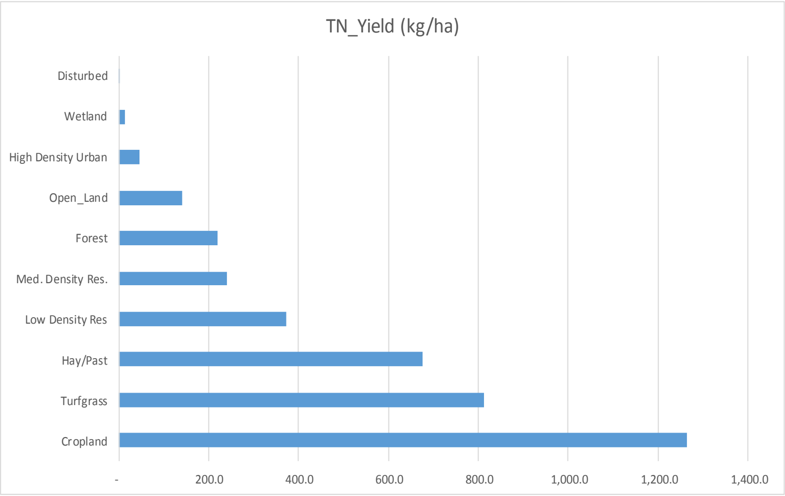


- MapShed

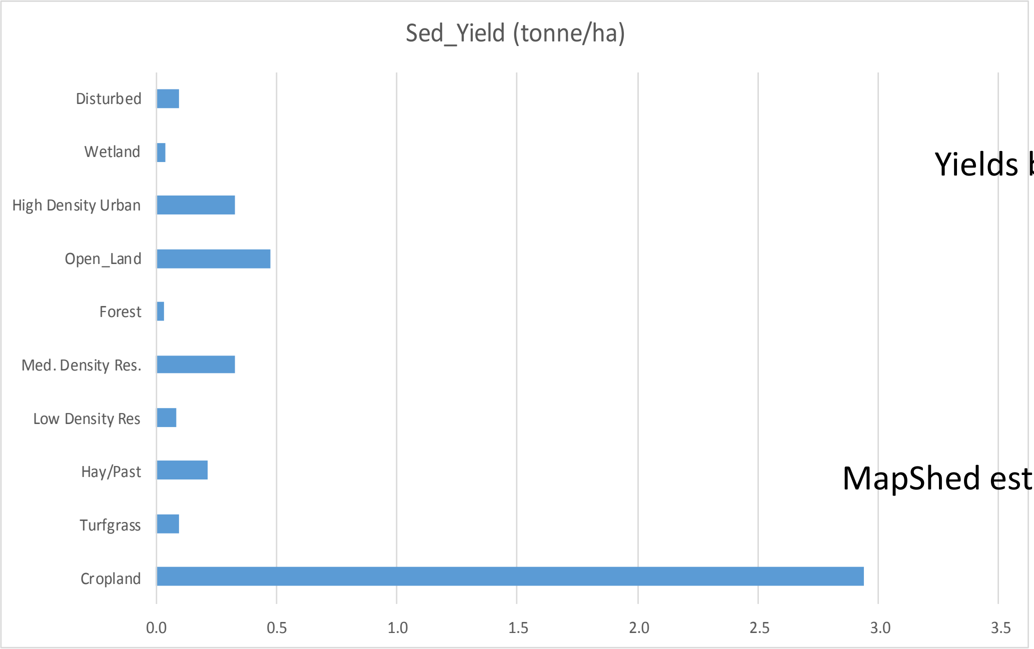


- SWAT (Soil and Water Assessment Tool)





Sources



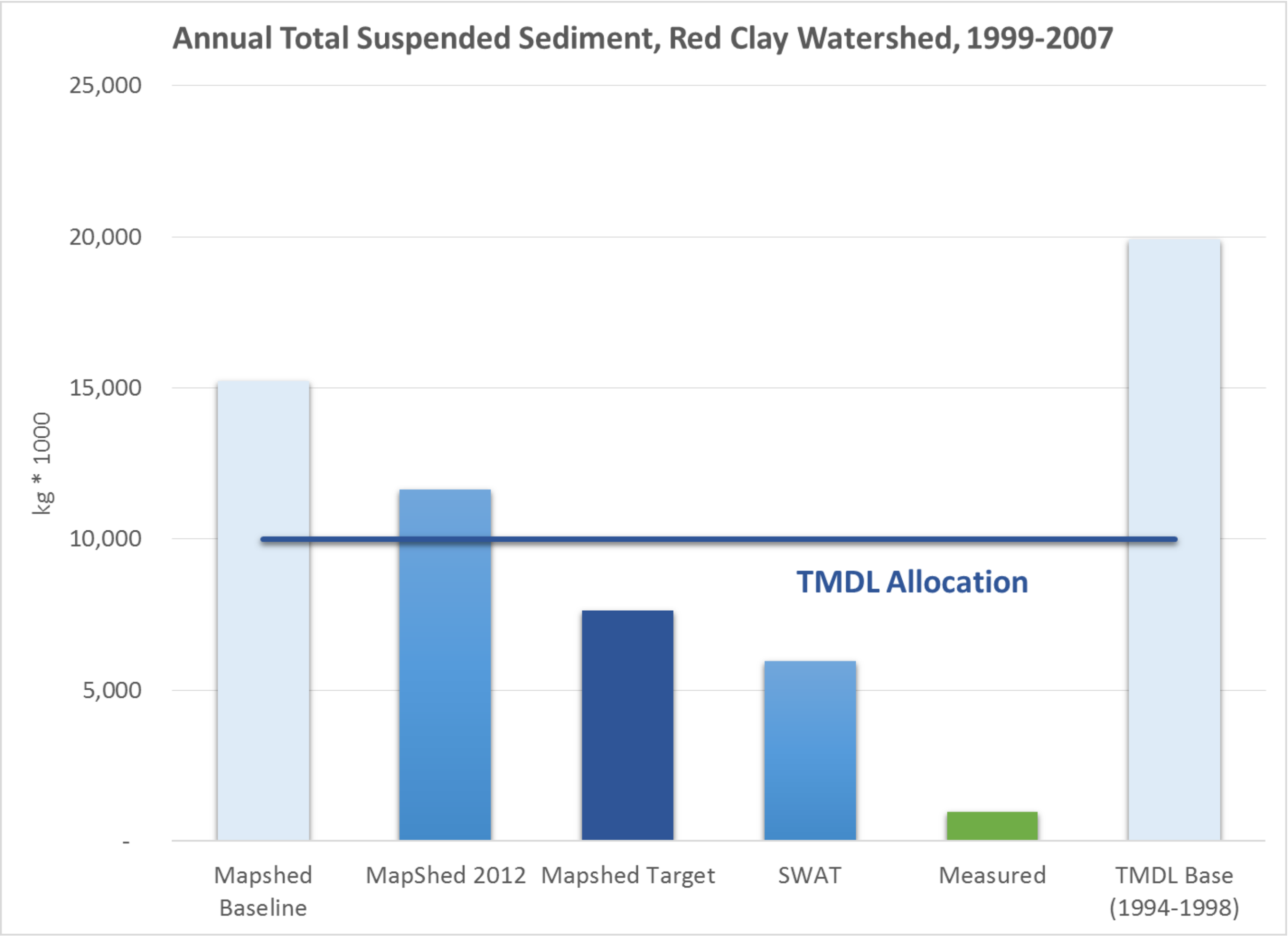
Yields by Land Cover

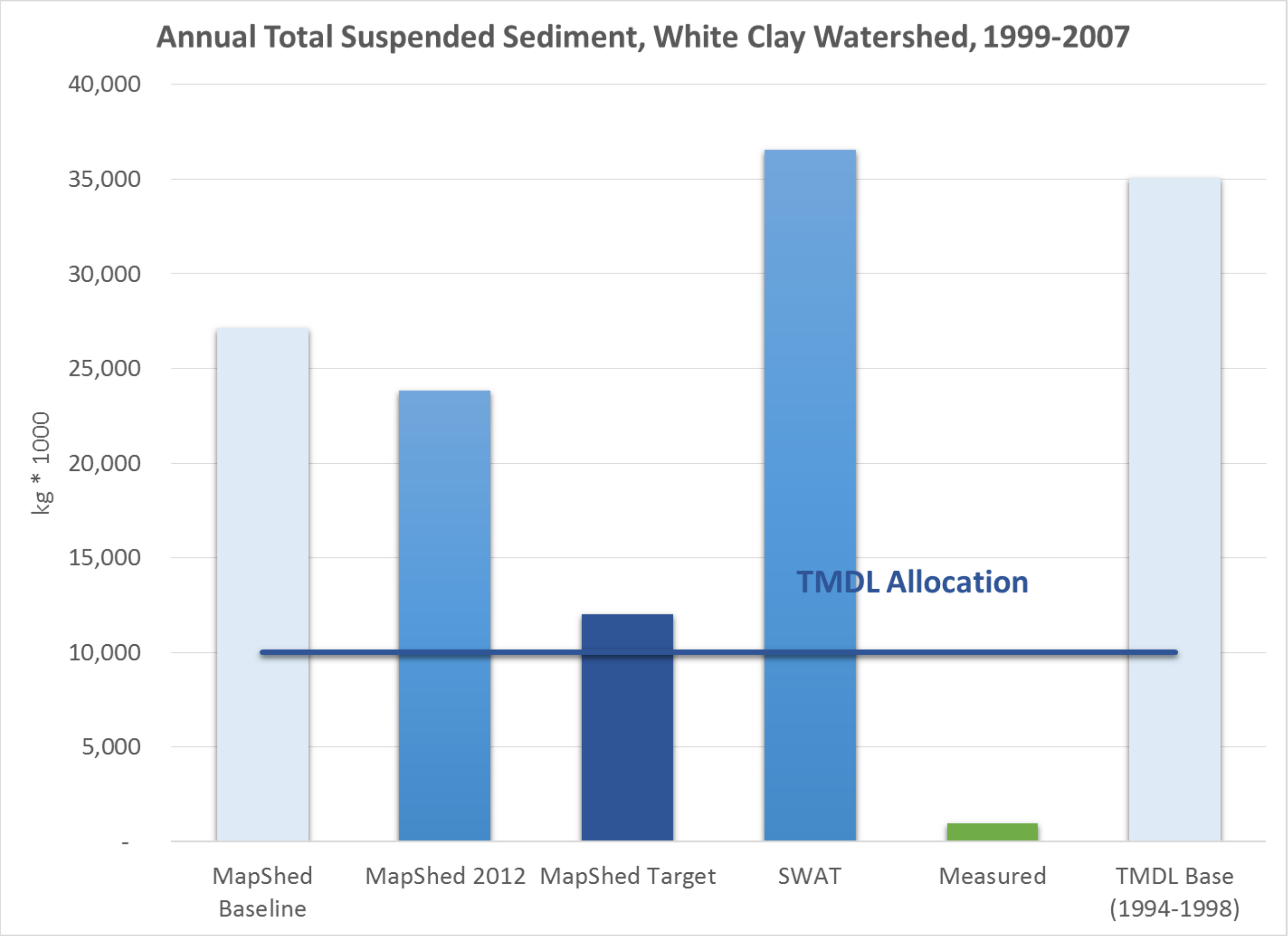
MapShed estimates

MapShed BMPs

Type	unit	UnitCostLow	UnitCostHi
Cover crops	ha	$ 86.49	$ 128.49
Conservation Tillage	ha	$ 6.72	$ 98.84
Nutrient management	ha	$ 7.41	$ 24.71
Riparian forest buffer	km	$ 40.36	$ 371.89
Animal fencing	km	$ 2,405.11	$ 2,405.11

- Riparian buffers
- Stream fencing


Annual Total Suspended Sediment, Red Clay Watershed, 1999-2007
25,000
20,000
15,000
10,000
5,000
-
kg * 1000
TMDL Allocation
Mapshed Baseline
MapShed 2012
Mapshed Target
SWAT
Measured
TMDL Base (1994-1998)



Annual Total Suspended Sediment, White Clay Watershed, 1999-2007
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
-
kg * 1000
TMDL Allocation
MapShed Baseline
MapShed 2012
MapShed Target
SWAT
Measured
TMDL Base (1994-1998)

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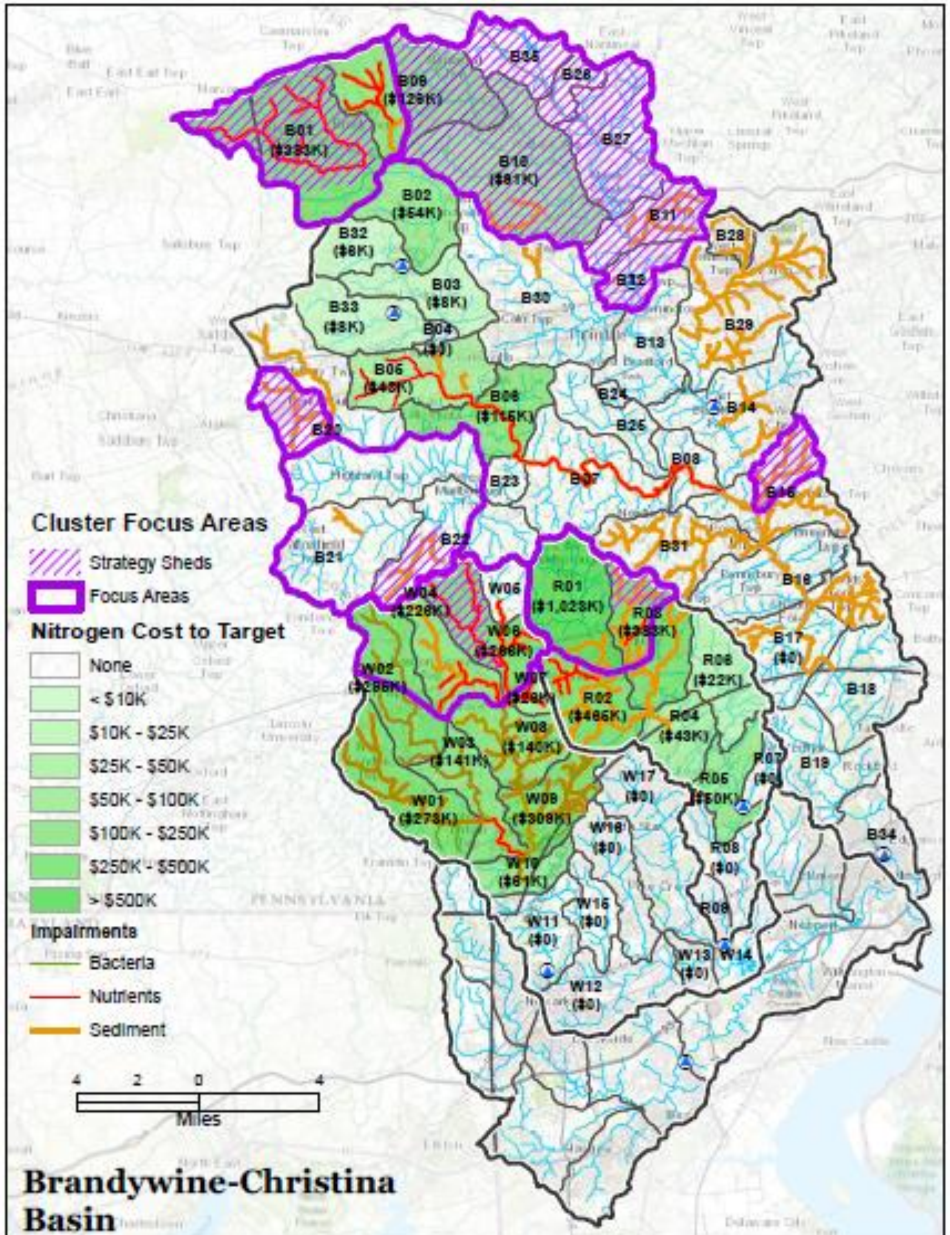
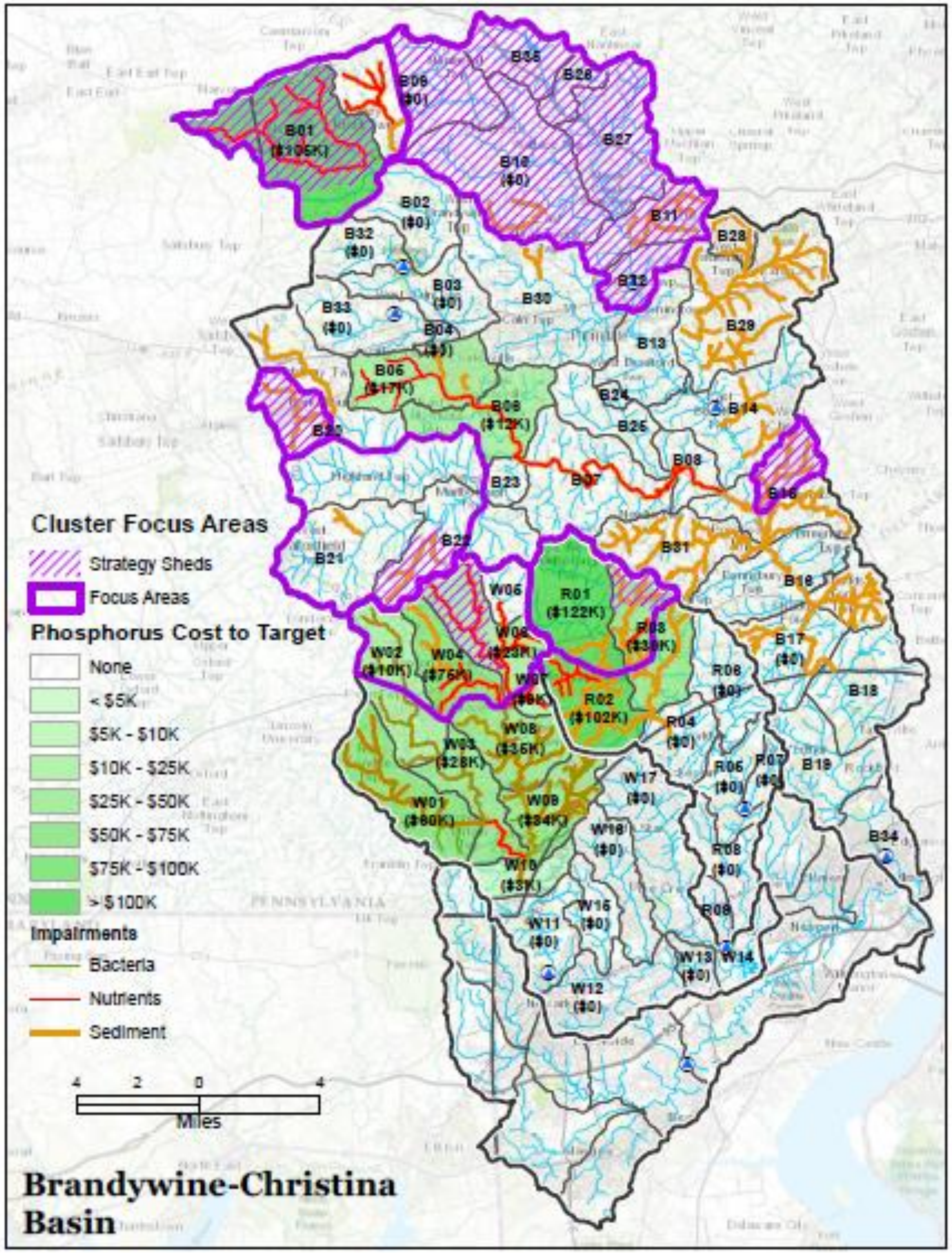
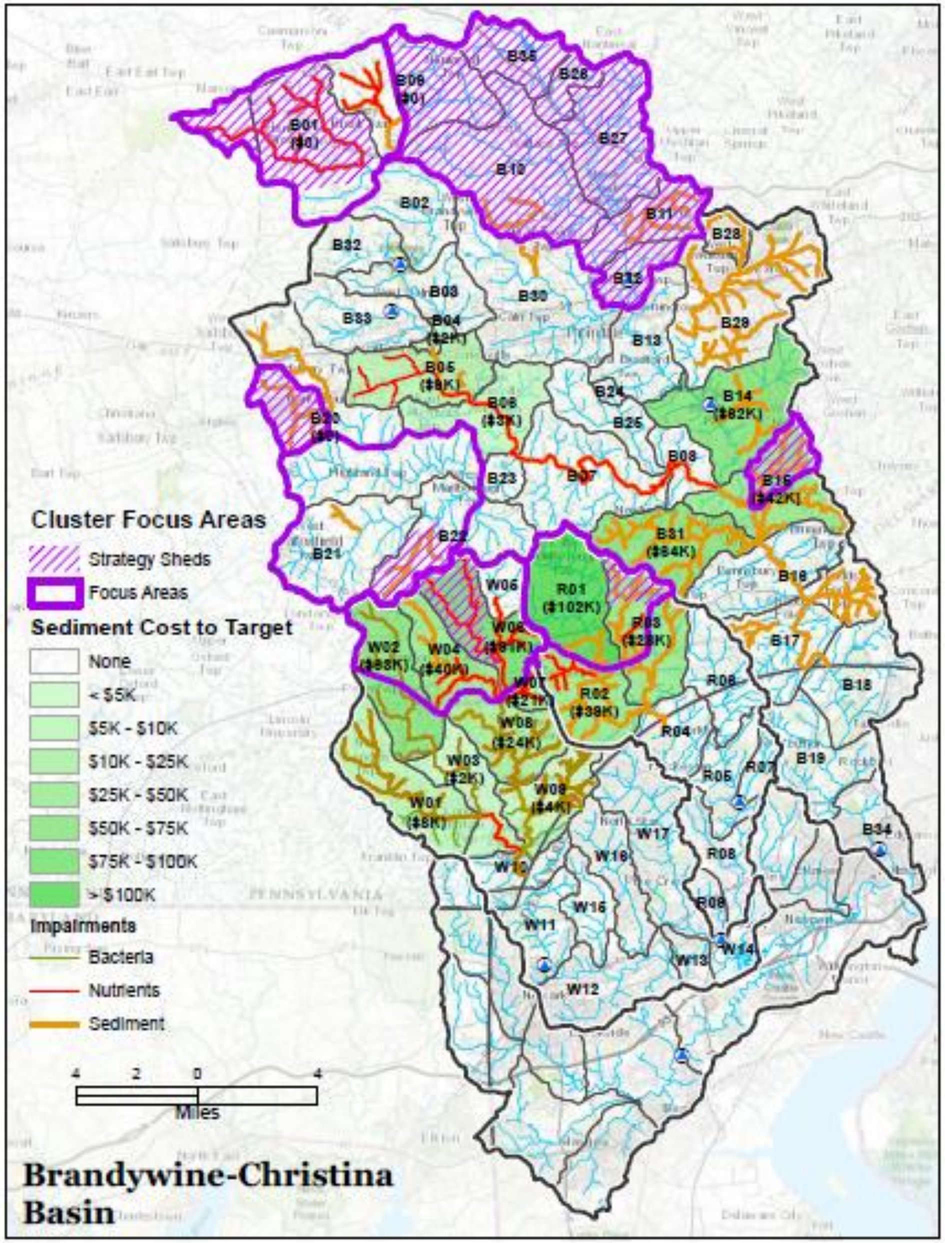




Cluster Focus Areas
Strategy Sheds
Focus Areas
Phosphorus Cost to Target
None
< $5K
$5K - $10K
$10K - $25K
$25K - $50K
$50K - $75K
$75K - $100K
> $100K
Impairments
Bacteria
Nutrients
Sediment
4 2 0 4
Miles
Brandywine-Christina Basin



Cluster Focus Areas
Strategy Sheds
Focus Areas
Sediment Cost to Target
None
< $5K
$5K - $10K
$10K - $25K
$25K - $50K
$50K - $75K
$75K - $100K
> $100K
Impairments
Bacteria
Nutrients
Sediment
4 2 0 4
Miles
Brandywine-Christina Basin

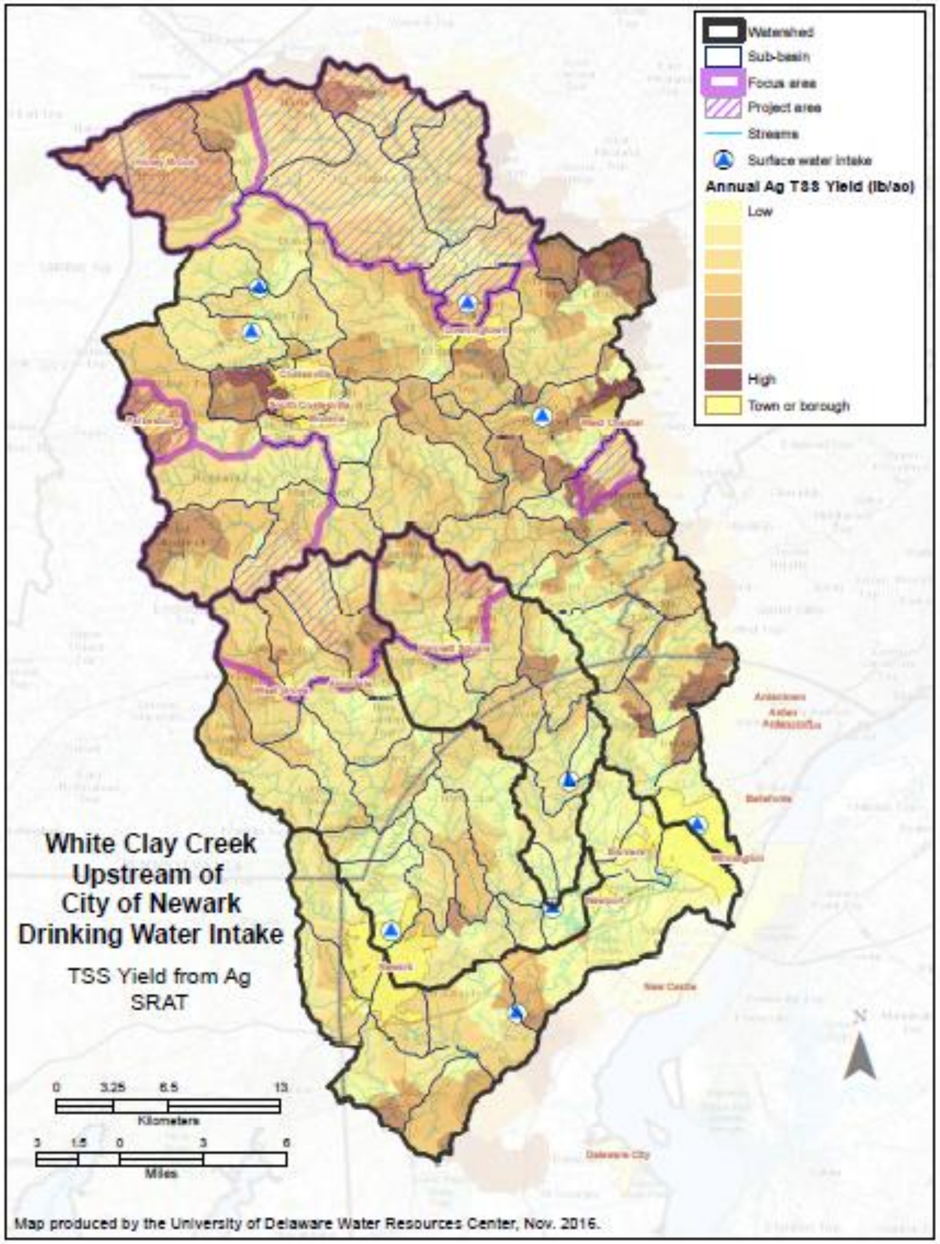
Red Clay Creek			
Constituent	Target reduction	Unit	Cost to target
Nitrogen	$ 88,657	kg	$ 1,995,017
Phosphorus	$ 5,223	kg	$ 254,247
Sediment	$ 1,658	tonne	$ 169,388
			$ 2,418,652

White Clay Creek			
Constituent	Target reduction	Unit	Cost to target
Nitrogen	$ 143,953	kg	$ 1,751,112
Phosphorus	$ 5,563	kg	$ 293,896
Sediment	$ 1,807	tonne	$ 284,552
			$ 2,329,560

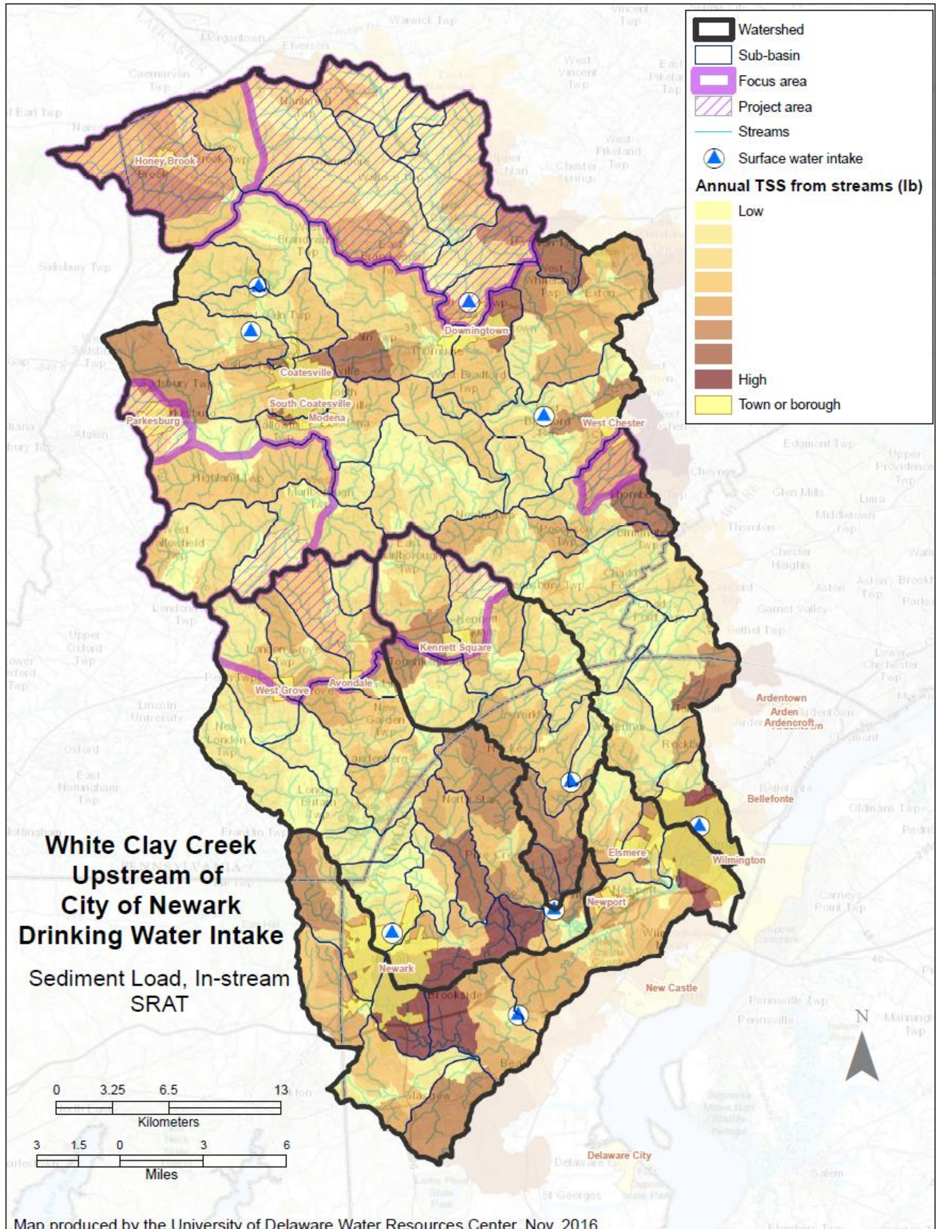
Brandywine, West Branch			
Constituent	Target reduction	Unit	Cost to target
Nitrogen	66100	kg	$ 602,699
Phosphorus	1864	kg	$ 134,377
Sediment	88	tonne	$ 12,912
			$ 749,988

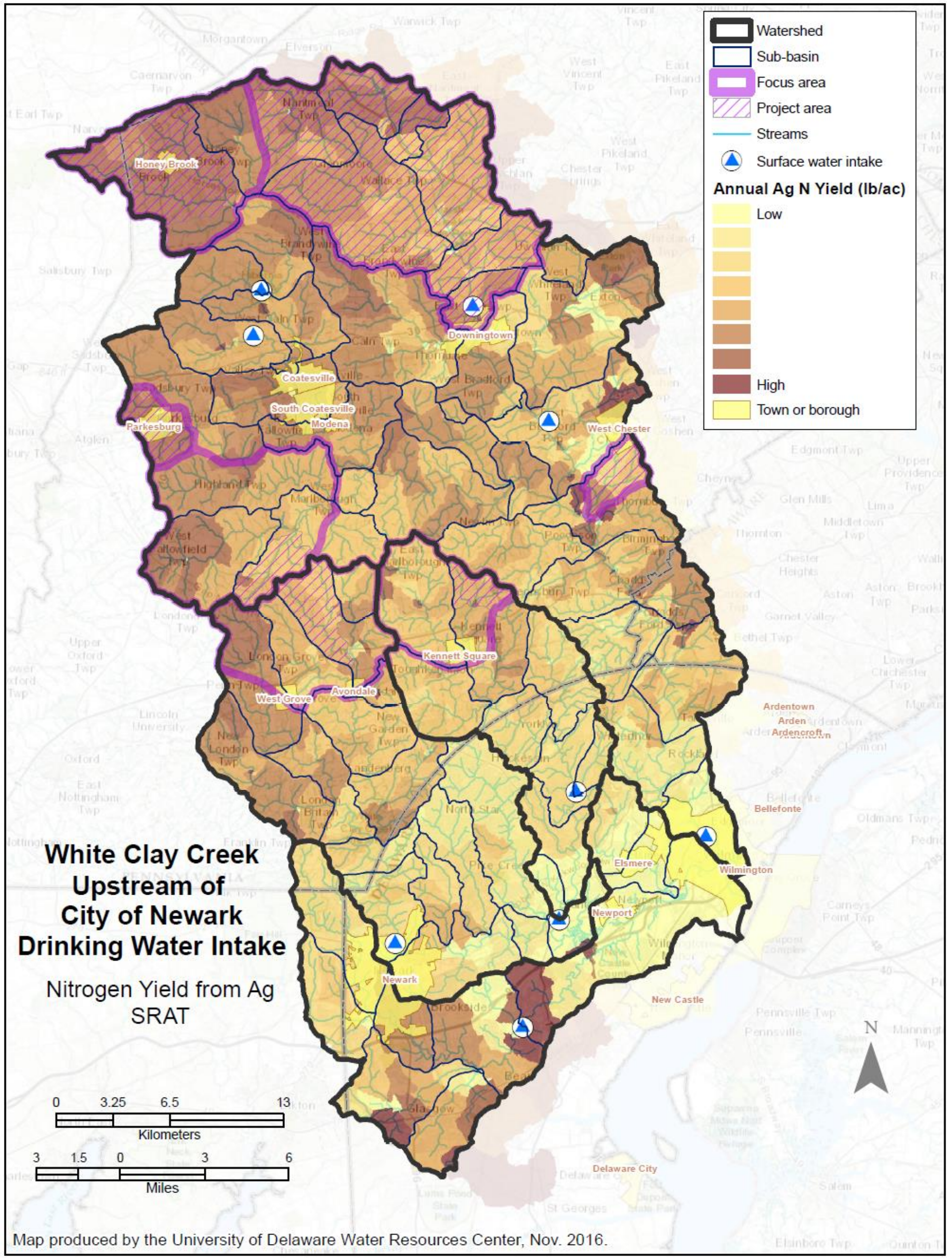
Brandywine, East Branch			
Constituent	Target reduction	Unit	Cost to target
Nitrogen	19,165	kg	$ 217,325
Phosphorus	0	kg	$ -
Sediment	567	tonne	$ 62,098
			$ 279,423

Brandywine, Main Stem			
Constituent	Target reduction	Unit	Cost to target
Nitrogen	0	kg	$ -
Phosphorus	0	kg	$ -
Sediment	619	tonne	$ 106,447
			$ 106,447


Watershed
Sub-basin
Focus area
Project area
Streams
Surface water intake
Annual Ag TSS Yield (lb/ac)
Low
High
Town or borough
White Clay Creek
Upstream of
City of Newark
Drinking Water Intake
TSS Yield from Ag
SRAT
0 3.25 6.5 13
Kilometers
3 1.5 0 3 6
Miles
Map produced by the University of Delaware Water Resources Center, Nov. 2016.

University of Delaware





Watershed
Sub-basin
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Streams
Surface water intake
Annual Ag N Yield (lb/ac)
Low
High
Town or borough
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Drinking Water Intake
Nitrogen Yield from Ag
SRAT
0 3.25 6.5 13
Kilometers
3 1.5 0 3 6
Miles
Map produced by the University of Delaware Water Resources Center, Nov. 2016.

Conclusion

- Modeling gives an objective, transparent way to prioritize project areas.
- Models can help
  - Ballpark costs for clean water.
  - Estimate the reductions for various strategies.
  - Inform (not determine) the process of picking projects the Fund will support.

Thanks to the Partnership

William Penn Foundation

Brandywine Conservancy

Brandywine Red Clay Alliance

Stroud Water Research Center

Chester County Water Resources Association, Chester County Conservation District

Natural Lands Trust, Academy of Natural Sciences of Drexel U, Open Space Institute, Partnership for the Delaware Estuary