

# Sources of Phosphorus, Chlorophyll, and Sediment to the Mississippi River Upstream of Lake Pepin: 1976-1996

By

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## ABSTRACT

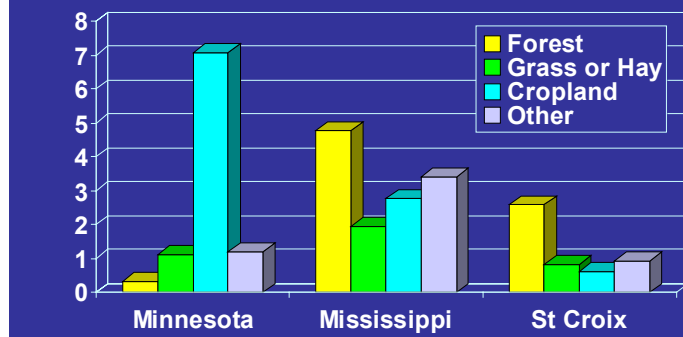
The Metropolitan Council Environmental Services (MCES) established a River Monitoring Program in 1976 to monitor the water quality of the Mississippi, Minnesota and St. Croix Rivers in the Twin Cities Metropolitan Area. For the period 1976 to 1996, total phosphorus (TP), soluble reactive phosphorus (SRP), total suspended solids (TSS), suspended volatile solids (SVS) and chlorophyll *a* were examined at three key locations: the Mississippi River at Lock and Dam No. 1 and near the mouths of the Minnesota and St. Croix Rivers. The FLUX program (Walker, 1990) was used to estimate annual and monthly TSS, TP and chlorophyll *a* loads. Information on phosphorus loads from point sources was compiled from the MCES, Minnesota Pollution Control Agency, and Wisconsin Department of Natural Resources.

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Land use varies greatly among the three river basins. The Minnesota River Basin (16,988 mi<sup>2</sup>) is dominated by row crops with extensive tile drainage, the Mississippi River Basin (19,884 mi<sup>2</sup>) is a mix of forest, row crops, and pasture/grass, and the St. Croix River Basin (7,722 mi<sup>2</sup>) is dominated by forest and pasture/grass.

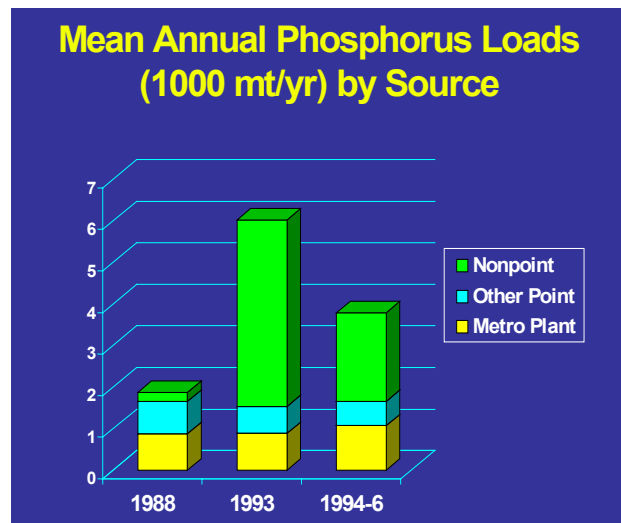
During the period of 1976-1996, the Mississippi River had the highest mean annual flow (9,250 cfs), followed by the Minnesota River (6,270 cfs) and the St. Croix River (5,530 cfs). However, mean annual runoff was highest in the St. Croix River Basin (9.67 in), followed by the Mississippi River Basin (6.31 in) and the Minnesota River Basin (5.04 in). The percentage of mean annual runoff was very high in the St. Croix River Basin (31.0%), followed by the Mississippi River Basin (22.4%) and the Minnesota River Basin (16.8%). In all three rivers, mean monthly flows were highest in April, with flows declining steadily through the summer. However, summer flows in the Minnesota River do not decline as rapidly as summer flows in the other two rivers, possibly due to the displacement of perennial vegetation with annual row crops and/or the geomorphology of the watershed.

**Land Use by River Basin, 1997  
(million acres)**

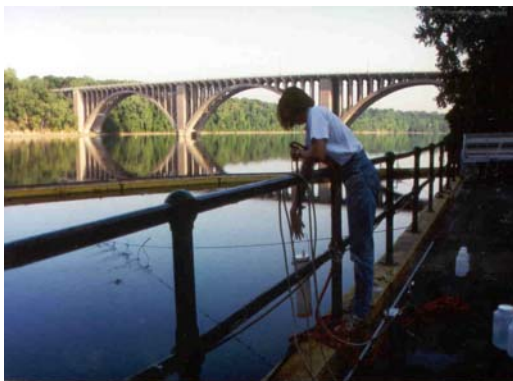


Rankings of the three rivers for annual average TP concentrations and loads: 1) Minnesota River (0.32 mg/L and 1,565 MT/yr); 2) Mississippi River (0.10 mg/L and 889 MT/yr); and 3) St. Croix River (0.05 mg/L and 262 MT/yr). In the same order, annual average phosphorus yields for the three rivers were 0.33, 0.16, and 0.14 lb/ac/yr. Mean monthly TSS and TP loads from the St. Croix River were highest in April, mimicking the pattern of an undisturbed, natural system. In the Minnesota and Mississippi Rivers, mean monthly TSS and TP loads peaked in June as well as April, possibly another outcome of the displacement of perennial vegetation with annual row crops. In the Minnesota River Basin, monthly precipitation and rainfall erosivity indices are relatively constant from June through August; however, as the row-crop canopy closes and evapotranspiration rates increase in late summer, flows and loads decrease dramatically.

During the near-normal flow years of 1994-1996, nonpoint sources contributed 51% of the TP load and point sources contributed 49% of the TP load upstream of Lock and Dam No. 3. The two largest TP sources were the Minnesota River Basin (35%) and Metropolitan Wastewater Treatment Plant (28%). Wastewater treatment plants discharge phosphorus at a relatively constant rate throughout the year, while phosphorus loads from nonpoint sources vary directly with precipitation and runoff. As a consequence, point sources dominate TP loads during low river flows, and nonpoint sources dominate during high river flows.



The mean annual chlorophyll *a* concentration was greatest in the Minnesota River at Fort Snelling and Jordan, 53 and 60 µg/L, respectively, followed by the Mississippi, 29 µg/L, and the St. Croix, 9 µg/L. The loading of chlorophyll *a* over the 21-year monitoring period was greatest in the Mississippi River (212 MT/yr), followed by the Minnesota River (174 MT/yr) and the St. Croix River (29 MT/yr). The Mississippi River is the largest source of algal-associated biomass in the river system during most years. This indicates that nutrient abatement programs should not be limited to the Minnesota River, but other systems as well.



Flow-weighted mean annual TSS concentrations and loads were very high in the Minnesota River (93 mg/L and 623 thousand MT/yr), lower in the Mississippi River (19 mg/L and 155 thousand MT/yr), and very low in the St. Croix River (5 mg/L and 24 thousand MT/yr). Annual average TSS yields from the Minnesota, Mississippi, and St. Croix River Basins were 134, 28, and 13 lb/ac/yr, respectively. Annual average inorganic content of the TSS in the Minnesota, Mississippi and St. Croix Rivers was 89, 69, and 50 percent, respectively.