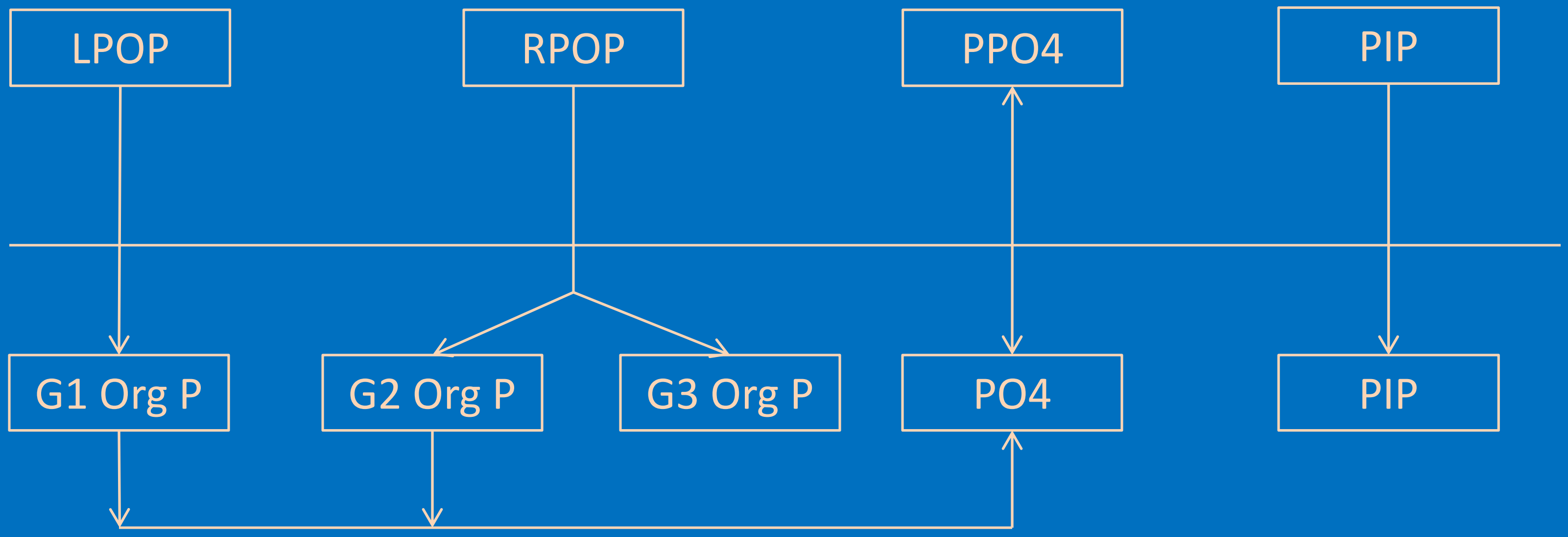
# Bank Nutrient Loads - Background

- Stakeholders are seeking nutrient reduction credits for activities that reduce shoreline erosion.
- The WQGIT wants us to incorporate bank nutrient loads into the WQSTM.
- Initial model runs showed an immense reaction to additional nutrient loads from bank erosion.
- The model code was not suited to handle large loads of potentially inert material.

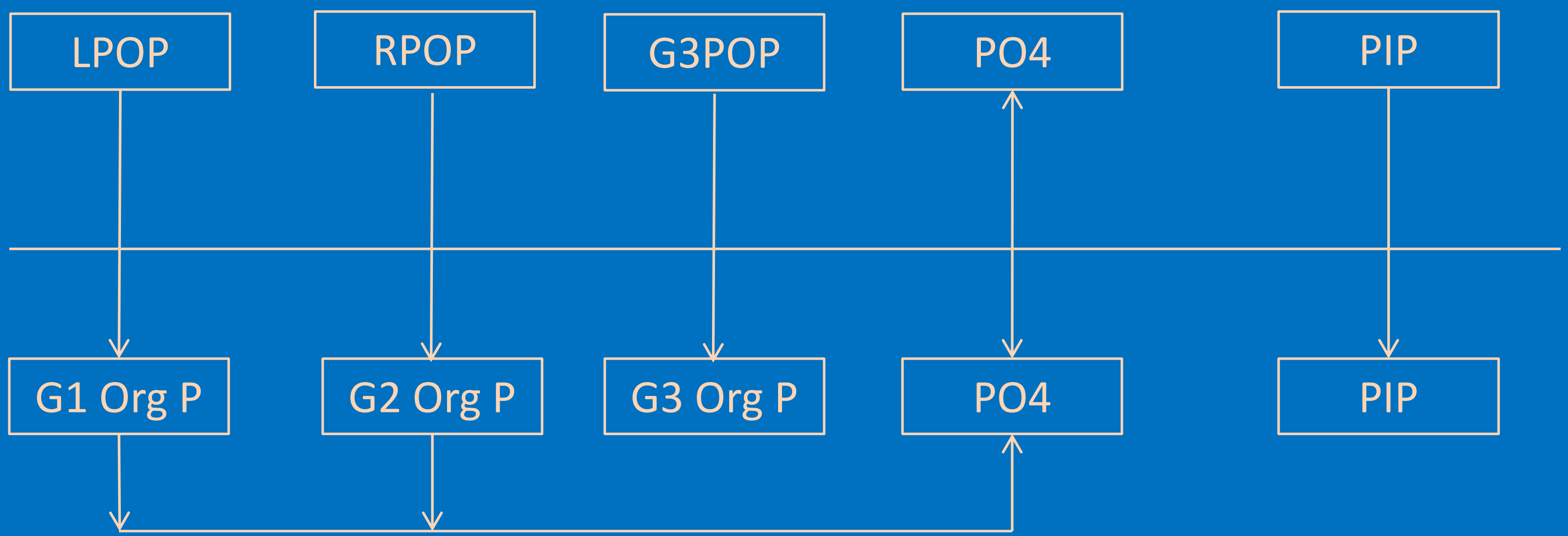
# Bank Nutrient Loads - Issues

- Model formulation.
- Quantify bank nutrient loads.  What is the solids nutrient content?
- How to partition bank nutrient loads into model state variables.  What is the reactivity of each fraction?

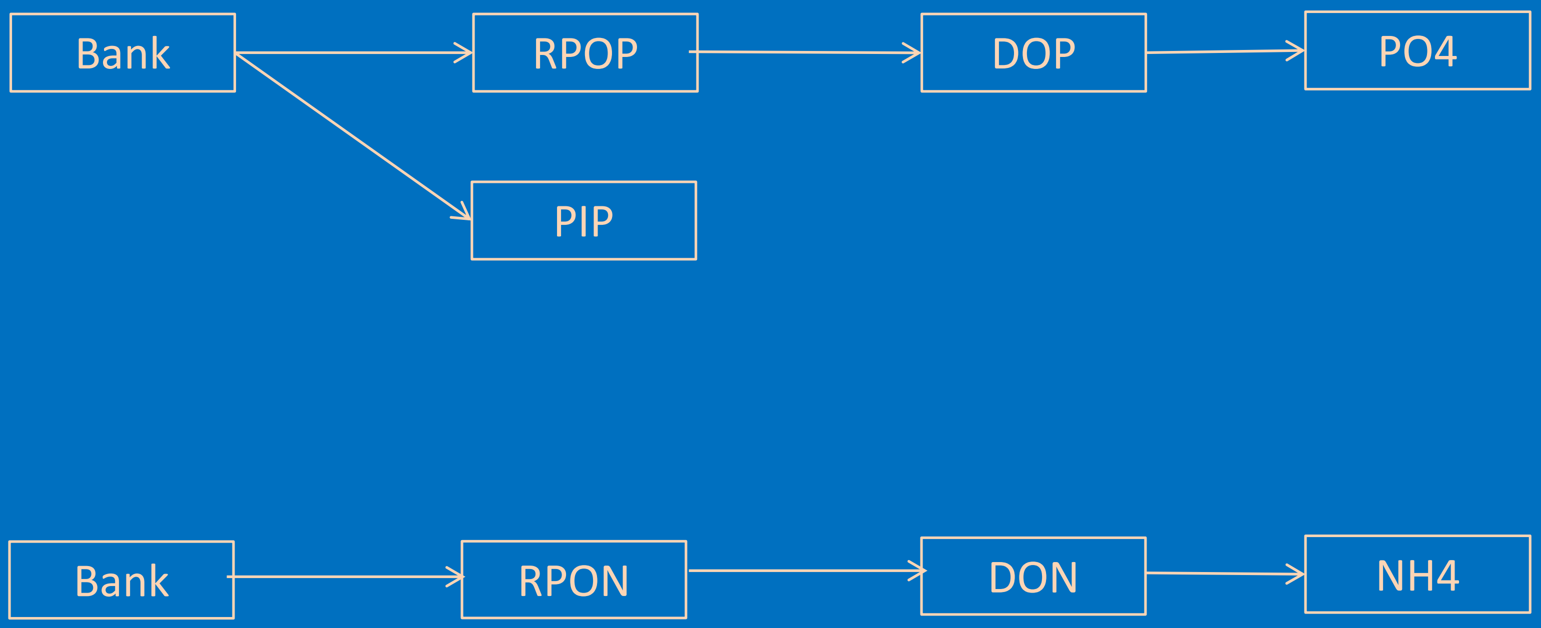
# Former Routing of Water Column P to Sediments



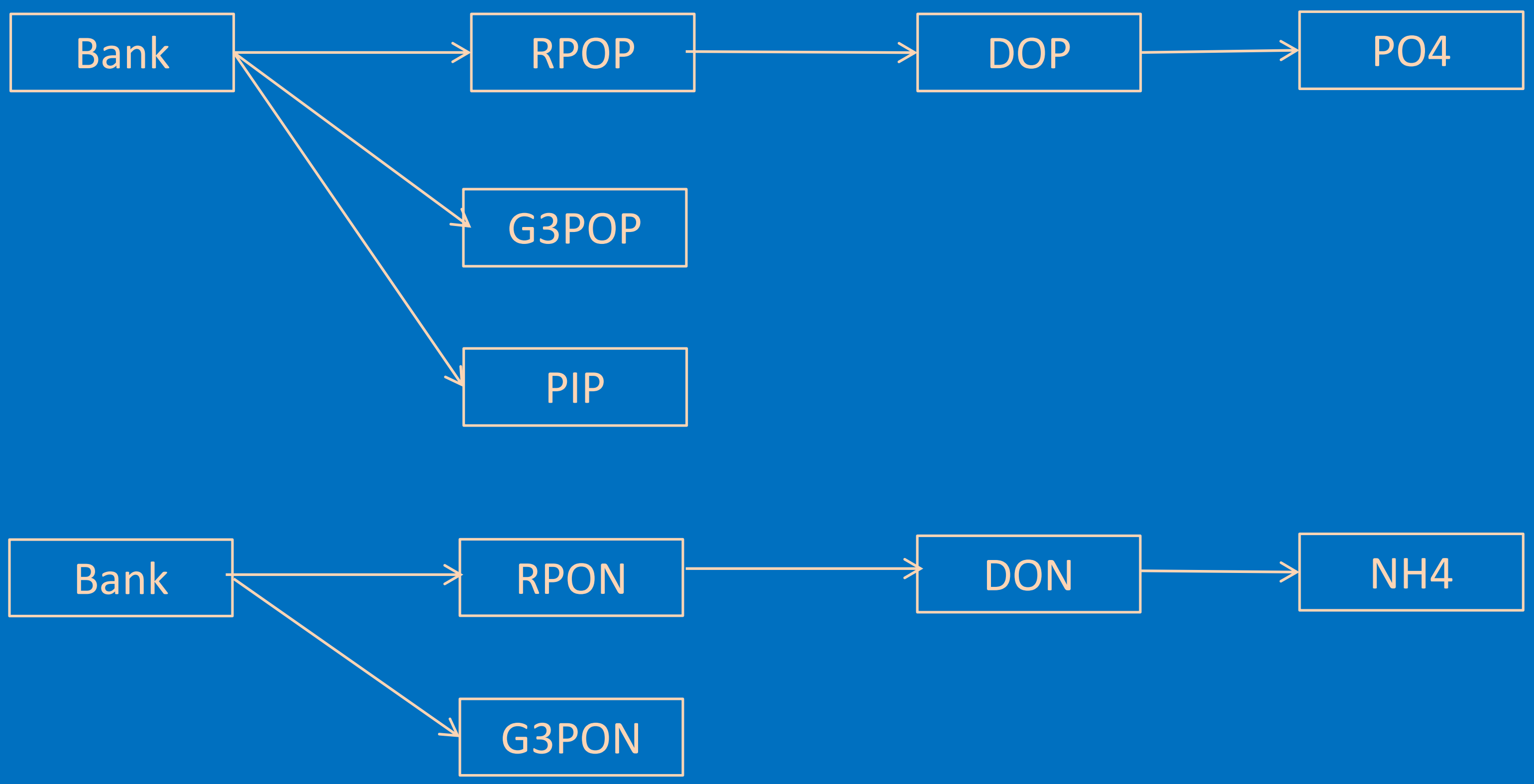
# Revised Routing of Water Column P to Sediments



# Initial Routing of Bank Nutrient Loads to Water Column



# Revised Routing of Bank Nutrient Loads to Water Column

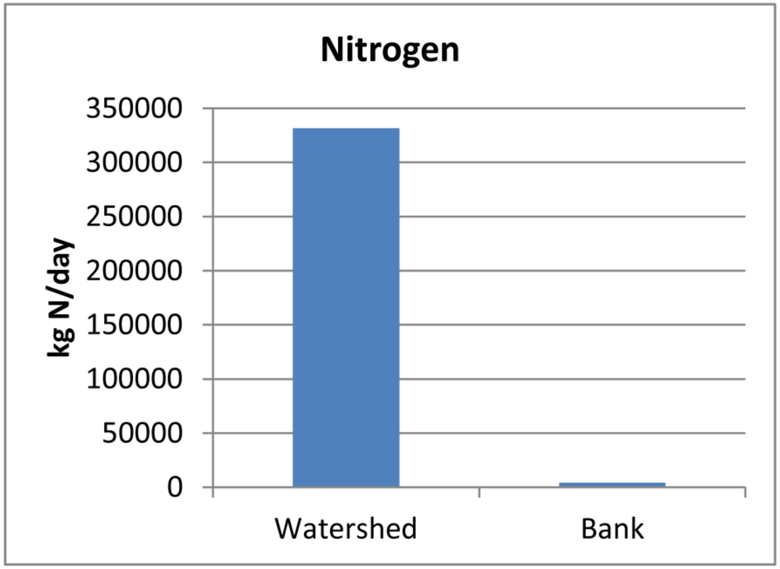


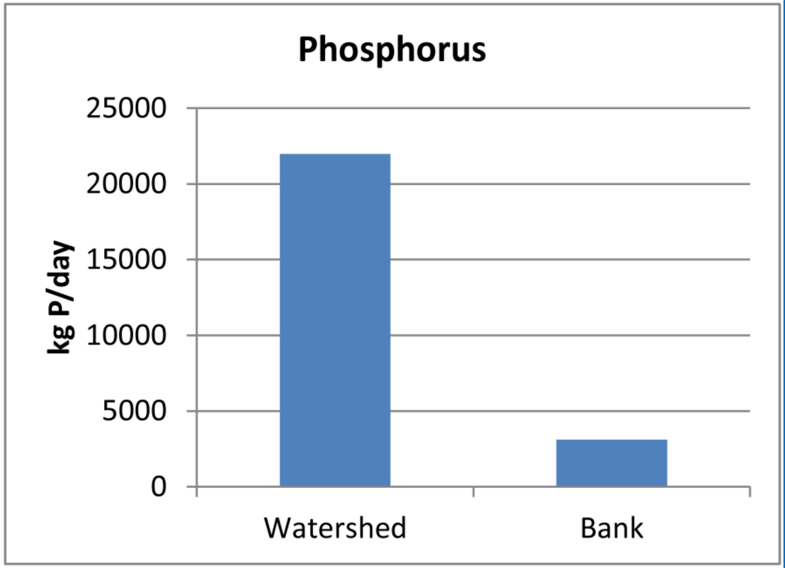
# Quantify Bank Nutrient Loads

- Our earlier model versions (e.g. Virginia Tributary Refinements) employed high nutrient content but considered only fine fraction of bank solids loads.
- The WQGIT recommended nutrient fractions are based on bulk bank solids loads (all size fractions).
- We are now using WQGIT nutrient fractions and bulk bank solids loads estimated for 50,000-cell model by Halka, Hopkins, Hardaway and company.
- 0.29 mg N/g solids, 0.205 mg P/g solids.

# Watershed vs Bank Nutrient Loads

- Watershed loads are 1991-2000 average from Phase 5.3.2 WSM.
- Bank loads are from WQGIT and 50,000 cell model solids loads.
- System-wide, bank nitrogen loads are 1.3% of watershed total nitrogen loads; bank phosphorus loads are 14.1% of watershed total phosphorus loads.



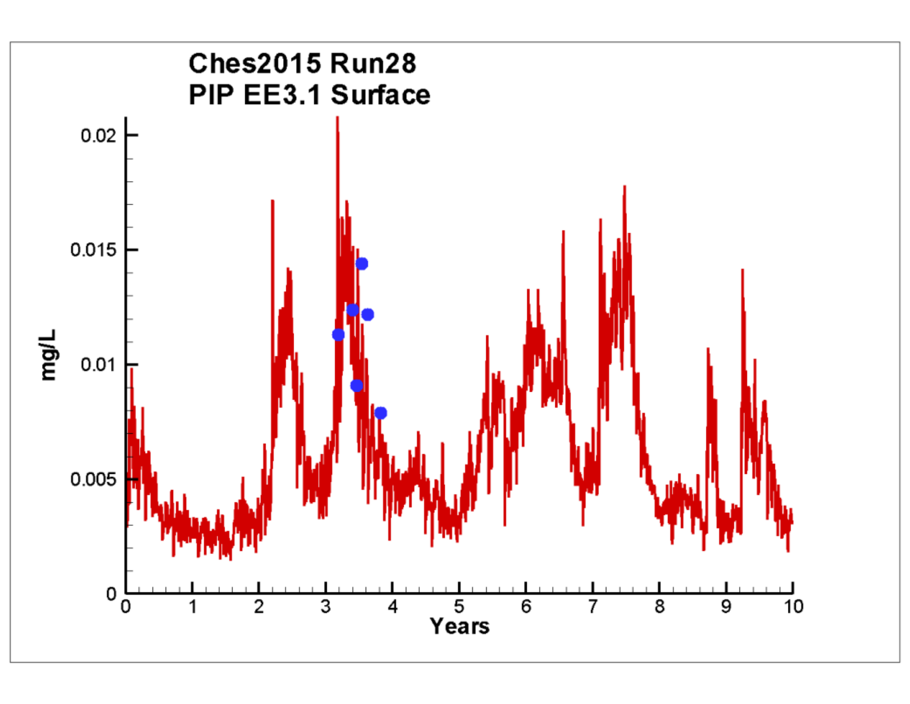
# Nitrogen Fractions/Reactivity

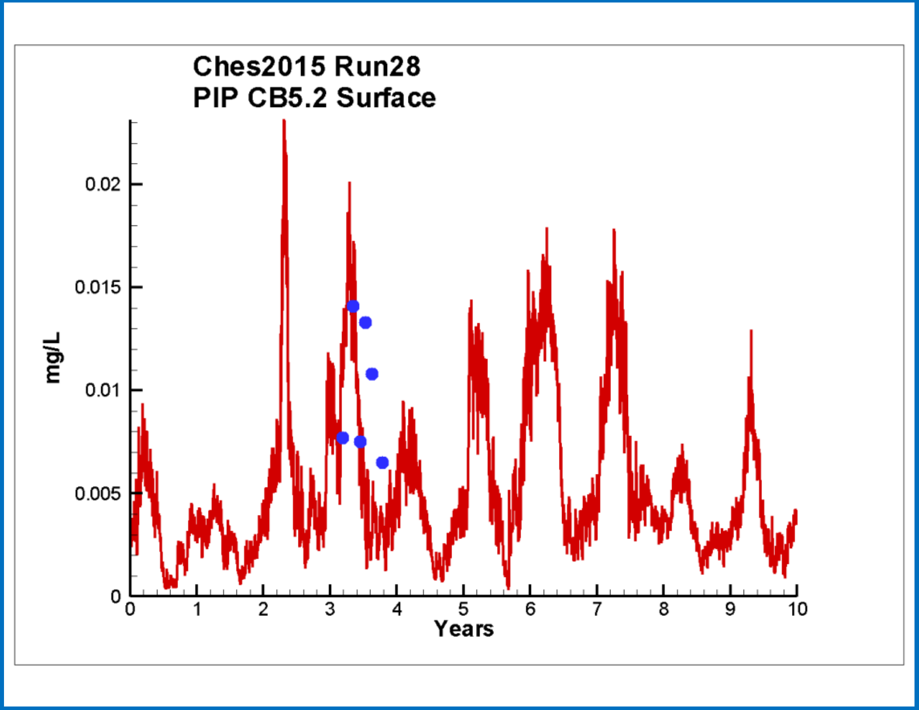
- We need to partition bank nitrogen loads into water column RPON, G3ON.
- When the previous RPON variable was incorporated into sediments, we split 80% G2, 20% G3.
- Use these fractions for initial partition of watershed loads, bank loads.
- Decay rates in water: RPON = 0.005/d, G3ON = 0.0/d
- Decay rates in sediments: G2 = 0.0018/d, G3 = 0.0/d.

# Phosphorus Fractions/Reactivity

- We need to partition bank phosphorus loads into water column RPOP, G3OP, PIP.
- PIP comprises 50% - 60% of watershed particulate phosphorus. When the previous RPOP variable was incorporated into sediments, we split 80% G2, 20% G3.
- Use these fractions for initial partition of bank loads: 50% PIP, 40% RPOP, 10% G3OP.
- Decay rates in water: PIP = 0.0/d, RPOP = 0.01/d, G3OP = 0.0/d,
- Decay rates in sediments: PIP = 0./d, G2 = 0.0018/d, G3 = 0.0/d.

# PIP from 1994




Our PIP computations need some tuning but they are "on the graph paper."

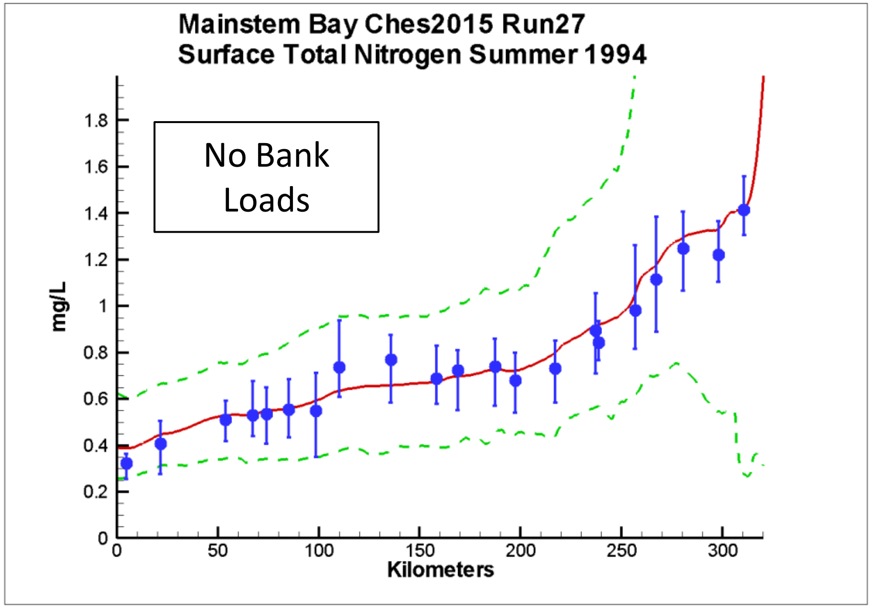
# Reactive Load Summary

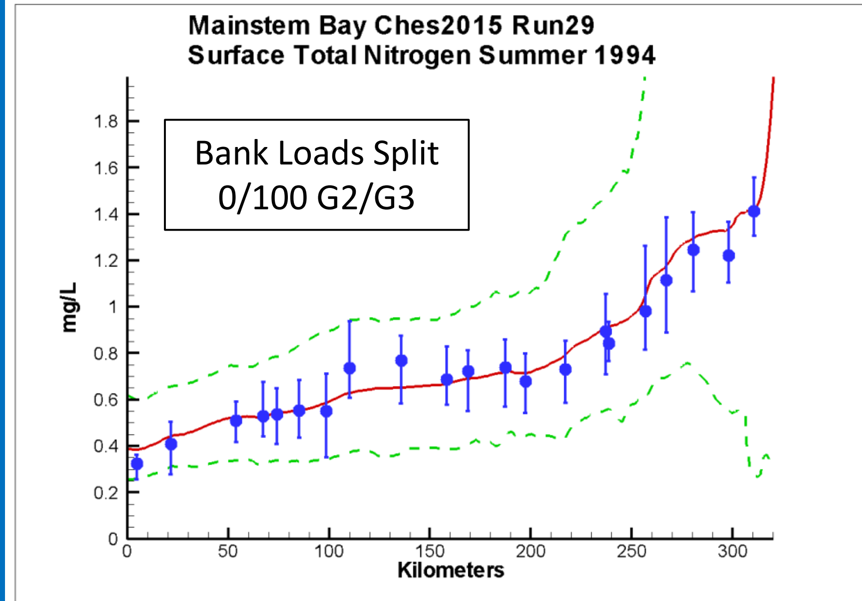
| | Watershed Dissolved | Watershed Reactive Particulate | Watershed Inert Particulate | Bank Reactive Particulate | Bank Inert Particulate |
|---|---|---|---|---|---|
| Nitrogen | 247834 | 67102 | 16775 | 3504 | 876 |
| Phosphorus | 7083 | 5273 | 9614 | 1239 | 1858 |

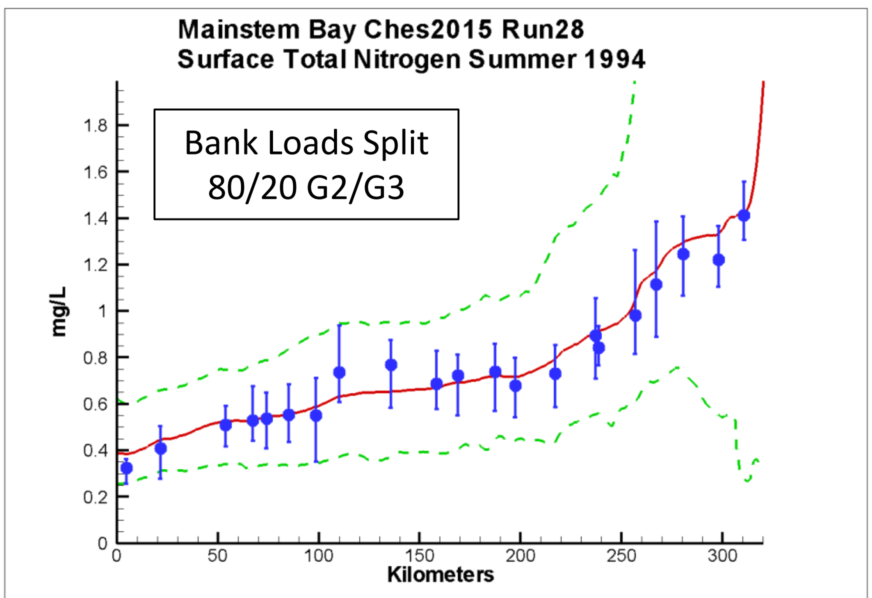
- All loads in kg/d for 1991-2000.
- Reactive nitrogen in bank nutrient loads is 1.1% of reactive watershed load.
- Reactive phosphorus in bank nutrient loads is 10% of reactive watershed load.

# Three Model Runs

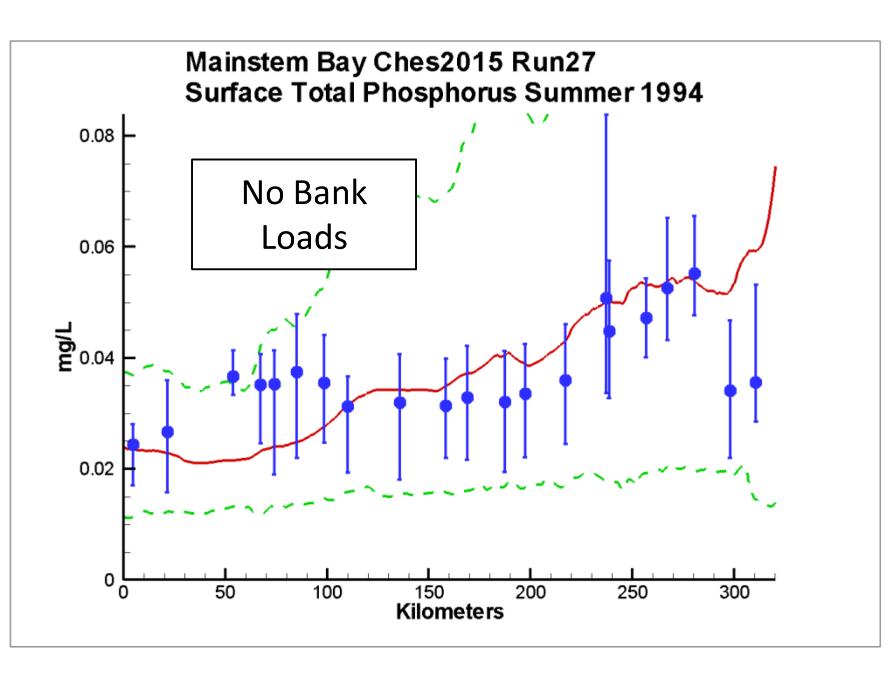
- Run 27 – No bank nutrient loads.
- Run 28 – Bank nutrient loads with 80% refractory, 20% inert split.
- Run 29 – Bank nutrient loads are 100% inert.

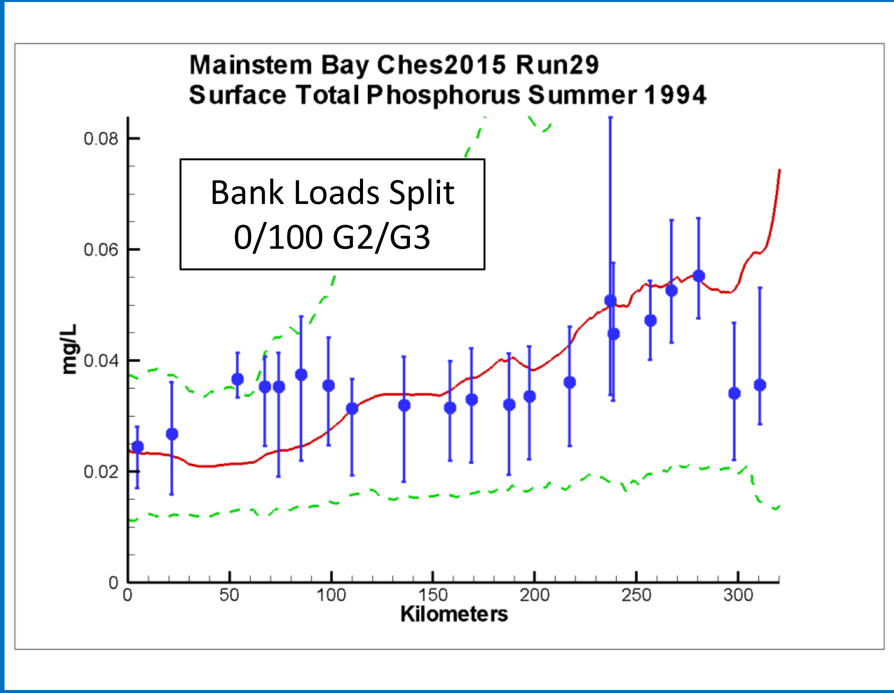


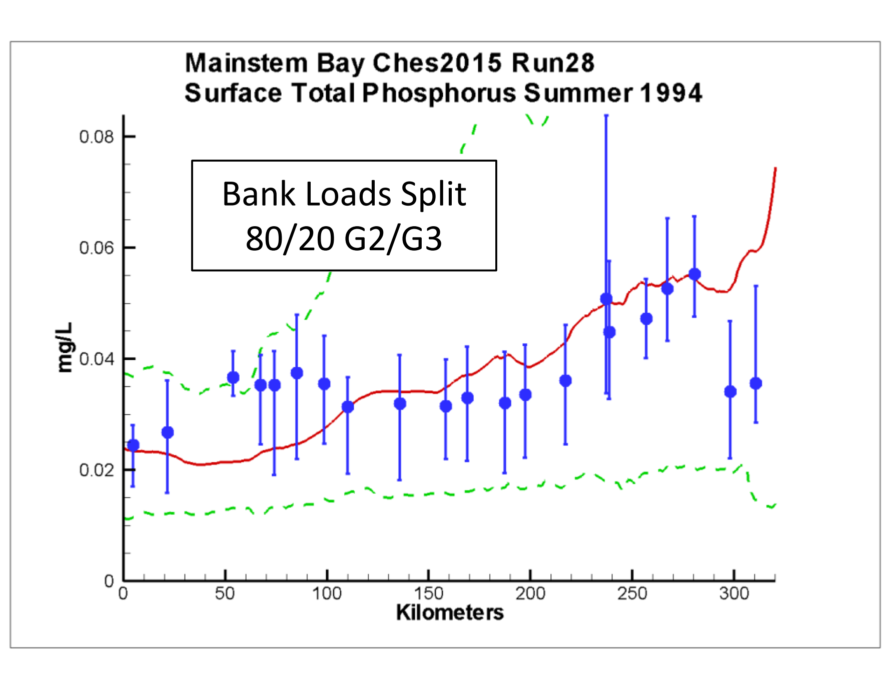



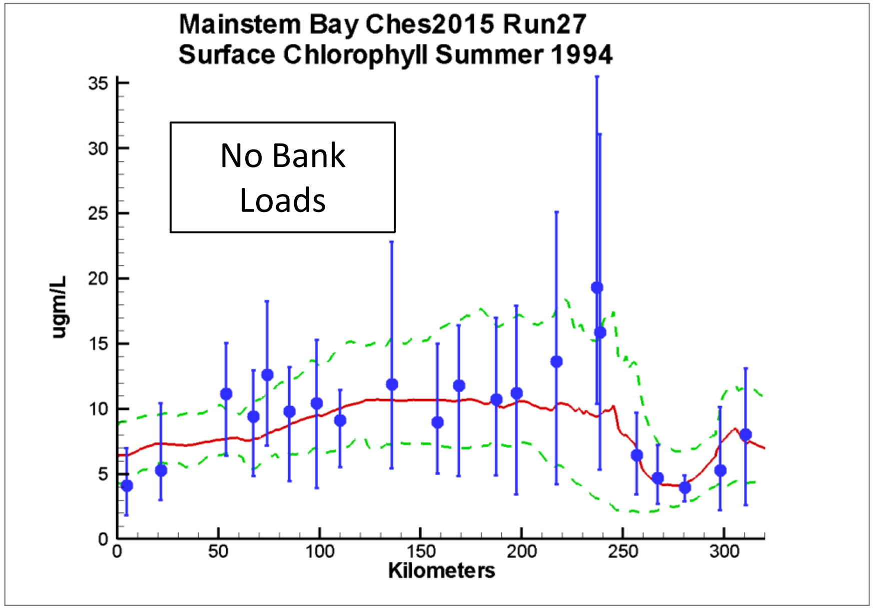

Total Nitrogen

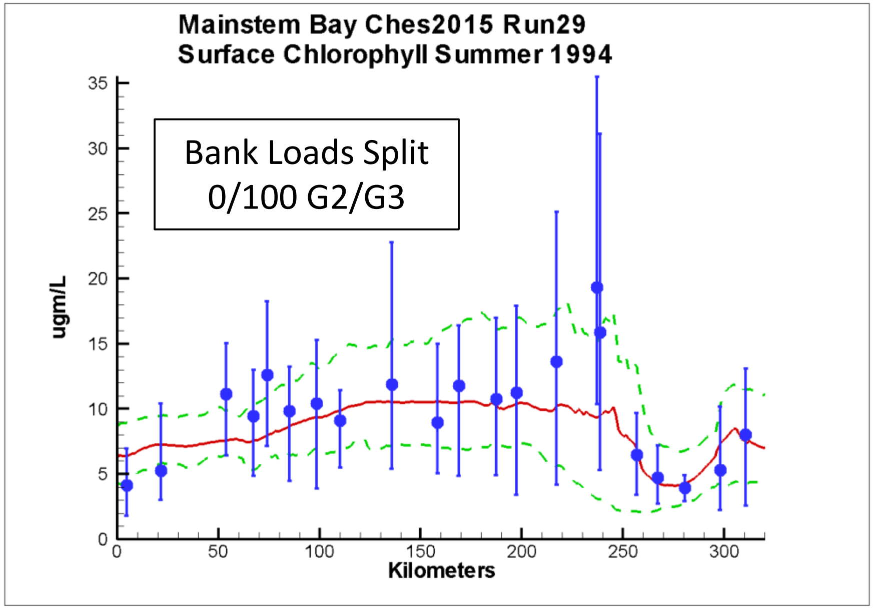


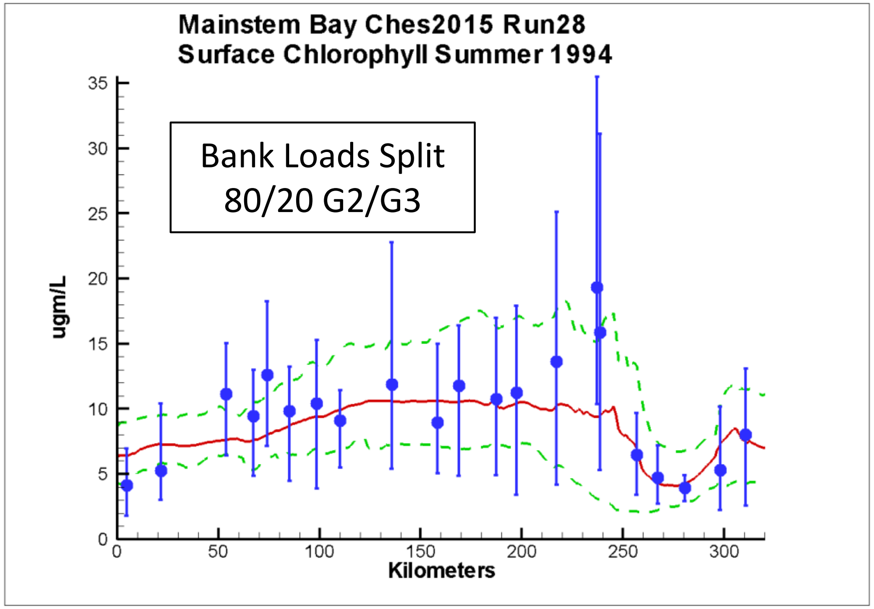



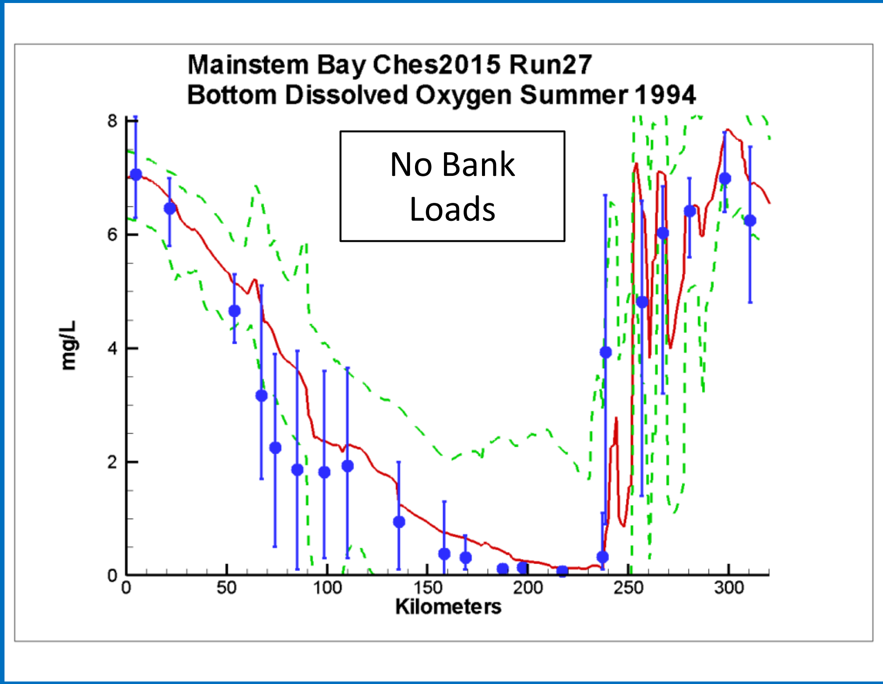

# Total Phosphorus

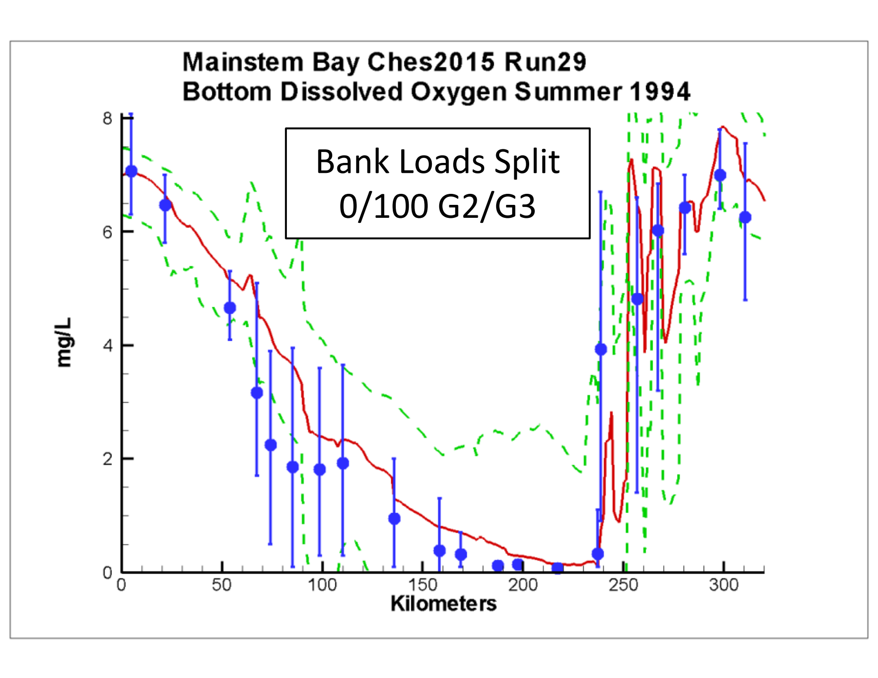


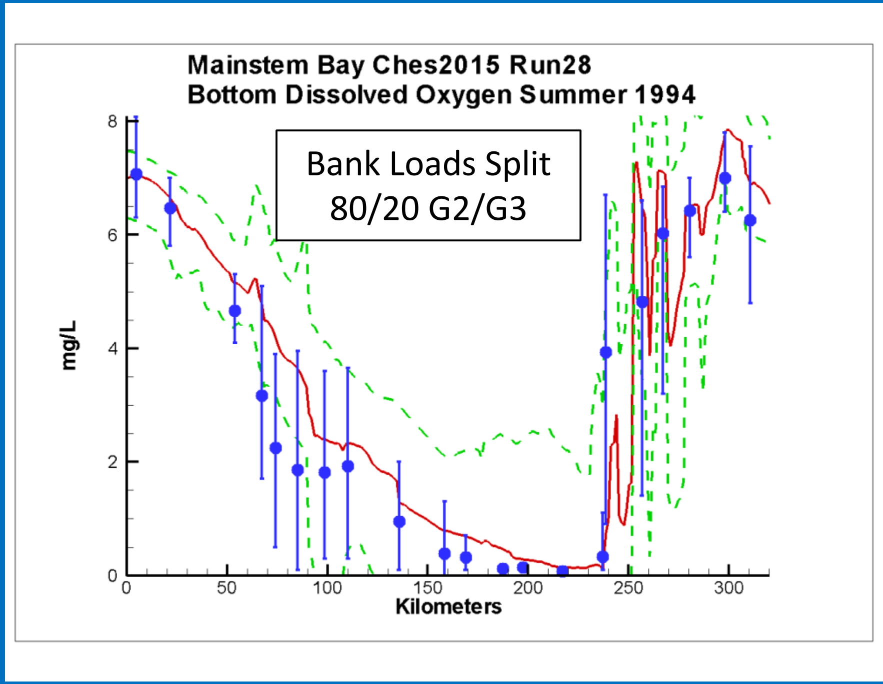




Chlorophyll




Dissolved Oxygen

# Good News / Bad News

- The Good News
  - We have the model formulated right. The formulation allows multiple loads with different reactive fractions, potential for resuspension.
  - The model behaves well, results are rational.
- The Bad News
  - I am not comfortable with the big change from previous results. Why did the previous version react so strongly?
  - We lack guidance for partitioning loads into reactive fractions.

# Bank Phosphorus Loads

- I looked at three references:
  - Jordan et al. 2008. “Changes in phosphorus biogeochemistry along an estuary salinity gradient: The iron conveyor belt,” L&O 53(1), 172-184
  - Ibison et al. 1992. “Eroding bank and nutrient verification study for the lower Chesapeake Bay,” Dept of Conservation and recreation, Gloucester Pt. VA
  - UMCES. 2007. “Development of an estuarine phosphorus sub-model for incorporation into the next-generation Potomac River environment Model: Phosphorus data and laboratory experiments,” TS-563-07

# Bank Phosphorus Loads

- The Ibison study indicates the vast majority of the bank material is organic phosphorus (more accurately, the majority of the phosphorus does not show up unless the sample is roasted at 475 $^{o}$C).
- The Jordan study indicates that runoff into the Patuxent and bottom sediments are largely iron-bound P, however, with organic P a small fraction of total P.
- The UMCES study in the Potomac comes to the same conclusions.
- So we are left with a puzzle.
  - The eroding banks are largely organic but the bottom sediments are not.
  - Or it may be that the different analytical methods are responsible.
  - Or there may be geographic differences in composition.

# Some Options for Partitioning

- Keep the reactive nutrient loads to the system exactly the same as for the TMDL model calibration. That means the reactivity of watershed loads decreases a bit to account for new reactive loads from bank nutrients (G2 organic nitrogen fraction in all loads = 76%, G3 organic phosphorus fraction = 65%).
- Split all loads as per watershed loads in previous calibration (80% G2, 20% G3). This option introduces new reactive material.
- Treat bank nutrient loads as 100% inert, no new loading of reactive material.

# The Best news

- We have this situation under control and we can move on to other issues (shallow water, sea-level rise, marsh erosion etc.)