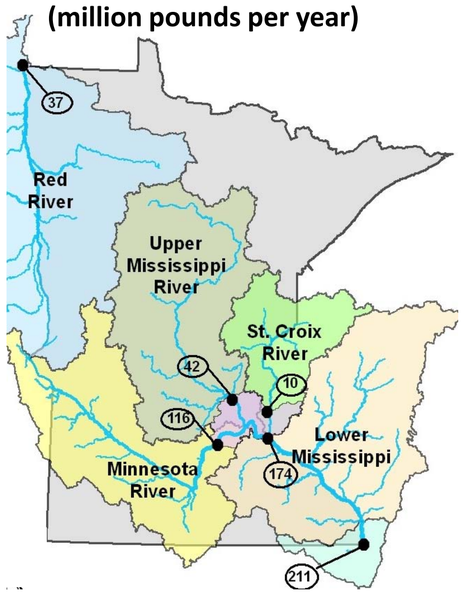
Minnesota Pollution Control Agency

Nitrogen Science

Existing Conditions & Sources to Waters

Monitoring Nitrogen Conditions

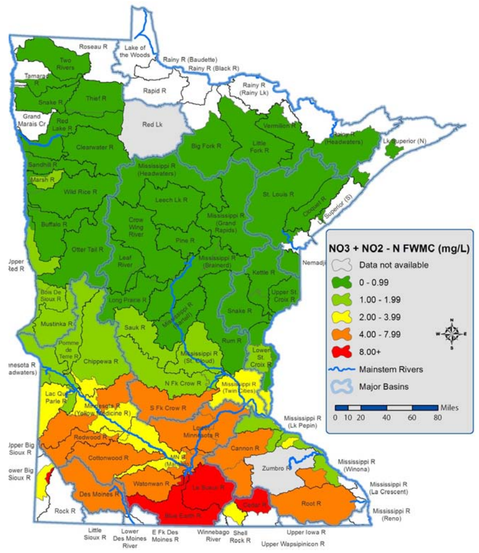
Major River Average TN Load (million pounds per year)



Above - Monitoring-based average annual total nitrogen (TN) loads at key points along mainstem rivers (1991-2010).

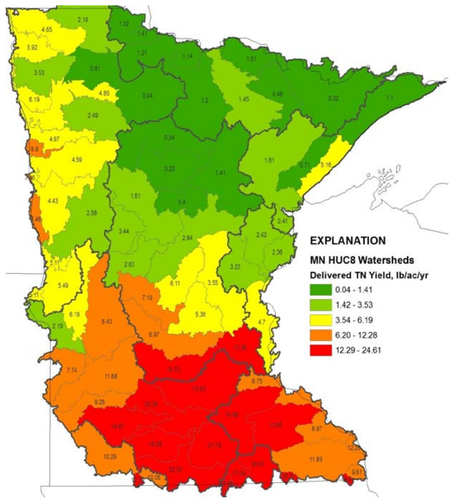
- The highest TN loading tributary to the Mississippi River is the Minnesota River, which contributes an average of 116 million lbs of nitrogen per year.
- River TN increases by an average of 6 million lbs per year through the Twin Cities Metro area.

Watershed outlet nitrate FWMC



Flow weighted mean conc.

Average annual flow-weighted mean concentrations for nitrite+nitrate-N near watershed outlets. One to three year averages derived from available information collected in 2007-09.

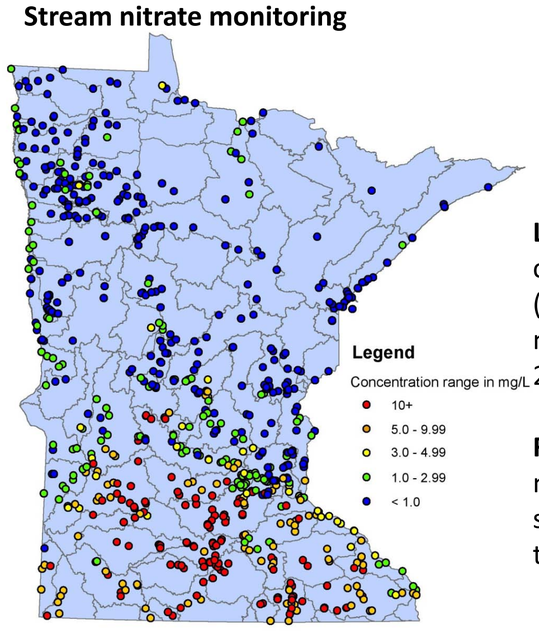


Nitrogen yield - SPARROW model

Simulated annual total nitrogen yields (left). Yields represent the total load delivered to the watershed outlet divided by the catchment area.

Results of the SPARROW model indicate that the top 15 loading HUC8 watersheds contribute 74% of the total load leaving the state in the Mississippi River.

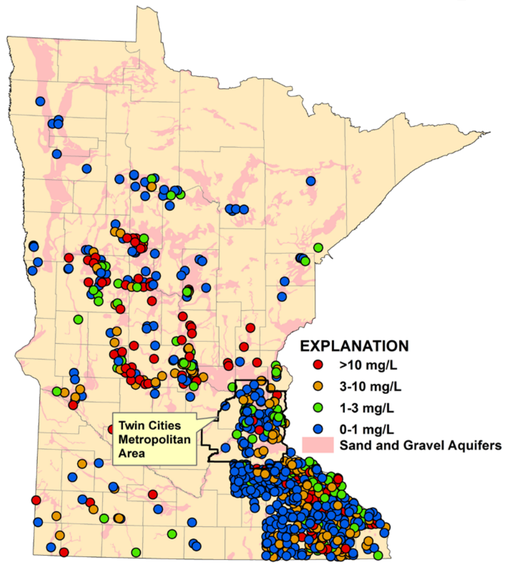
Stream nitrate monitoring



Left – 90th percentile nitrate-N concentrations at 728 sites (2000 -2010). Maximum nitrate-N exceeded 10 mg/l at 27% of sites.

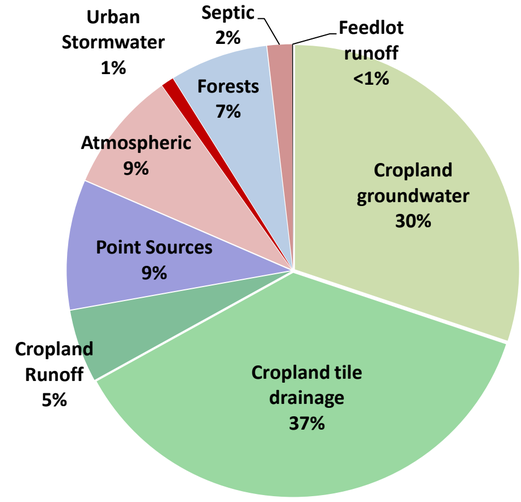
Right – Well water monitoring nitrate-N concentrations show somewhat different patterns as the stream nitrate levels.

Groundwater nitrate monitoring



Nitrogen Sources to Surface Waters - Statewide

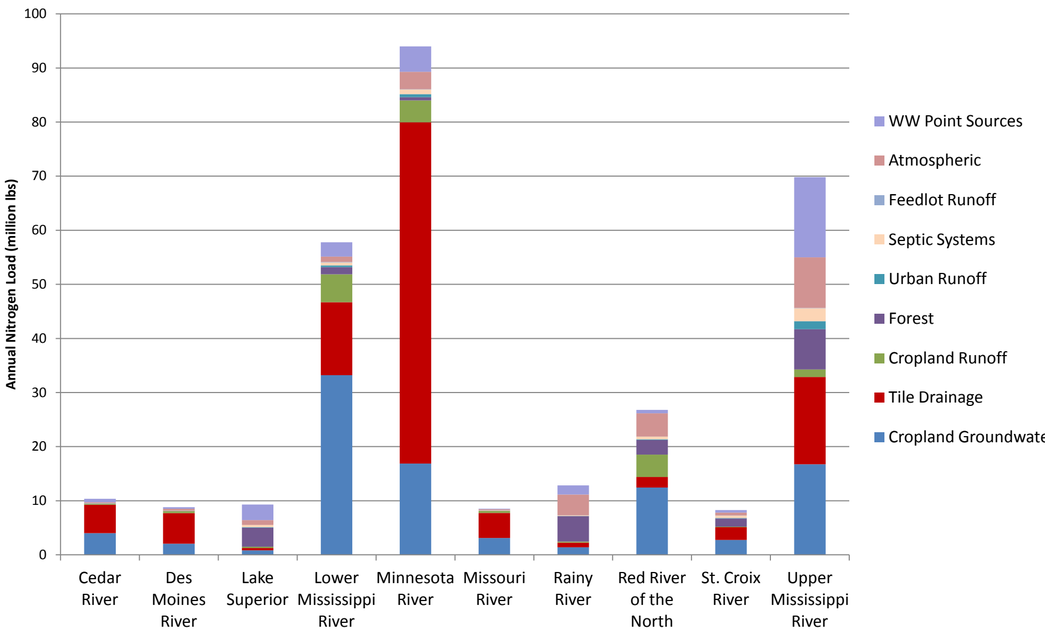
(average precipitation yr.)



- Cropland sources contribute an estimated 73 percent of the statewide N load during an average precipitation year.
- Cropland nitrogen is primarily delivered to surface waters through subsurface pathways of tile drainage and groundwater.

Nitrogen Sources for Each River Basin

- The proportion of each source varies by geographic area. For example, cropland tile drainage is 67% of the load in the Minnesota River Basin and is 23% in the Lower Mississippi Basin (SE MN).



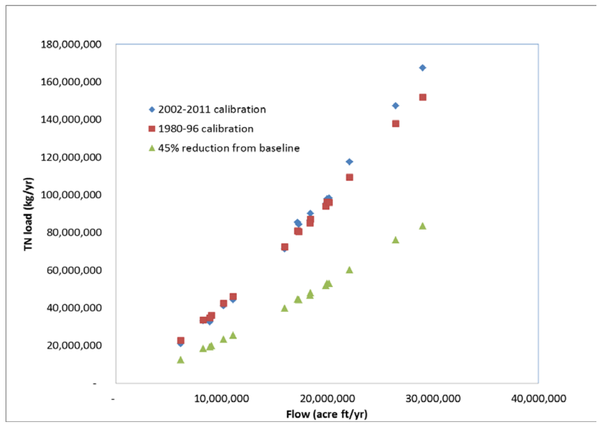
Minnesota Pollution Control Agency

Nitrogen Science
Trends and Reductions

River Monitoring Trends

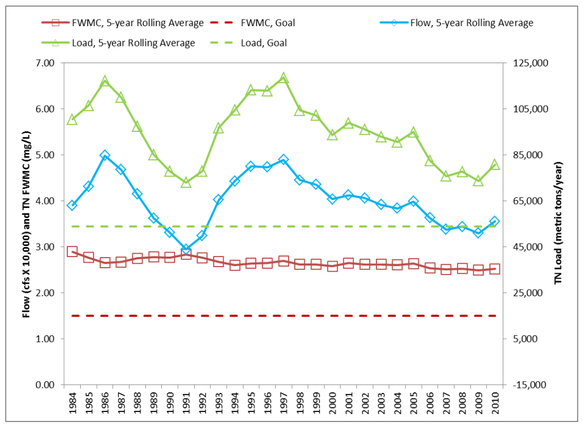
Mississippi River
Red Wing, MN (Lock and Dam 3)

At Hastings, total nitrogen loads in the 2002-11 period (red above) were nearly the same as those during the 1980-96 baseline period for the Mississippi River (blue above). Green represents the final goal TN loads.



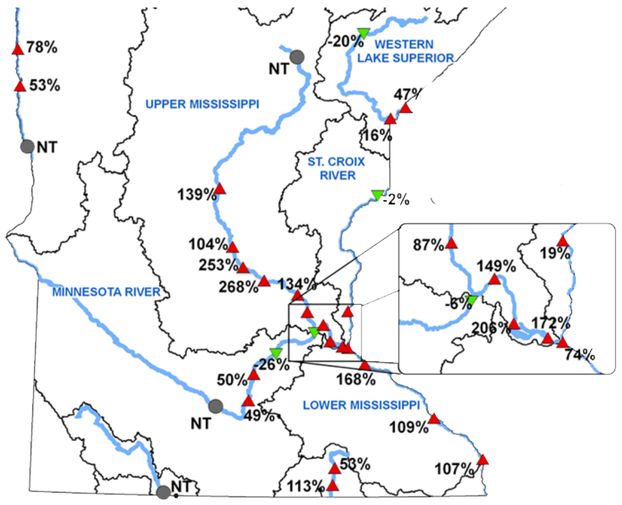
Mississippi River at Iowa Border

Total nitrogen loads (green) have dropped in the Mississippi River at the Iowa border since the late 1990's, but the flow-weighted mean concentration has remained largely unchanged (red). The load reduction is mostly influenced by parallel changes in river flow (blue) rather than actual reductions.



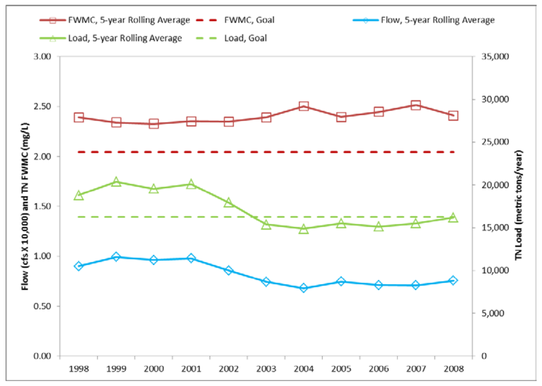
Nitrate concentrations since 1976

- Flow adjusted nitrate concentrations increased in Mississippi River from 1976-2010 by 87 to 268%, and is still increasing at a rate of 1 to 4% per year in recent years.
- Minnesota River nitrate concentrations remain high but have started to show decreases in recent years.

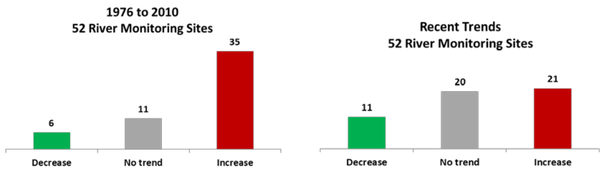


Red River at MN/Manitoba Border

Total nitrogen loads in the Red River at the Canadian border (green below) dropped between 2001 and 2004, following the pattern of river flow trends (blue below). The flow weighted mean concentration (red) did not change much between 1998 and 2007.

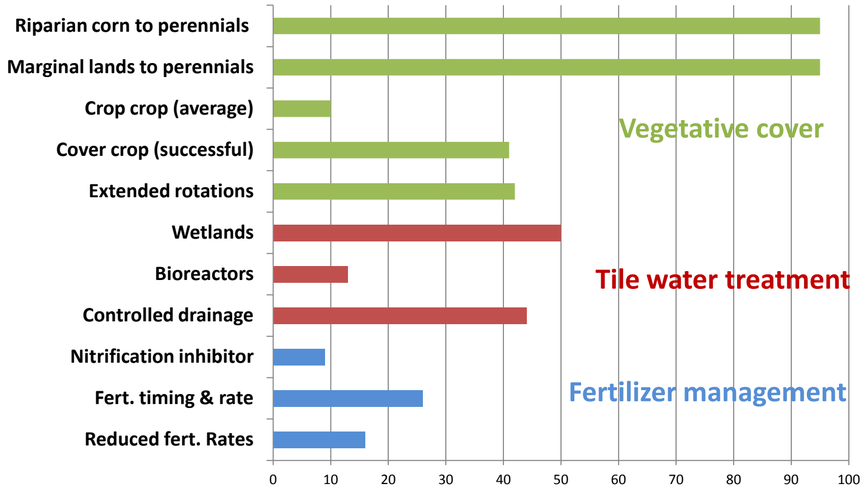


Nitrate concentration trends across the state – flow adjusted



Nitrogen Source Reduction Estimates

Cropland Best Management Practices



Typical percent nitrogen reduction load to water water (in area with BMP)

Treated area nitrogen reductions

Typical nitrogen reductions (%) to waters when applying the BMP in a specific field. Actual reductions can vary greatly from field to field and from year to year.

percent nitrogen reduction in water (statewide)

Statewide nitrogen reductions

Estimated nitrogen reductions (%) to waters when applying BMPs everywhere in the state where the given BMP is applicable. Many landscapes and fields are not suitable for each BMP.

Nitrogen BMP category	Example BMP	Mississippi River	Red River
		Total new acres (million acres)	Total new acres (million acres)
Increasing Fertilizer Use Efficiencies	Reduce regional average N rates to U of MN rates. Note: "new" acres include current rates with and without BMPs	13.2	6.0
Increase and Target Living Cover	Cover crops	0.3	0.2
	Riparian buffers	0.3	0.3
	Conservation reserve	0.2	0
Drainage Water Retention and Treatment	Wetlands and controlled drainage	1.1	0.001

BMP adoption to achieve the milestone targets

Estimated additional acreages of agricultural BMPs (below) expected to result in Minnesota attaining the first milestone reduction target (assuming also 20% reductions from wastewater sources as well.