Evaluation of the Ecological Benefits of Dredging Lake Sediment Using a 3-Dimensional Hydrodynamic and Water Quality Model

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Background/Objectives
Fountain Lake is an impounded reservoir located within a predominantly agricultural watershed in Albert Lea, Minnesota. Decades of nutrient rich sediment inputs have impaired the water quality of Fountain Lake. Phosphorus is the primary pollutant affecting lake water quality; more than 65 percent of the phosphorus loading to the lake is from sediments that have deposited in the lake. The elevated phosphorus concentrations in sediments and external phosphorus loading to the lake has led to excess phosphorus in the water column, severe algal blooms, increased turbidity, and low dissolved oxygen when algal populations crash. Dredging to remove sediments with elevated phosphorus concentrations from the lake was identified as one of the key best management practices for decreasing phosphorus concentrations in the water column, improving lake water quality, enhancing recreation and improving fish habitat.

Approach/Activities
A 3-dimensional hydrodynamic and ecological model (Delft 3D) was developed to predict water quality and habitat benefits of dredging and guide the sediment dredging planning process (extent, depth, lake area). The Delft 3D model is able to model the physical, chemical and biological effects that targeted dredging could have on the water quality of Fountain Lake. Dredge prisms were defined to maximize the removal of phosphorus species that contribute most to internal lake phosphorus loading; these included iron bound phosphorus (often called mobile phosphorus) and phosphorus incorporated into organic matter (often called organically-bound phosphorus). In addition to simulating the effects of various phosphorus removal scenarios, the model was used to evaluate the potential effects that dredging could have on important physical lake processes such as temperature stratification, lake mixing frequency, water movement, and light penetration. These physical conditions influence habitat suitability, light availability for algal growth, dissolved oxygen concentrations, and several other chemical conditions. All of these effects were considered during development of the dredging plan for Fountain Lake.

Results/Lessons Learned.
The lake management tool (Delft 3D model) developed for Fountain Lake was used to evaluate the effects that various dredging and external phosphorus loading conditions could have on Fountain Lake water quality. Using the conceptual site model developed for the site and physical, chemical and biological data collected for Fountain Lake, we were able to develop a better understanding of the interrelated physical, chemical, and biological processes that affect the water quality of Fountain Lake. This tool was critical for understanding the interrelated lake processes and communicating the potential effects that dredging and changes in external nutrient loading could have to project stakeholders and permitting agencies.

Keith Pilgrim
Keith Pilgrim has nearly two decades of experience on projects involving aquatic toxicology and toxicity identification evaluations, water-quality modeling, nutrient management, stormwater treatment, and NPDES permitting. His work includes designing surface-water quality monitoring programs for large mining developments, designing water and chemical balances for industrial facilities, developing one- and three-dimensional water-quality models, and conducting thermal balance studies for power plants.