Cayuga Lake Modeling Project
Major Findings and Management Implications

April 2017

Photo: Bill Hecht

Permit requirements and deliverables

REQUIREMENT	DATE (S)	COMPLIANCE
MODELING PROJECT		
• Workplan and QAPP- monitoring	March 2013	☑
• Workplan and QAPP- modeling	Dec. 2014	☑
• Final Report and model hand-off	Dec. 2016	☑
OUTFALL REDESIGN		
• Workplan approval	May 2014	☑
• Progress reports	Jan. 2015, Sept. 2015, May 2016	☑
• Final Report	Nov. 2016	☑
BIOMONITORING		
• Workplan	Feb .2014	☑
• Final report	April 2015	Permit Modification ☑
CAMPUS BMPS		
• Annual Reports	Feb. 2014, 2015, 2016, 2017	☑☑☑☑
SUPPORT DEC WITH OUTREACH		
• Technical meetings	May 2014, Nov. 2014, Oct. 2015	☑☑☑
• Stakeholder meetings	Multiple (30 +)	☑☑☑☑☑☑☑☑☑
• Public meetings (pre-TMDL)	Dec. 2013, July 2014, March 2016	☑☑☑

Cayuga Lake Modeling Project (CLMP) Overview

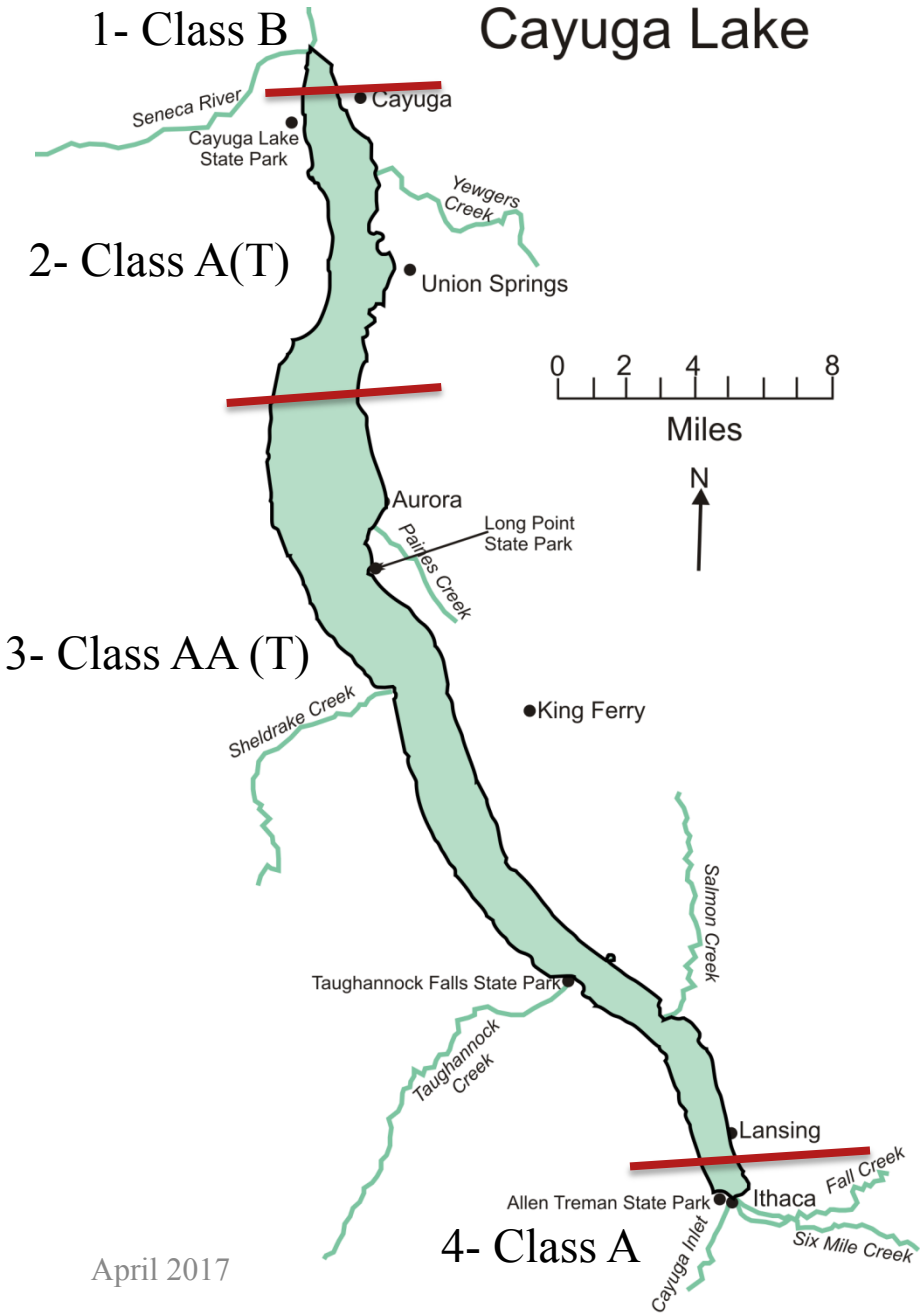
- Investigated phosphorus (P) inputs and phytoplankton growth
- Developed mathematical models of the lake and watershed
- Provided NYSDEC with tools for a science-based approach to lake management

Project Overseen and Directed by NYSDEC

- Workplan and QAPP
- Technical meetings to review progress and model assumptions
  - EPA convened Model Evaluation Group
  - DEC convened Technical Advisory Committee
- Presentations to watershed stakeholder groups
  - Regular updates to the WRC Monitoring Partnership
- Open public meetings
- 20+ technical peer-reviewed publications

Opportunity to Advance Science and Policy

- Engage world-class researchers to improve understanding of Cayuga Lake
- Integrate science into policy decisions
- Apply an ecosystem-based management approach to examine human impacts on natural systems, including water, air, and lands



Key Questions

- What are the point and nonpoint sources of TP? Why is TP elevated in Segment 4?
- How much of measured TP supports phytoplankton growth?
- How does water movement affect distribution of TP and phytoplankton?

How do the answers to these key questions inform our understanding of impacts of Cornell's Lake Source Cooling facility?

3 Integrated Models to Answer the Questions

- Watershed Model (SWAT)

  Quantifies relationship of land use, soils, slopes, and management practices on nutrient & sediment export

- Lake Water Quality Model (CL-W2)

  Projects the impact of point and nonpoint sources on lake nutrients, algae, clarity, and other metrics

- Hydrodynamic Model (Si3D)

  Simulates water movement in the lake (three dimensional)

What did we learn from the models?

Photo: Bill Hecht

What are the point and nonpoint sources of TP? Why is TP elevated in Segment 4?

Site-specific investigations

- Lake, tributary streams, and point sources were monitored (capturing storm events)

Model Integration

- Watershed model identifies P contributing areas and practices
- Lake water quality model tracks P fractions and predicts phytoplankton growth

Findings

- Tributaries contribute > 97% TP to lake
- Elevated TP on the shelf is associated with sediment from runoff during storm events

How much of measured TP supports phytoplankton?

Site-specific Investigations

- P bioavailability testing of streams, point sources, LSC return flow, Cayuga Lake

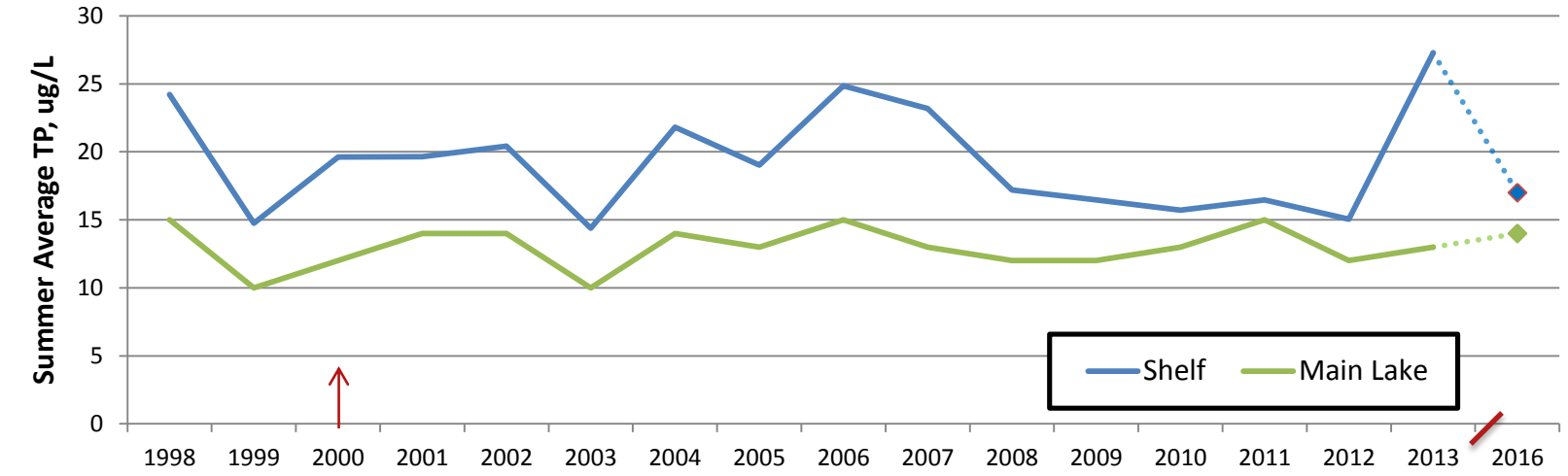
Model Integration

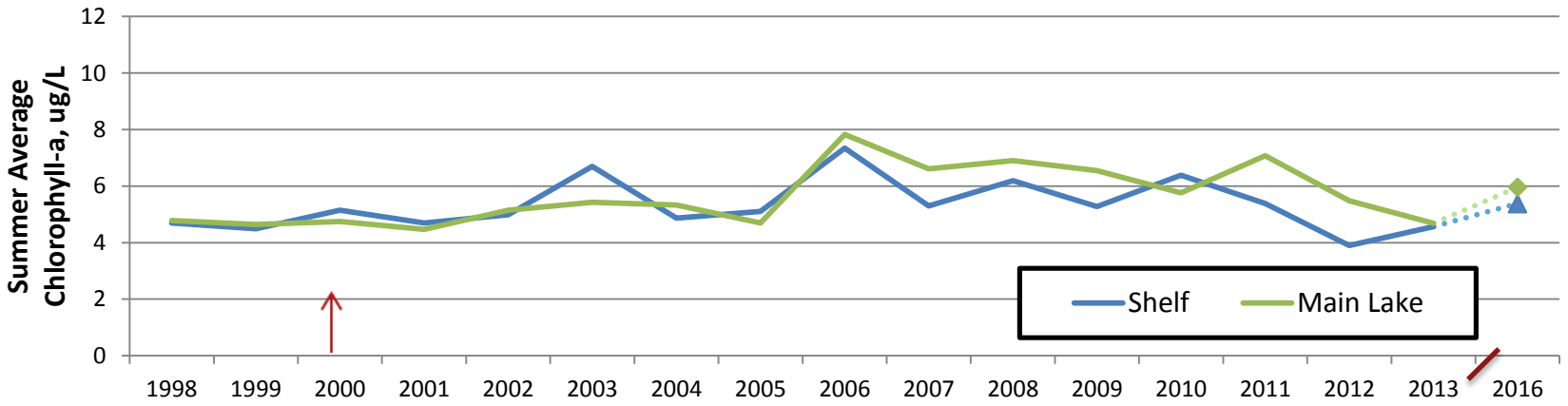
- Lake water quality model explicitly tracks P fractions with respect to their algal growth potential
- Watershed model tracks dissolved and particulate P

Findings

- Occasional elevated TP on shelf after storm events, low bioavailability of P sorbed to these clay-sized particles ~3%
- Tributary streams contribute ~95% of Bioavailable P to the lake

Total P and Chlorophyll-a, 1998- 2013, 2016





How does water movement affect distribution of TP and phytoplankton?

Site-specific Investigations

- Instrumentation to record lake current velocity & temperature
- Collaboration with US Naval Research Observatory for fly-over during intensive grid study (August 2014)

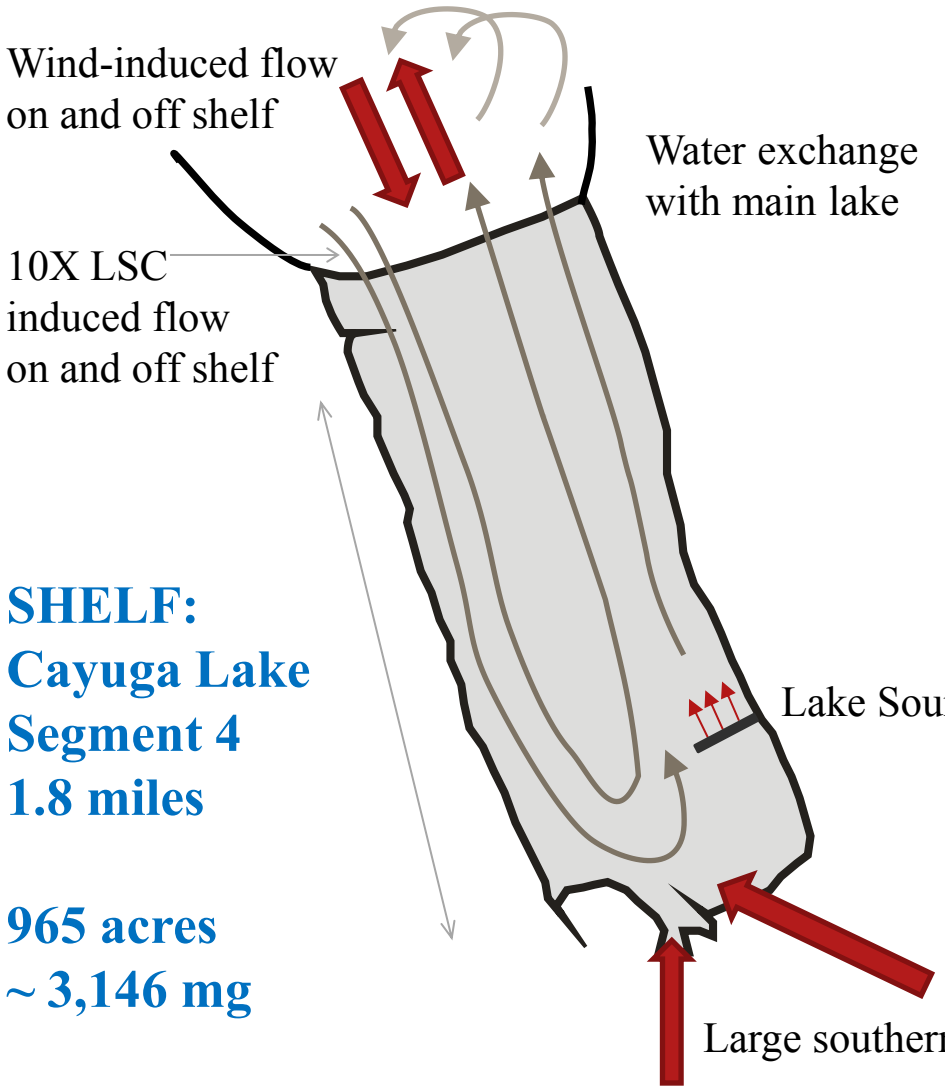
Model Integration

- Si3D model was applied to define LSC mixing zone and shelf dynamics
- Lake water quality model was applied to examine the impact of shelf water residence time on phytoplankton

Findings

- LSC induced flow is 10X larger than LSC discharge
- Outfall relocation increases shelf residence time by 67%, with associated increase in TP, chlorophyll, & turbidity

Mixing processes prevent development of higher phytoplankton biomass on the shelf



"Flushing rate of the shelf from mixing is rapid relative to phytoplankton growth rates"

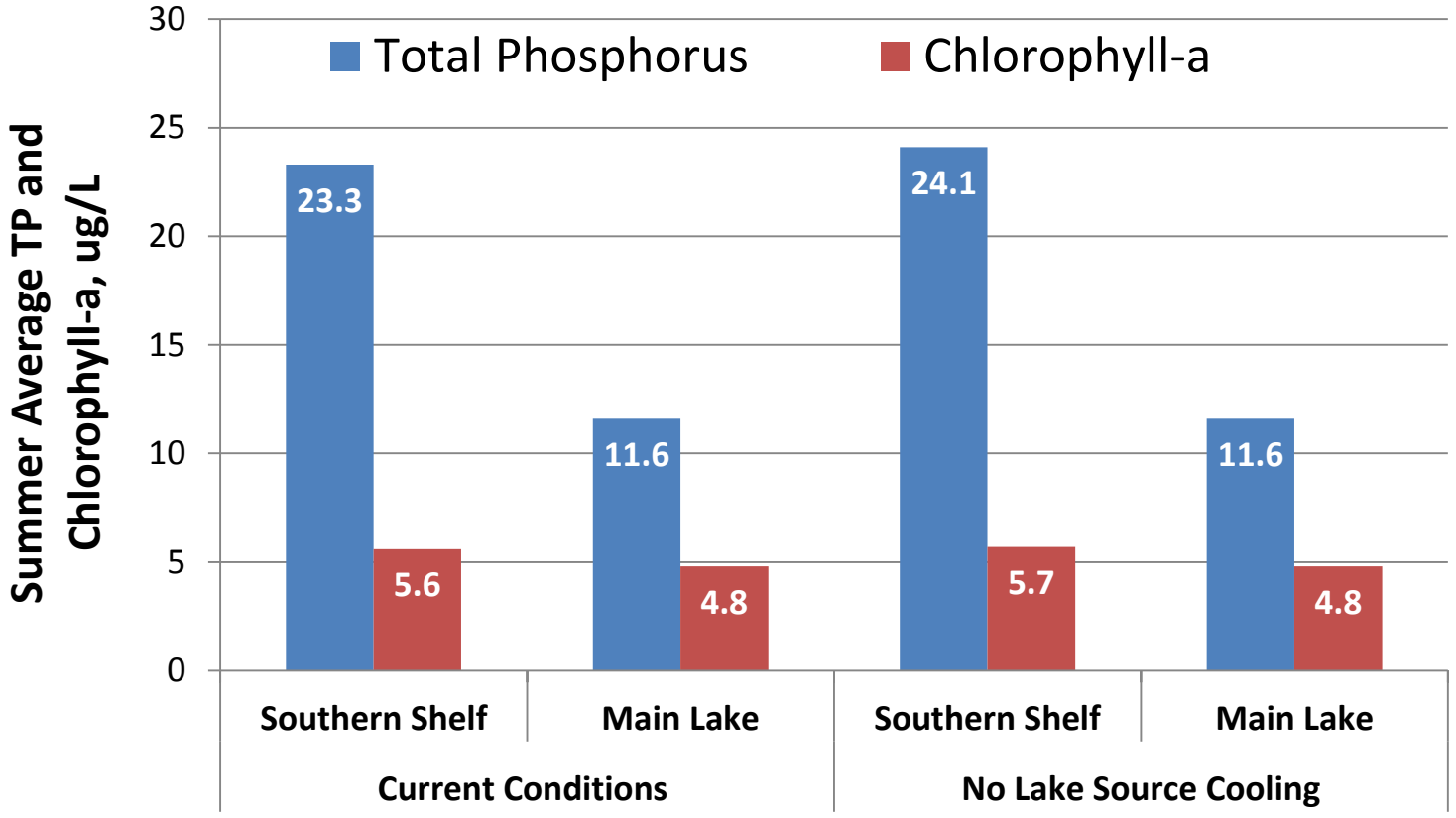
(Effler et al. 2010; Gelda et al. 2015a)

SHELF:
Cayuga Lake
Segment 4
1.8 miles

965 acres
~ 3,146 mg

Implications for the LSC SPDES permit renewal

Projected TP and Chlorophyll-a, With and Without LSC Discharge to Segment 4



Source: UFI, Dec. 2016. Phase 2 Final Report. Table 7-17, page 7-88.

Adverse Impacts of Extending the LSC Outfall

- Environmental
  - No water quality benefit to shelf or main lake; may slightly exacerbate impairment of Segment 4 for TP and silt/sediment
- Energy & Climate
  - Increased energy use from pumping diminishes the benefits of LSC
  - Retreat from University and NYS commitments to climate action
- Fiscal
  - Expensive, costs borne by NYS-supported colleges and the University

Permitting Challenges

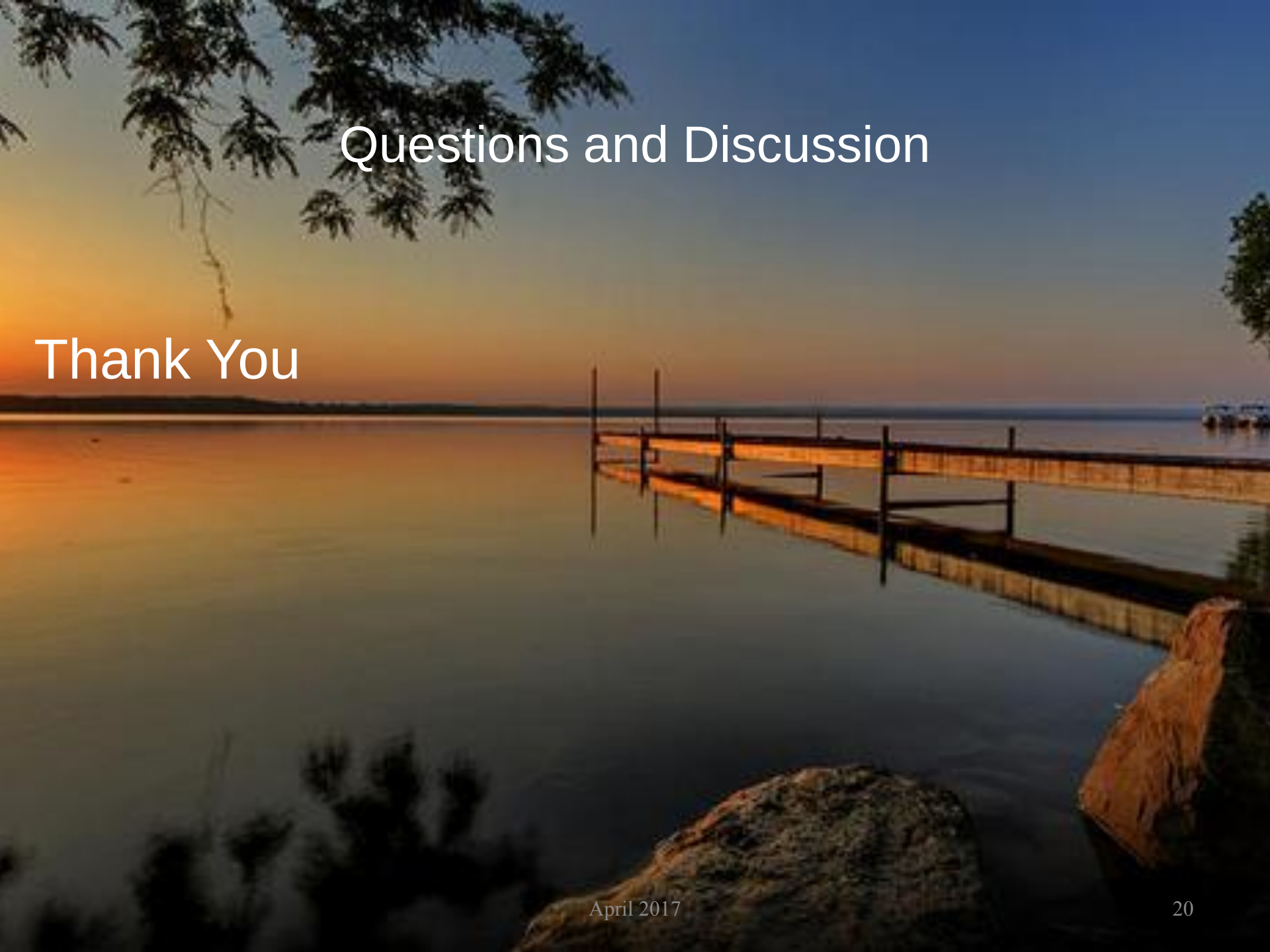
- Currently, need to restrict LSC during high demand periods to meet interim TP limit of 6.4 ppd
- Final TP limit 4.8 ppd would severely impact University operations
- Outfall extension has adverse impacts on air & water quality, plus state and University finances
- Construction of new chillers to replace LSC capacity would be even more costly and environmentally damaging

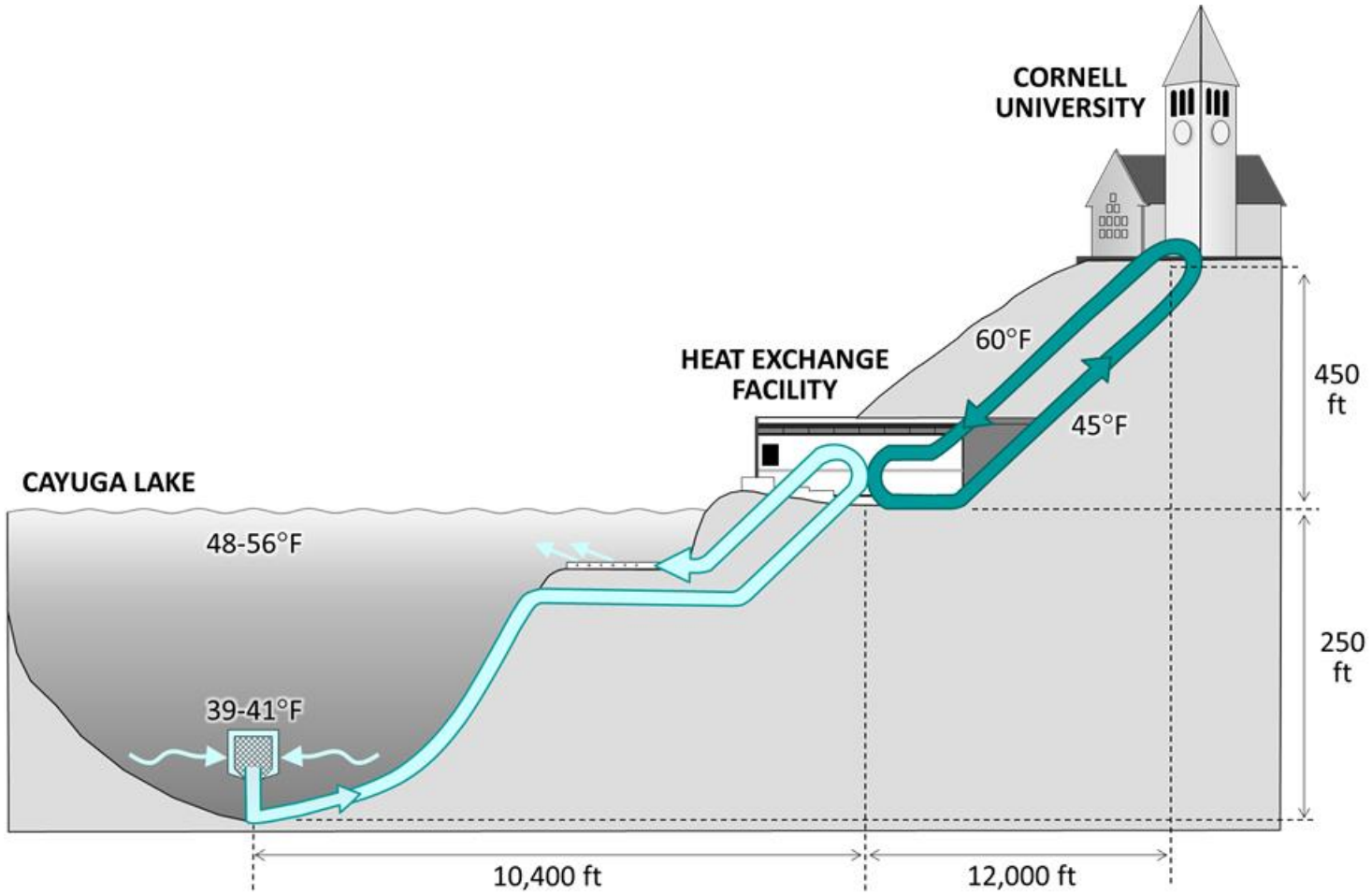
Looking Ahead

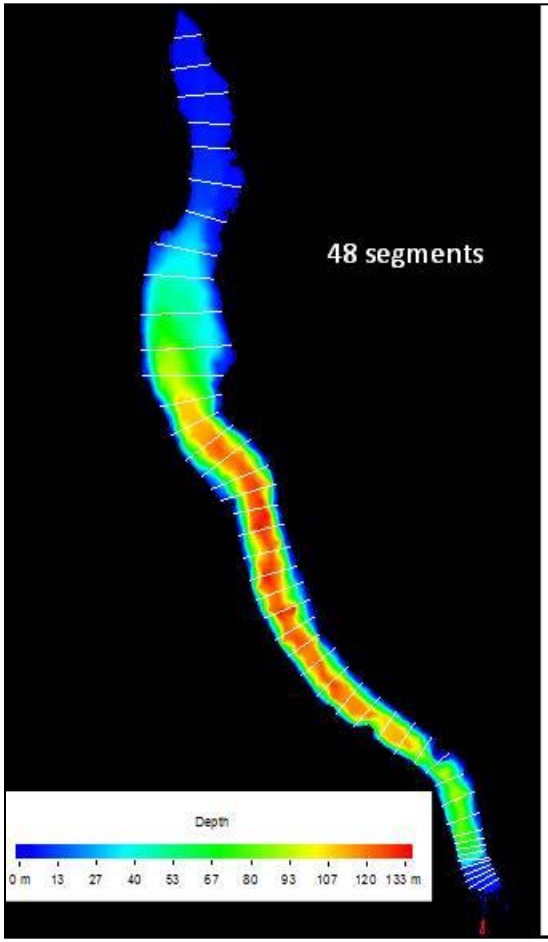
- The CLMP illustrates Ecosystem-based Management approach to water resources
  - State-of-the-art modeling
  - Develop "place-based" information
  - Active stakeholder engagement
  - Recognition that humans are part of the ecosystem; manage for multiple uses; and consider impacts on land, air, and climate as well as water
- Opportunity for NYS to continue leadership on climate actions

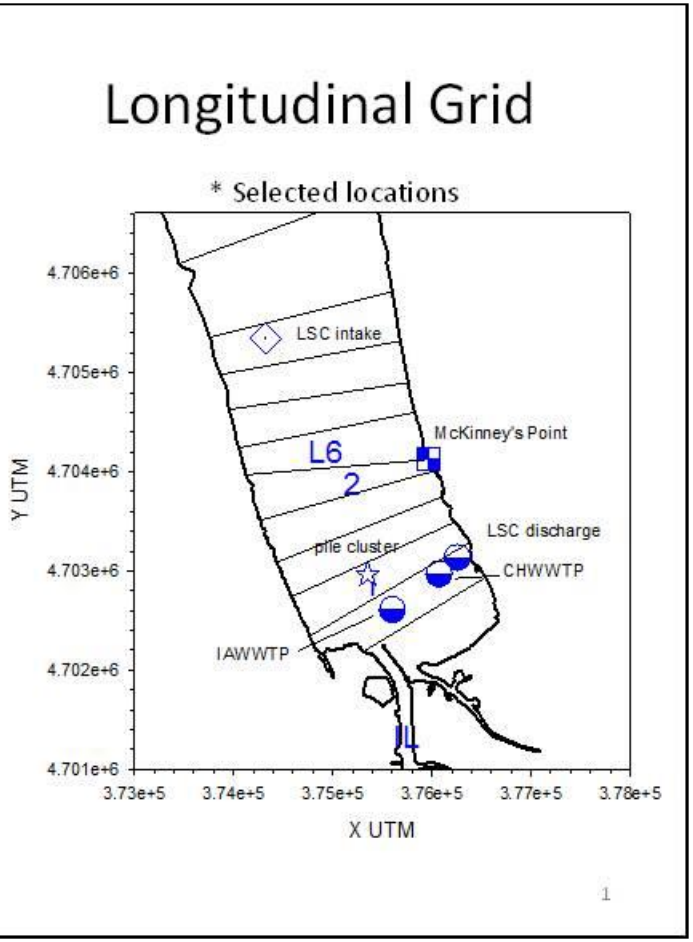
All Reports, Presentations, Technical Papers and Data are on the Cayuga Lake Modeling Project Webpage

www.cayugalakemodelingproject.cornell.edu

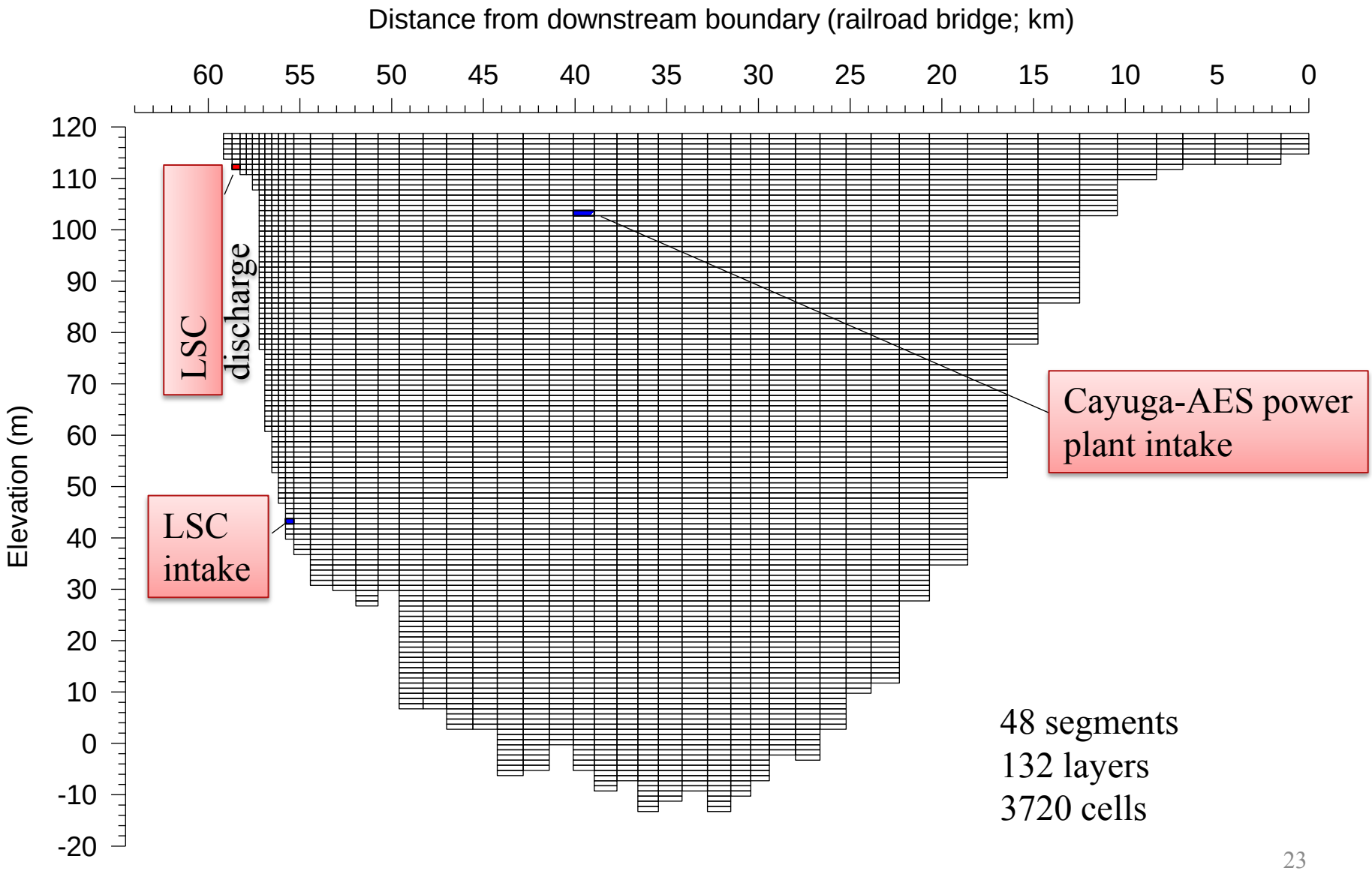

Questions and Discussion
Thank You


CORNELL
UNIVERSITY
HEAT EXCHANGE
FACILITY
60°F
45°F
450
ft
CAYUGA LAKE
48-56°F
39-41°F
250
ft
10,400 ft
12,000 ft


48 segments
Depth
0 m 13 27 40 53 67 80 93 107 120 133 m


Longitudinal Grid
* Selected locations
4.706e+6
4.705e+6
4.704e+6
4.703e+6
4.702e+6
4.701e+6
Y UTM
LSC intake
McKinney's Point
L6
2
LSC discharge
pile cluster
CHWWTP
IAWWTP
IL
3.73e+5
3.74e+5
3.75e+5
3.76e+5
3.77e+5
3.78e+5
X UTM
1

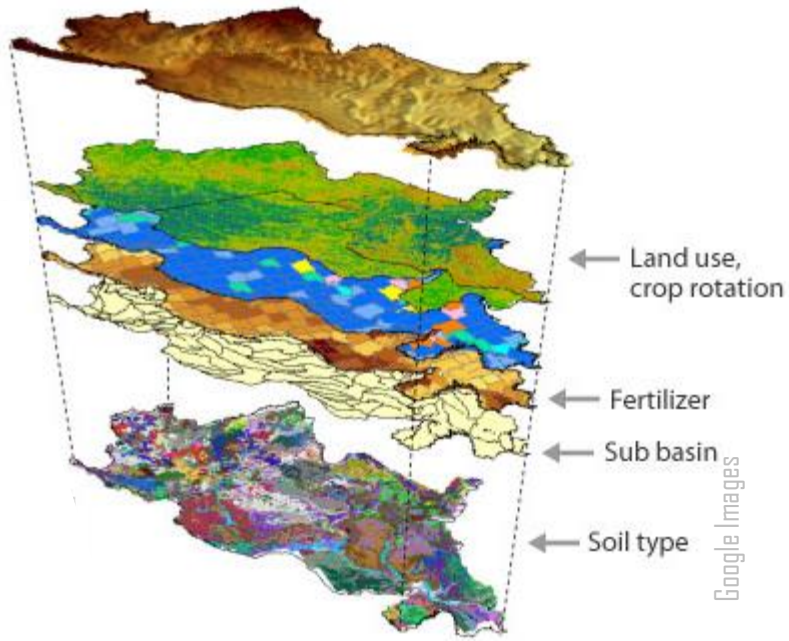
Longitudinal-Vertical Grid - Cayuga Lake



Watershed Model

Soil Water Assessment Tool (SWAT)

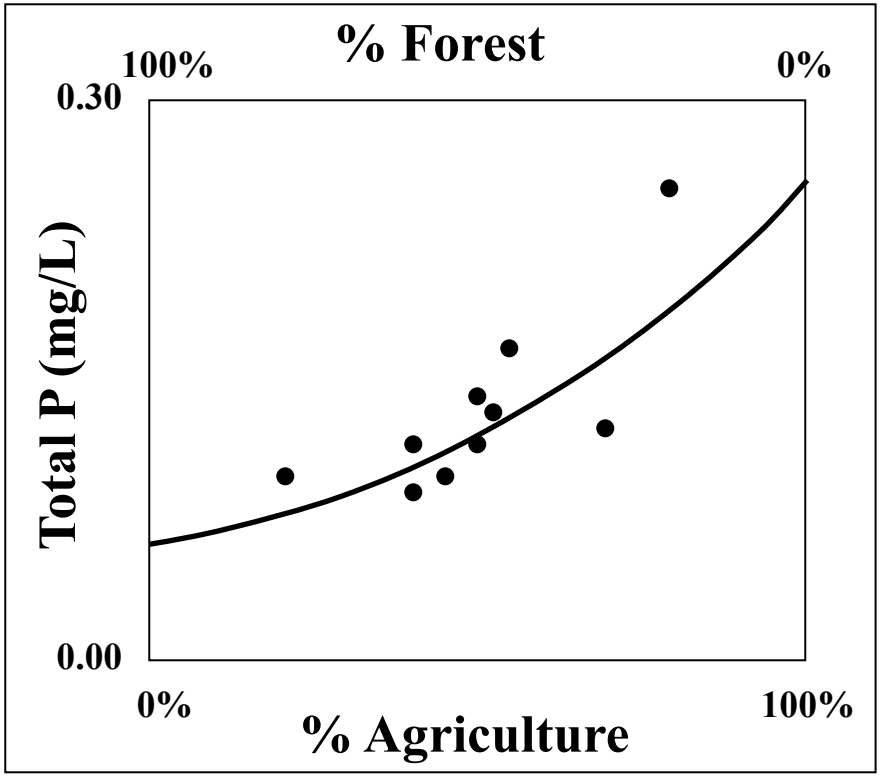
- Developed by USDA-ARS, Texas A&M
- Widely used in TMDL-type projects
- Simulates dissolved & particulate P
- Adaptable to local conditions
- Flexible management input



Land Use/Land Cover Affect Phosphorus Export

- Streams draining agricultural areas have higher phosphorus concentrations

Lyon, Walter, et al. 2006. *JAWRA.* 42(3): 793-804



Objectives of the Watershed Model

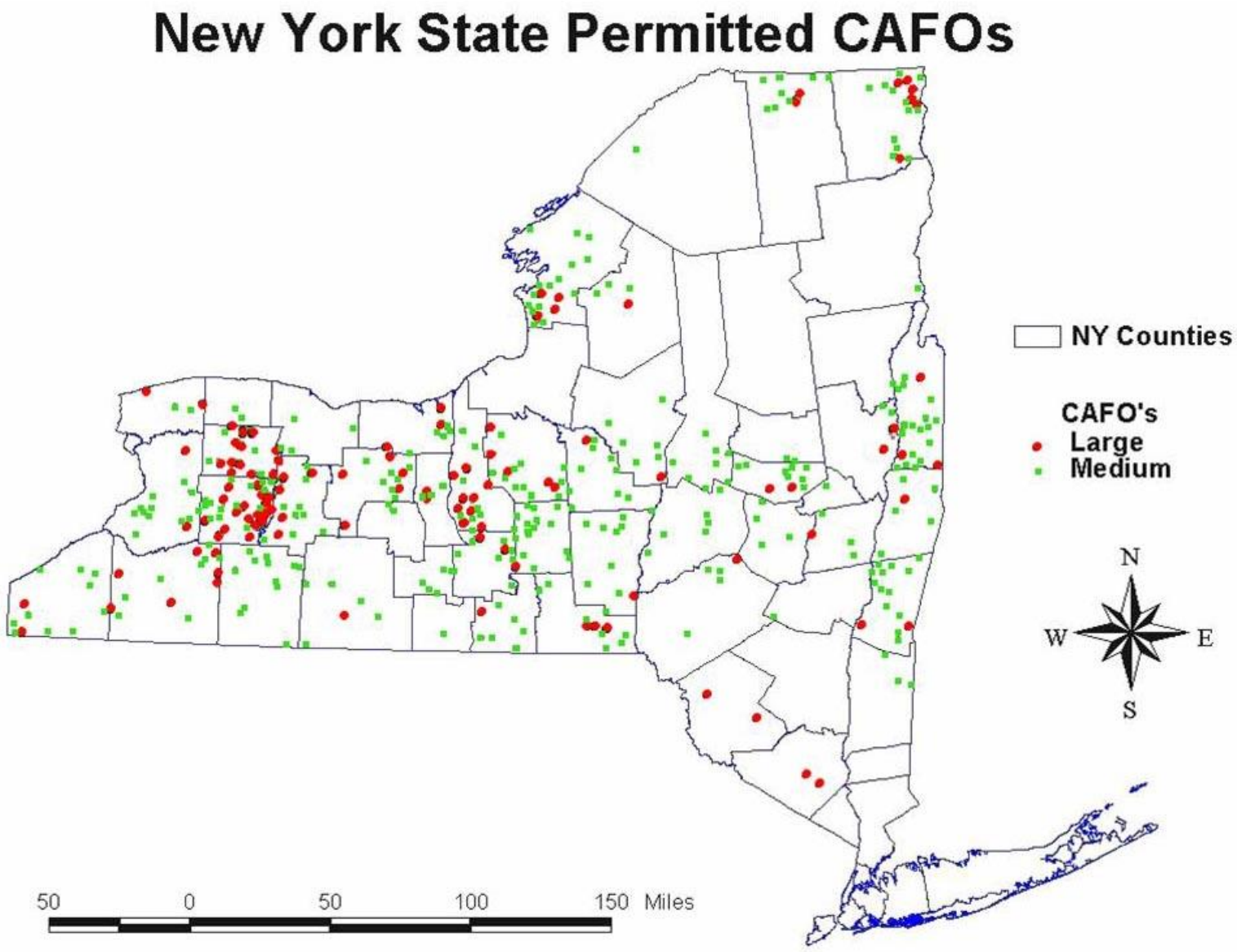
- Estimate phosphorus loads from the watershed
  - Inform lake model inputs
- Provide a tool to test management ("what-if") scenarios

Watershed Modeling Tool

- Current conditions
- Hindcast: *What were sediment and phosphorus loads pre-settlement (1700s)?*
- Management:
  - *Turn off individual sources*
  - *Implement agricultural Best Management Practices*
    - Change the timing of manure applications ~ avoid forecasted rain
    - Change the placement of manure ~ buffers around concentrated flow paths
    - Other recommended practices ~ cover crops, swales
- Forecast: *Potential changes in a future climate*

Agriculture and livestock

- Cayuga watershed land use is about 50% active agriculture (24% row crops; 25% pasture)
- Animal counts are not publicly available, approximately 12 CAFOs, many smaller farms
- Per James Knighton (Cornell BEE doctoral student, applied SWAT model to Cayuga Lake):
  - Extrapolating from detailed work in Fall Creek, estimated 333 million kg (dry) fertilizer applied annually within lake watershed >100,000 cattle; Equivalent to >1.5 million people


New York State Permitted CAFOs
NY Counties
CAFO's
Large
Medium
N
W
E
S
50
0
50
100
150 Miles