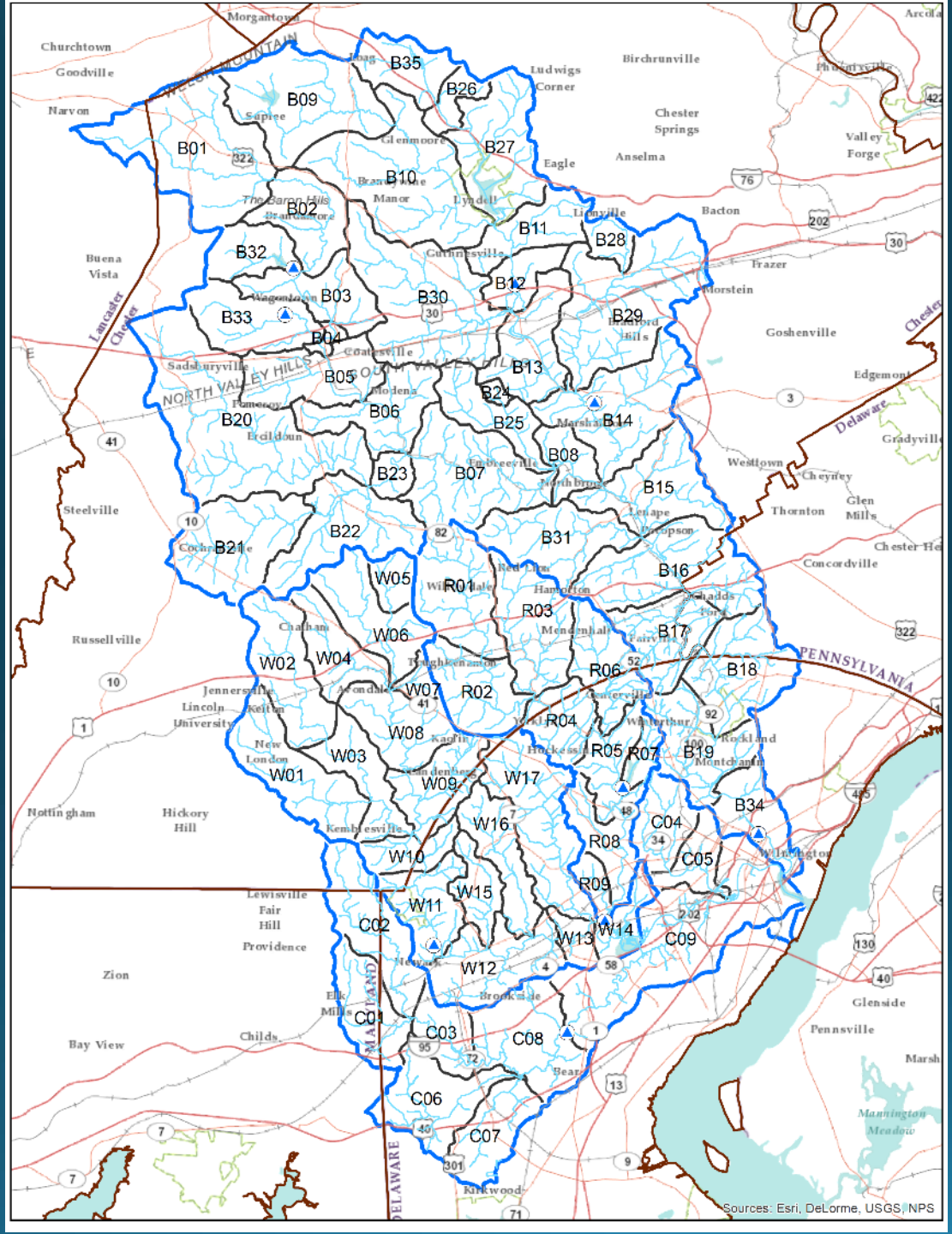
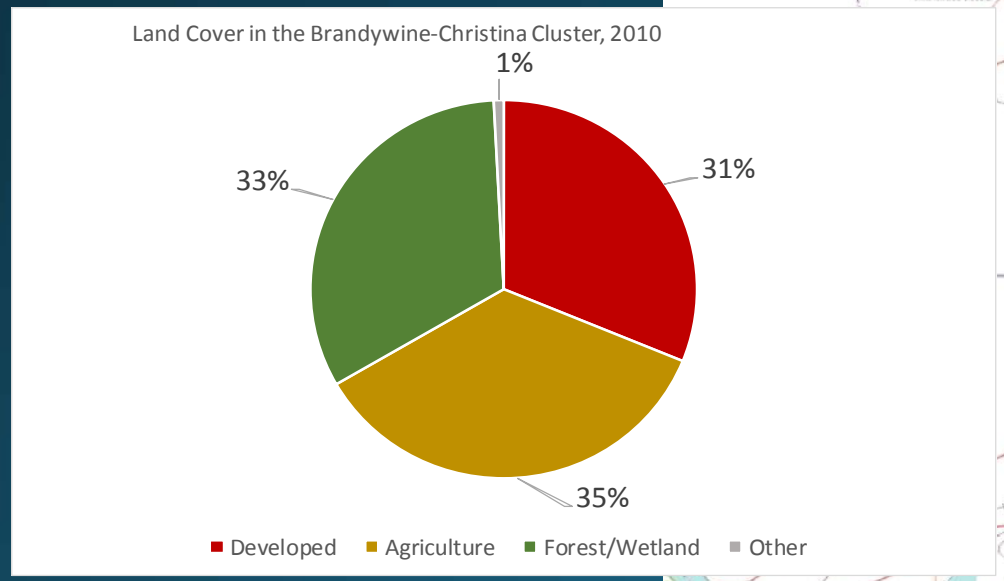
Brandywine-Christina Healthy Water Fund

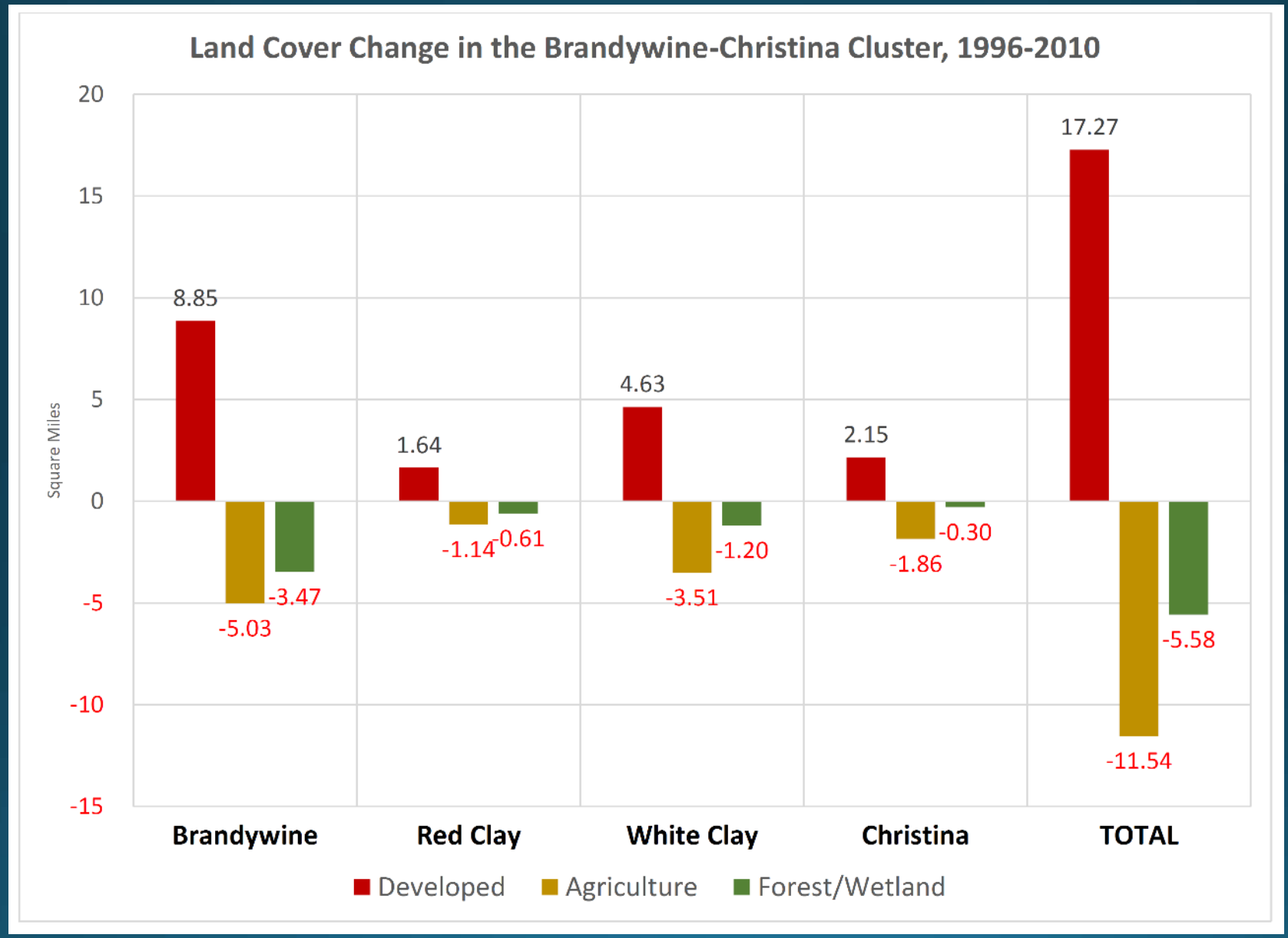
Technical Analysis Summary

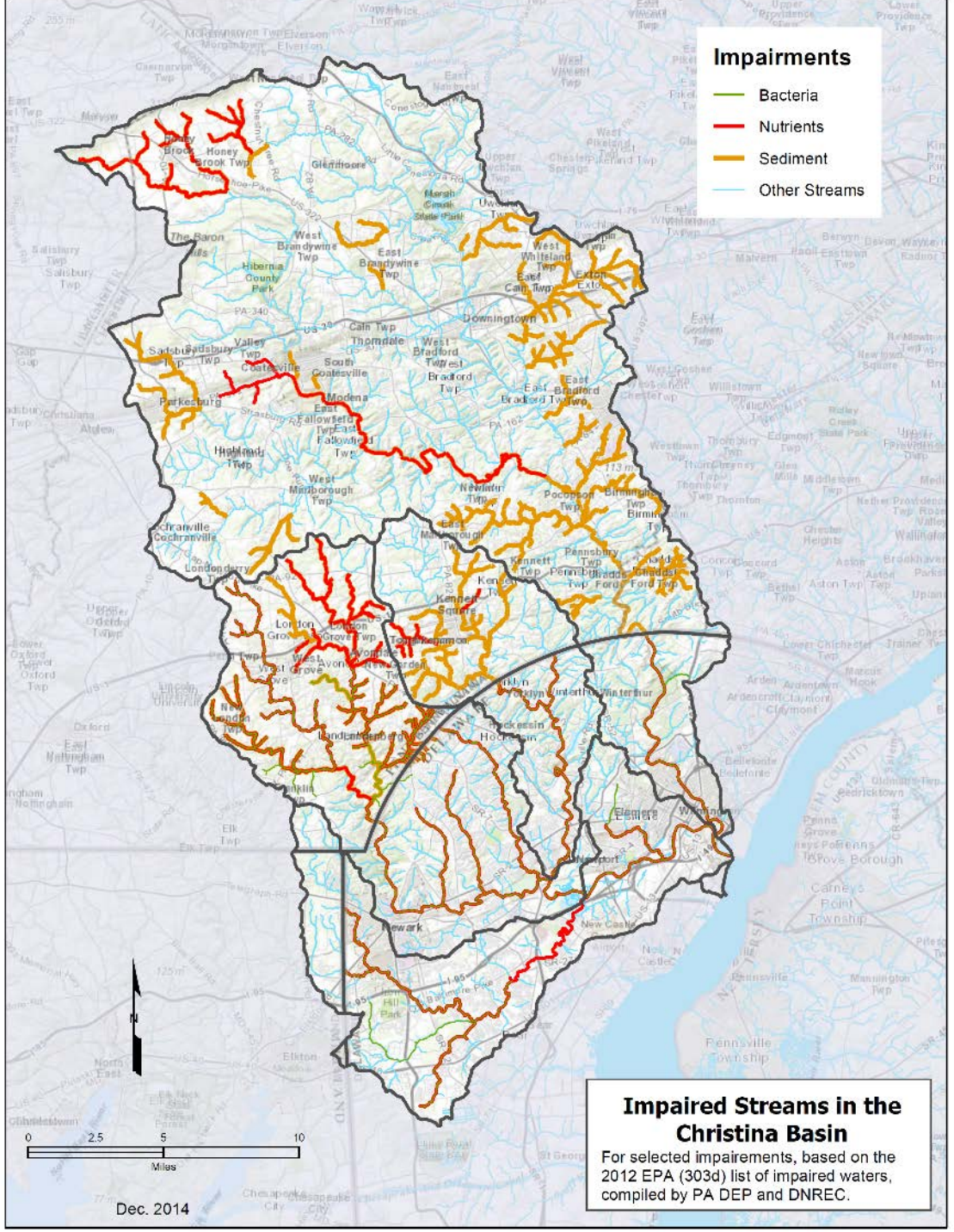
Jerry Kauffman and Andrew Homsey, University of Delaware Water Resources Center


B01
B02
B03
B04
B05
B06
B07
B08
B09
B10
B11
B12
B13
B14
B15
B16
B17
B18
B19
B20
B21
B22
B23
B24
B25
B26
B27
B28
B29
B30
B31
B32
B33
B34
B35
C01
C02
C03
C04
C05
C06
C07
C08
C09
W01
W02
W03
W04
W05
W06
W07
W08
W09
W10
W11
W12
W13
W14
W15
W16
W17
R01
R02
R03
R04
R05
R06
R07
NORTH VALLEY HILLS
Sources: Esri, DeLorme, USGS, NPS



Sources: Esri, DeLorme, USGS, NPS


Land Cover Change in the Brandywine-Christina Cluster, 1996-2010
Square Miles
20
15
10
5
0
-5
-10
-15
8.85
-5.03
-3.47
1.64
-1.14
-0.61
4.63
-3.51
-1.20
2.15
-1.86
-0.30
17.27
-11.54
-5.58
Brandywine
Red Clay
White Clay
Christina
TOTAL
Developed
Agriculture
Forest/Wetland


Impairments
Bacteria
Nutrients
Sediment
Other Streams
0
2.5
5
10
Miles
Dec. 2014
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.

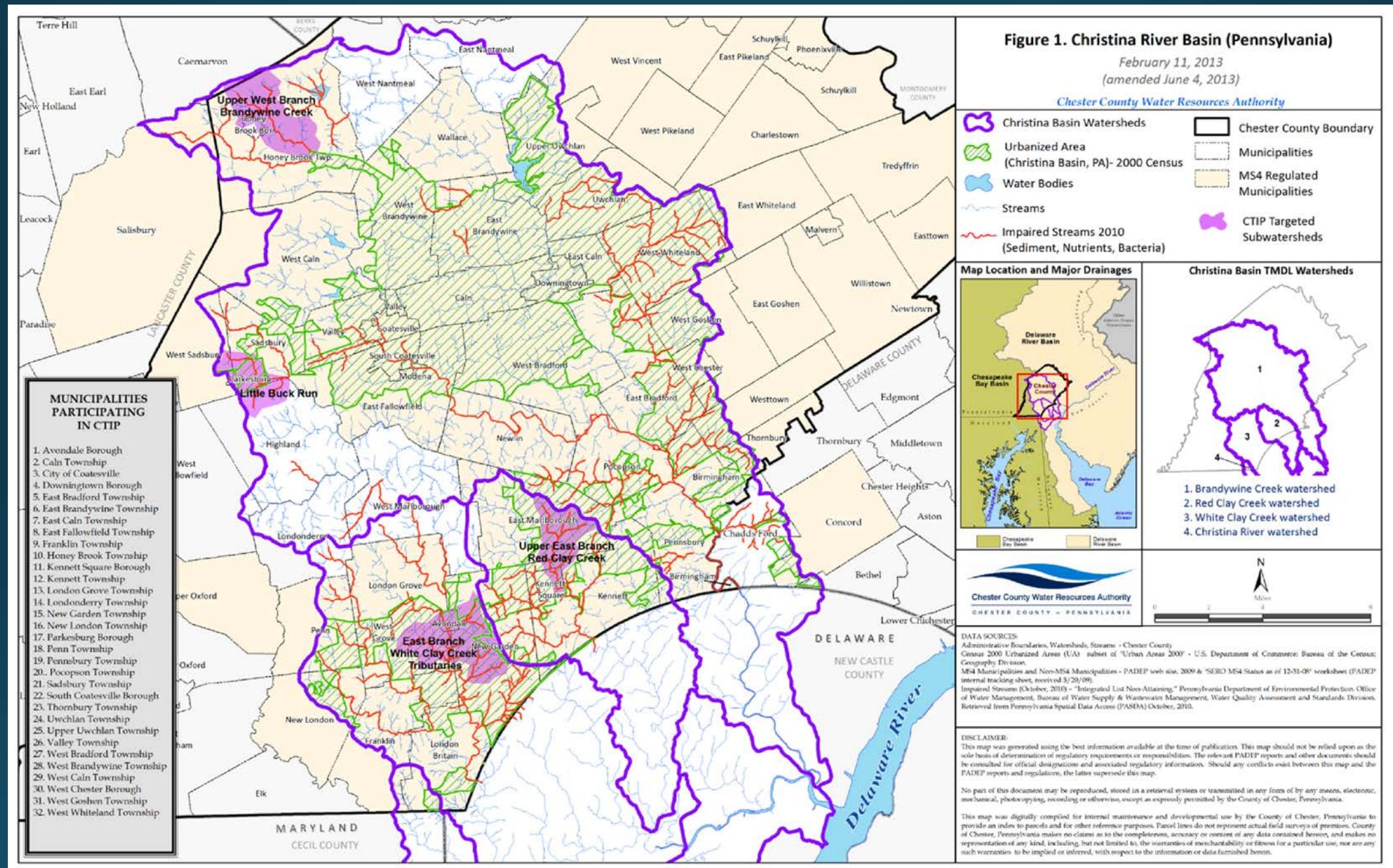


Figure 1. Christina River Basin (Pennsylvania)
February 11, 2013
(amended June 4, 2013)
Chester County Water Resources Authority
Christina Basin Watersheds
Urbanized Area (Christina Basin, PA)- 2000 Census
Water Bodies
Streams
Impaired Streams 2010 (Sediment, Nutrients, Bacteria)
Chester County Boundary
Municipalities
MS4 Regulated Municipalities
CTIP Targeted Subwatersheds
Map Location and Major Drainages
Delaware River Basin
Chesapeake Bay Basin
Christina Basin TMDL Watersheds
1. Brandywine Creek watershed
2. Red Clay Creek watershed
3. White Clay Creek watershed
4. Christina River watershed
MUNICIPALITIES PARTICIPATING IN CTIP
1. Avondale Borough
2. Caln Township
3. City of Coatesville
4. Downingtown Borough
5. East Bradford Township
6. East Brandywine Township
7. East Caln Township
8. East Fallowfield Township
9. Franklin Township
10. Honey Brook Township
11. Kennett Square Borough
12. Kennett Township
13. London Grove Township
14. Londonderry Township
15. New Garden Township
16. New London Township
17. Parkesburg Borough
18. Penn Township
19. Pennsbury Township
20.. Pocopson Township
21. Sadsbury Township
22. South Coatesville Borough
23. Thornbury Township
24. Uwchlan Township
25. Upper Uwchlan Township
26. Valley Township
27. West Bradford Township
28. West Brandywine Township
29. West Caln Township
30. West Chester Borough
31. West Goshen Township
32. West Whiteland Township
Upper West Branch Brandywine Creek
Little Buck Run
Upper East Branch Red Clay Creek
East Branch White Clay Creek Tributaries
Chester County Water Resources Authority
CHESTER COUNTY ~ PENNSYLVANIA
DATA SOURCES:
Administrative Boundaries, Watersheds, Streams - Chester County
Census 2000 Urbanized Areas (UA) subset of "Urban Areas 2000" - U.S. Department of Commerce; Bureau of the Census; Geography Division.
MS4 Municipalities and Non-MS4 Municipalities - PADEP web site, 2009 & "SERO MS4 Status as of 12-31-08" worksheet (PADEP internal tracking sheet, received 5/20/09).
Impaired Streams (October, 2010) - "Integrated List Non-Attaining," Pennsylvania Department of Environmental Protection, Office of Water Management, Bureau of Water Supply & Wastewater Management, Water Quality Assessment and Standards Division. Retrieved from Pennsylvania Spatial Data Access (PASDA) October, 2010.
DISCLAIMER:
This map was generated using the best information available at the time of publication. This map should not be relied upon as the sole basis of determination of regulatory requirements or responsibilities. The relevant PADEP reports and other documents should be consulted for official designations and associated regulatory information. Should any conflicts exist between this map and the PADEP reports and regulations, the latter supersede this map.
No part of this document may be reproduced, stored in a retrieval system or transmitted in any form of by any means, electronic, mechanical, photocopying, recording or otherwise, except as expressly permitted by the County of Chester, Pennsylvania.
This map was digitally compiled for internal maintenance and developmental use by the County of Chester, Pennsylvania to provide an index to parcels and for other reference purposes. Parcel lines do not represent actual field surveys of premises. County of Chester, Pennsylvania makes no claims as to the completeness, accuracy or content of any data contained hereon, and makes no representation of any kind, including, but not limited to, the warranties of merchantability or fitness for a particular use, nor are any such warranties to be implied or inferred, with respect to the information or data furnished herein.
Delaware River
MARYLAND
CECIL COUNTY
DELAWARE
NEW CASTLE COUNTY
LANCASTER COUNTY
DELAWARE COUNTY

The following table specifies the goals, timeline and responsibilities for the CCCD's agricultural compliance strategy. Full implementation of the activities described in this strategy is dependent on adequate funding and staffing of CCCD and agency partners. With complete implementation of the agricultural strategy, pollutant loads should be significantly reduced for nutrients and sediment attributable to stormwater runoff from agricultural lands.

CCCD Program Year	Total Years	Assessment, Outreach & Education	% planned	% plans implemented	BMP Assessment (%)	Responsibility
2012-2013	1	Plan and BMP Assessment; "Toolkit" Replacement			50	CCCD & CTIP
2013-2015	3	Plan and BMP Assessment			100	CCCD & CTIP
2015-2017	5	Priority Farms/Operations	15	15		CCCD & CTIP
2017-2021	9	Priority Farms/Operations	30	30		CCCD & CTIP
2021-2024	12	Priority Farms/Operations	45	40		CCCD & CTIP
2024-2027	15	All Farms	60	55		CCCD & CTIP
2027-2030	18	All Farms	80	70		CCCD & CTIP
2030-2034	22	All Farms	100	80		CCCD & CTIP
2034-2037	25	All Farms		100		CCCD & CTIP

C-TIP TMDL implementation plan (Gaadt Perspectives, CCWRA, CCCD)

	Potential General Priority Contaminant Sources	
Priority Contaminant or Contaminant Group	**Dry Weather**	**Wet Weather**
Flow*	Wastewater discharges & groundwater withdrawals	Urban/Suburban Stormwater Runoff
Pathogens	Wastewater & sediment regrowth/release	Agriculture, wildlife, sediment resuspension, suburban runoff
Disinfection By Products	Wastewater	Trees, agriculture, urban/suburban stormwater runoff
Algae	Wastewater	Agriculture
Chlorides	Wastewater	Road Salt Runoff
Turbidity	Construction & accidents	Urban/Suburban Stormwater Runoff & Agriculture
Alkalinity	Groundwater	Urban/Suburban Stormwater Runoff
Nutrients	Wastewater	Agriculture & Urban/Suburban Stormwater Runoff
Metals	Groundwater	Urban/Suburban Stormwater & Road Runoff
Trace Organics (includes pharmaceuticals)	Wastewater	Agriculture & Urban/Suburban Stormwater Runoff

Wilmington Sourcewater Plan, 2010

RED Streams BLUE
A BVA PROGRAM

Streams
- Radley Run
- Plum Run
- Valley Run
- Little Buck Run
- Shamona Creek
- Upper West Branch

Watershed Stewards

Watershed Helpline

Water Quality Resources & Links

Environmental Stream Teams

MS4 Stormwater

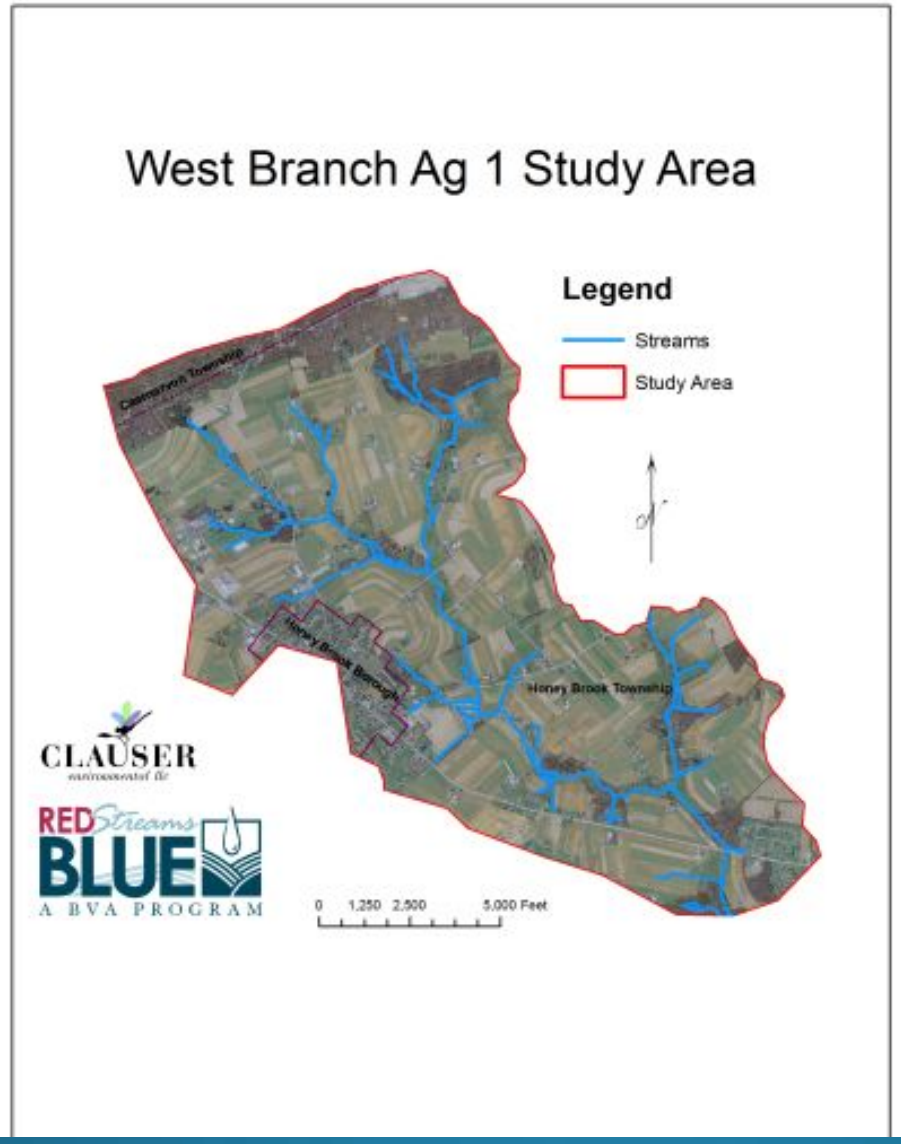
Pollution Prevention

Robert G. Struble, Jr.
Watershed Conservation Director
rstruble@bva-rcva.org

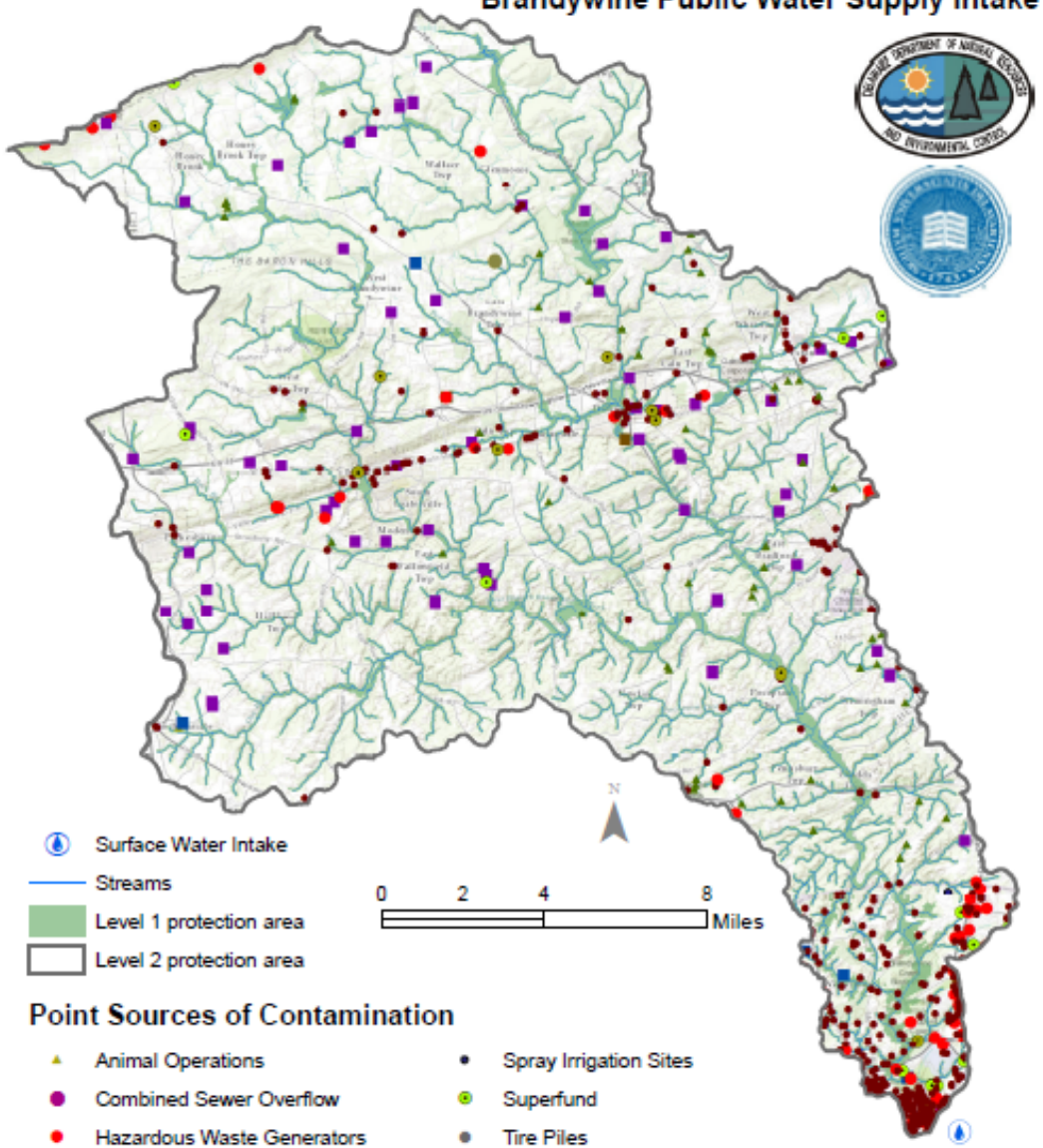
Sign up for emails about our programs!

Upper West Branch

Restoration Plan View Map



Discrete Potential Sources of Contamination
City of Wilmington
Brandywine Public Water Supply Intake

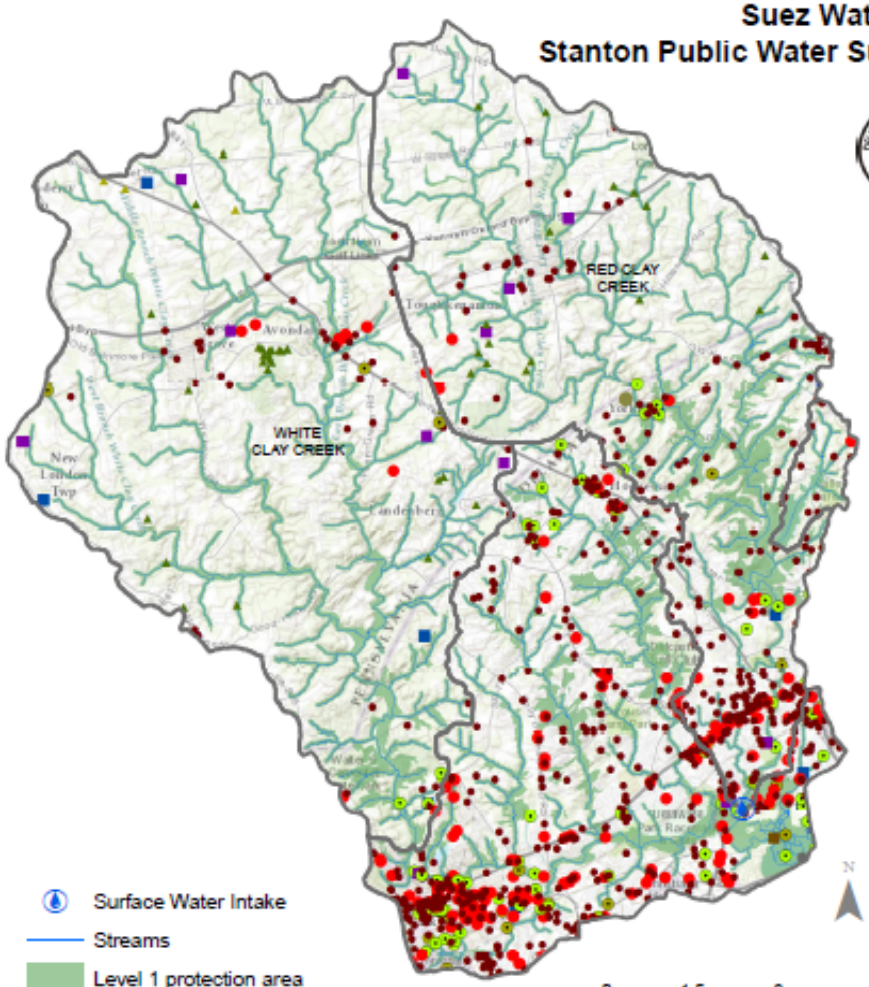


- Surface Water Intake
- Streams
- Level 1 protection area
- Level 2 protection area

Point Sources of Contamination

- Animal Operations
- Combined Sewer Overflow
- Hazardous Waste Generators
- Landfills & Dumps
- Pesticide Loading, Mixing & Storage
- Salvage Yards
- Sludge Application Sites
- Spray Irrigation Sites
- Superfund
- Tire Piles
- Toxics Release Inventory Sites
- Underground Storage Tanks
- Waste Water Outfalls

Discrete Potential Sources of Contamination
Suez Water Delaware
Stanton Public Water Supply Intake



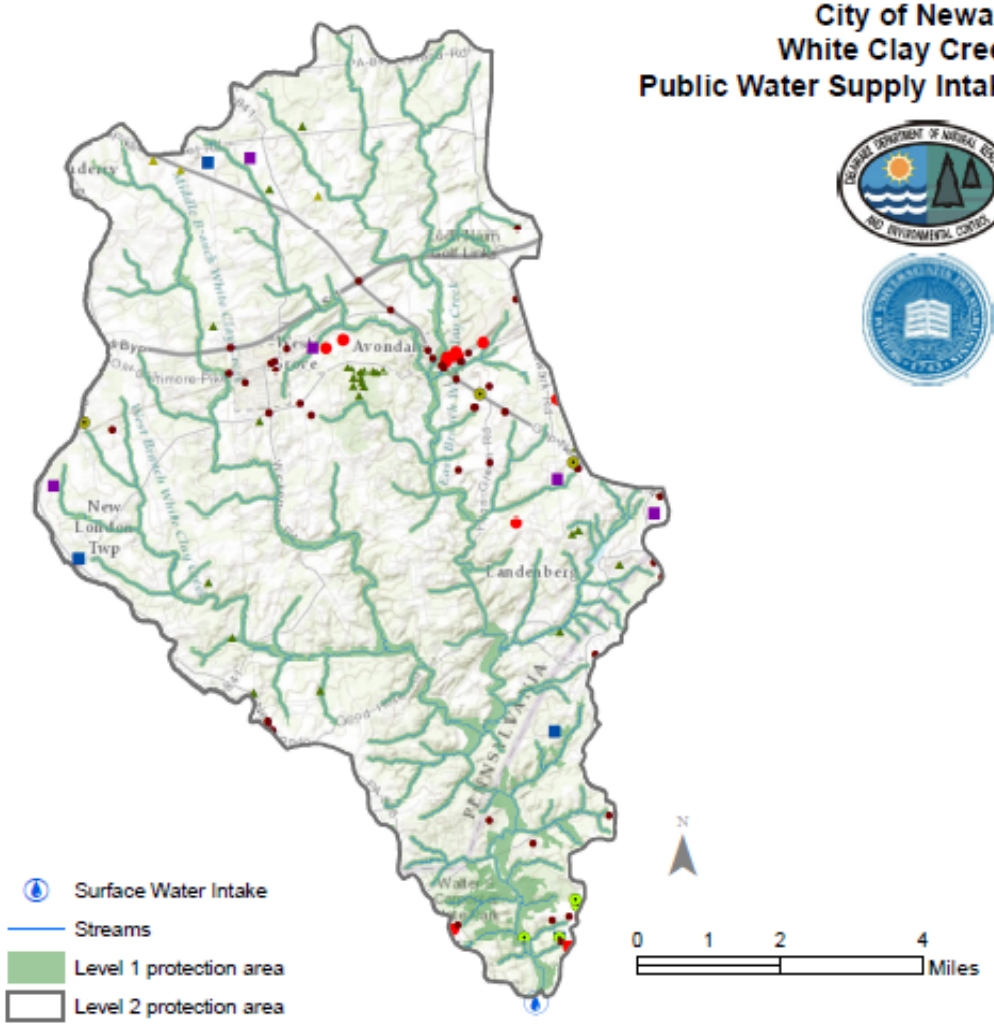
Surface Water Intake
Streams
Level 1 protection area
Level 2 protection area

0 1.5 3 6
Miles

Point Sources of Contamination

- Animal Operations
- Combined Sewer Overflow
- Hazardous Waste Generators
- Landfills & Dumps
- Pesticide Loading, Mixing & Storage
- Salvage Yards
- Sludge Application Sites
- Spray Irrigation Sites
- Superfund
- Tire Piles
- Toxics Release Inventory Sites
- Underground Storage Tanks
- Waste Water Outfalls

Discrete Potential Sources of Contamination
City of Newark
White Clay Creek
Public Water Supply Intake

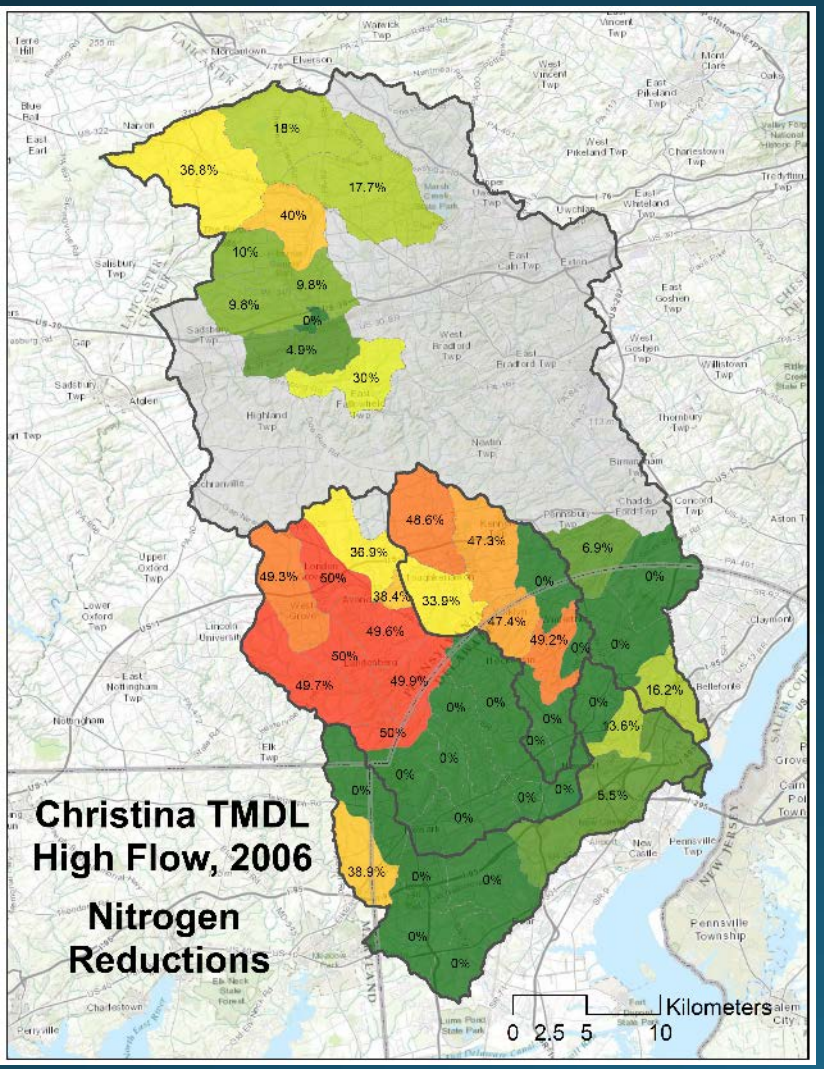


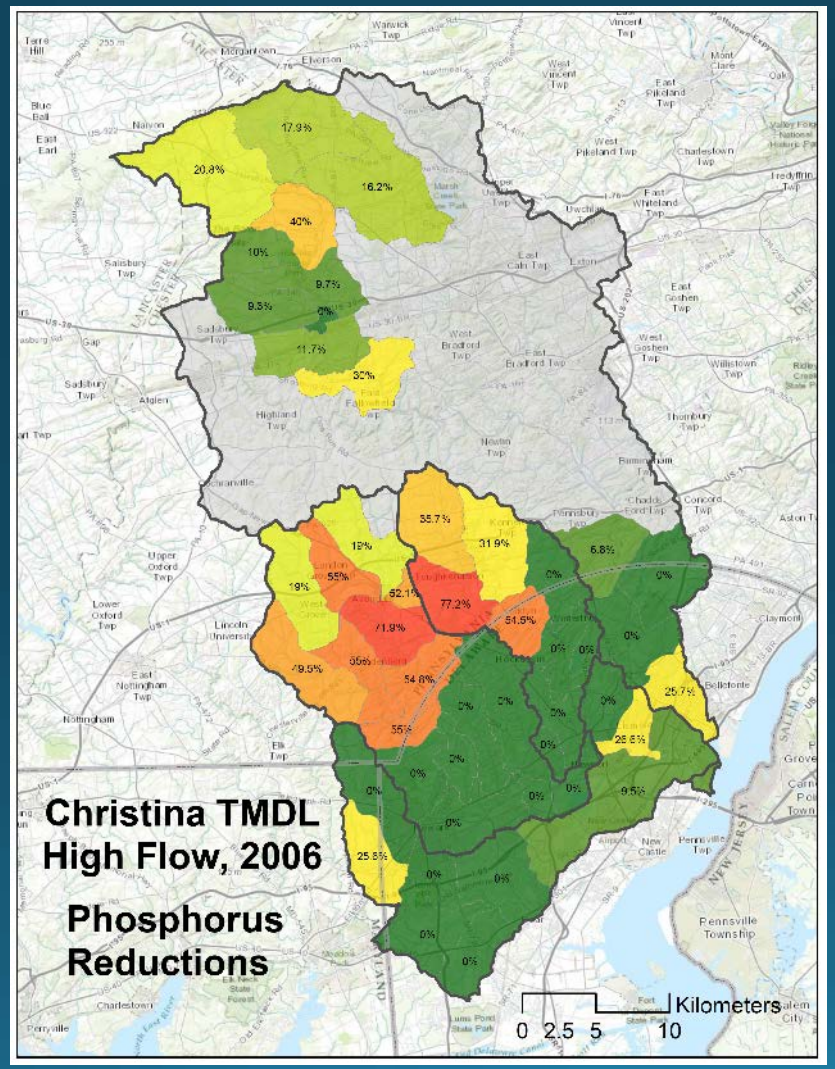
- Surface Water Intake
- Streams
- Level 1 protection area
- Level 2 protection area

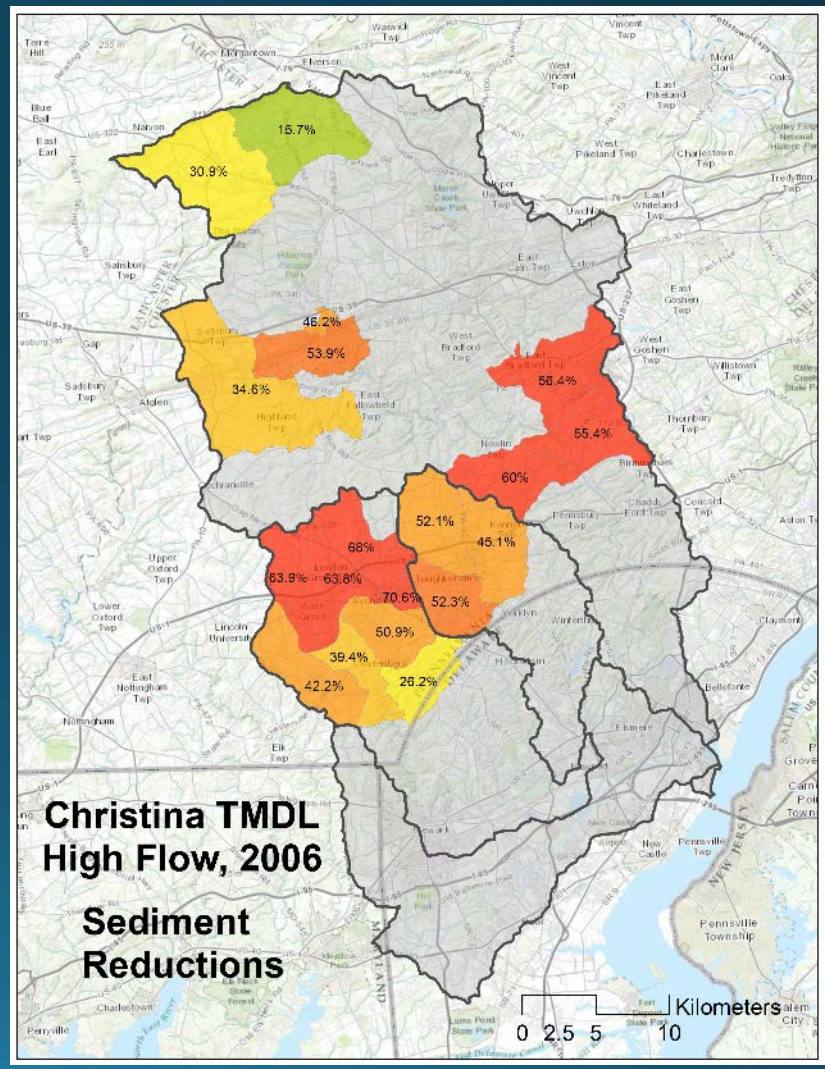
Point Sources of Contamination

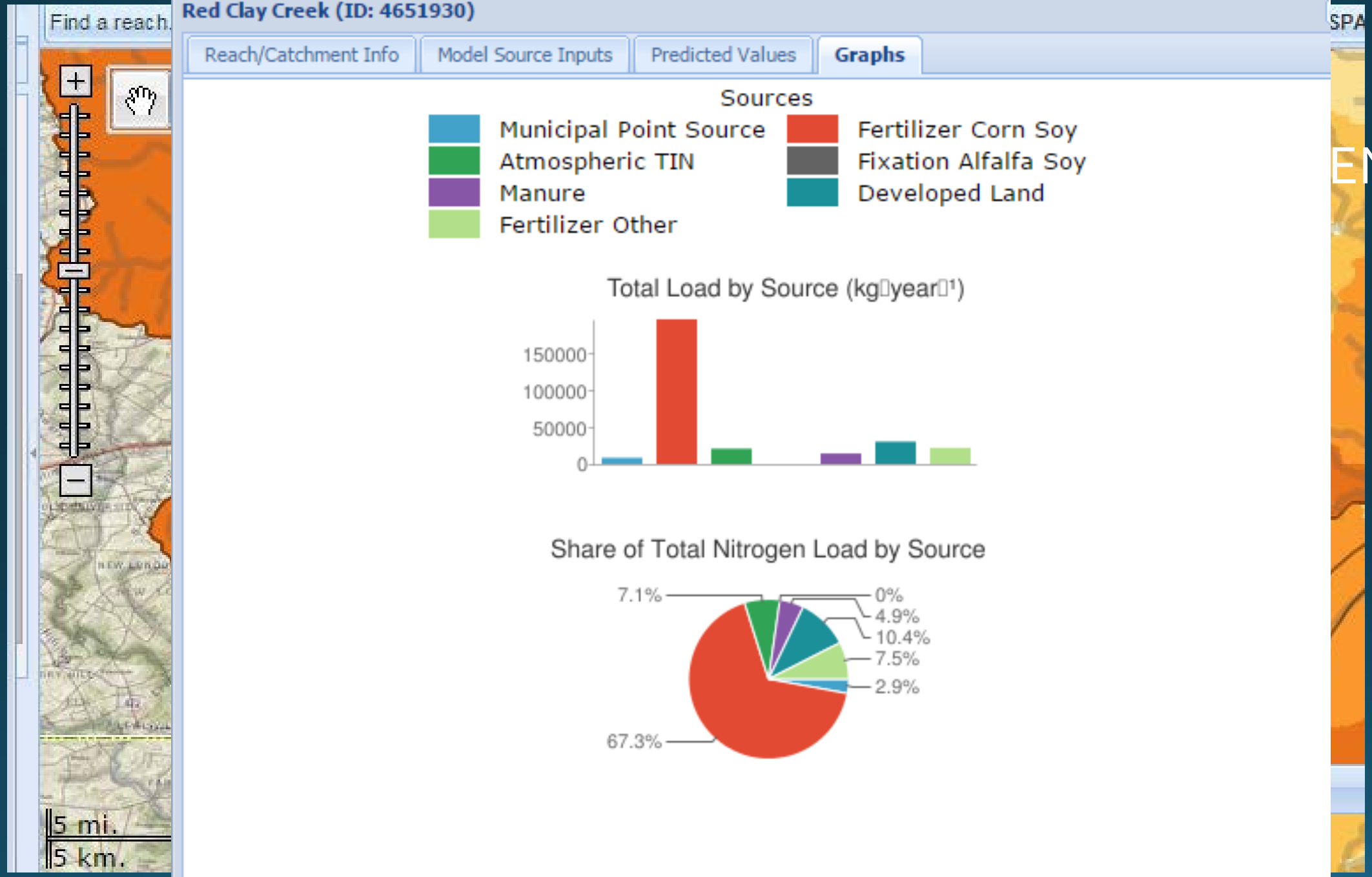
- Animal Operations
- Combined Sewer Overflow
- Hazardous Waste Generators
- Landfills & Dumps
- Pesticide Loading, Mixing & Storage
- Salvage Yards
- Sludge Application Sites
- Spray Irrigation Sites
- Superfund
- Tire Piles
- Toxics Release Inventory Sites
- Underground Storage Tanks
- Waste Water Outfalls

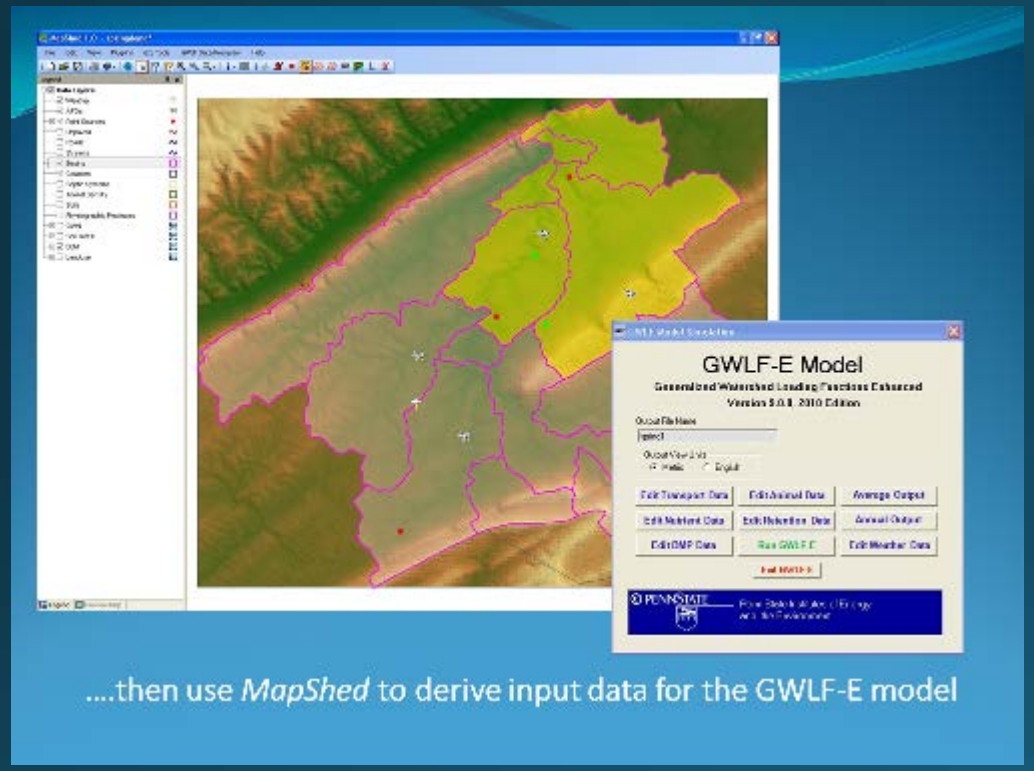
TMDL, based on HSPF (1994-1998)



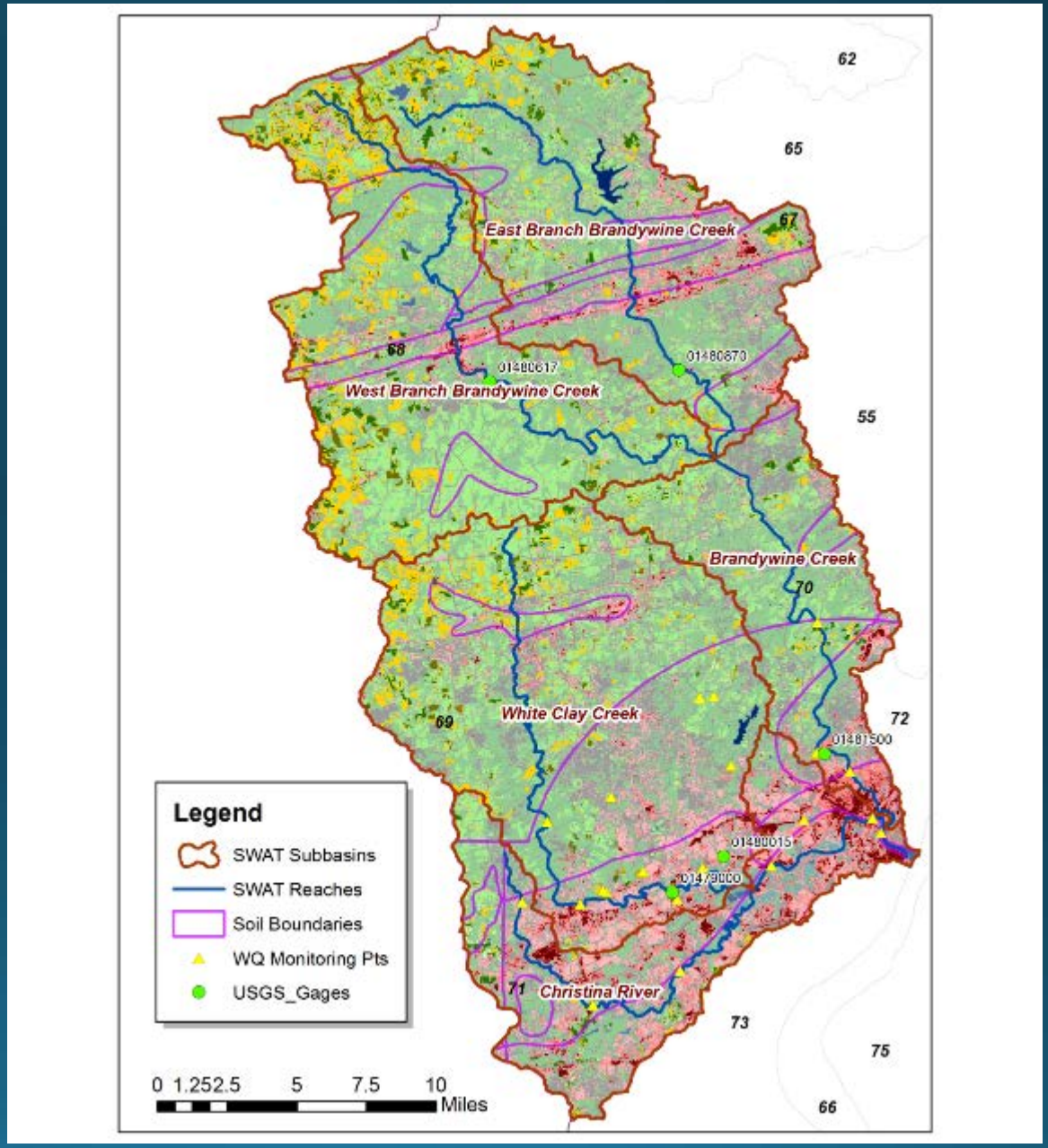





Find a reach.
Red Clay Creek (ID: 4651930)
Reach/Catchment Info
Model Source Inputs
Predicted Values
Graphs
Sources
Municipal Point Source
Atmospheric TIN
Manure
Fertilizer Other
Fertilizer Corn Soy
Fixation Alfalfa Soy
Developed Land
Total Load by Source (kg year⁻¹)
150000
100000
50000
0
Share of Total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



- MapShed analysis



- SWAT

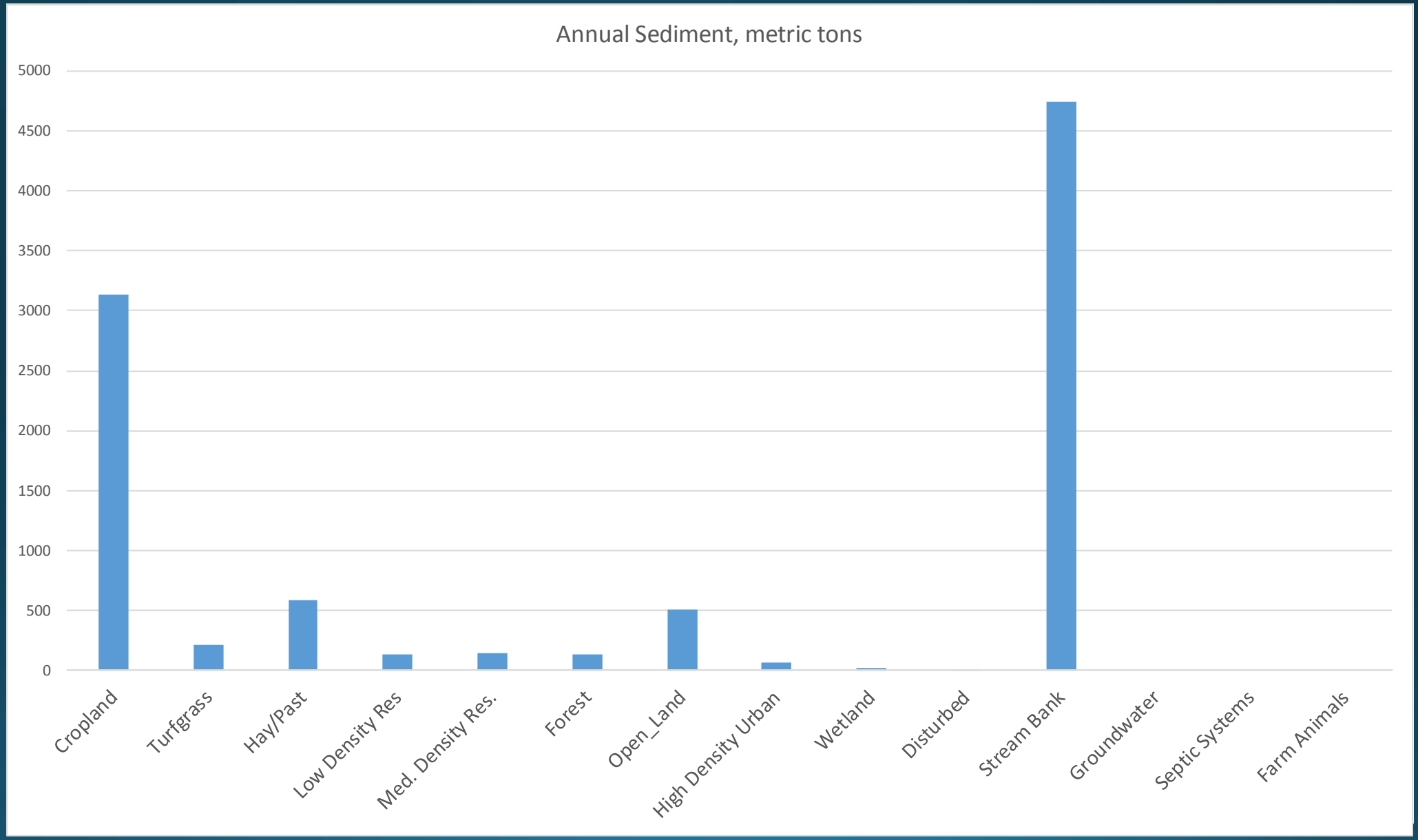
Center for Naval Analyses

MapShed BMPs

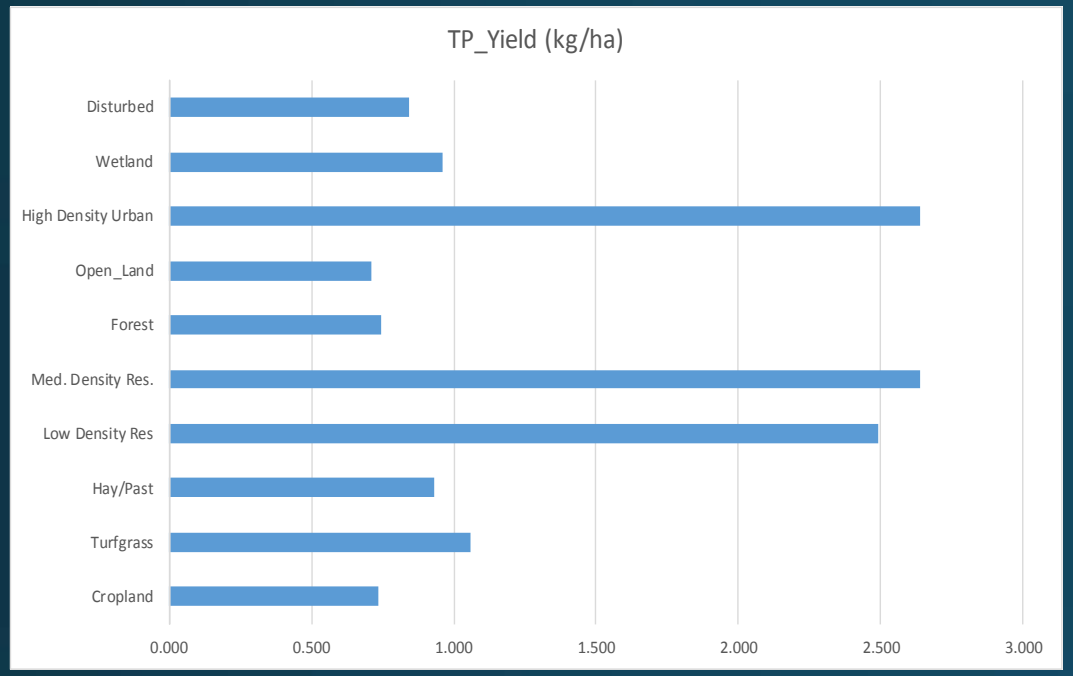
- Cover crops
- No till/Conservation tillage
- Nutrient management
- Riparian buffers
- Stream fencing

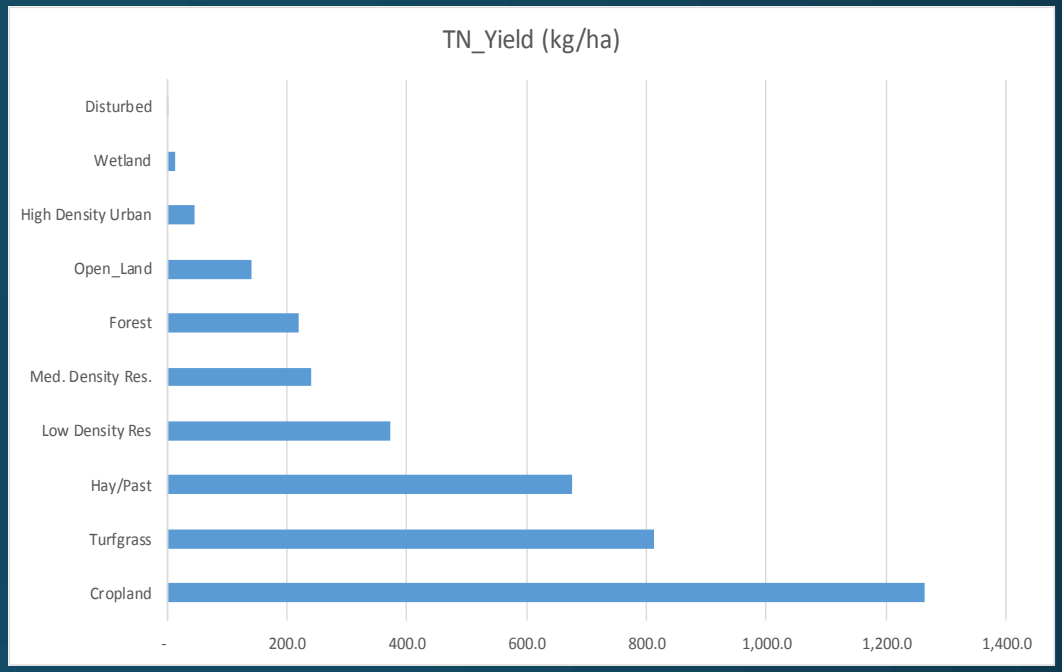
Type	unit	UnitCostLow	UnitCostHi
Cover crops	ha	$ 86.49	$ 128.49
Conservation Tillage	ha	$ 6.72	$ 98.84
Nutrient management	ha	$ 7.41	$ 24.71
Riparian forest buffer	km	$ 40.36	$ 371.89
Animal fencing	km	$ 2,405.11	$ 2,405.11

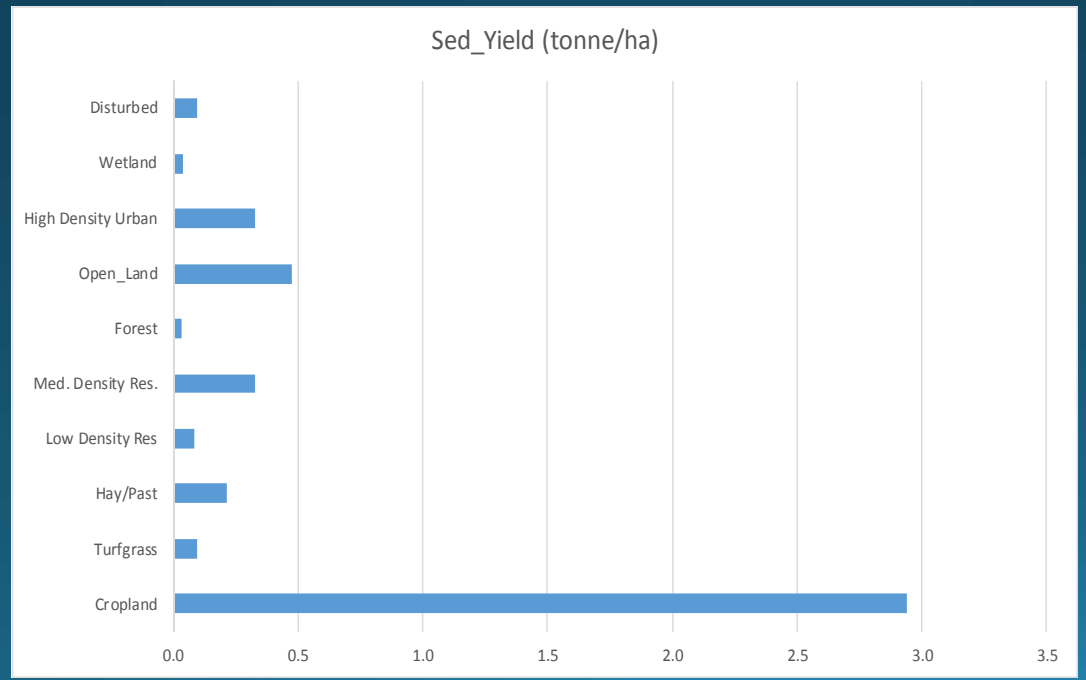
Sources



MapShed estimates



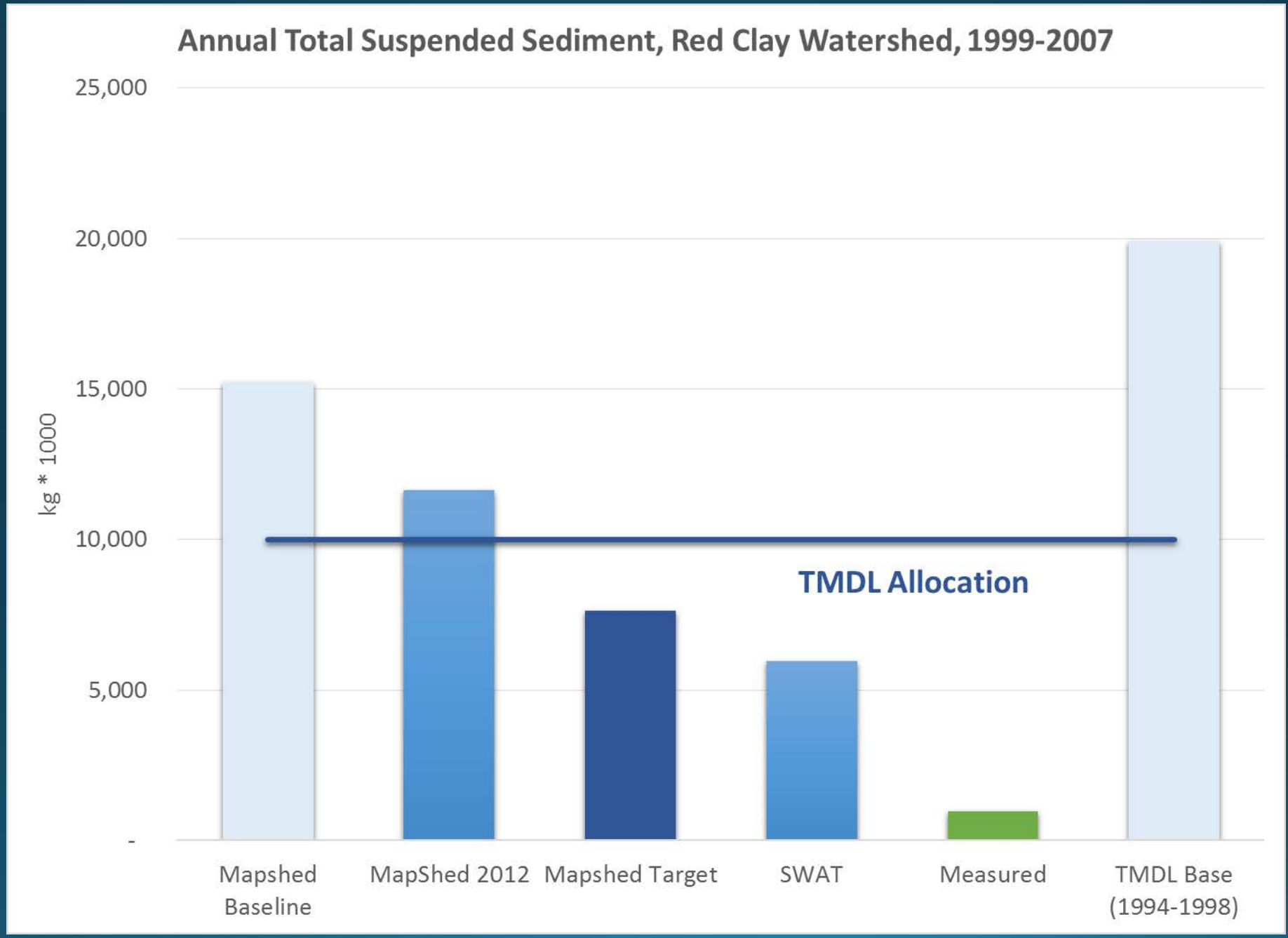


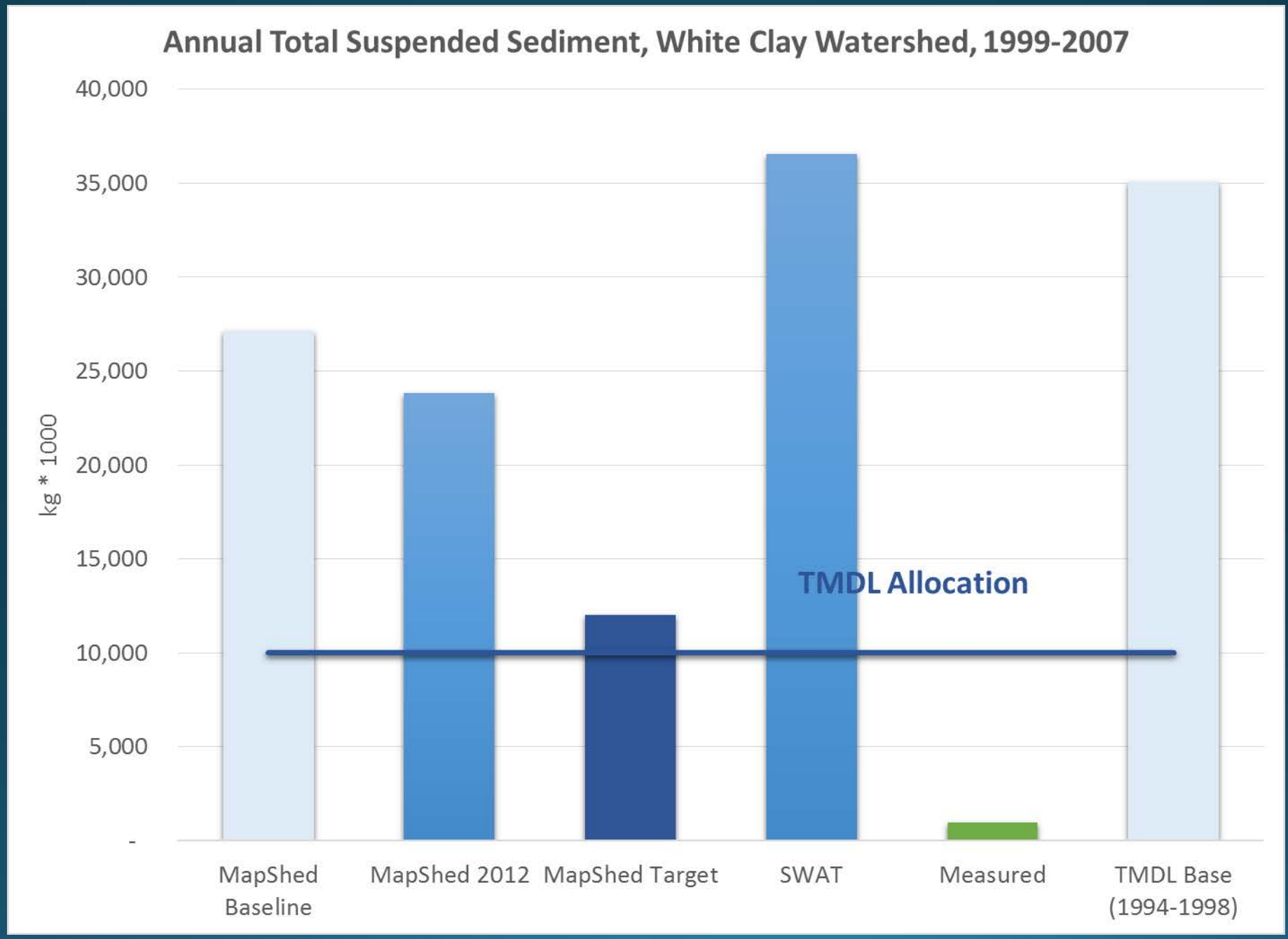


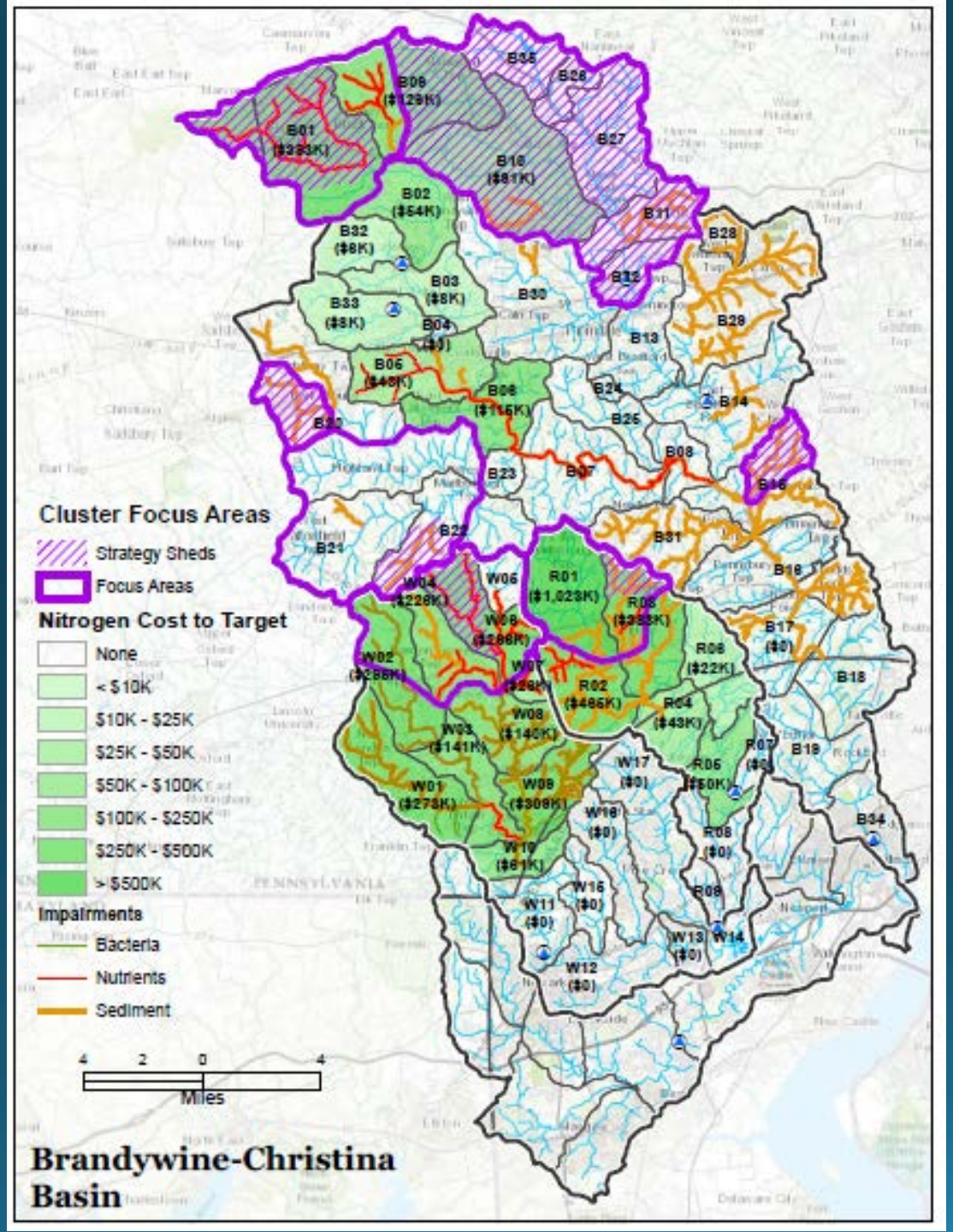
Sources

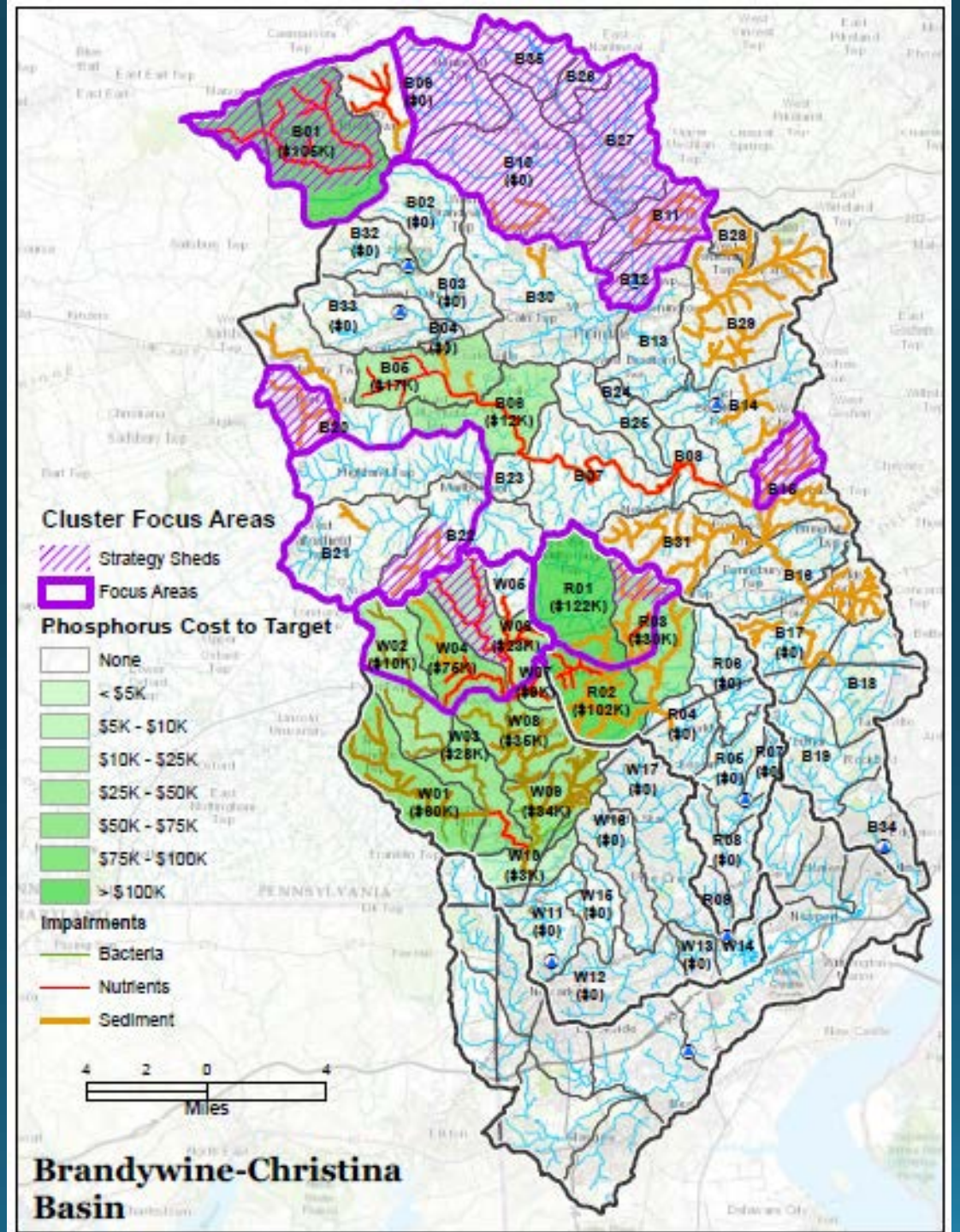
Yields by Land Cover

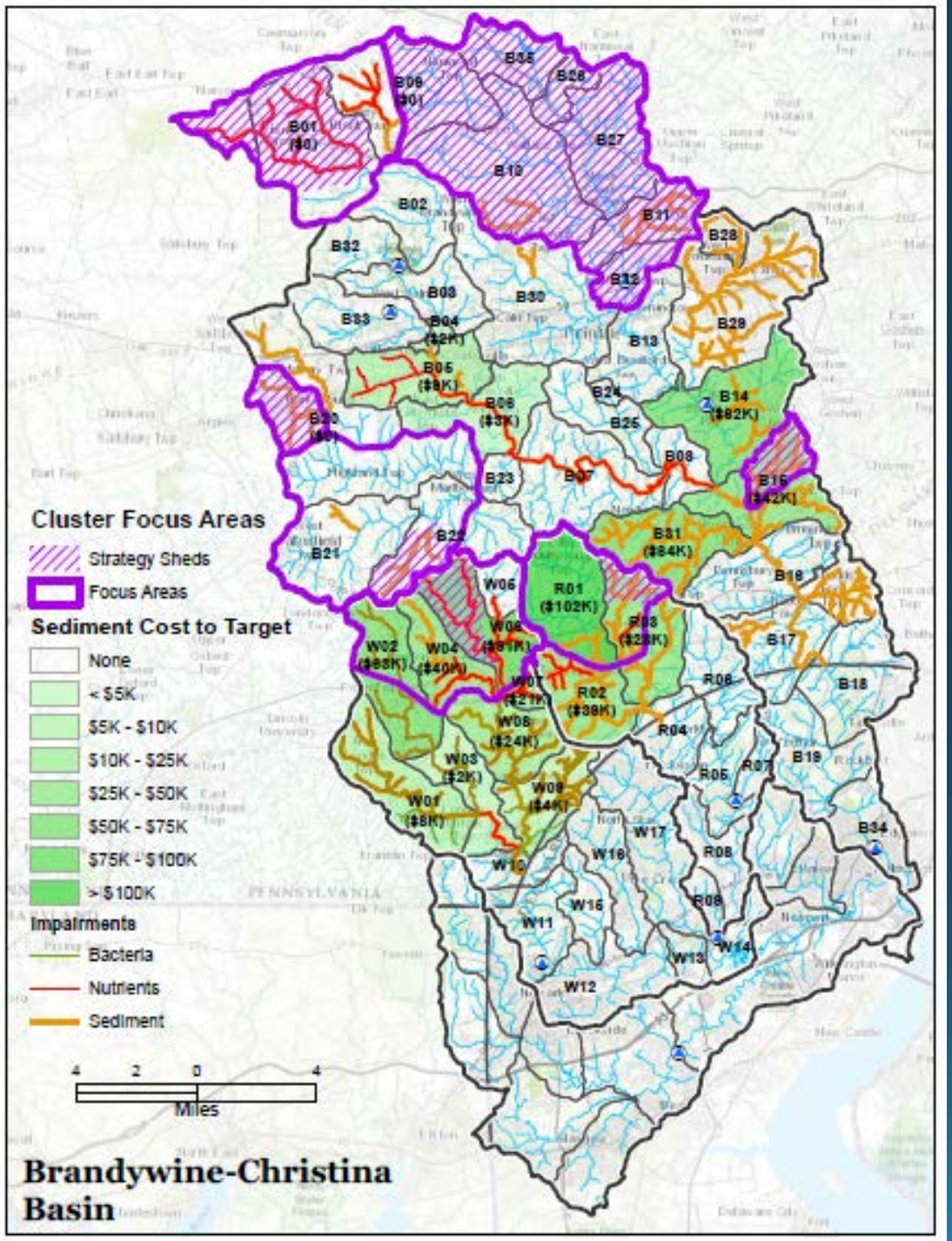
MapShed estimates


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)


Cluster Focus Areas
Strategy Sheds
Focus Areas
Nitrogen Cost to Target
None
< $10K
$10K - $25K
$25K - $50K
$50K - $100K
$100K - $250K
$250K - $500K
> $500K
Impairments
Bacteria
Nutrients
Sediment
4 2 0 4
Miles
Brandywine-Christina Basin


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

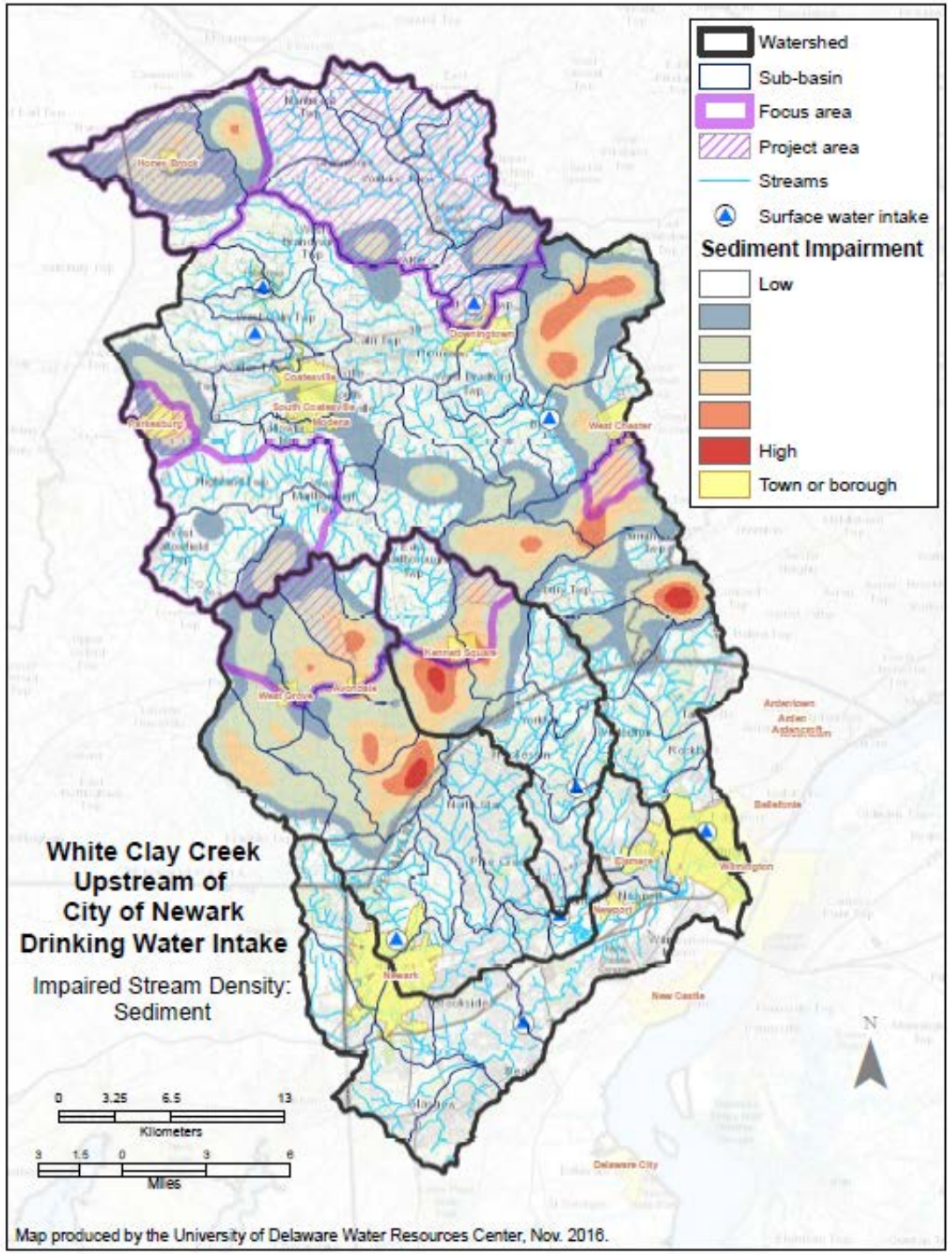
Constituent	Target reduction	Unit	Cost to target
Nitrogen	66100	kg	$ 602,699
Phosphorus	1864	kg	$ 134,377
Sediment	88	tonne	$ 12,912
			$ 749,988

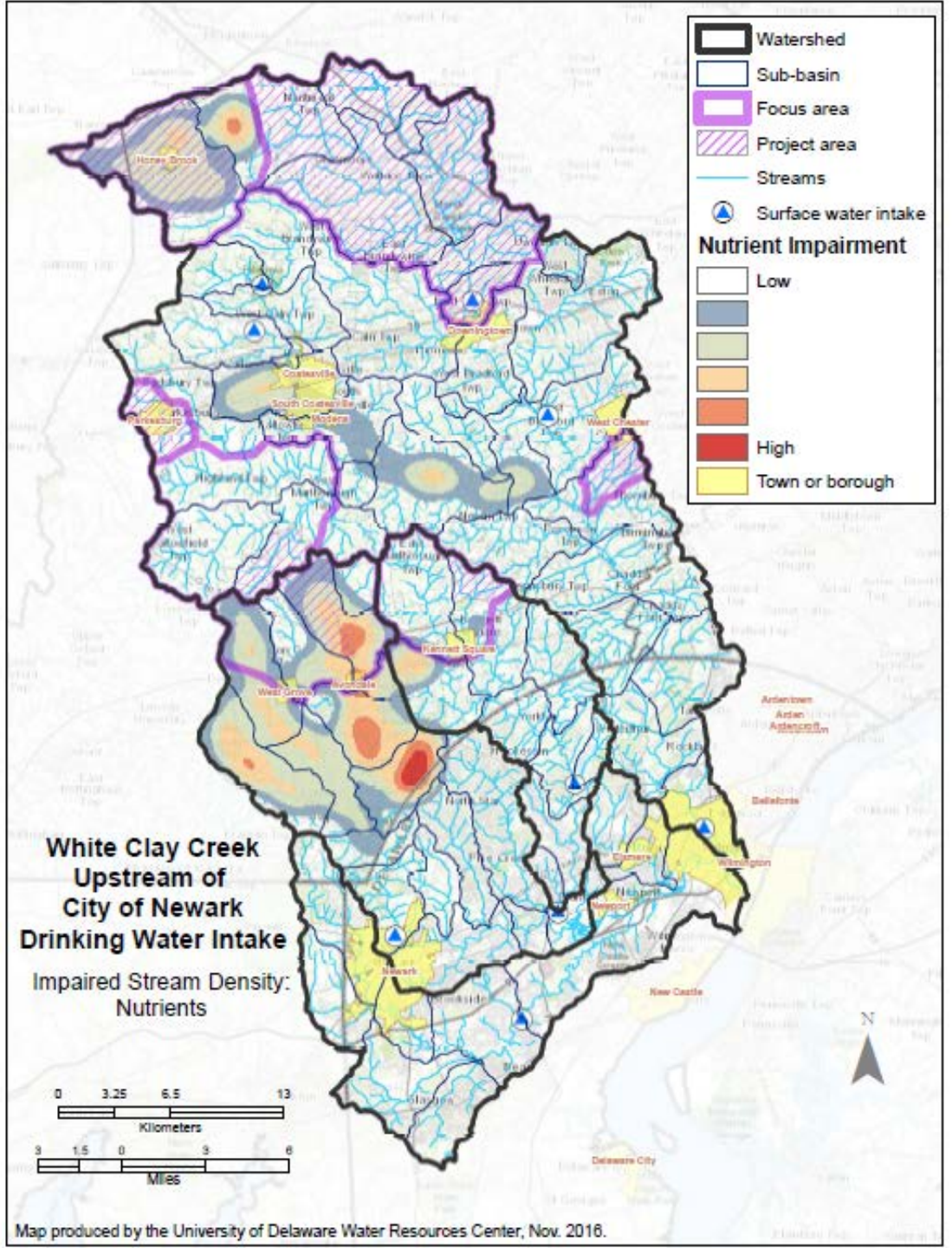
Brandywine, East Branch

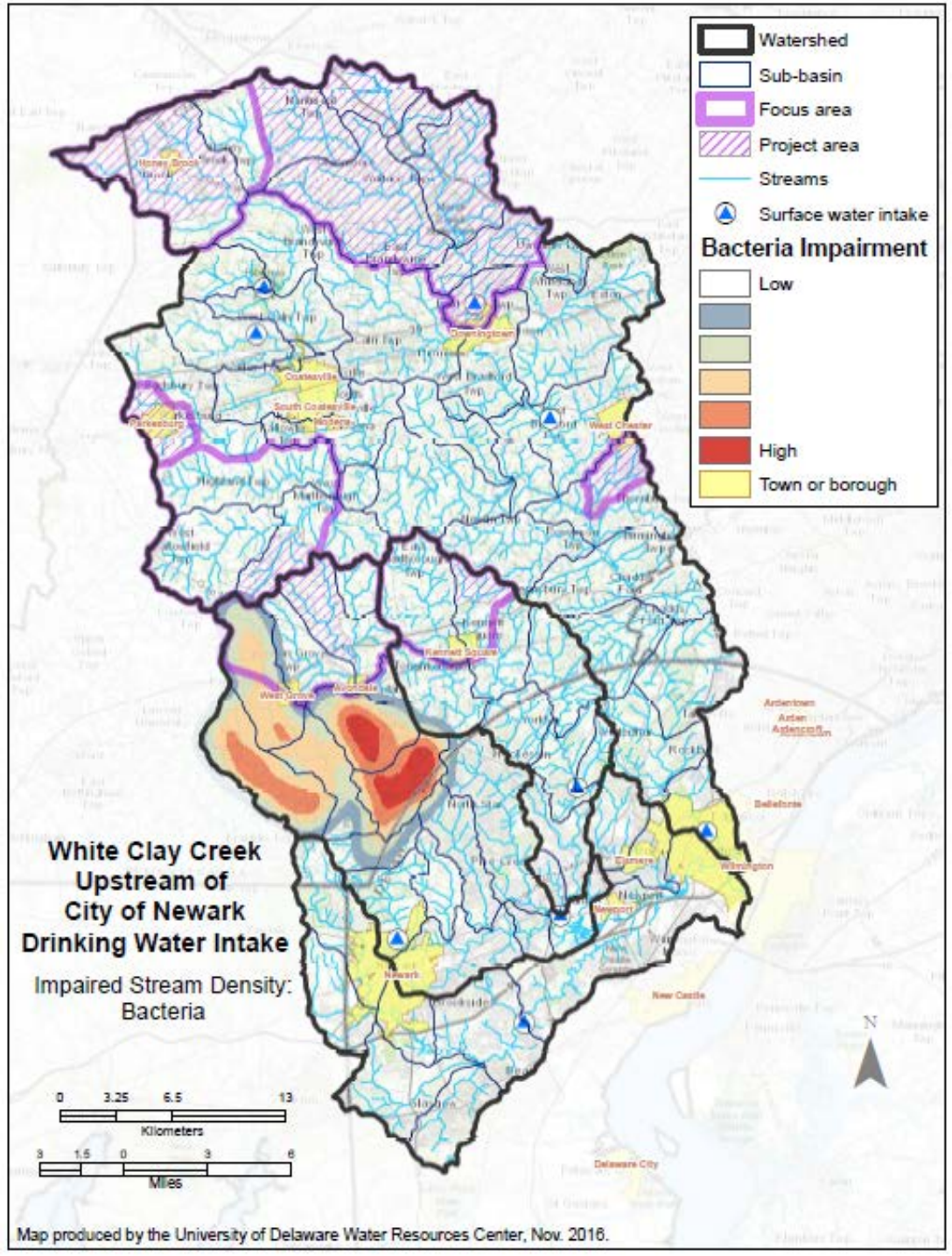
Constituent	Target reduction	Unit	Cost to target
Nitrogen	19,165	kg	$ 217,325
Phosphorus	0	kg	$ -
Sediment	567	tonne	$ 62,098
			$ 279,423

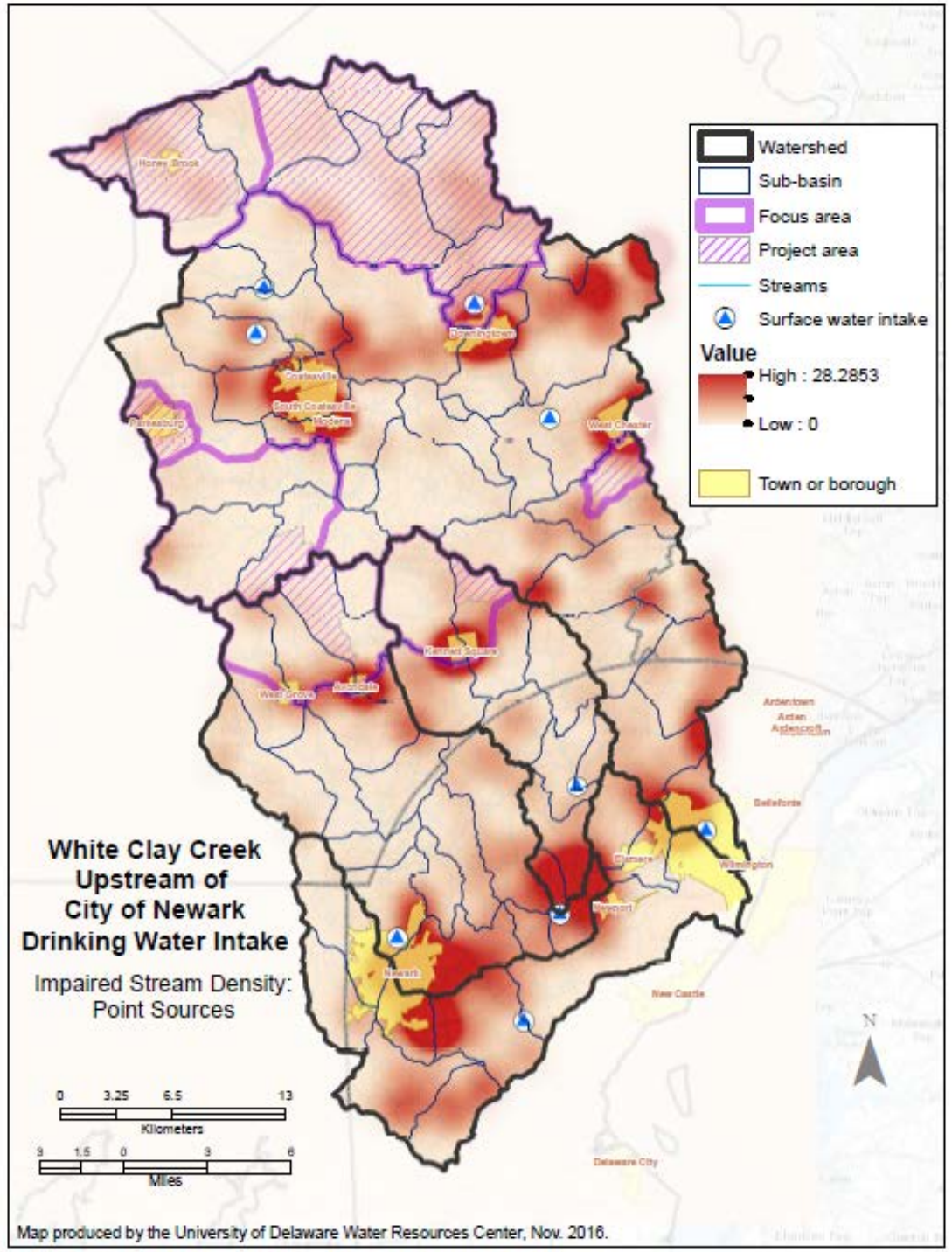
Brandywine, Main Stem

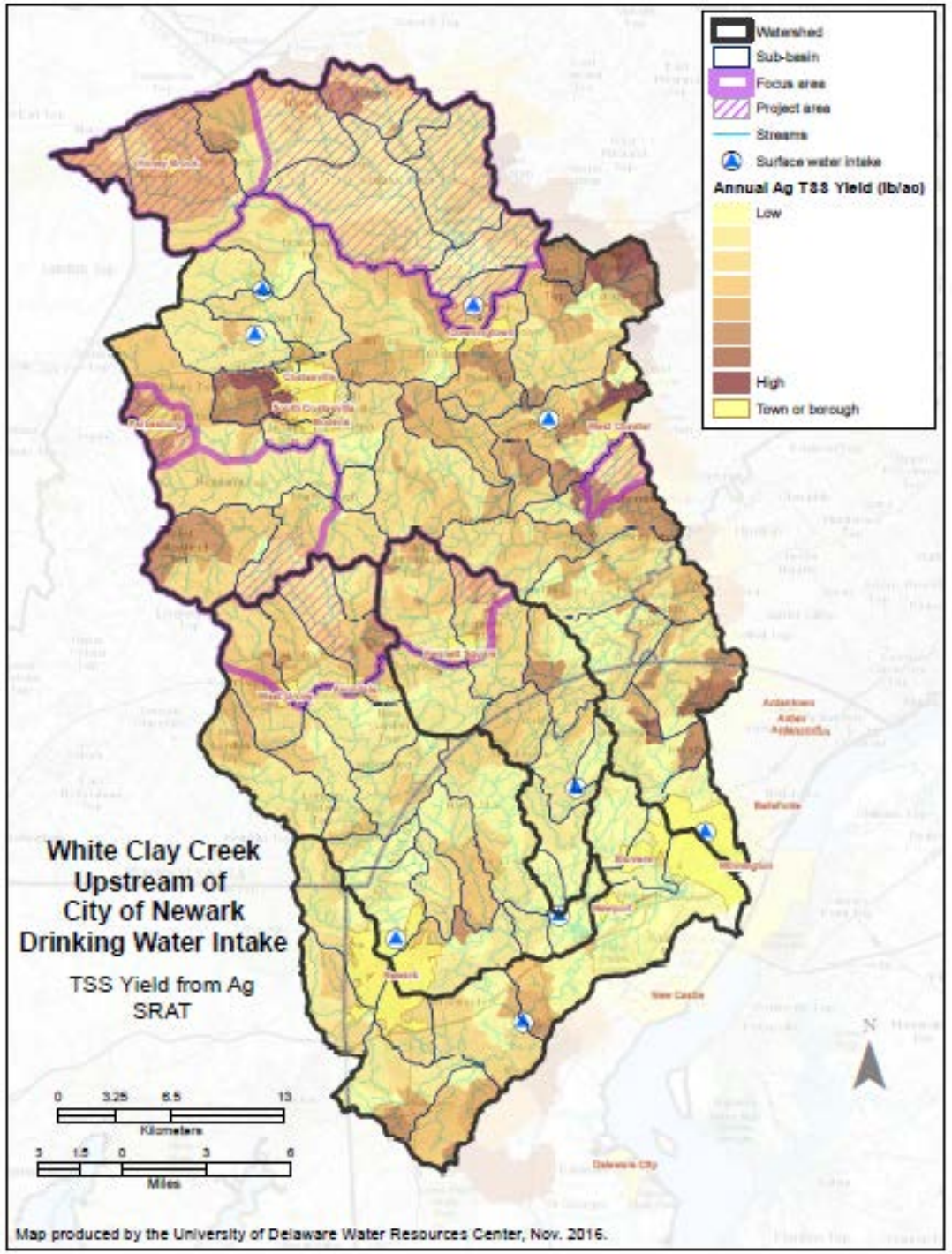
Constituent	Target reduction	Unit	Cost to target
Nitrogen	0	kg	$ -
Phosphorus	0	kg	$ -
Sediment	619	tonne	$ 106,447
			$ 106,447

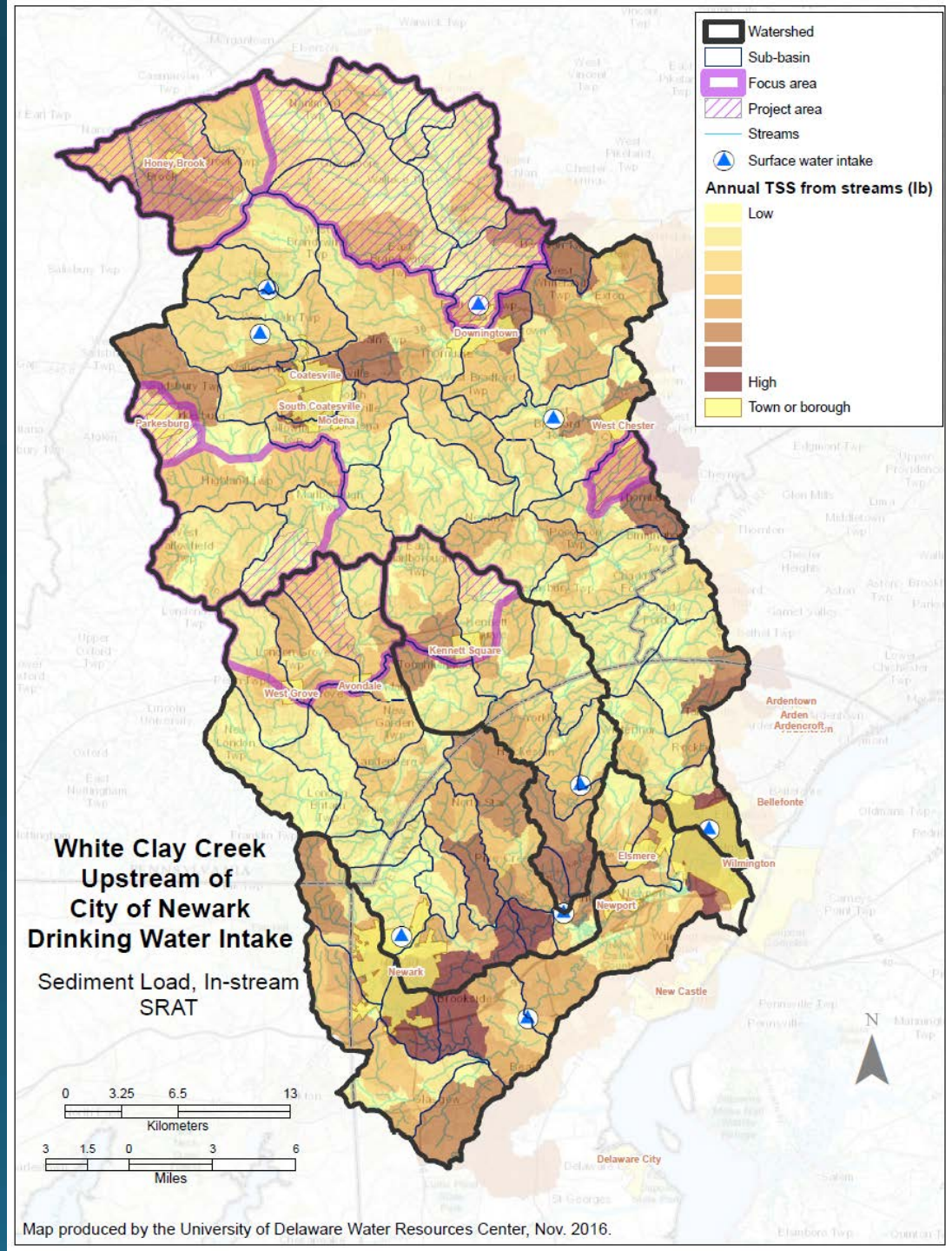

Watershed
Sub-basin
Focus area
Project area
Streams
Surface water intake
Sediment Impairment
Low
High
Town or borough
White Clay Creek
Upstream of
City of Newark
Drinking Water Intake
Impaired Stream Density:
Sediment
0 3.25 6.5 13
Kilometers
3 1.5 0 3 6
Miles
N
Map produced by the University of Delaware Water Resources Center, Nov. 2016.


Watershed
Sub-basin
Focus area
Project area
Streams
Surface water intake
Nutrient Impairment
Low
High
Town or borough
White Clay Creek
Upstream of
City of Newark
Drinking Water Intake
Impaired Stream Density:
Nutrients
0 3.25 6.5 13
Kilometers
3 1.5 0 3 6
Miles
N
Map produced by the University of Delaware Water Resources Center, Nov. 2016.

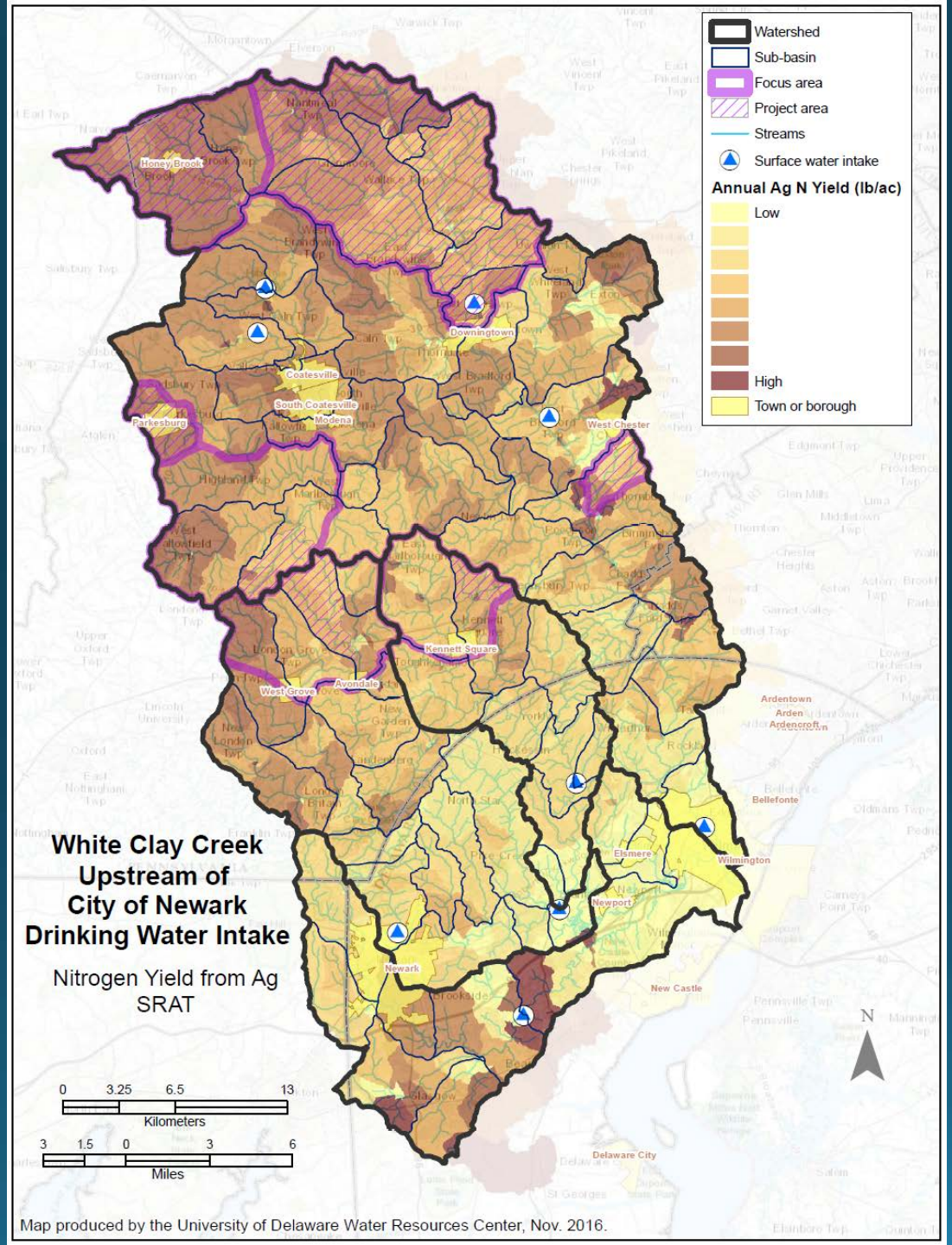

Watershed
Sub-basin
Focus area
Project area
Streams
Surface water intake
Bacteria Impairment
Low
High
Town or borough
White Clay Creek
Upstream of
City of Newark
Drinking Water Intake
Impaired Stream Density:
Bacteria
0 3.25 6.5 13
Kilometers
3 1.5 0 3 6
Miles
N
Map produced by the University of Delaware Water Resources Center, Nov. 2016.

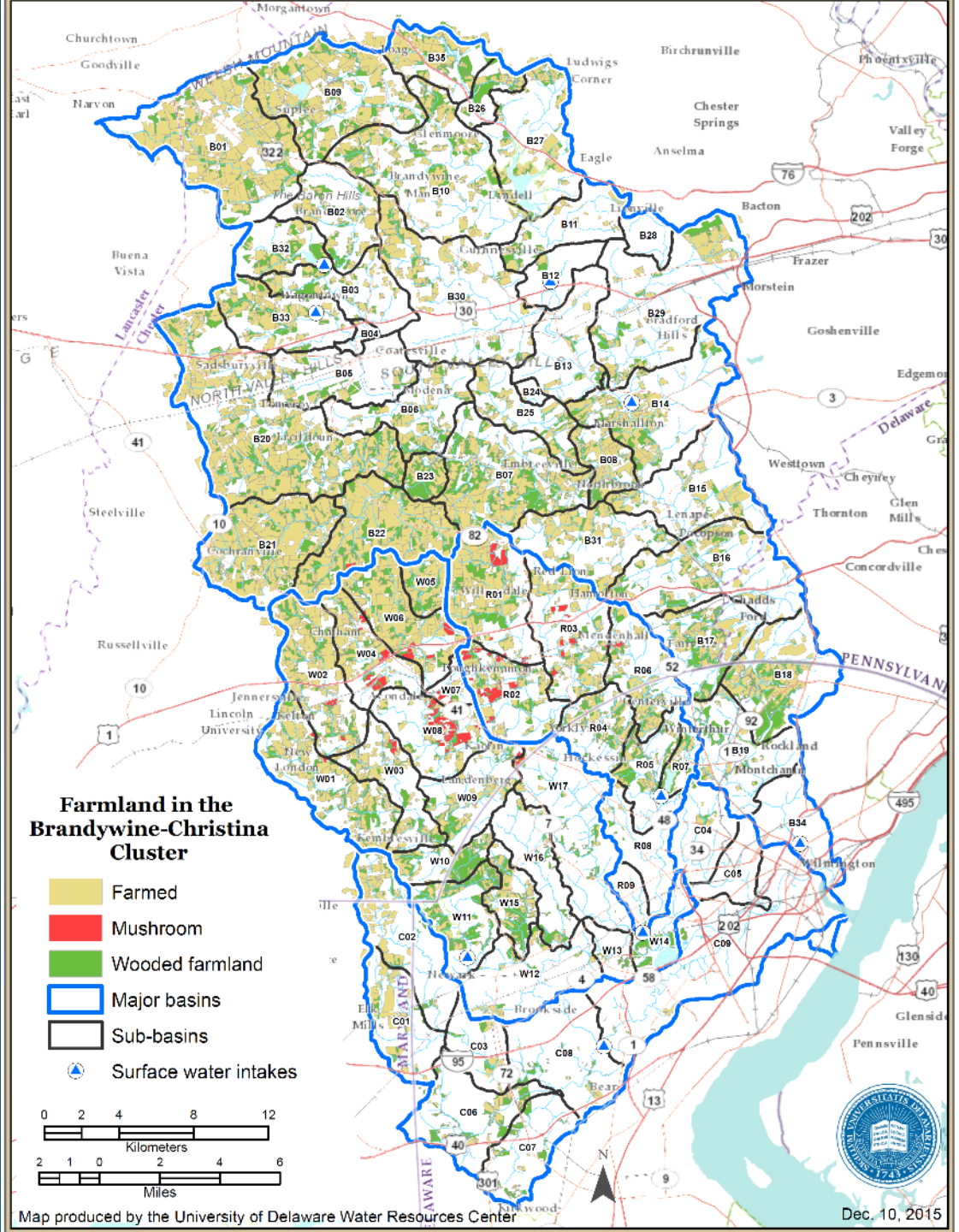

Watershed
Sub-basin
Focus area
Project area
Streams
Surface water intake
Value
High : 28.2853
Low : 0
Town or borough
White Clay Creek
Upstream of
City of Newark
Drinking Water Intake
Impaired Stream Density:
Point Sources
0 3.25 6.5 13
Kilometers
3 1.5 0 3 6
Miles
N
Map produced by the University of Delaware Water Resources Center, Nov. 2016.

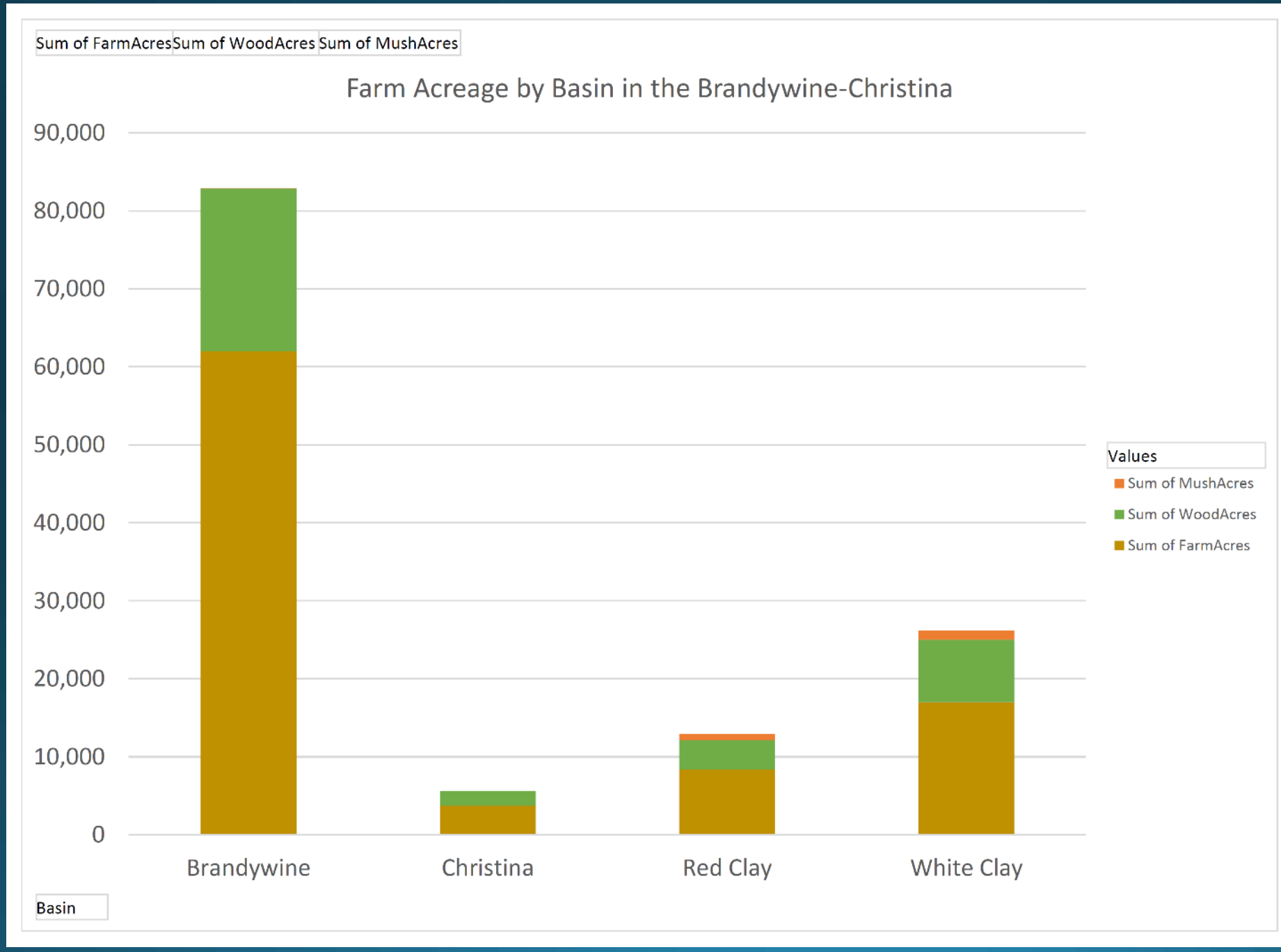

Watershed
Sub-basin
Focus area
Project area
Streams
Surface water intake
Annual Ag TSS Yield (lb/ac)
Low
High
Town or borough
White Clay Creek
Upstream of
City of Newark
Drinking Water Intake
TSS Yield from Ag
SRAT
0 3.25 6.5 13
Kilometers
3 1.5 0 3 6
Miles
N
Map produced by the University of Delaware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

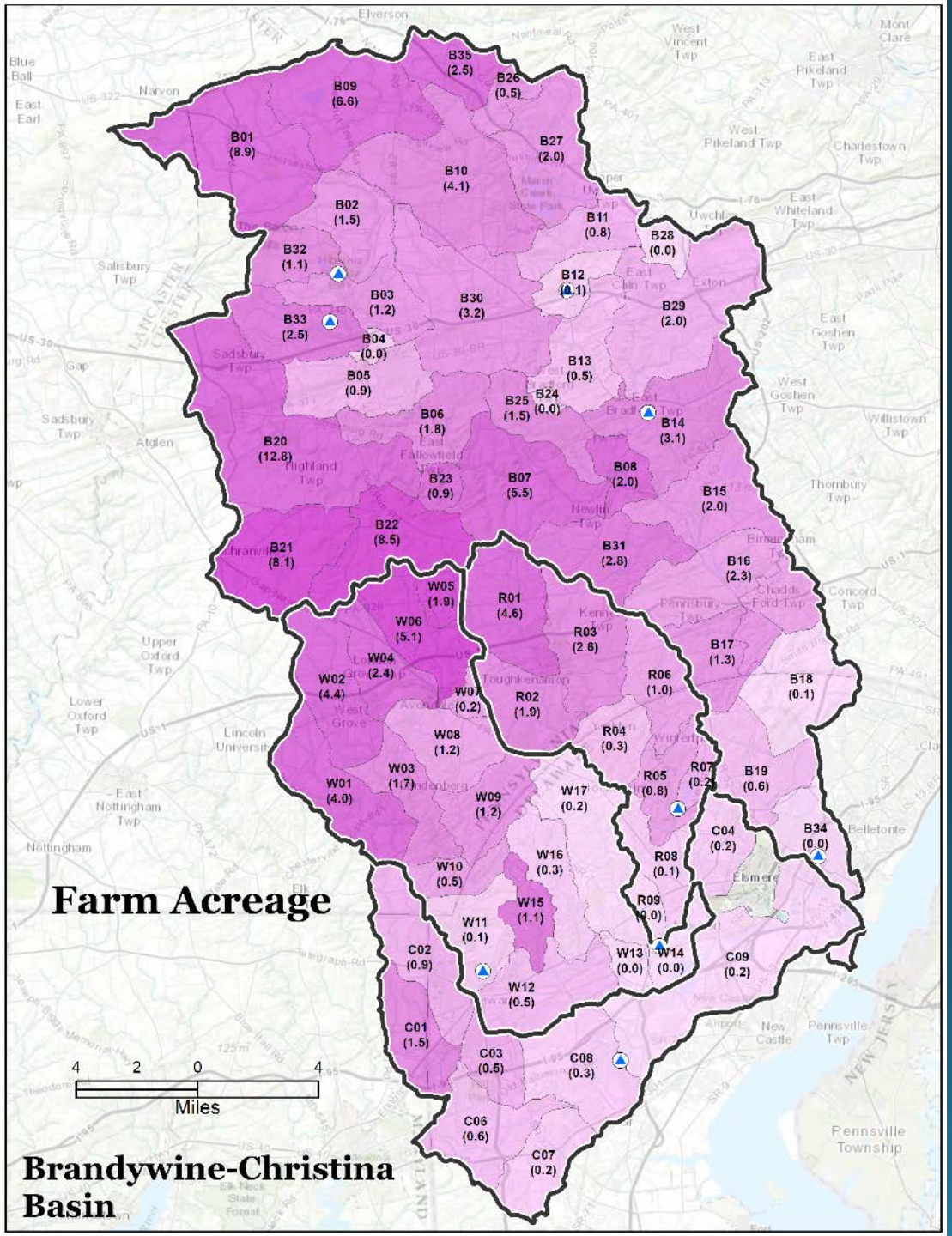


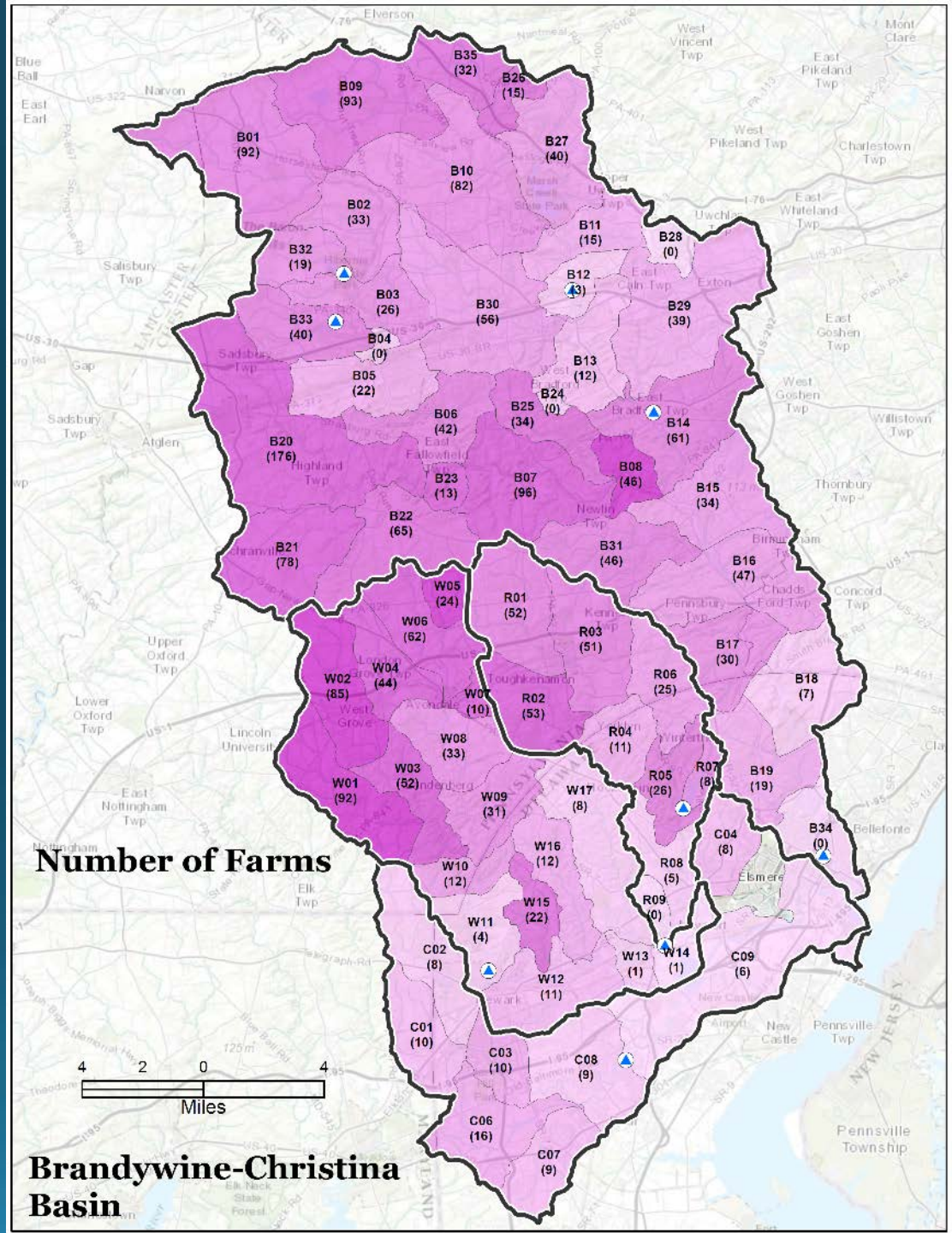
Map produced by the University of Delaware Water Resources Center, Nov. 2016.

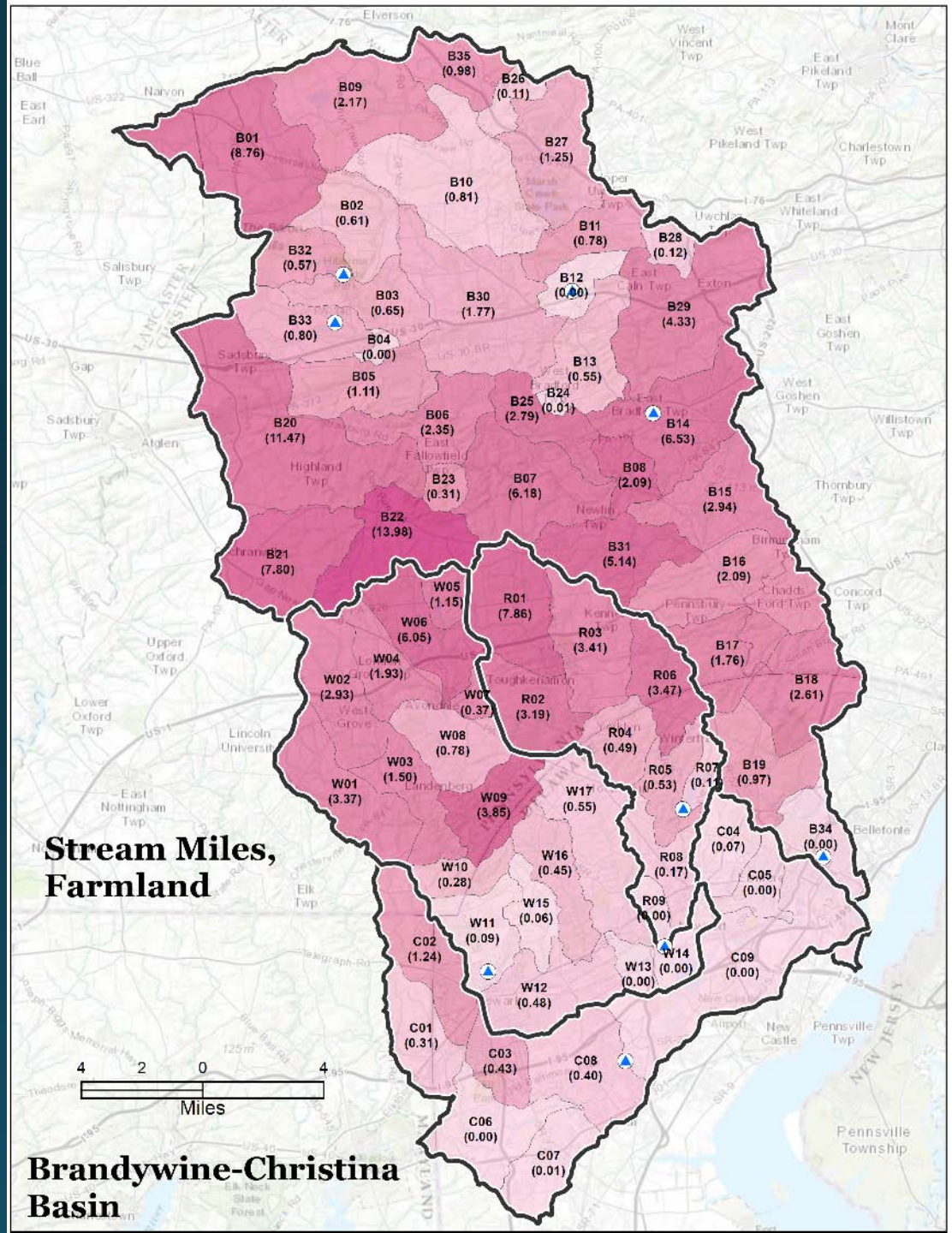

Watershed
Sub-basin
Focus area
Project area
Streams
Surface water intake
Annual Ag N Yield (lb/ac)
Low
High
Town or borough
White Clay Creek
Upstream of
City of Newark
Drinking Water Intake
Nitrogen Yield from Ag
SRAT
0 3.25 6.5 13
Kilometers
3 1.5 0 3 6
Miles
N
Honey Brook
Downingtown
Coatesville
South Coatesville
Modena
Parkesburg
West Chester
Kennett Square
Avondale
West Grove
Ardentown
Arden
Ardencroft
Bellefonte
Elsmere
Wilmington
Newport
Newark
New Castle
Delaware City
Map produced by the University of Delaware Water Resources Center, Nov. 2016.

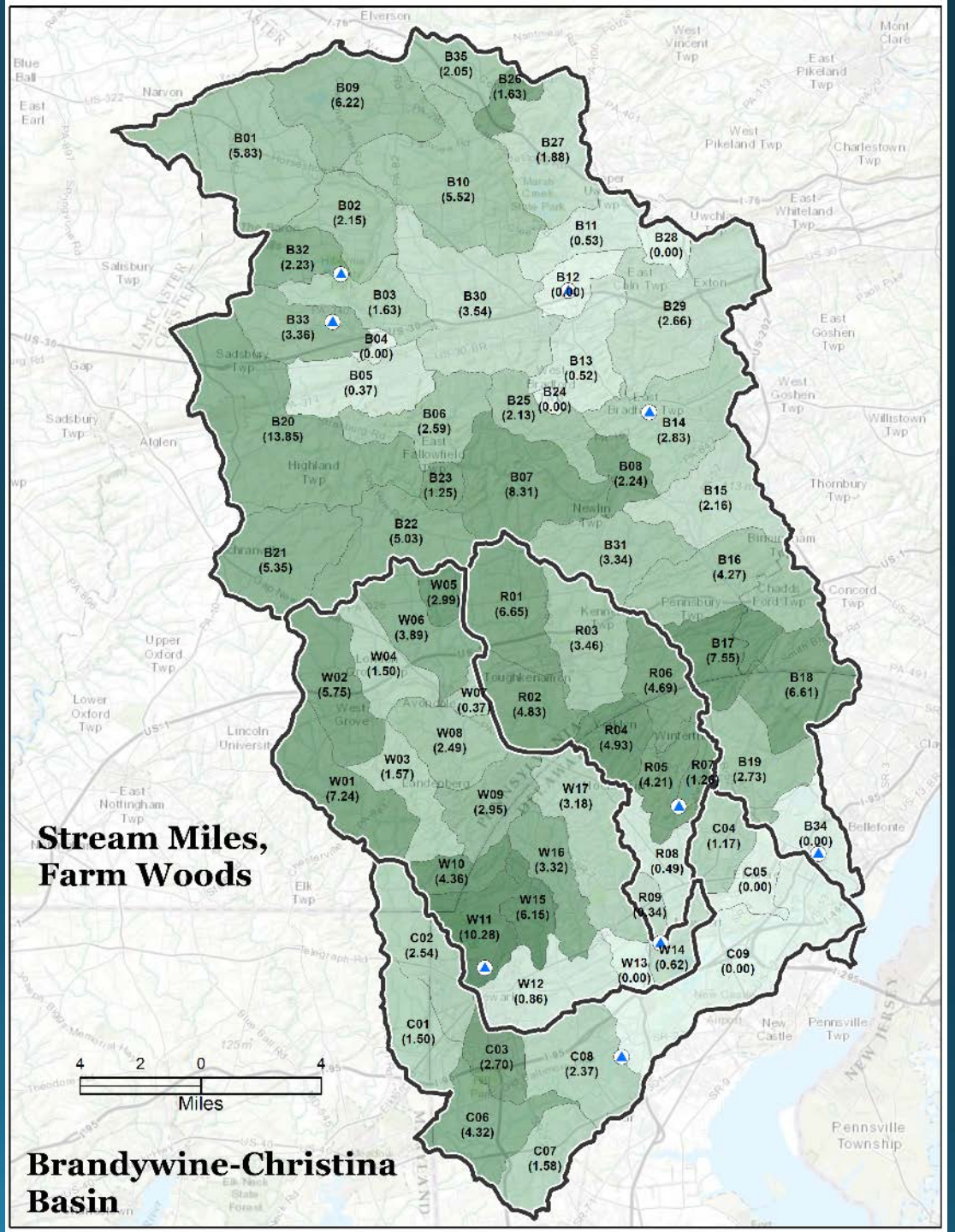

Farmland in the Brandywine-Christina Cluster
Farmed
Mushroom
Wooded farmland
Major basins
Sub-basins
Surface water intakes
0 2 4 8 12
Kilometers
2 1 0 2 4 6
Miles
Map produced by the University of Delaware Water Resources Center
Dec. 10, 2015

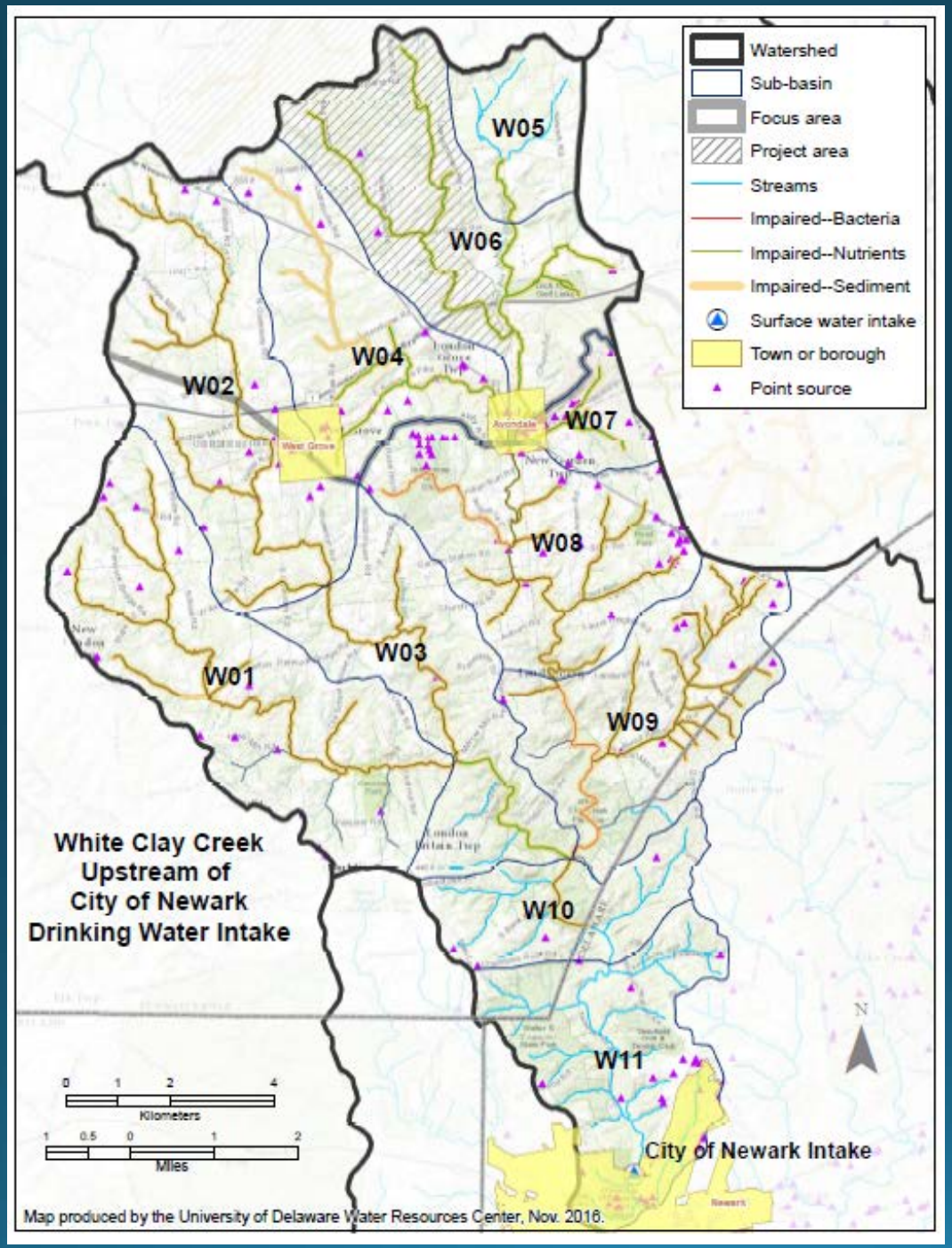

Sum of FarmAcres
Sum of WoodAcres
Sum of MushAcres
Farm Acreage by Basin in the Brandywine-Christina
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Brandywine
Christina
Red Clay
White Clay
Basin
Values
Sum of MushAcres
Sum of WoodAcres
Sum of FarmAcres

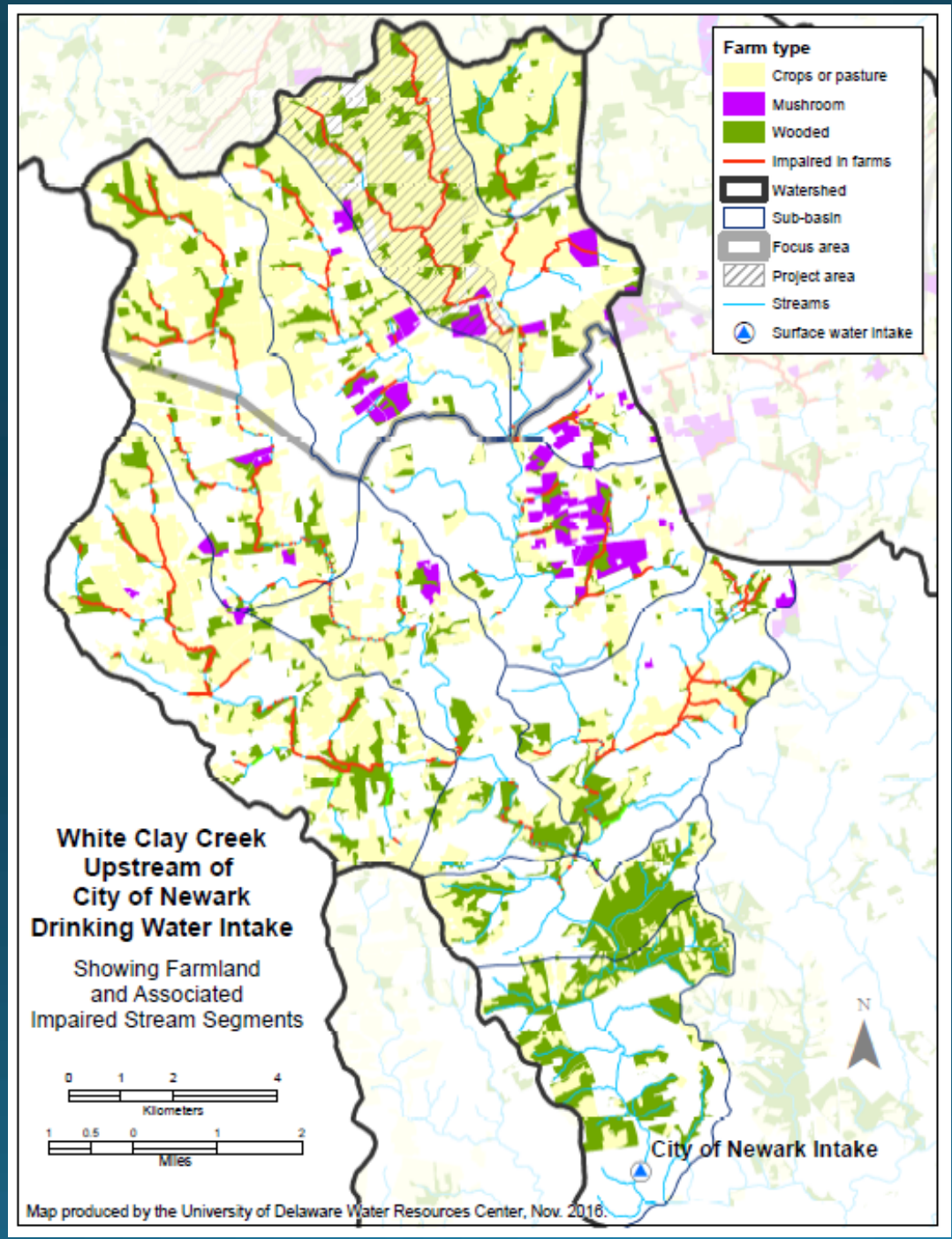

Farm Acreage
B35 (2.5)
B26 (0.5)
B09 (6.6)
B01 (8.9)
B27 (2.0)
B10 (4.1)
B02 (1.5)
B11 (0.8)
B28 (0.0)
B32 (1.1)
B12 (0.1)
B03 (1.2)
B30 (3.2)
B29 (2.0)
B33 (2.5)
B04 (0.0)
B13 (0.5)
B05 (0.9)
B24 (0.0)
B25 (1.5)
B06 (1.8)
B14 (3.1)
B20 (12.8)
B08 (2.0)
B23 (0.9)
B07 (5.5)
B15 (2.0)
B22 (8.5)
B21 (8.1)
B31 (2.8)
B16 (2.3)
W05 (1.9)
R01 (4.6)
W06 (5.1)
R03 (2.6)
B17 (1.3)
W04 (2.4)
R06 (1.0)
W02 (4.4)
B18 (0.1)
W07 (0.2)
R02 (1.9)
W08 (1.2)
R04 (0.3)
W03 (1.7)
R05 (0.8)
R07 (0.2)
B19 (0.6)
W01 (4.0)
W09 (1.2)
W17 (0.2)
C04 (0.2)
B34 (0.0)
W16 (0.3)
W10 (0.5)
R08 (0.1)
W15 (1.1)
R09 (0.0)
W11 (0.1)
C02 (0.9)
W13 (0.0)
W14 (0.0)
C09 (0.2)
W12 (0.5)
C01 (1.5)
C03 (0.5)
C08 (0.3)
C06 (0.6)
C07 (0.2)
4 2 0 4
Miles
Brandywine-Christina Basin

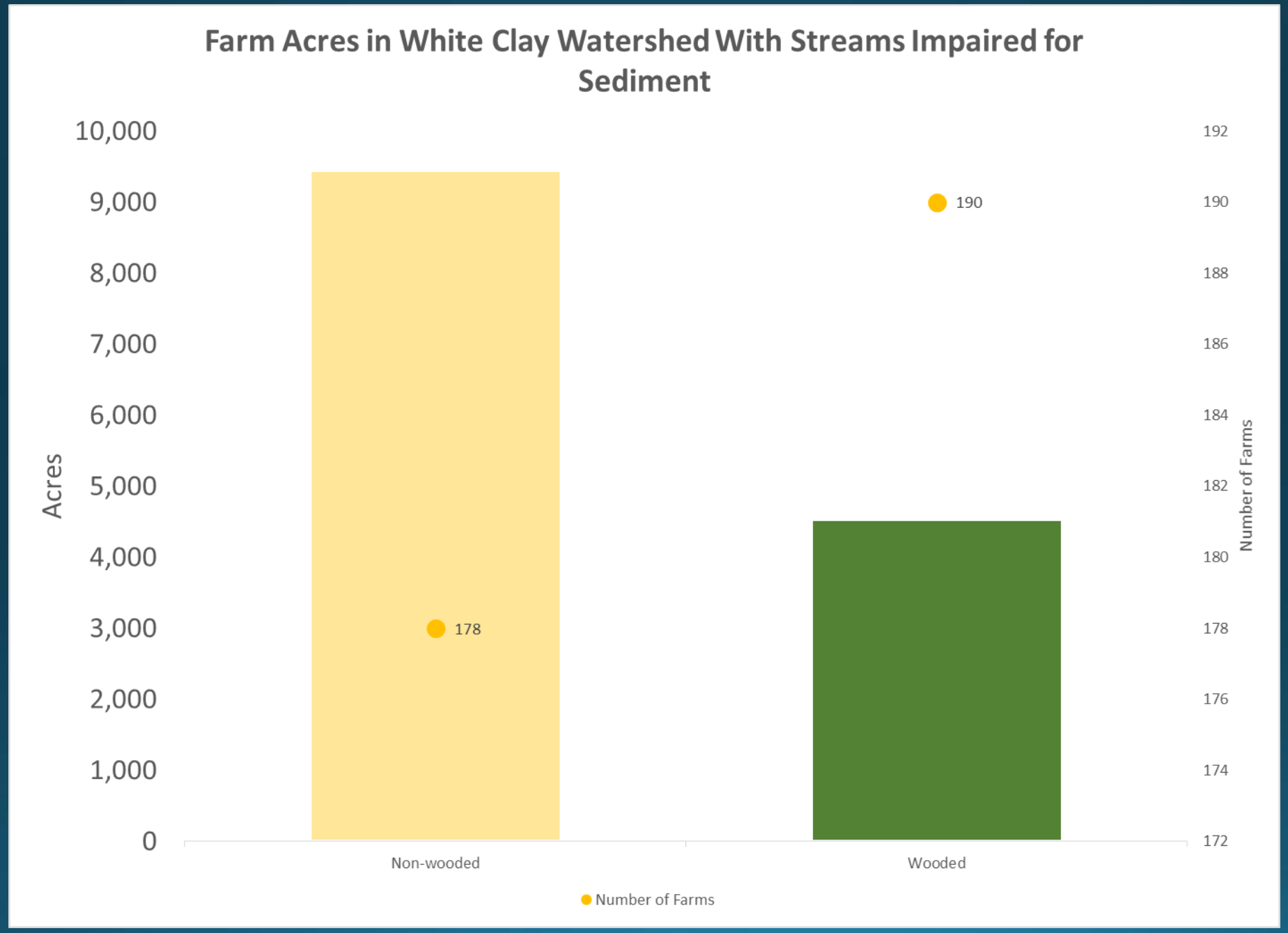

Number of Farms
B35 (32)
B26 (15)
B09 (93)
B01 (92)
B27 (40)
B10 (82)
B02 (33)
B11 (15)
B28 (0)
B32 (19)
B12 (3)
B03 (26)
B30 (56)
B29 (39)
B33 (40)
B04 (0)
B13 (12)
B05 (22)
B24 (0)
B25 (34)
B06 (42)
B14 (61)
B20 (176)
B08 (46)
B23 (13)
B07 (96)
B15 (34)
B22 (65)
B21 (78)
B31 (46)
B16 (47)
W05 (24)
R01 (52)
W06 (62)
R03 (51)
B17 (30)
W04 (44)
R06 (25)
W02 (85)
B18 (7)
W07 (10)
R02 (53)
W08 (33)
R04 (11)
W03 (52)
R05 (26)
R07 (8)
B19 (19)
W01 (92)
W09 (31)
W17 (8)
C04 (8)
B34 (0)
W16 (12)
W10 (12)
R08 (5)
W15 (22)
R09 (0)
W11 (4)
C02 (8)
W13 (1)
W14 (1)
C09 (6)
W12 (11)
C01 (10)
C03 (10)
C08 (9)
C06 (16)
C07 (9)
4 2 0 4
Miles
Brandywine-Christina Basin


B35 (0.98)
B26 (0.11)
B09 (2.17)
B01 (8.76)
B27 (1.25)
B10 (0.81)
B02 (0.61)
B11 (0.78)
B28 (0.12)
B32 (0.57)
B12 (0.00)
B03 (0.65)
B30 (1.77)
B29 (4.33)
B33 (0.80)
B04 (0.00)
B13 (0.55)
B05 (1.11)
B24 (0.01)
B25 (2.79)
B20 (11.47)
B06 (2.35)
B14 (6.53)
B23 (0.31)
B07 (6.18)
B08 (2.09)
B15 (2.94)
B22 (13.98)
B21 (7.80)
B31 (5.14)
B16 (2.09)
W05 (1.15)
R01 (7.86)
W06 (6.05)
R03 (3.41)
B17 (1.76)
W04 (1.93)
W02 (2.93)
R06 (3.47)
B18 (2.61)
W07 (0.37)
R02 (3.19)
W08 (0.78)
R04 (0.49)
W03 (1.50)
R05 (0.53)
R07 (0.11)
B19 (0.97)
W01 (3.37)
W09 (3.85)
W17 (0.55)
C04 (0.07)
B34 (0.00)
W10 (0.28)
W16 (0.45)
R08 (0.17)
C05 (0.00)
W15 (0.06)
R09 (0.00)
W11 (0.09)
C02 (1.24)
W14 (0.00)
C09 (0.00)
W13 (0.00)
W12 (0.48)
C01 (0.31)
C03 (0.43)
C08 (0.40)
C06 (0.00)
C07 (0.01)
Stream Miles, Farmland
4 2 0 4
Miles
Brandywine-Christina Basin


B35 (2.05)
B26 (1.63)
B09 (6.22)
B01 (5.83)
B27 (1.88)
B10 (5.52)
B02 (2.15)
B11 (0.53)
B28 (0.00)
B32 (2.23)
B12 (0.00)
B03 (1.63)
B30 (3.54)
B29 (2.66)
B33 (3.36)
B04 (0.00)
B13 (0.52)
B05 (0.37)
B24 (0.00)
B25 (2.13)
B20 (13.85)
B06 (2.59)
B14 (2.83)
B23 (1.25)
B07 (8.31)
B08 (2.24)
B15 (2.16)
B22 (5.03)
B21 (5.35)
B31 (3.34)
B16 (4.27)
W05 (2.99)
R01 (6.65)
W06 (3.89)
R03 (3.46)
B17 (7.55)
W04 (1.50)
W02 (5.75)
R06 (4.69)
B18 (6.61)
W07 (0.37)
R02 (4.83)
W08 (2.49)
R04 (4.93)
W03 (1.57)
R05 (4.21)
R07 (1.26)
B19 (2.73)
W01 (7.24)
W09 (2.95)
W17 (3.18)
C04 (1.17)
B34 (0.00)
W10 (4.36)
W16 (3.32)
R08 (0.49)
C05 (0.00)
W15 (6.15)
R09 (0.34)
W11 (10.28)
C02 (2.54)
W14 (0.62)
C09 (0.00)
W13 (0.00)
W12 (0.86)
C01 (1.50)
C03 (2.70)
C08 (2.37)
C06 (4.32)
C07 (1.58)
Stream Miles, Farm Woods
4 2 0 4
Miles
Brandywine-Christina Basin


Watershed
Sub-basin
Focus area
Project area
Streams
Impaired--Bacteria
Impaired--Nutrients
Impaired--Sediment
Surface water intake
Town or borough
Point source
W01
W02
W03
W04
W05
W06
W07
W08
W09
W10
W11
White Clay Creek
Upstream of
City of Newark
Drinking Water Intake
City of Newark Intake
N
0 1 2 4
Kilometers
1 0.5 0 1 2
Miles
Map produced by the University of Delaware Water Resources Center, Nov. 2016.


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.


Farm Acres in White Clay Watershed With Streams Impaired for Sediment
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Acres
192
190
188
186
184
182
180
178
176
174
172
Number of Farms
178
190
Non-wooded
Wooded
Number of Farms

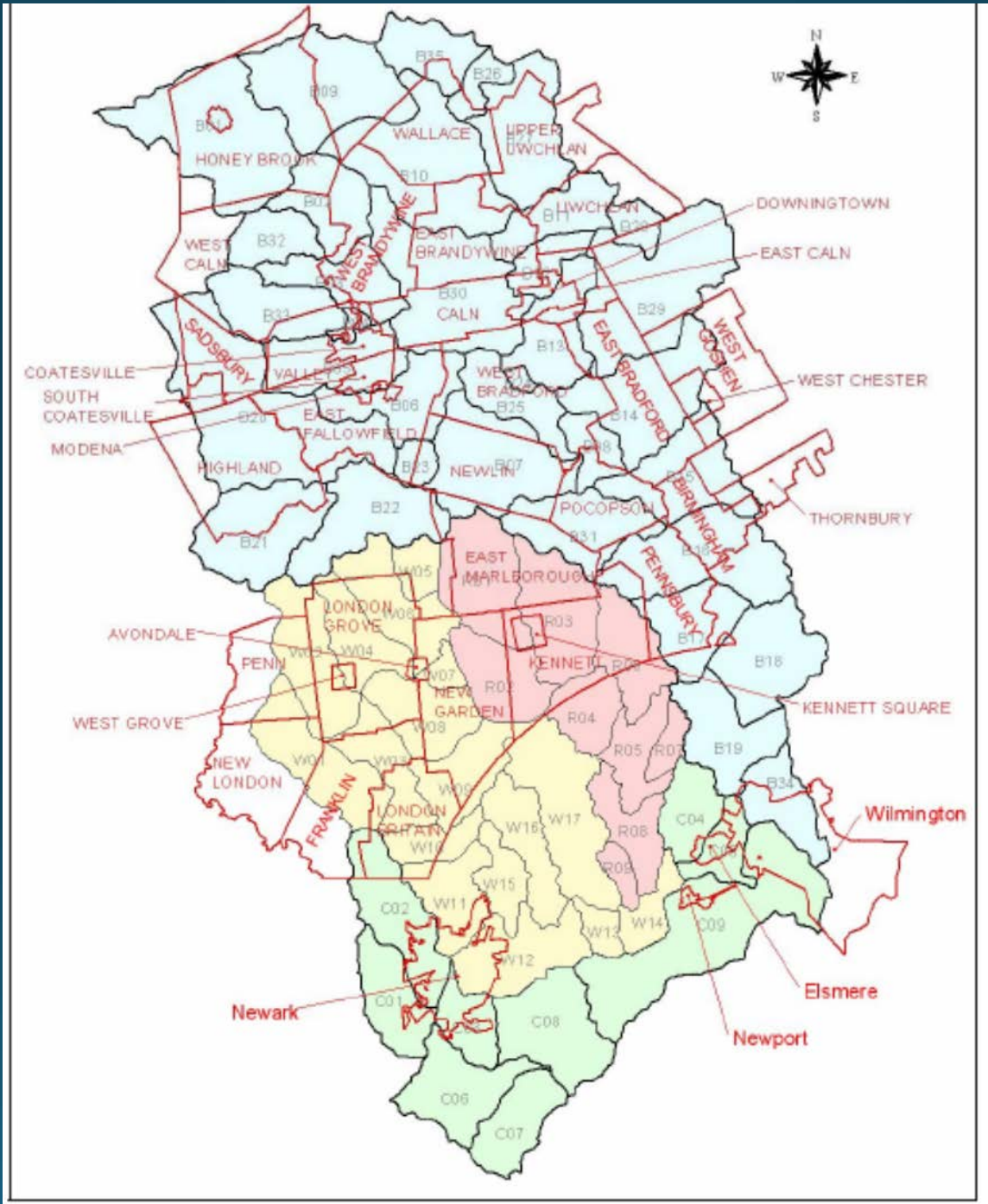


Figure 2-2. Municipalities with MS4 permits in Christina River Basin

Christina Watersheds Partnership
Potential Pilot Areas

Agricultural
Honey Brook Borough,
Honey Brook Township

Urban
Caln, Coatesville,
Modena, South Coatesville, Valley

Suburban
Avondale, Franklin, London Britain,
London Grove, New Garden, West Grove

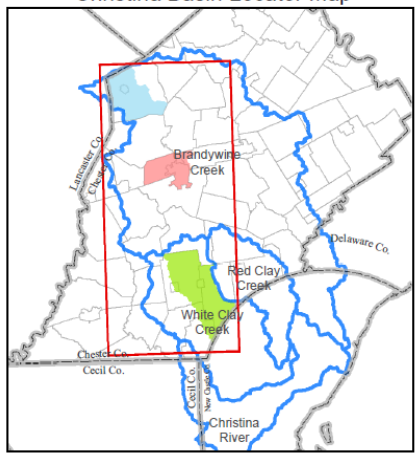
- Watershed boundary
- USGS HUC12 unit
- Municipal boundary
- Stream

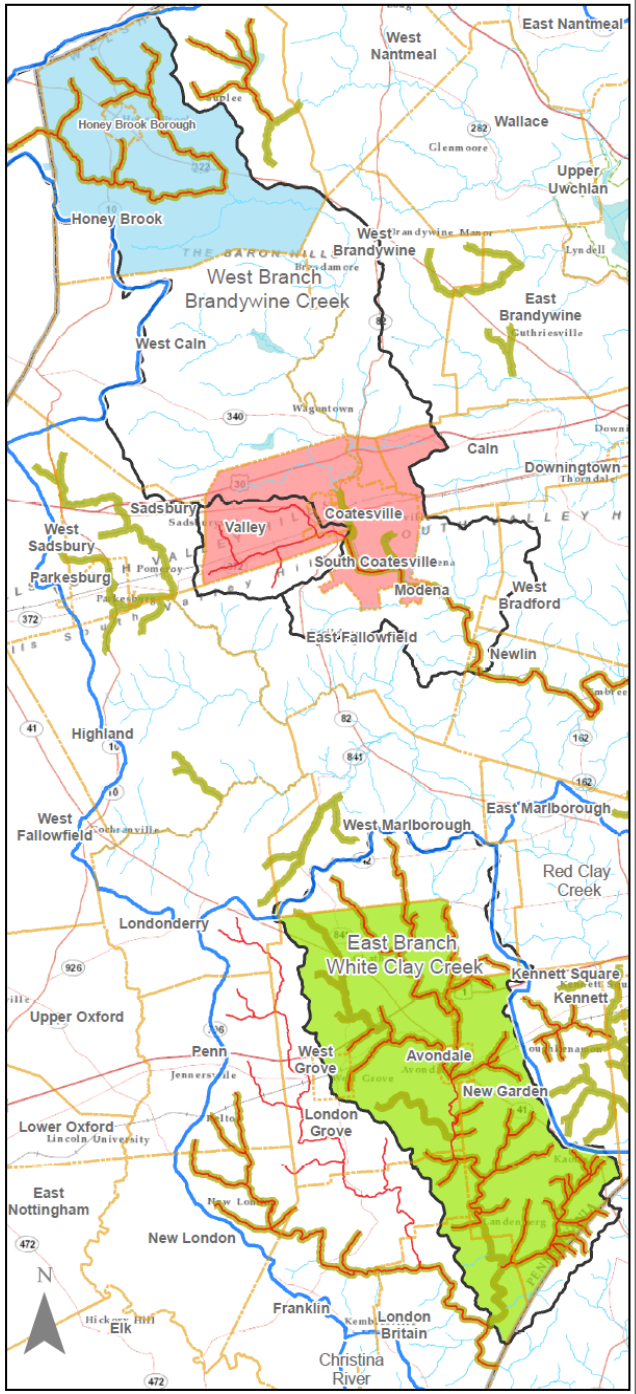
2014 Stream Impairments

- Nutrients
- Sediment

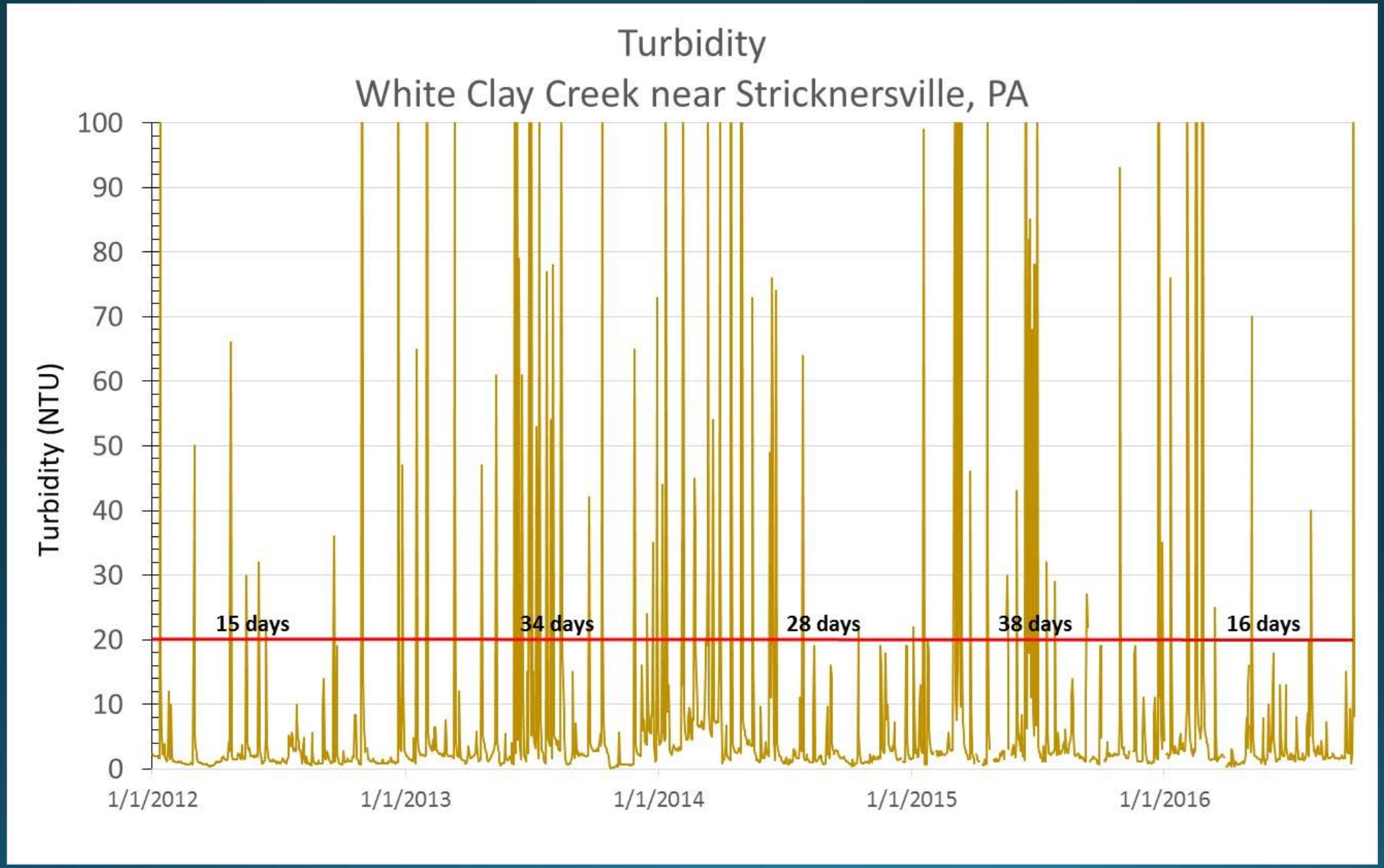
3 1.5 0 3
Miles

Christina Basin Locator Map





Map produced by the University of Delaware Water Resources Center Map created on 8/17/2016


Turbidity
White Clay Creek near Stricknersville, PA
Turbidity (NTU)
100
90
80
70
60
50
40
30
20
10
0
15 days
34 days
28 days
38 days
16 days
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016

PIKE CREEK

WATER QUALITY IMPROVEMENT PLAN

PILOT PROJECT FINAL REPORT

September 2012

Prepared for:

New Castle County Department of Special Services
187A Old Churchman's Road
New Castle, Delaware 19720

and

Delaware Department of Transportation
800 Bay Road
Dover, Delaware 19901

Prepared by:

Duffield Associates, Inc.
5400 Limestone Road
Wilmington, Delaware 19808

In partnership with:

Water Resources Agency at the University of Delaware
180 Graham Hall
Newark, Delaware 19716

Using these data and assumptions, the six locations identified for dry pond retrofits to infiltration would cost approximately $400,000 to construct and the 16 example infiltration facilities would cost just under $3 million. The five vegetated channels and one constructed wetlands were estimated to be approximately $100,000 for the vegetated channels and $36,000 for the wetlands.

All told, the retrofits and new facilities described above, if able to be constructed in the field, would cost approximately $3.5 million. These expenditures would be intended to provide benefits described herein and are summarized in Table 8 (average between low and high values used for pollutants):

Table 8 – Per unit reduction costs of suggested BMPs.

	Reduction	Per Unit Cost
Runoff Reduction	5.5 acre-feet	$640,000
Total Nitrogen	272 lbs/year	$12,900
Total Phosphorous	150 lbs/year	$23,300
Enterococcus Bacteria	2,575 bn CFU/year	$1,400

For comparison, the "Nutrient Credit Trading for the Chesapeake Bay – An Economic Study," prepared in May 2012 for the Chesapeake Bay Commission, indicated that infiltration costs for nitrogen and phosphorous removal in urban environments were on the order of $200 to $600 and $5,000 to $20,000, respectively. As stressed, much of the cost information used in this report is very approximate and sometimes unsubstantiated and intended for demonstration purposes. Fine tuning of the WQIP approach would be expected to provide more reliable data.

Assuming a 20-year time frame and 3% interest rate, the Principal Permittees would need to invest about $240,000 each year to implement this plan. It is important to note that these capital costs do not include annual maintenance costs.

The site prioritization and field reconnaissance yielded potential BMP or retrofit locations where the DURMM/WQIP model numerically demonstrated BMP or retrofit effects or impacts. Based on [illegible] determined that six acre-feet of runoff reduction volume would [illegible]n untreated Effective Impervious Area (EIA)"

Strategies/BMPs

Of the 46 locations visited, 6 existing dry basin conversions to infiltration, 16 new infiltration facilities, 5 vegetated channels and 1 constructed wetland were identified as example projects. Using the BMP-REALCOST structure sizing and cost approximations, based on drainage area, it was found that the 6 conversions would provide 1.77 acre-feet of storage while the 16 infiltration facilities would result in 3.87 acre-feet of storage. Runoff reduction practices placed after October 1998 (end of the sampling which formed the basis for the TMDL) were estimated to result in approximately a half-acre foot of storage. The non-infiltrating BMPs do not receive runoff reduction credits in DURMM, and therefore, do not count towards the six acre-feet goal. However, their removal efficiencies were factored into the pollutant reduction calculations.

The BMP-REALCOST structure sizing and cost approximations were used to develop a budgetary cost estimate for many of the example BMPs and retrofits. It is stressed that this sizing and cost information, based on "best fit" curves, is very imprecise in nature and intended as a planning tool only. Using these data and assumptions, the six locations identified for dry pond retrofits to [illegible]nately $400,000 to construct, and the 16 example infiltration facilities [illegible]n. The five vegetated channels and one constructed wetland were [illegible]y $100,000 and $36,000, respectively.

Reductions and cost per unit

Using values for reductions that have been approved by DNREC, it was found that the example retrofits and BMPs would result in 272 and 150 lb/year reductions in total nitrogen and total phosphorous loadings and a 2,575 billion (bn) CFU/year reduction in enterococcus bacteria. All told, the retrofits and new facilities described above, if able to be constructed, would cost approximately $3.5 million. This equates to $640,000 per acre-foot runoff reduction, $12,900 and $23,300 per pound total nitrogen and total phosphorous reduction per year, and $1,400 bn CFU annual reduction in enterococcus bacteria.

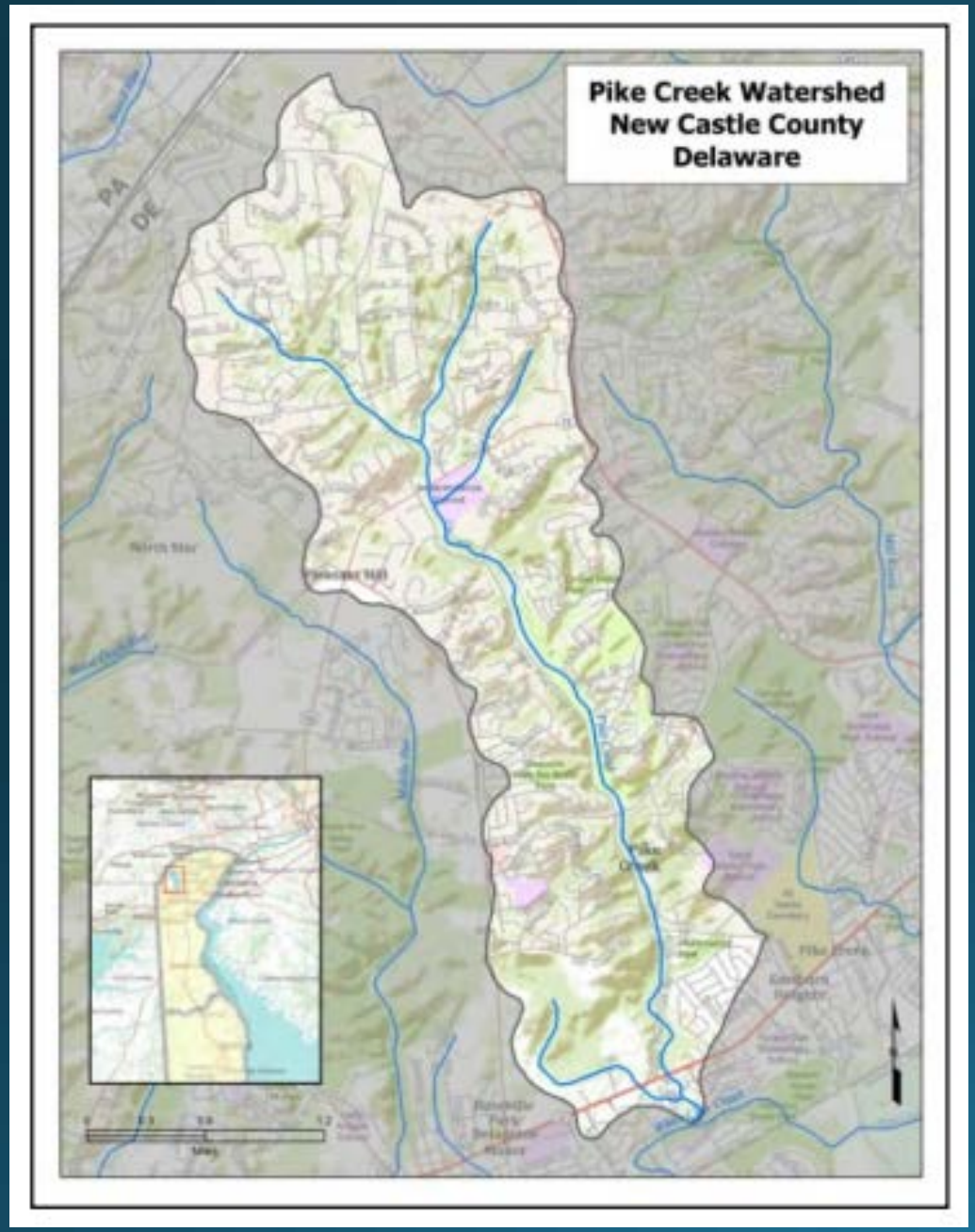
Conclusions and Recommendations

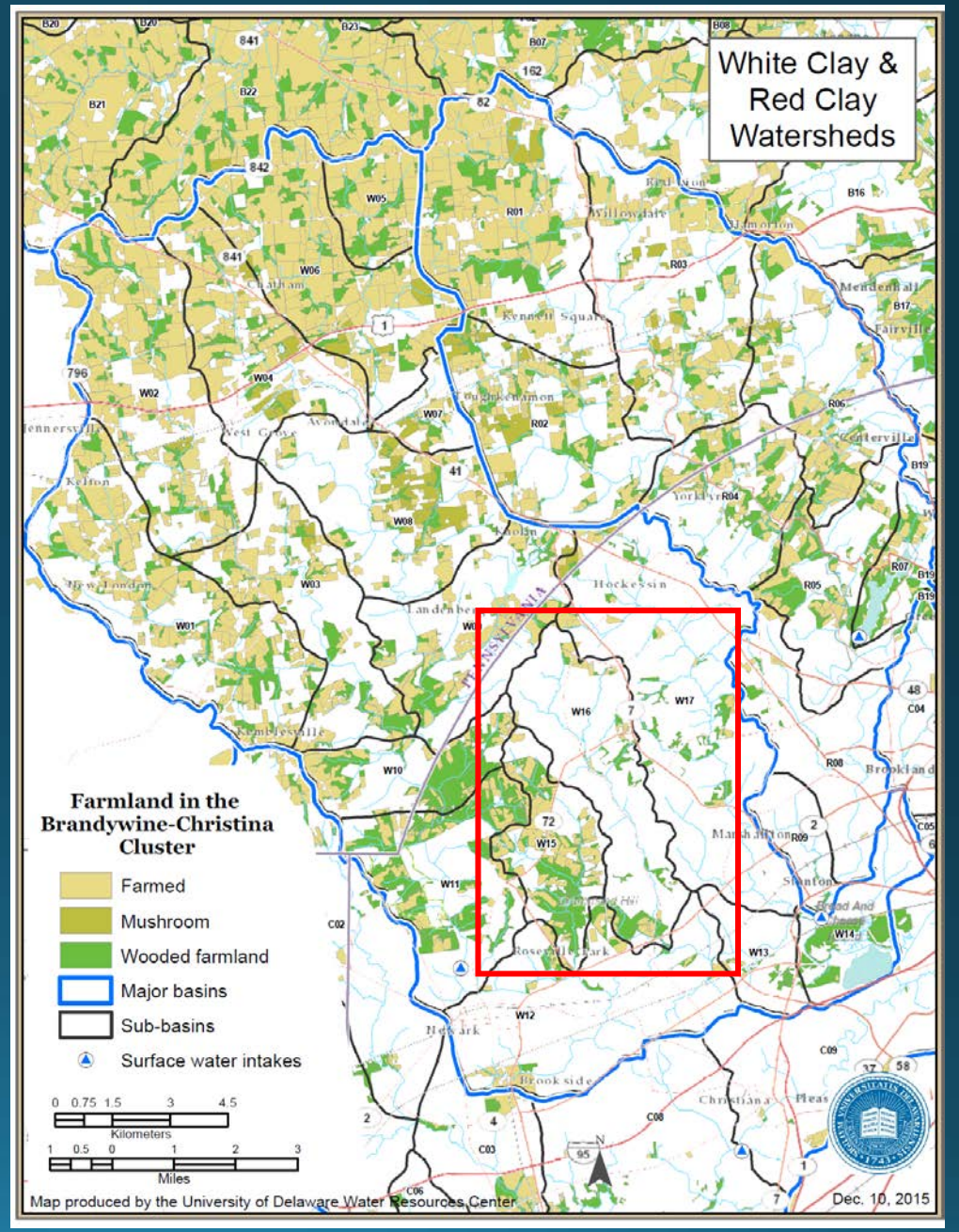
Pike Creek WQIP Example BMP implementation

Potential sites	Dry pond retrofits	Infiltration basins	vegetated channel	constructed wetlands	Total sites
49	6	16	5	1	28
TOTAL COST	$ 400,000	$ 3,000,000	$ 100,000	$ 36,000	$ 3,536,000

Table 8 – Per unit reduction costs of suggested BMPs.

	Reduction	Per Unit Cost
Runoff Reduction	5.5 acre-feet	$640,000
Total Nitrogen	272 lbs/year	$12,900
Total Phosphorous	150 lbs/year	$23,300
Enterococcus Bacteria	2,575 bn CFU/year	$1,400


Pike Creek Watershed
New Castle County
Delaware
PA
DE


White Clay &
Red Clay
Watersheds
Farmland in the
Brandywine-Christina
Cluster
Farmed
Mushroom
Wooded farmland
Major basins
Sub-basins
Surface water intakes
0 0.75 1.5 3 4.5
Kilometers
1 0.5 0 1 2 3
Miles
Map produced by the University of Delaware Water Resources Center
Dec. 10, 2015

Pike Creek WQIP Example BMP implementation
Nitrogen Reductions

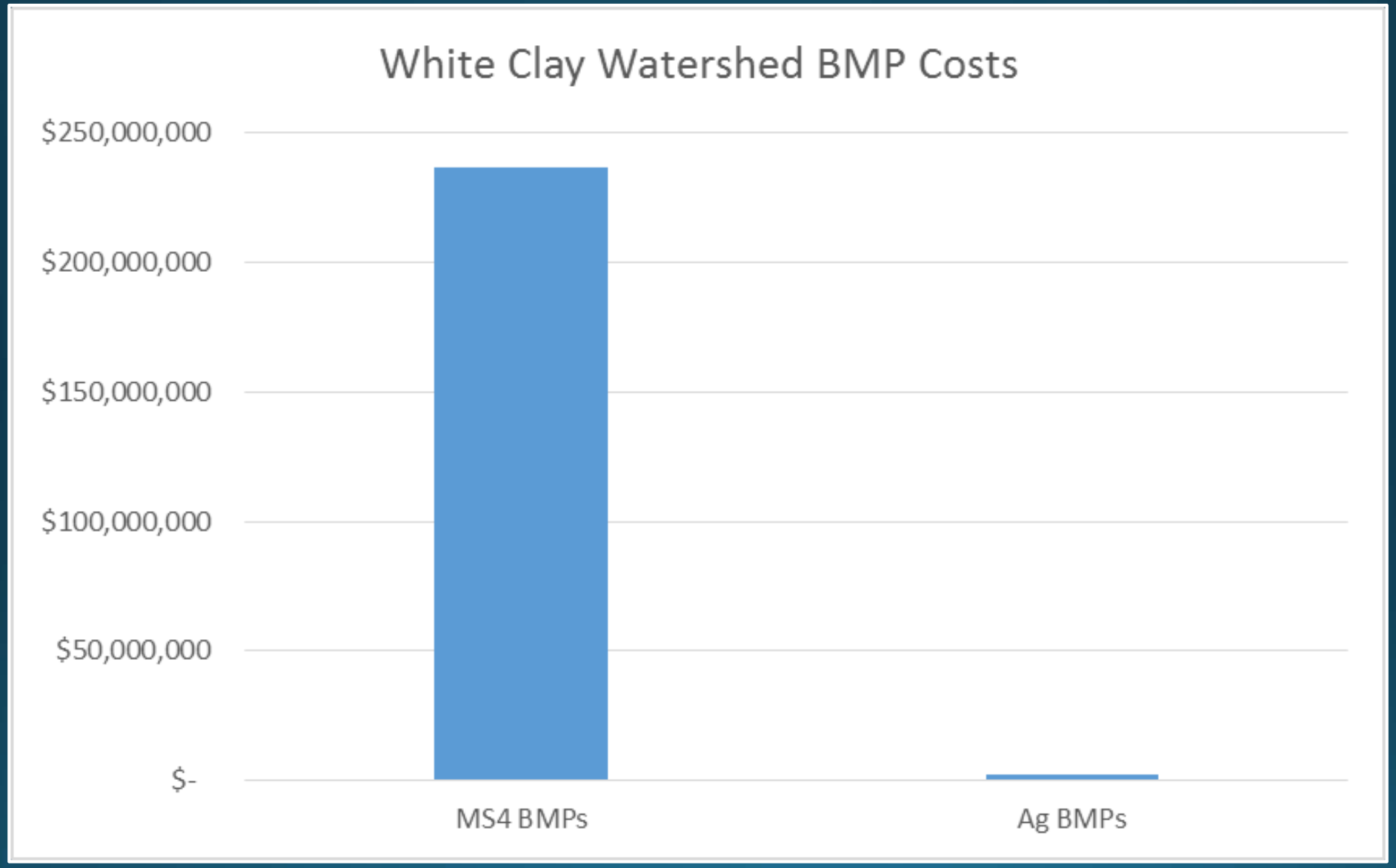
W16	$ 3,500,000	$240,000/year	Total reduction, Pike Creek	
	28 of 49 BMPs		272.00	lb/year
			123.38	kg/year
			0.34	kg/day

Pike Creek WQIP Example BMP implementation Nitrogen Reductions

- 457 kg nitrogen reduction required per TMDL in White Clay
- To hit target at similar reduction costs for MS4 BMPs
  - $6,495,636,085 total, with 20 year loan at 3% interest ($324,781,804 per year)
  - $4,736,401,312 total, without debt load.
  - $236,820,066 per year without debt load

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)


White Clay Watershed BMP Costs
$250,000,000
$200,000,000
$150,000,000
$100,000,000
$50,000,000
$-
MS4 BMPs
Ag BMPs

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

Next steps

- Purveyors
- Utility Commissions
- MS4
- Cluster Partners = Implementors
- Leveraged Funding
- Stacked Investment
- Design and set up fund