Meeting of Model Expert Panel with DRBC Staff

Report to the Water Quality Advisory Committee

Delaware River Basin Commission

March 20, 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	Tuffs 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 2012-2013
  - 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											
	Intensive Ambient Data Collection & Data Analysis	x	x	x		x	x	x	x	x											
	Water Quality Model Development and Calibration			x	x	x	x	x	x	x											
	Determination of higher levels of DO & protection to aquatic species.			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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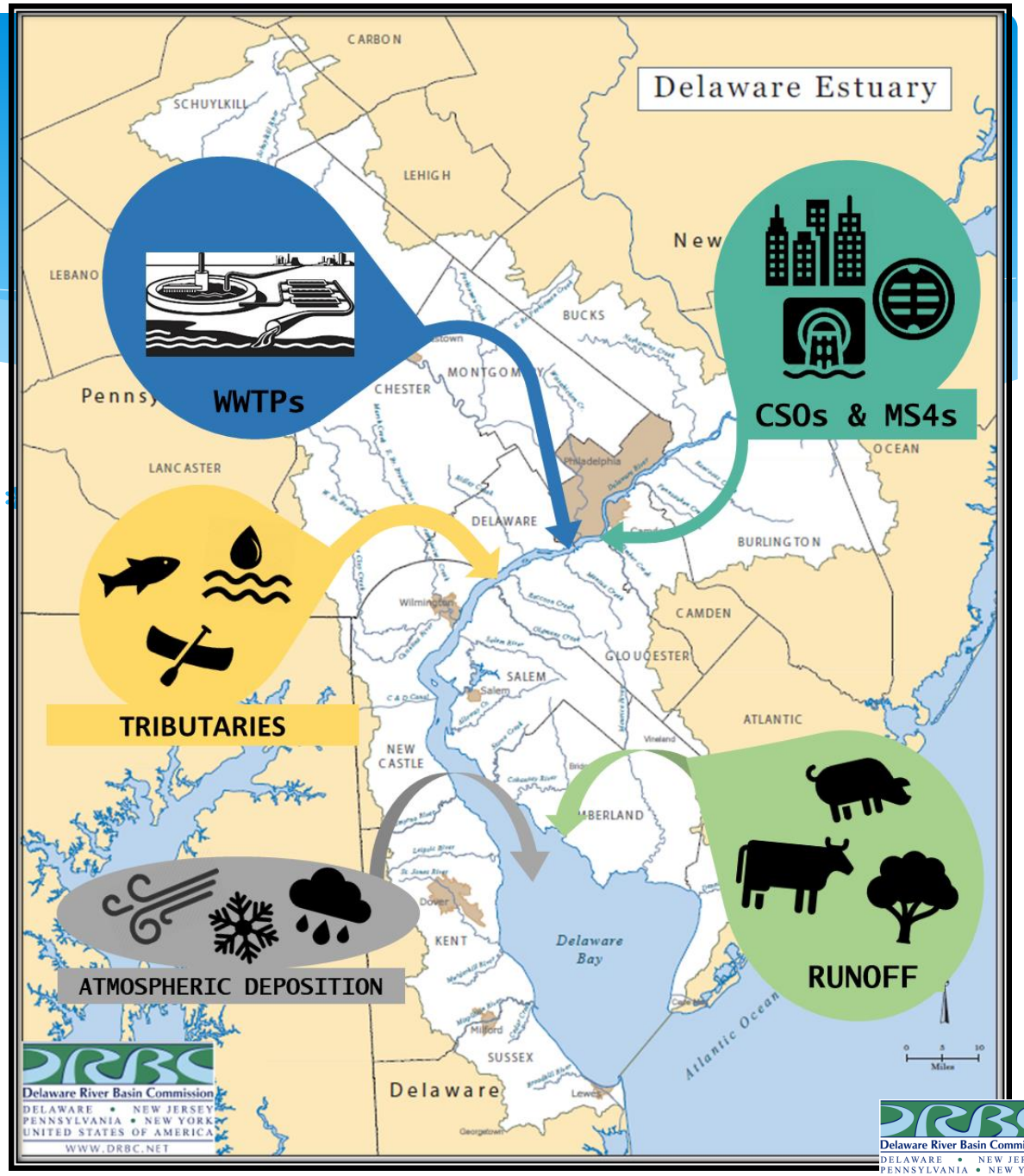
Conceptual Model
Nutrient Load Boundaries

* 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



Boundary Load Estimates for Tribs and WWTPs "First cut" daily loads for 2012-2013 simulation

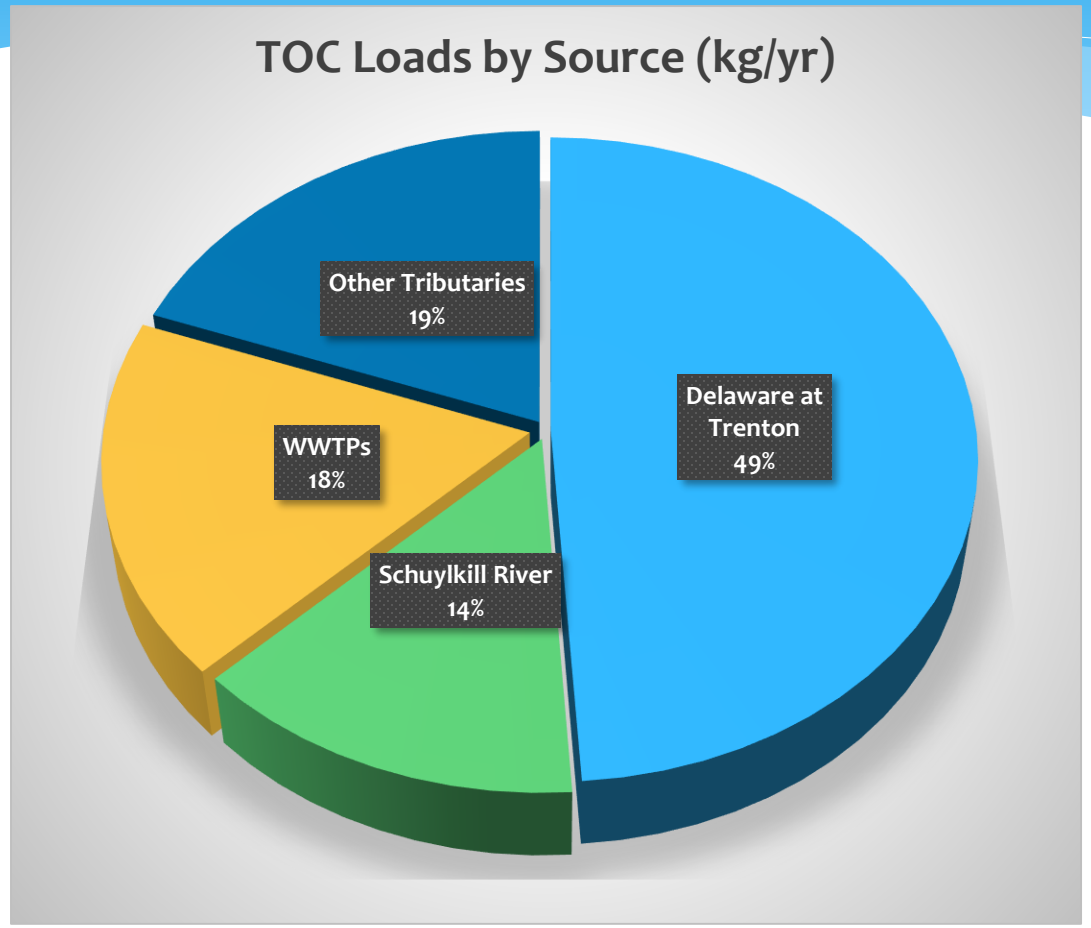
Sources

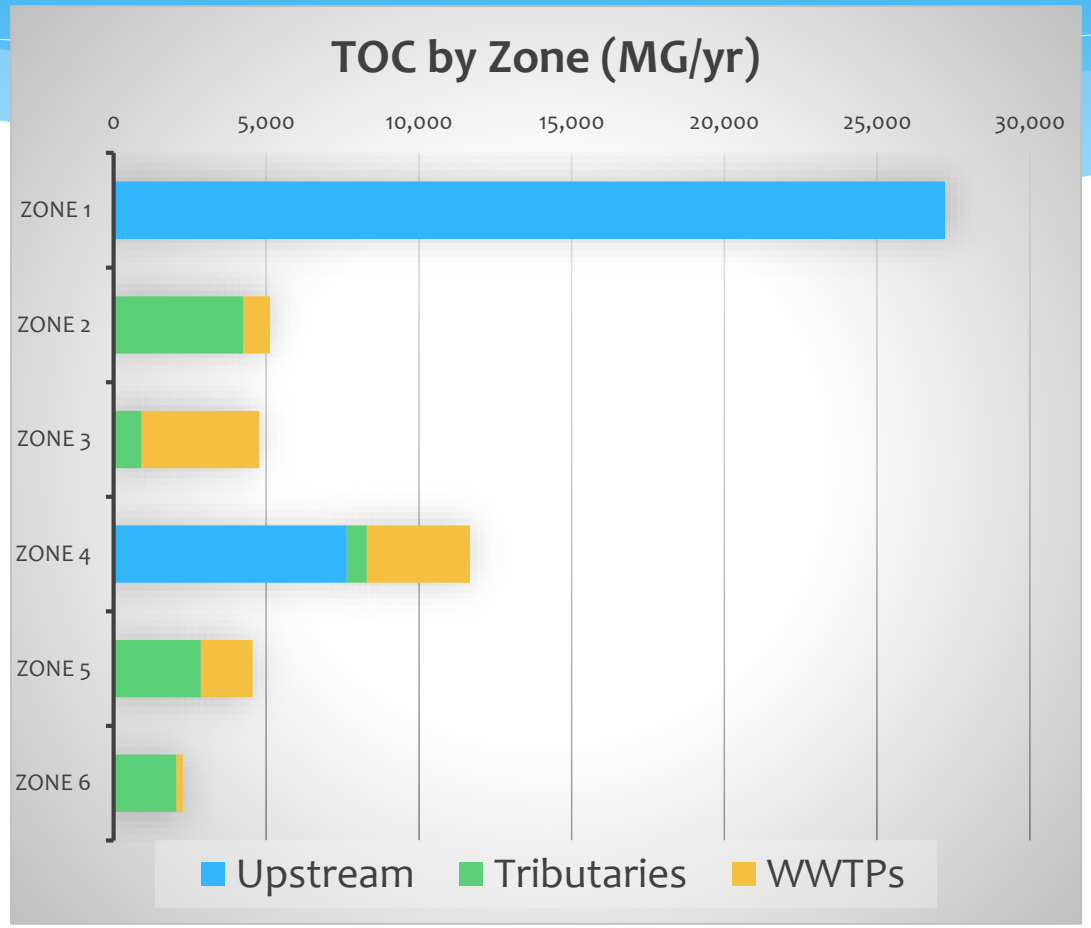
- WWTPs
  - Sampled 2011 – 2015
  - Daily load = concentration × daily flow
  - Average load calculated
- Tributaries
  - As first cut, PWD methodology used
    - Concentrations assigned for 3 seasons and 2 flows (high/low) based on 1990-2013 data
    - High/low flow threshold = 80th percentile
    - Unmonitored tribs borrow assigned concentrations from nearby tribs

Nutrients

- Total Organic Carbon
  - TOC = DOC + POC
  - TOC, DOC measured directly
- Total Nitrogen
  - TN = Nitrate(+Nitrite) + TKN
  - Nitrate, Nitrite, TKN measured directly
- Ammonia (NH3-N)
  - Measured directly
- Total Phosphorus
  - TP = PO4 + DOP + POP
  - TP, PO4 measured directly

Total Organic Carbon





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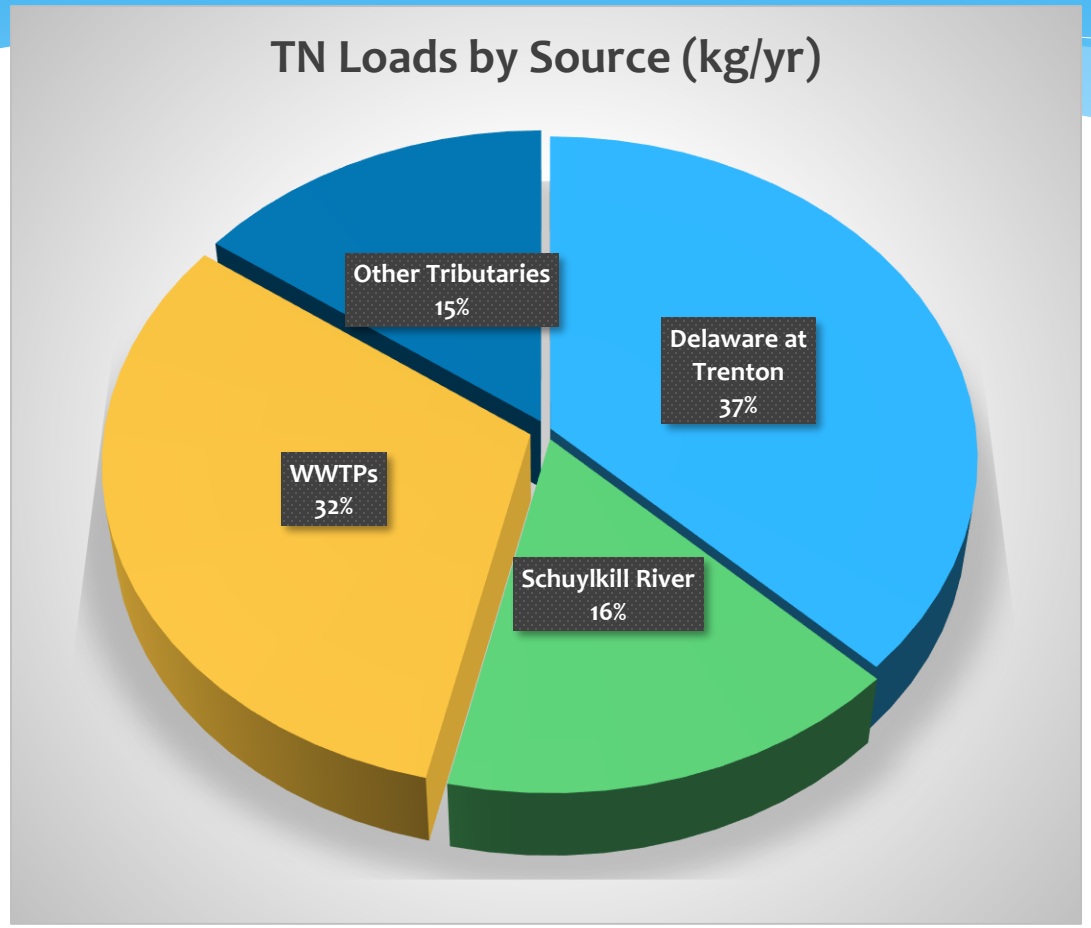
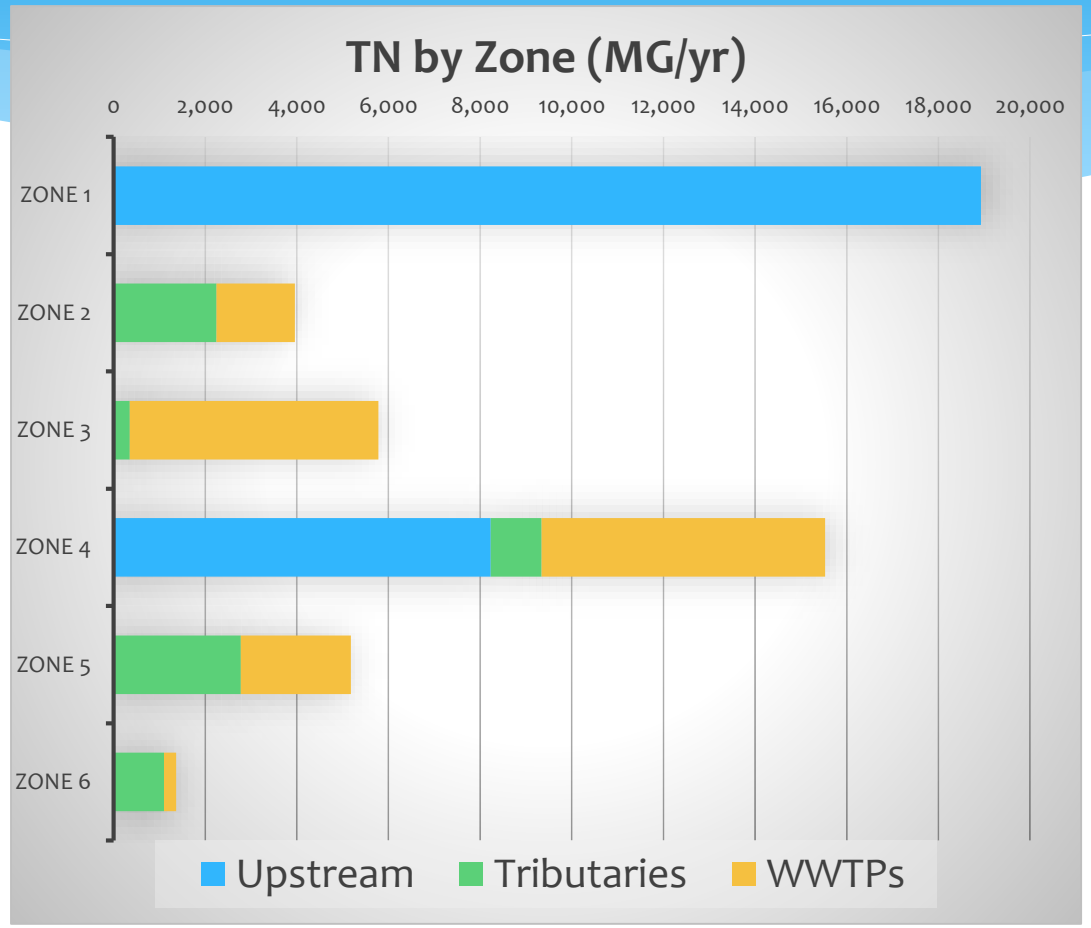
Total Nitrogen





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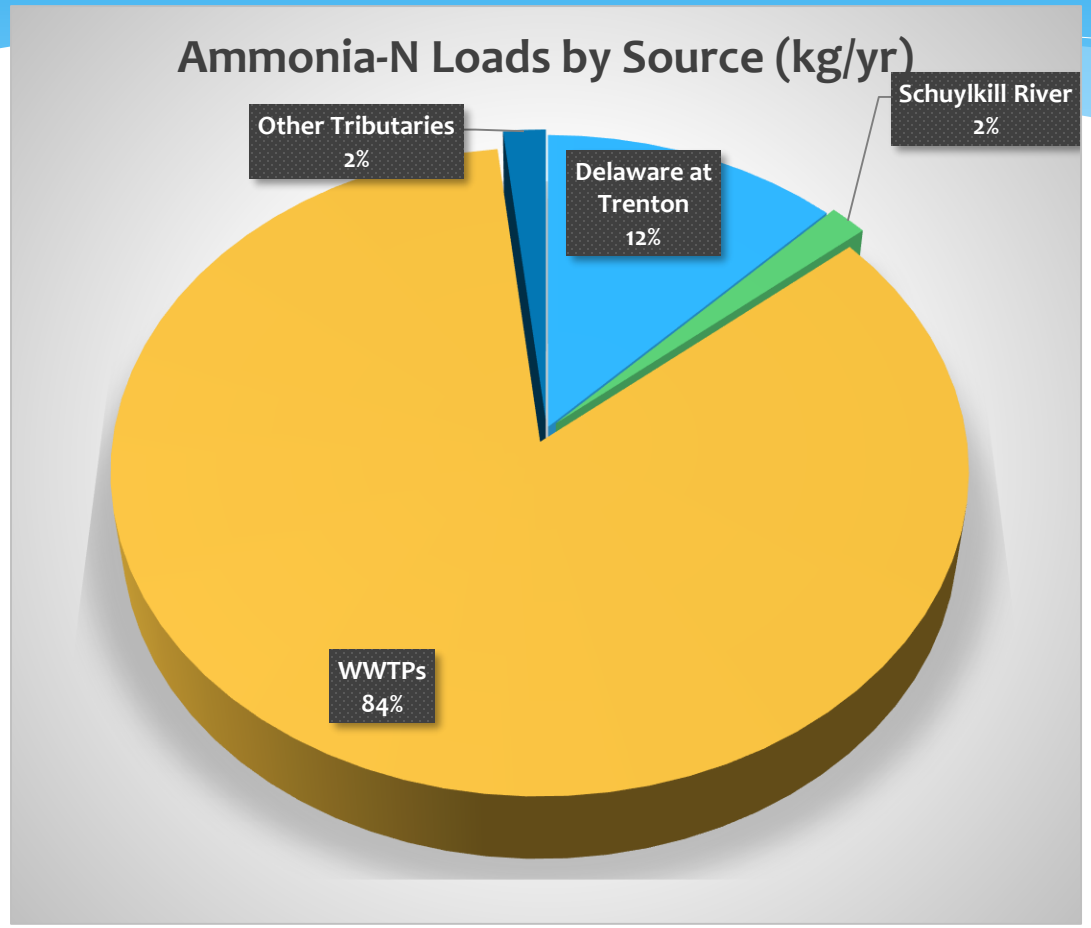
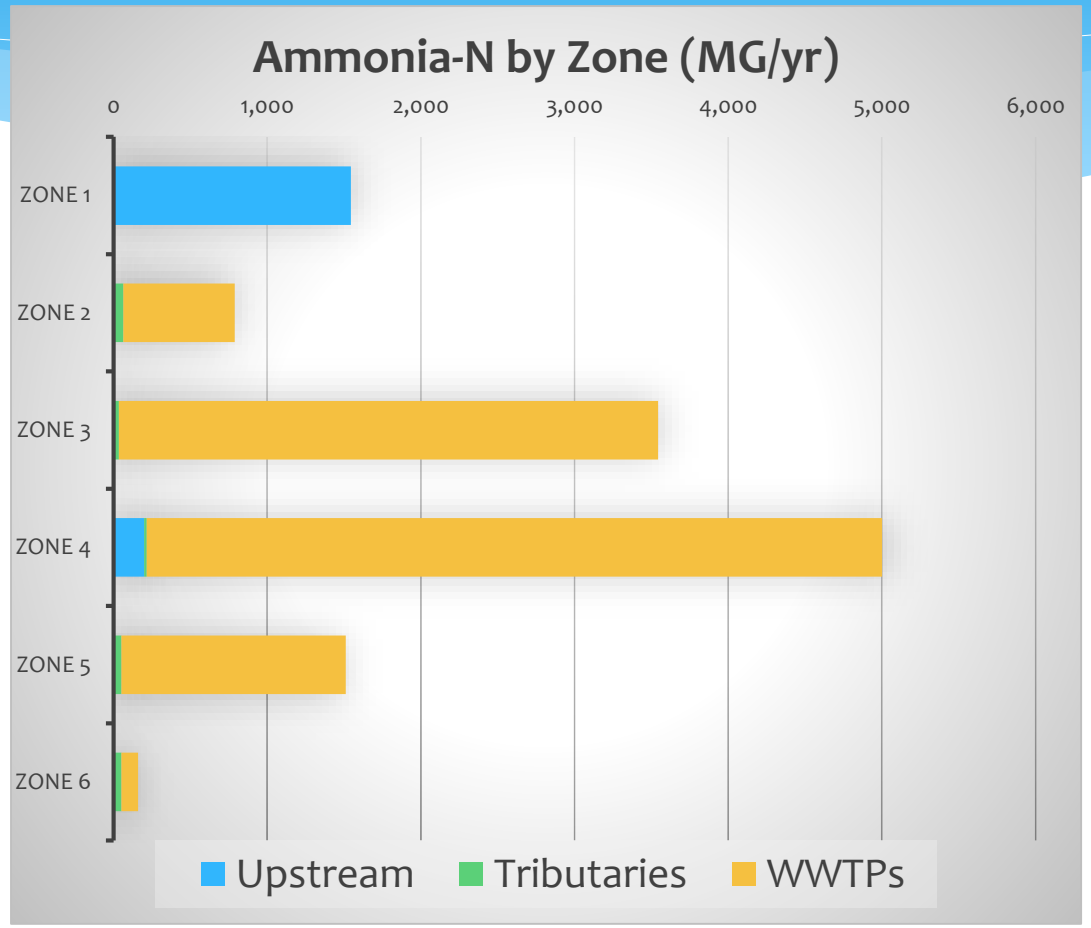
Ammonia-Nitrogen





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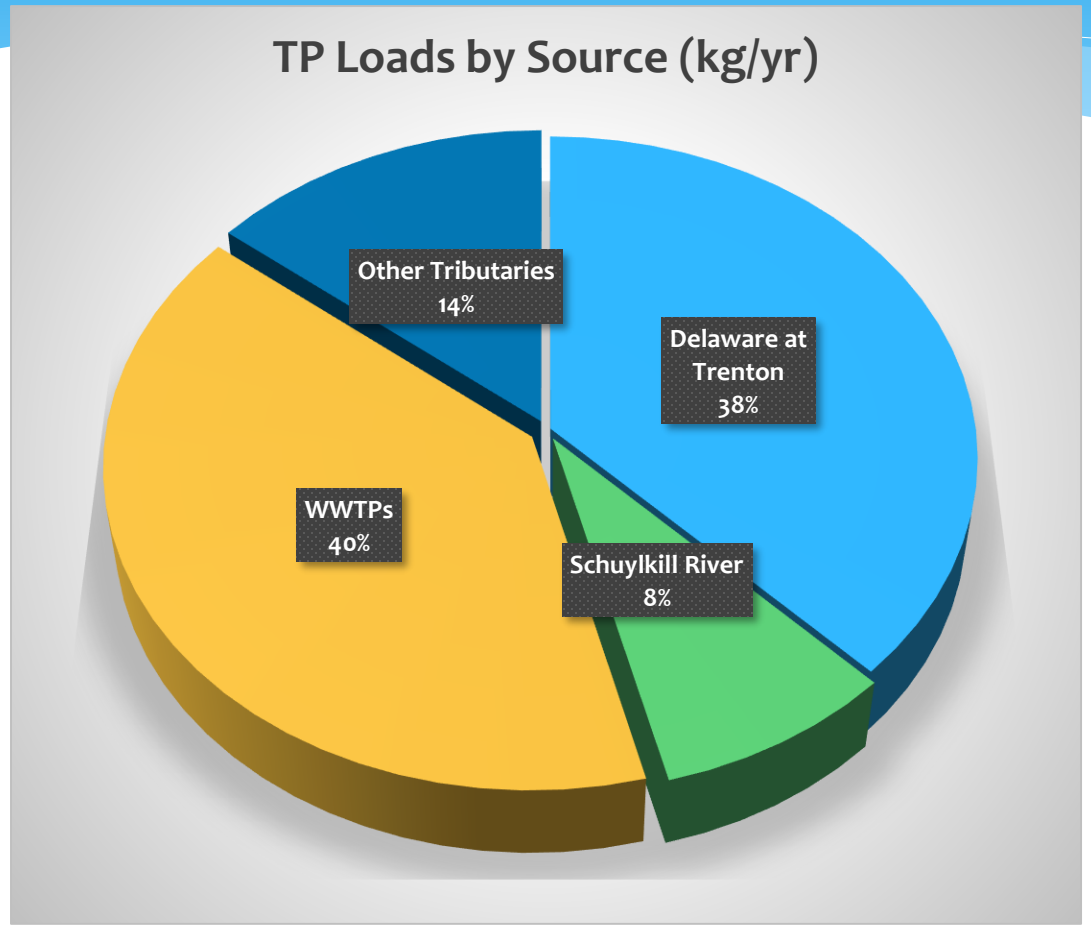
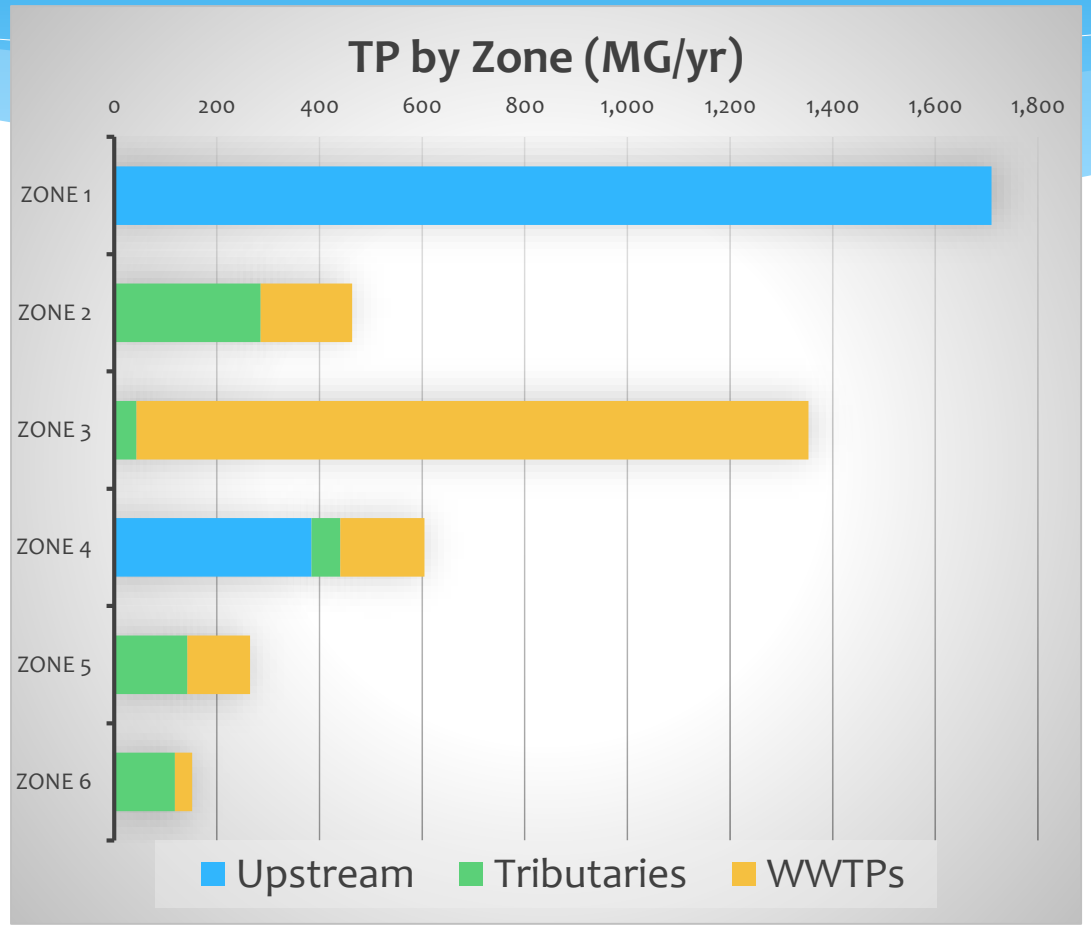
Total Phosphorus





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2018-2019 Monitoring Program

WWTPs

* Frequency
  * Weekly for Tier 1 (Top 12)
  * Monthly for Tier 2 (Next 20)
* Parameters
  * COD, TOC, DOC, CBOD5
  * Ammonia, Nitrite, Nitrate, TKN, SKN
  * TP, SRP
  * TSS, TDS or conductivity
  * *In-situ* DO, pH, and temperature

Tributaries

* Frequency
  * 2x/month (Delaware at Trenton, Schuylkill)
  * Monthly April-Nov at 25 other tribs
* Parameters
  * COD, TOC, POC, DOC, CBOD5
  * Ammonia, Nitrate+Nitrite, TKN
  * TP, OrthoP, PIP
  * Chloride, Silica, Sulfate
  * Alkalinity, Chlorophyll-a
  * TSS, TS, TVS

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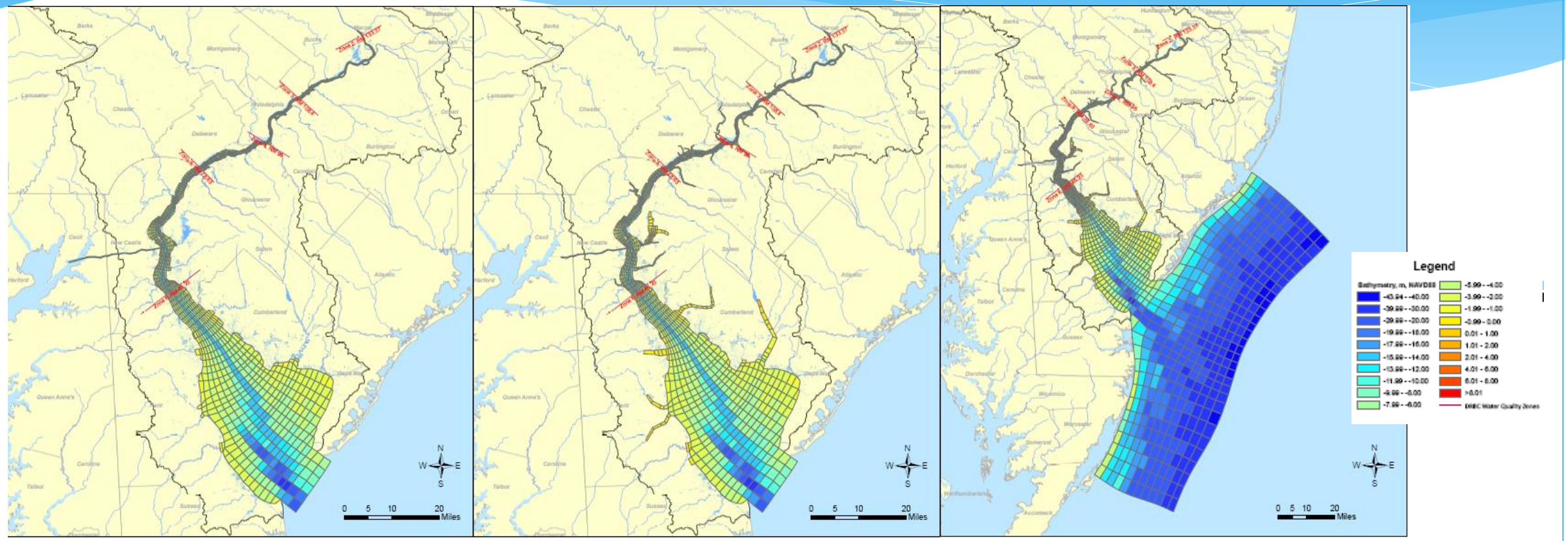
Modeling Progress to Date

* Preliminary calibration of EFDC hydrodynamic model
  * Water surface elevation
  * Salinity
  * Water temperature
* Continued cross-checking of EFDC-WASP8 linkage
  * Flow rates
  * Salinity transport
  * Mass balance check in WASP8
* WASP8 test simulations
  * TN and TP with chemical-biological kinetics turned off
  * Oxygen consumption by NH4-N, CBOD, and SOD

Hydrodynamics Model Grid - Bathymetry

- Model Grid and Bathymetry (Grid 5, Grid 1, and Grid 2) – Bathymetry *(Based on FEMA 2011 DEM, Reflects 2016 dredging depth). Vertical datum is NAVD88.*



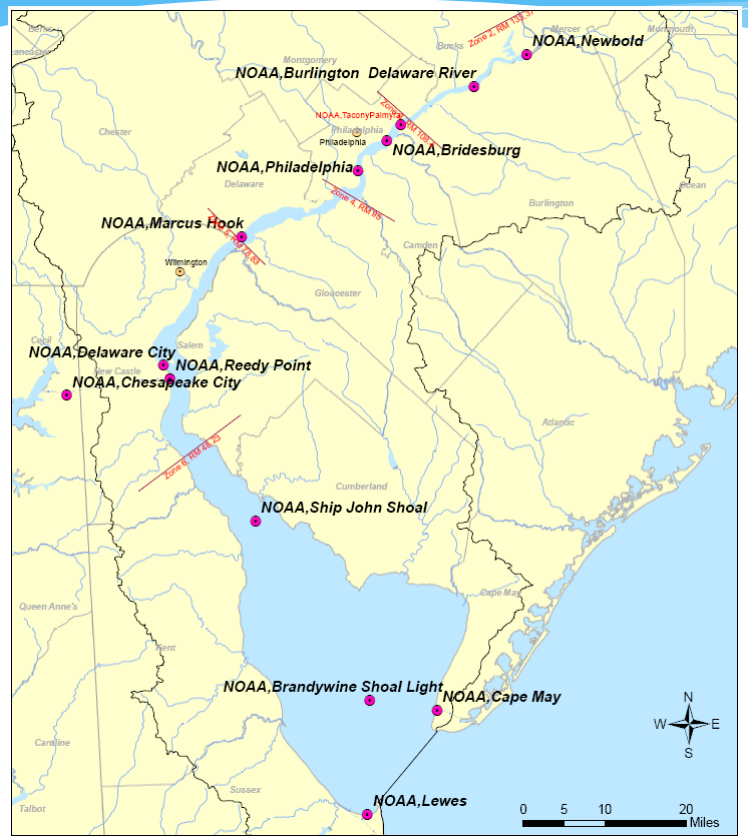
Grid 5, 1933 cells
KC = 5

Grid 1, 2281 cells
KC = 10

Grid 2, 2641 cells
KC = 20

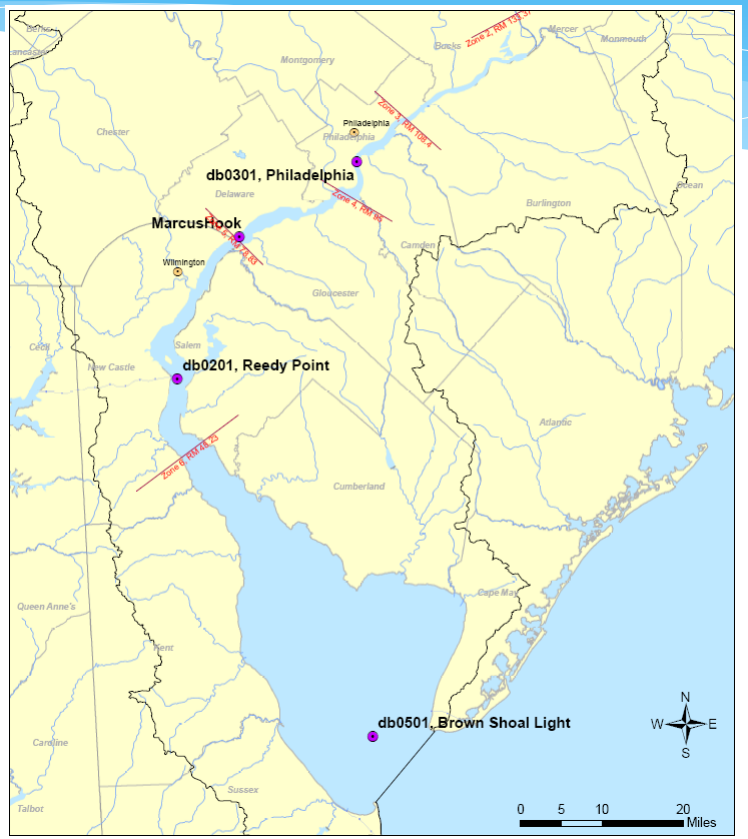
Data for Hydrodynamics Model Calibration

Location of NOAA and USGS Stations



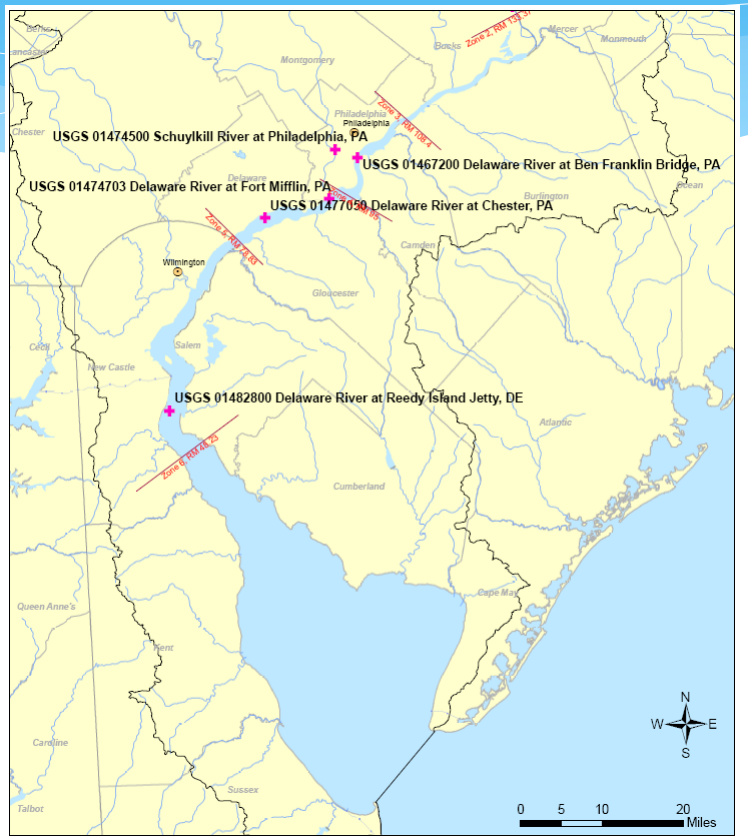
NOAA Stations

Tide/Water Temperature, Conductivity



NOAA Stations

Current Velocity



USGS Stations

Water Temperature, Specific Conductance

(Data from Reedy Island, Chester, and Ben Franklin Bridge were used)

Calibration Results – Grid 5 (2017-2018): Water Surface Elevation

Reedy Point

$Y = 0.9792\ X - -0.0145$
$R^2 = 0.9767$
$N = 17056$
$RMSE = 0.0961$
$ubRMSE = 0.0947$
$Bias = -0.0166$
$Skill = 0.9939$

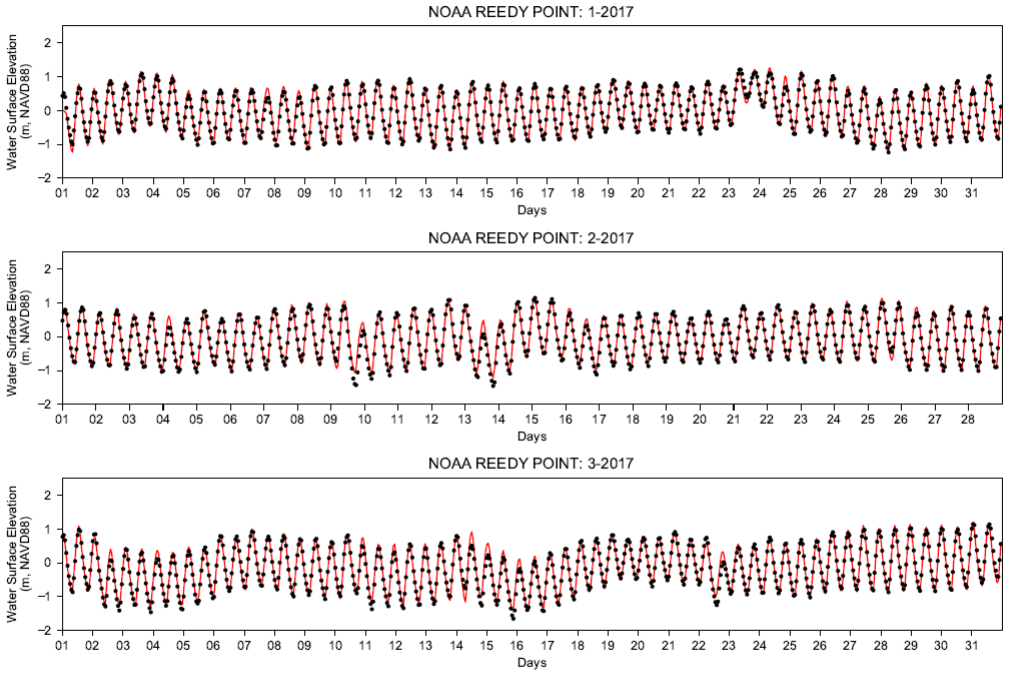


Figure XX

Observed and Predicted Water Surface Elevation at NOAA REEDY POINT

NOAA hourly verified data were used. Station ID: 8551910
Run ID: EFDC_FGD_GVC_HYDRO_NFPNOC_1902-05, Fine grid GVC, KC =5. CTE3=3.5
Spatial variable z0. 1933 cells. dt=20s. Sal adjustment = 3.5 ppt. NOAA NCDC weather data.

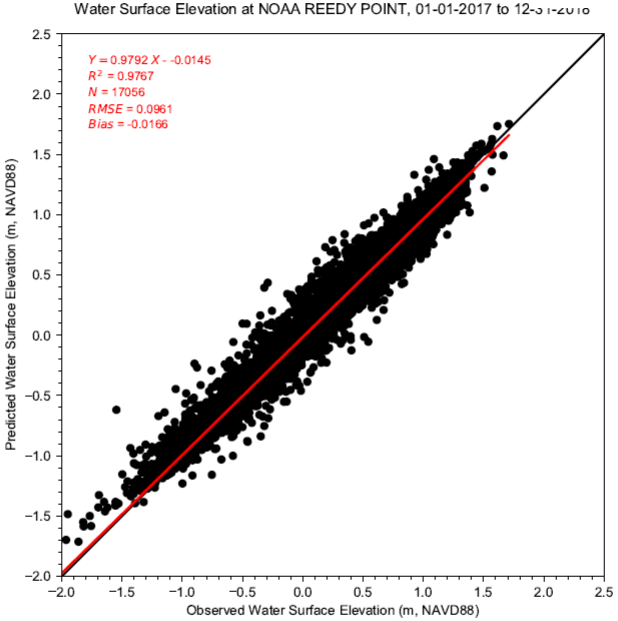


Figure --

Comparison of Observed and Predicted Water Surface Elevation at NOAA REEDY POINT

NOAA hourly verified data were used. Station ID: 8551910
Run ID: EFDC_FGD_GVC_HYDRO_NFPNOC_1902-05, Fine grid GVC, KC =5. CTE3=3.5
Spatial variable z0. 1933 cells. dt=20s. Sal adjustment = 3.5 ppt. NOAA NCDC weather data.

Calibration Results – Grid 5: Salinity (2017-2018)

Reedy Island

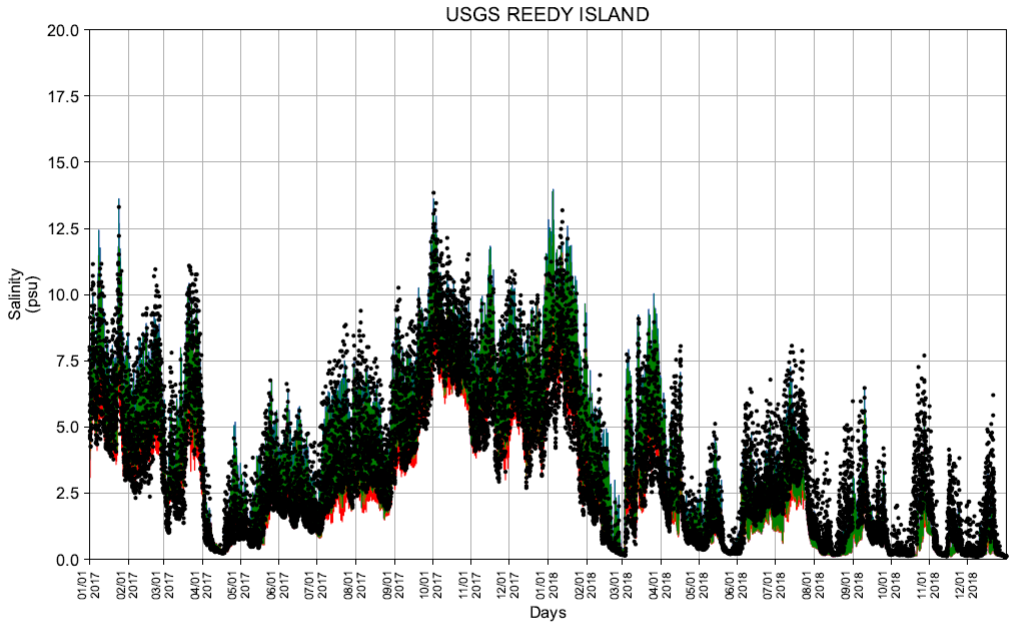


Figure XX

Observed and Predicted Salinity at USGS REEDY ISLAND

Station ID: 01482800, USGS REEDY ISLAND
Run ID: EFDC_FGD_GVC_HYDRO_NFPNOC_1902-05, Fine grid GVC, KC =5. CTE3=3.5, dt=15s. Salinity adjustment = 3.5 ppt.

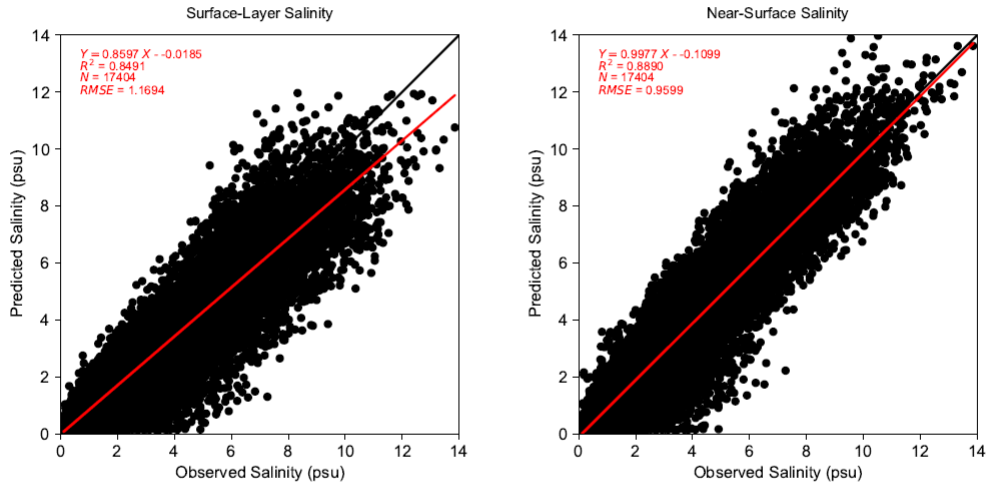


Figure --

Comparison of Observed and Predicted Salinity at
USGS REEDY ISLAND during 01-01-2017 to 12-31-2018 period.

Station ID: 01482800
Run ID: EFDC_FGD_GVC_HYDRO_NFPNOC_1902-05, Fine grid GVC, KC =5. CTE3=3.5, dt=15s. Salinity adjustment = 3.5 ppt.

Calibration Results – Grid 5: Water Temperature

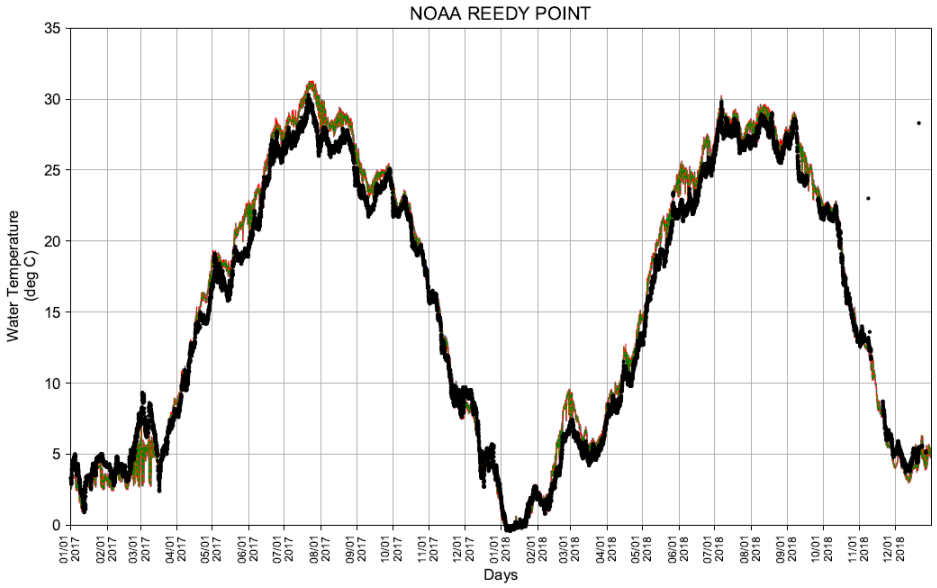


Figure XX

Observed and Predicted Water Temperature at NOAA REEDY POINT

Station ID: 8551910, NOAA REEDY POINT
Run ID: EFDC_FGD_GVC_HYDRO_NFPNOC_1902-05, Fine grid GVC, KC =5. CTE3=3.5, Salinity adjustment = 3.5 ppt. NOAA NCDC weather data were used. dt=15s

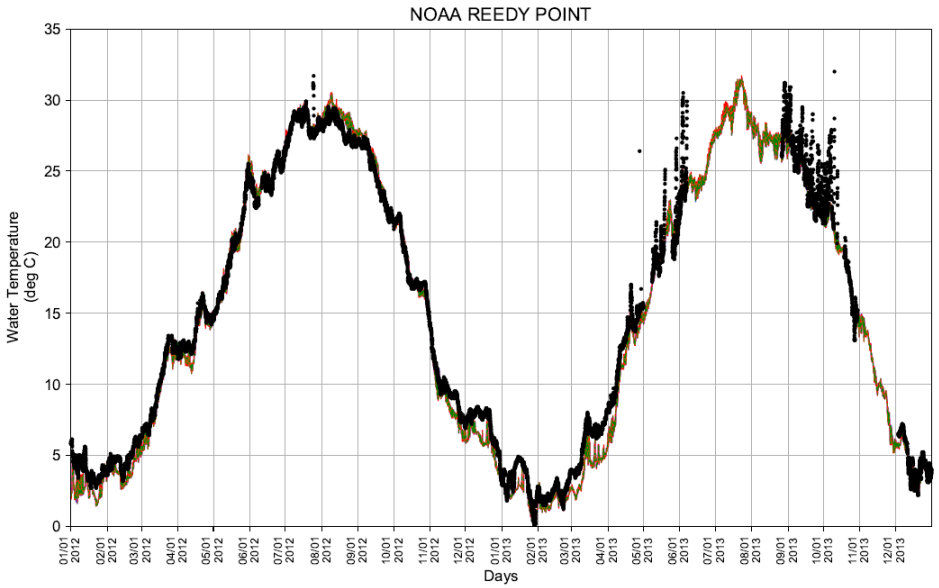


Figure XX

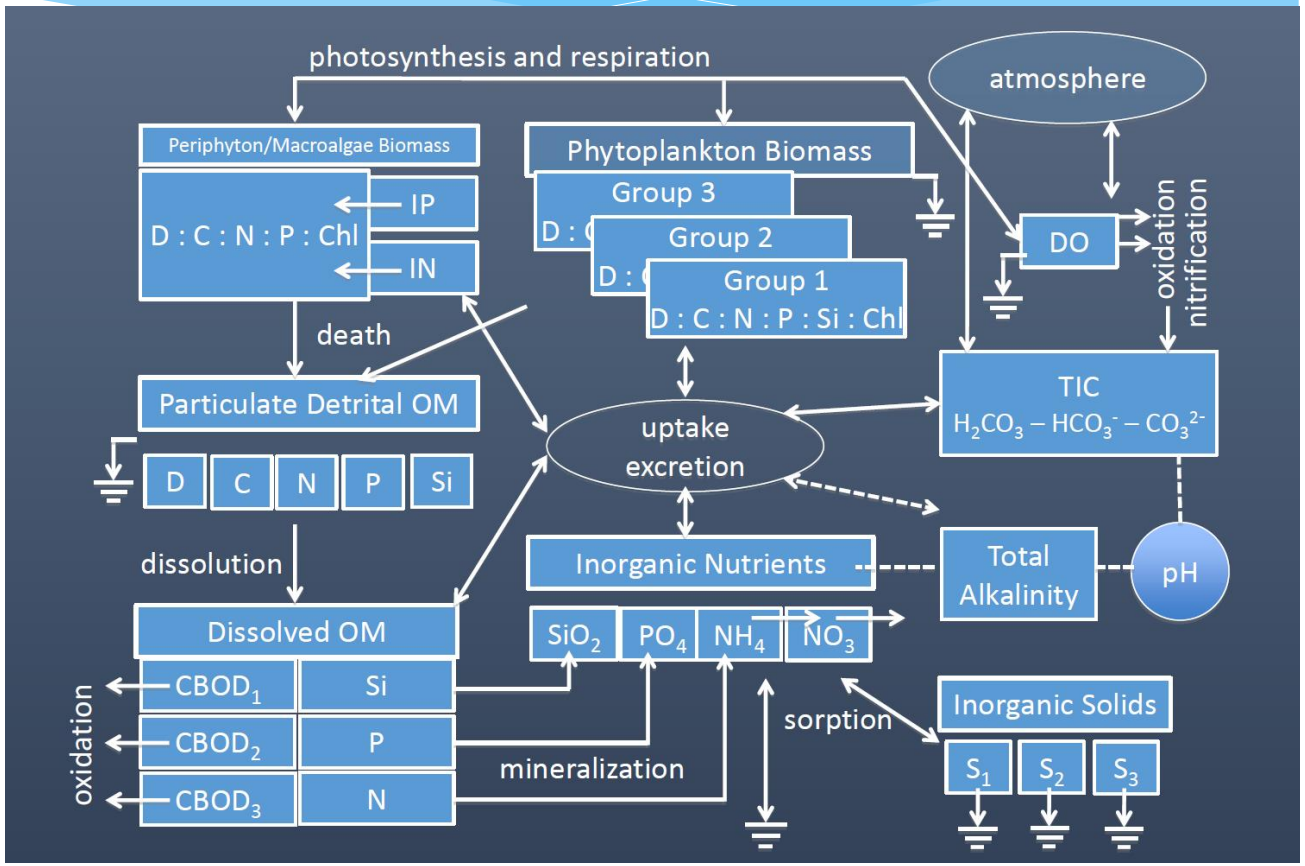
Observed and Predicted Water Temperature at NOAA REEDY POINT

Station ID: 8551910, NOAA REEDY POINT
Run ID: EFDC_FGD_GVC_HYDRO_NFPNOC_1902-06, Fine grid GVC, KC =5. CTE3=3.5, Salinity adjustment = 3.5 ppt. NOAA NCDC weather data were used. dt=15s

2017-2018 Reedy Point 2012-2013

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

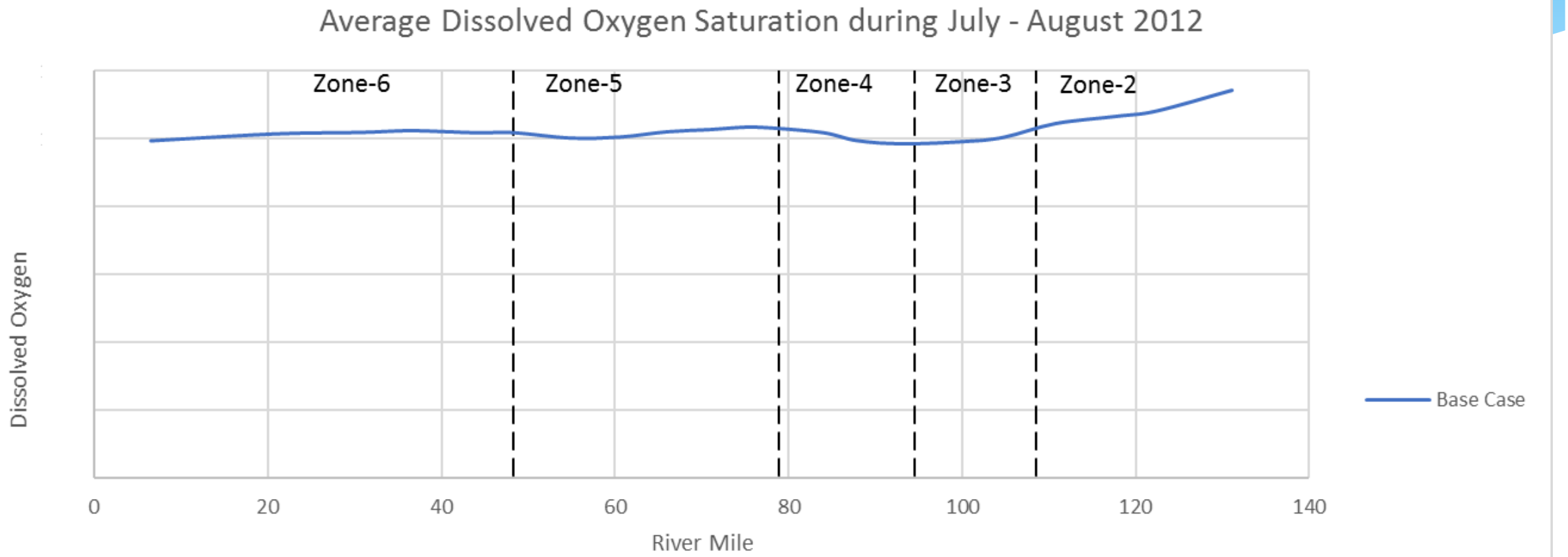


WASP8 Test Simulations for DO

* Zero loads (except DO)
  * Re-aeration only
* Oxygen consumption by NH4-N
  * Point source loads only
  * Tributary loads only

Zero Loading (Except DO) with Re-aeration

Base case



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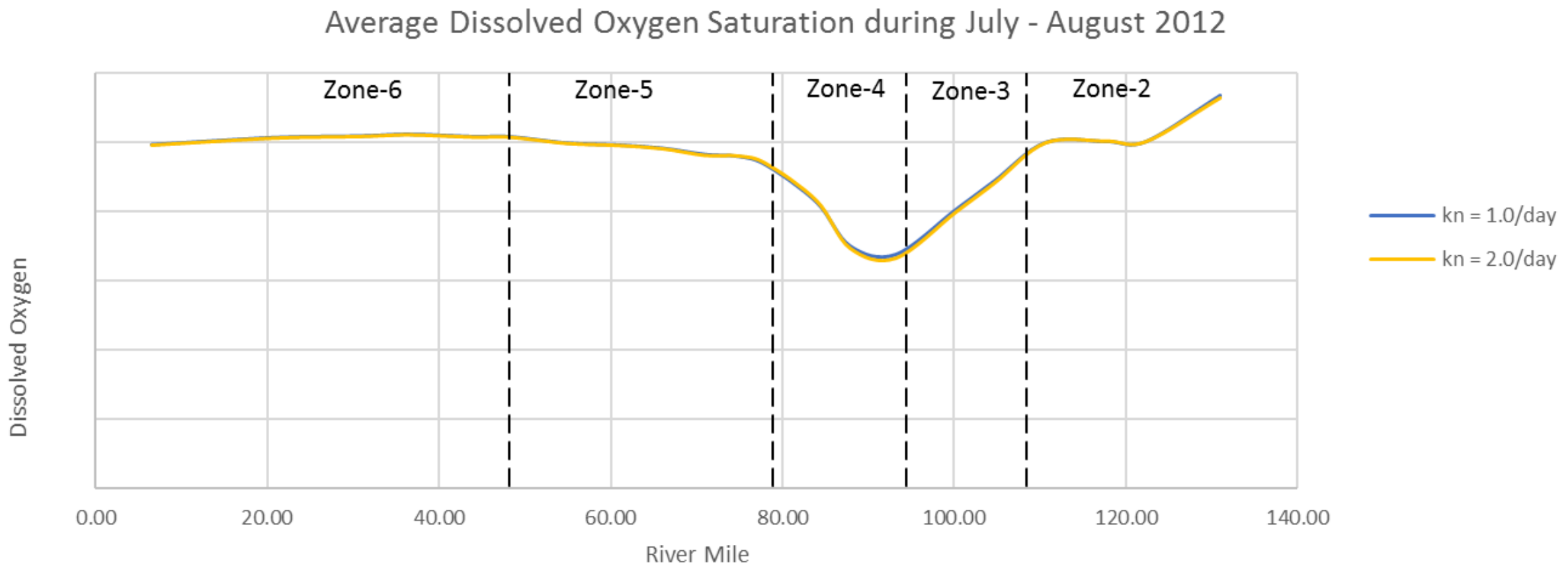
Oxygen Consumption by NH_4

from point source loads only



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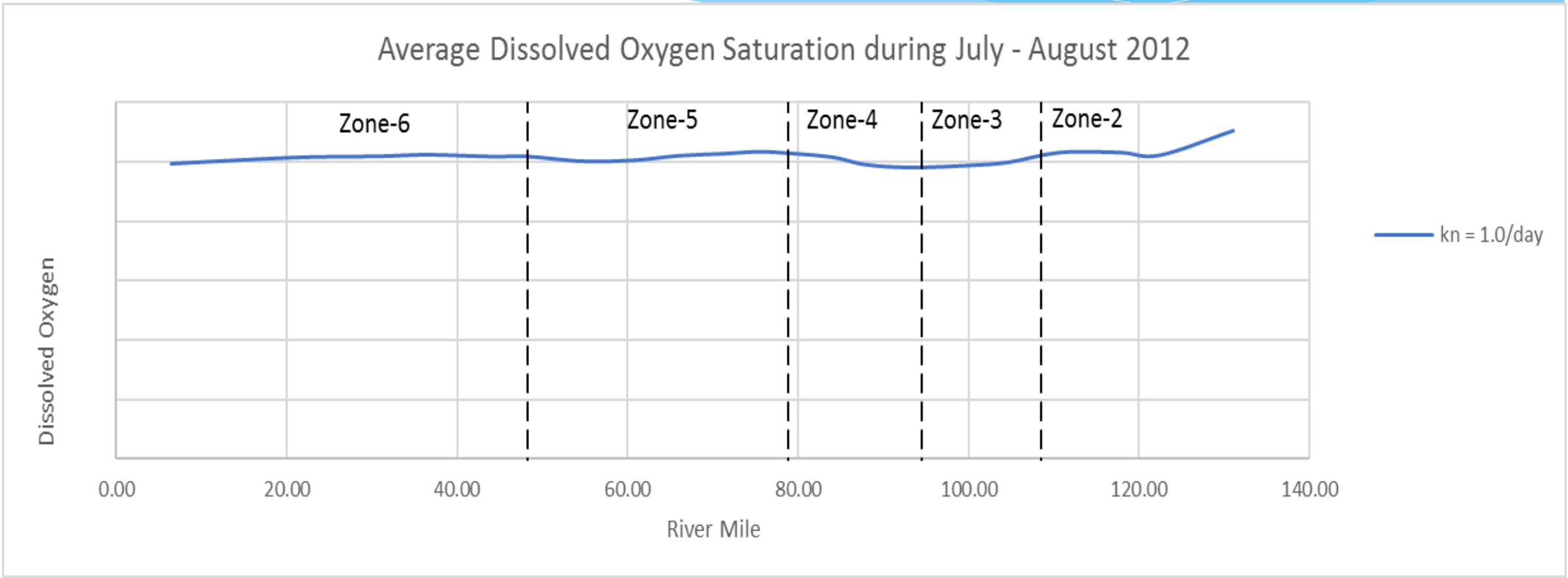
Oxygen Consumption by NH_4

from tributary loads only



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Path Forward

- Significant progress on model development and calibration since March, 2018
- Finalize calibration of EFDC hydrodynamic model
- Evaluate and resolve EFDC - WASP8 linkage issues
- Develop and refine remaining model inputs to WASP8
- Begin calibration of WASP8
- Implement Expert Panel recommendations to monitoring program