Buckeye Lake: What do we know?

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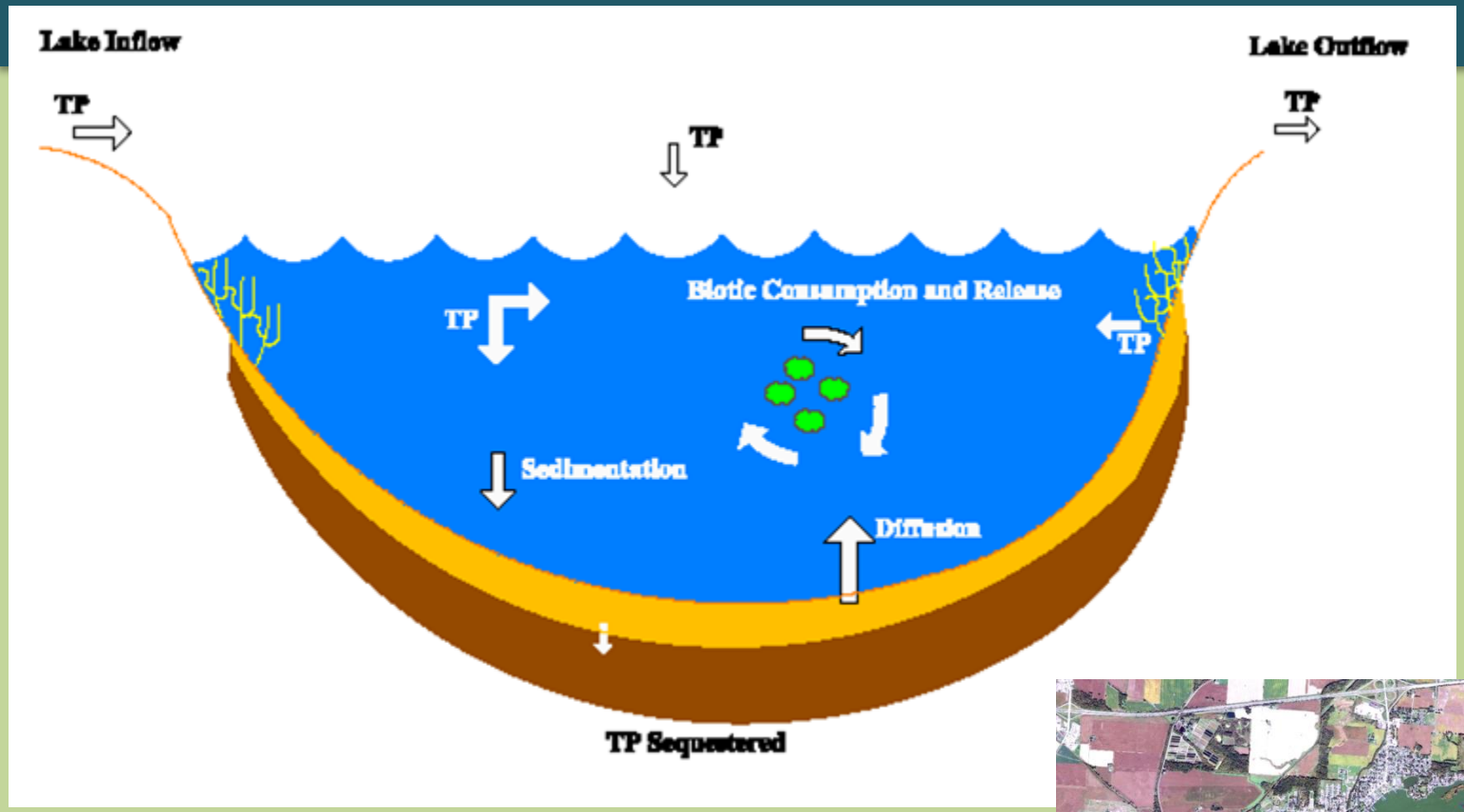
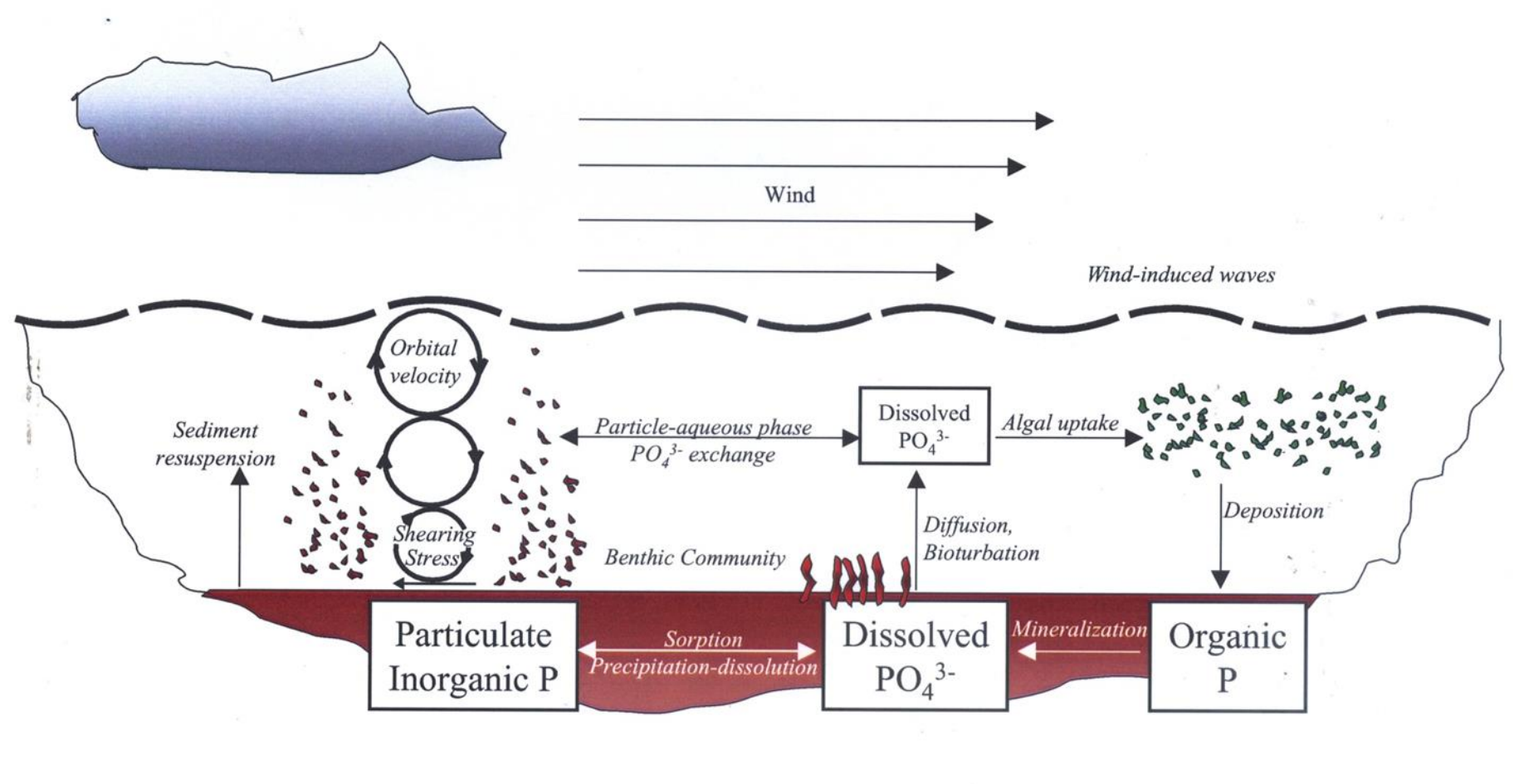
General Limnology



General Limnology



Buckeye Lake

- Shallow, Hyper-eutrophic Lake
- High Phosphorus, High Chlorophyll
- HABs
  - Microcystin at Beaches
    - 2011: Avg = 2.6 µg/L
    - 2012: Avg = 4.0 µg/L
    - **2013: Avg = 26.0**

Buckeye Lake

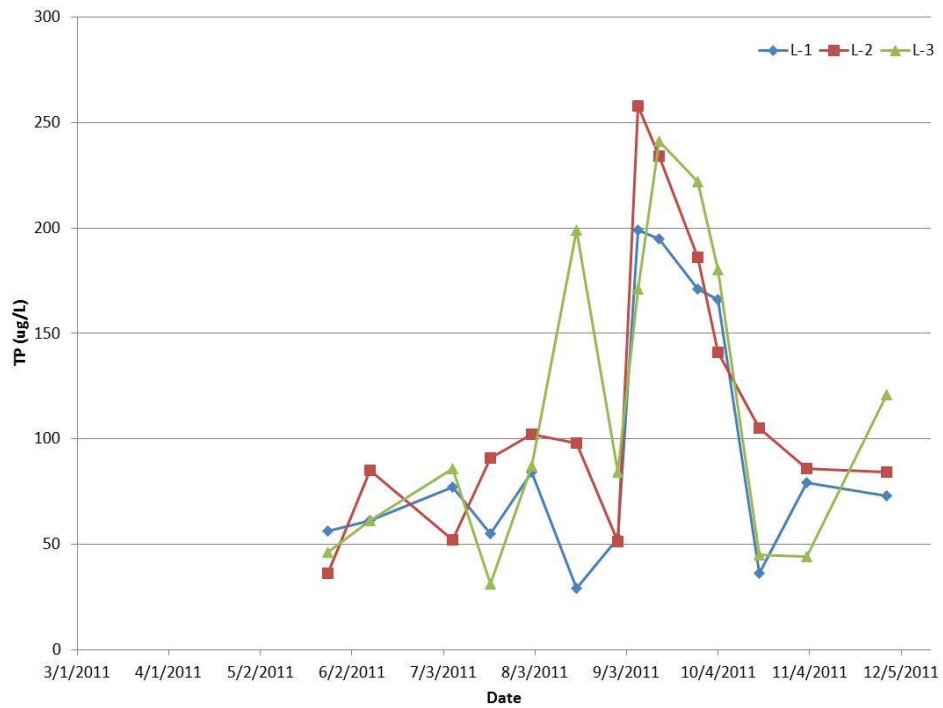
- Historical Data

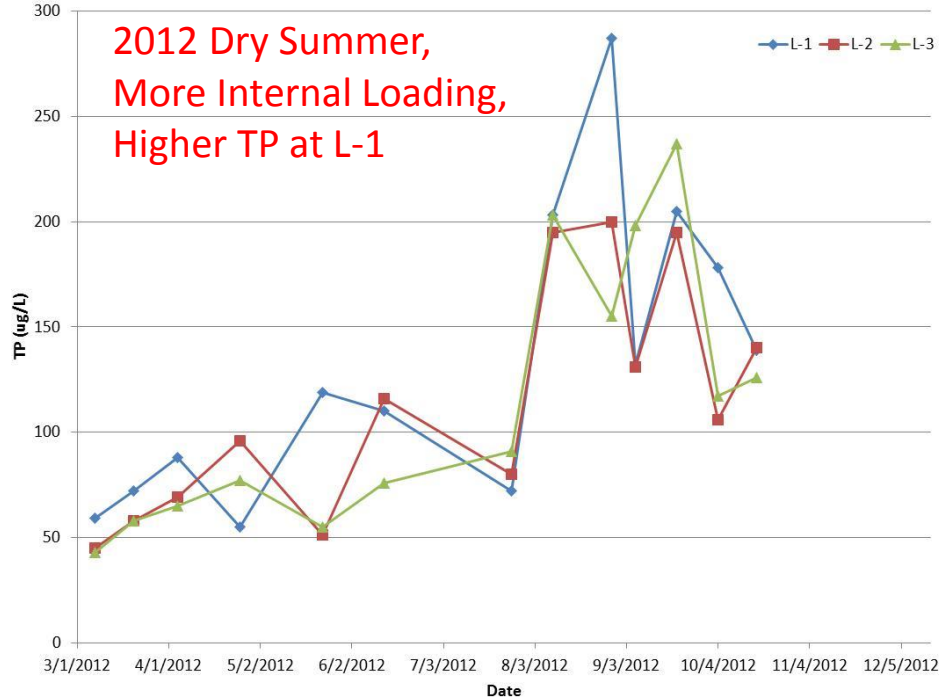
Date	Mean TP (µg/L)	Mean Chla (µg/L)	Mean Secchi Disk (m)
4/26/1973	173	247	0.2
7/30/1973	165	141	0.3
10/8/1973	273	172	0.3

- Current Data

Year	Summer Mean TP (µg/L)	Summer Mean Chla (µg/L)	Summer Mean Secchi Disk (m)
2011	121	197	0.3
2012	160	196	0.3

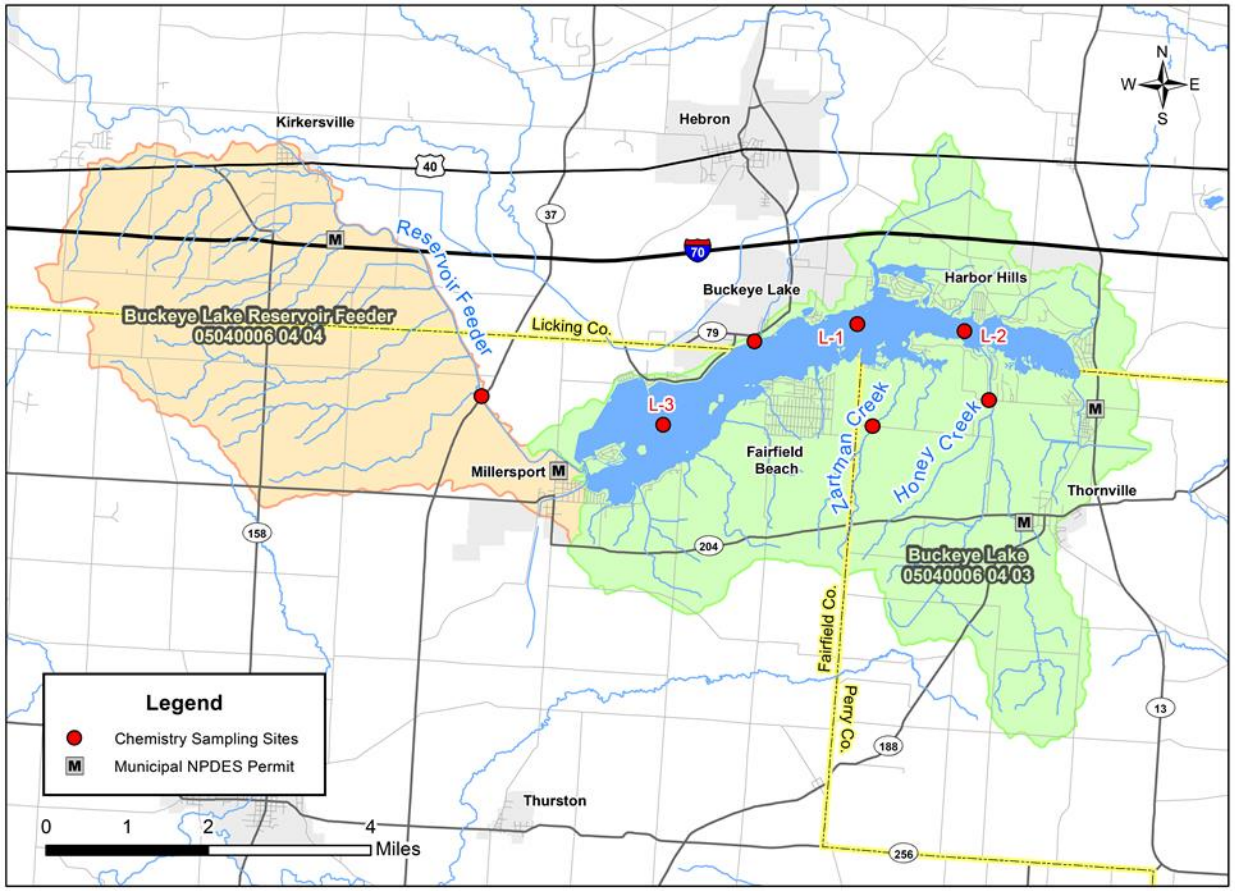
- Similar TP patterns
- Peaks in TP late summer
  - Typical of Internal Loading
- In Lake TP Goal
  - Annual Average 50 µg/L
- 2011 Mean = 109 µg/L
- 2012 Mean = 121 µg/L





Tributaries

- **Feeder Creek**
  - 16.9 mi^2 (43.7 km^2)
- Zartman Creek
  - 1.74 mi^2 (4.5 km^2)
- Honey Creek
  - 6.9 mi^2 (17.8 km^2)
- **Minor Tribs/Nearshore Drainage**
  - 14.3 mi^2 (37.1 km^2)



Tributary TP Concentrations

- Tributary Inflow TP significantly lower in 2011 & 2012 than in 1973/1974

	Feeder Creek	Honey Creek	Zartman Creek
Annual Mean TP (µg/L)			
1973-1974	239	214	no data
2011	115	66	**31**
2012	77	**47**	**33**
Summer Mean TP (µg/L)			
1973-1974	415	279	no data
2011	90	66	26
2012	113	55	41

*Red text indicates where goal of 50 µg/L met

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Buckeye Lake P Loading

- Phosphorus Mass Balance Model
  - Ohio EPA
  - May 2011 to October 2012
- Better understanding of not only magnitude of external vs. internal loading but also **timing**
- For many lakes with excess P loading

It is quantity and timing of phosphorus availability "within" the lake that is important!

Buckeye Lake P Loading

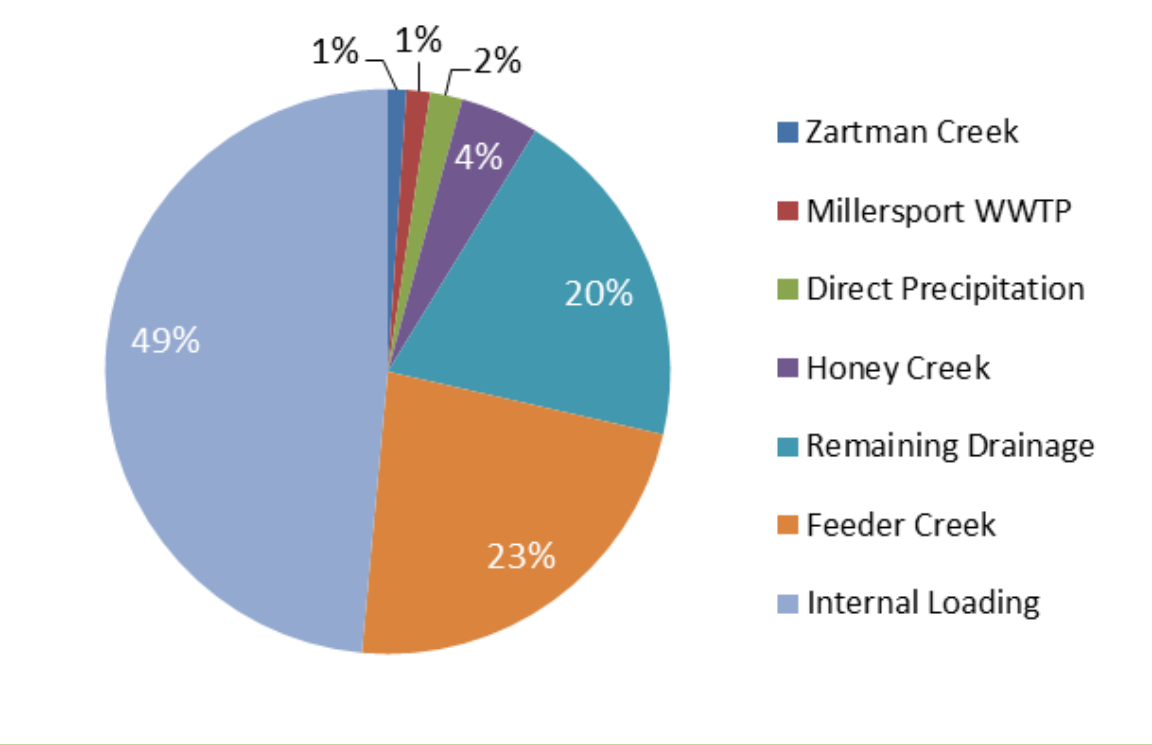
- Sediment P build up eutrophic lakes is related to:
  - usually long water residence times
  - significant internal P loading during summer
- Impacts of internal P loading
  - External sources fuel internal cycling which occurs dominantly in the summer
    - This internal loading drives the cyanobacteria production
    - Can continue for decades
    - Mechanism can be combination of abiotic and biotic reactions

Buckeye Lake P Loading

- Results from Ohio EPA mass balance modeling
  - Internal Loading dominant during summer months (June – September)
    - **90% of Summer TP Load in 2011**
    - **78% of Summer TP Load in 2012**
  - Annually (October 23rd, 2001 to October 20th, 2012)
    - Internal Loading 49% of Total TP Load
    - External Loading 51% of Total TP Load
      - Feeder Creek contributed 23%
      - Minor Tribs/Nearshore Drainage contributed 20%

Buckeye Lake P Loading

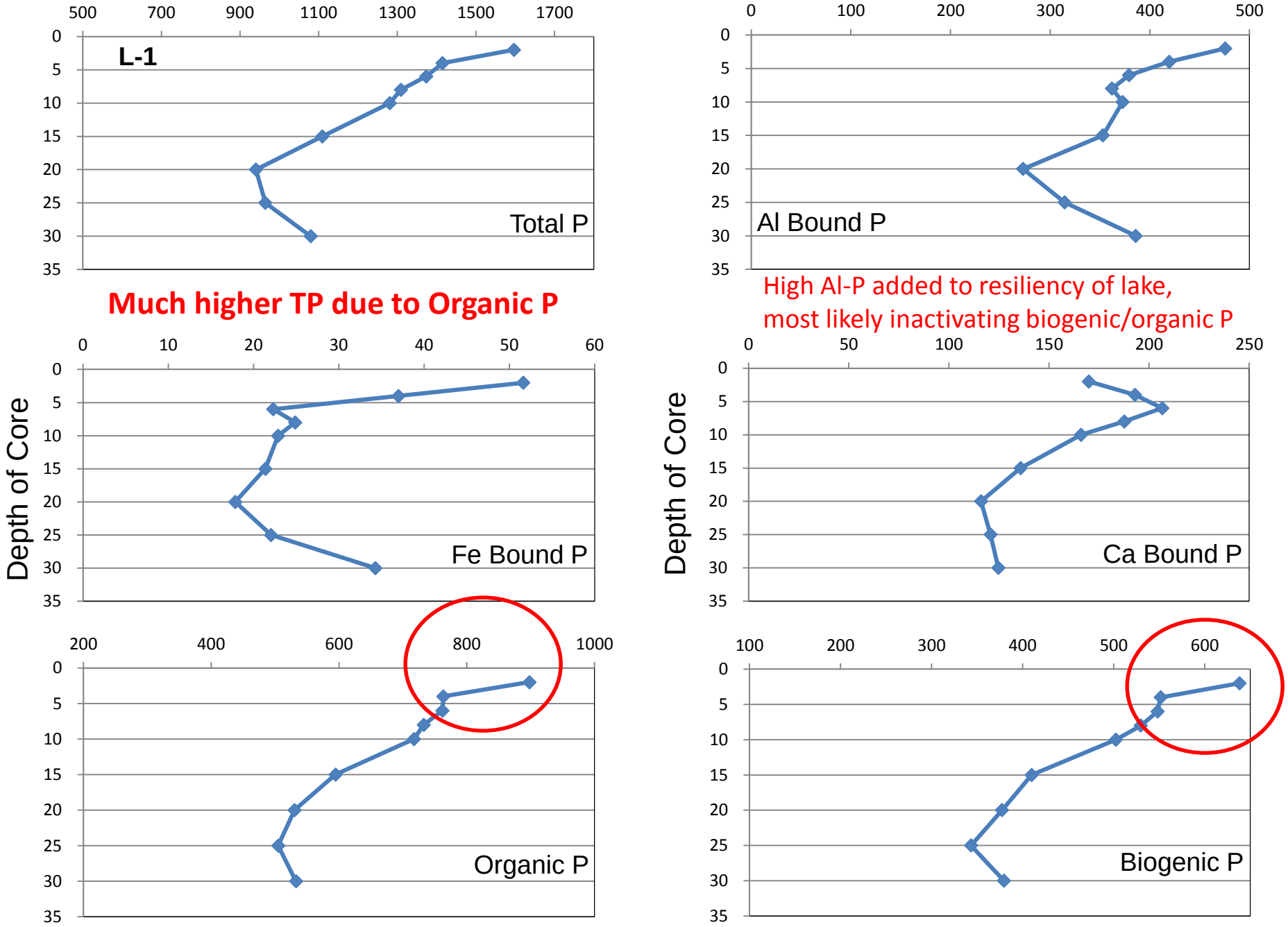
- **1973/1974** Annual TP Loading
  - Feeder 53%
  - Minor Tribs/Nearshore 7%
  - Honey Creek 8%
  - Internal Loading via Nürnberg eq. 36%
- Data Gaps with current mass balance
  - Lack of flow data



2011/2012 Annual TP Load Contributions

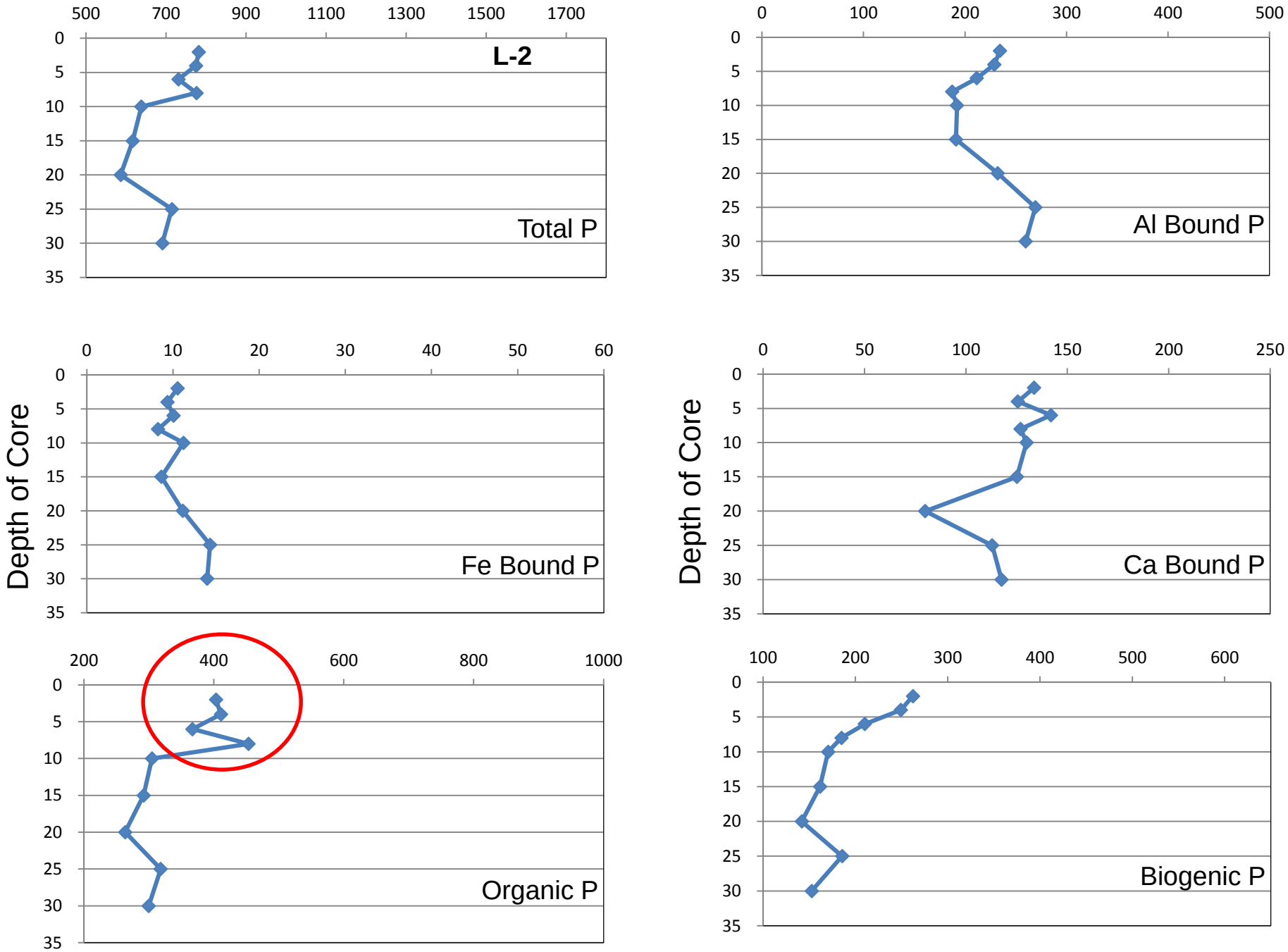
Buckeye Lake Sediment Cores

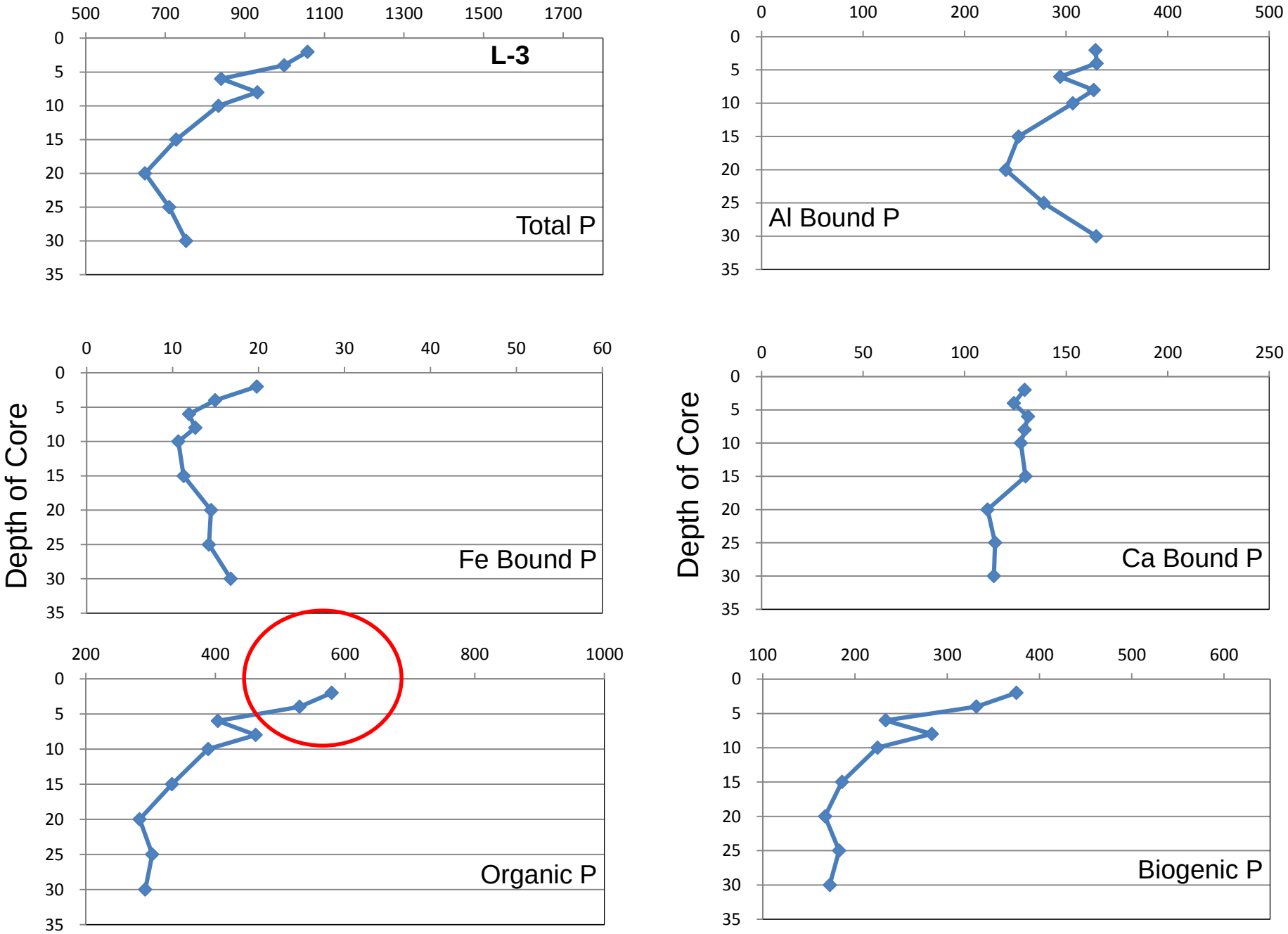
- Collected by Ohio EPA
- 3 locations; L-1, L-2, L-3
- Sediment analyzed for total P, organic P, biogenic P, Iron and Aluminum bound P



Much higher TP due to Organic P

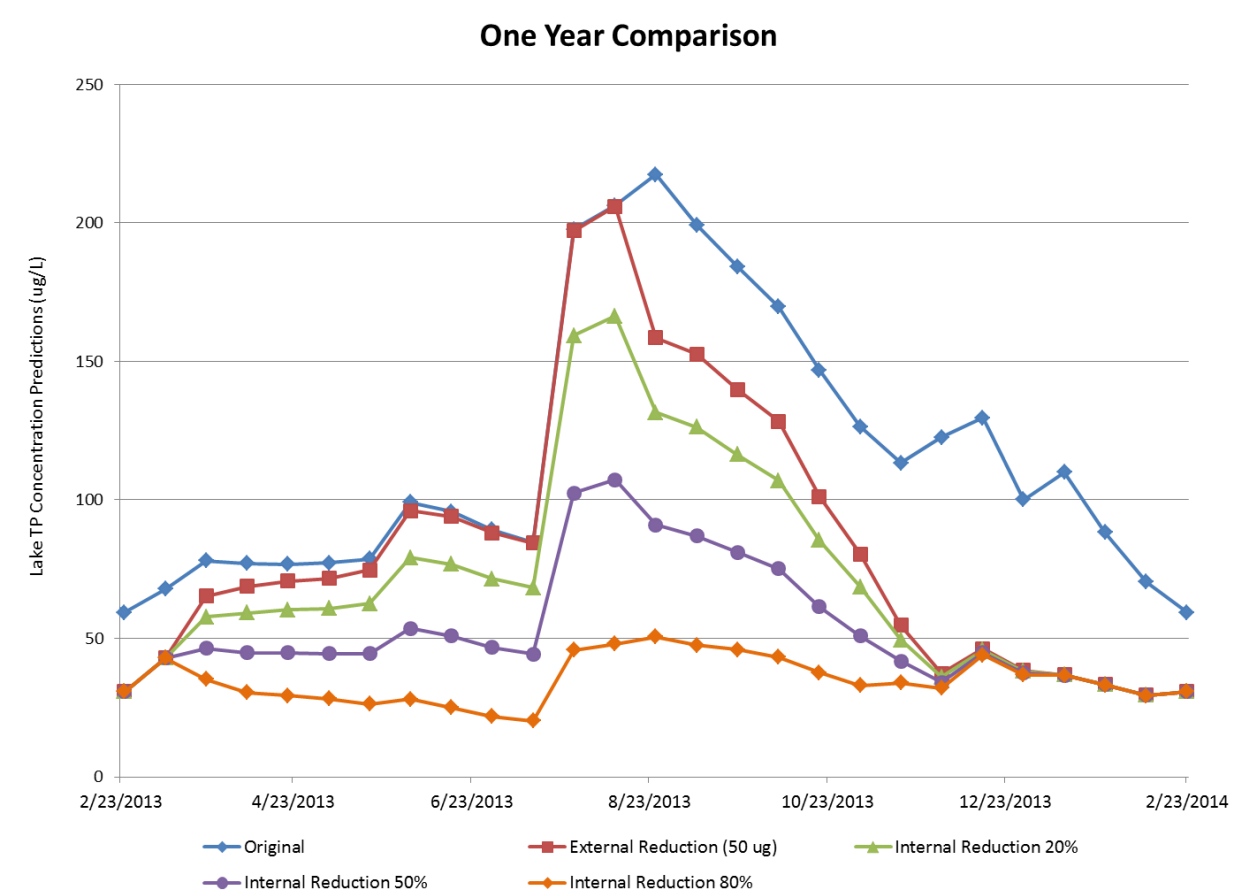
High Al-P added to resiliency of lake, most likely inactivating biogenic/organic P


L-2
Total P
Al Bound P
Fe Bound P
Ca Bound P
Organic P
Biogenic P
Depth of Core
Depth of Core


L-3
Total P
Al Bound P
Fe Bound P
Ca Bound P
Organic P
Biogenic P
Depth of Core
Depth of Core

Nutrient Reduction Strategies

- Ohio EPA used mass balance model to predict lake response to reductions in external & internal loading



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Nutrient Reduction Strategies

- Must reduce both external and internal
  - Currently appears that internal is driving cyanobacteria in Buckeye Lake
  - Following trends external loading goal of 50 µg/L is attainable
- Buckeye Lake Nutrient Reduction Plan by BLT
  - External Load Reductions
    - Control Feeder Creek **YES!**
    - Implement 4R concept
    - Constructed wetlands great idea
    - Control/Detail high storm events

Nutrient Reduction Strategies

- Buckeye Lake Nutrient Reduction Plan by BLT
  - External Load Reductions
    - Possible to add alum interception with constructed wetlands
    - Bank stabilization and Cover Crops: Good BMPs
  - Internal Load Reductions
    - Canada Geese Removal **YES!**
      - And other non-migratory waterfowl (seagulls, ducks) ?
      - Green Lake, Seattle, WA very successful
      - Lake Stevens, WA very successful
      - Lake Ballinger, WA (total loading reduced from 25% to <1%)

Nutrient Reduction Strategies

- Buckeye Lake Nutrient Reduction Plan by BLT
  - Internal Load Reductions
    - Lake Dredging (has to be followed by alum)
      - Focus near mouth of Feeder Creek
      - Very costly and would need to remove a significant amount of sediment given sediment P concentrations
    - Nutrient Inactivation
      - Given Sediment P concentrations this option makes the most sense
      - Opportunity to inactive sediment P for several years if dosed accurately
      - Have to time application prior to onset of significant blooms and focus on middle, deeper portion of the lake

Recommendations

- Better flow data
  - Install level loggers to continuously monitor Feeder Creek and outflow of lake
  - Better understanding of water budget and can refine external loading
- Implement BMPs in watershed
  - Constructed wetlands, cover crops, P-free fertilizer
  - Source identification throughout the watershed
- In lake treatment
  - Canada Geese Removal/other waterfowl
  - Nutrient Inactivation
  - Small scale dredging/with alum
- Continue Public Education