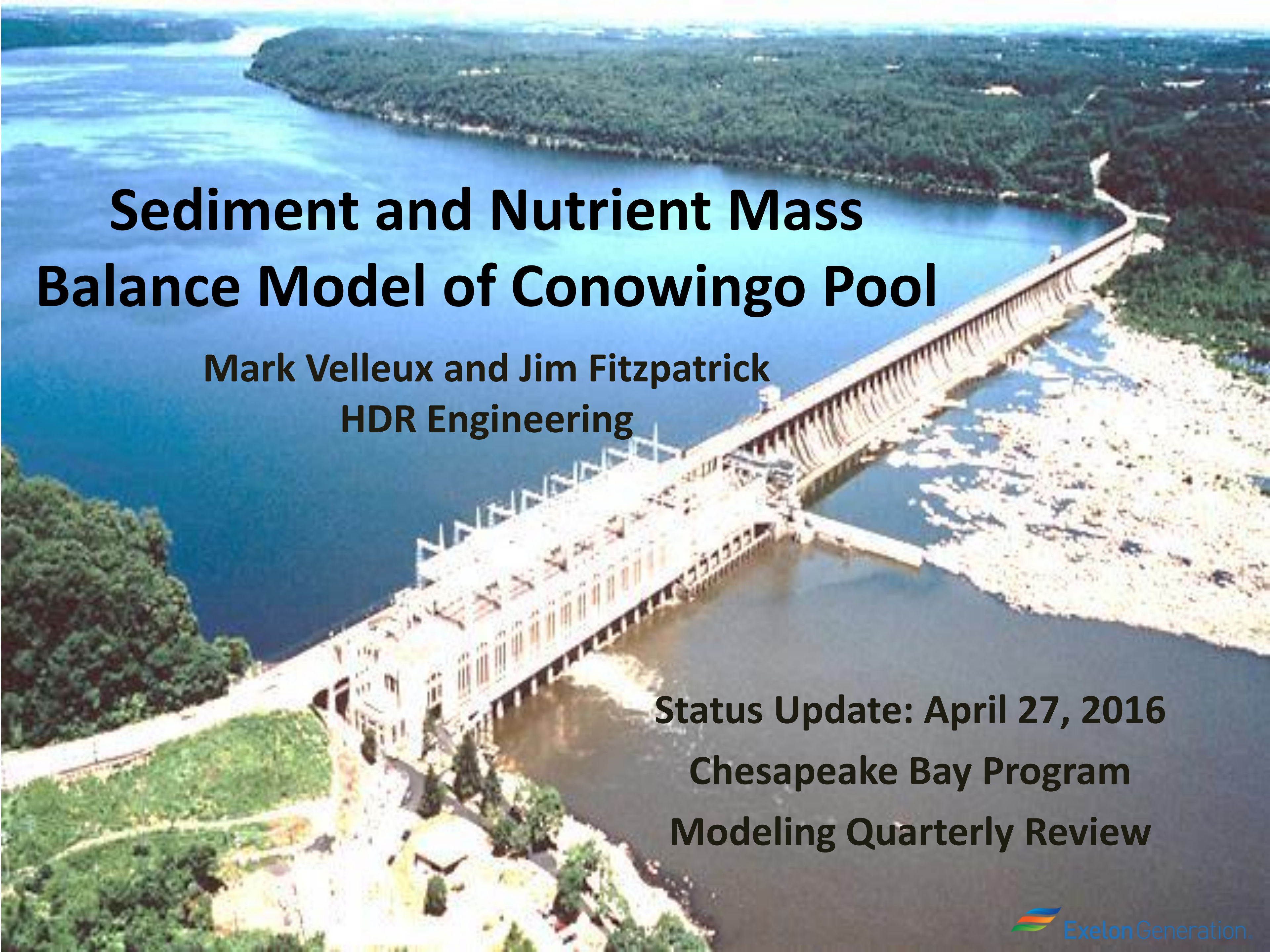


Sediment and Nutrient Mass Balance Model of Conowingo Pool

Mark Velleux and Jim Fitzpatrick

HDR Engineering

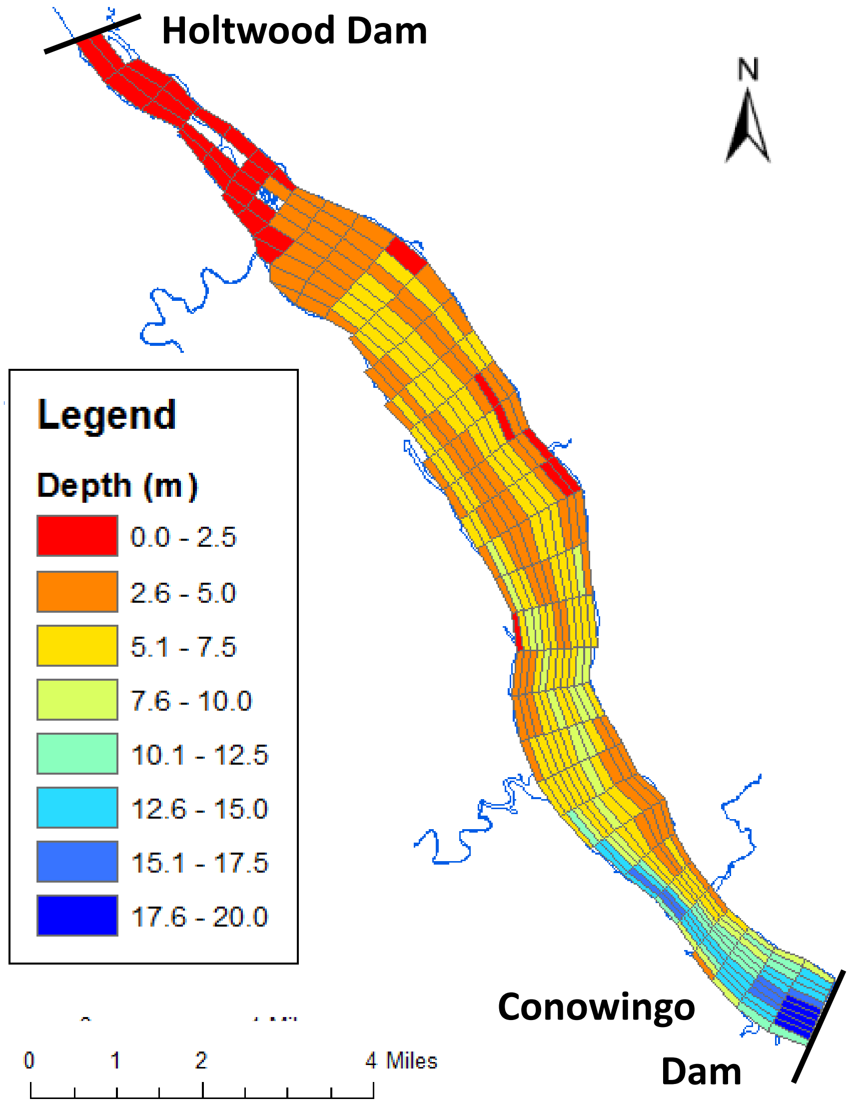
Status Update: April 27, 2016

Chesapeake Bay Program

Modeling Quarterly Review

Exelon Generation.

Model Grid and Spatial Resolution

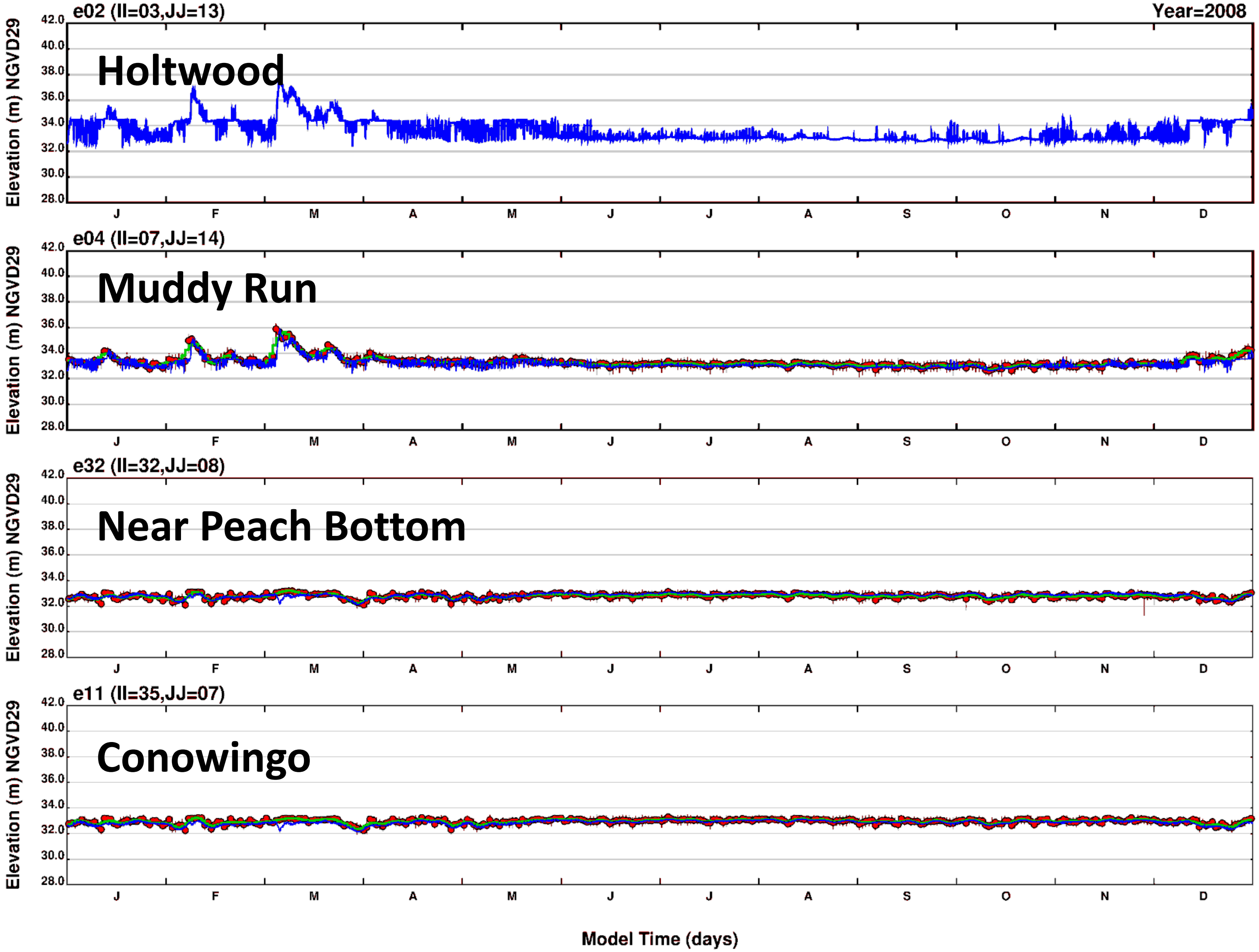


- Resolves primary features of physical system:
  - Remnant channels
  - Depth changes
- Provides 305 cells
  - More detail where Pond is wider
  - 5 vertical (sigma) layers
- Balance spatial resolution and computational burden
- Referenced to full pool:
  - 109.2 ft NGVD29
  - 2015 bathymetry shown

Hydrodynamics and Sediment Transport

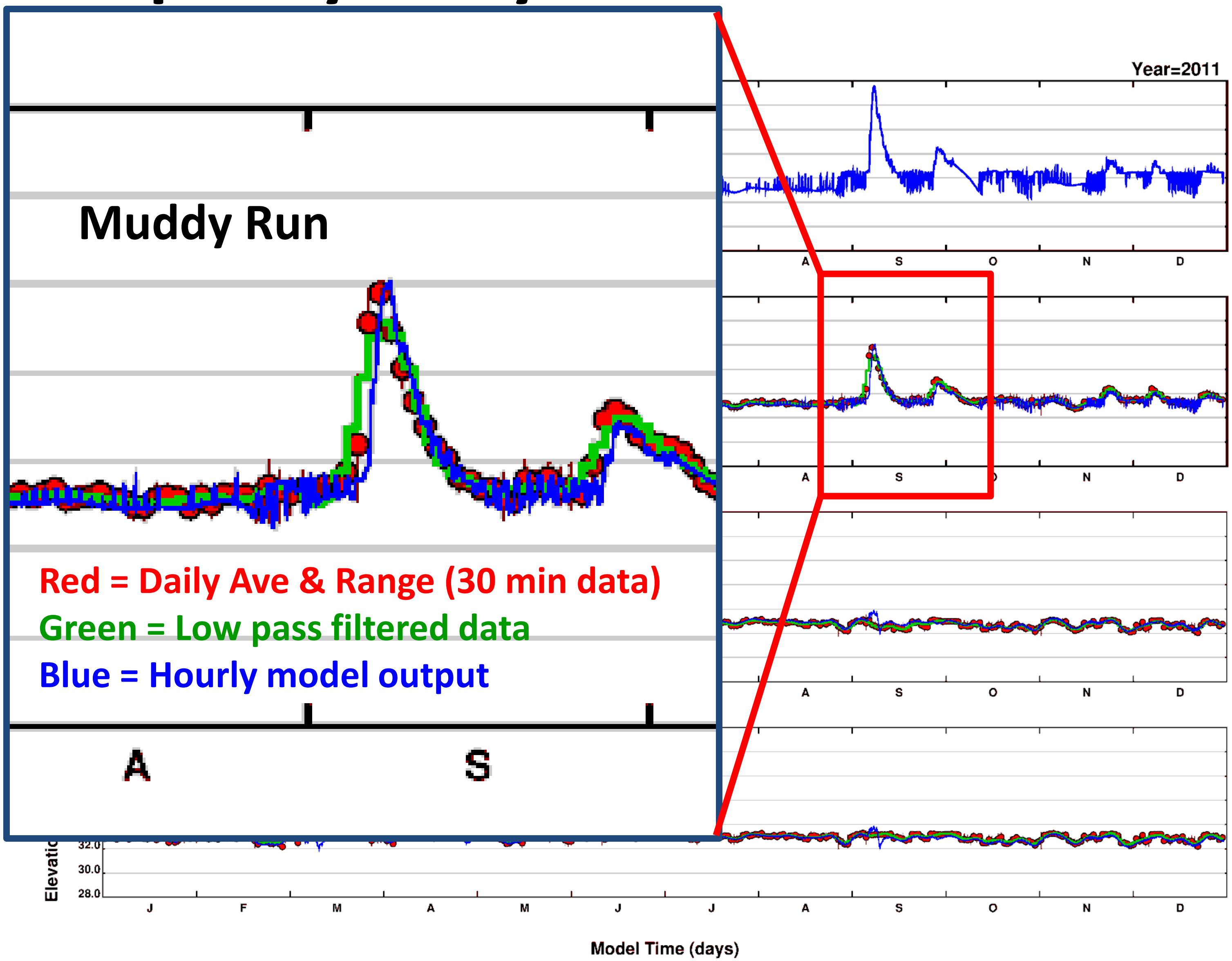
- **Represent spatial, temporal dynamics of flow and sediment transport in and out of Conowingo Pond**
- **Coupled with water quality/sediment flux model**
  - **Calibration: 2008-2014**
  - **Confirmation: 1996-2014 (and 1984-2014 if practical)**
- **Hydrodynamics:**
  - **Flow and temperature from USGS, HSPF, other sources**
  - **Reproduce water surface elevations and temperature**
- **Sediment Transport (still under development):**
  - **Four size classes: sand, silt, clay, coal**
  - **Erosion properties based on SEDFLUME core results**
  - **Dynamic bed (depth change with erosion & deposition)**

Example Hydrodynamic Results: 2008



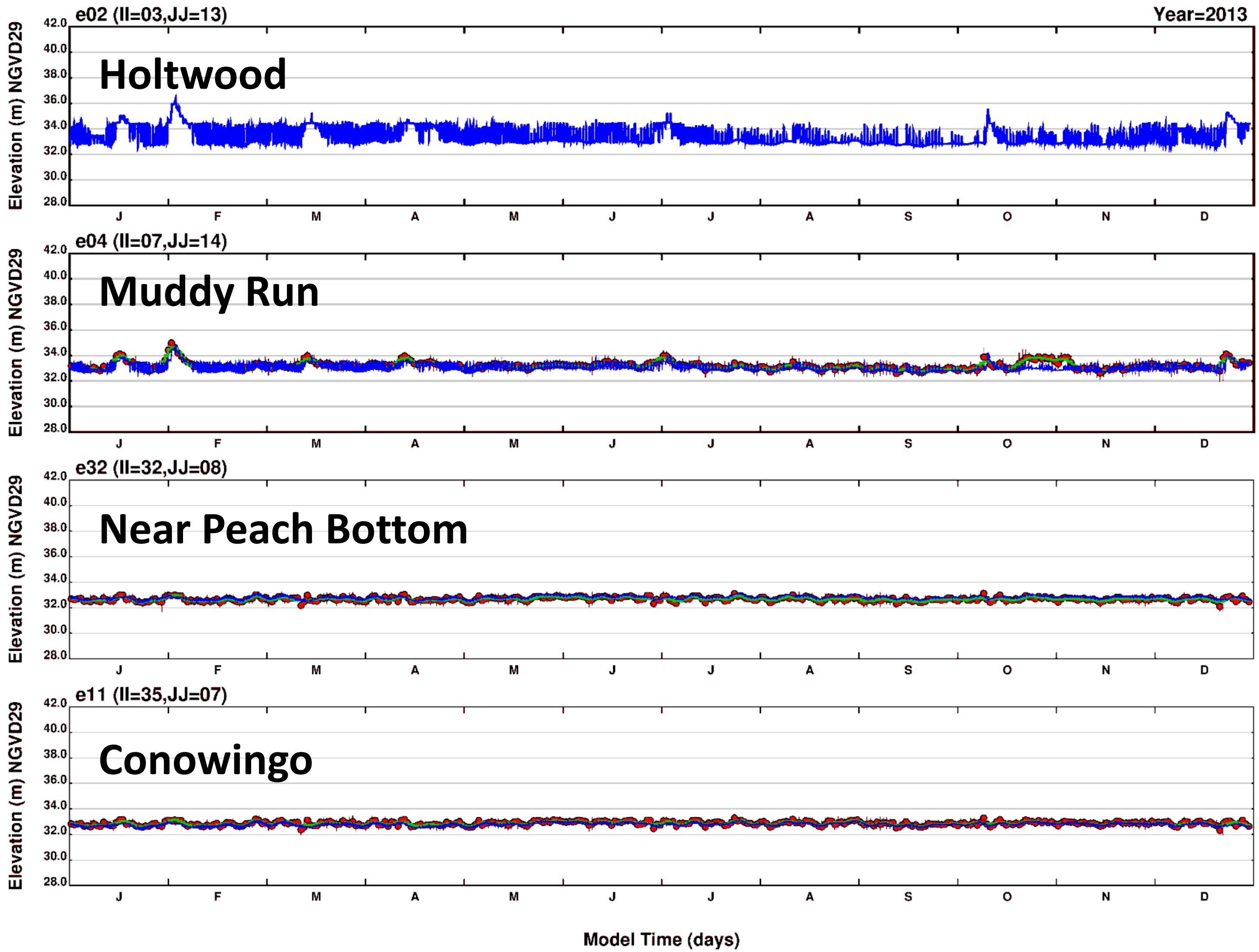
Exelon Generation.

Example Hydrodynamic Results: 2011



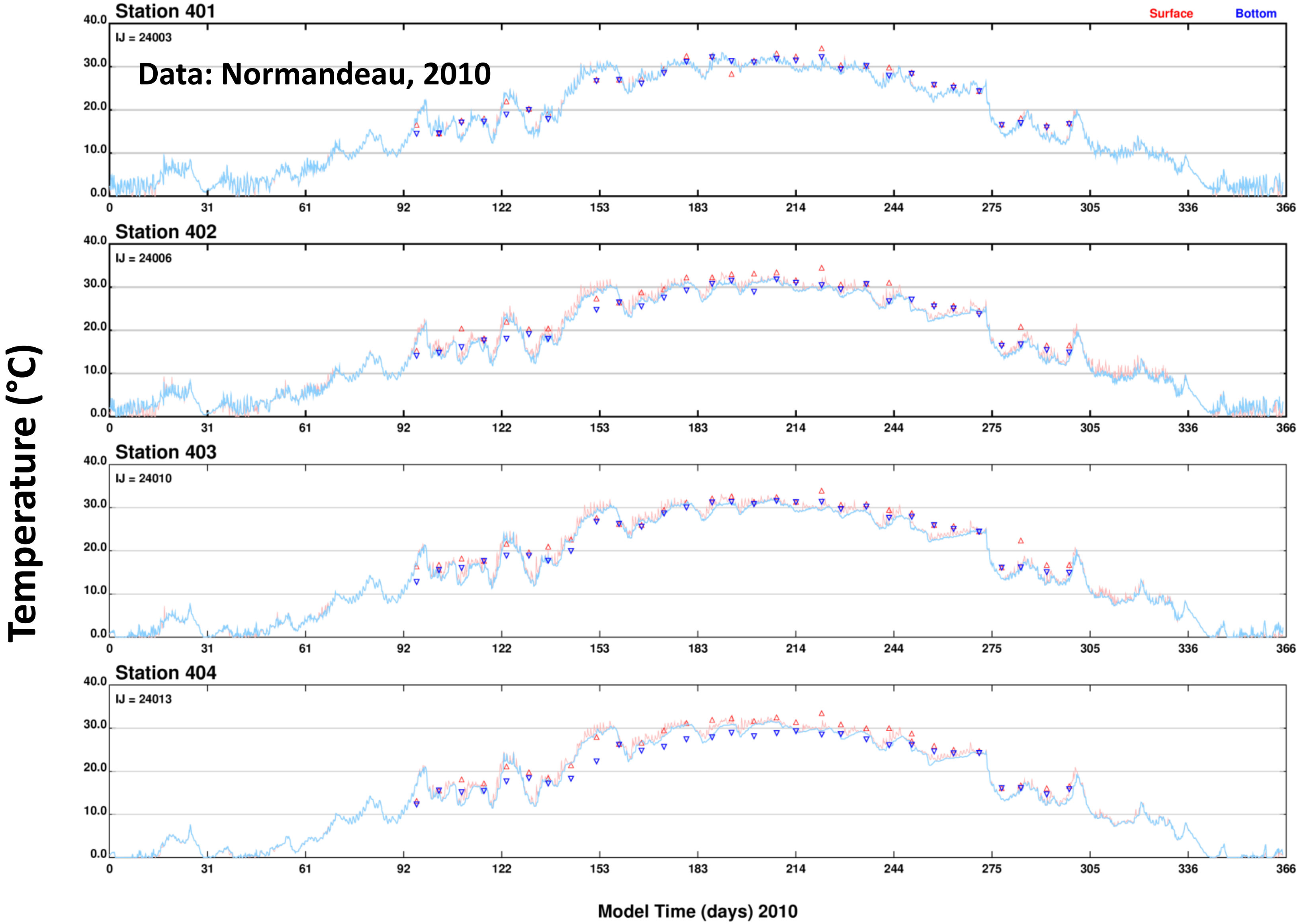
Exelon Generation.

Example Hydrodynamic Results: 2013



Exelon Generation.

Example Temperature Results: 2010



Exelon Generation.

Some Lessons Learned so Far…

- **Biggest challenge to date:**
  - **Constructing a reliable flow balance for Conowingo Pond to drive hydrodynamics**
  - **Even relatively "tight" data can imply large differences in water surface elevations over time**
  - **For example: flows in and out of Conowingo Pond as obtained from early draft HSPF output differed by 0.2%**
  - **However, when volumes differences occur over 9,000 acre area of Conowingo Pond, those small differences implied an elevation decrease of 294 feet over time…**
  - **Flow and elevation measurements sometimes disagree**

Sediment Transport

- Model under development with completion in 2+ weeks
- Preliminary simulations for 2008-2014 have been performed
- Bulk sediment bed properties defined from SRBC (2000), and USACE (2012) sediment cores
  - Factions gravel, sand, silt, clay, and coal
  - Wet/dry bulk densities
  - Spatial variation estimated by geostatistics (cokriging with bed elevation/water depth)
- Analysis of USGS (2012) SEDFLUME cores:
  - Used to define erosion characteristics of Pond sediment
  - Challenges arise from uncertainties in SEDFLUME data…

Sediment Flux Model Update

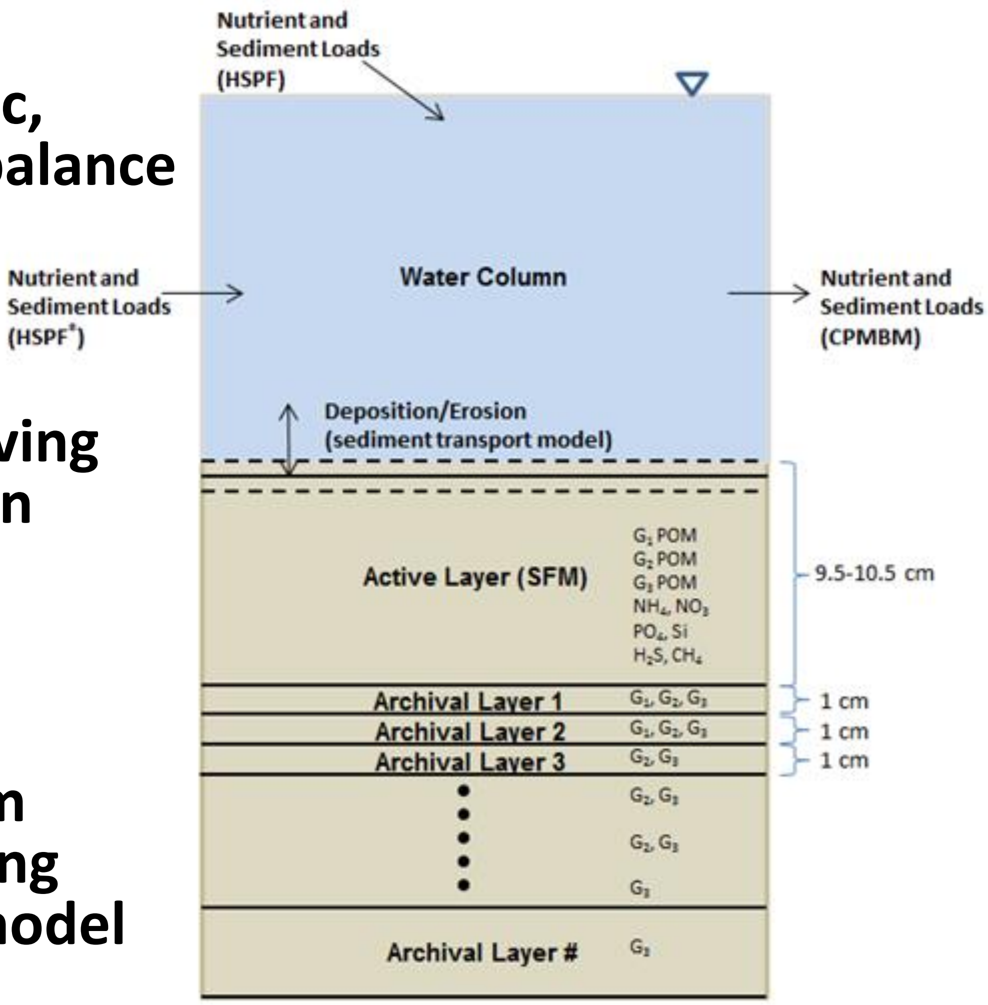
Goals

- develop coupled hydrodynamic, sediment transport, nutrient balance model for Conowingo Pond

- determine composition/ bioavailability of nutrients leaving the pond during a resuspension event

Today

- preliminary computations from stand-alone SFM, while awaiting calibration of hydro/sedtran model



Exelon Generation.

Sediment Flux Model Update

Preliminary Mass Balance Method

- Utilize loadings provided by the USEPA CBPO WSM
- Mass balance:

  Conowingo Pond – (Holtwood + Muddy Run + Broad Creek)

  if > 0, then export from pond (production or resuspension)

  If < 0, then loss within pond (utilization or settling)
- Since WSM determines just organic C, N, P and need to split into particulate/dissolved and G_1 (labile), G_2 (refractory), G_3(inert) started with USACE guesstimates
- Calibration data: Walt Boynton's 1981/1982 SOD data, 2000 SRBC sediment bed data, 2015 UMCES field program

Exelon Generation.

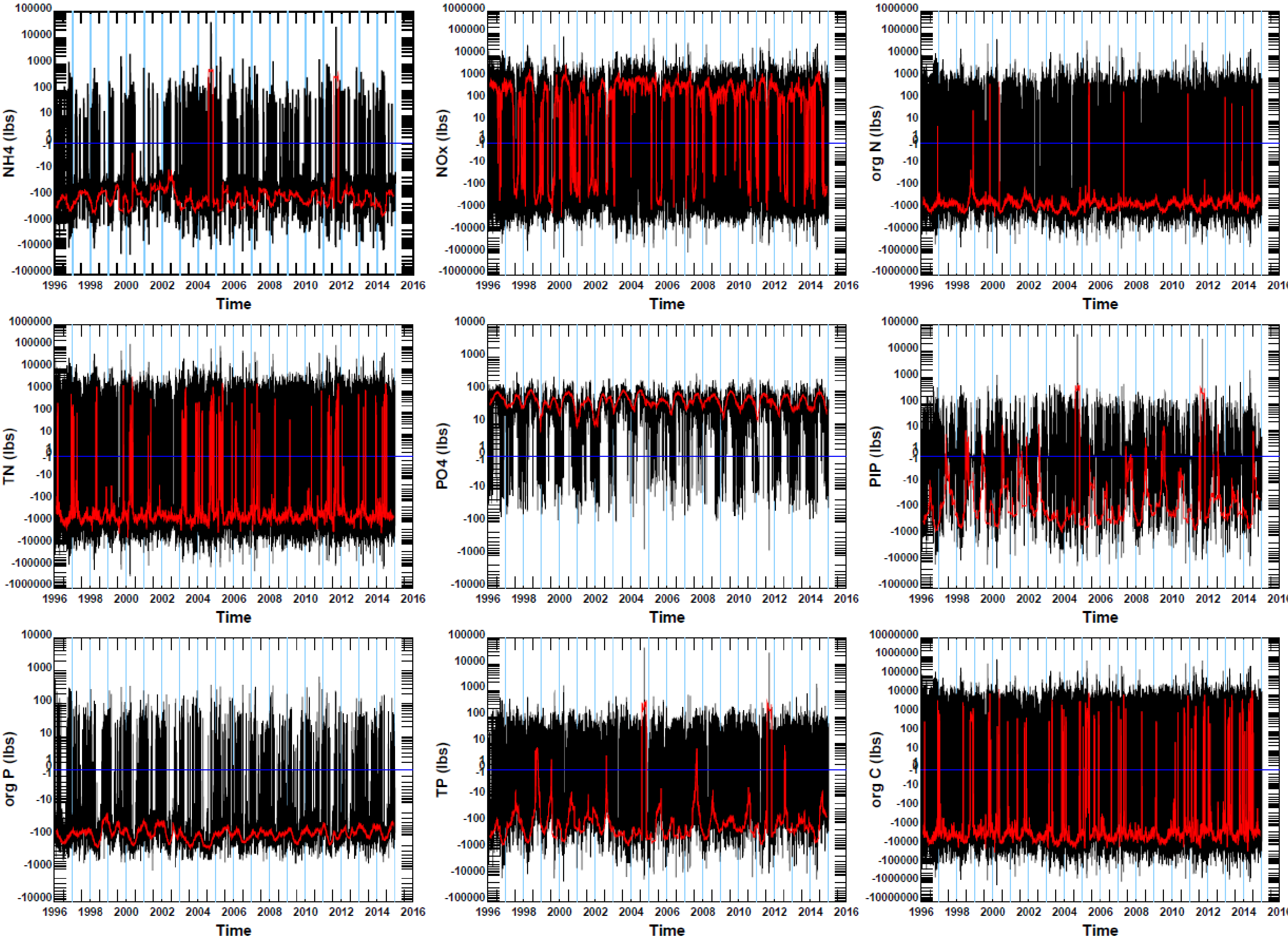
Sediment Flux Model Update

Initial WSM-based splits

- Phytoplankton estimated from WSM via

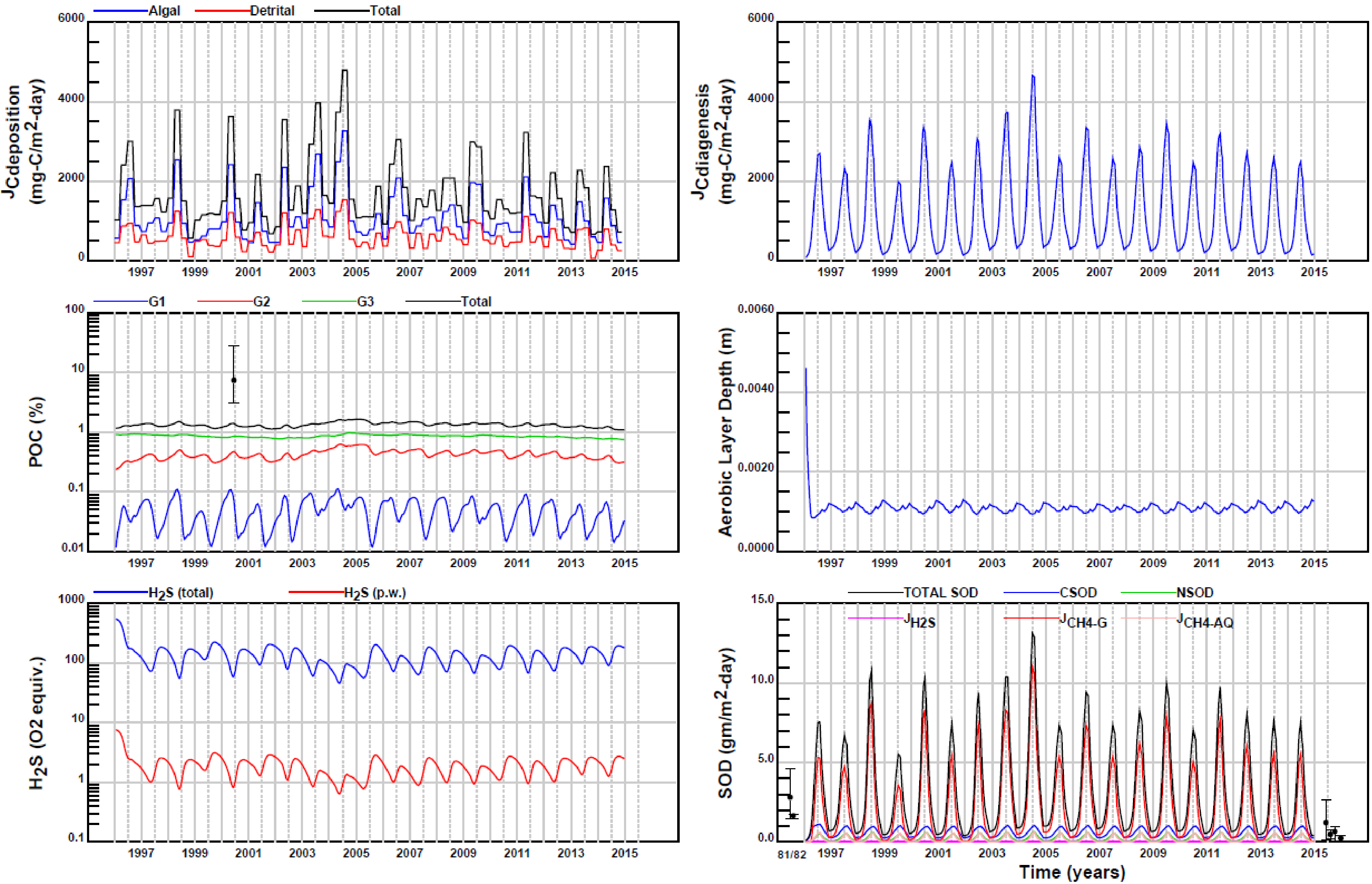
  PHYT (lbs) = TSSX (lbs) - SAND (lbs) - SILT (lbs) - CLAY (lbs)

  and assuming that carbon fraction is 49%
- Correct ORGN and ORGP loads for phytoplankton content
- PON is constant fraction (0.40) of TON and split into G1, G2, and G3 as 0., 0.76, and 0.24
- Multiply the four ORGN pools by 8.0 to get ORGC
- Combine ORGP and PIP into a single variable and assume that 0.774 is particulate
- Further assume that PIP is 0.58 of the particulate combined ORGP and PIP
- Split the non-PIP particulate into G1, G2 and G3 assuming 0., 0.648 and 0.352



Daily Average Conowingo Reservoir Mass Balance

Exelon Generation

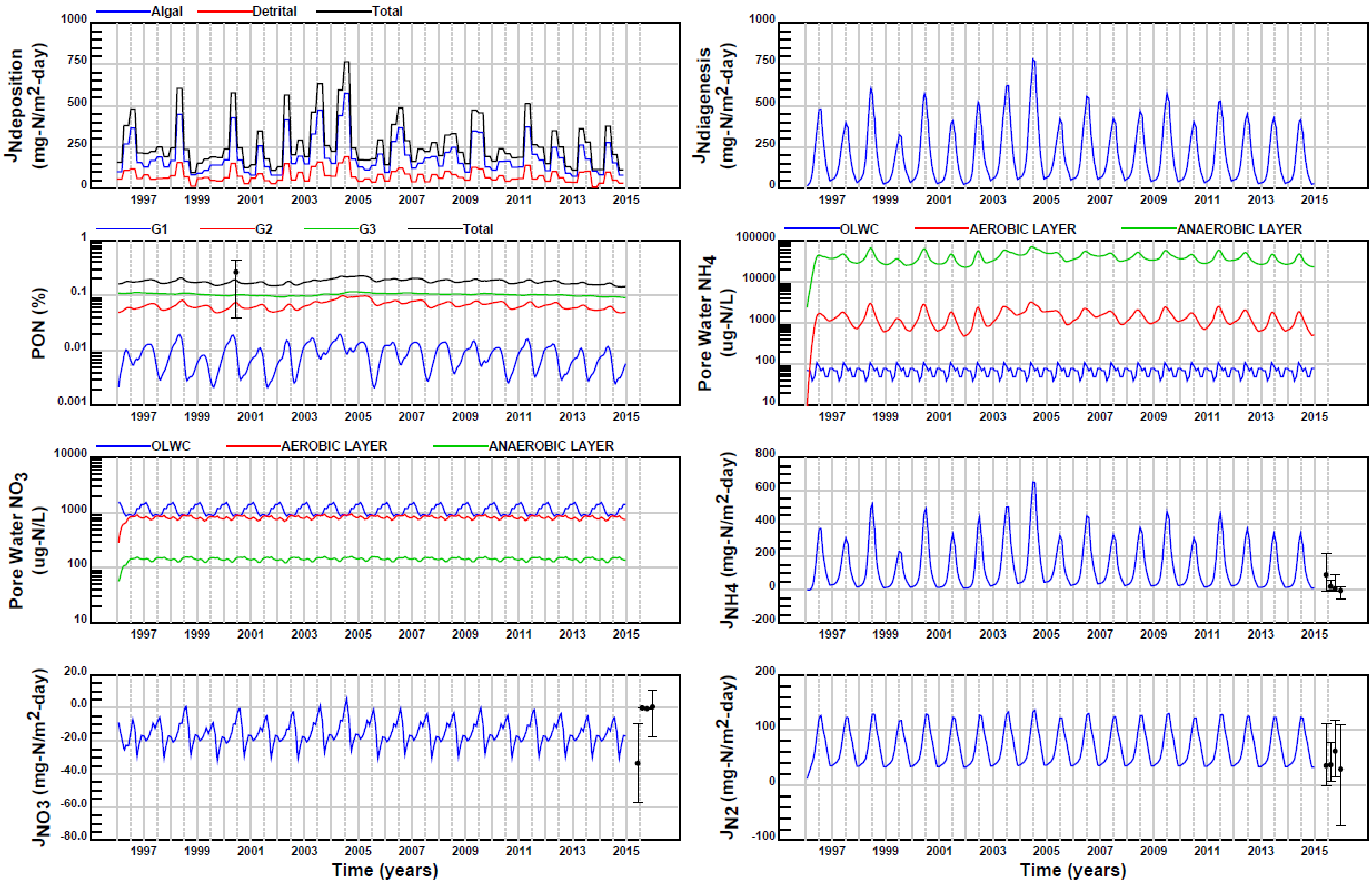


CARBON AND SOD

CONOWINGO POND STAND ALONE SFM

Exelon Generation

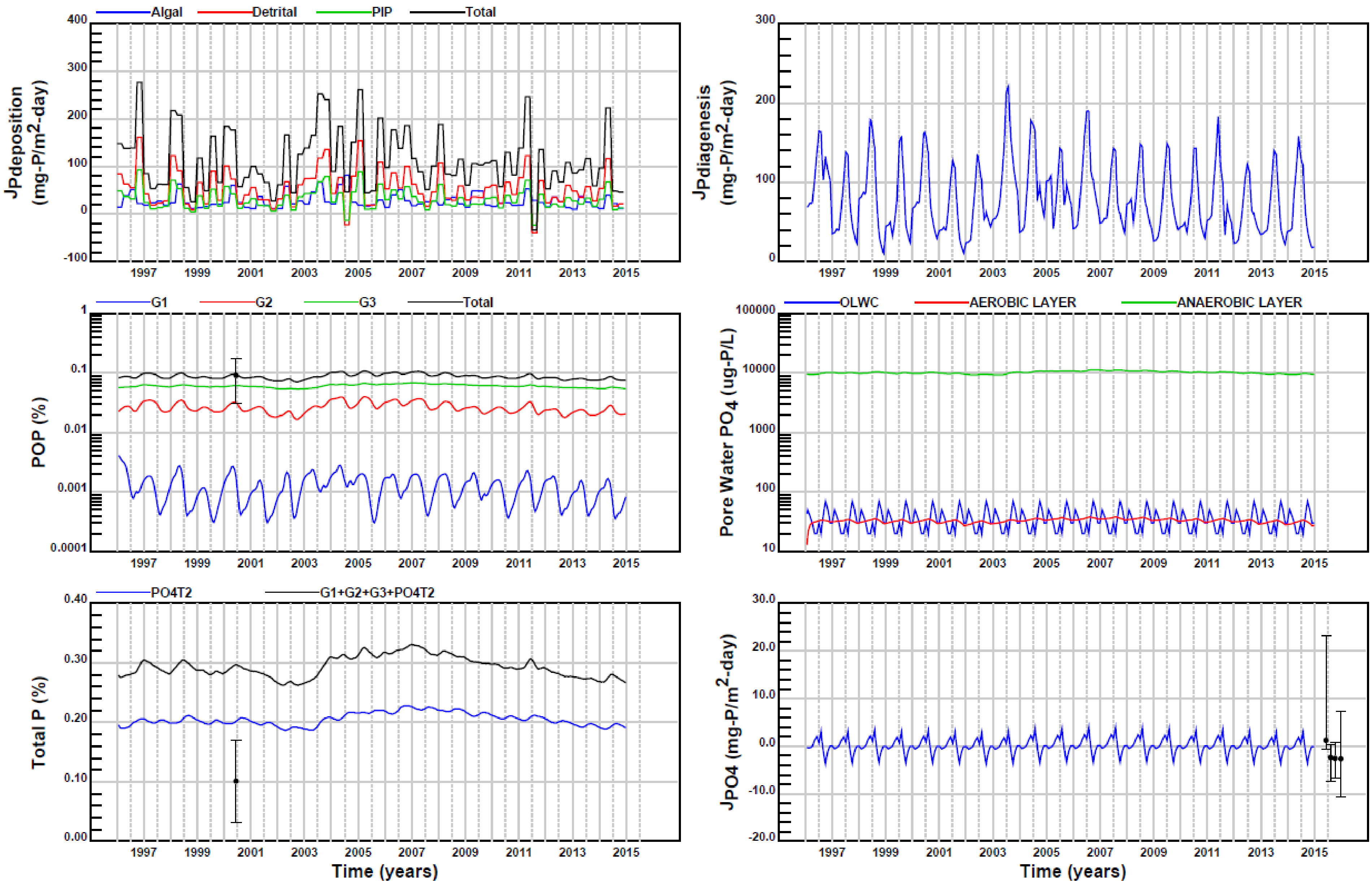
01, EPA WSM values



NITROGEN

CONOWINGO POND STAND ALONE SFM

01, EPA WSM values



PHOSPHORUS

CONOWINGO POND STAND ALONE SFM

01, EPA WSM values

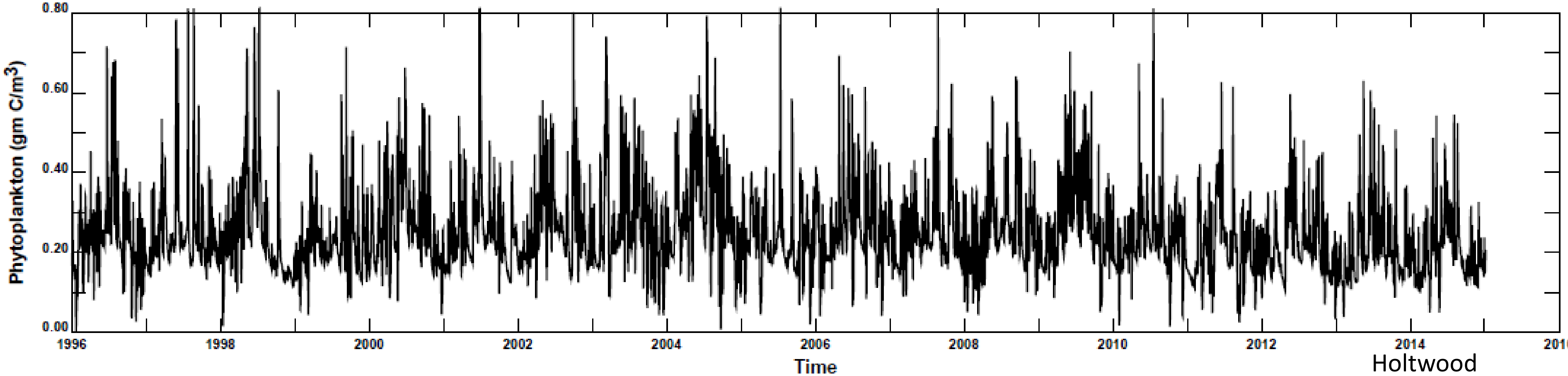
Sediment Flux Model Update

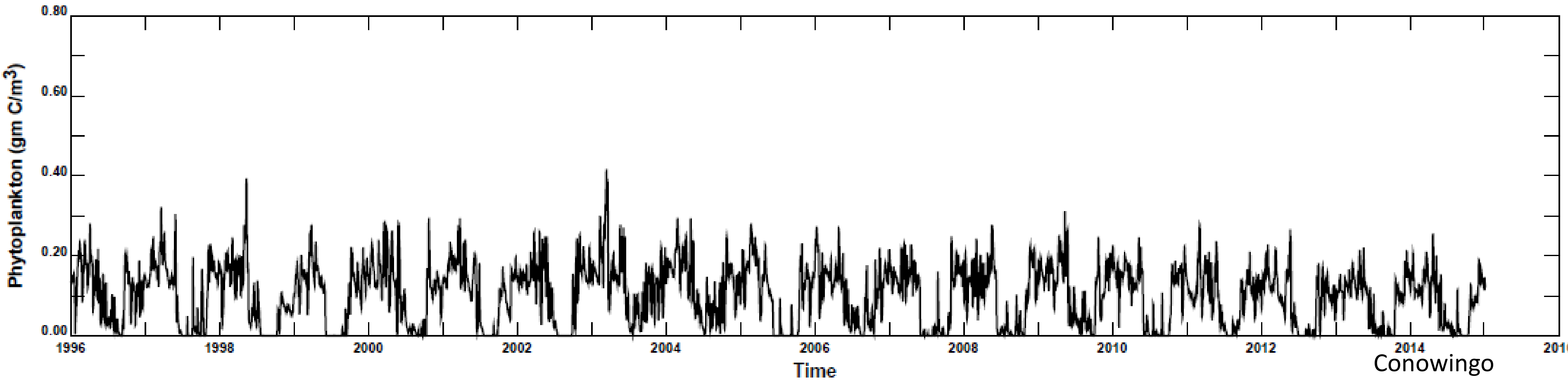
Revisions to CBPO WSM guesstimates

- USGS Conowingo gauge data suggest POC:SS ratio of 0.29
- ORGC G1, G2, G3 splits 0., 0.2, 0.8
- ORGN G1, G2, G3 splits, 0., 0.25, 0.75
- ORGP G1, G2, G3 splits 0., 0.352, 0.648
- 50% reduction in algal C, N, P deposition
- 85% reduction in PIP deposition

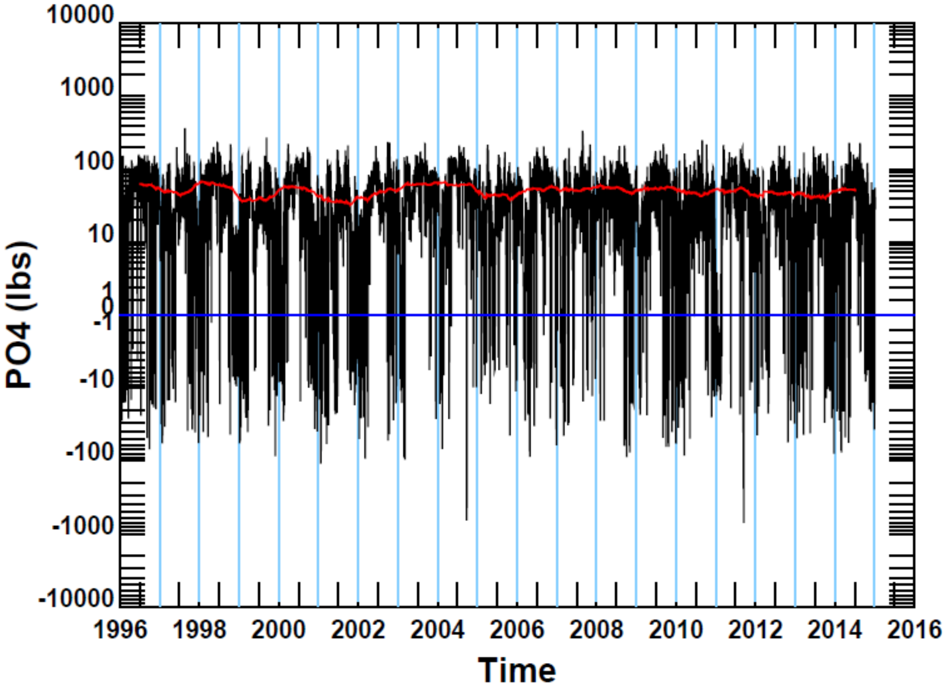
Exelon Generation.

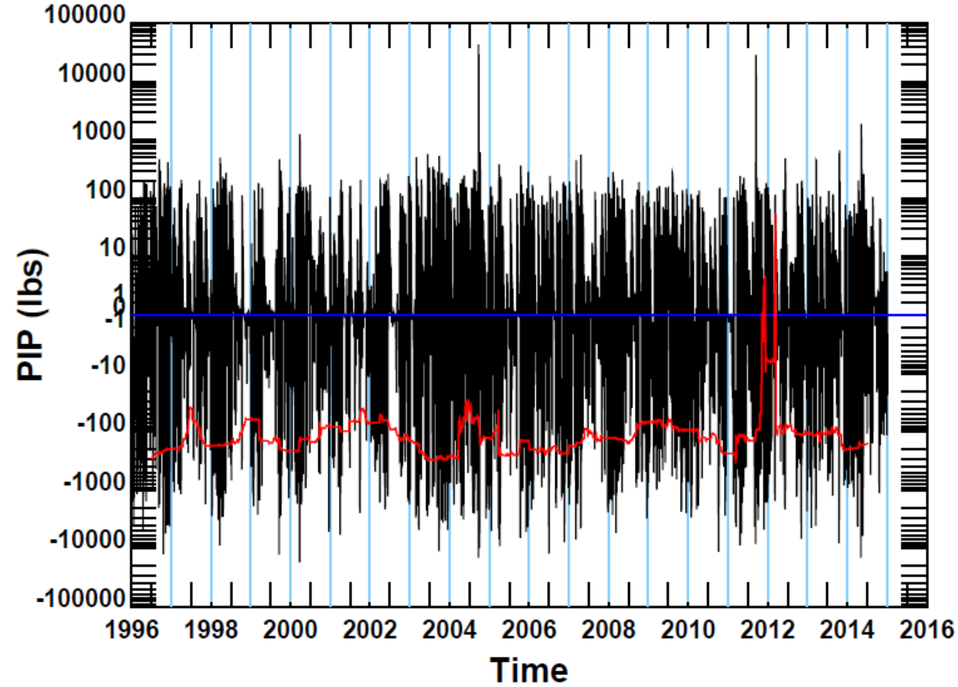
Sediment Flux Model Update

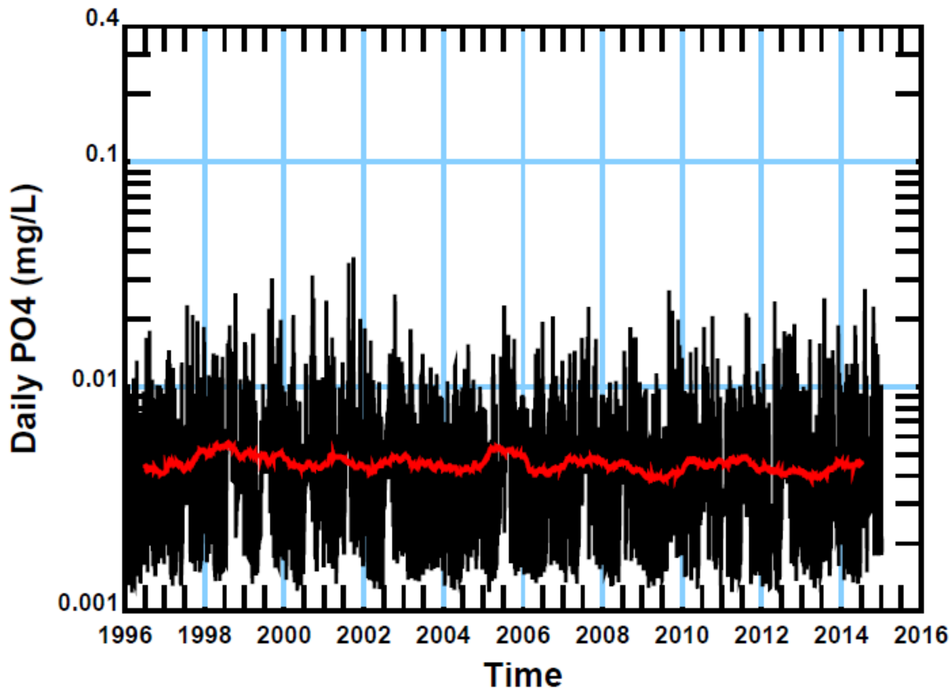


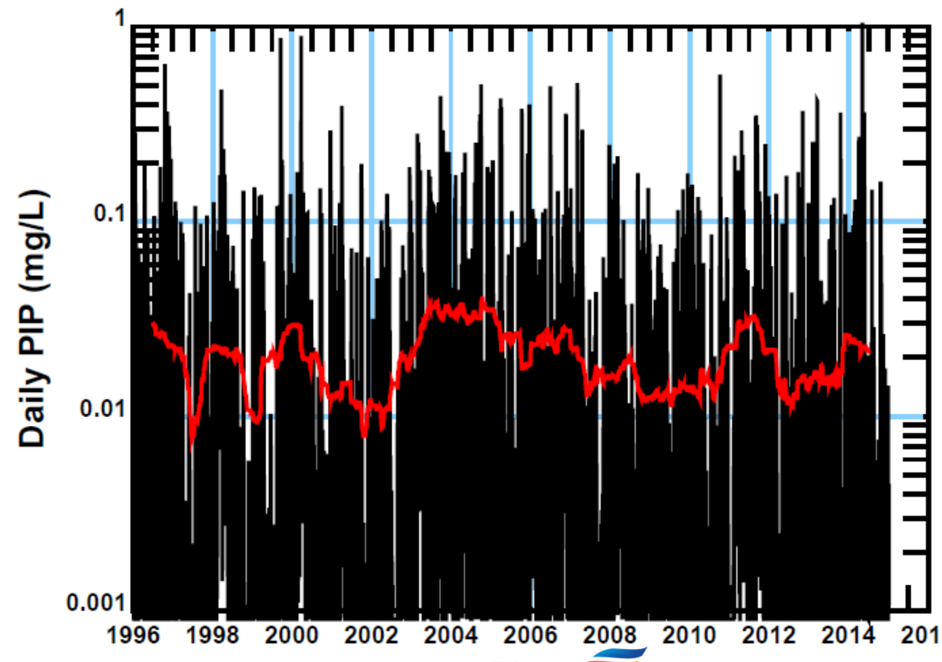


Exelon Generation.









Exelon Generation

Sediment Flux Model Update

Guesstimate as to PIP fraction of total PO4

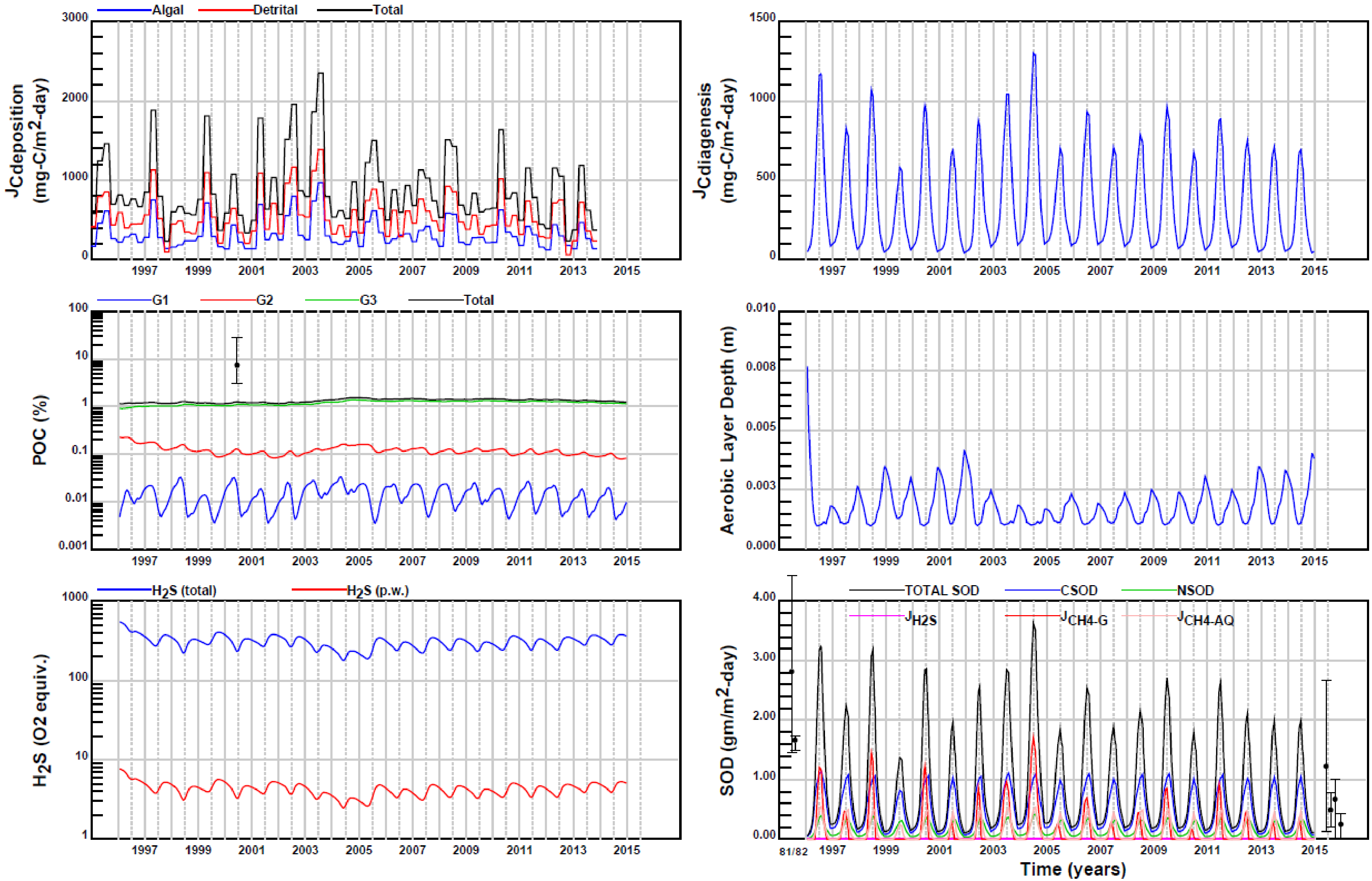
- **Potomac Eutrophication Model data – 1960's-1970's found ~15% of TPO4 was particulate**
- **Based on equilibrium partitioning**

$$f_d = \frac{1}{1+\Pi_{PO4} \cdot m}$$

Assume upper bound sediment bed partition coefficient for PO4 = 30,000 L/kg and an average *m* of 40 mg/L based on Conowingo USGS data

f_d = 1/(1 + 30000 L/kg * 40 mg/L * kg/10^6 mg) = 1/2.2 = .45

45% dissolved vs. 55% particulate

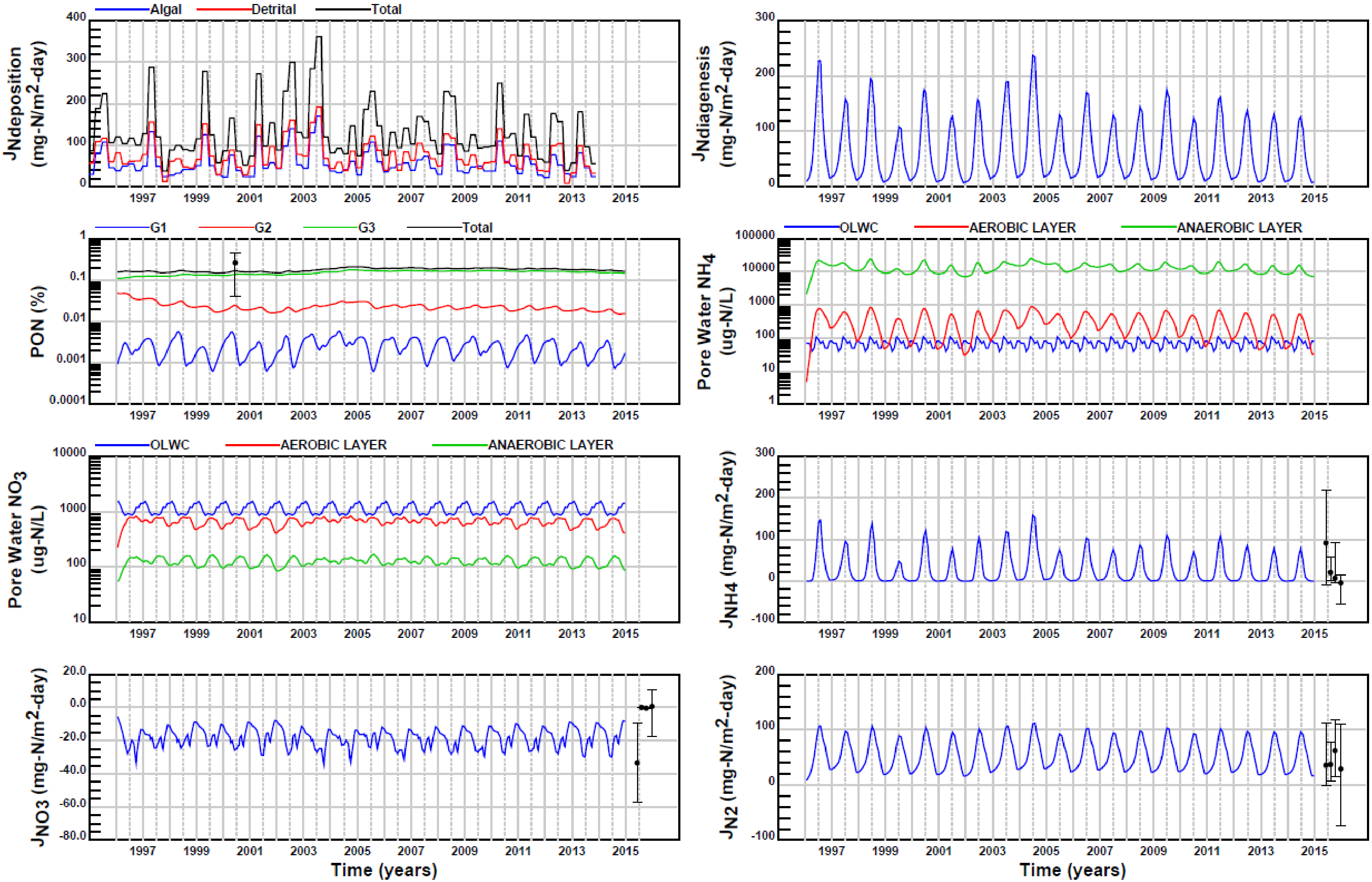


CARBON AND SOD

CONOWINGO POND STAND ALONE SFM

09, POC:TSS=0.29, detrital fraction C, 50% reduction in algal, 85% reduction in PIP

Exelon Generation.



NITROGEN

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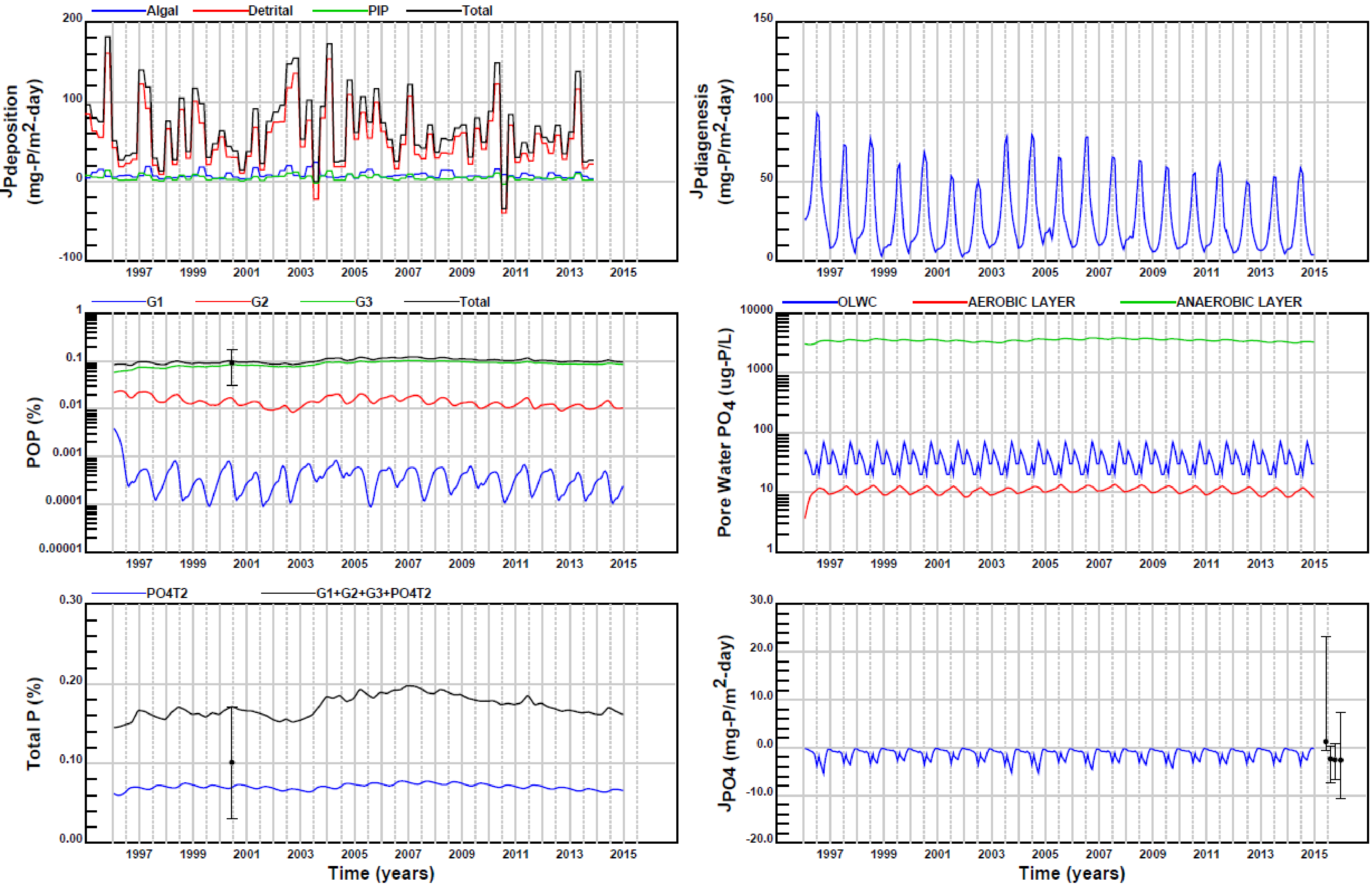

PHOSPHORUS

CONOWINGO POND STAND ALONE SFM

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Exelon Generation.


Questions?
Exelon Generation