

# Water Quality Modeling Update to the DRBC Water Quality Advisory Committee

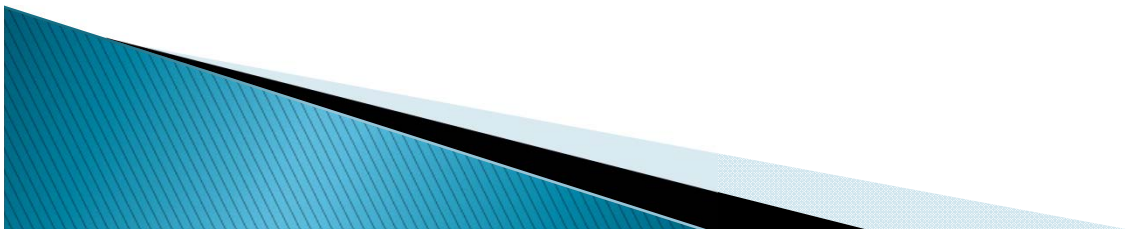
*Philadelphia Water Department*

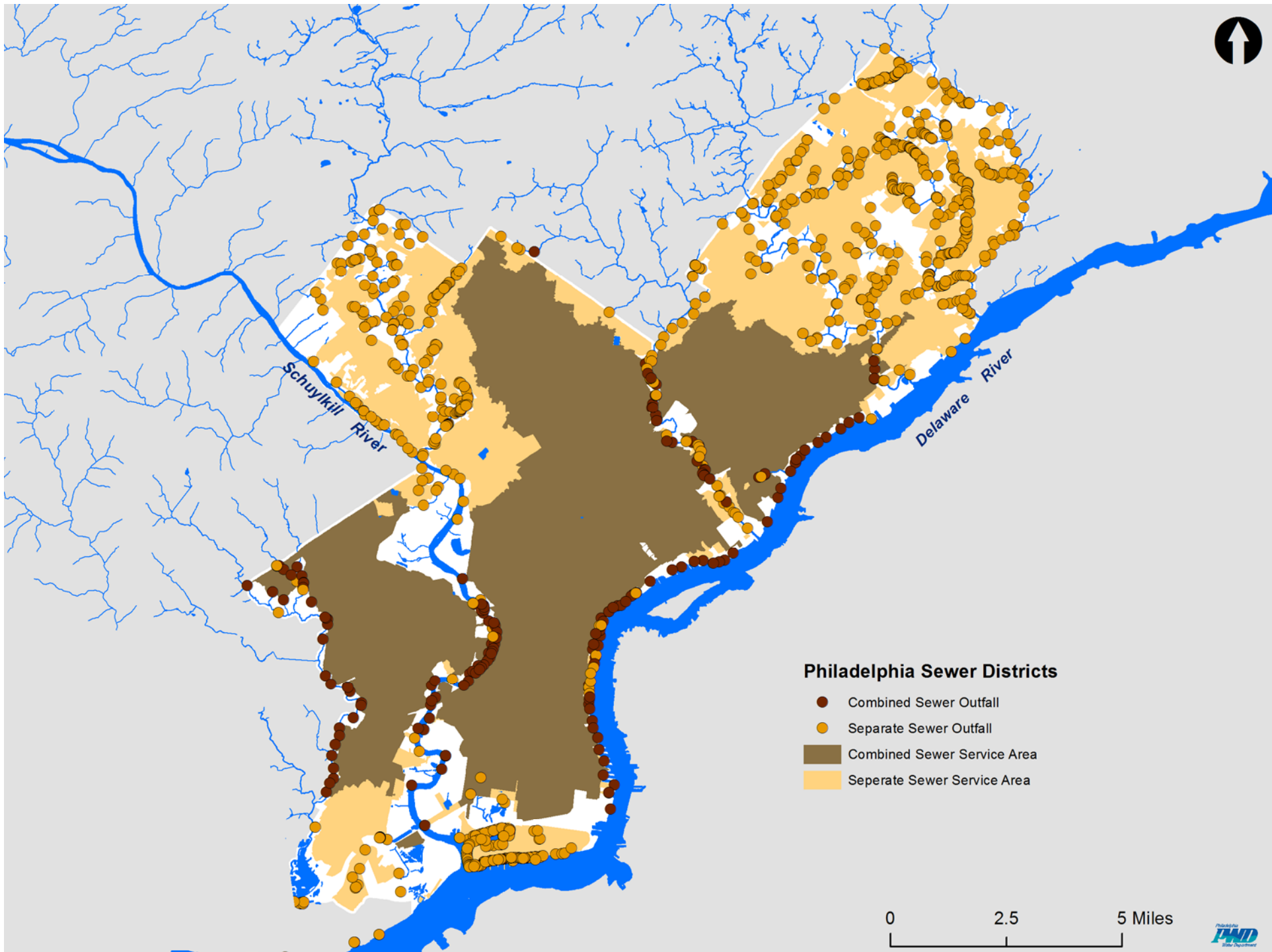
*9/24/13*



# Outline

- ▶ Need for PWD to develop water quality models of Delaware and tidal Schuylkill Rivers
- ▶ Overview of data collection and modeling efforts
  - Hydrodynamics and water quality
- ▶ Progress to date





# Philadelphia Water Department

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YOUR WATERSHED

WATERSHED ISSUES

WHAT WE'RE DOING

WHAT'S IN IT FOR YOU

## Green City, Clean Waters

Green City, Clean Waters is Philadelphia's 25-year plan to protect and enhance our watersheds by managing stormwater with innovative green infrastructure. The Philadelphia Water Department developed Green City, Clean Waters to provide a clear pathway to a sustainable future while strengthening the utility, broadening its mission, and complying with environmental laws and regulations.

Nationwide, water utilities are confronting a new set of complex environmental, demographic and financial challenges while also trying to meet customer expectations for a safe and affordable water supply; the collection and treatment of wastewater and stormwater; flood protection; and clean, attractive, fishable, swimmable rivers and streams. There are also new challenges posed by aging infrastructure and the impacts of climate change on human health and our ecosystems. Meeting these challenges requires either a significant new investment in "grey" infrastructure (underground storage tanks and pipes) or a paradigm shift in our approach to urban water resources.

Over the past decade, PWD has created, tested and implemented new strategies to promote the economic and social growth of the City and meet environmental, ecological and business missions. As the City agency charged with ensuring compliance with the Federal Clean Water Act, PWD developed Green City, Clean Waters to protect and enhance our waterways by using green infrastructure systems that assist or mimic natural processes.



Images above are design concepts only

### 2011-2012 Green City, Clean Waters Year in Review

There has been lots of excitement and major successes for the City of Philadelphia

COMMONWEALTH OF PENNSYLVANIA  
DEPARTMENT OF ENVIRONMENTAL PROTECTION

IN THE MATTER OF:

City of Philadelphia  
Philadelphia County

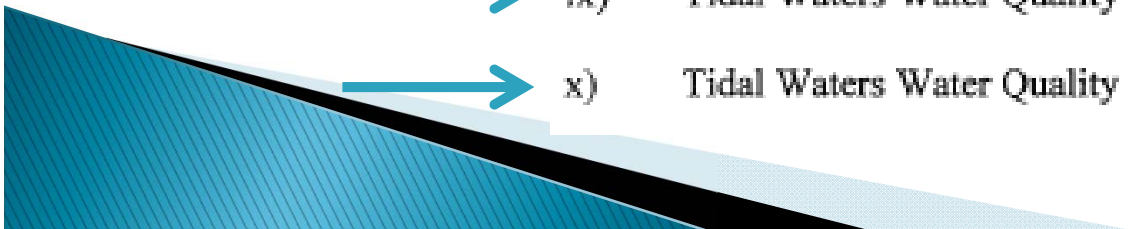
Clean Streams Law  
Sewage

CONSENT ORDER AND AGREEMENT

This Consent Order and Agreement ("COA") is entered into this 1<sup>st</sup> day of June, 2011, by and between the Commonwealth of Pennsylvania, Department of Environmental

**Deliverables:** Submit to the Department the following Deliverables<sup>1</sup> by the dates given:

- i) Implementation and Adaptive Management Plan (6 months);
- ii) Green Infrastructure Maintenance Manual development process plan (12 months);
- iii) Comprehensive Monitoring Plan (18 months);
- iv) Facility Concept Plans for each of the three Water Pollution Control Plants (24 months);
- v) Updated Nine Minimum Controls Report (24 months);
- vi) Tributary Water Quality Model - Bacteria (24 months);
- vii) Tributary Water Quality Model - Dissolved Oxygen (36 months);
- viii) Green Infrastructure Maintenance Manual - First Edition (36 months);
- ix) Tidal Waters Water Quality Model - Bacteria (48 months); and
- x) Tidal Waters Water Quality Model - Dissolved Oxygen (48 months).



# Collaborations

- ▶ NOAA
- ▶ US Army Corps
- ▶ DRBC
- ▶ USEPA Region 3
- ▶ Tetra Tech
- ▶ Woods Hole Group
- ▶ Academy of Natural Sciences of Drexel University
- ▶ Chesapeake Biogeochemical Associates
- ▶ University of Delaware
- ▶ University of Maryland



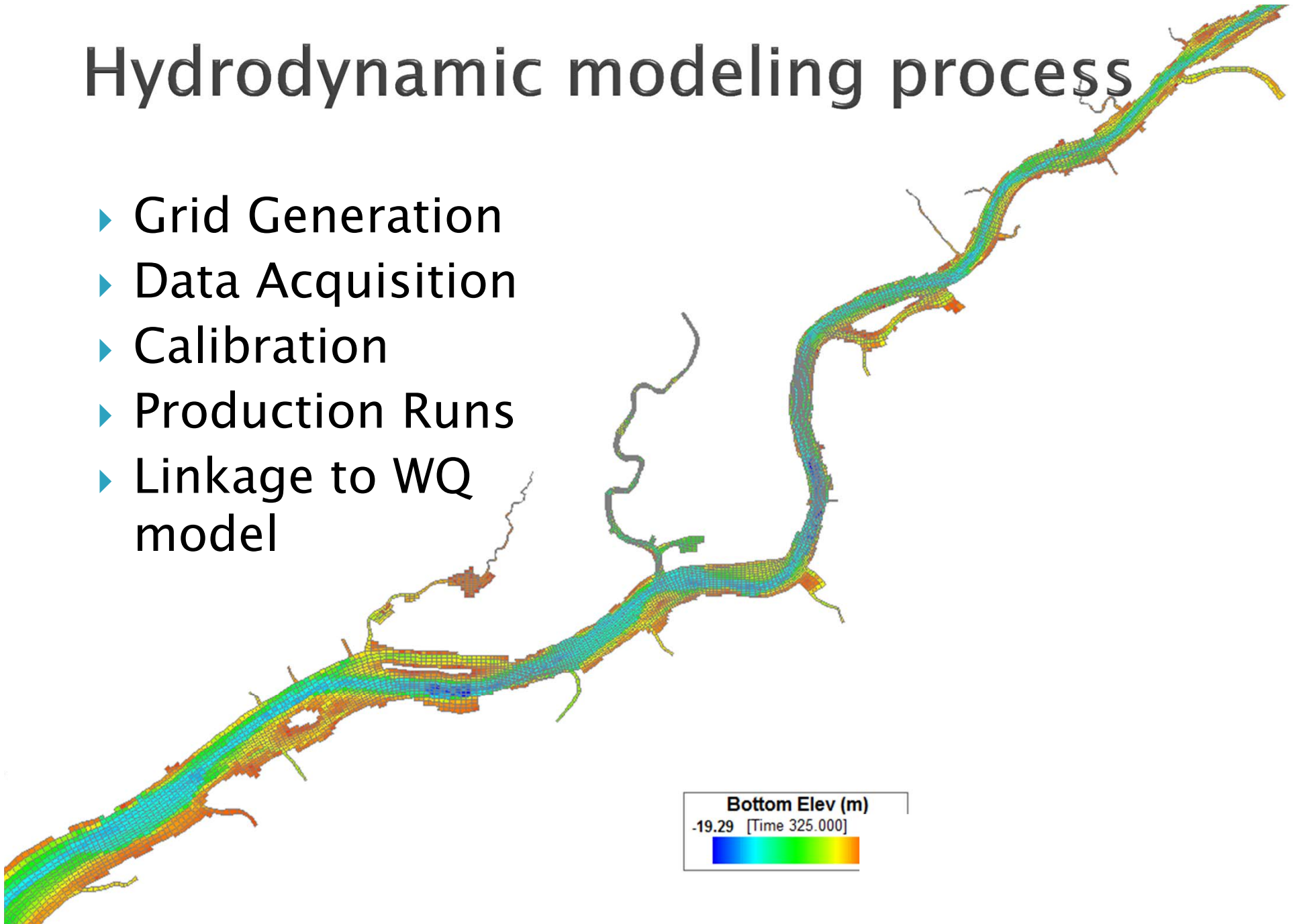
# Tidal Rivers Hydrodynamic Model Objectives

- ▶ Model the Delaware River from Trenton to Delaware City, and the tidal Schuylkill River
- ▶ Provide numerical model to link with water quality model
- ▶ Accurately reproduce physical processes in tidal Delaware and Schuylkill Rivers
- ▶ Improve on existing models from DRBC, USACE, NOAA
  - All have coarse resolution in upper freshwater portion at Philadelphia and above



# Hydrodynamic modeling process

- ▶ Grid Generation
- ▶ Data Acquisition
- ▶ Calibration
- ▶ Production Runs
- ▶ Linkage to WQ model





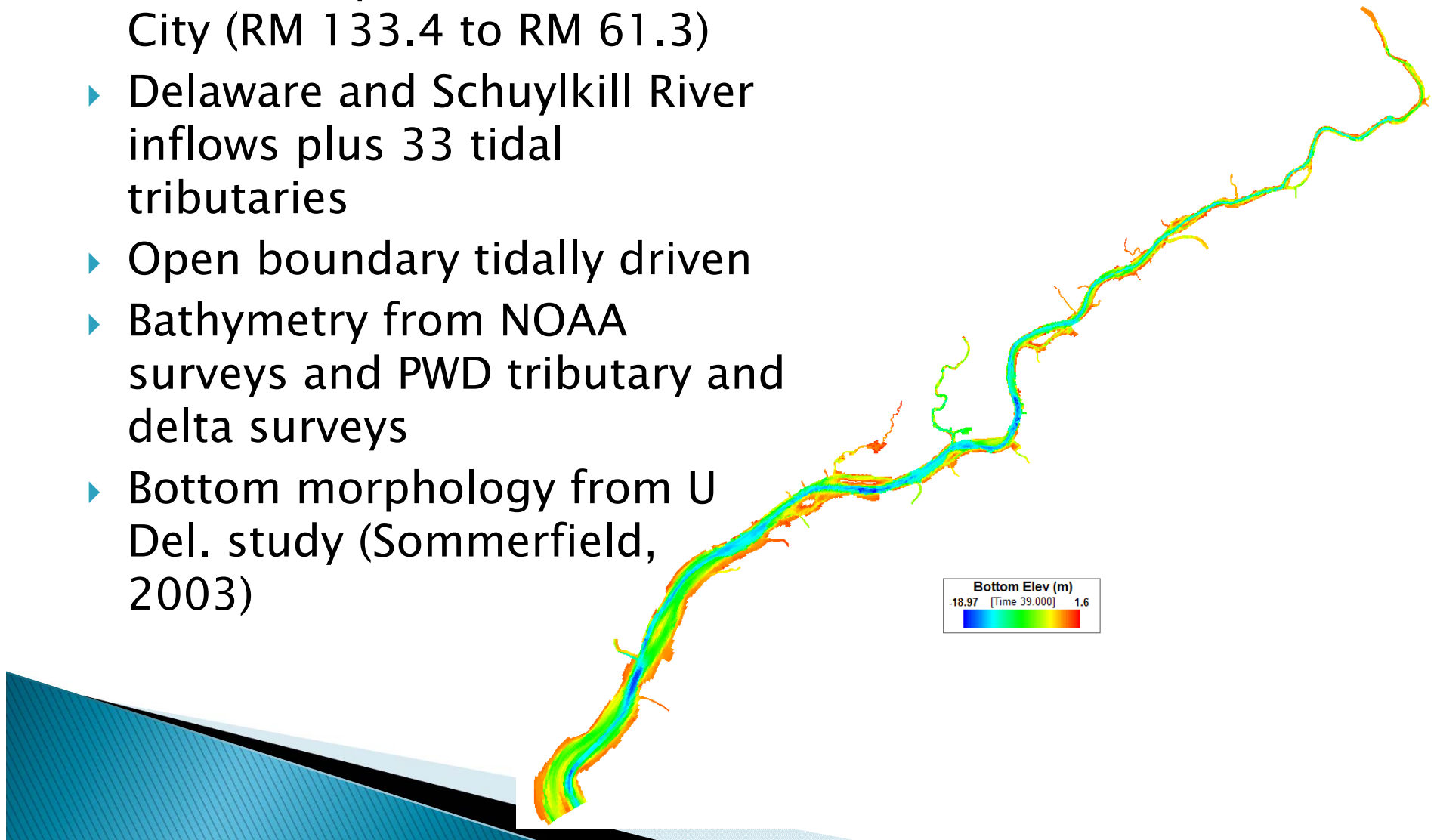
# Description of modeling tool

- ▶ EFDC – Environmental Fluid Dynamics Code
- ▶ Hydrodynamics code capable of 1–, 2– or 3– dimensional simulations
- ▶ EFDC HD model provides vessel to convey biological processes
- ▶ One of most widely used, technically defensible hydrodynamic models worldwide
- ▶ Part of EPA TMDL Toolbox



# Model domain

- ▶ Trenton rapids to Delaware City (RM 133.4 to RM 61.3)
- ▶ Delaware and Schuylkill River inflows plus 33 tidal tributaries
- ▶ Open boundary tidally driven
- ▶ Bathymetry from NOAA surveys and PWD tributary and delta surveys
- ▶ Bottom morphology from U Del. study (Sommerfield, 2003)



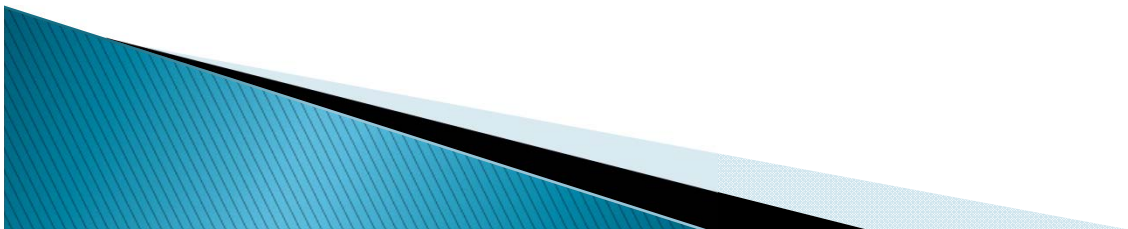
# Data collection

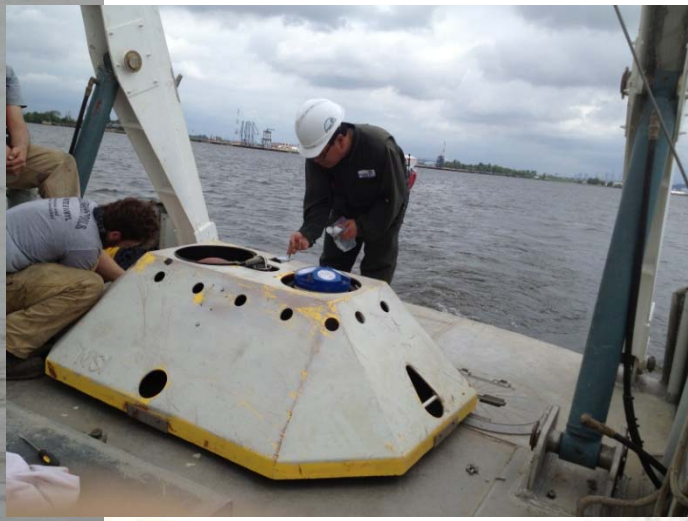
- ▶ **Historic/Contemporary**
  - NOS Del River & Bay Circulation Survey: 1984–85
  - NOAA PORTS
  - NCDC Meteorological Data
  - USGS/NWIS discharge, conductivity, temp
  - NOAA/NOS bathymetry surveys
- ▶ **Contemporary**
  - PWD/WHG Current Meter Deployment
  - USACE Bathymetry
  - PWD tributary bathymetry survey



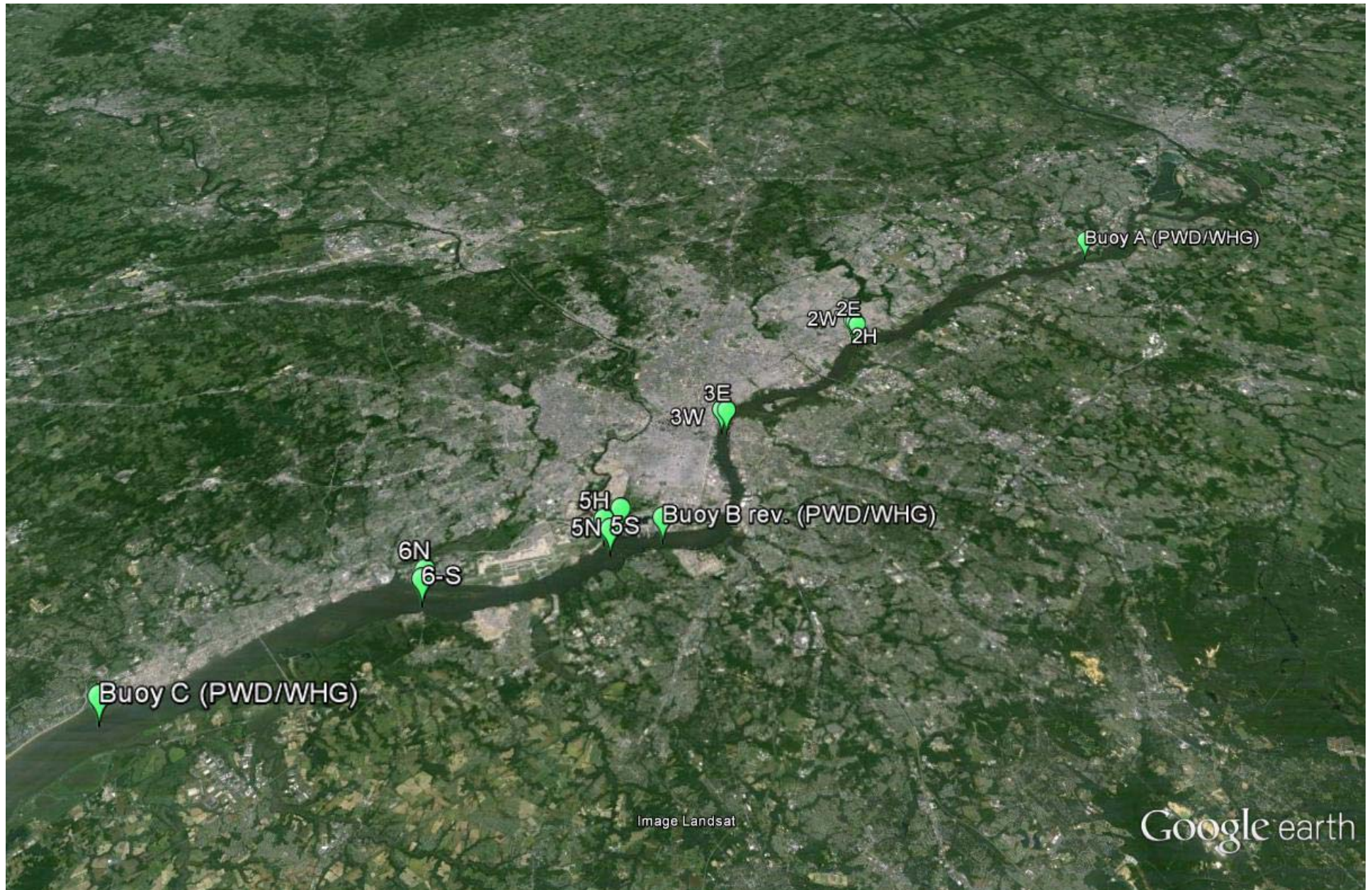
# Woods Hole Group activities

- ▶ Current meter deployment
  - Long term: 3 Acoustic Doppler Current Profilers (ADCPs) ( $\geq 1$  year)
    - Characterize current at different depths in the water column
    - 3 meters recording reliable data since August 2012 (Burlington, Eagle Point, Marcus Hook)
  - Short term: 4 sites with combination of side looking and bottom mounted ADCPs (30 day)
    - Characterize current across a transect

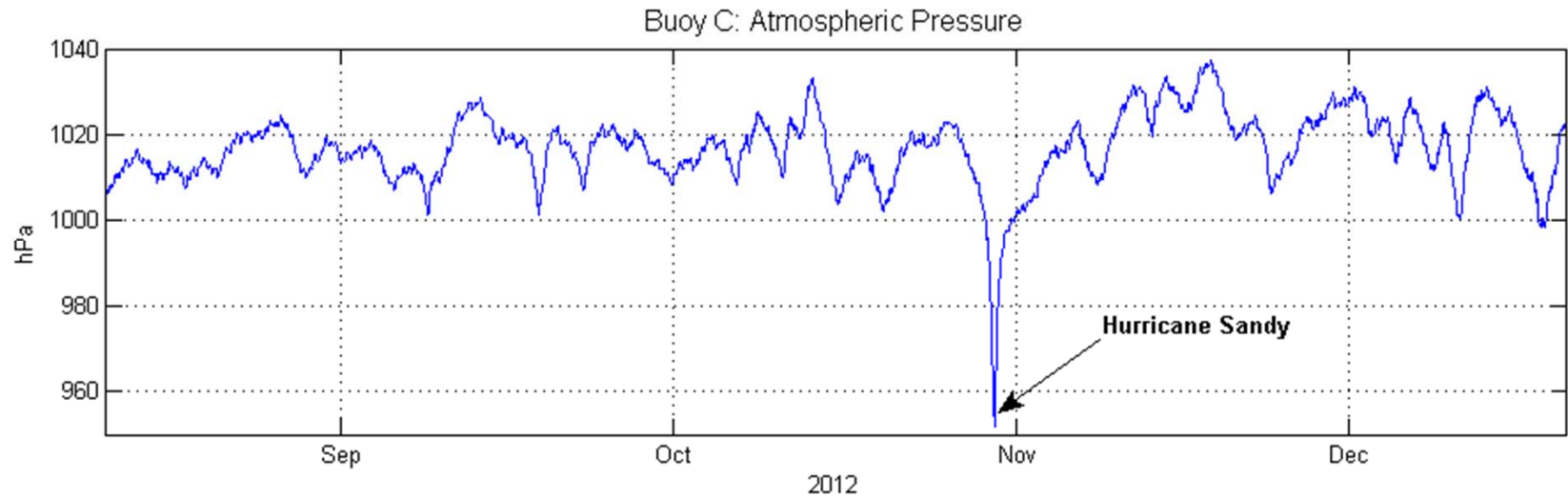




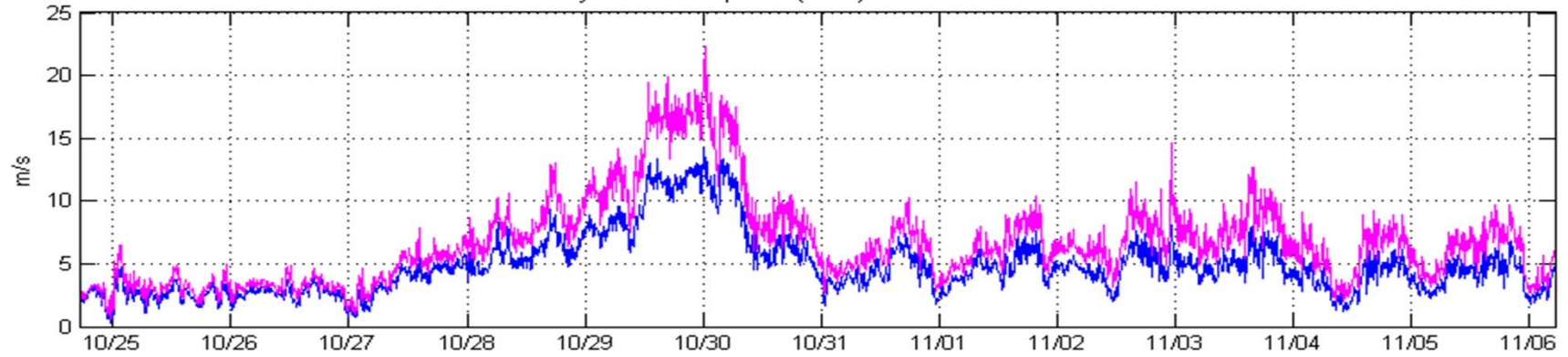
# Current Stations: Long- and Short-term locations



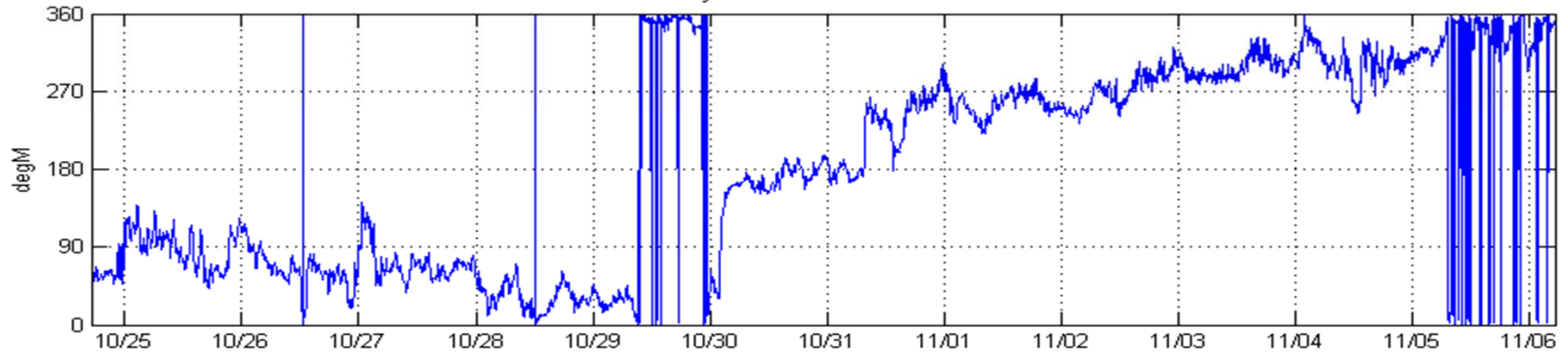
# Data collected during Sandy



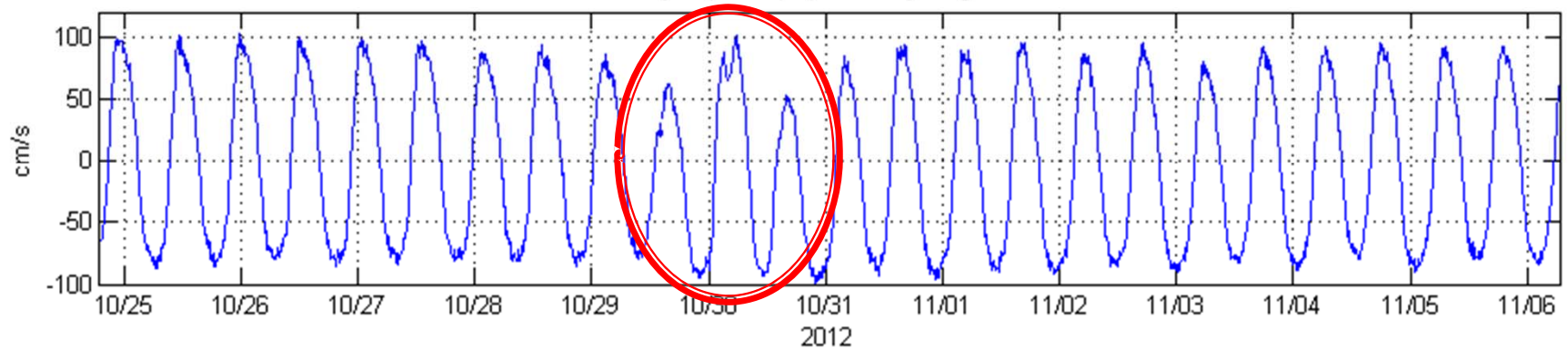
Buoy C: Wind Speed (blue) and 3s Gust



Buoy C: Wind Direction



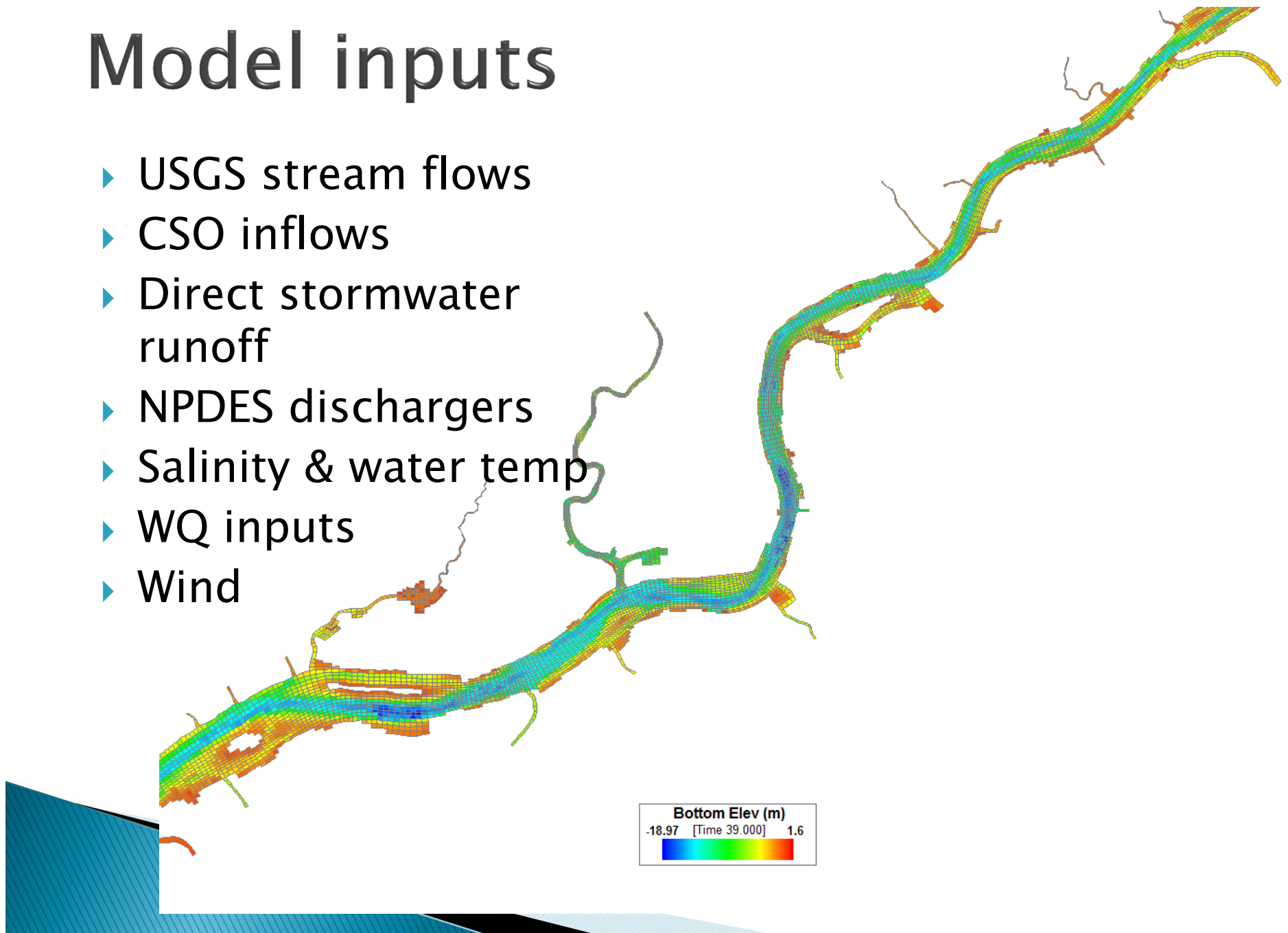
Bouy C (4m depth): Velocity Magnitude



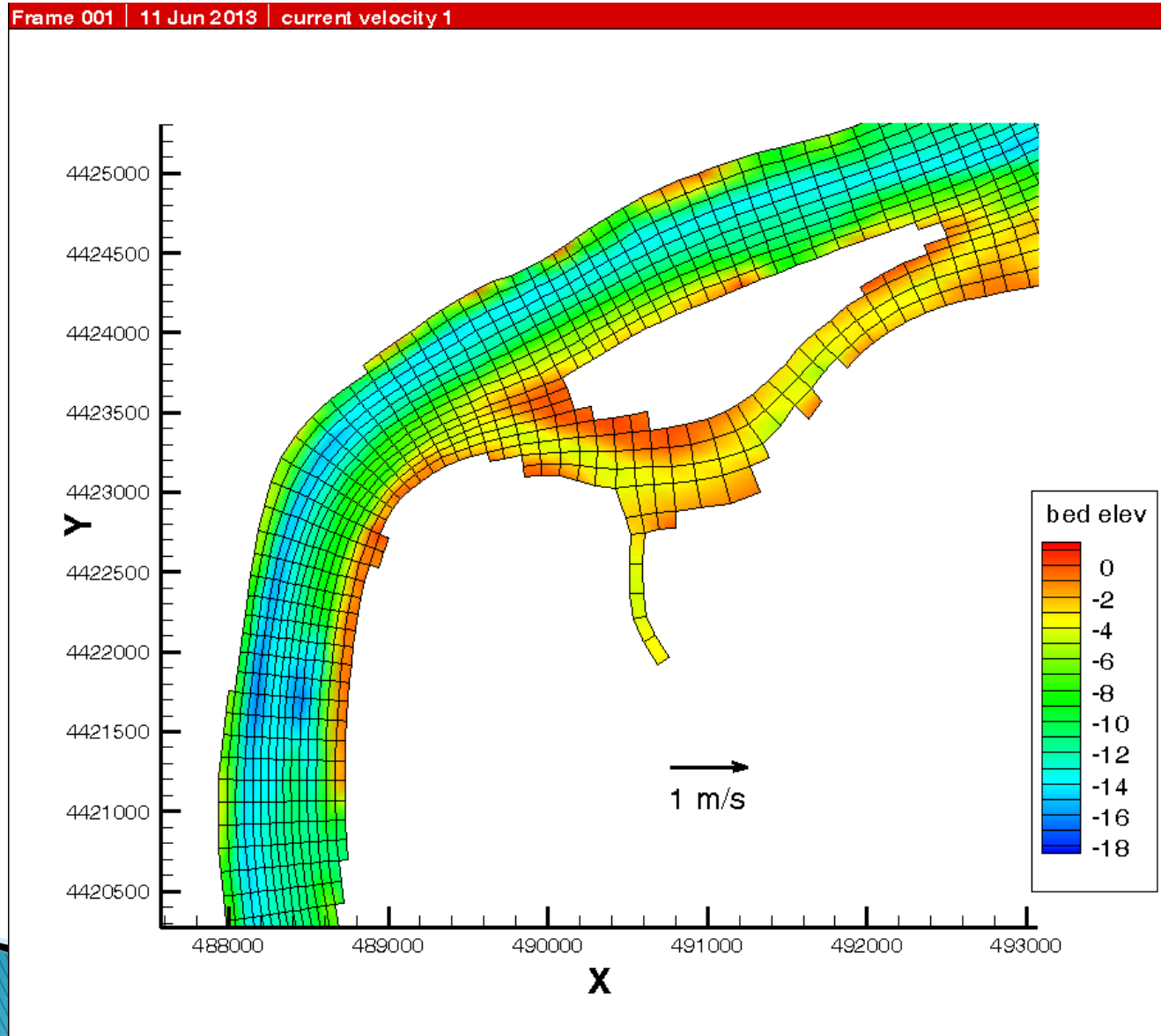


# Model inputs

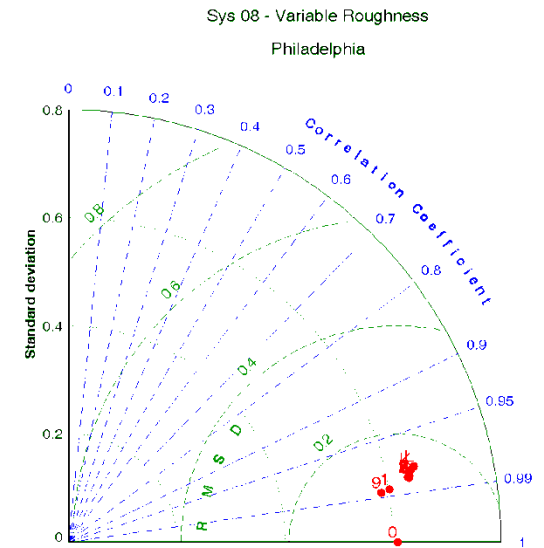
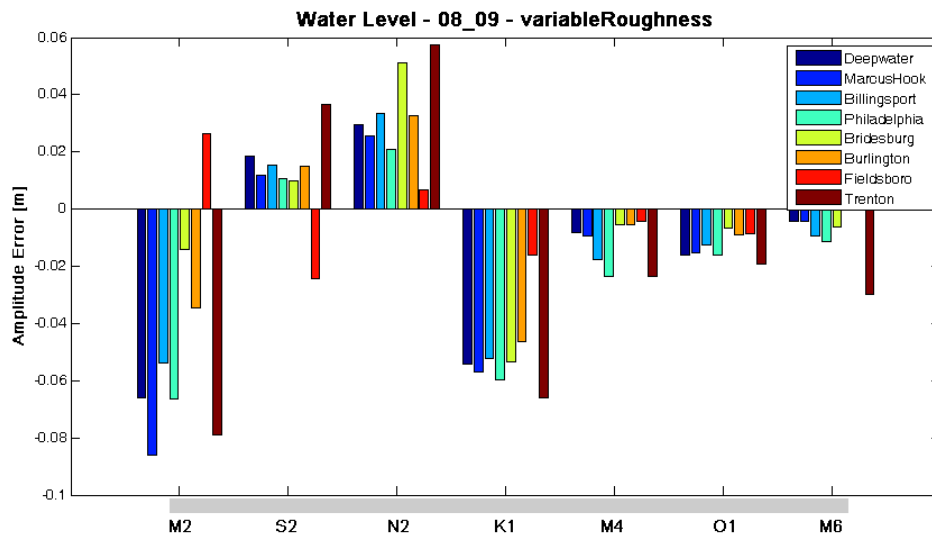
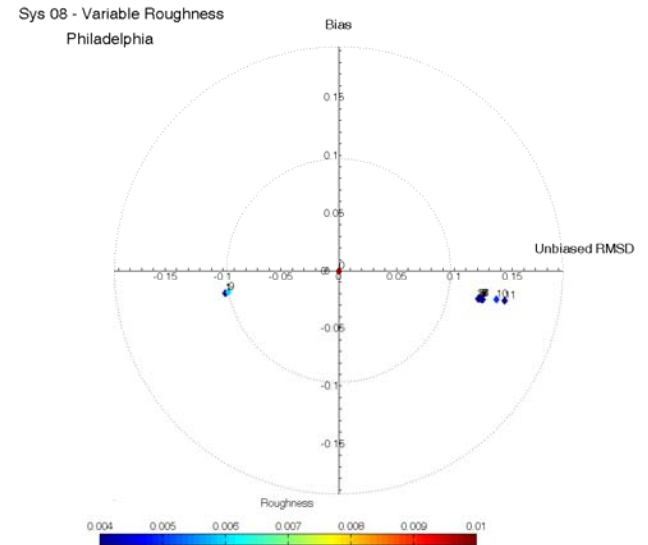
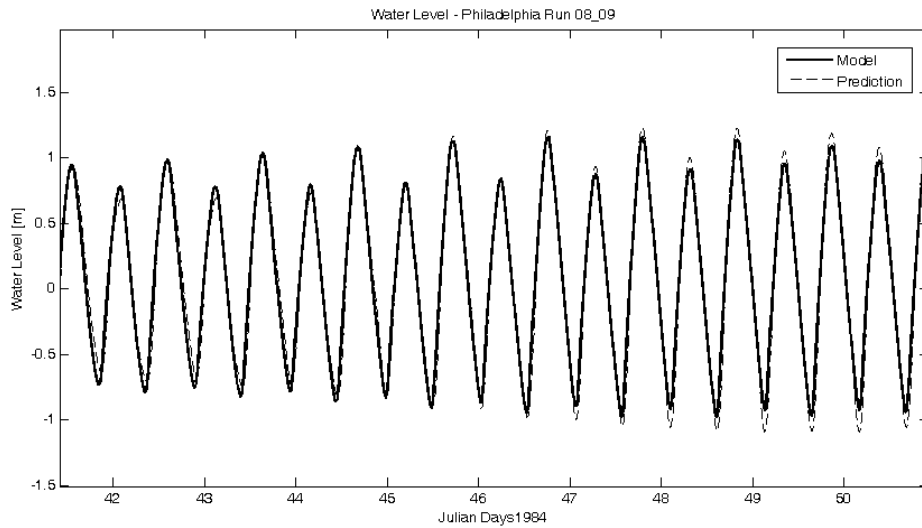
- ▶ USGS stream flows
- ▶ CSO inflows
- ▶ Direct stormwater runoff
- ▶ NPDES dischargers
- ▶ Salinity & water temp
- ▶ WQ inputs
- ▶ Wind



# EFDC demonstration at Petty Island



# Validation process





# DRBC 1997 Dye Study

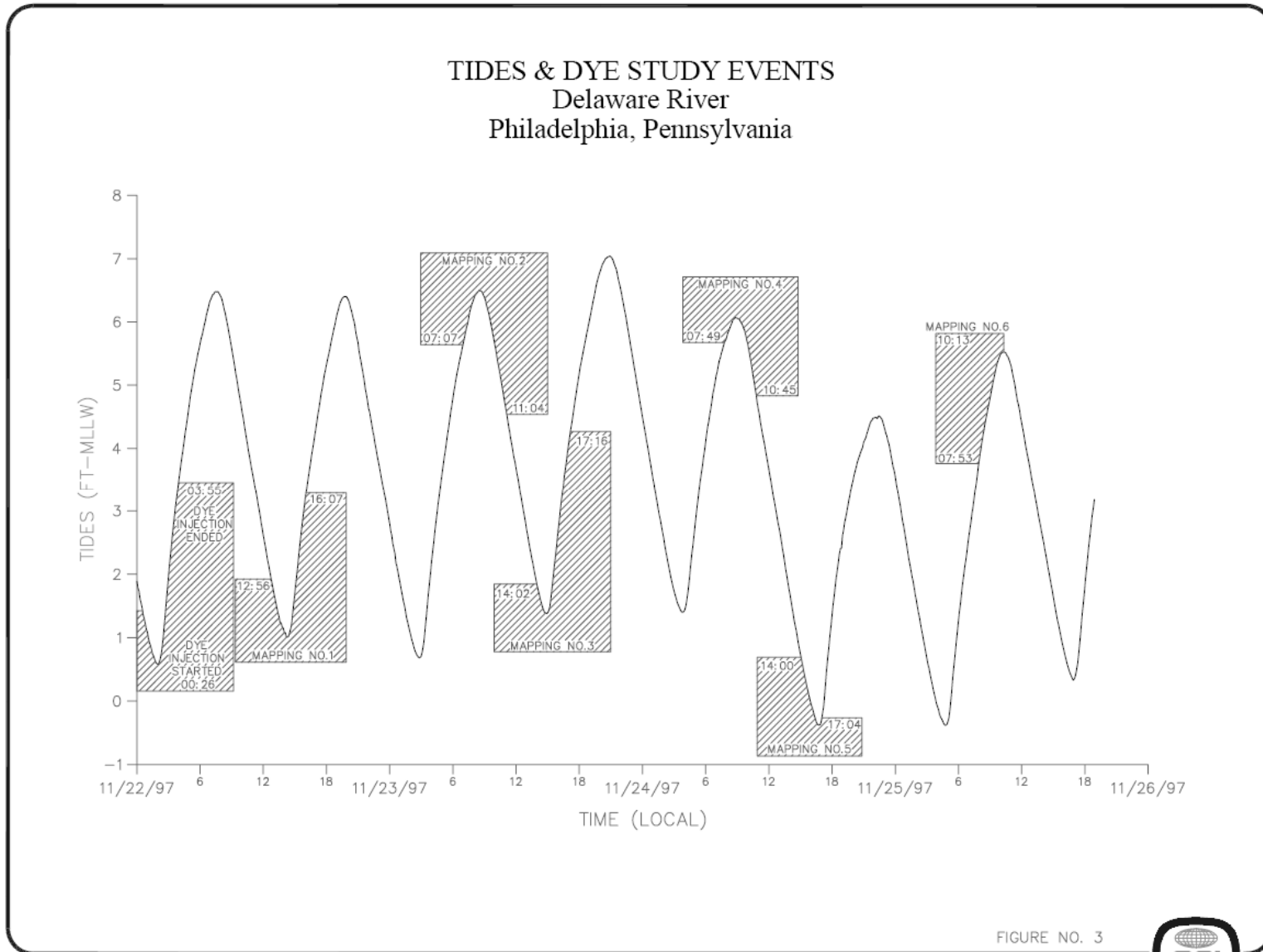
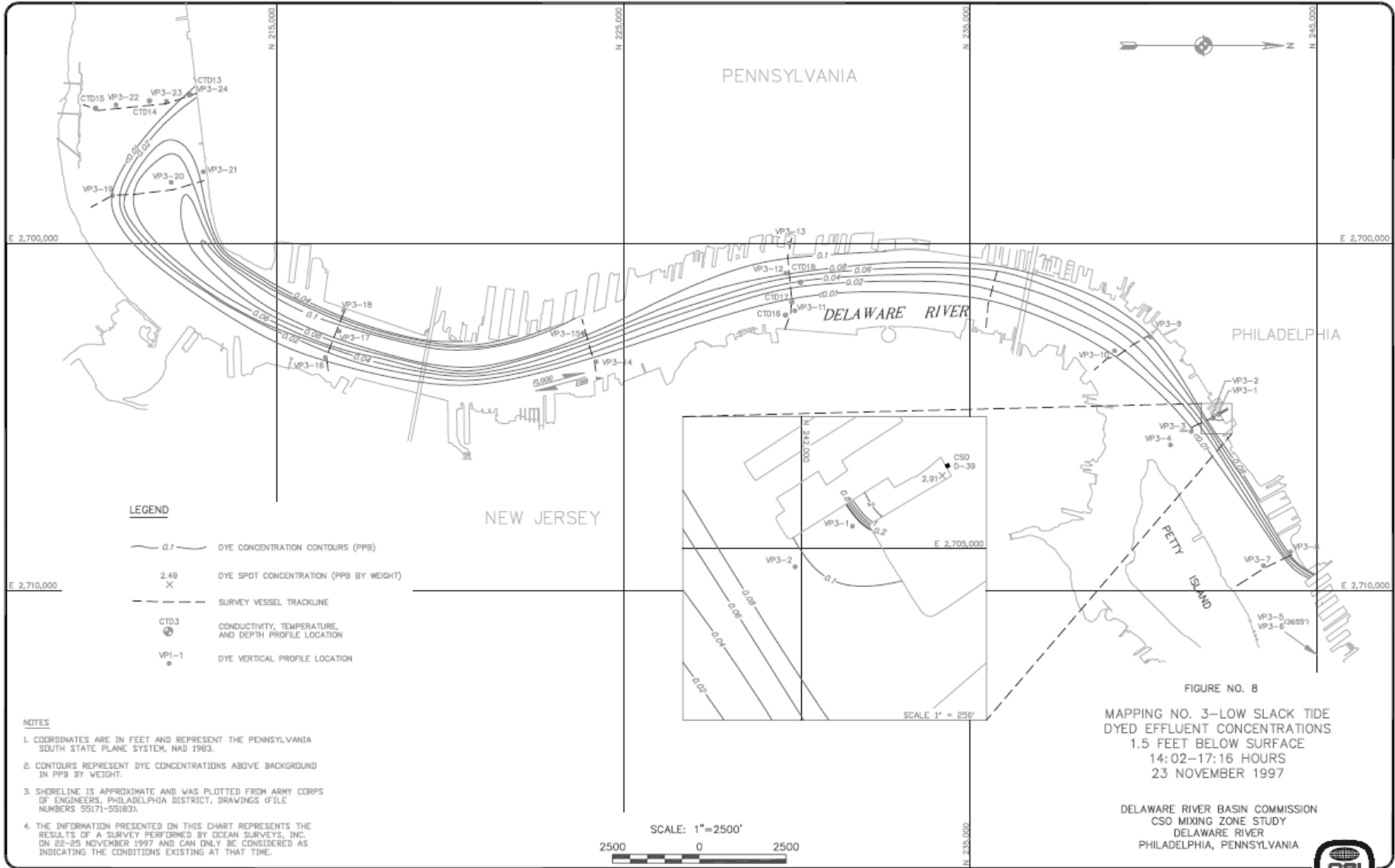
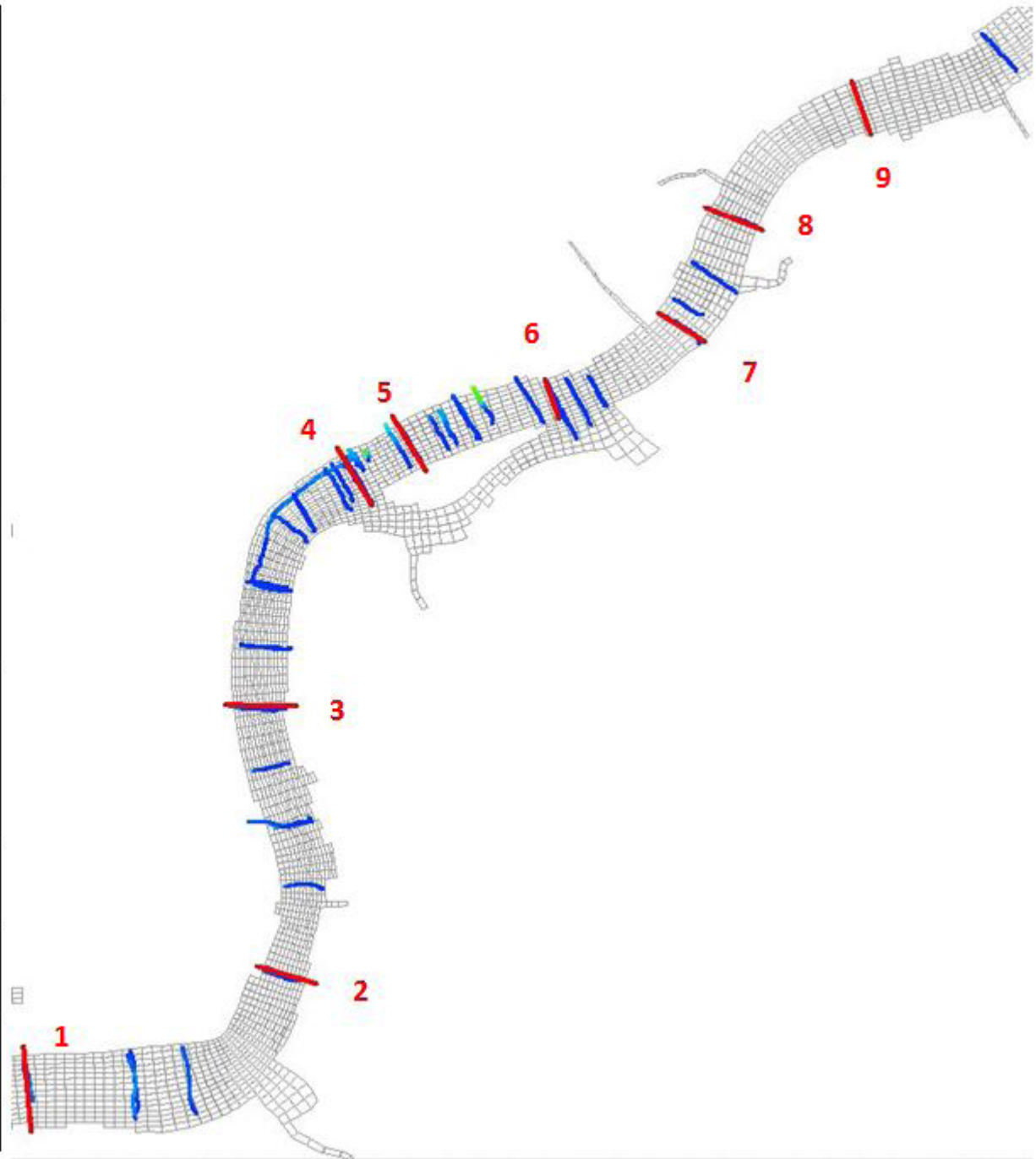


FIGURE NO. 3

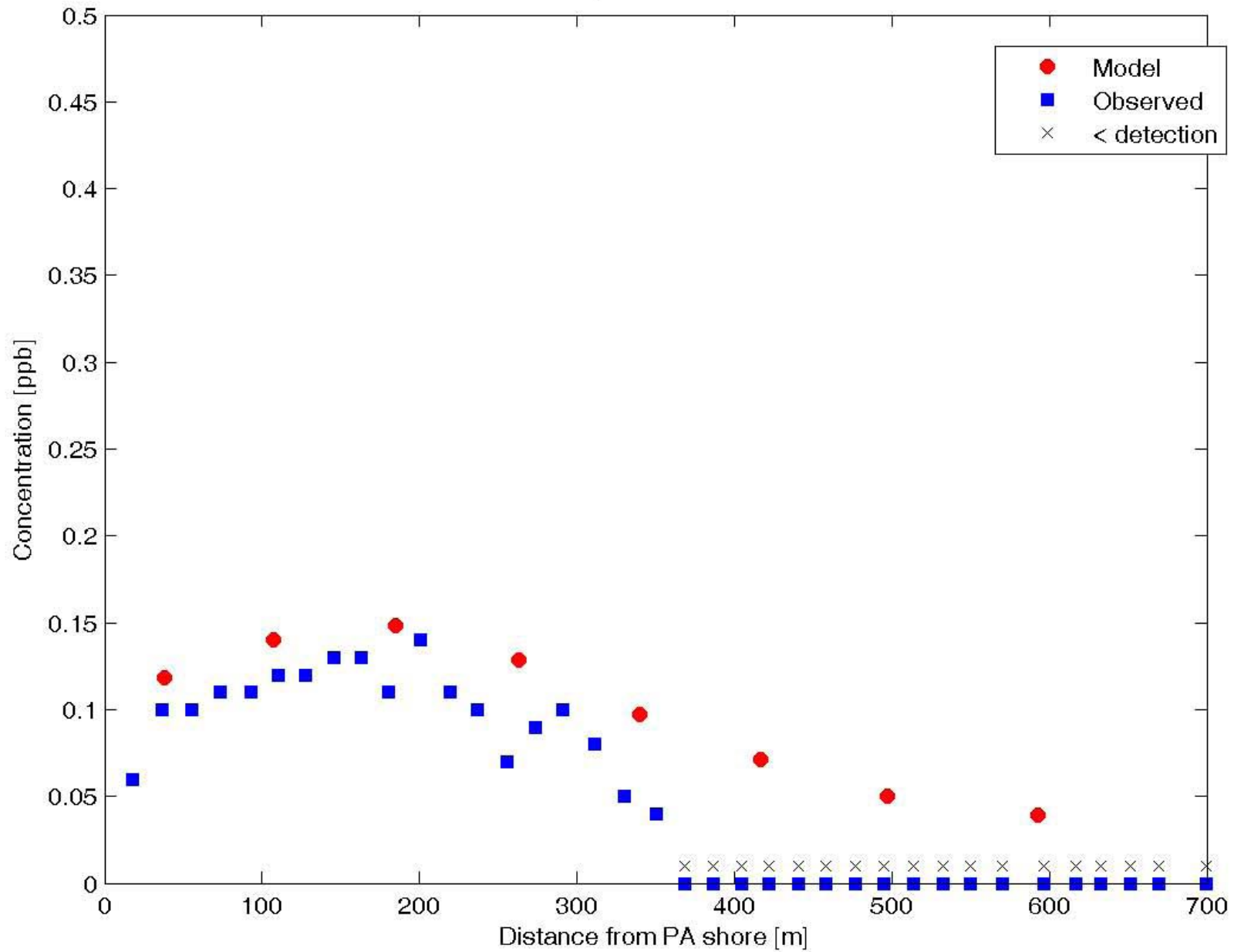




Profile 1	1	11/23/1997 16:14
	2	11/24/1997 17:06
Profile 2	1	11/23/1997 15:43
	2	11/24/1997 16:37
Profile 3	1	11/23/1997 15:19
	2	11/24/1997 8:09
	3	11/24/1997 15:43
Profile 4	1	11/22/1997 13:07
	2	11/22/1997 13:13
	3	11/22/1997 13:29
	4	11/23/1997 8:19
	5	11/23/1997 14:26
	6	11/24/1997 8:44
	7	11/24/1997 14:46
	8	11/25/1997 8:11
Profile 5	1	11/22/1997 20:58
	2	11/24/1997 9:00
	3	11/24/1997 14:31
	4	11/25/1997 8:37
Profile 6	1	11/23/1997 9:23
	2	11/23/1997 14:41
Profile 7	1	11/23/1997 9:37
	2	11/24/1997 9:52
Profile 8	1	11/23/1997 9:51
	2	11/24/1997 10:24
Profile 9	1	11/23/1997 10:06

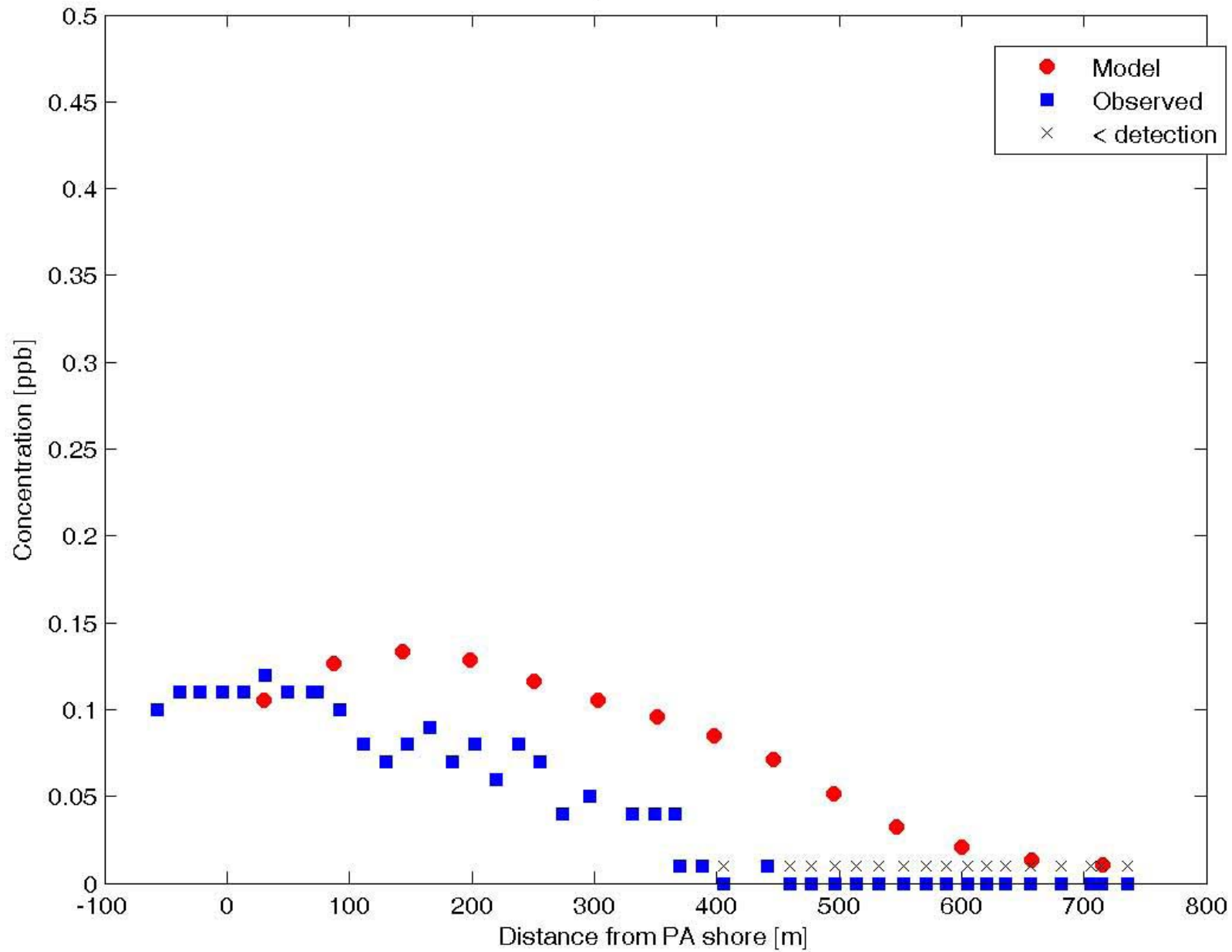


Profile P7<sub>1</sub> - 11/23/1997 09:37

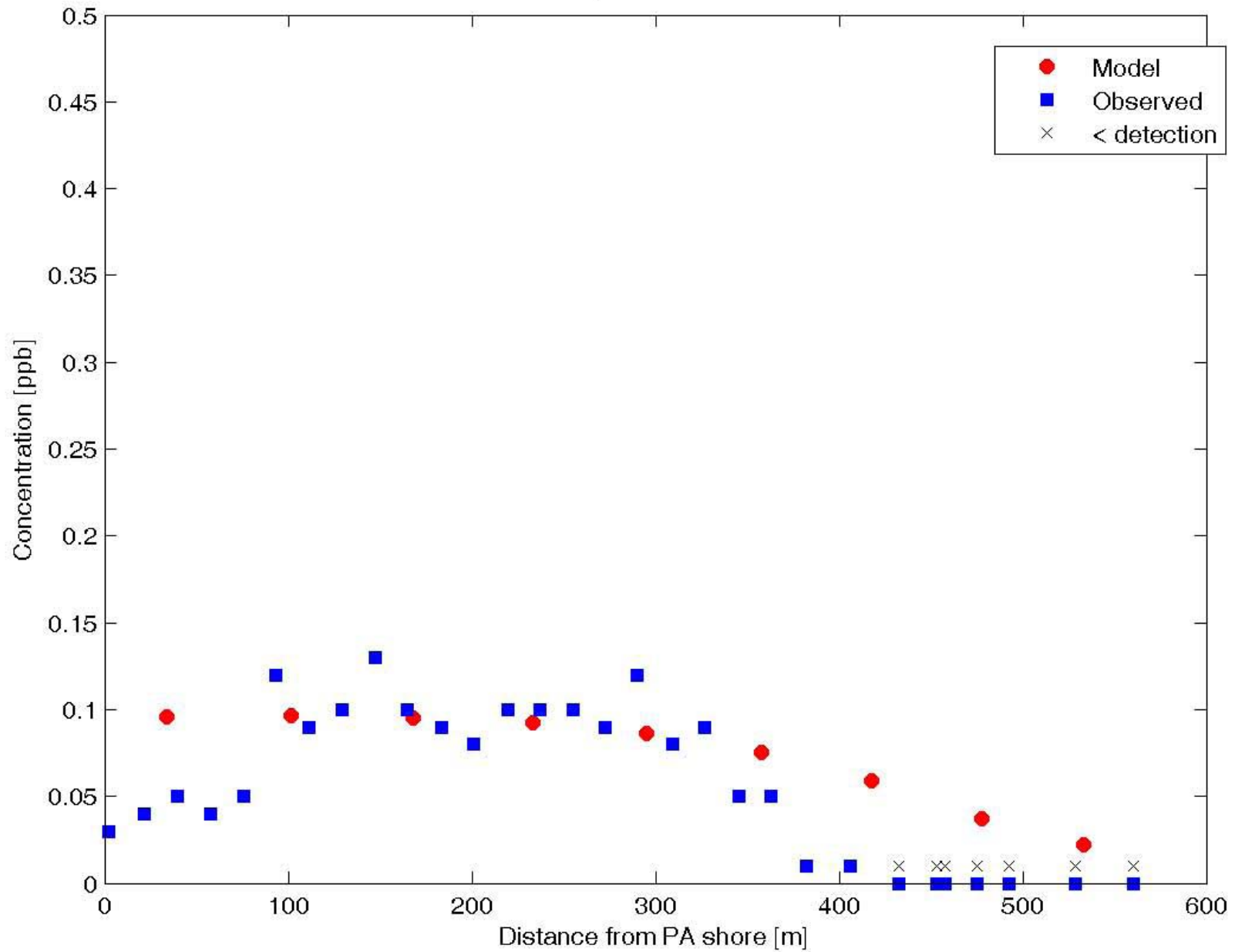




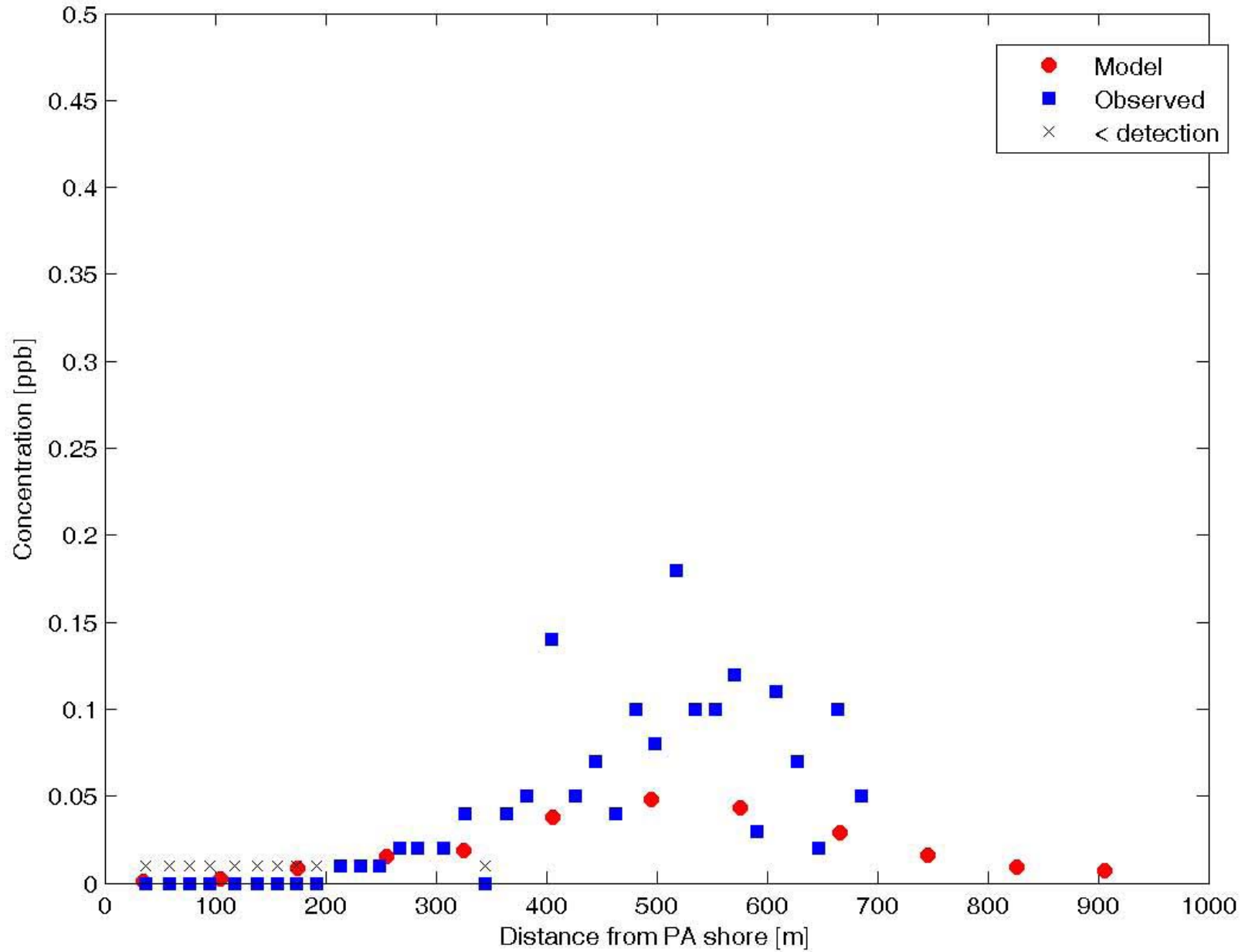
Profile P3<sub>1</sub> - 11/23/1997 15:19



Profile P2<sub>1</sub> - 11/24/1997 16:37

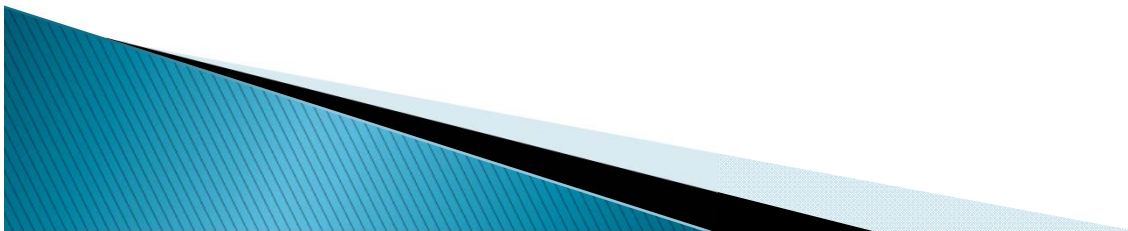


Profile P1<sub>2</sub> - 11/24/1997 17:06



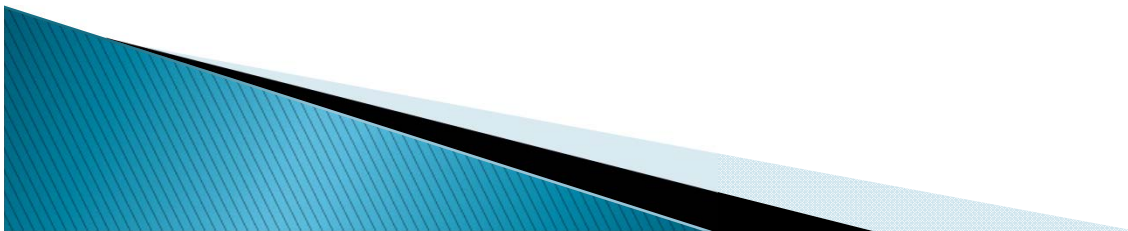
# 1997 dye study limitations

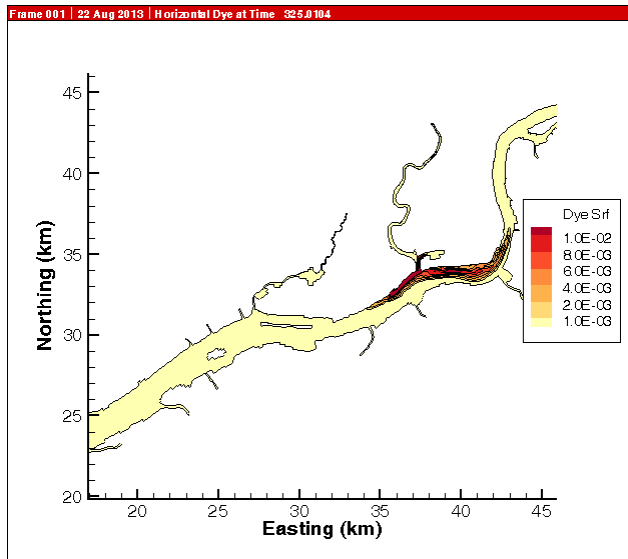
- ▶ Disturbance from wind event
- ▶ Only 2 dye profiles were provided at high and low slack tide per 24 hours
- ▶ A single sampling window included both flood and ebb
- ▶ No sampling occurred at night
- ▶ No mass balance analysis on injected dye



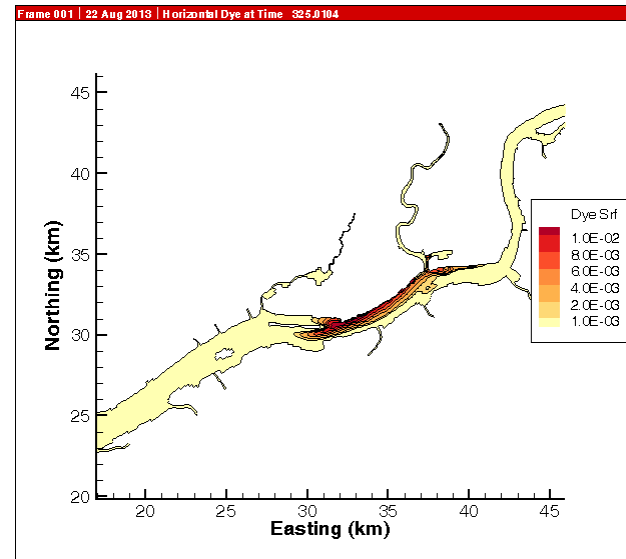
# 2014 prospective dye study

- ▶ Conduct at dry weather in summer (target low discharge, no wind conditions)
- ▶ 4 dye profiles per tidal cycle (~ one profile per 3 hours); 24 hour coverage for 6 tidal cycles
- ▶ Characterize entire longitudinal and lateral extent of plume
- ▶ Further step in model validation
- ▶ Requires funding partners

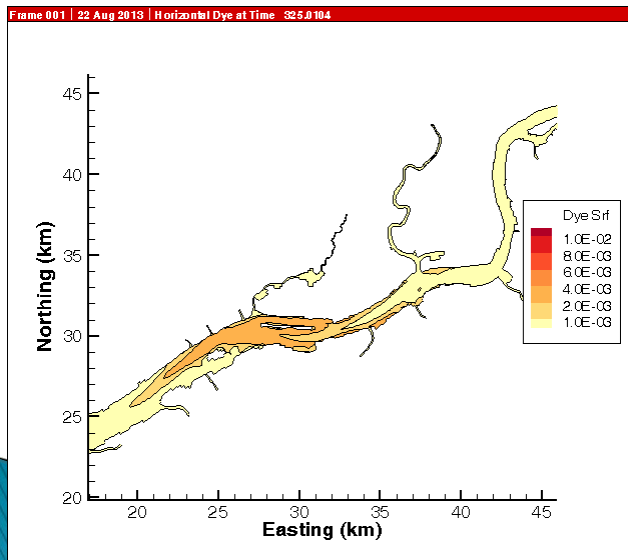




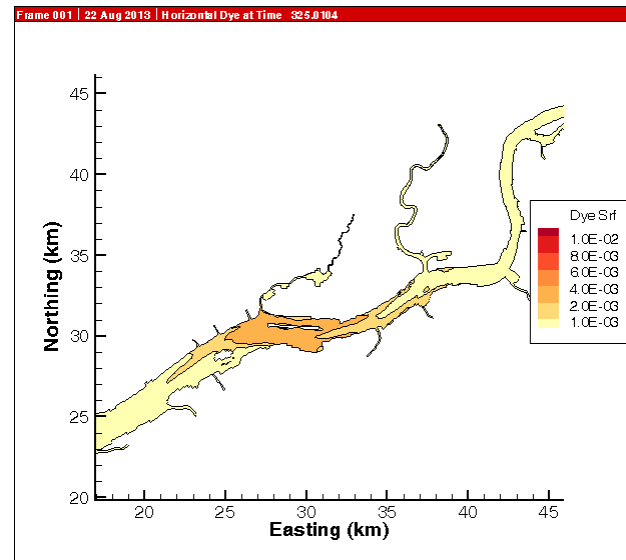
~ 9 hours



~ 12 hours



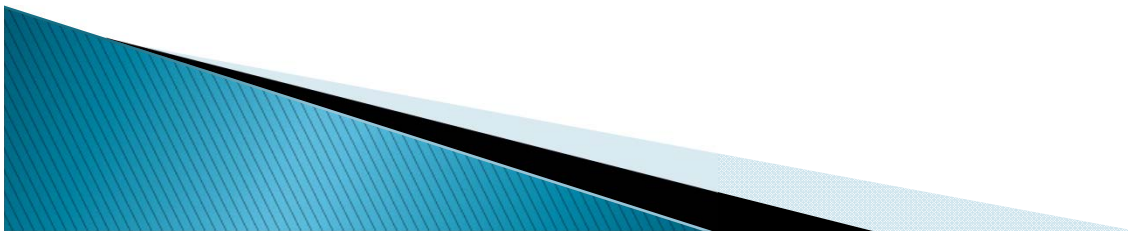
~ 63 hours



~ 66 hours

# Tidal Rivers Water Quality Model Objectives

- ▶ Simulate fate and transport of bacteria and dissolved oxygen processes in model domain
- ▶ Reflect observed spatial and temporal trends
- ▶ Utilize contemporary and past data sources for model input and validation
- ▶ Investigate relative effects of various sources



# Tidal rivers water quality modeling

- ▶ Use EFDC Water Quality model
- ▶ Data collection
  - Compiling existing data from other sources
    - DRBC, U Delaware, state agencies, USGS etc.
  - PWD monthly boat runs at low tide (with EPA Region 3 support) since June 2011
  - SOD and surrogate parameter study
  - Sediment nutrient fluxes study
  - Ultimate BOD and nitrification rate analyses
- ▶ Model segmentation, setting of boundary conditions, parameterization etc. planned to begin in 2014





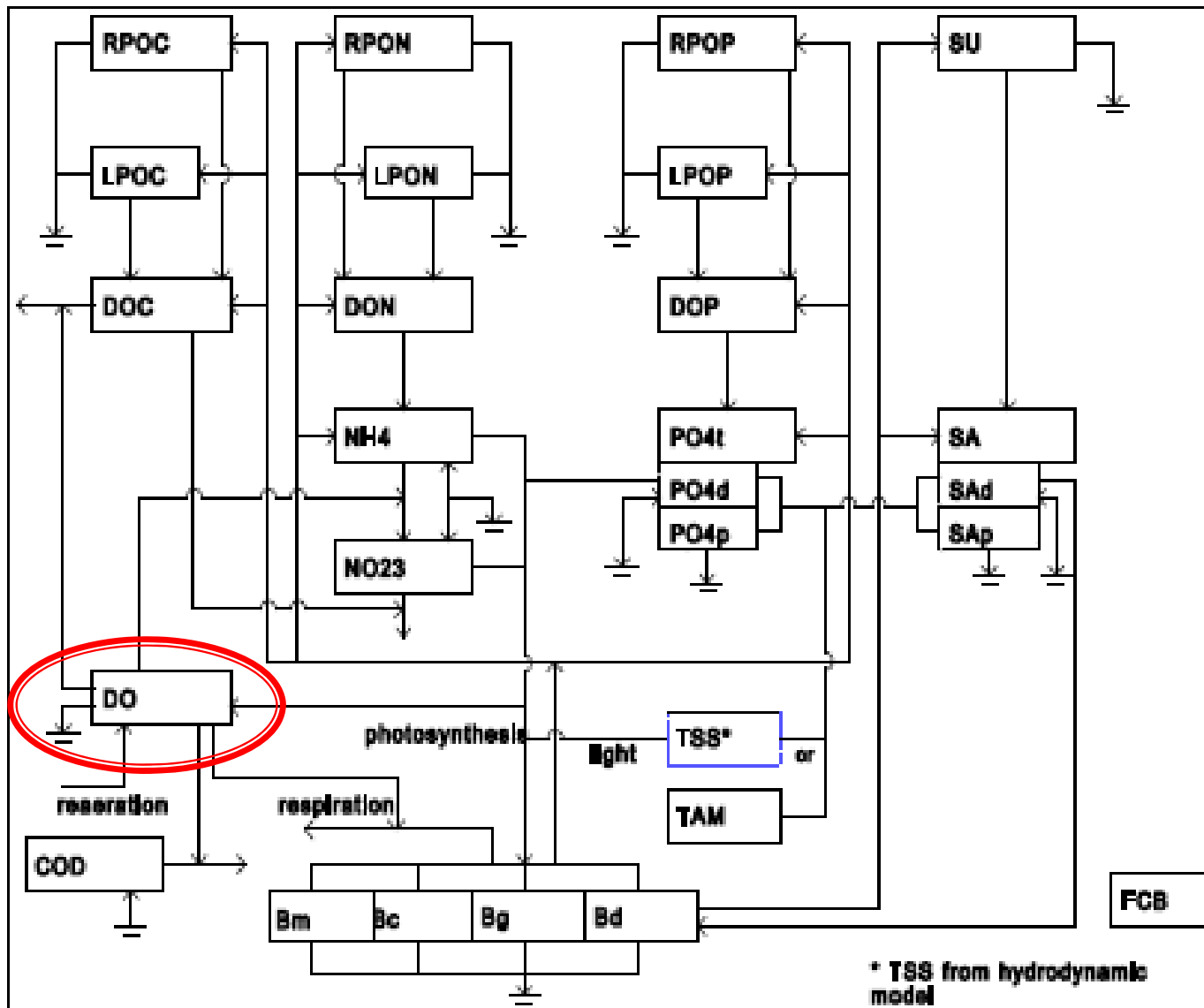
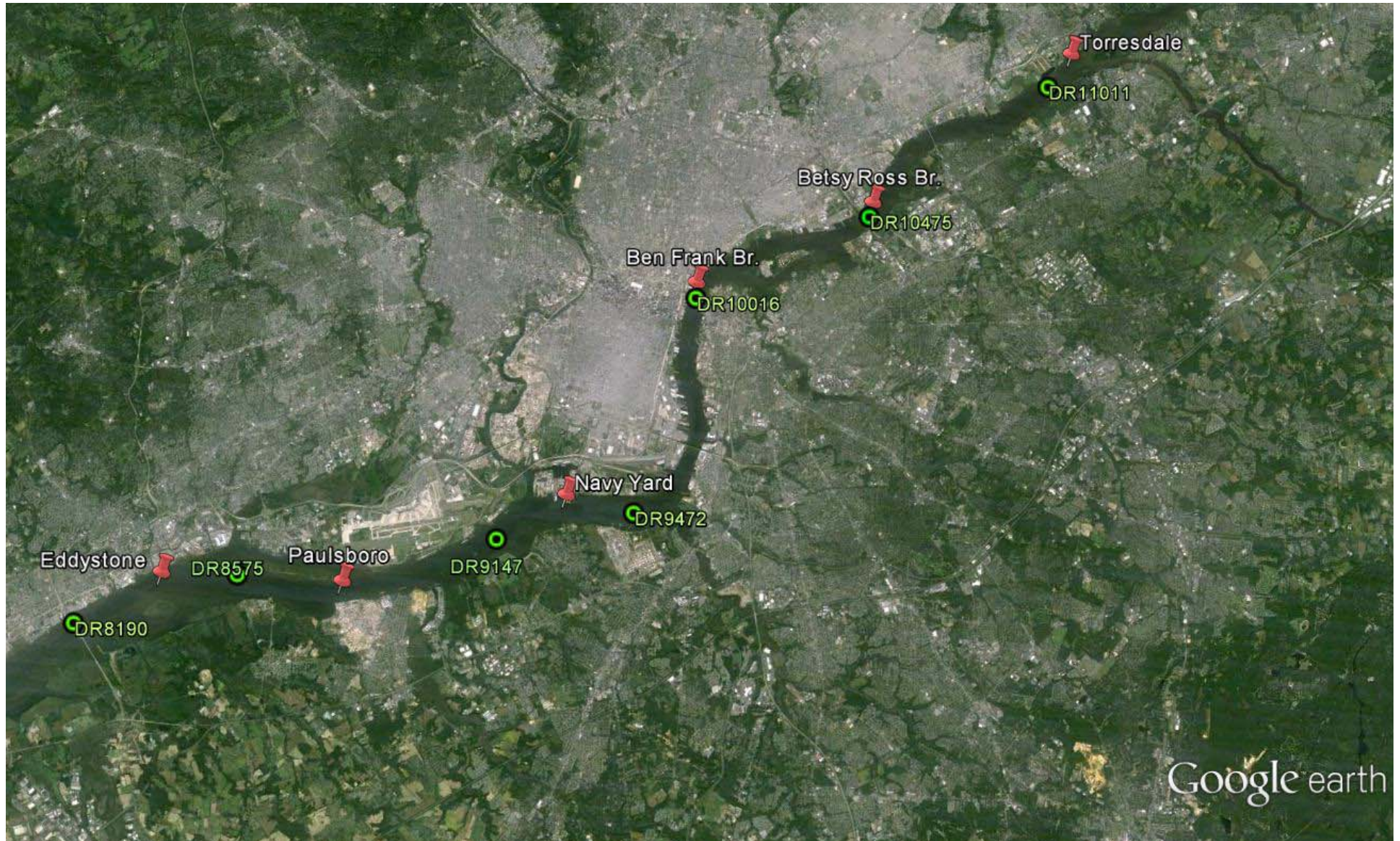


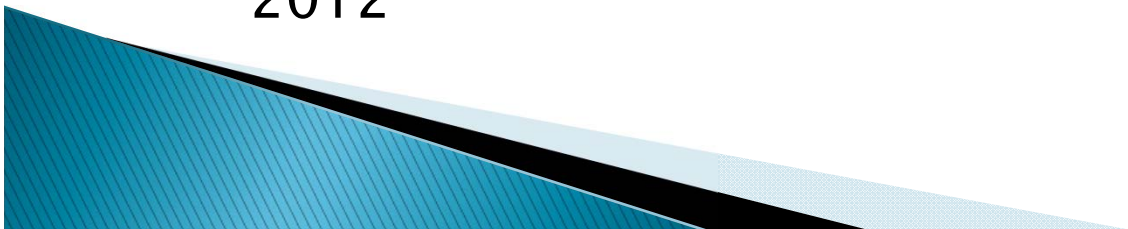
Figure 2.1 Schematic diagram of EFDC Water Quality Model Structure.

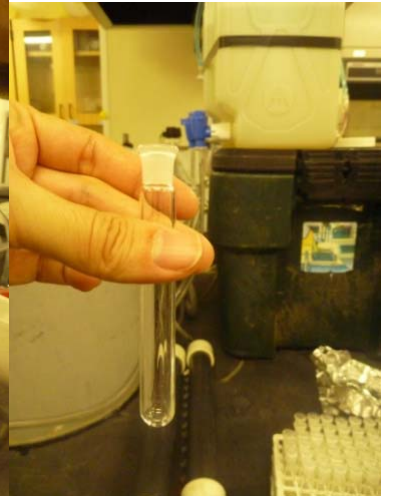
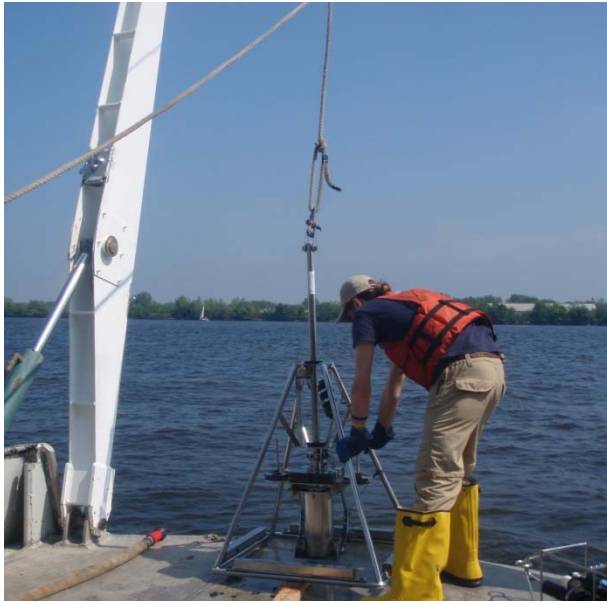
# Boat Run Monitoring: PWD and DRBC locations



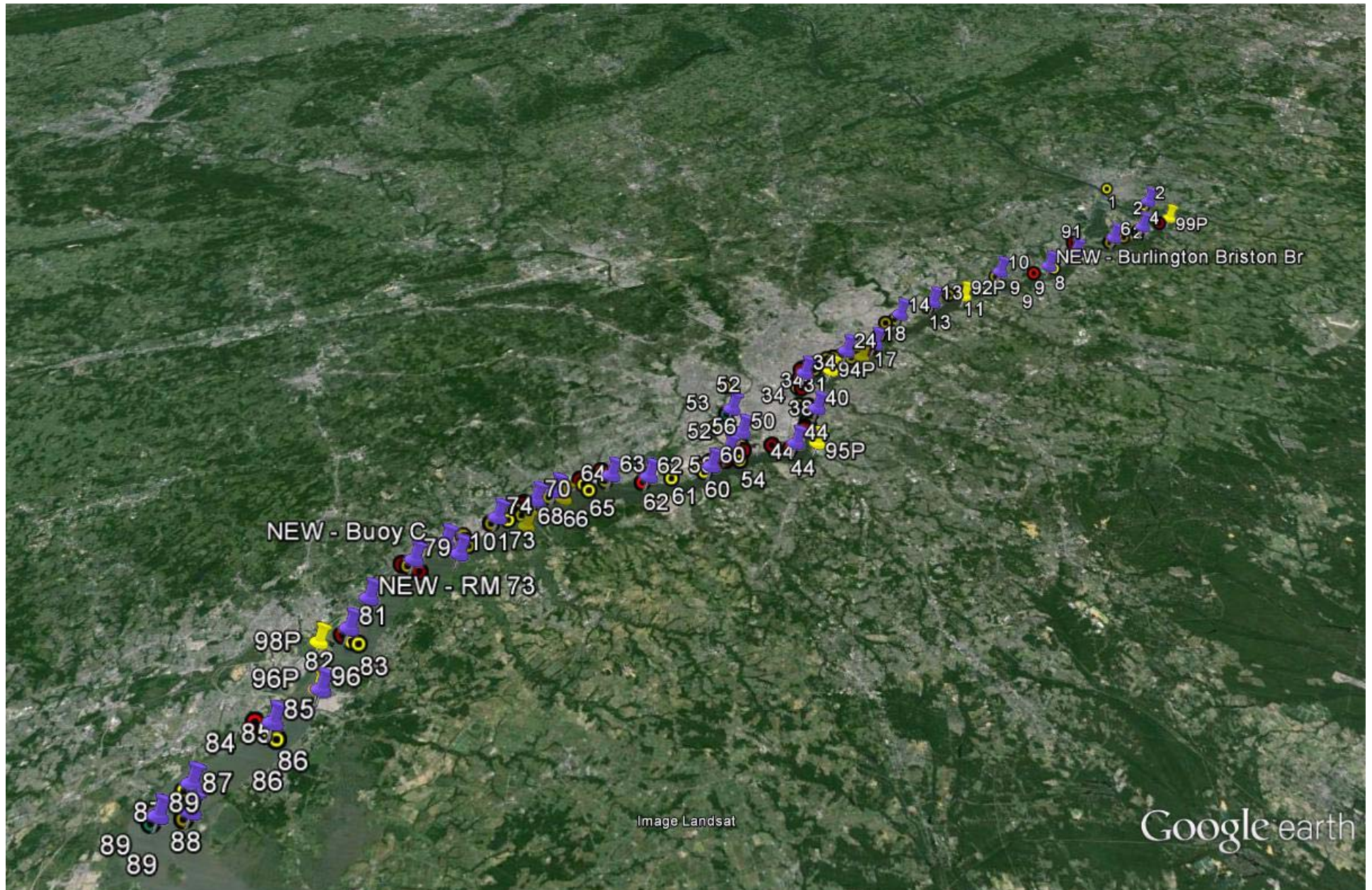
# Tidal Rivers SOD study

- ▶ Delaware/Schuylkill Rivers sediment oxygen demand (SOD) monitoring
  - Collaboration of Woods Hole Group, Academy of Natural Sciences of Drexel University, and Chesapeake Biogeochemical Associates
  - SOD surveys
    - 2012 Summer survey (48 sites)
      - Included 10 sites with nutrient flux samples
    - 2012 Fall survey (32 sites)
    - 2013 Spring survey (32 sites); all with nutrient flux samples
    - 2013 Summer survey (32 sites); all with nutrient flux samples
  - Surrogate parameter analysis (88 sites) completed June 2012





# Sediment sampling sites (2012–2013)



# Ultimate BOD and Nitrification Rate Sampling Sites (August 2013)

