Annual Nutrient Loads for the Inland Bays Watershed

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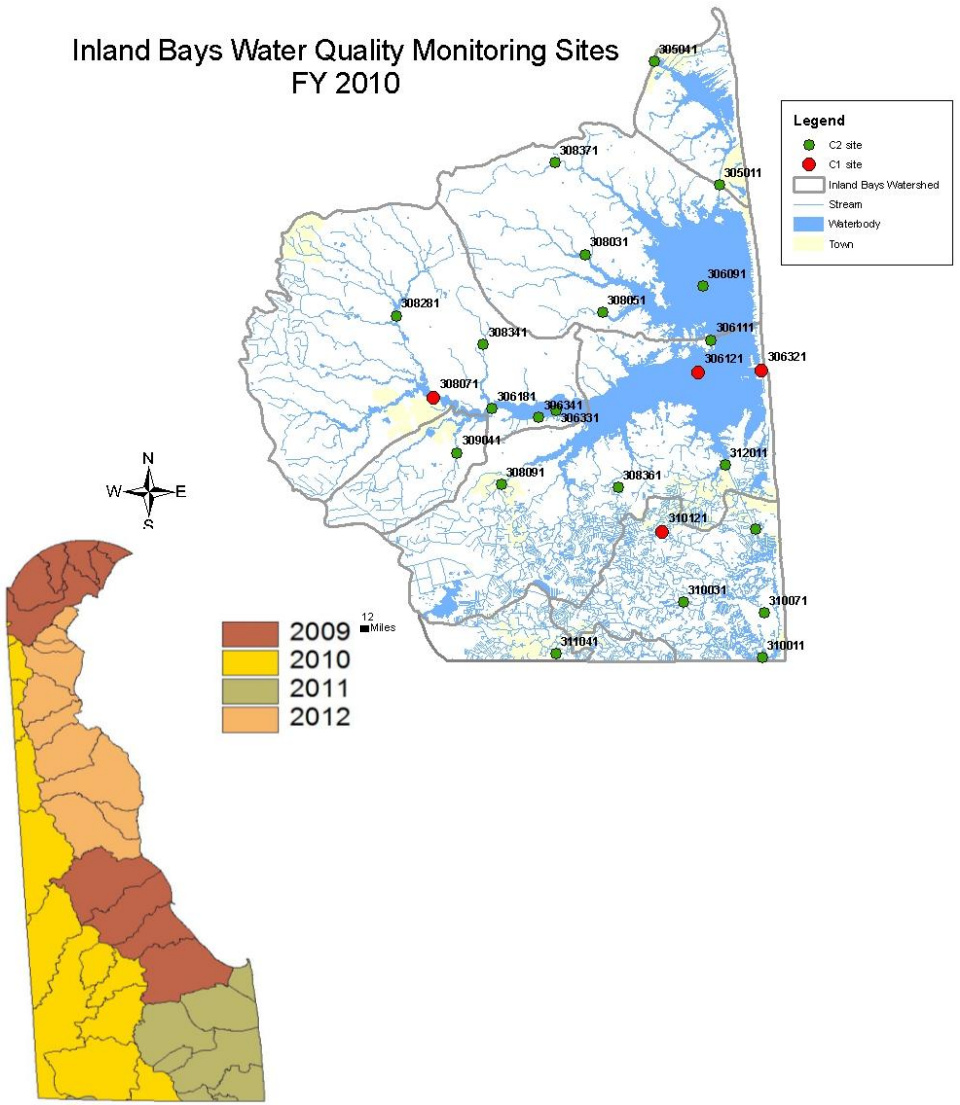
Outline

- DNREC water quality monitoring
- Annual load calculation
- Assumptions, limitations, and plan for improvement
- Comparison with other studies (Millsboro Pond Project, TMDLs)

DNREC Water Quality Monitoring

- 22 sites (9 free flowing)
- 5 Year rotating basin schedule:
  - Monthly sampling for 2 years
  - Bi-monthly sampling for 3 years
  - Except 4 Category 1 sites that are always monitored monthly



Water Samples are Analyzed for:

- **Nutrients**
  - Phosphorus (dissolved, total)
  - Soluble Ortho-phosphorus
  - Nitrogen (dissolved, total)
  - Ammonia Nitrogen (dissolved, total)
  - Nitrite + Nitrate N (dissolved, total)
- **Carbon and Organics**
  - Organic Carbon (dissolved, total)
  - BOD_5, N-Inhib (CBOD5)
  - BOD_{20}, N-Inhib (CBOD20)
  - Chlorophyll-a
- **Bacteria**
  - Enterococcus
- **General**
  - Dissolved oxygen
  - Total Suspended Solids
  - Alkalinity
  - Hardness
  - pH
  - Specific Conductance
  - Salinity
  - Temperature
  - Secchi Depth
  - Light Attenuation
  - Turbidity
- **Metals (dissolved and total)**
  - Copper
  - Lead
  - Zinc

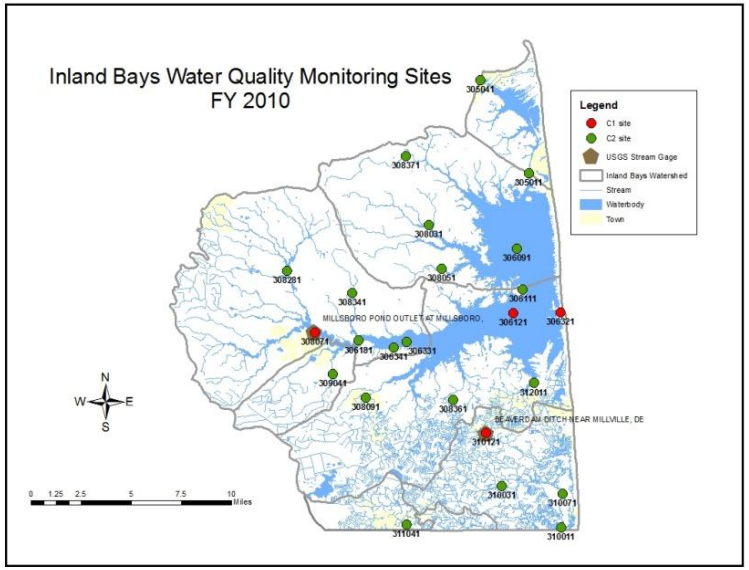
Calculating Annual Nutrient Loads

- Annual nutrient loads are calculated to track progress toward achieving:
  - Total Maximum Daily Loads (TMDLs) and
  - Pollution Control Strategy (PCS) targets

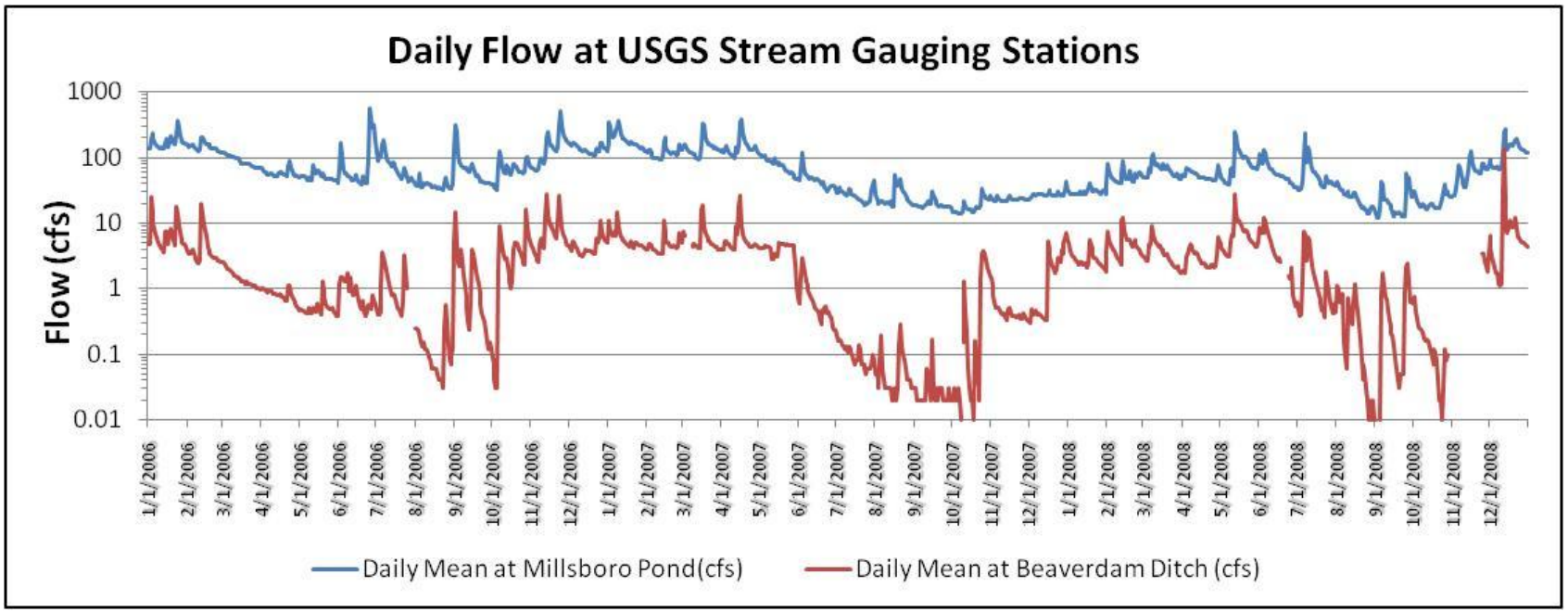
- Annual non-point source nutrient loads are calculated for the Inland Bays (and many other watersheds) for the years 2006, 2007, and 2008

Annual Load Calculation

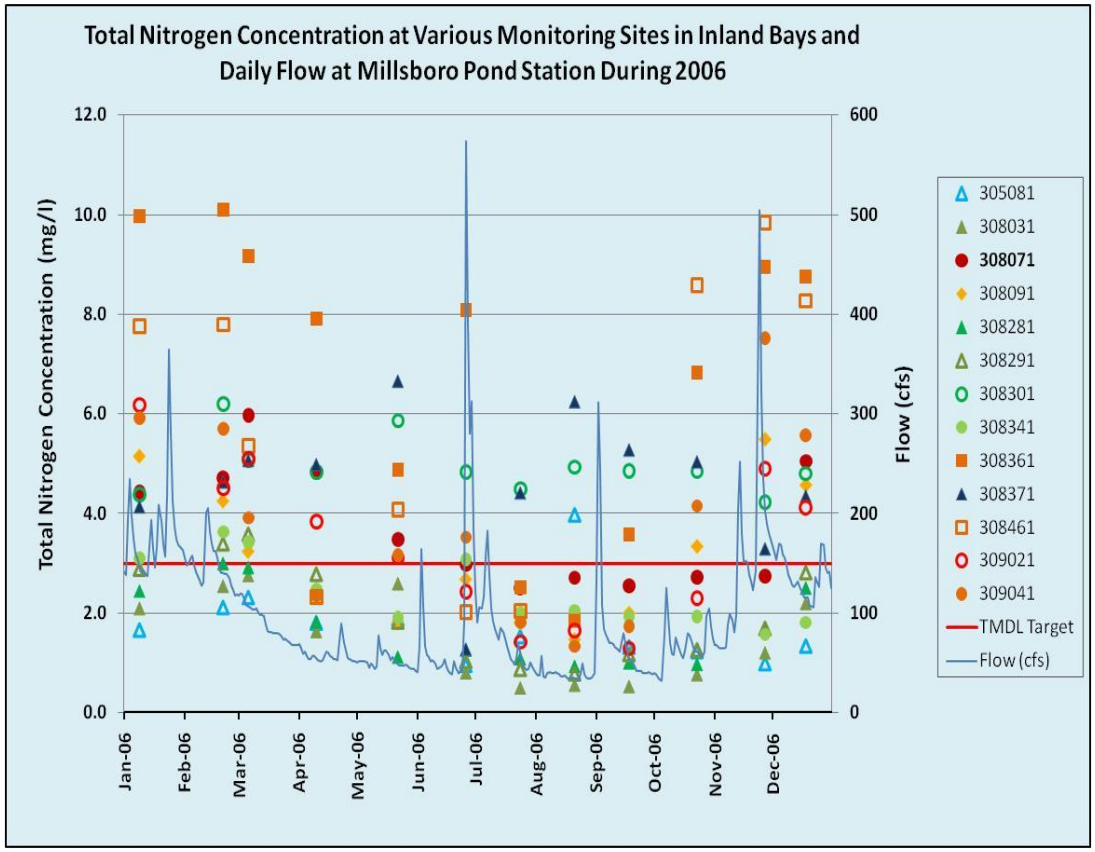
1. For each month, average concentration of N and P at all free flowing sites within a watershed is calculated
2. monthly-average flow for the entire watershed is calculated using stream gage flow data
3. Monthly load of N and P is calculated by multiplying monthly-average concentration and monthly flow for the watershed
4. Annual load is calculated by adding monthly loads for entire year

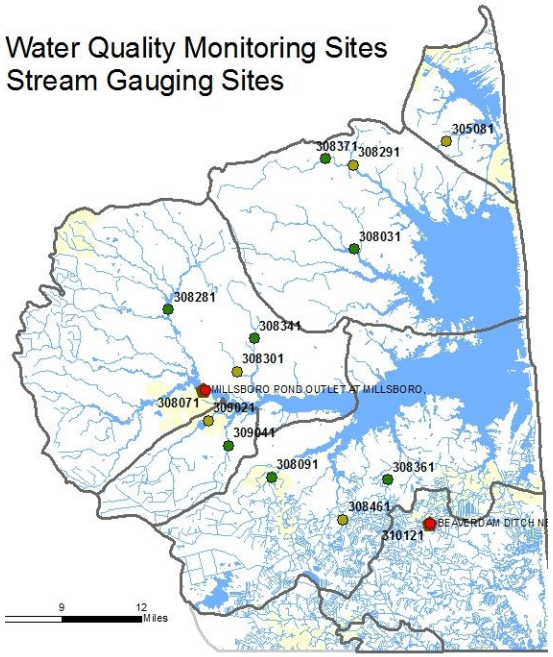


Because of differences in watershed characteristics, nutrient loads for Little Assawoman Bay drainage area is calculated separately from the rest of the Inland Bays watershed


Daily Flow at USGS Stream Gauging Stations
Flow (cfs)
1000
100
10
1
0.1
0.01
1/1/2006
2/1/2006
3/1/2006
4/1/2006
5/1/2006
6/1/2006
7/1/2006
8/1/2006
9/1/2006
10/1/2006
11/1/2006
12/1/2006
1/1/2007
2/1/2007
3/1/2007
4/1/2007
5/1/2007
6/1/2007
7/1/2007
8/1/2007
9/1/2007
10/1/2007
11/1/2007
12/1/2007
1/1/2008
2/1/2008
3/1/2008
4/1/2008
5/1/2008
6/1/2008
7/1/2008
8/1/2008
9/1/2008
10/1/2008
11/1/2008
12/1/2008
Daily Mean at Millsboro Pond(cfs)
Daily Mean at Beaverdam Ditch (cfs)

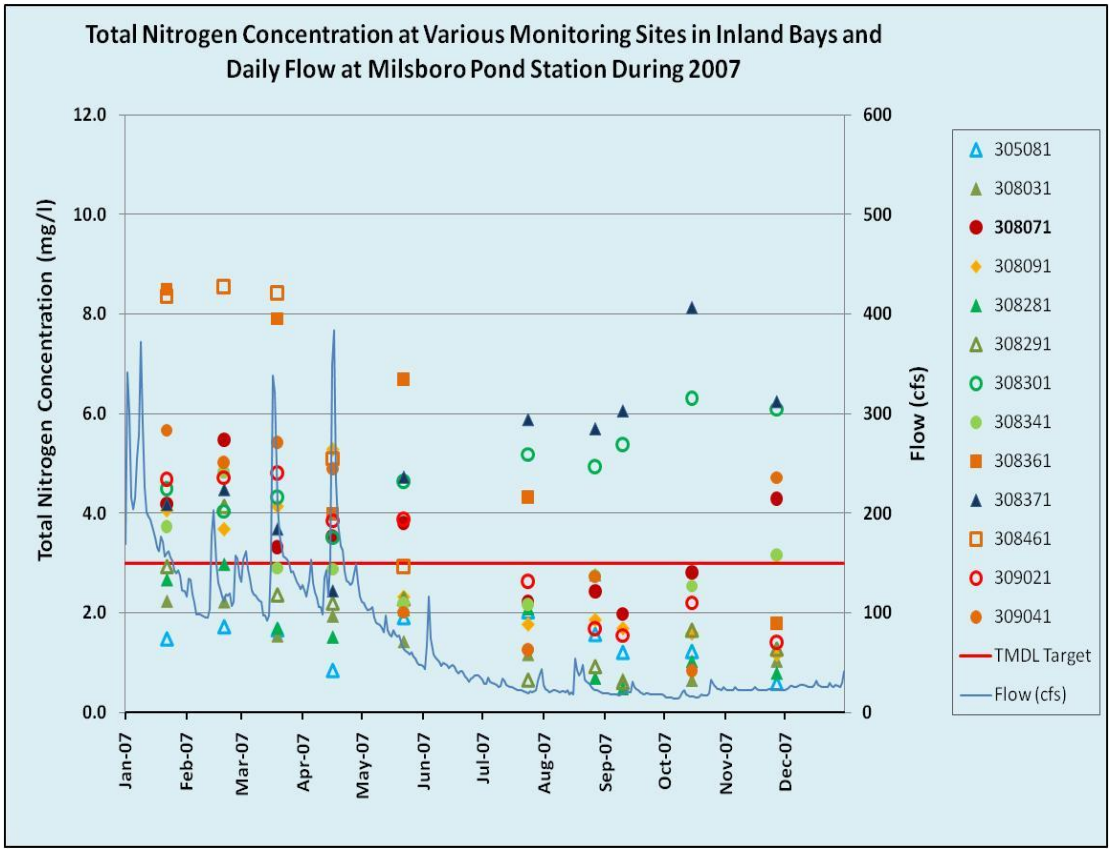

USGS

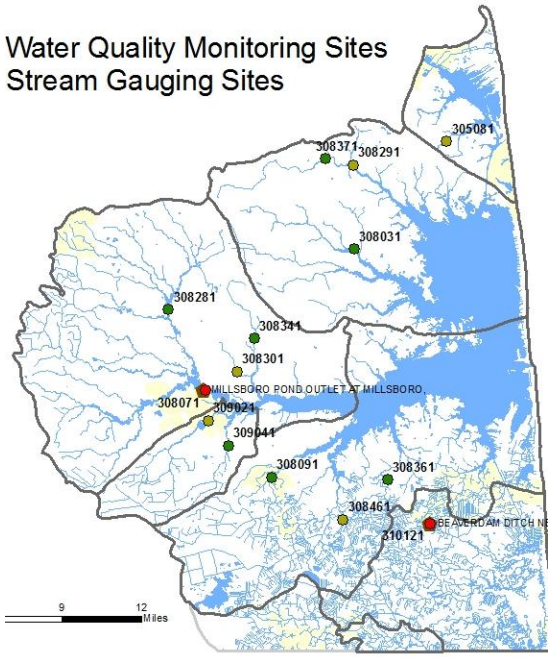




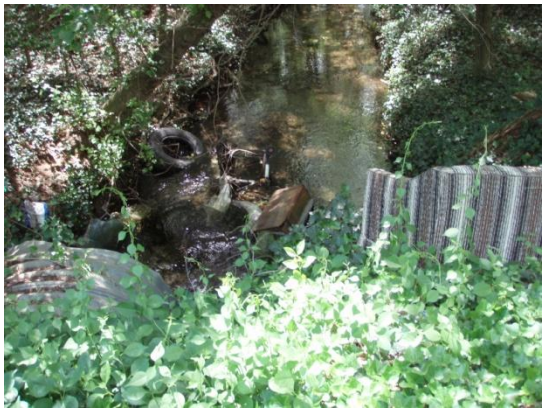
Blackwater Creek - 308361

Munchy Branch - 305081

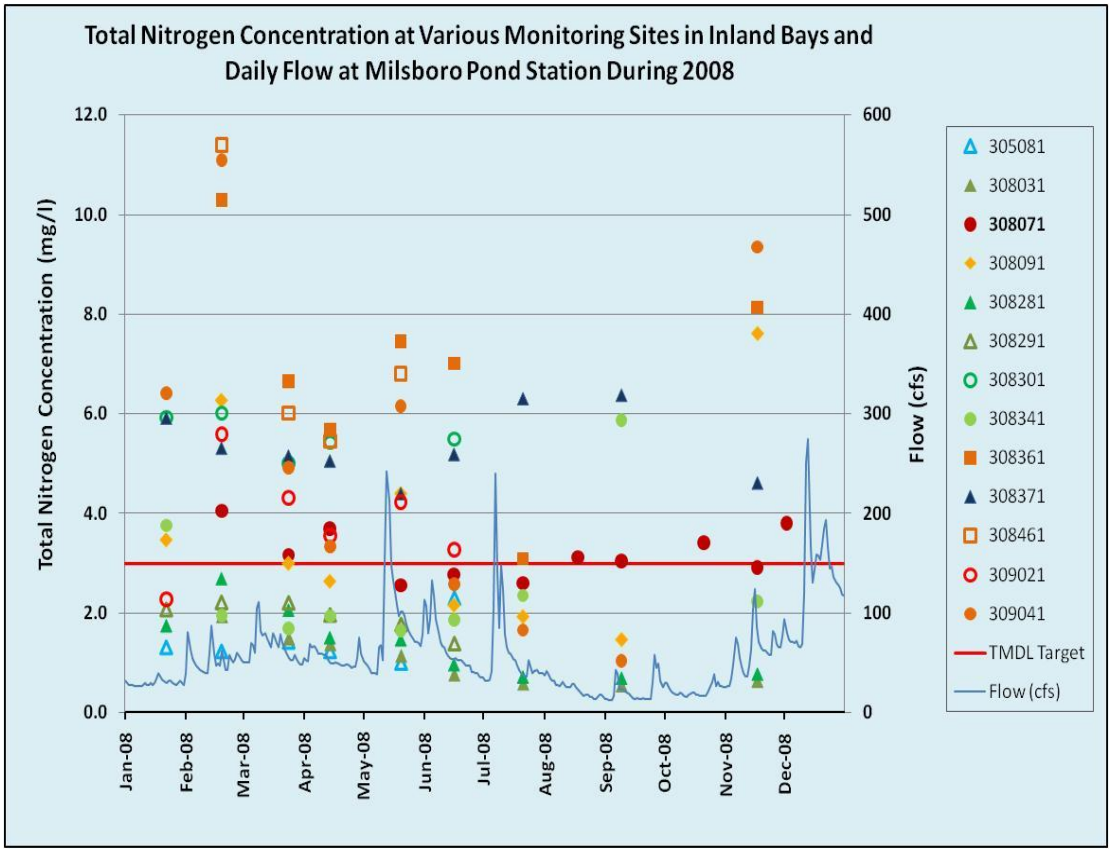


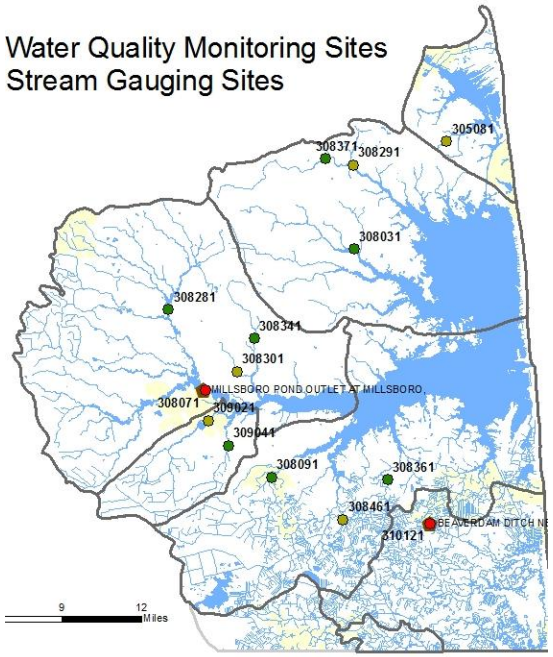


Bundick's Branch – 308371



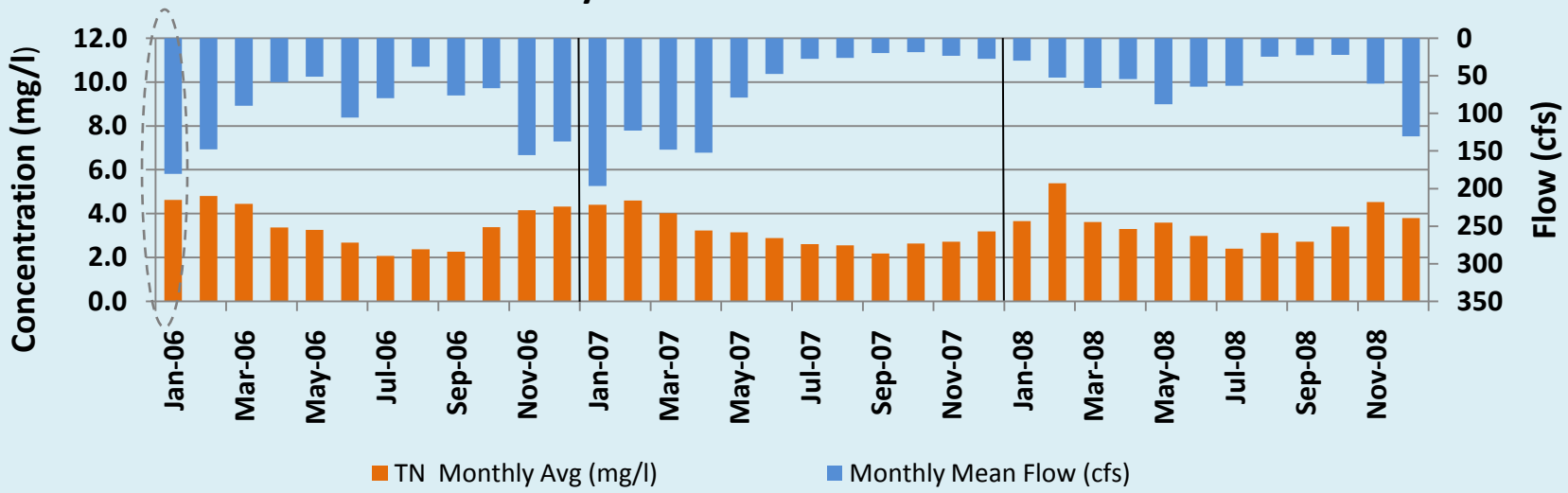
Swan Creek- 308301



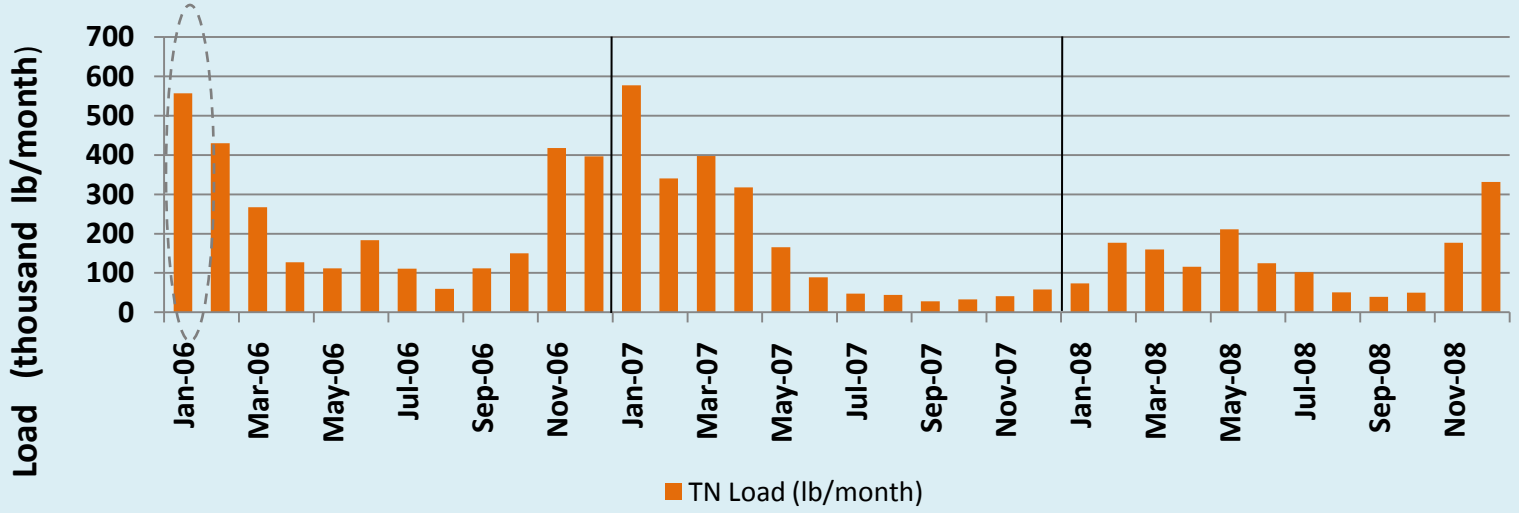


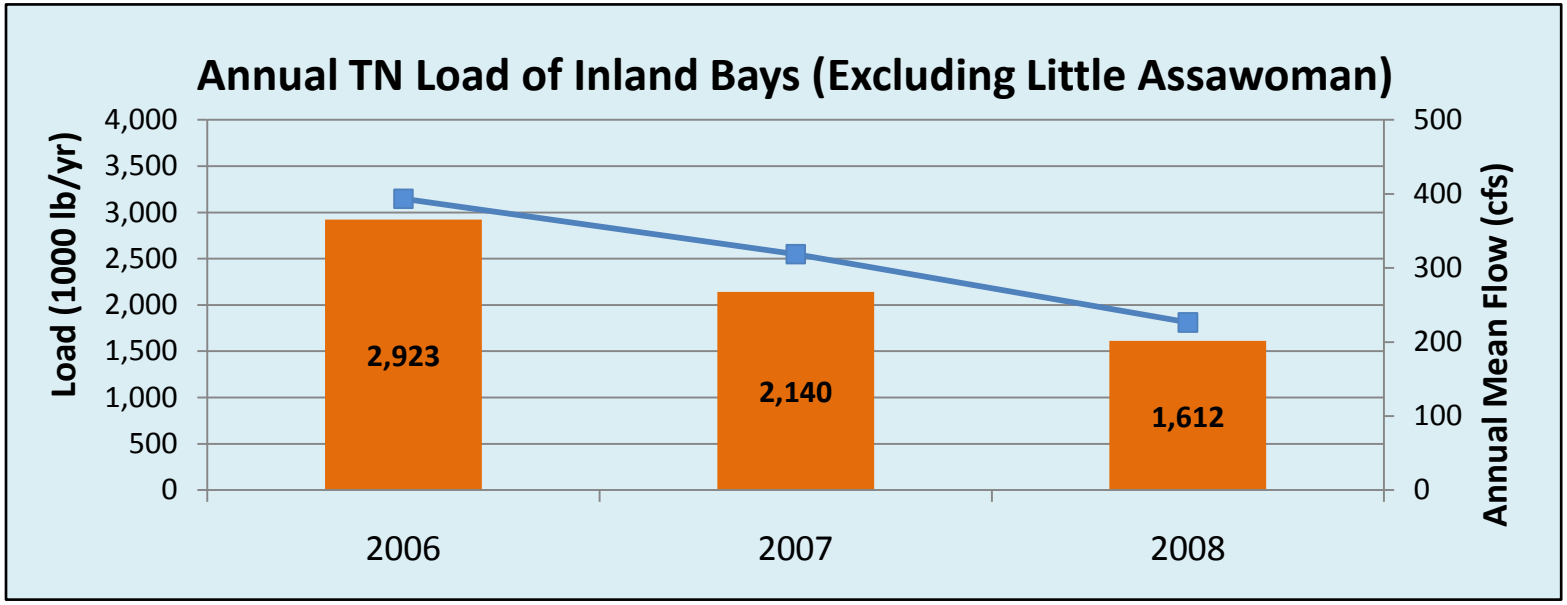
Wharton Branch - 309041

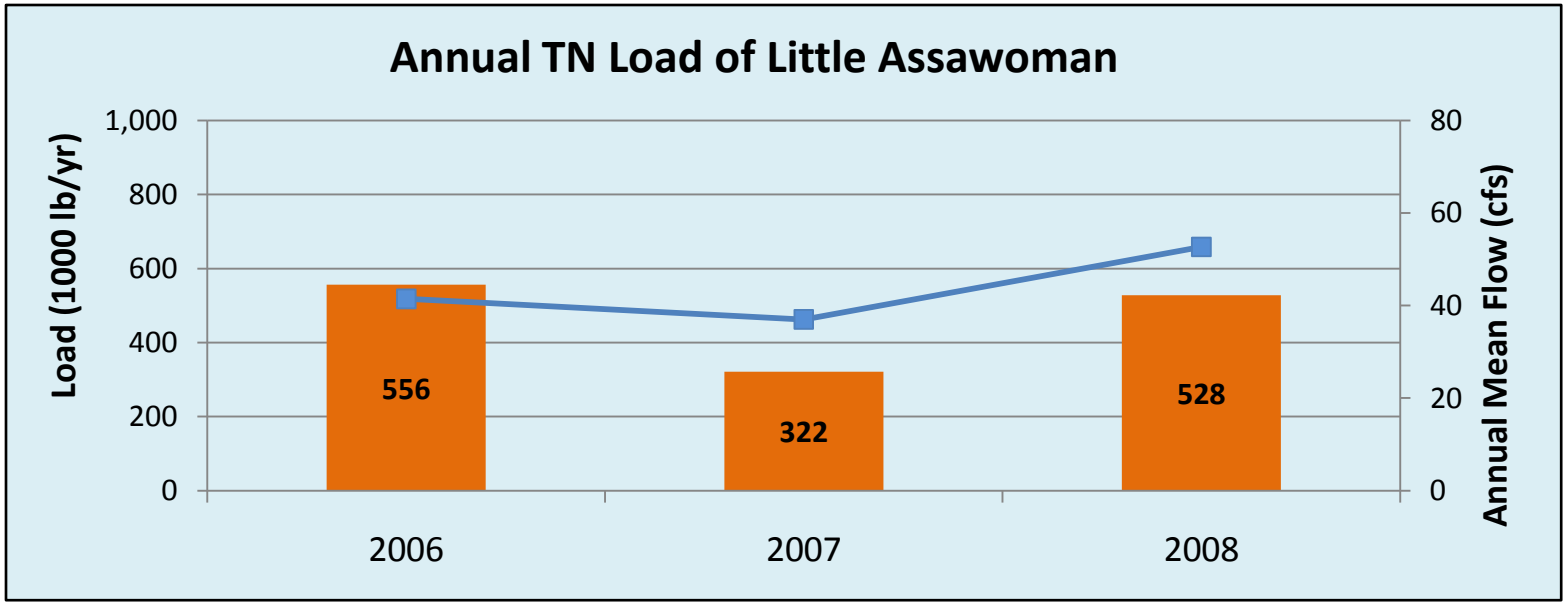
Averaged TN Concentration of Each Month throughout Inland Bays and Monthly Mean Flow at Millsboro Pond

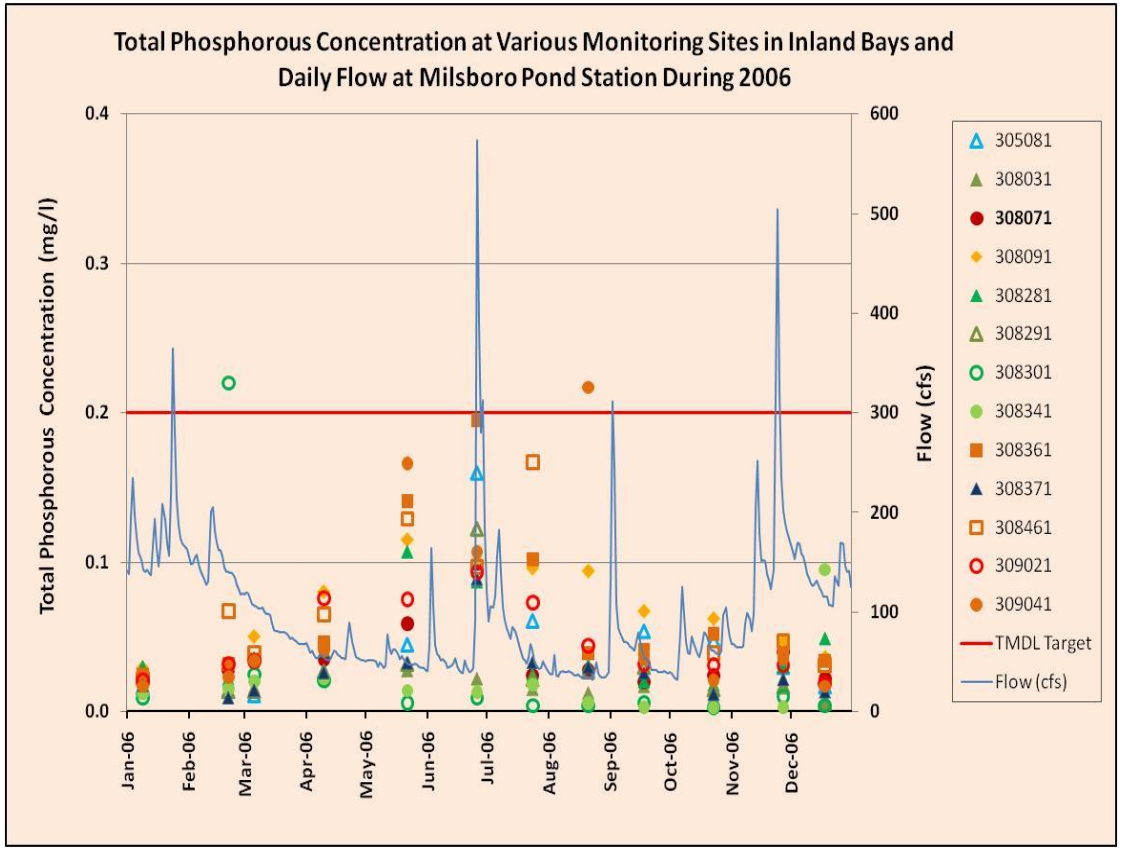


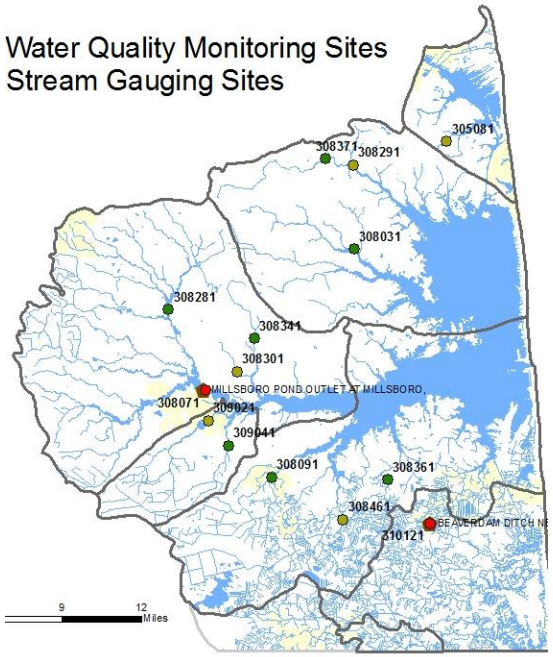
Average TN Load from Inland Bays




Annual TN Load of Inland Bays (Excluding Little Assawoman)
Load (1000 lb/yr)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
500
400
300
200
100
0
Annual Mean Flow (cfs)
2,923
2,140
1,612
2006
2007
2008

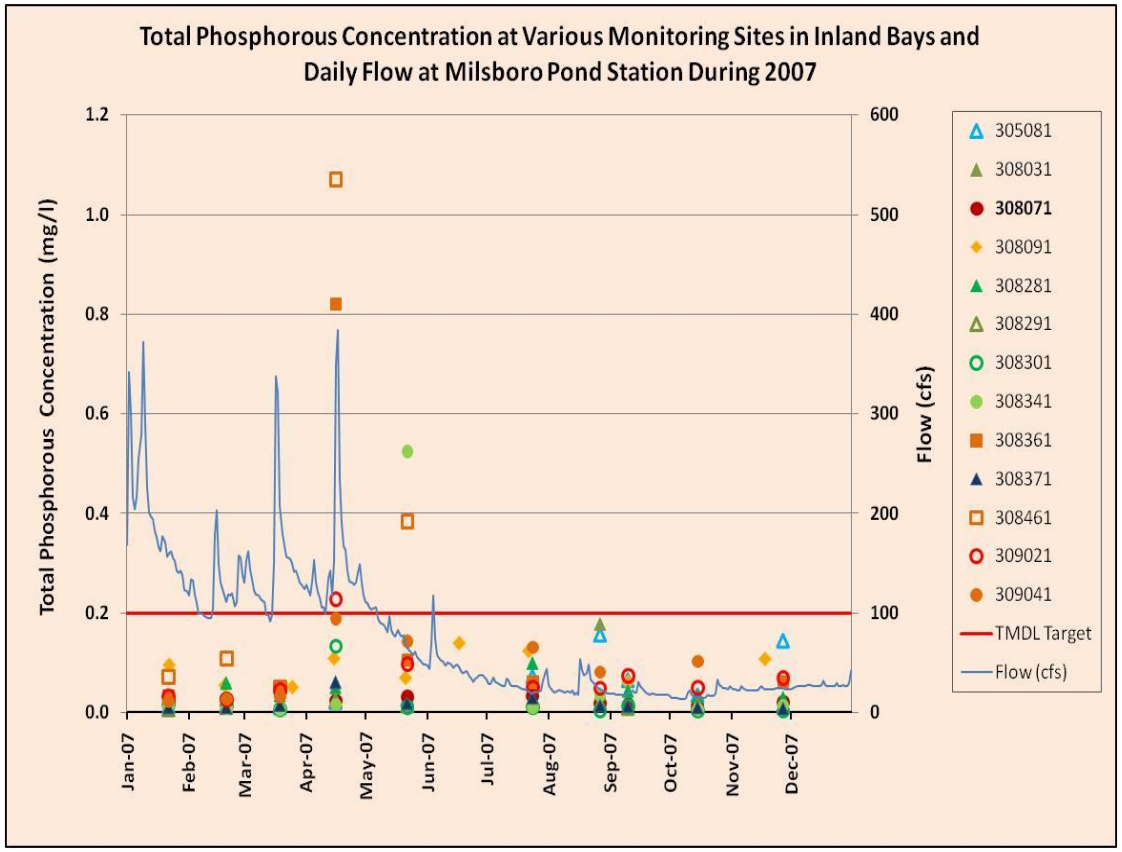

Annual TN Load of Little Assawoman
Load (1000 lb/yr)
1,000
800
600
400
200
0
80
60
40
20
0
Annual Mean Flow (cfs)
556
322
528
2006
2007
2008

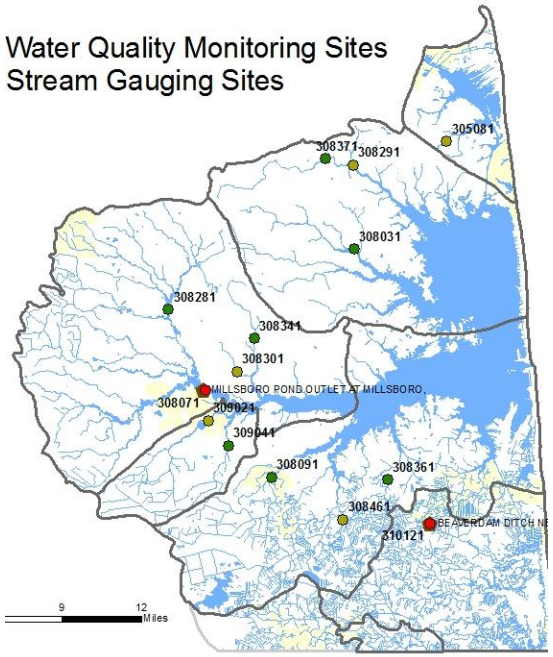




Swan Creek- 308301

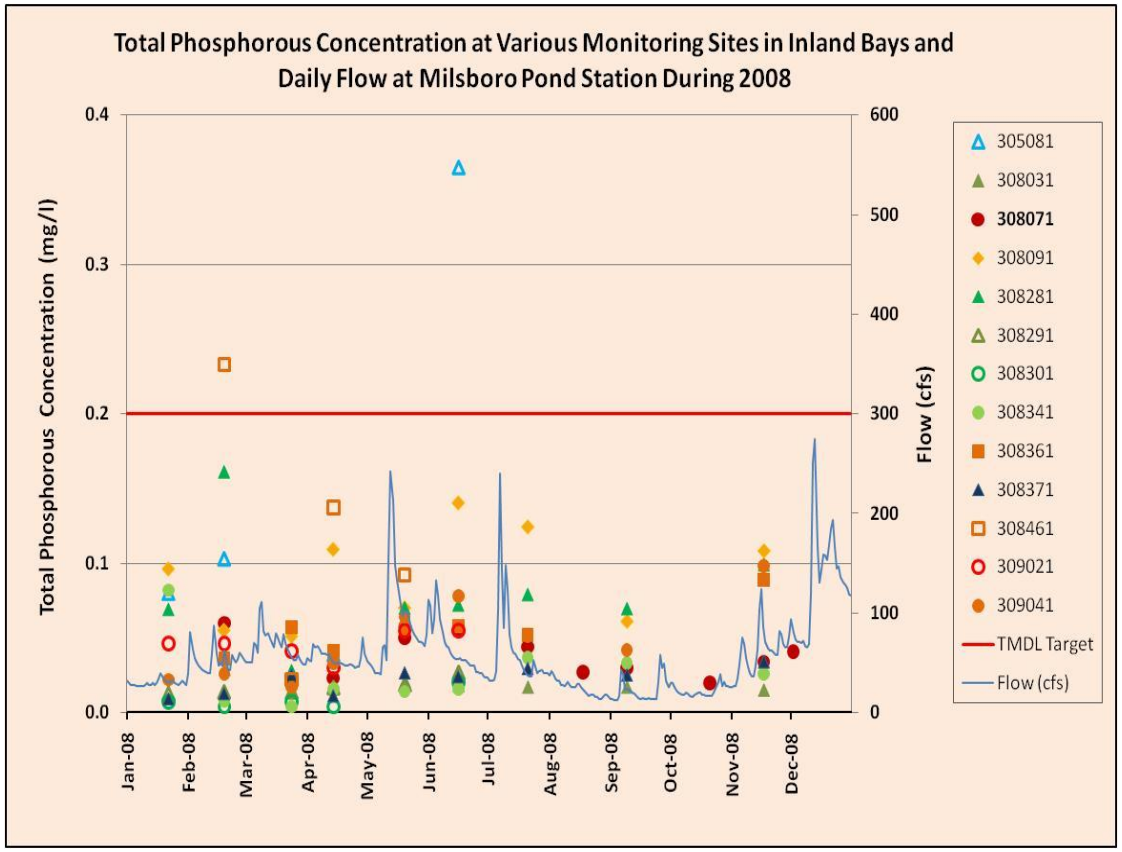
Wharton Branch - 309041

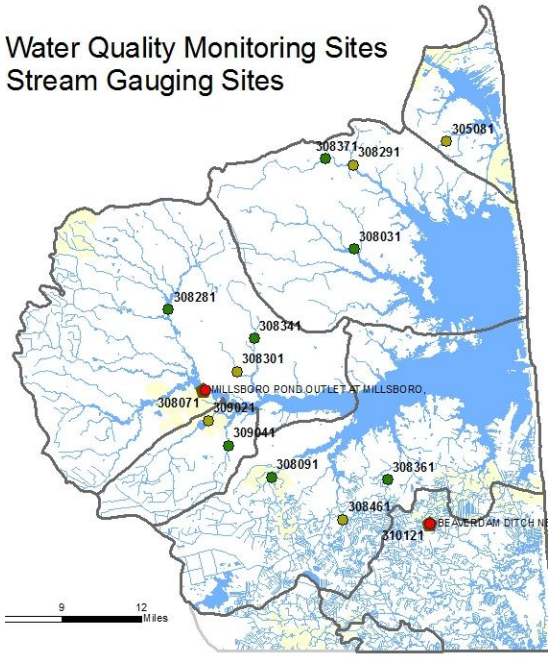




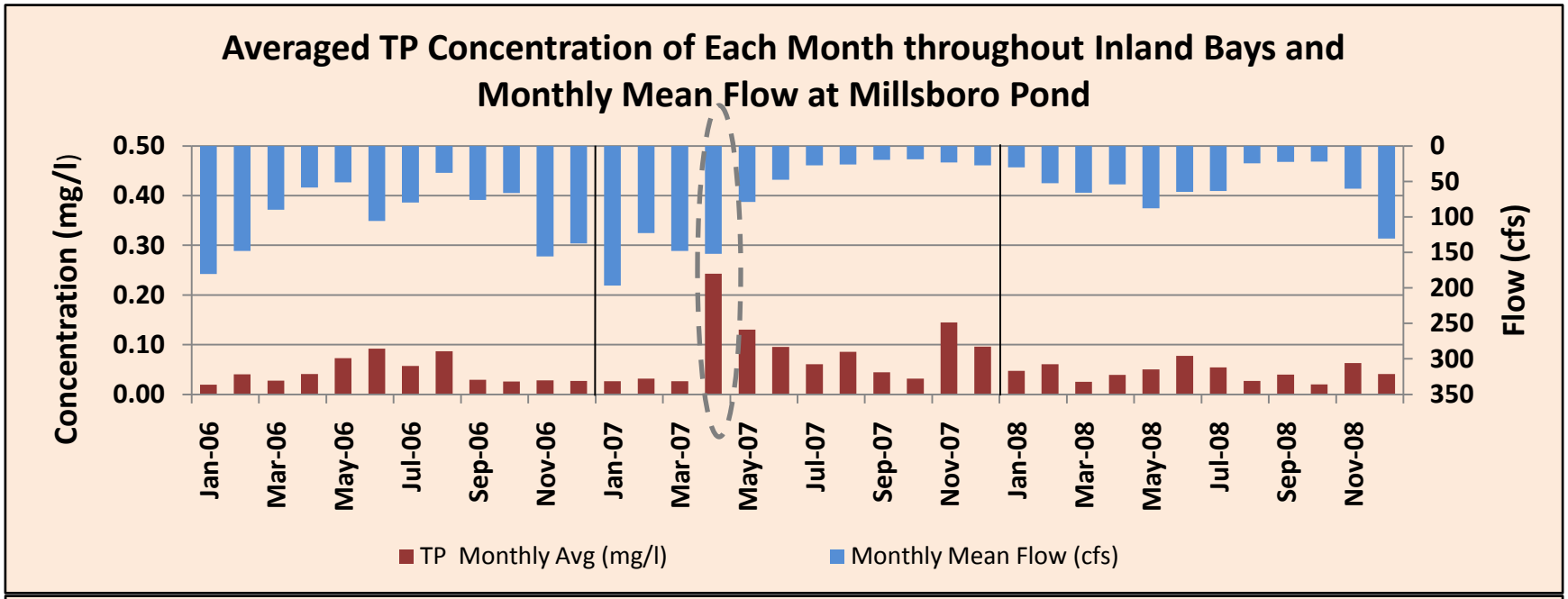
Deep Hole Branch- 308461

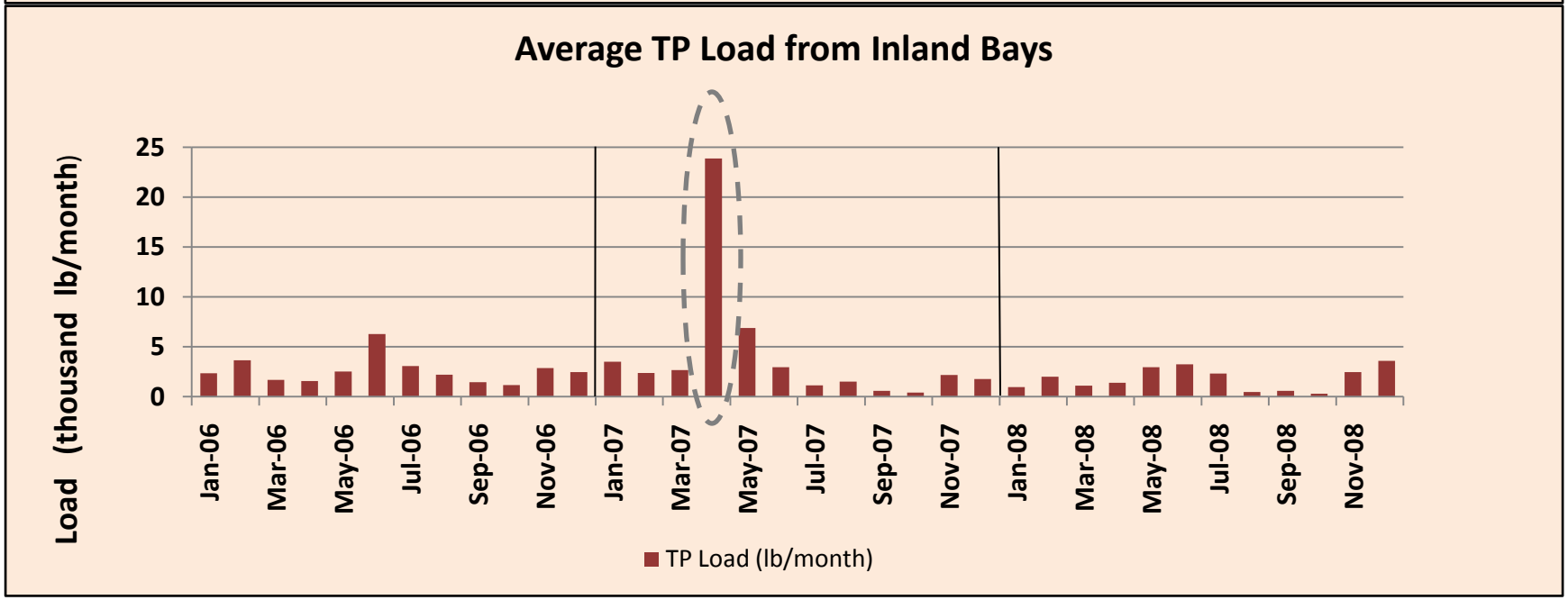
Swan Creek at 297 Bridge - 308341

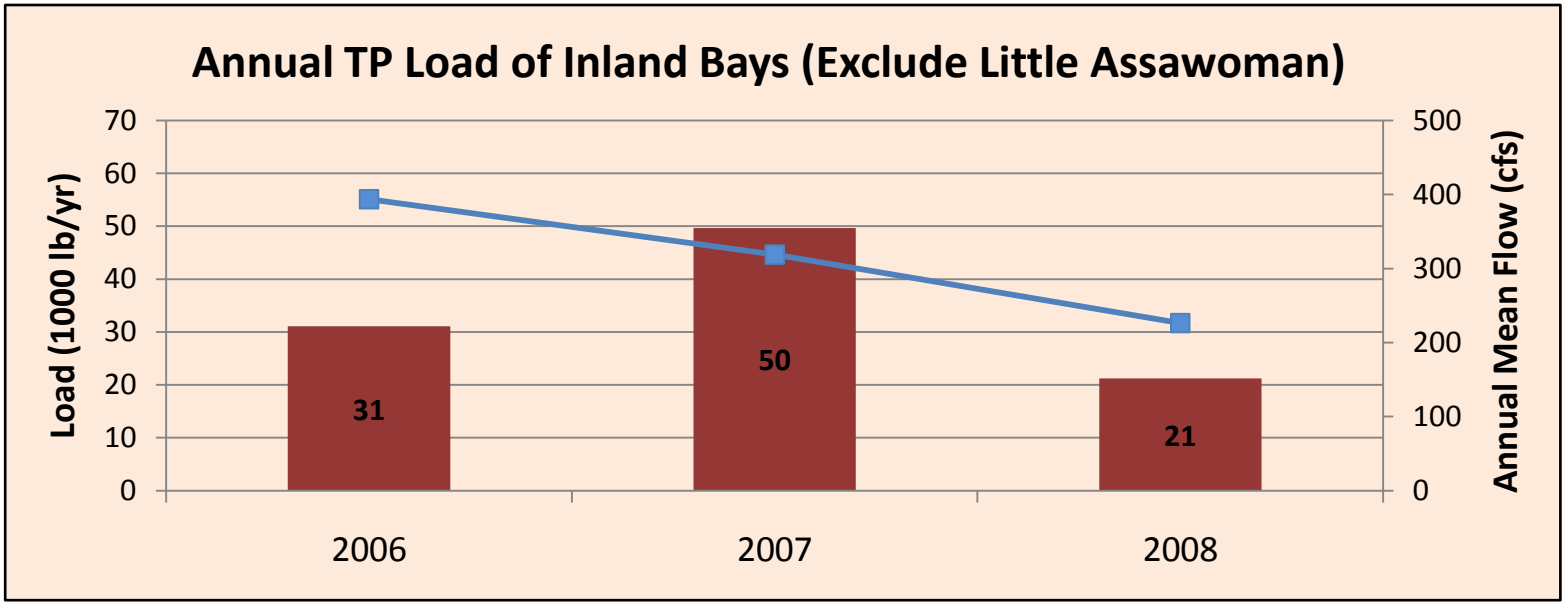


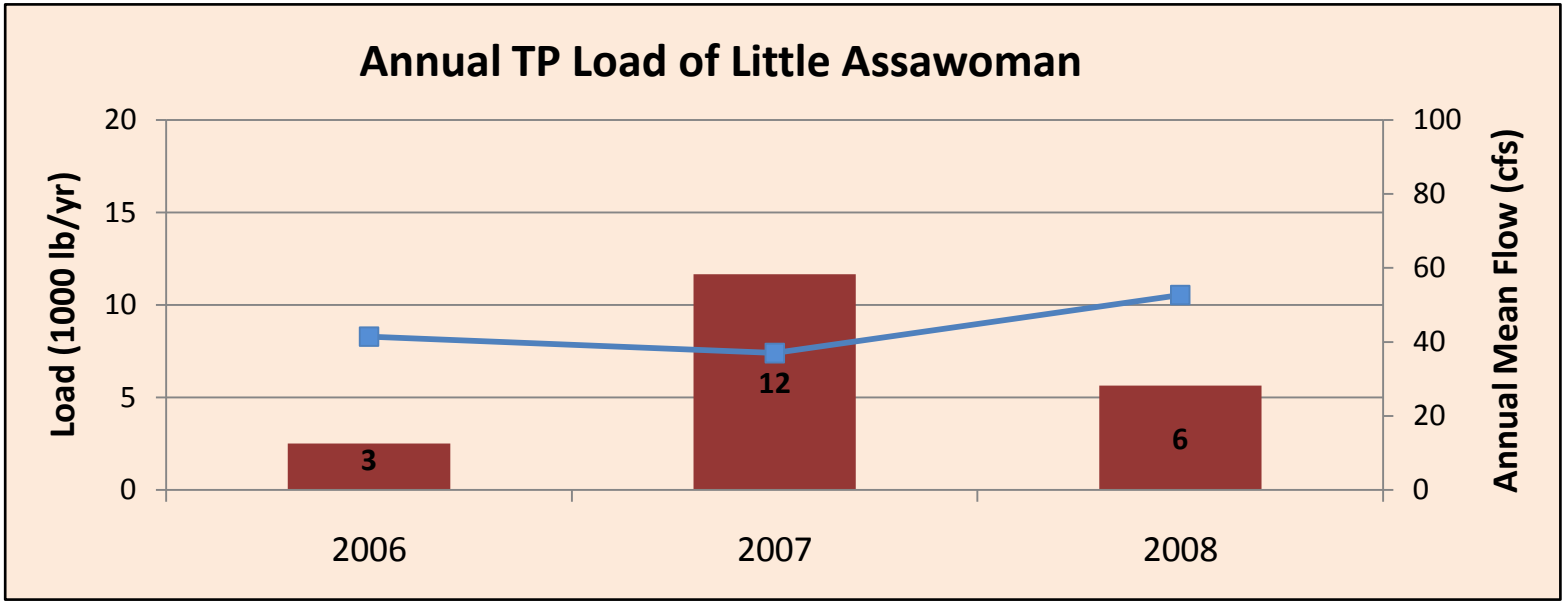


Munchy Branch - 305081


Averaged TP Concentration of Each Month throughout Inland Bays and Monthly Mean Flow at Millsboro Pond
Concentration (mg/l)
0.50
0.40
0.30
0.20
0.10
0.00
Flow (cfs)
0
50
100
150
200
250
300
350
Jan-06
Mar-06
May-06
Jul-06
Sep-06
Nov-06
Jan-07
Mar-07
May-07
Jul-07
Sep-07
Nov-07
Jan-08
Mar-08
May-08
Jul-08
Sep-08
Nov-08
TP Monthly Avg (mg/l)
Monthly Mean Flow (cfs)

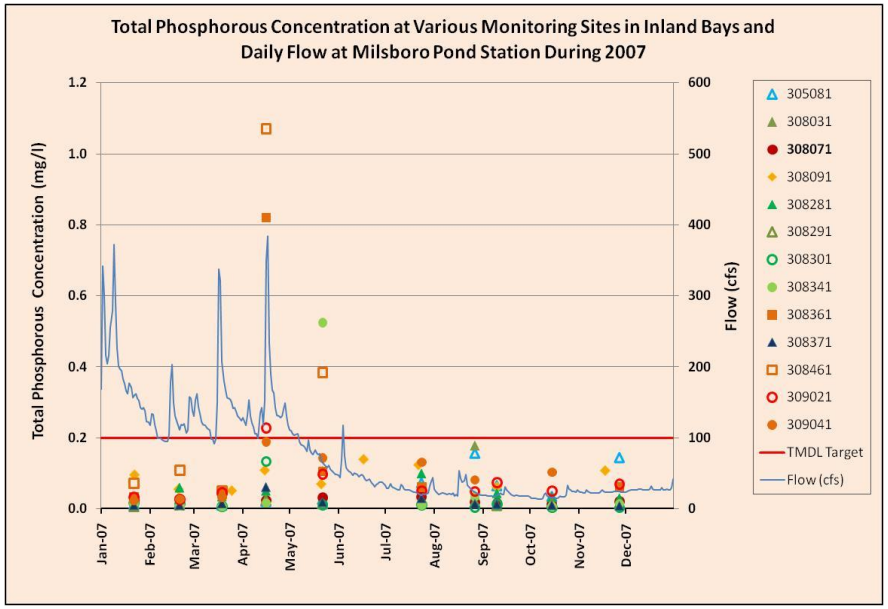

Average TP Load from Inland Bays
Load (thousand lb/month)
25
20
15
10
5
0
Jan-06
Mar-06
May-06
Jul-06
Sep-06
Nov-06
Jan-07
Mar-07
May-07
Jul-07
Sep-07
Nov-07
Jan-08
Mar-08
May-08
Jul-08
Sep-08
Nov-08
TP Load (lb/month)


Annual TP Load of Inland Bays (Exclude Little Assawoman)
Load (1000 lb/yr)
70
60
50
40
30
20
10
0
500
400
300
200
100
0
Annual Mean Flow (cfs)
31
50
21
2006
2007
2008


Annual TP Load of Little Assawoman
Load (1000 lb/yr)
20
15
10
5
0
100
80
60
40
20
0
Annual Mean Flow (cfs)
3
12
6
2006
2007
2008

Assumptions, Limitations, and Plan for Improvement

- In this method, we assume that average concentration of N and P during the day of monitoring represents monthly-average concentration.
- It appears that this assumption is acceptable for nitrogen. However, for phosphorus, it generally underestimates monthly load (except when sample is taken during storm event)
- To address this limitation, we have started collecting 3 stormwater samples per year at all free flowing category 1 sites

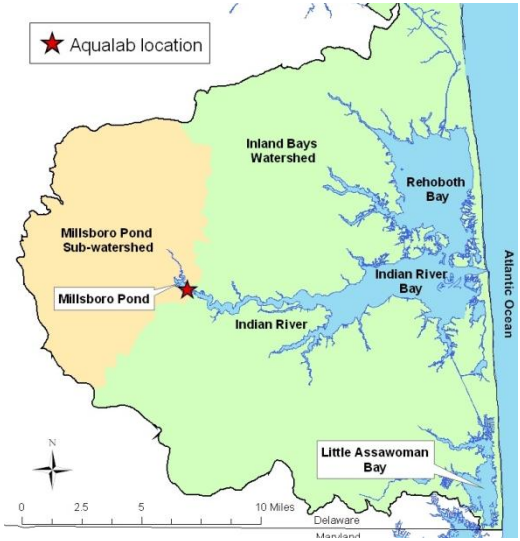


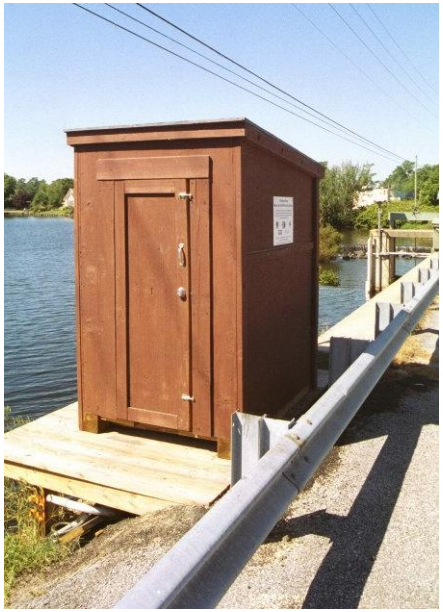
Comparison with other Studies

- Nutrient loads calculated here is compared with loads estimated by the following two studies:
  - Millsboro Pond (Aqualab) project
  - The 1998 and 2004 Inland Bays TMDLs analyses

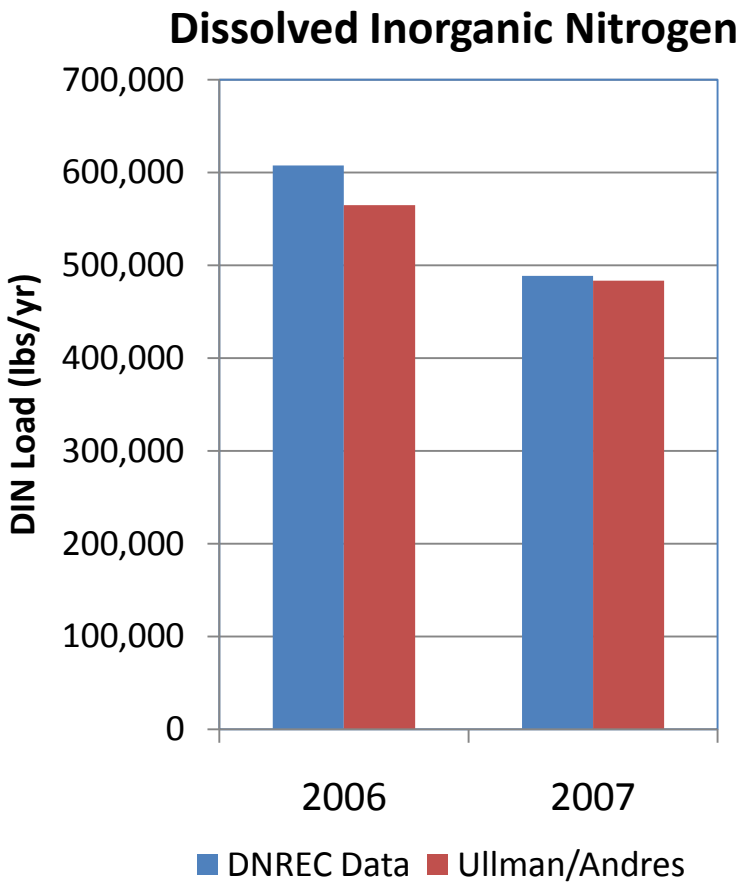
Millsboro Pond/Aqualab Project

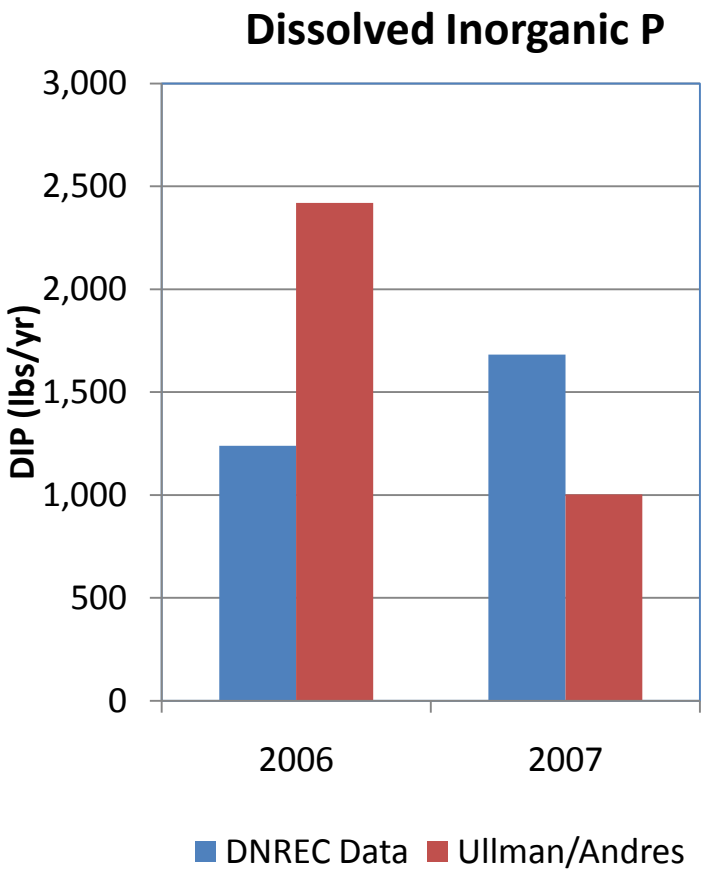
- Project started in 2004 under the direction of Dr. Ullman and Scott Andres by installing a Greenspan Aqualab water quality analyzer at Millsboro Pond
- Aqualab is a self-contained, automated analyzer and measures dissolved oxygen, pH, conductivity, temperature, turbidity, nitrate, ammonium, and phosphate with high frequency
- Considering that nutrients are measured every 4 hours at this site, the load estimate should be very accurate





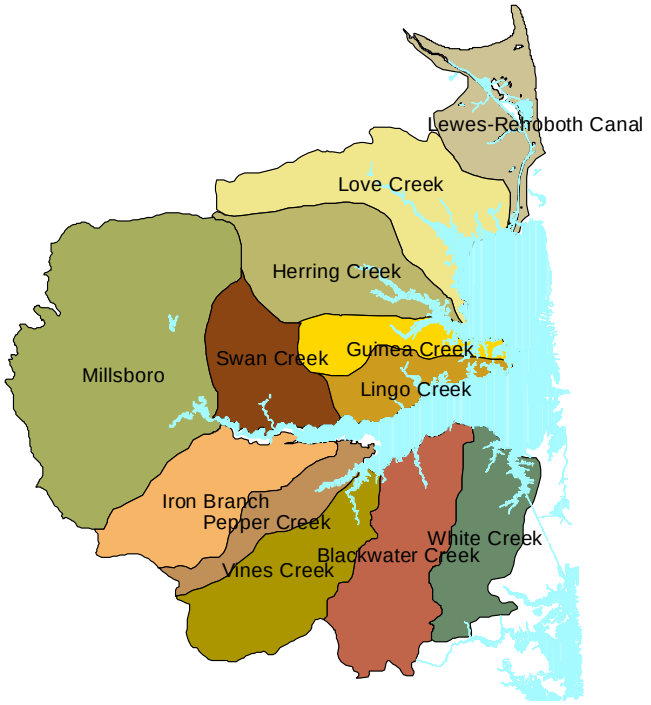
Comparison of DNREC Load Estimates for Millsboro Pond Drainage Area With Aqualab Estimates

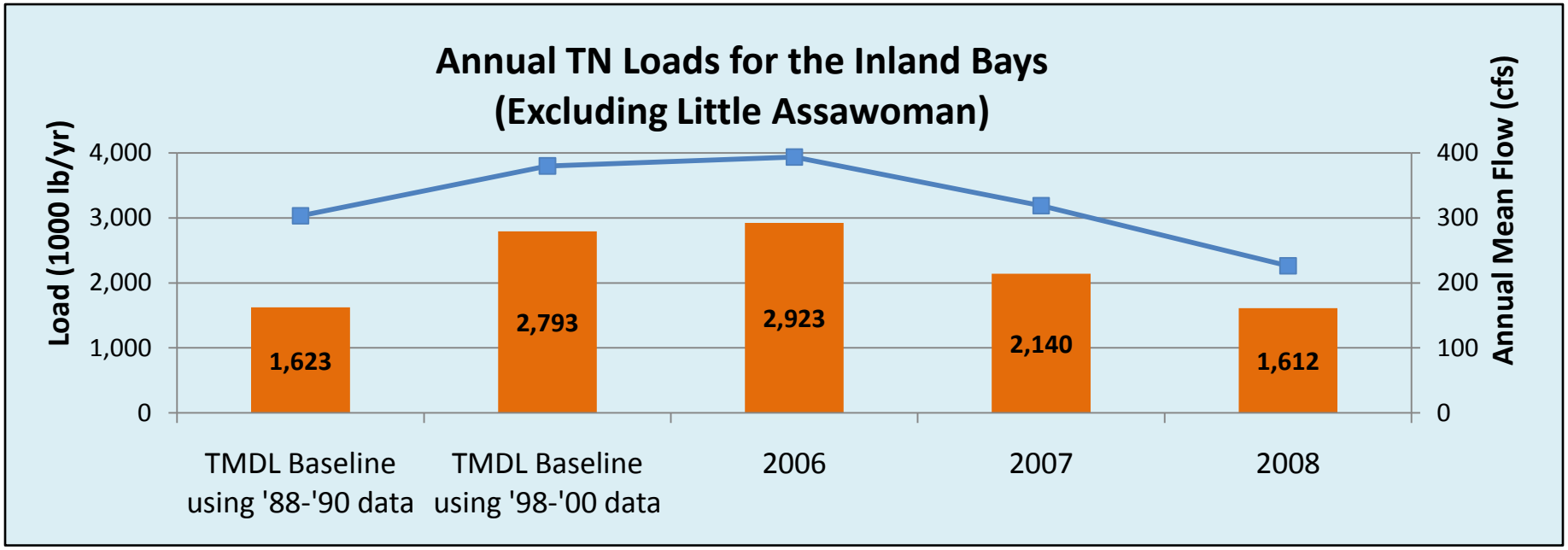


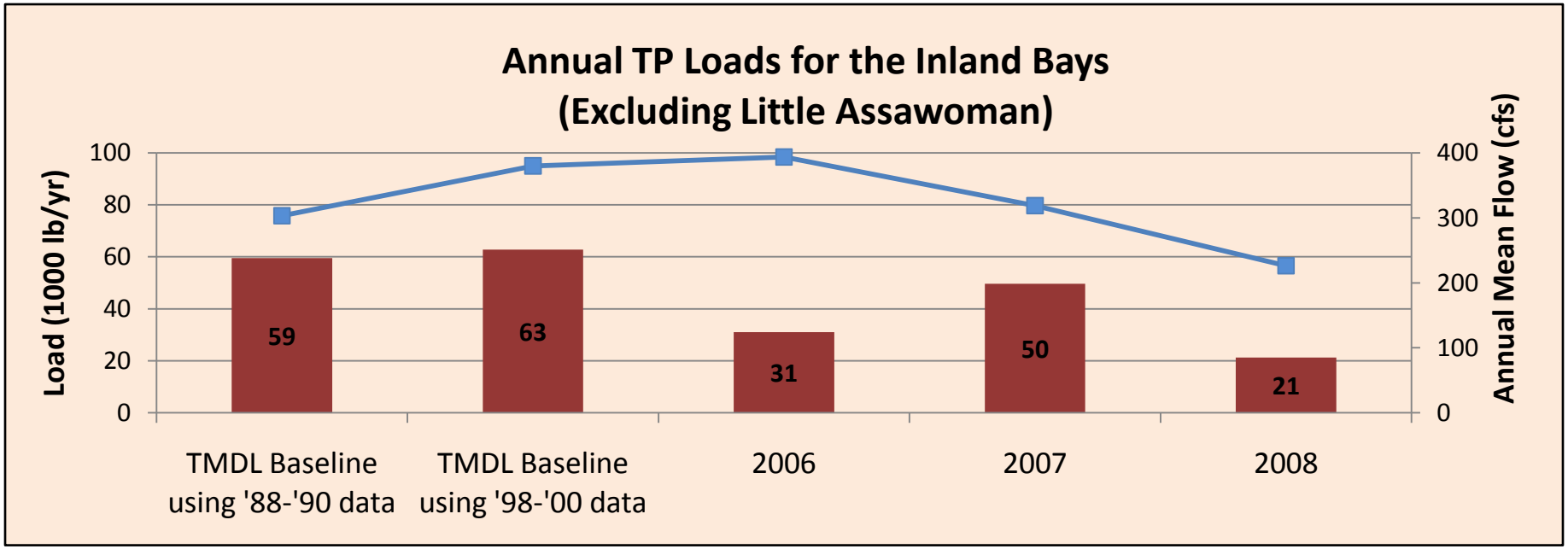


The 1998 and 2004 TMDLs

- The 1998 TMDL covered only Indian River/Bay and Rehoboth Bay and was based on data collected during 88-90 (baseline period)
- The 2004 TMDL covers the entire Inland Bays watershed including Little Assawoman Bay and is based on data collected during 98-2000



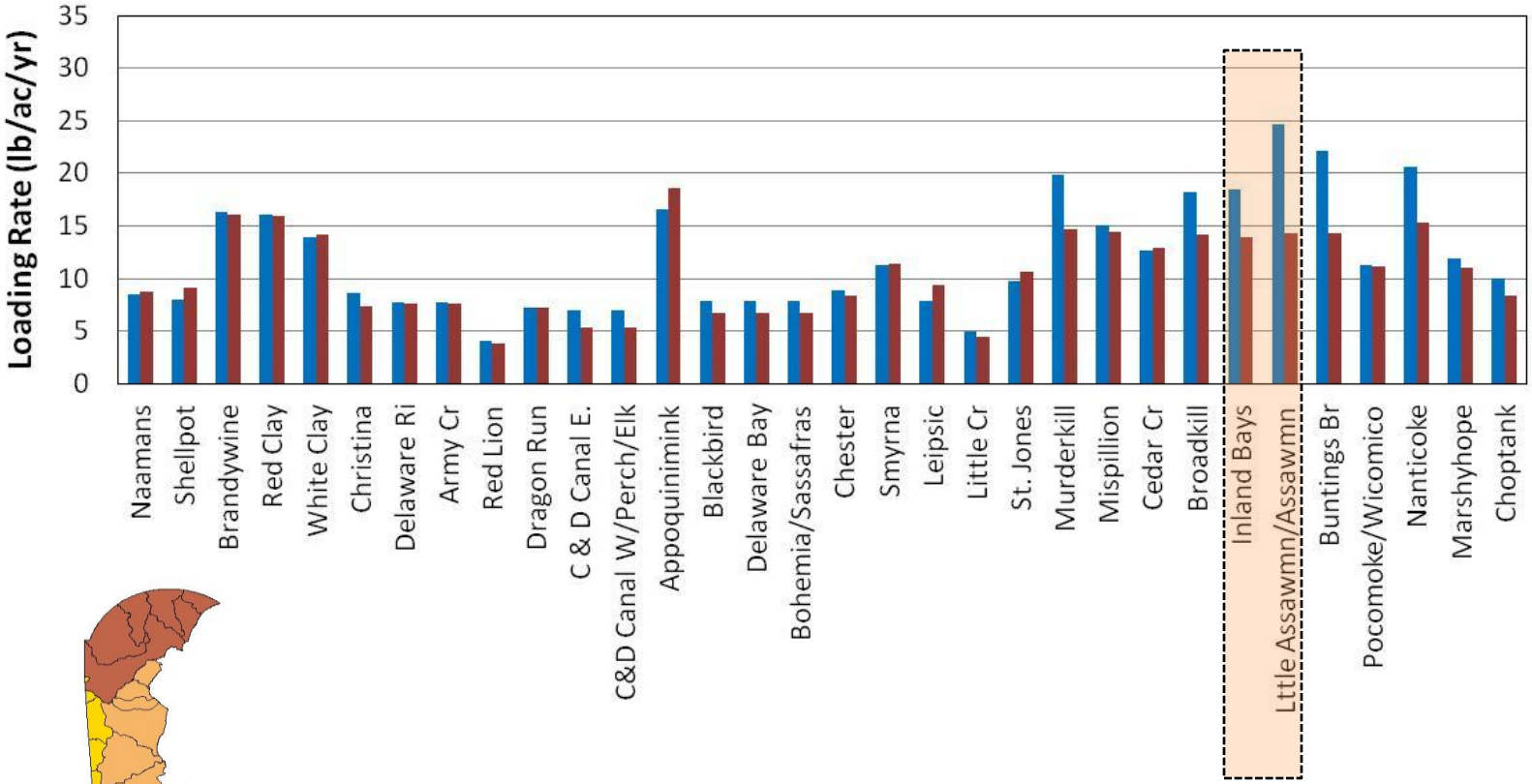

Annual TN Loads for the Inland Bays
(Excluding Little Assawoman)
Load (1000 lb/yr)
Annual Mean Flow (cfs)
4,000
3,000
2,000
1,000
0
400
300
200
100
0
1,623
2,793
2,923
2,140
1,612
TMDL Baseline using '88-'90 data
TMDL Baseline using '98-'00 data
2006
2007
2008

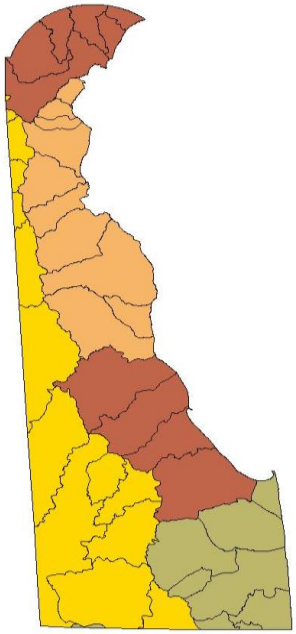

Annual TP Loads for the Inland Bays
(Excluding Little Assawoman)
Load (1000 lb/yr)
Annual Mean Flow (cfs)
100
80
60
40
20
0
400
300
200
100
0
59
63
31
50
21
TMDL Baseline using '88-'90 data
TMDL Baseline using '98-'00 data
2006
2007
2008

How Inland Bays Nutrient Loads are Compared to other watersheds in the State

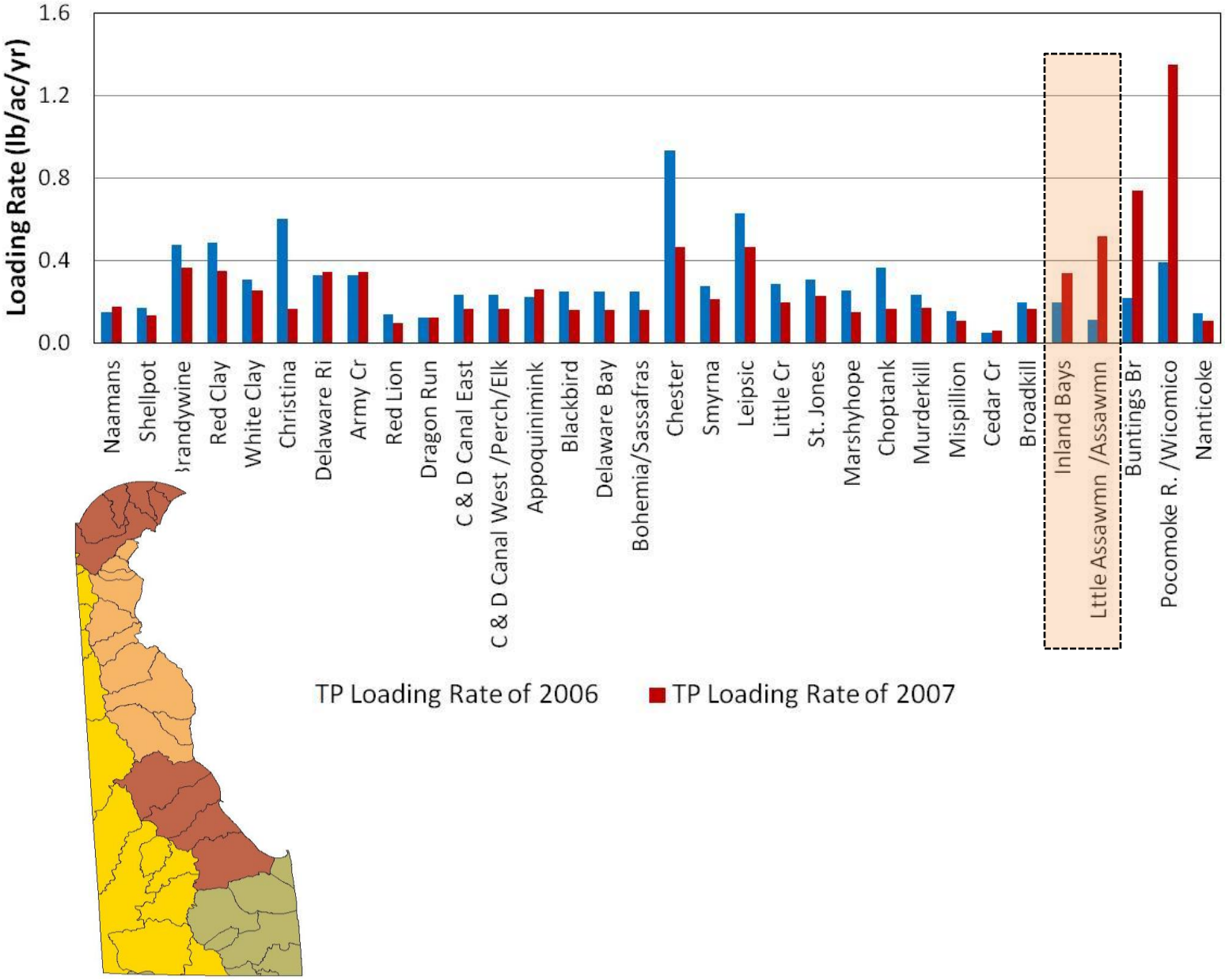
- To compare Inland Bays nutrient loads with other watersheds, nutrient loading rates (lbs of nutrients/acre/year) are calculated for all watersheds for the years 2006 and 2007.

Total Nitrogen Loading Rate





Total Phosphorus Loading Rate



Thank You!

For additional information:

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Hassan.mirsajadi@state.de.us

Watershed Assessment Section

DNREC Division of Water Resources

302-739-9939