

Summary

Comparing Chinese and United States lake management and protection

In 2007, the United States and China entered into an agreement to create and sustain a partnership focused on energy and the environment. Water quality was one area of emphasis, with lakes being a specific focus. A Sister Lakes Program was formed to provide a basis for this collaboration.

In 2011, during the conference on policy of water environment, Lake Pepin in the U.S. (State of Minnesota) and Liangzi Lake in China (Hubei Province) were selected for this partnership. This required a collaborative effort between the U.S. Environmental Protection Agency (U.S.EPA) and Ministry of Environmental Protection

(MEP) of China and the State of Minnesota (Minnesota Pollution Control Agency, MPCA) and Hubei Province (Hubei Department of Environmental Protection, DEP).

Representatives from Minnesota and Hubei Province visited Liangzi Lake (October 2012) and Lake Pepin (January 2013). A formal memorandum of cooperation and a workplan were developed in 2013. The memorandum described specific areas of cooperation, including scientific research on restoration and protection of lakes with a focus on Liangzi Lake and Lake Pepin. Topics to be included were water quality assessment, biological monitoring, pollutant source identification, and pollutant trading. Of particular interest to the Chinese partners, was development of Total Maximum Daily Loads (TMDLs) and the planning and implementation associated with that.

This report represents a starting point for this effort. Comparisons between the two lakes demonstrate similarities and differences in approaches for monitoring, assessment of condition, and watershed management. A summary of some of the observations follows.



The red star is the approximate latitude of Wuhan, Hubei Province, which is similar to New Orleans, Louisiana.

Relative latitude and climate comparison

Lake Pepin is located in the upper Midwest portion of the U.S. (Figure 1) and experiences distinct seasons. Even though it is a run-of-the river lake, it freezes over in the winter months. Precipitation near Lake Pepin averages 0.4 m in the summer and 0.8 m annually. Annual average temperature maximum is 12.8 C and average minimum is 0.9 C.

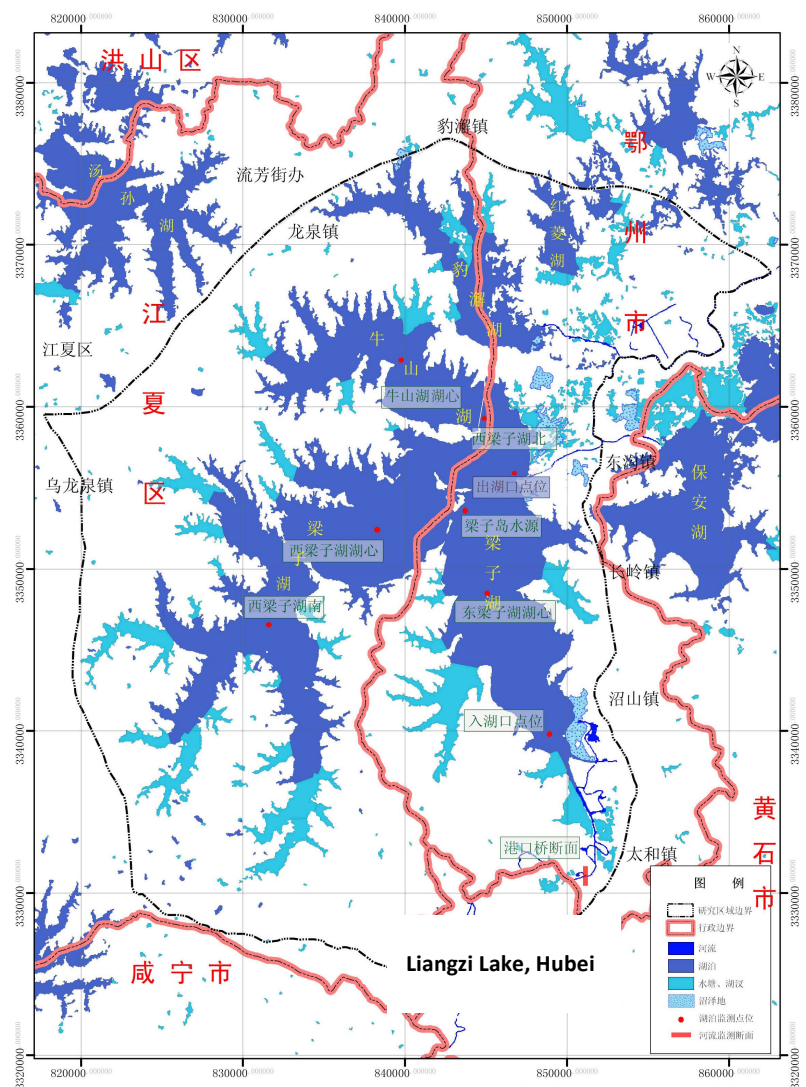
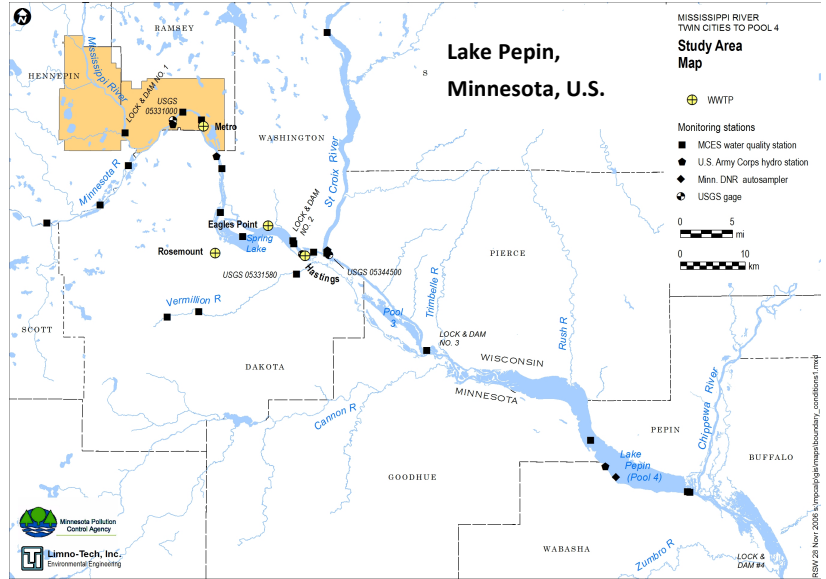
Liangzi Lake, in contrast, is located at a more southerly latitude than Lake Pepin (similar to New Orleans, LA) and has much higher precipitation of 0.6 m in summer and 1.27 m annually. Temperatures are much higher as well with annual average maximum of 29.8 C average minimum of 4.6 C.

Physical description, watershed characteristics, and climate

Lake Pepin is a natural lake on the Mississippi River. It has a surface area of about 103 square kilometers and a mean depth of 5.4 meters. Its very large watershed is about 122,000 square km — more than half of Minnesota’s total land area plus a portion of Wisconsin. The watershed: lake surface ratio (1,232:1) results in a short water retention time of about 16 days on average.

Since over 60% of Minnesota drains through Lake Pepin, the relative composition of land use reflects Minnesota as a whole. Forest and wetland land uses are dominant in the northern portion of the Upper Mississippi River Basin. Urbanized (developed) land use is a small percentage, but a majority of this is in the Twin Cities Metropolitan Area, which includes Minneapolis and St. Paul and is immediately upstream from Lake Pepin. More than 4 million people live within the watershed boundaries. With the Twin Cities metro area so close, the lake is popular for recreation.

Liangzi Lake includes numerous bays or fingers and has a surface area of about 304



square kilometers and a mean depth of 3 meters. The Liangzi Lake system includes Liangzi Lake, Ya'er Lake, Sanshan Lake, and Bao'an. The total watershed area of the system is 3,265 square km; the watershed area of Liangzi Lake is 2,085 square km, much smaller than Lake Pepin's watershed. There are more than 30 rivers flowing into Liangzi Lake, the largest being the Gaoqiao River. Liangzi Lake's watershed: lake surface ratio is 11:1, as compared to Lake Pepin's ratio of 1,232:1, and Liangzi Lake's water retention time is longer at about 193 days on average.

More than 730,000 people live within the watershed boundaries. Liangzi Lake is one of the emergency sources of drinking water for Wuhan City. Most of the land use in its watershed is agricultural and aqua-farming. Agriculture consists of paddies, orchards, vegetable fields, and gardens and of this, the majority is paddy field.

Water quality comparison

Lake Pepin has an extensive water quality monitoring record, with data collection extending back several decades. Because of its elongate shape, water quality is measured at selected sites along the length of the lake. This strategy provides a basis for describing the changes in water quality from the headwaters, at the inflow of the Mississippi River, to its outlet 33 km downstream. Long-term monitoring at established sites allows for describing changes in water quality over time or changes related to differing flow-years. In general, phosphorus, algae (measured as chlorophyll-a), and suspended sediment concentrations are high in the shallower upper segment of Lake Pepin. In the lower segment of Lake Pepin, suspended sediment, phosphorus, and algae concentrations are much lower because of settling processes in this deeper portion of the lake. This results in higher water transparency and increased rooted plant growth in the shallower portions of the lower segment. Long-term phosphorus concentrations have decreased over time because of upstream reductions in point and nonpoint sources of phosphorus.



Sailboats on Lake Pepin

Liangzi Lake has a shorter water quality monitoring record. Because it has numerous bays or fingers, there is a need to sample a variety of locations across Liangzi Lake to describe spatial patterns and characterize its overall quality. The approach taken in the 2013-2015 monitoring was to sample along the length of the main bays of the lake. This provides a good basis for evaluating any gradients in water quality as water moves through the lake. Water quality varies among different locations in the lake and varies seasonally as well. In general, phosphorus and nitrogen concentrations are relatively low in Liangzi, as compared to Lake Pepin and other lakes in China. However, Hubei DEP noted that submerged vegetation is sparser than desired in many locations, and this may be caused by low transparency.



Sunset view of Liangzi Lake

Water quality standards and classification systems

The U.S. and China have different ways of classifying lakes and judging their condition. In the U.S., water quality standards (WQS), developed in response to the Federal Clean Water Act, are the primary means for judging condition. WQS are developed by the USEPA or the states and are used in conjunction with a classification system to ensure that waters meet their designated uses. Minnesota developed lake nutrient WQS in 2008 to protect aquatic recreational uses as specified for Class 2 waters. Lake Pepin is a Class 2B water. When its phosphorus, chlorophyll-a, and transparency measurements were compared to the WQS, it was found to exceed standards and placed on Minnesota's CWA 303(d) "Impaired Waters" list. This meant that a Total Maximum Daily Load (TMDL) was required for Lake Pepin. A TMDL defines the reductions needed (in this case, phosphorus) so that the lake will meet water quality standards. This work is underway for Lake Pepin.

China's MEP assigns waters to various classes and then uses the "class" as a basis for describing water quality. Each class has standard values for basic water quality variables, with Class I having the lowest concentrations and Class V having the highest concentrations. The five classes consider how the water is used and bears some similarity to Minnesota's use-class system. The description of Class III in China's system is similar to Minnesota's Class 2B, which is Lake Pepin's classification. Liangzi Lake is comprised of numerous bays (lakes), which vary in quality both spatially and seasonally, and different classes are used to describe the water quality of the lake.

Water pollution concerns and strategies

Both lakes have a wide range of land uses and point sources that contribute to the pollution of the lakes. Various forms of agricultural and developed land uses are common in both watersheds. Excess nutrients and sediments are a concern in both lakes. Because Lake Pepin has a very large watershed, there are numerous point sources (e.g., wastewater treatment facilities) and nonpoint sources (agricultural and urban) throughout the watershed. Point source discharges are regulated through Clean Water Act discharge permits. Since phosphorus is the primary pollutant associated with lake eutrophication and Lake Pepin's TMDL, point sources throughout the watershed have been highly regulated. There has been significant reduction in upstream point source phosphorus loads since 2000, and this has resulted in lower phosphorus concentrations in Lake Pepin. However, more reductions in nonpoint source phosphorus loads need to be made.

Excess sediment is a significant problem in the upper segment of Lake Pepin, and most of this comes from upstream agricultural and streambank sources. While suspended sediment reductions have been observed, more work is needed.

While Liangzi Lake receives excess amounts of phosphorus, nitrogen, and sediment loading, the relative amounts are less than that of Lake Pepin, because its watershed is smaller and is currently less developed. However, agricultural and livestock operations are a large contributor of excess phosphorus and nitrogen to the lake. Based on conversations during the mutual visits, China faces some of the same problems as the U.S. when trying to address nonpoint pollutants from agricultural sources. As the watershed of Liangzi Lake becomes more urbanized, this will increase the significance of urban stormwater runoff and potentially wastewater treatment as well.

Summary

This report represents a starting point for this effort, providing useful comparisons between Lake Pepin in Minnesota and Liangzi Lake in Hubei Province, China. Each lake has distinct management challenges, and the report shows the similarities and differences in approaches for monitoring, assessment of condition, and watershed management. This information will provide a basis for future cooperation, helping to protect and improve both of these valuable resources.