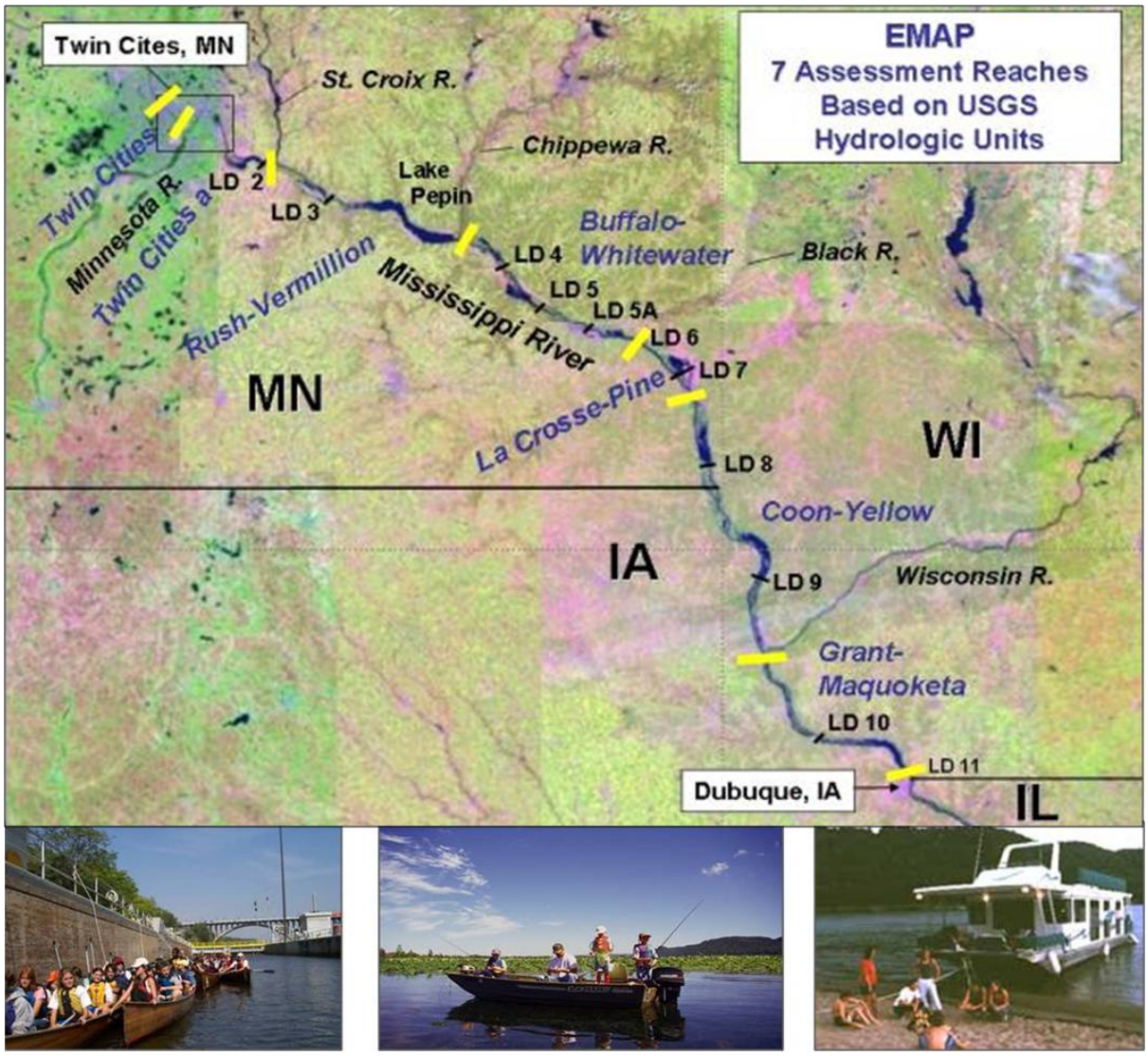
Mississippi River Pools 1 through 8: Developing River, Pool, and Lake Pepin Eutrophication Criteria

(Update of July 2010 Report)



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Acronyms, Abbreviations, and Commonly Used Terms in this Report

ALUS	Aquatic Life Use Standard
benthic algae	algae that live attached to substrates in stream; also referred to as periphyton
BOD_5	5-day biochemical oxygen demand
CDF	cumulative distribution function (also referred to as frequency distribution)
CHF	North Central Hardwood Forests ecoregion
cfs	Cubic feet per second
Chl-a	chlorophyll-a, corrected for pheophytin
Chl-T	total chlorophyll-a, which includes chlorophyll-a +pheophytin
CI	confidence interval
DA	Driftless Area ecoregion
diel	A chronological day (24 hours)
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
HUC	hydrologic unit code
IBI	Index of biotic Integrity
ISS	Inorganic suspended solids
LAP	Lake Agassiz Plain, another name for RRV ecoregion
LTRMP	Long Term Resource Monitoring Program
m	meters
max	maximum
MCES	Metropolitan Council Environmental Services
MDH	Minnesota Department of Health
med	median
metric	used to refer to a biological measurement or class of organisms
mg/L, mgL^{-1}	milligrams per liter; equivalent to parts per million
mg/m^2	milligram per meter squared; an areal-based measure commonly used to express periphyton biomass or chlorophyll-a
min	Minimum
Minn.	Minnesota River
Miss.	Mississippi river
MPCA	Minnesota Pollution Control Agency
NGP	Northern Glaciated Plains ecoregion
NLF	Northern Lakes and Forests ecoregion
NMW	Northern Minnesota Wetlands ecoregion
NPS	Nonpoint Source
NTU	Nephelometric turbidity units
P	Phosphorus
Quantile	Division of ordered data into equally sized portions. For example, quartiles are the division of data into 4 equal portions and percentiles are the division of data into 100 equally sized portions

Introduction

Minnesota promulgated lake eutrophication standards in 2008 and is currently developing river eutrophication criteria as a part of EPA nation-wide effort to develop nutrient criteria for lakes, rivers, wetlands, and estuaries. Data from representative medium to large rivers has shown strong, reproducible relationships among TP, sestonic Chl-a, and biochemical oxygen demand (BOD_5) (Heiskary and Markus 2001). Advancements since this original work have established linkages among these variables, diurnal DO flux, and fish and invertebrate metrics (Heiskary 2008 and Heiskary et al. 2010). Relationships among these variables combined with statistical analysis of thresholds have resulted in draft ranges of criteria (Table 1a). The criteria have been developed in a regional context that is somewhat similar to aggregated EPA Level III ecoregions. The draft criteria and technical documentation have undergone initial review by EPA Region V and EPA Headquarters. The MPCA is updating that work and reviewing the draft ranges based on comments received.

In a related effort, the MPCA, in conjunction with numerous collaborators, including MDNR, WDNR, MCES, and others, has been developing site specific criteria for Lake Pepin as a part of the Lake Pepin TMDL. This effort has made use of modeling conducted by LTI and a variety of research in support of the Lake Pepin TMDL. As this work progressed, it became evident that site specific criteria for Lake Pepin needed to be linked with criteria for the Mississippi River pools and the criteria for the major rivers that drive the water quality of Lake Pepin and the pools: Upper Mississippi, Minnesota, and St. Croix Rivers. This current analysis, combined with previous analysis for Lake Pepin (Heiskary and Wasley 2010), is intended to provide a basis for developing eutrophication criteria for the Upper Mississippi River pools and Lake Pepin in Minnesota.

within Lake Pepin allow particulate TP to be effectively trapped in the system; however, internal recycling allows for conversion of particulate P to DOP (Heiskary and Walker 1988) that may promote downstream algal and SAV growth.

The Mississippi River navigations pools offer abundant opportunity for hunting, wildlife observation, and a host of water-based activities, including swimming, fishing, and pleasure boating (MDNR 2004 and St. Mary's University 2007). Much of the river in Minnesota below Lake Pepin is part of the Upper Mississippi River National Wildlife and Refuge system, which allows for a wide variety of uses. A recreational boating study conducted by the MDNR, WDNR, USFWS, and USACE in 2003 provides some insights into recreational uses of the pools. MDNR (2004) notes that the reach from Pool 4 to Pool 9 contains nearly 130,000 acres of boating water and a substantial number of facilities (public and private) that help support water-based recreation on the pools. It has been estimated that the quantity of usage exceeds one-million-boat hours during the summer period. This is a very high level of usage and boating intensity (boats per acre of water) on the Mississippi River is at a level similar to Minnesota's non-metropolitan lake regions. One of the findings of the study was that boaters spend about equal amounts of time in the main channel area, side channel, and backwater areas. As an activity group, anglers spend most of their time in side channels and backwaters, while pleasure boaters spend most of their time in the main channel (MDNR 2004). In summary, Pools 1 to 8 on the Mississippi are highly used by a variety of people for a wide variety of purposes, and many of these uses are enhanced by good water quality (Figure 4).

Extensive fishery studies have been conducted in these pools and in general indicate a very robust and healthy fishery. Dietermann (2009) in an assessment of Pools 3-9 notes, "Fish populations between Hastings, Minnesota and the Iowa border were generally healthy. Generally, good recruitment and growth of most game-fish species has occurred since 1994." In reference to Pool 5, he notes, "Aquatic habitat conditions were generally good to excellent throughout the pool. Dense and diverse beds of SAV were widespread and prevalent in most aquatic areas surveyed. This was the first year since monitoring began in 1993 that SAV was observed growing in portions of the lower pool in depths greater than nine feet (personal observation)." Similar notes on good habitat and extensive beds of submerged aquatic vegetation are noted for Pools 6 and 7 as well. In summary he notes "Aquatic habitat conditions were again very poor in the Lower Vermilion River; improving into the "good" range in Pool 3; and generally excellent from the lower portion of Pool 4 including the foot of Lake Pepin through Pools 5, 5A, 6, 7, 8, and upper Pool 9. Depth of observed SAV, in some pools, increased to levels (10 feet) not seen during the 16 years of this monitoring program. Even Pool 3 aquatic habitat conditions improved to the best condition measured during this program." Fish populations were described as generally healthy and stable.

Meerbeek (2008) reporting on conditions in Pool 4 and Lake Pepin shares similar observations "They have also found submerged aquatic vegetation to be scarce in and above Lake Pepin and along the main and secondary channels; however, since 2004, LTRMP biologists have documented increasing trends of percent frequency of occurrence of submersed, floating-leaf, and emergent vegetation in upper and lower Pool 4. The isolated and contiguous backwaters below Lake Pepin are generally rich in submergent species."

There are fewer survey reports for Pool 1 and the Mississippi River at Anoka. A 2009 standard lake survey report for Pool 1 (MDNR 2009) notes "Compared to the previous population assessment conducted in 1995, smallmouth bass abundance has increased significantly." The report goes on to note, "Looking at the number of gamefish sampled compared to the total number of fish sampled, the proportion of gamefish has increased. In 2009, six gamefish species comprised 68.9 percent of the total number of fish sampled. In 1995, smallmouth bass and walleye represented 11.6 percent of all fish sampled. Northern pike, channel catfish, flathead catfish and white bass were not sampled in 1995, while they were seen in 2009." Survey information and anecdotal information for the reach from the Coon Rapids Dam to the Crow River mouth suggests a good smallmouth bass fishery based on increased numbers of sampled fish, angler usage and monitoring of tournaments. As with the other surveys reviewed and noted in this report, MDNR fishery managers caution that valid statistical comparisons cannot be made among surveys over time in a given pool or among pools for a variety of reasons associated with sampling technique, location etc. (e.g. Dodds 2010, personal communication). Overall, a consistent theme emerges that suggests improvements in the fishery over time and high usage by anglers.

In view of the differences among free-flowing rivers and these managed navigation pools and wide array of usage (aquatic recreation) the pools receive, it was decided that site specific eutrophication criteria should be developed for Pools 1-8 (St. Anthony Falls in Minneapolis to the Iowa border on the southern edge of the state). The assessment-reaches roughly correspond to river segments previously established by the five states of the Upper Mississippi River Basin Association and are segmented based on major tributary inflows (Figure 1). The reaches defined in this work: Upper Mississippi River (Pool 1), Minnesota River to St. Croix (Pool 2), St. Croix to Lake Pepin (Pools 3 and Upper Pool 4 - Lake Pepin), Chippewa River to Black River (Lower Pool 4, 5, 6, Black River to Minnesota state line (Pools 7 and 8) provide a reasonable framework for developing the criteria and conducting assessments. Appendix C provides aerial photos of Pools 1-3.

Habitats within the pools are quite variable. Using Pool 8 as an example (Figure 3) it is evident that depth may vary substantially among the various habitats, whereby channel areas are somewhat deeper while backwaters may be quite shallow. For Pool 8, 75 percent of the pool is 2 m or less in depth. Given the wide array of aquatic areas in the pools (Figure 3) and that each area provides one or more forms (opportunities) for aquatic recreation, it was difficult to decide on the specific focus for the criteria and which data should be used to develop the criteria and ultimately assess the pools. Upon review of various data sets and monitoring site locations from MCES, LTRMP, WDNR, and the MPCA, it was decided that the criteria should focus on the water quality as measured in the main river channel and near-dam area of each pool. Data collected near the dam (e.g. MCES site at UM-815.6 immediately above Lock and Dam 2) or the various LTRMP or WDNR sites located at or immediately below the dam serve to integrate the upstream water quality of the pool (e.g. Lock and Dam 8 in Figure 5b). As such, these sites provide a reasonable basis for evaluating water quality relationships, characterizing pool water quality, establishing the criteria, and eventually assessing compliance with the criteria. The focus for nutrient criteria development for the pools is on aquatic recreation with a strong emphasis on minimizing the frequency and magnitude of algal blooms in the pools. Figures 5a and b provides an example of what constitutes a severe nuisance bloom.