# Meeting of Model Expert Panel with DRBC Staff

## Report to the Water Quality Advisory Committee

## Delaware River Basin Commission

## December 5, 2019



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# DRBC Expert Panel Members

| Name | Organization | Service |
|---|---|---|
| Carl Cerco | U.S. Army Corps of Engineers (Retired) | Panel Members |
| Bob Chant | Rutgers University | |
| Steve Chapra | Tufts University | |
| Tim Wool | U.S. EPA Region 4 | |
| Vic Bierman | LimnoTech | Consultant to DRBC |
| Scott Hinz | LimnoTech | |

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# DRBC Participants

| Name | Title | Specialty and Responsibility |
|---|---|---|
| Tom Amidon | Manager, Modeling Section | Modeling general / multi-task / Atmospheric deposition |
| Jacob Bransky | Aquatic Biologist | Primary productivity / ichthyoplankton / algal speciation study |
| Fanghui Chen | Water Resource Engineer | Hydrodynamic modeling / data retrieval / post processing |
| Vince DePaul | Hydrologist (USGS) | WQ Modeling / wetlands interaction |
| Elaine Panuccio | Water Resource Scientist | Tributary / point source data management / load calculation |
| Namsoo Suk | Director, Science and WQ Management | Project management / multi-task / modeling |
| John Yagecic | Manager, Water Quality Assessment | Data retrieval & analysis / multi-task / light extinction |
| Li Zheng | Senior Water Resource Engineer | Hydrodynamic and WQ modeling |

# Goal

- Develop a technically sound eutrophication model for the Delaware Estuary and Bay utilizing the current state of the science within a timeframe established by the Commission
  - Identify appropriate levels of source controls, especially in relation to dissolved oxygen

# Modeling Approach

- Develop a linked hydrodynamic and water quality model
  - Environmental Fluid Dynamics Code (EFDC)
  - Water Quality Analysis Simulation Program (WASP8)
- Assess available data and conduct additional monitoring to fill gaps
  - Sources
  - Ambient water
- Calibrate linked model
  - Historical data, primarily 2012
  - Intensive monitoring period 2018-2019
- Conduct forecast simulations with calibrated model
  - Determine levels of external sources required to achieve varying levels of ambient dissolved oxygen

# Targeted Schedule

| | Activity | 2017 | | | | 2018 | | | | 2019 | | | | 2020 | | | | 2021 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| Designated Use Program Tasks | Hydrodynamic Model Development | x | x | x | x | x | x | x | x | x | x | x | x | | | | | | | | |
| | Intensive Ambient Data Collection & Data Analysis | x | x | x | x | x | x | x | x | x | x | x | x | | | | | | | | |
| | Water Quality Model Development and Calibration | | | x | x | x | x | x | x | x | x | x | x | | | | | | | | |
| | Determination of higher levels of DO & protection to aquatic species. | | | x | x | x | x | x | | x | x | x | x | | | | | | | | |
| | Develop wasteload & load allocations | | | | | | | | | | | | | | | | | | | | |
| | Report Preparation | | | | | | | | | | | | | | | | | | | | |

Legend

Program Tasks supported by the bordering states/DRBC Agreement

Lighter shading indicates preliminary or follow-up work

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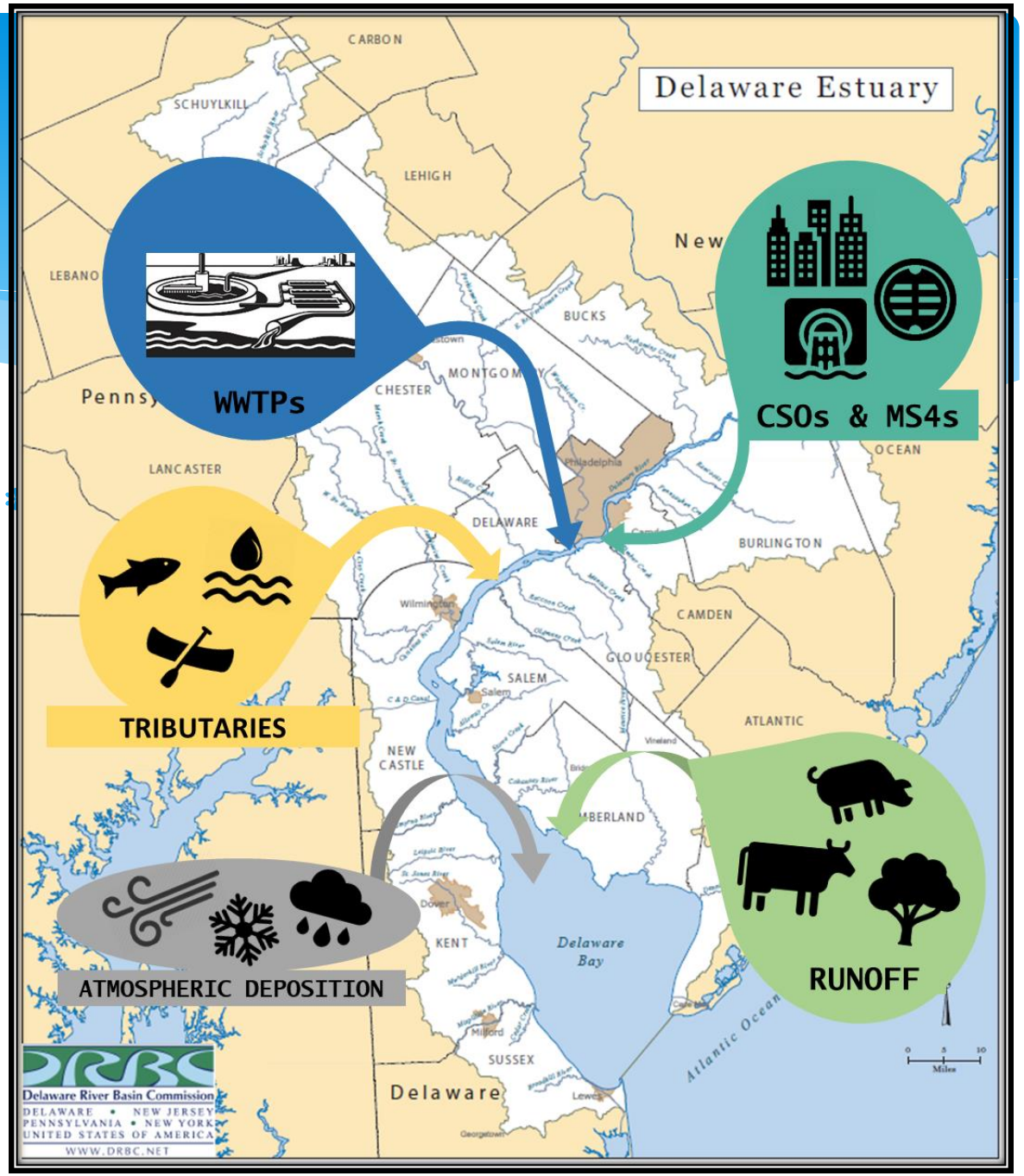
# Key Tasks Performed since March 2019

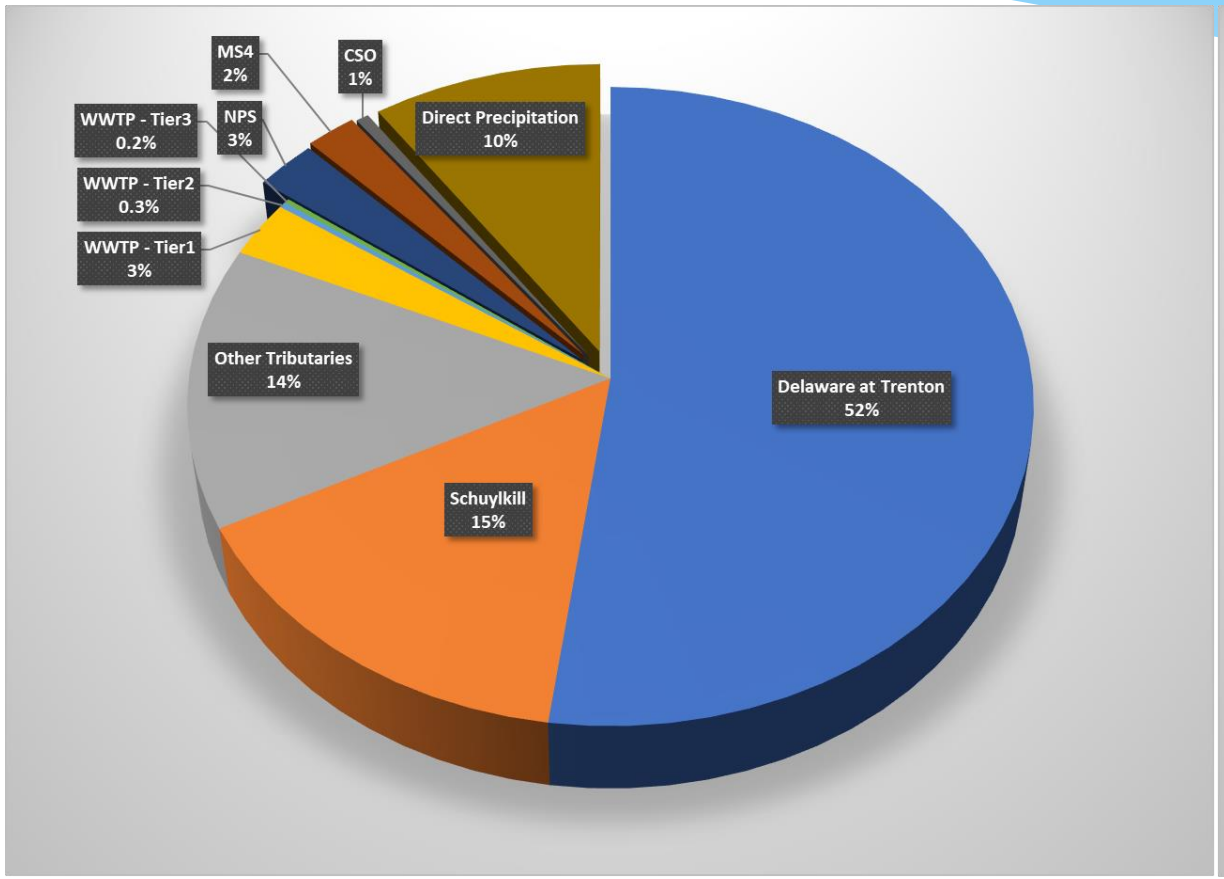
- EFDC Model
  - Evaluated impacts of ocean boundary conditions, C&D Canal and vertical resolution
  - Modified spatial grid, model code and linkage file to WASP8 to ensure internal consistency for water and mass balances
- WASP8 Model
  - Constructed input file and conducted test runs
  - Developed methods for post-processing WASP8 model outputs
- Continued data collection for watershed sources and ambient water
- Developed and applied estimation methods for inflows and mass loads from point and nonpoint sources

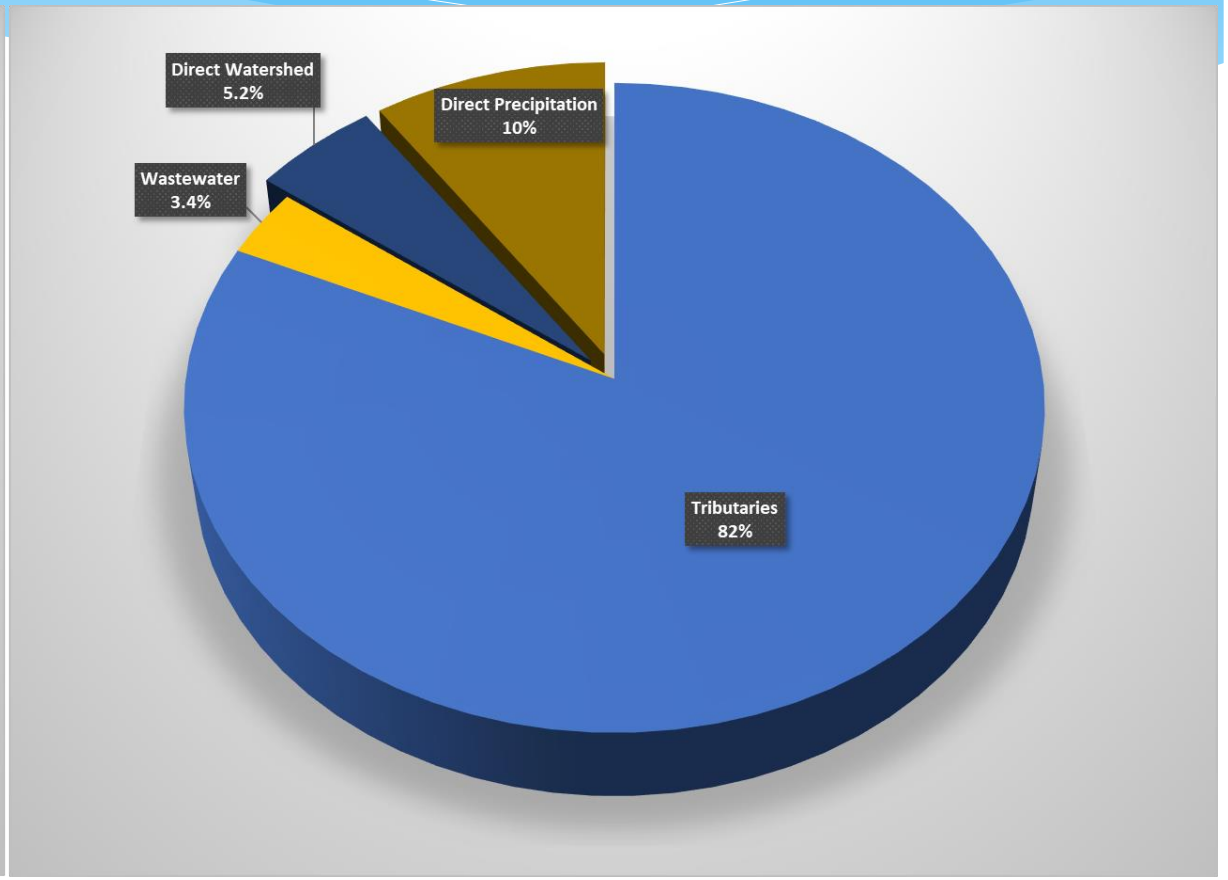
# Conceptual Model Load Boundaries

- Tributary Loads
  - Delaware River at Trenton (Zone 1)
  - Schuylkill River
  - ~ 29 other tributaries
- Tidal Boundaries
  - Ocean at mouth of Delaware Bay
  - C&D Canal
- Direct Basin Loads
  - Wasteloads: **WWTPs**, CSOs, MS4
  - Nonpoint Source (runoff outside MS4)
  - Wet/Dry deposition onto water surface

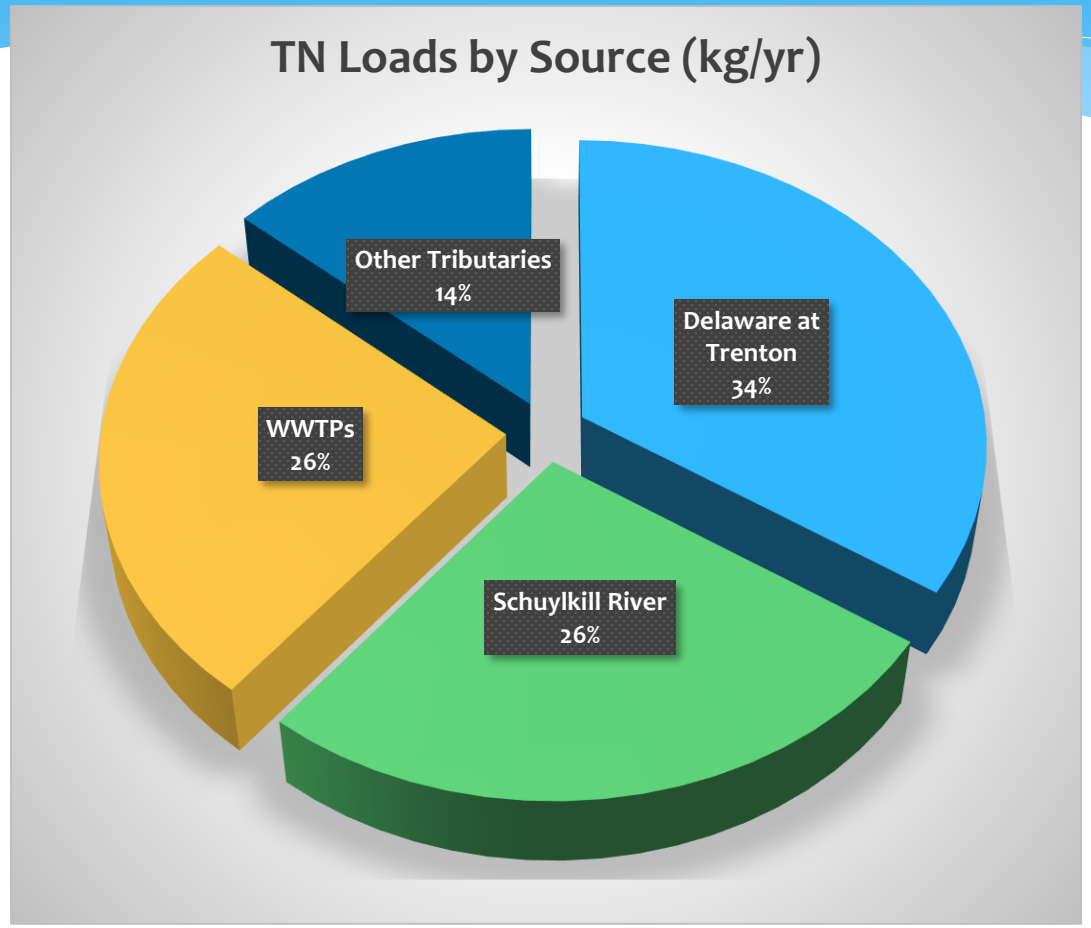


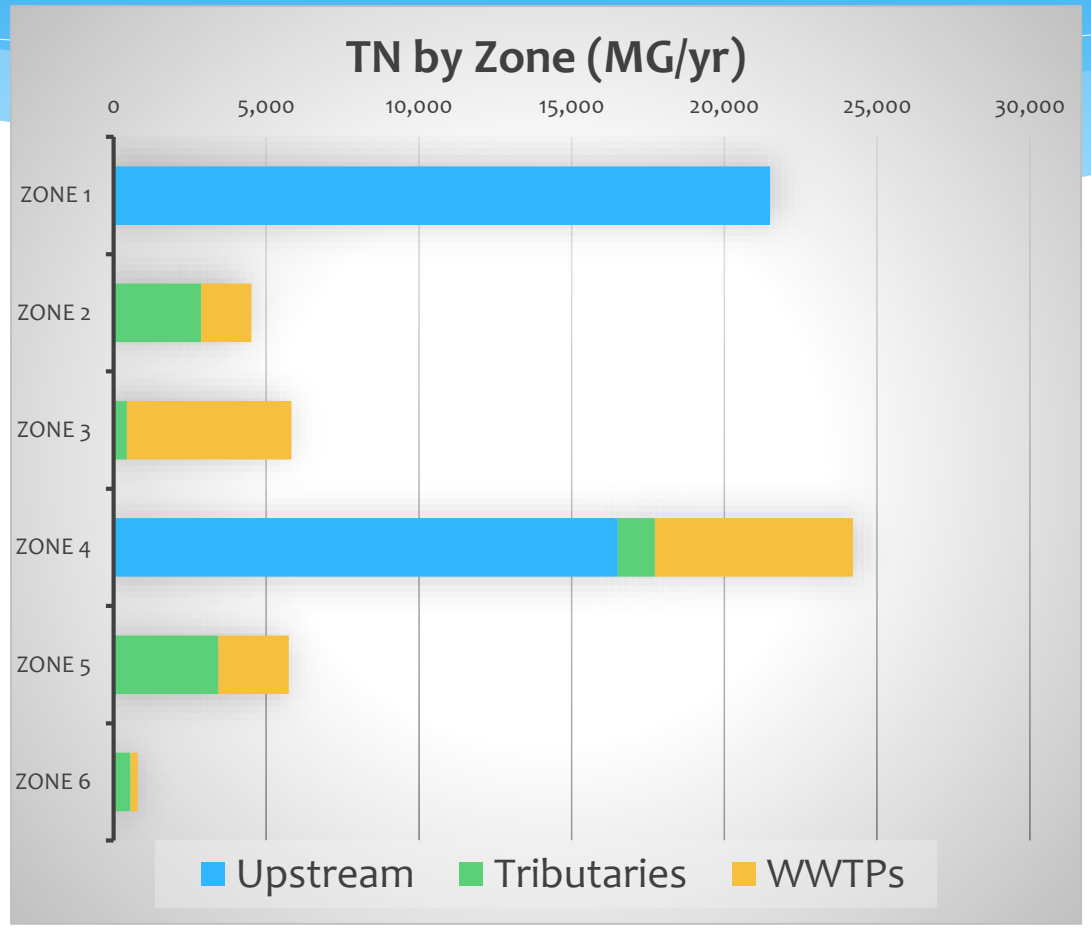
# Water Loads in 2018



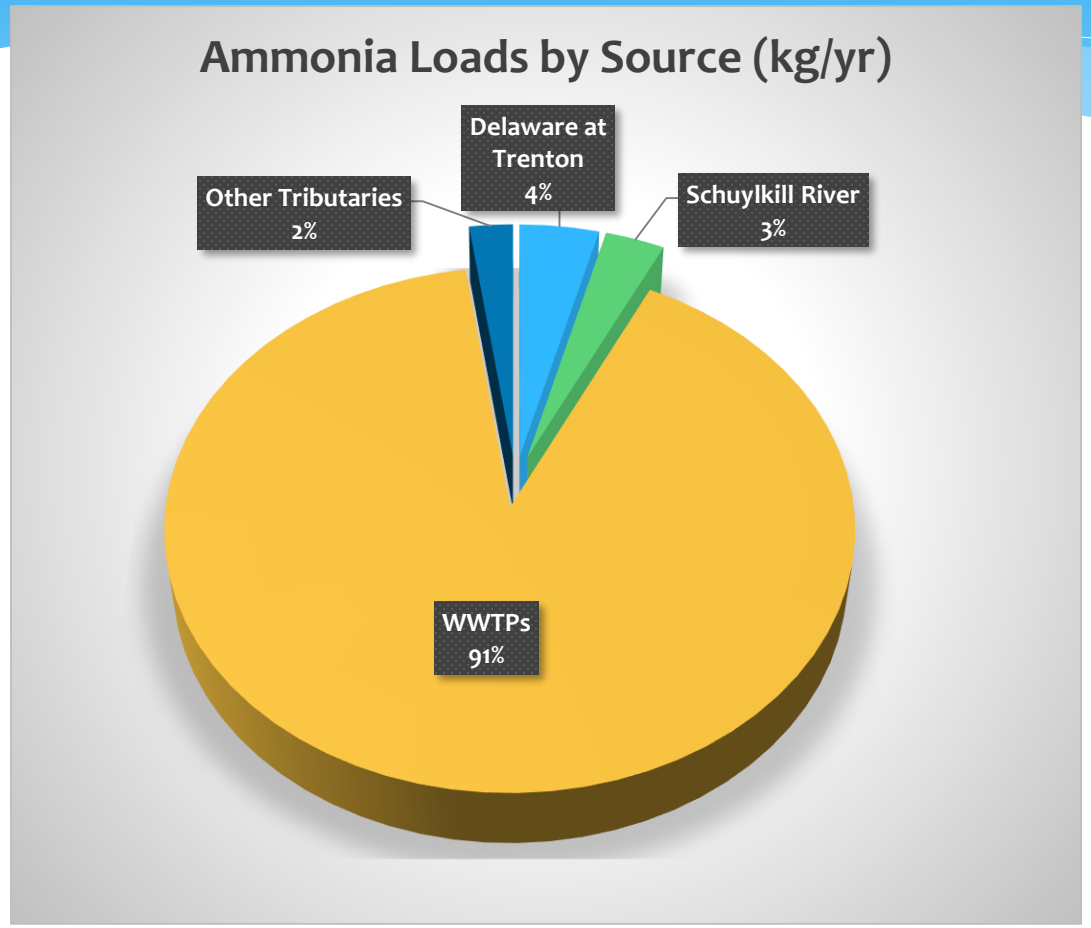



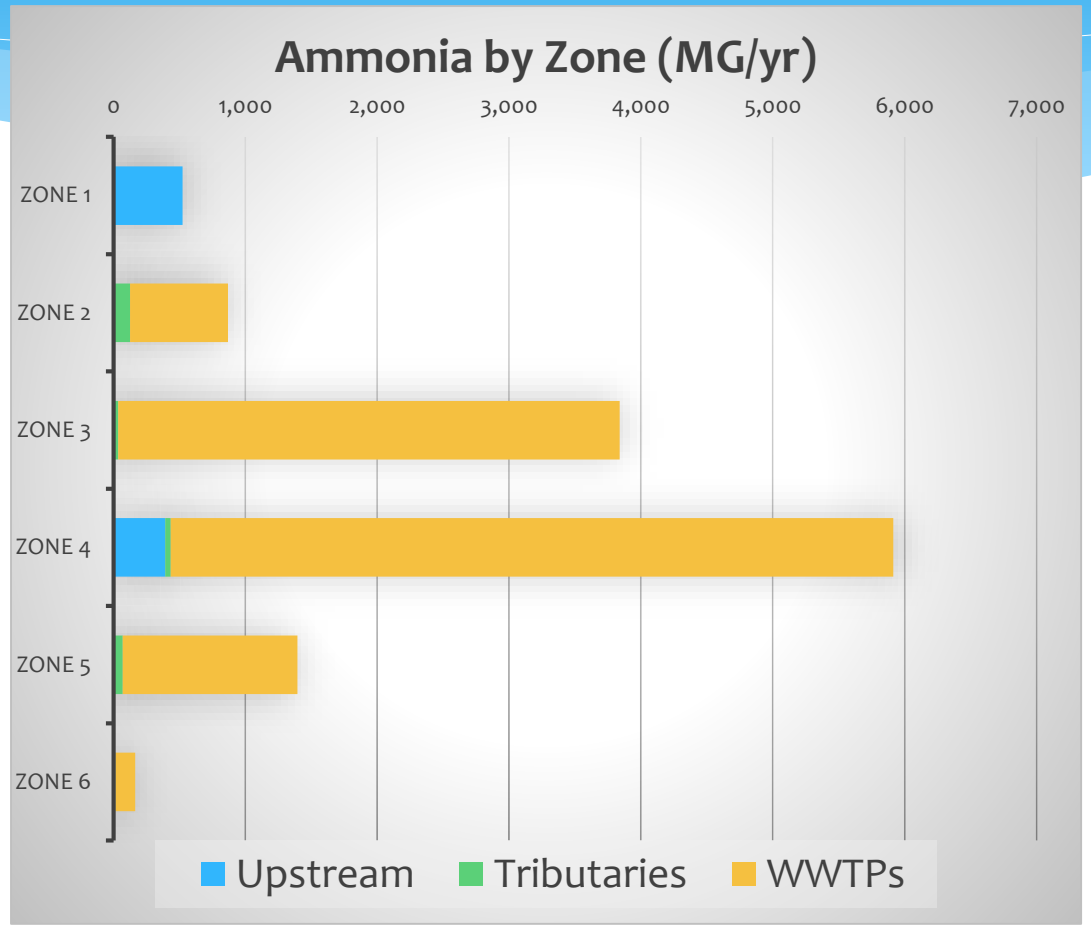
# Total Nitrogen in 2018



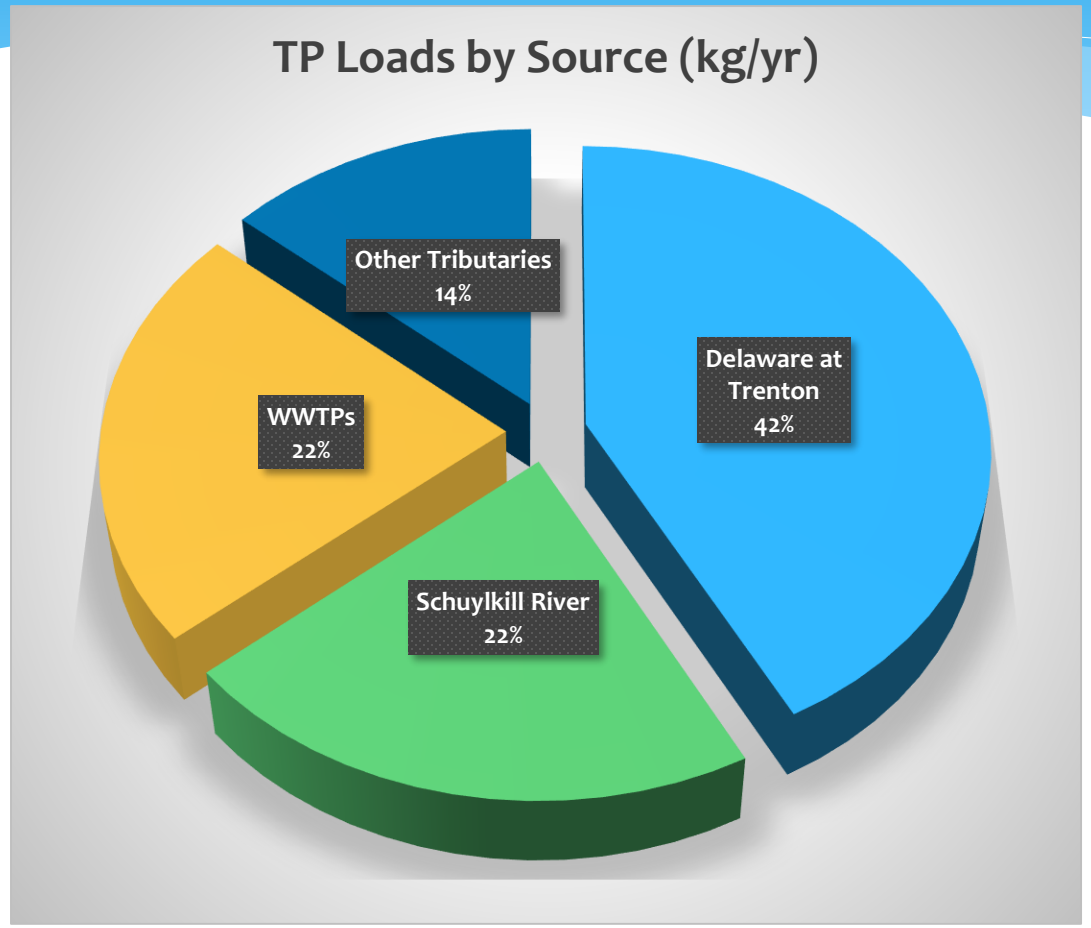



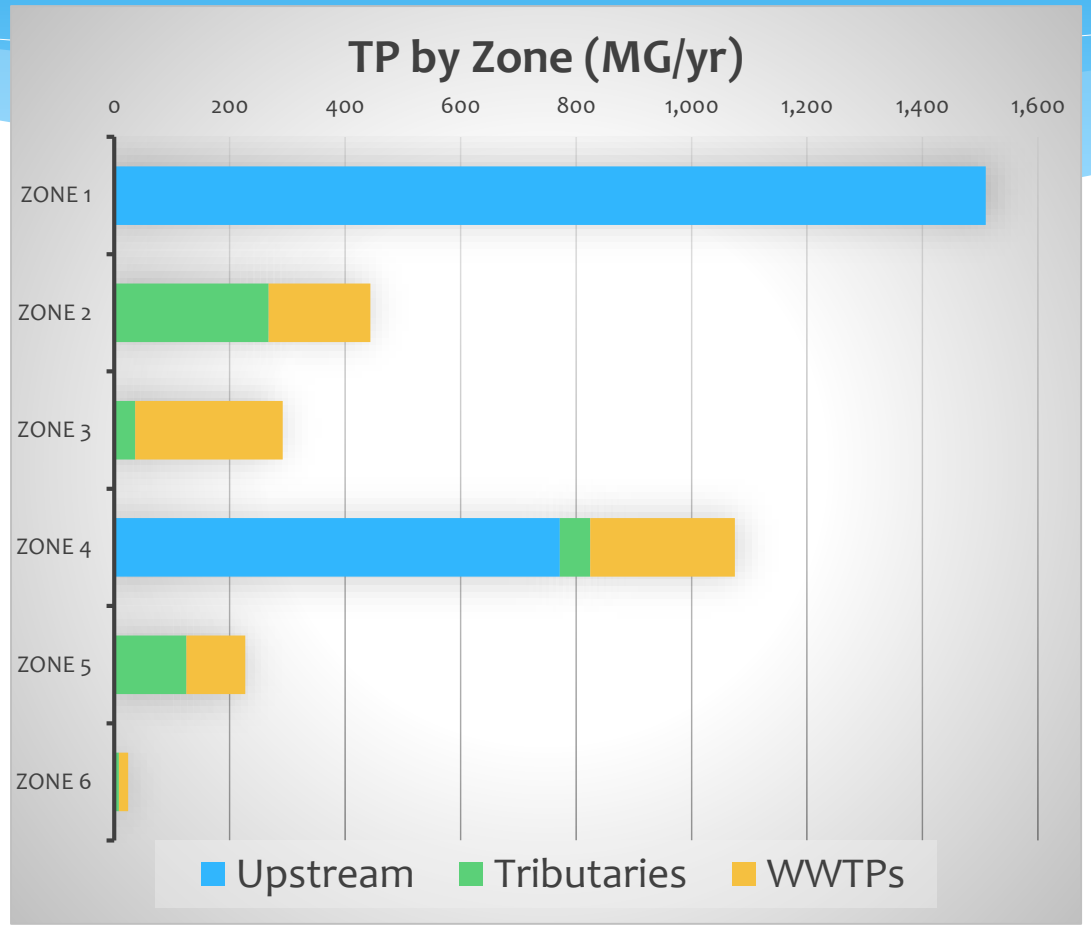
# Ammonia-Nitrogen in 2018



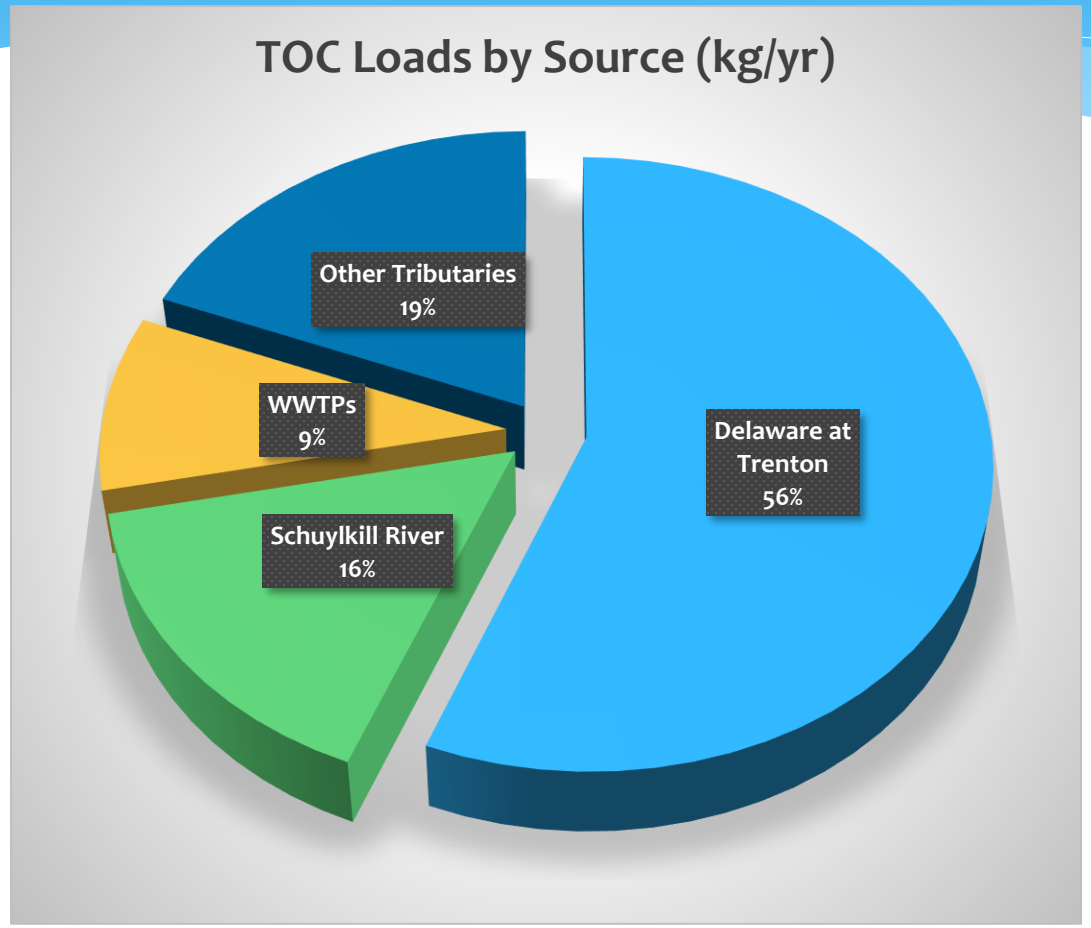



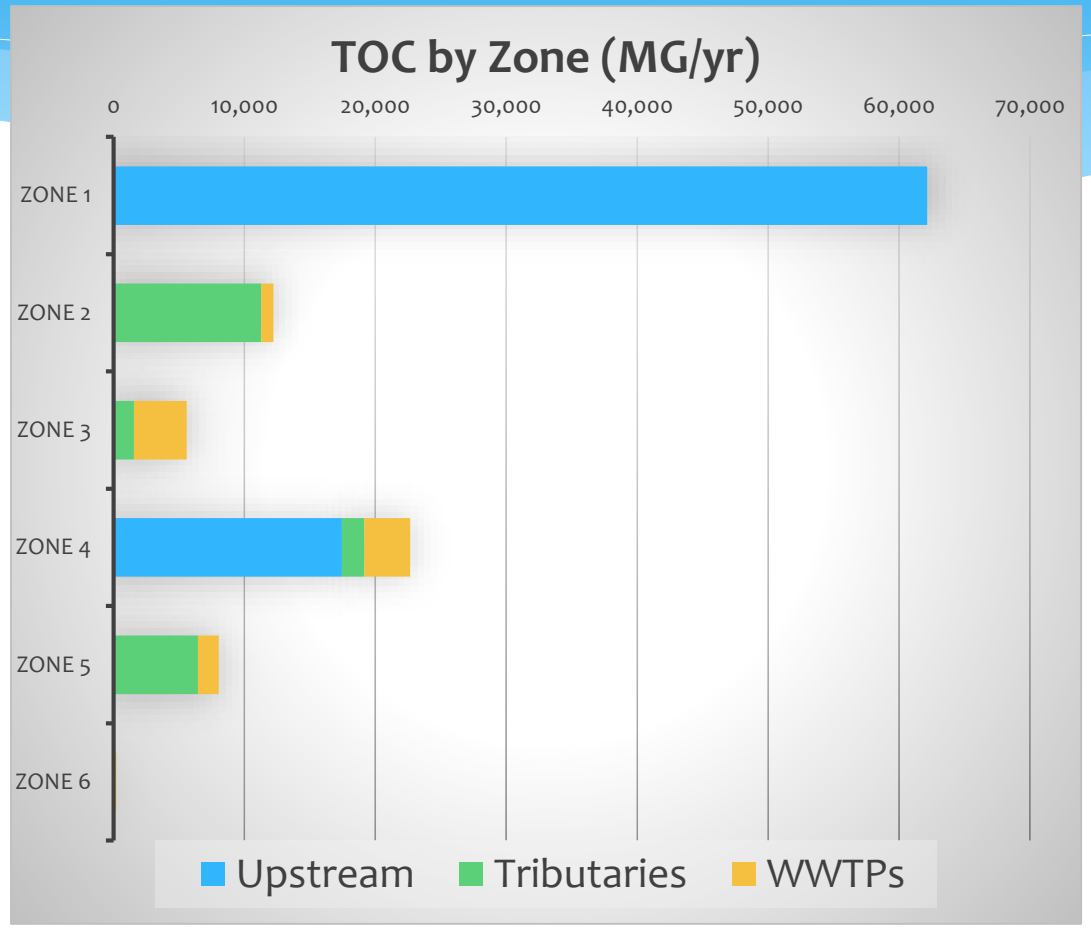
# Total Phosphorus in 2018



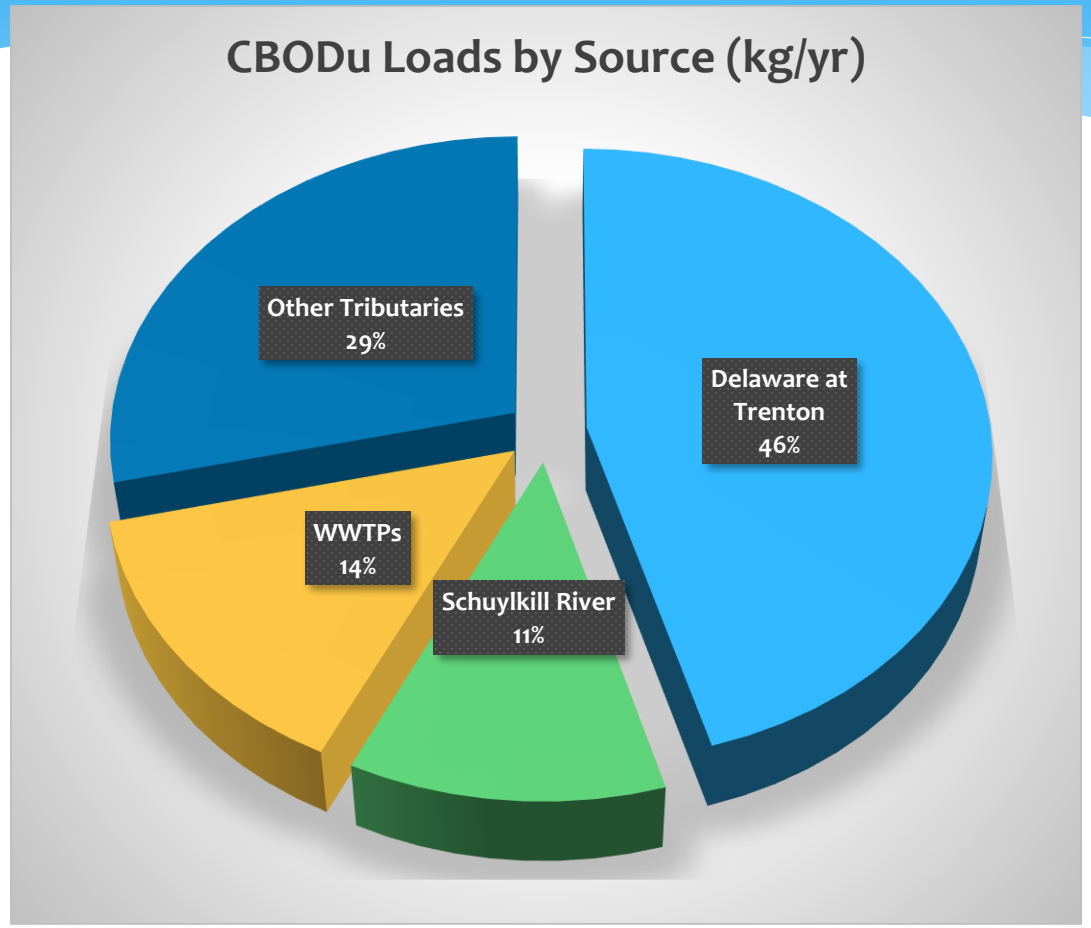



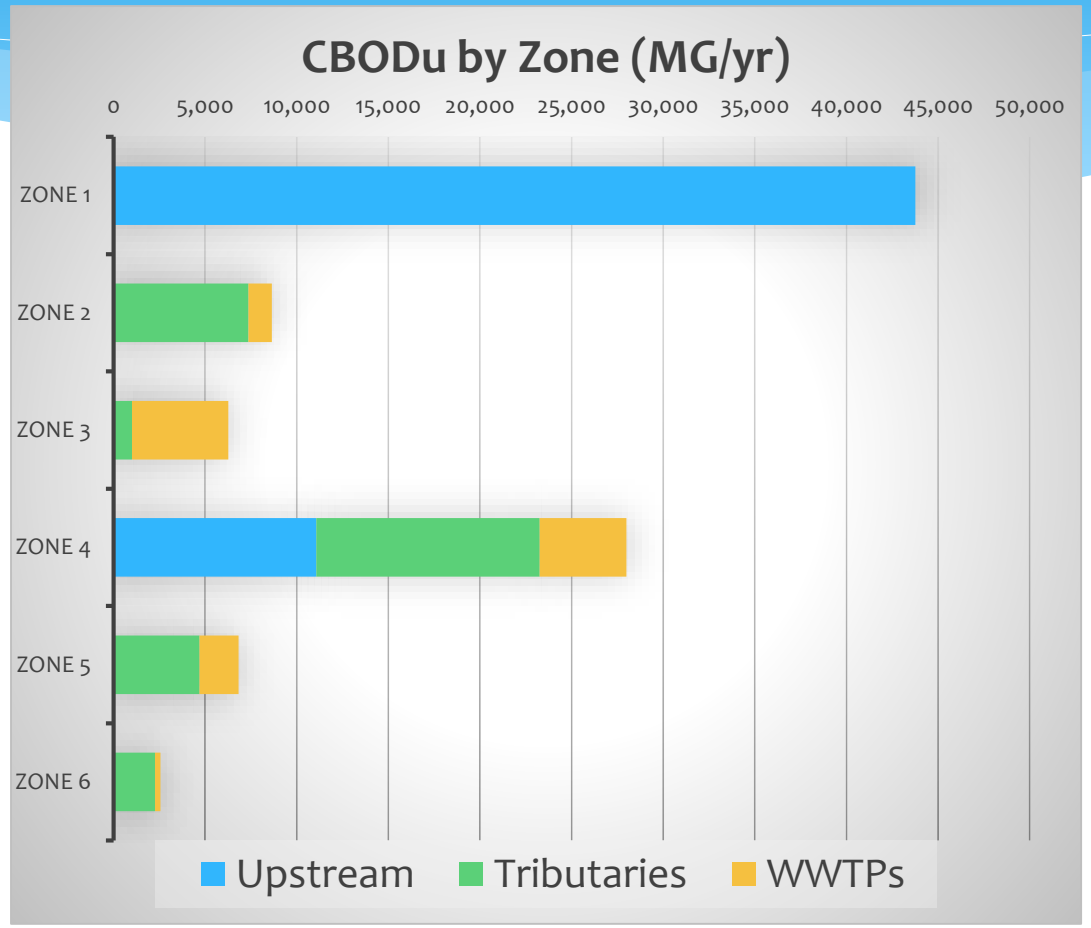
# Total Organic Carbon in 2018



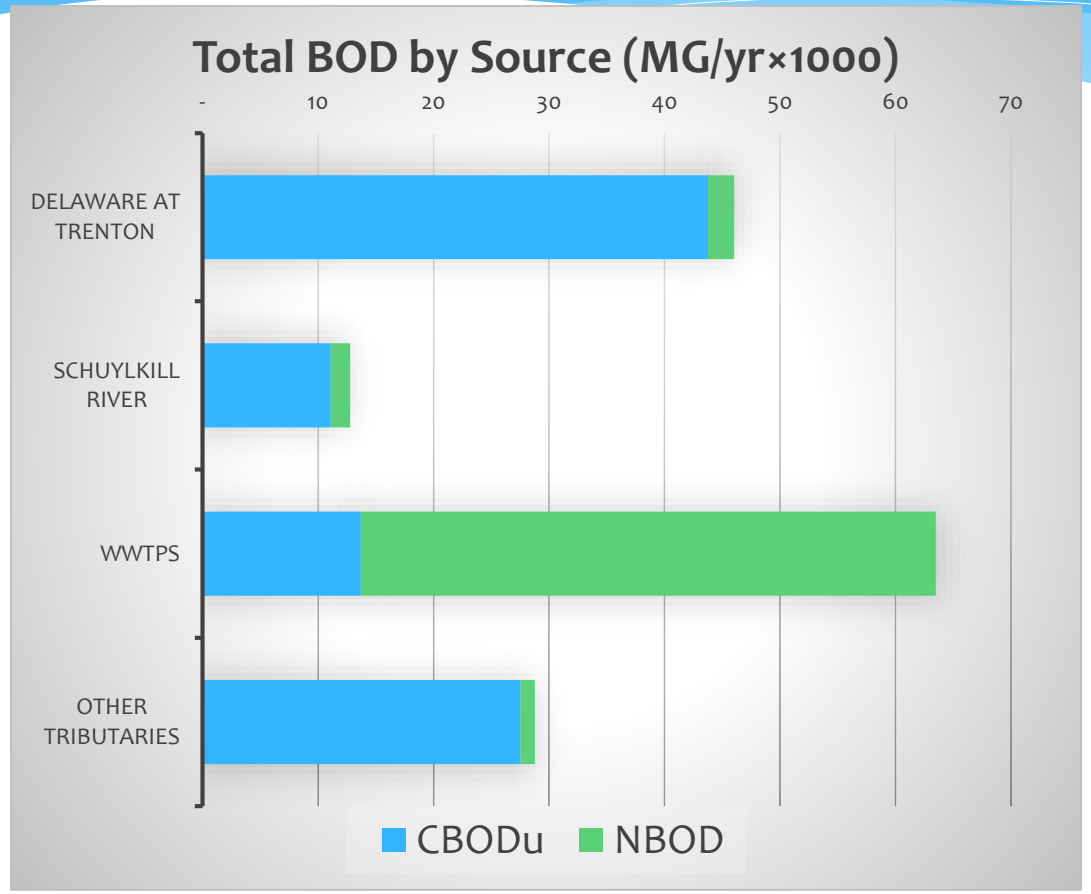



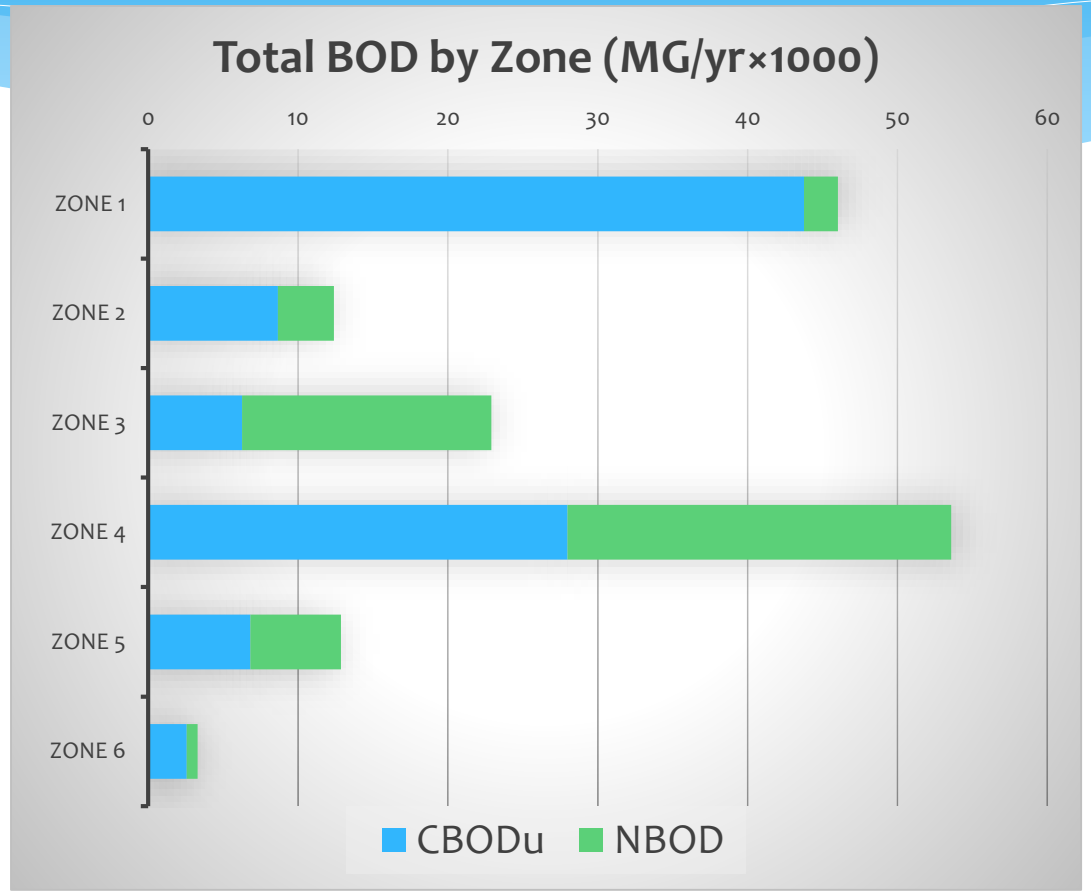
# Ultimate CBOD in 2018



# CBOD and NBOD in 2018



# Next Steps

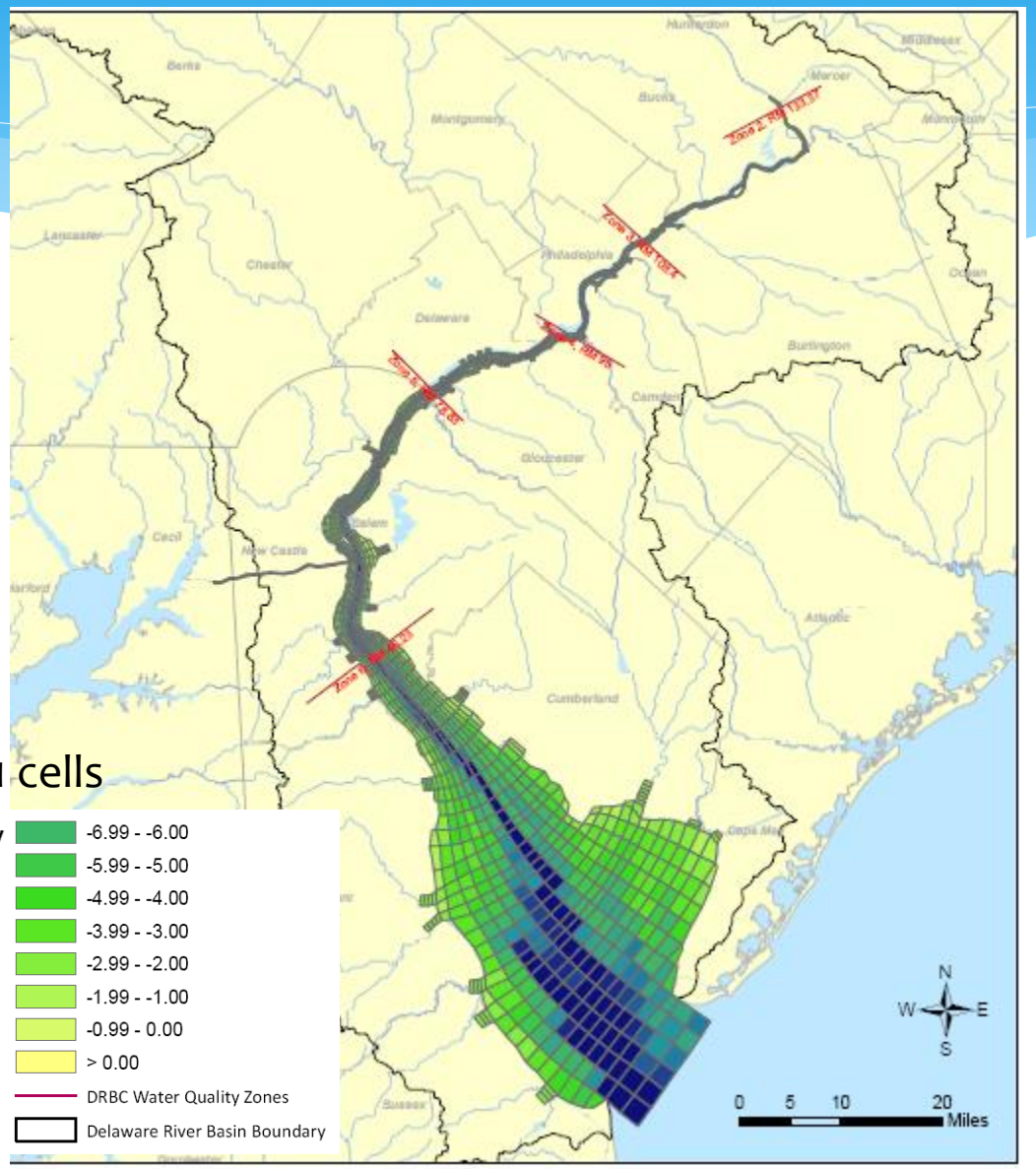
- Calculate loads for direct watershed contributions (NPS, MS4)
- Assign CSO flows and concentrations (pending data from dischargers)
  - Replace calculated MS4 flows in CSO areas with CSOs
- Assign wet and dry atmospheric deposition loads
- QA/QC R-scripts used to implement state variable assignment methodology for tribs and point sources

# Hydrodynamics Model Development
# Grid 6.3 -continue

* **Grid Modifications**

***Goal → improve the model performance for run time mass balance with wetting and drying***

- ✓ Removed a loop in Zone 2
- ✓ Removed cells that often experienced wetting and drying
- ✓ Simplification of tributary representation



# EFDC Model Files

- Input files (7)
  - Bathymetry, water surface elevation, flows, salinity, temperature, wind, weather
  - 330,000 total records (ASCII)
- Output linkage file for WASP8
  - 700 GB (binary)

# Hydrodynamics Model Calibration

## Grid 6.3 – Calibration Results: Tidal Water Surface Elevation

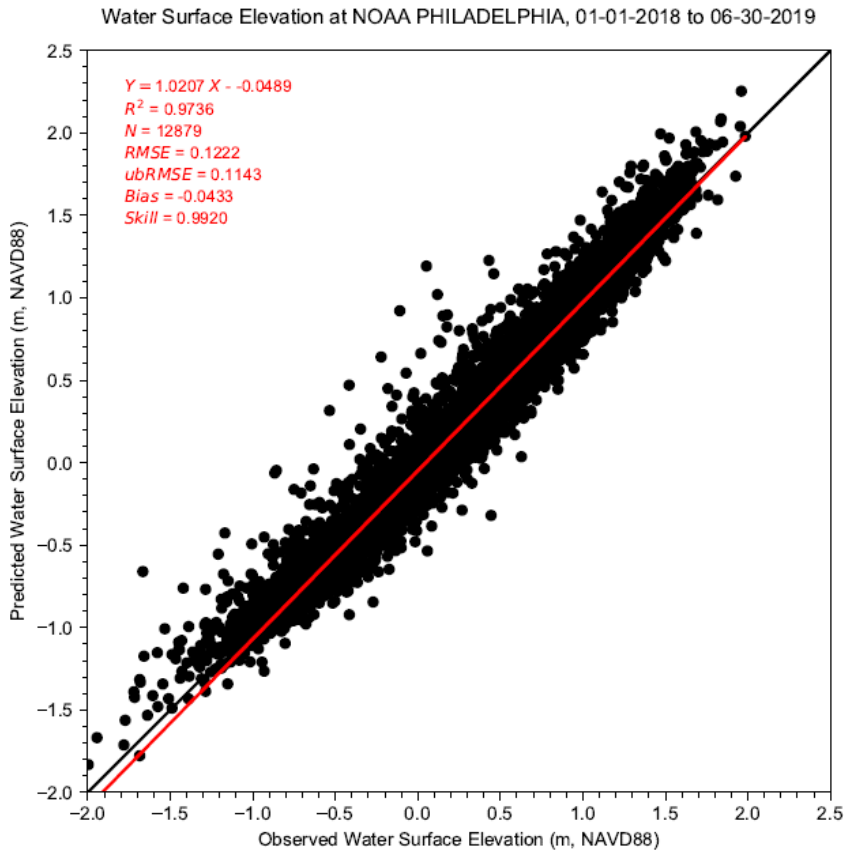



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**Figure --**
Comparison of Observed and Predicted Water Surface Elevation at NOAA PHILADELPHIA, 01-01-2018 to 06-30-2019

*Notes: NOAA hourly verified data were used.*
*Run ID: EFDC_FGD_GVC_HYDRO_NFPNOC_KC5_G63_1910-05_COSMIC_CET3_12_dt6s_50x_a.*
*GVC, KC =5, Grid 6.3, COSMIC, CTE=12, dt = 6s, adjusted CD tide by -2 cm.*

# Hydrodynamics Model Calibration

## Grid 6.3 – Calibration Results: Water Temperature

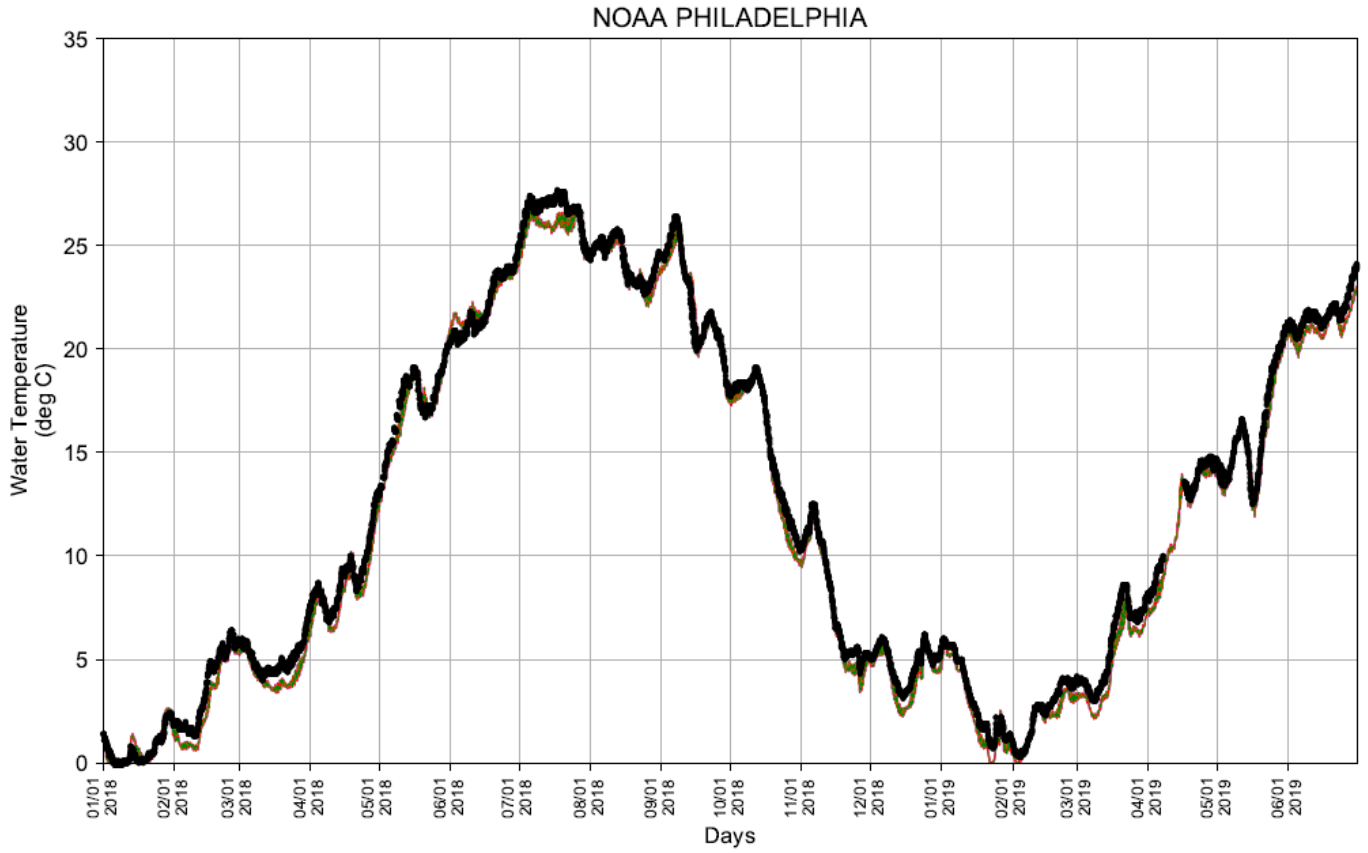



**Figure XX**

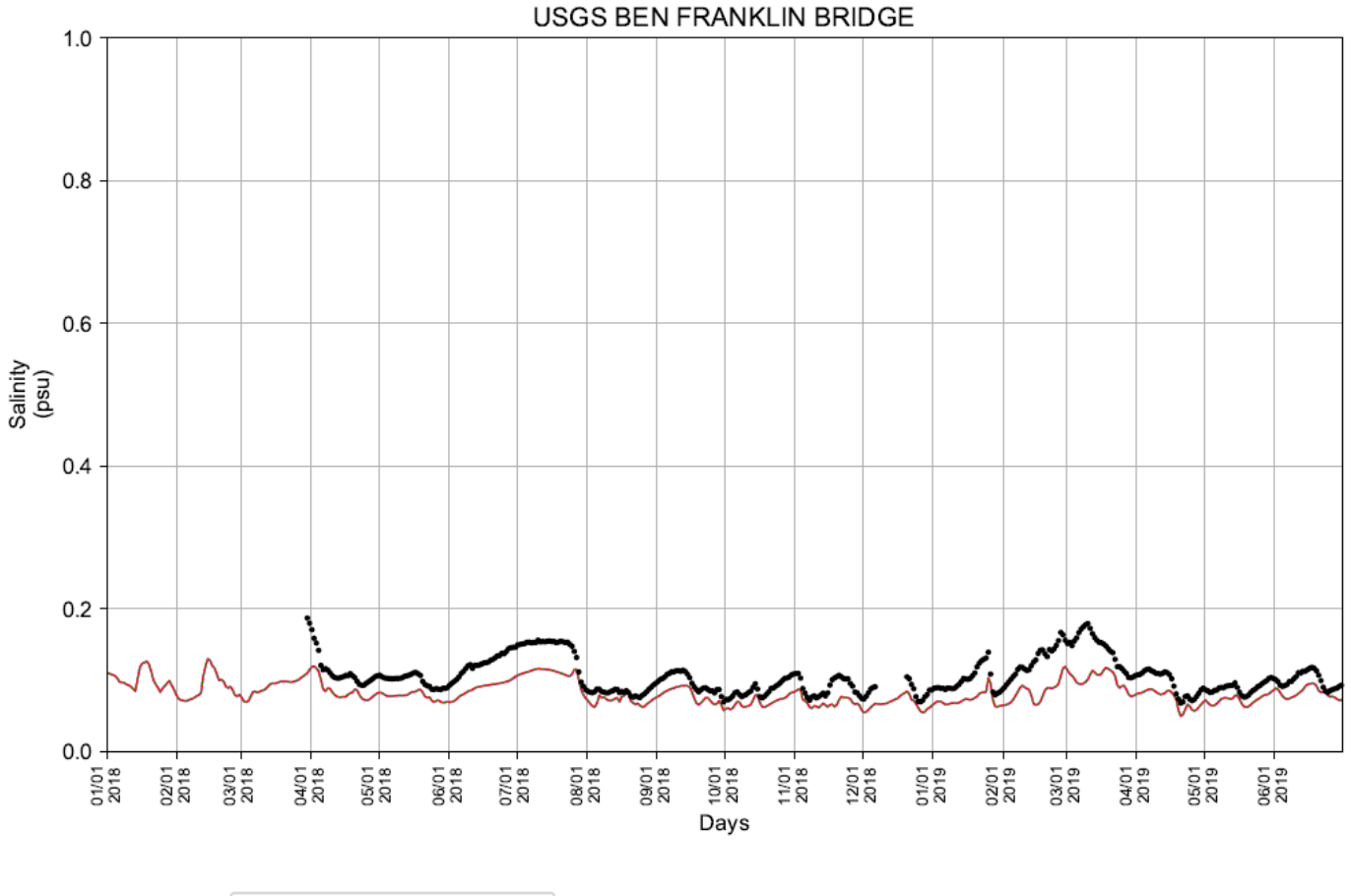
Observed and Predicted Water Temperature at NOAA PHILADELPHIA

*Station ID: 8545240, NOAA PHILADELPHIA*

*Run ID: EFDC_FGD_GVC_HYDRO_NFPNOC_KC5_G63_1910-05_COSMIC_CET3_12_dt6s_50x_a, GVC, KC =5, Grid 6.3. COSMIC, CTE=12, dt = 6s, adjusted CD tide by -2 cm.*

# Hydrodynamics Model Calibration

## Grid 6.3 – Calibration Results: Salinity, USGS Data 2018-2019




Daily averaged Results

**Figure XX**

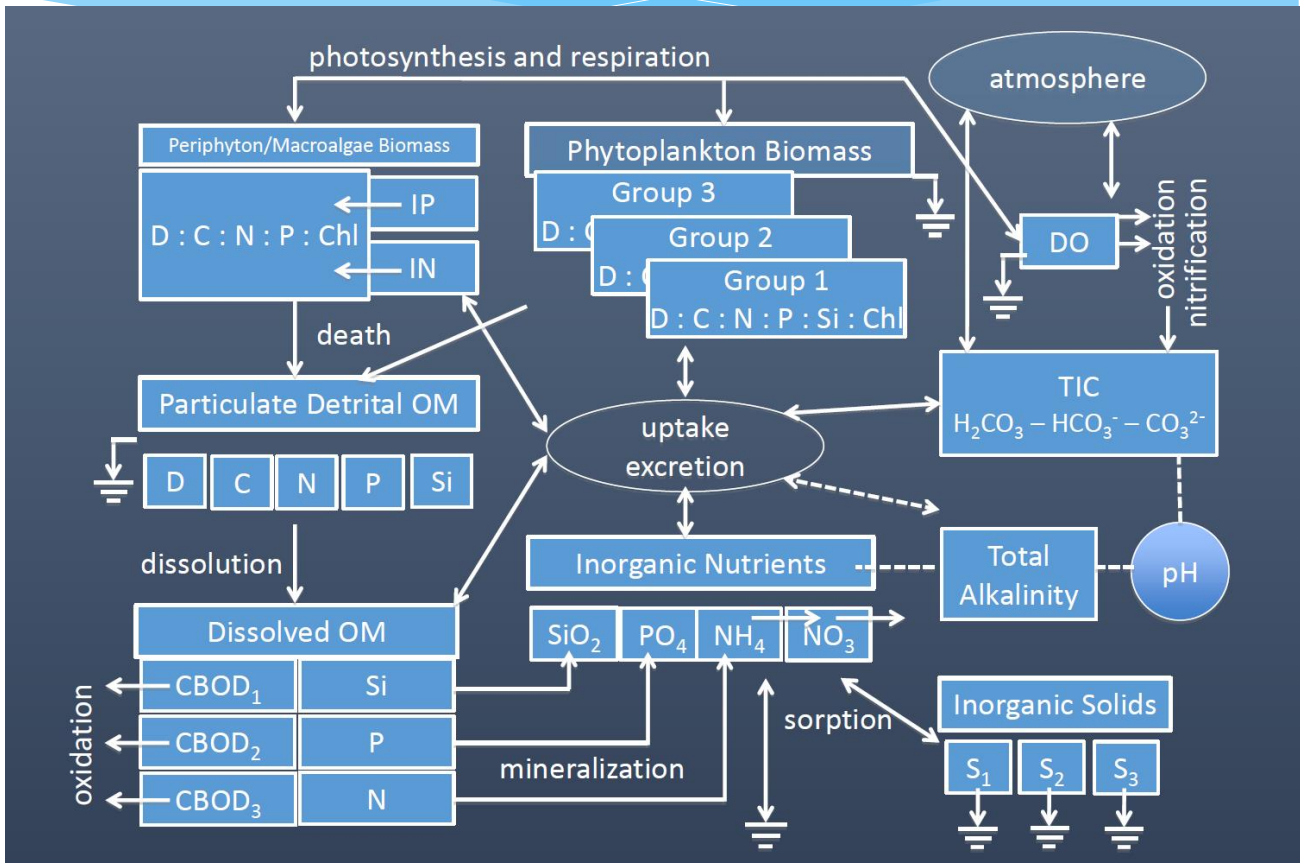
Observed and Predicted Daily Salinity at USGS BEN FRANKLIN BRIDGE

*Station ID: 01467200, USGS BEN FRANKLIN BRIDGE*

*Run ID: EFDC_FGD_GVC_HYDRO_NFPNOC_KC5_G63_1910-05_COSMIC_CET3_12_dt6s_50x_a, GVC, KC =5, Grid 6.3. COSMIC, CTE=12, dt = 6s, adjusted CD tide by -2 cm.*

# Conceptual Framework
# Water Quality Model – WASP8

- Eutrophication Process
  - 5 phytoplankton classes
  - 3 Periphyton/Macroalgae (benthic algae)
  - Nutrient cycling – N, P, Si
  - 3 CBOD and dissolved oxygen
  - pH and alkalinity
  - Water Temperature



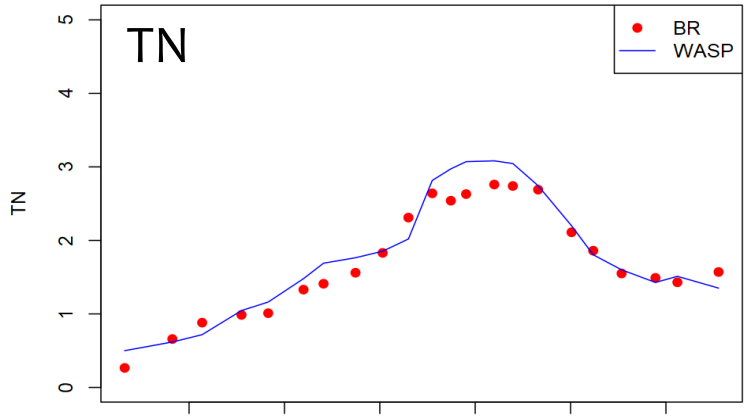
# WASP8 Model Files

- Master input file
  - 31 MB (GUI)
- Water resource file
  - 133 MB (database)
- Output files (2)
  - 37 GB (binary)

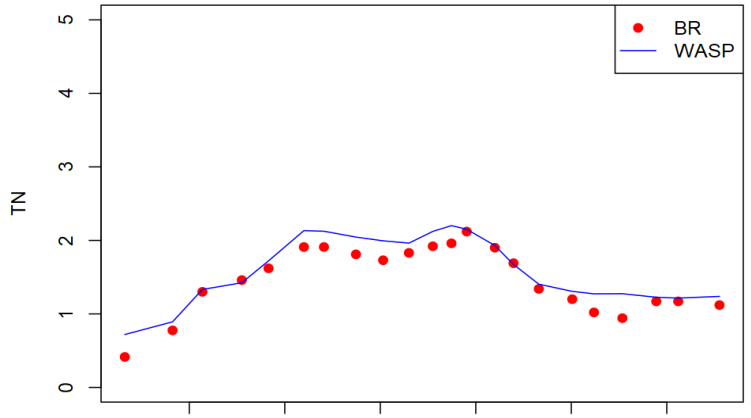
# Scenario - 1

## All load inputs without any loss processes

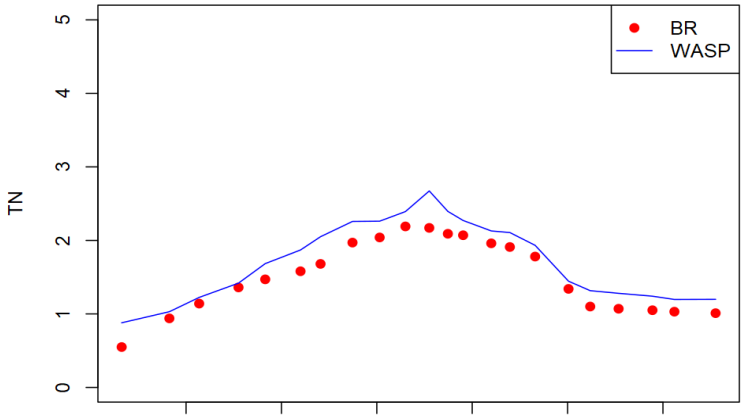
Boat Run 2018-07-09 RMSE= 0.22



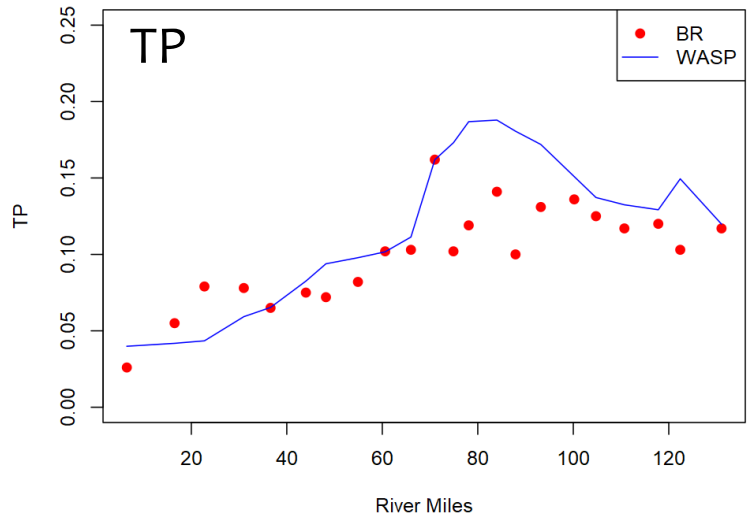

Boat Run 2018-08-13 RMSE= 0.17



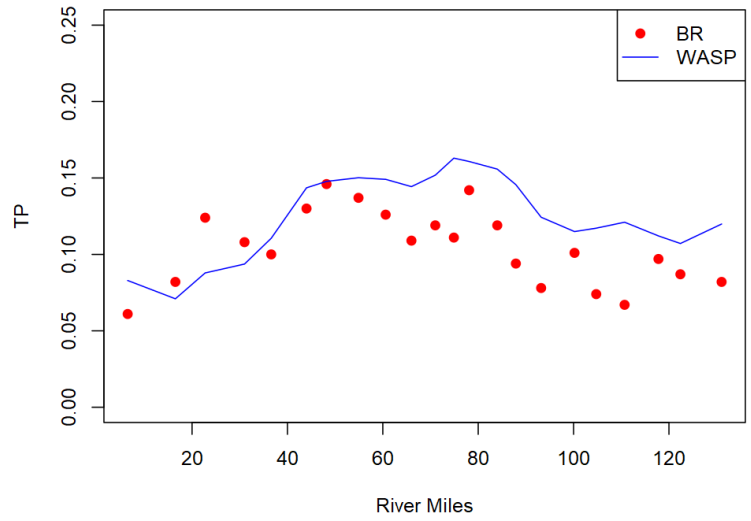

Boat Run 2018-09-17 RMSE= 0.24



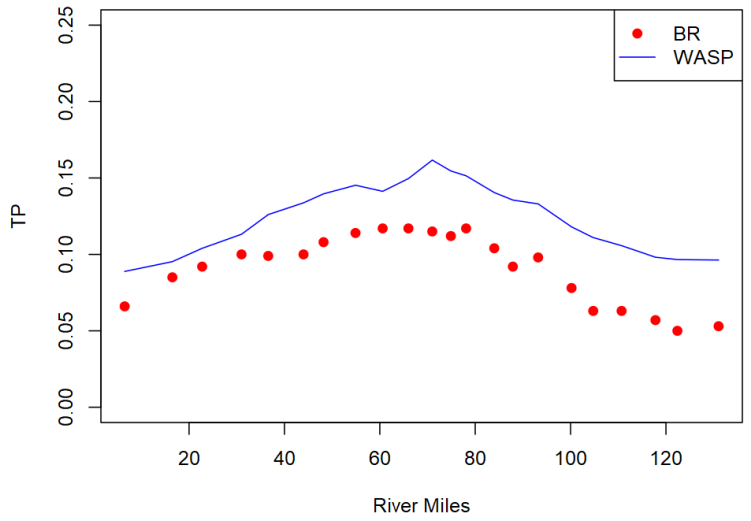

Boat Run 2018-07-09 RMSE= 0.03




Boat Run 2018-08-13 RMSE= 0.03




Boat Run 2018-09-17 RMSE= 0.04



# Path Forward

- Implement Expert Panel recommendations
  - Explore parallel versions of EFDC-WASP8 to optimize calibration
    - 2D production version (run time ca. hours)
    - Full 3D version (run time ca. tens of hours)
- Complete ambient data collection and analysis
- Finalize calibration of EFDC-WASP8 model
- Explore design conditions for waste load allocations