Cornell University
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Cayuga Lake Modeling Project Final Summary

Objective

The Cayuga Lake Modeling Project (CLMP), a condition of the 2013 SPDES permit issued to Cornell University for continued operation of the Lake Source Cooling (LSC) facility, has now been completed. Under New York State Department of Environmental Conservation (NYSDEC) oversight, Cornell was required to fund and manage development of mathematical models of the sources, transport, and fate of phosphorus reaching Cayuga Lake. NYSDEC needs models of Cayuga Lake and watershed to complete its planned phosphorus Total Maximum Daily Load (TMDL) allocation for the lake. Now that the models are complete, NYSDEC will apply them to evaluate the effectiveness of various management strategies for protecting Cayuga Lake's water quality and will develop a phosphorus TMDL based on the model projections. NYSDEC plans to release the draft phosphorus TMDL for public comment in 2017.

Development of the Models

The CLMP included three distinct models developed by separate groups under overall oversight of NYSDEC and their expert reviewers. Each model was supported by extensive monitoring and analytical efforts.

- The **Lake Phosphorus-Eutrophication Model** was developed by the Upstate Freshwater Institute (UFI), which also conducted lake and stream monitoring for the project.
- The **Watershed Model** was created by Professor Todd Walter of Cornell University's Department of Biological and Environmental Engineering, who also serves as Director of the Water Resources Institute, in association with his graduate students.
- The **Three-Dimensional Hydrodynamic Model** was developed by Professor Todd Cowen and Dr. Allie King of Cornell's DeFrees Hydraulic Laboratory to evaluate how the LSC facility affects water circulation.

Scientists and engineers from many other divisions of Cornell were involved in project management, technical reviews, and communications support.

Collaboration and Communication

Throughout the four-year project, NYSDEC fostered close coordination among the Cornell project team, water resources professionals from local, county, and state agencies, the US Environmental Protection Agency (USEPA), and other interested stakeholders. NYSDEC convened a Technical Advisory Committee (TAC) to ensure that local knowledge was incorporated in developing the models. USEPA appointed a Model Evaluation Group (MEG) of national and international experts in water quality modeling to review the underlying model assumptions. Information sharing throughout the project illustrates the joint NYSDEC/Cornell commitment to collaboration:

- NYSDEC convened four day-long technical meetings with members of the Cornell project team, the TAC, and the MEG to review progress and discuss preliminary findings.
- NYSDEC led four open public meetings to describe CLMP objectives and progress.
- Members of the Cornell project team provided updates at over 30 meetings of local stakeholder groups.
- The Cayuga Lake Monitoring Partnership (part of the Tompkins County Water Resources Council) met 20 times to review progress with the NYSDEC project manager and members of the Cornell project team.

- The Cornell project team and NYSDEC technical staff held workshops to facilitate model transfer.
- Both NYSDEC and Cornell developed and maintained linked project web sites to post data, interim reports, meeting agendas and presentations, final reports, and technical publications.

In addition to these efforts to keep state and local stakeholders informed, Cornell project team members prepared scientific papers for publication in peer-reviewed journals to keep the larger scientific community apprised of major findings and implications for lake management. To date, more than 20 papers describing various aspects of the CLMP have been published. The project both benefited from and supported the work of faculty, postdoctoral research associates, and graduate students in various University colleges and programs, in alignment with Cornell's commitment to envisioning campus facilities as a Living Laboratory. The Cornell project team is confident that the significant investment in the CLMP will benefit other lakes and watersheds in the Finger Lakes and beyond.

Major Findings

The CLMP has generated new and important information on several topics relevant to the long-term management of Cayuga Lake and other waterbodies.

- **The significance of phosphorus bioavailability**. Phosphorus fractions (dissolved, particulate, etc.) differ in their ability to support algal growth. To control phytoplankton growth, it is essential to identify and limit the supply of biologically available phosphorus. In Cayuga Lake, about 95% of bioavailable phosphorus originates from watershed nonpoint sources. The implication is that long-term management of the lake will depend on measures such as setbacks and buffers that reduce the risk of phosphorus-enriched runoff reaching streams.
- **Total phosphorus concentration is a flawed indicator of trophic state in nearshore areas affected by inflows from large tributary streams**. The CLMP investigations documented that the elevated total phosphorus concentrations in nearshore areas following storms are associated with sediment particles (mud) flowing in from erodible tributary basins. The phosphorus bound to these mud particles has a very low bioavailability and thus does not stimulate algal growth.
- **Cayuga Lake circulation is complex and dynamic.** Significant mixing occurs among the regulatory-defined segments of the lake, so isolating the southern shelf as the focus of a TMDL for phosphorus was not a viable approach to a water quality protection plan. In light of this information, NYSDEC has decided to prepare a whole lake TMDL.
- **Food web complexities.** The proliferation of invasive dreissenid species (zebra and quagga mussels) in Cayuga Lake has affected the cycling of nutrients and energy. Phosphorus concentrations in the deeper water have increased over time, with no related increase in lakewide algal abundance as measured by chlorophyll-*a*. This finding reinforces the need to take an ecosystem-based management approach.
- **The Lake Source Cooling facility has no adverse impact on Cayuga Lake water quality, lakewide or on the southern shelf.** The LSC return flow reduces water residence time of the southern shelf which has two positive water quality impacts. First, since residence time is shorter than phytoplankton growth rate, algal blooms do not develop despite the point and nonpoint source phosphorus loads to this segment. Second, the enhanced flushing of the shelf helps replace the sediment-laden stream water entering during storm events with clear water from deep in the lake. The phosphorus-eutrophication model projects that total phosphorus, chlorophyll-*a*, and sediment in the waters of the southern shelf would be higher without the circulation of water through the LSC facility. Relocating the LSC outfall into deeper water would have a similar effect; sediment and total phosphorus levels on the shelf would not decline (and may increase slightly), with no improvement to the overall lake. Thus, imposing flow limits on the facility or extending the outfall are counter indicated as a means to water quality improvement.