TAHOE: STATE OF THE LAKE REPORT 2014

NUTRIENTS AND PARTICLES

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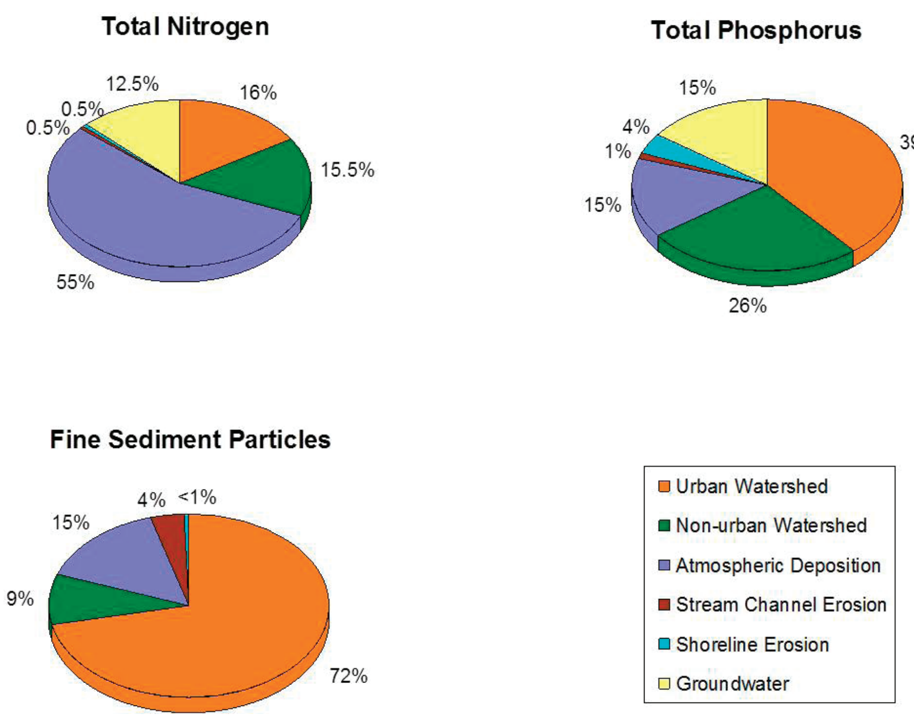
Sources of clarity-reducing pollutants

Previous research has quantified the primary sources of nutrients (nitrogen and phosphorus) and particulate material that are causing Lake Tahoe to lose clarity in its upper waters. One of the major contributors to clarity decline are extremely fine particles that primarily originate from the urban watershed (70-75 percent), even though these areas cover only 10 percent of the land area. For nitrogen, atmospheric deposition is the major source (55 percent). Phosphorus is primarily introduced by the urban (39 percent) and non-urban (26 percent) watersheds. These categories of pollutant sources form the basis of a strategy to restore Lake Tahoe's open-water clarity by agencies including the Lahontan Regional Water Quality Control Board, the Nevada Division of Environmental Protection, and the Tahoe Regional Planning Agency. (Data were generated for the Lake Tahoe TMDL Program and this figure appeared in previous years' State of the Lake Reports.)



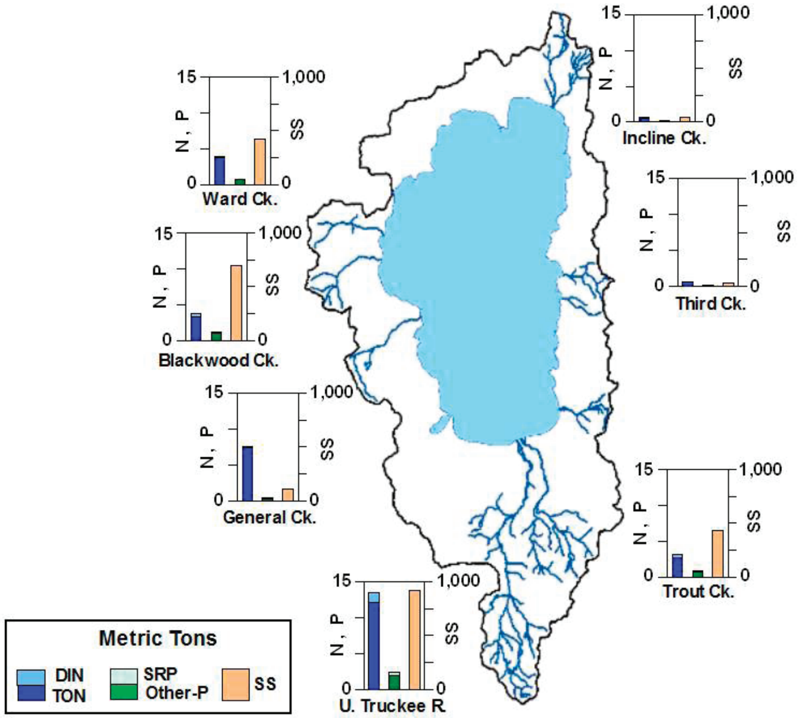
NUTRIENTS AND PARTICLES

Pollutant loads from seven watersheds

In 2013

The Lake Tahoe Interagency Monitoring Program (LTIMP) measures nutrient and sediment input from seven of the 63 watershed streams – a reduction of three streams since 2011. Most of the suspended sediment contained in the 7 LTIMP streams is from the Upper Truckee River, Blackwood Creek, Trout Creek and Ward Creek. Over 75 percent of the phosphorus and nitrogen comes from the Upper Truckee River, Trout Creek and Blackwood Creek. Pollutant loads from the west-side streams were a factor of four lower in 2013 and 2012, compared with 2011. This was largely due to the drier years that the basin experienced.

The LTIMP stream water quality program is supported by the U.S. Geological Survey in Carson City, Nevada, UC Davis TERC and the Tahoe Regional Planning Agency. Additional funding was provided by the USFS – Lake Tahoe Basin Management Unit.



N = Nitrogen
P = Phosphorus
DIN = Dissolved Inorganic Nitrogen
SRP = Soluble Reactive Phosphorus
TON = Total Organic Nitrogen
SS = Suspended Sediment

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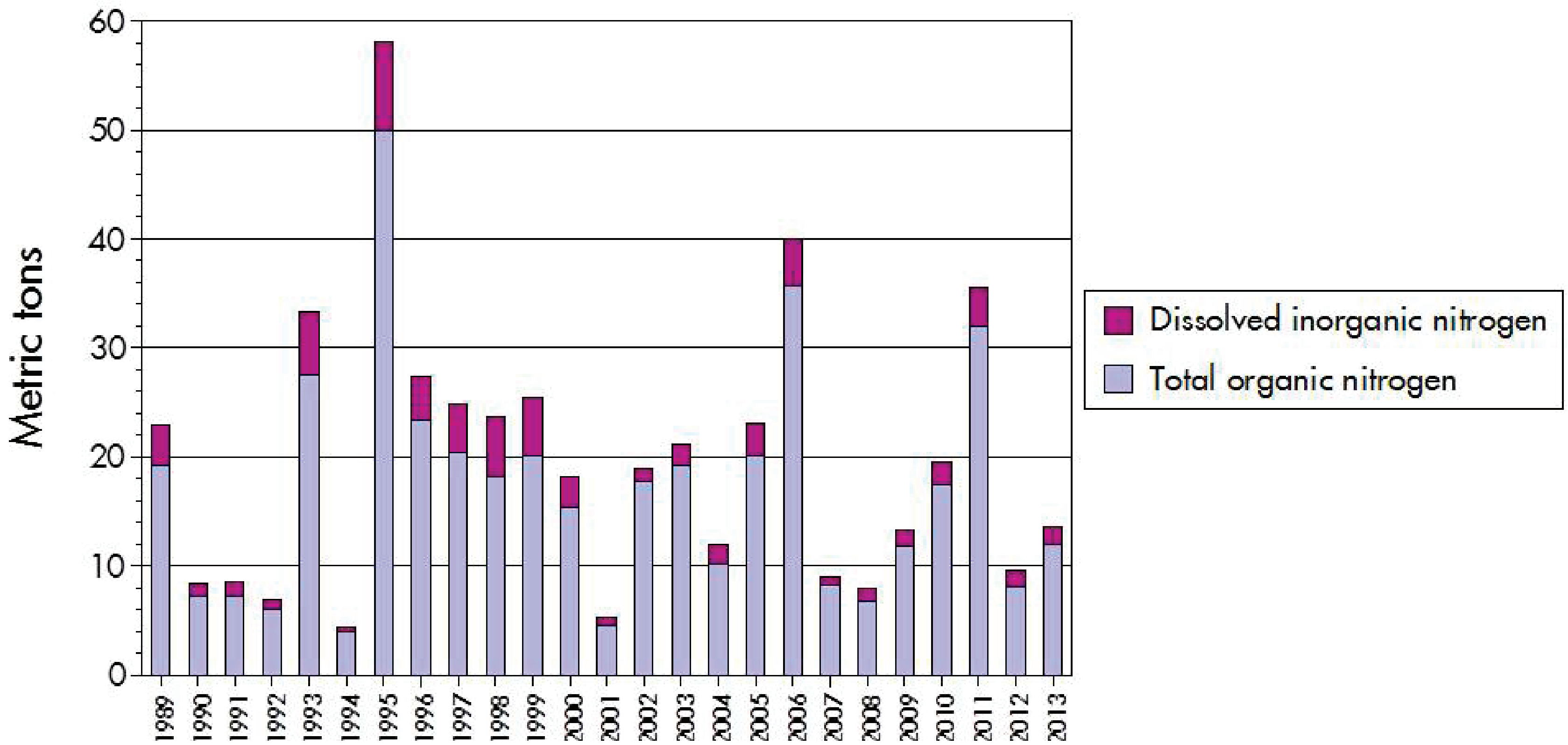
Nitrogen contribution by Upper Truckee River

Yearly since 1989

Nitrogen (N) is important because it, along with phosphorus (P), stimulates algal growth. The Upper Truckee River is the largest of the 63 streams that flow into Lake Tahoe, contributing about 25 percent of the inflowing water. The river's contribution of dissolved inorganic nitrogen (nitrate and ammonium) and total organic nitrogen loads are shown here. The year-to-year variations primarily reflect changes in precipitation. For example, 1994 had 16.6 inches of precipitation and a low nitrogen load, while 1995 had 60.8 inches of precipitation and a very high nitrogen load. Similarly 2013 had 25.19 inches of precipitation and 2012 had 22.48 inches of precipitation. (One metric ton = 2,205 pounds.)

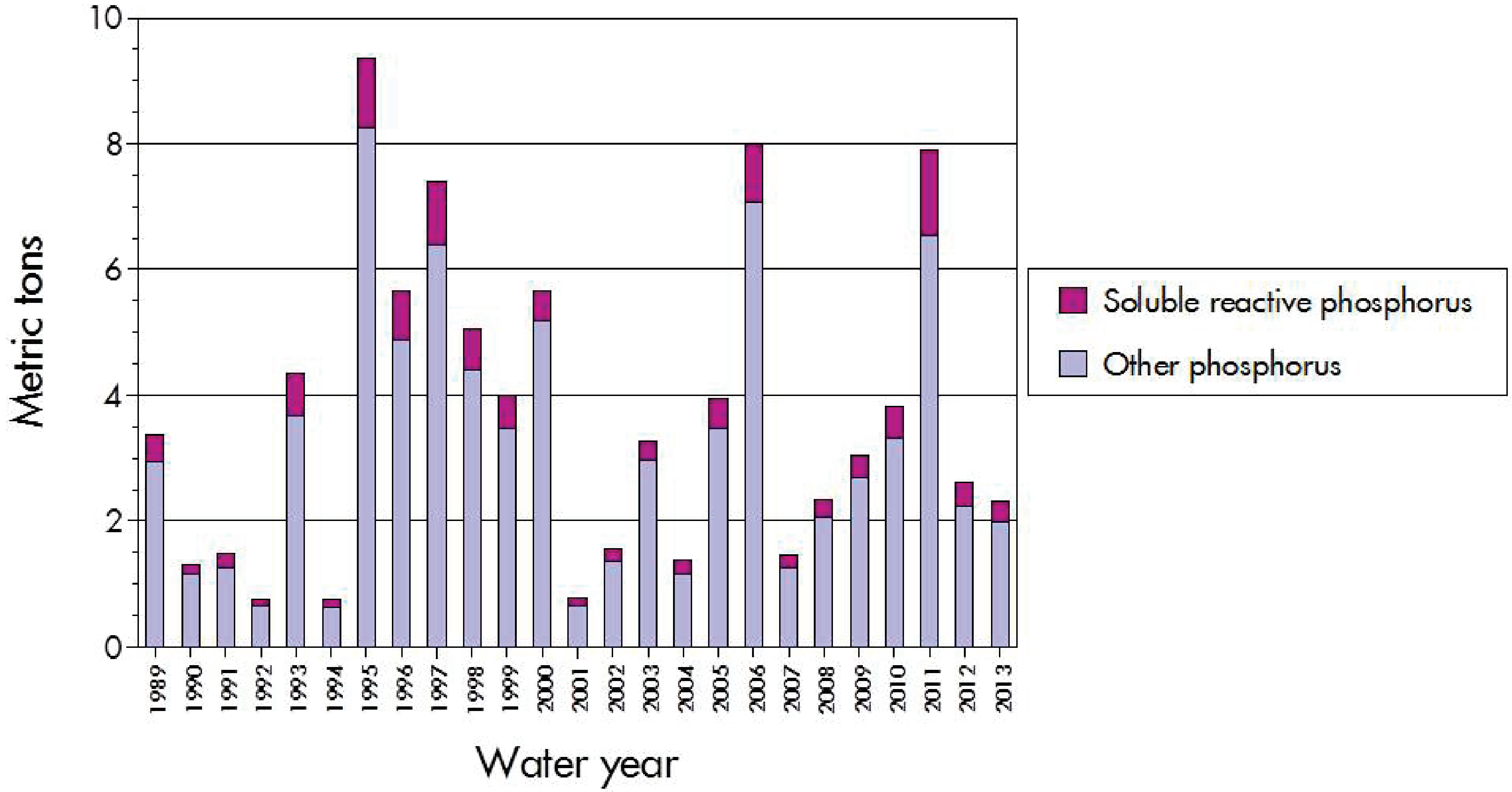


NUTRIENTS AND PARTICLES

Phosphorus contribution by Upper Truckee River

Yearly since 1989

Soluble reactive phosphorus (SRP) is that fraction of phosphorus immediately available for algal growth. As with nitrogen, the year-to-year variation in load largely reflects the changes in precipitation. Below average precipitation in 2013 resulted in a factor of four reduction of the phosphorus load over 2011. Total phosphorus is the sum of SRP and other phosphorus, which includes organic phosphorus and phosphorus associated with particles. (One metric ton = 2,205 pounds.)



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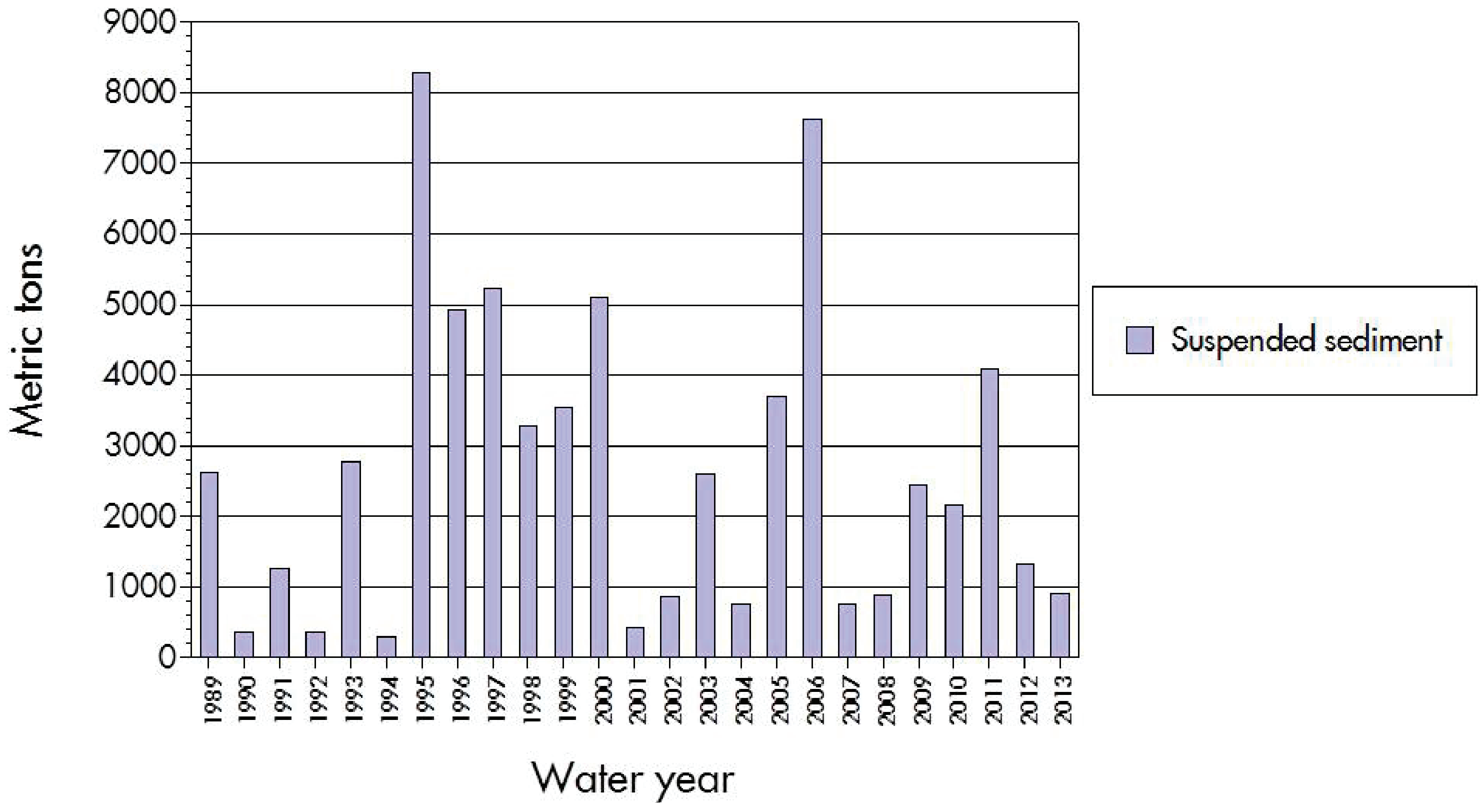
Suspended sediment contribution by Upper Truckee River

Yearly since 1989

The load of suspended sediment delivered to the lake by the Upper Truckee is related to landscape condition and erosion as well as to precipitation and stream flow. Certainly, inter-annual variation in sediment load over shorter time scales is more related to the latter. Below average precipitation in 2013 resulted in a factor of four decrease of the suspended sediment load compared with 2011. This and the previous two figures illustrate how greatly changes in hydrological conditions affect pollutant loads. Plans to restore lake clarity emphasize reducing loads of very fine suspended sediment (less than 20 microns in diameter). Efforts to restore natural stream function and watershed condition focus on reducing loads of total sediment regardless of size, as well as restoration of habitat for plants and wildlife.

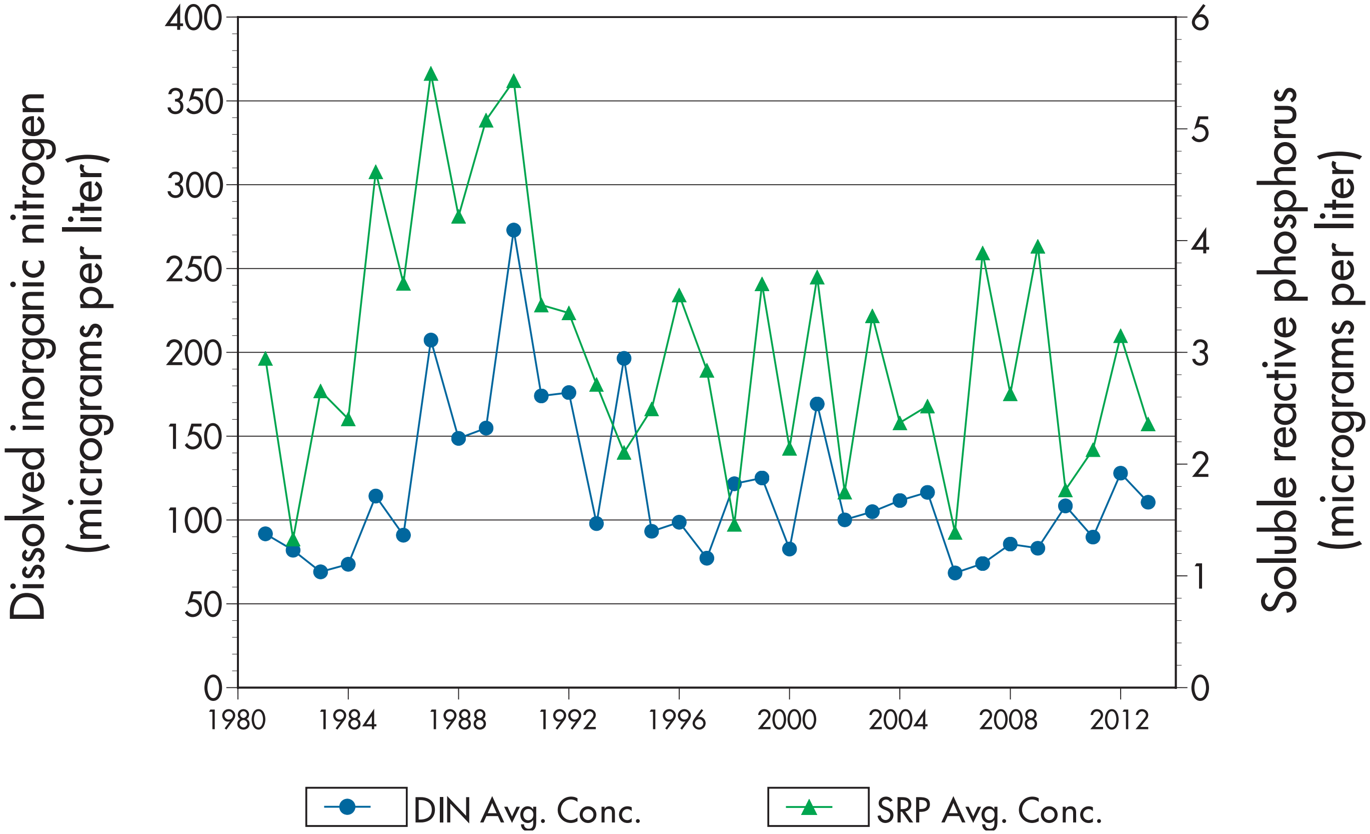


NUTRIENTS AND PARTICLES

Nutrient concentrations in rain and snow

Yearly since 1981

Nutrients in rainwater and snow (called wet deposition) contribute large amounts of nitrogen, but also significant phosphorus, to Lake Tahoe. Nutrients in precipitation have been measured near Ward Creek since 1981, and show no consistent upward or downward trend since peaking in the late 1980's. Annual concentrations in precipitation of dissolved inorganic nitrogen (DIN) and soluble reactive phosphorus (SRP) vary from year to year. In 2013, concentrations of DIN and SRP decreased from the previous year. The ratio of N:P concentration in precipitation is on average 42:1 (±16). As this is the concentration in precipitation, it is not necessaarily affected by the relatively dry conditions of 2013.

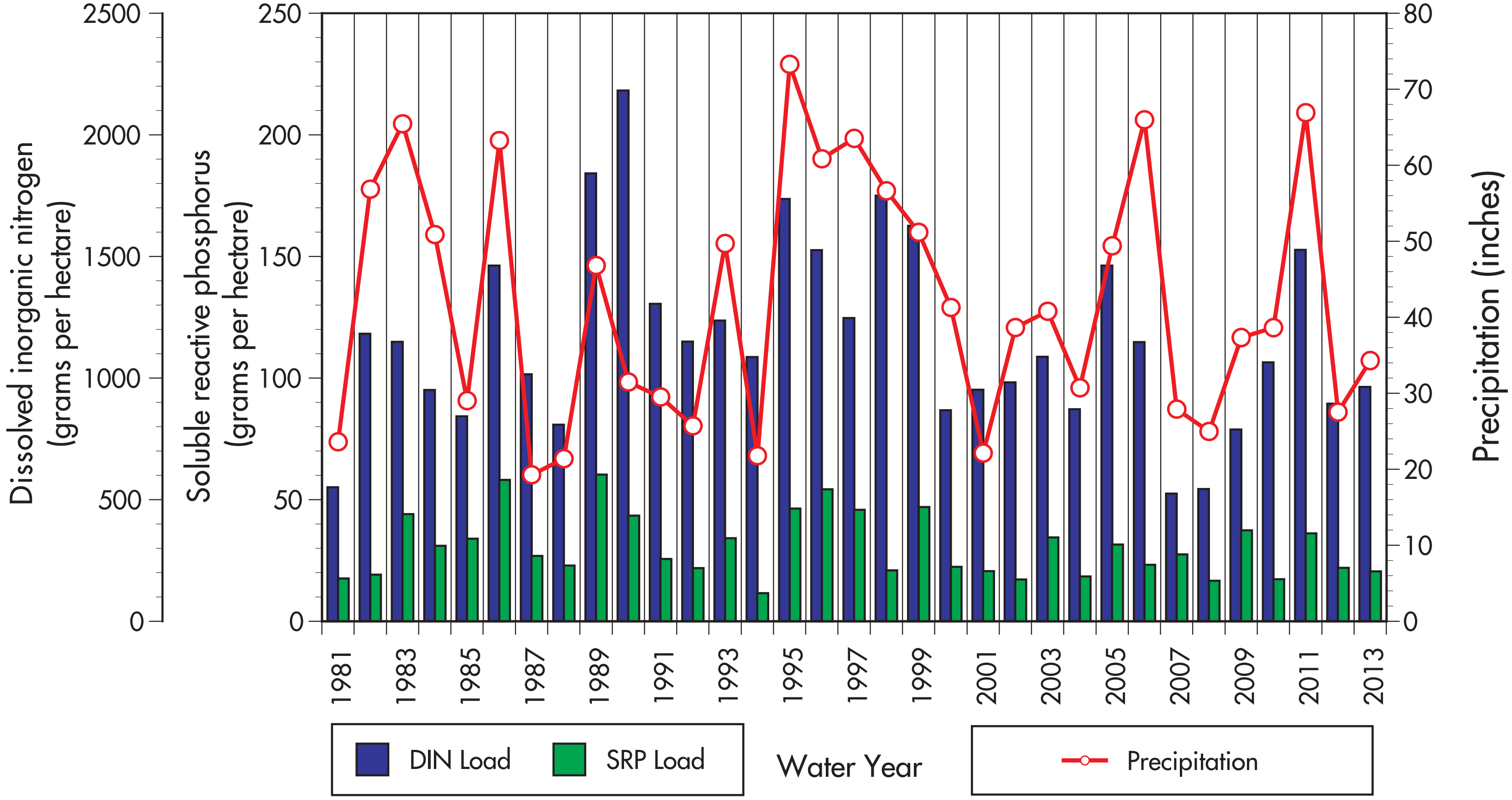


NUTRIENTS AND PARTICLES

Nutrient loads in rain and snow

Yearly since 1981

The annual load for wet deposition is calculated by multiplying the concentration of dissolved inorganic nitrogen (nitrate and ammonium) and soluble reactive phosphorus (in the previous graph) by total annual precipitation. While nitrogen and phosphorus loads from precipitation have varied from year to year at the Ward Creek monitoring site, no obvious long-term trend has emerged. In 2013, the nitrogen and phosphorus loads were within the range seen in previous years.



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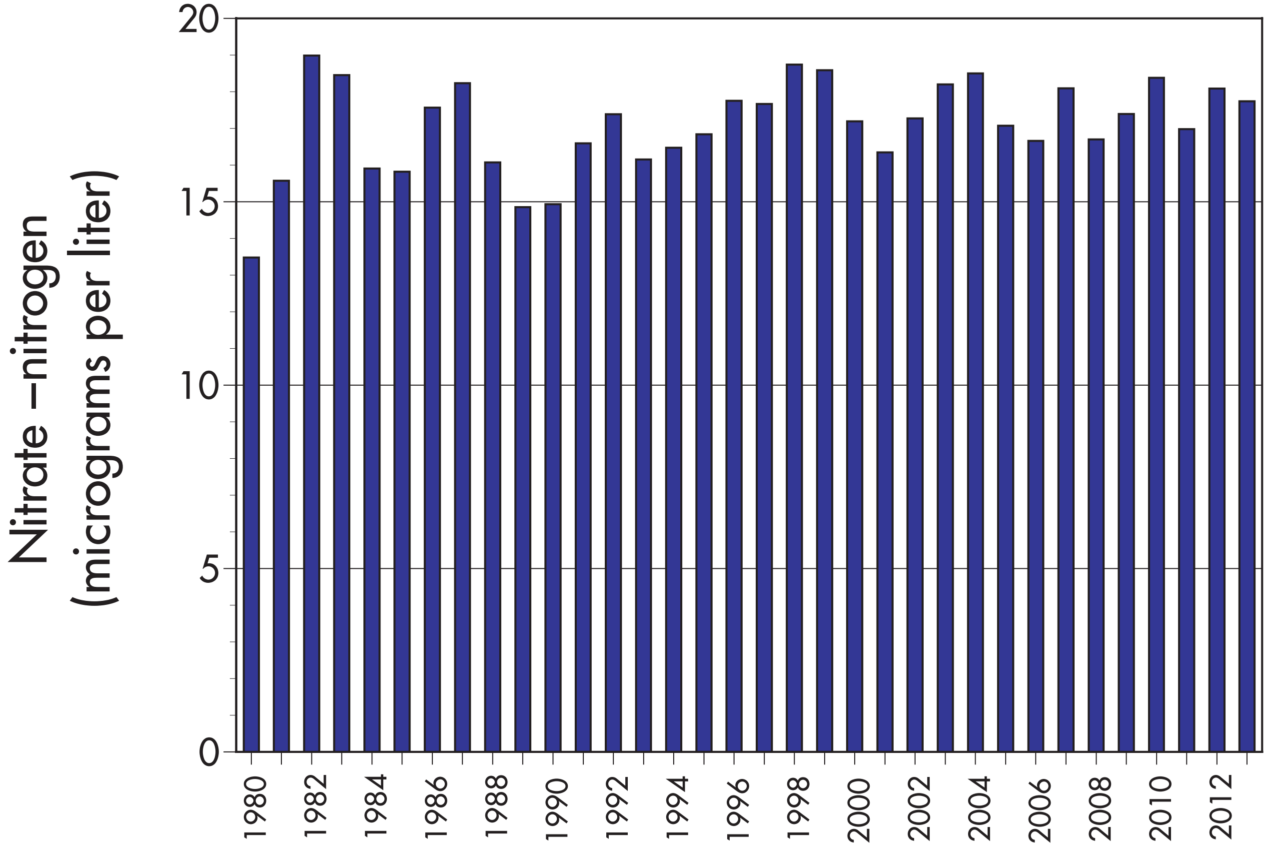
Lake nitrate concentration

Yearly since 1980

Since 1980, the volume-weighted annual average concentration of nitrate-nitrogen has remained relatively constant, ranging between 13 and 19 micrograms per liter. In 2013, the volume-weighted annual average concentration of nitrate-nitrogen was 17.7 micrograms per liter. Water samples are taken from the R/V John LeConte at the MLTP (mid-lake) station at 13 depths from the surface to 450 m. The nutrient analysis is performed at the TERC laboratory in Incline Village, Nevada.



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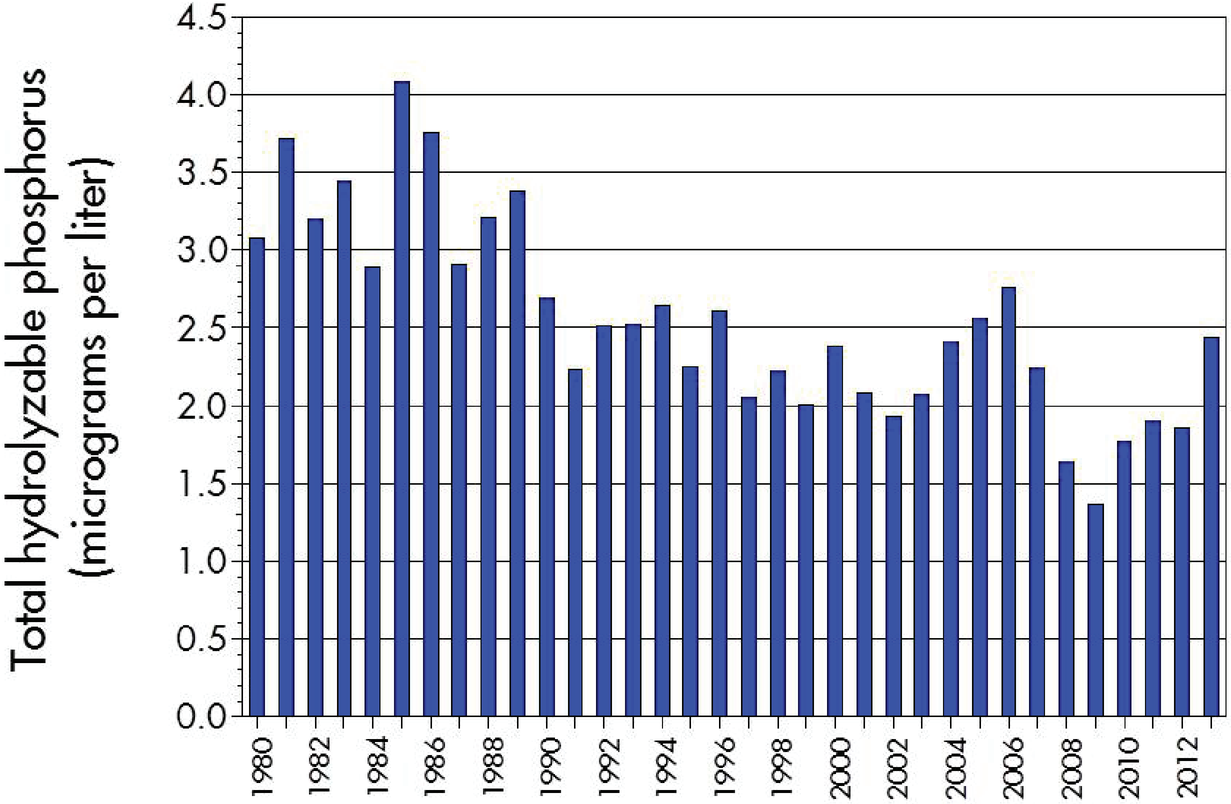
Lake phosphorus concentration

Yearly since 1980

Phosphorus naturally occurs in Tahoe Basin soils and enters the lake from soil disturbance and erosion. Total hydrolyzable phosphorus, or THP, is a measure of the fraction of phosphorus that algae can use to grow. It is similar to the SRP that is measured in the streams. Since 1980, THP has tended to decline. In 2013, the volume-weighted annual average concentration of THP was approximately 2.4 micrograms per liter, an increase over the previous year. Water samples are taken from the R/V John LeConte at the MLTP (mid-lake) station at 13 depths from the surface to 450 m. The nutrient analysis is performed at the TERC laboratory.



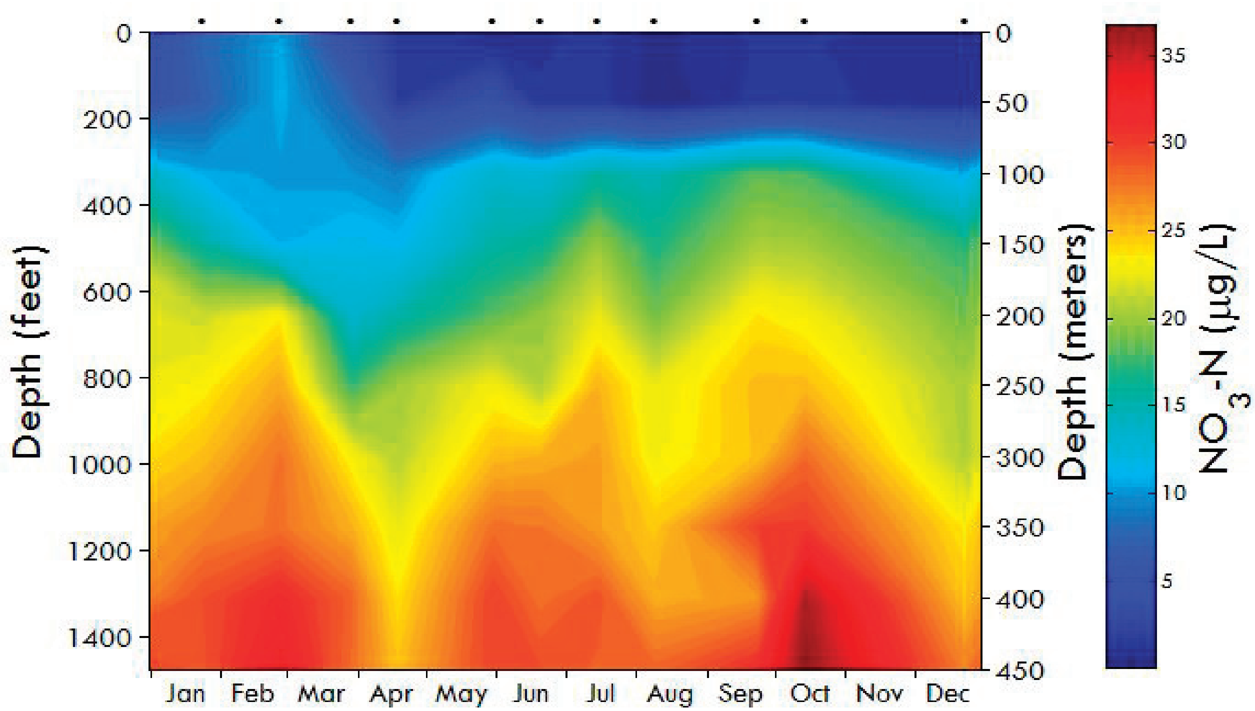
NUTRIENTS AND PARTICLES

Nitrate Distribution

In 2013

Water samples are collected approximately every month (on dates indicated by dots at the top of the figure) at 13 depths at the middle of the lake, and analyzed in the TERC lab for nutrient concentrations. Here the nitrate concentration is shown in the form of color contours.

Most evident in this figure is the vertical distribution of nitrate. Concentrations below a depth of about 400 feet are generally high. The surface waters, where there is sunlight to enable algae to grow usually has low concentrations of nitrate. Although most of the nitrate enters at the surface through atmospheric deposition, it is rapidly used up by the algae. As algae eventually sink and decompose, the nitrate they consumed eventually reappears deep in the lake. At these depths, however, there is insufficient light for algae to grow and to assimilate the nutrients. When deep lake mixing occurs, the deep nitrate can be brought back to the surface. This process is evident in February-March. An increase in nitrate at the surface (light blue color) is being produced by the mixing of water down to 590 feet. 2013 was a year with very shallow mixing, and so most of the nitrate remained trapped in the deep water.



NUTRIENTS AND PARTICLES

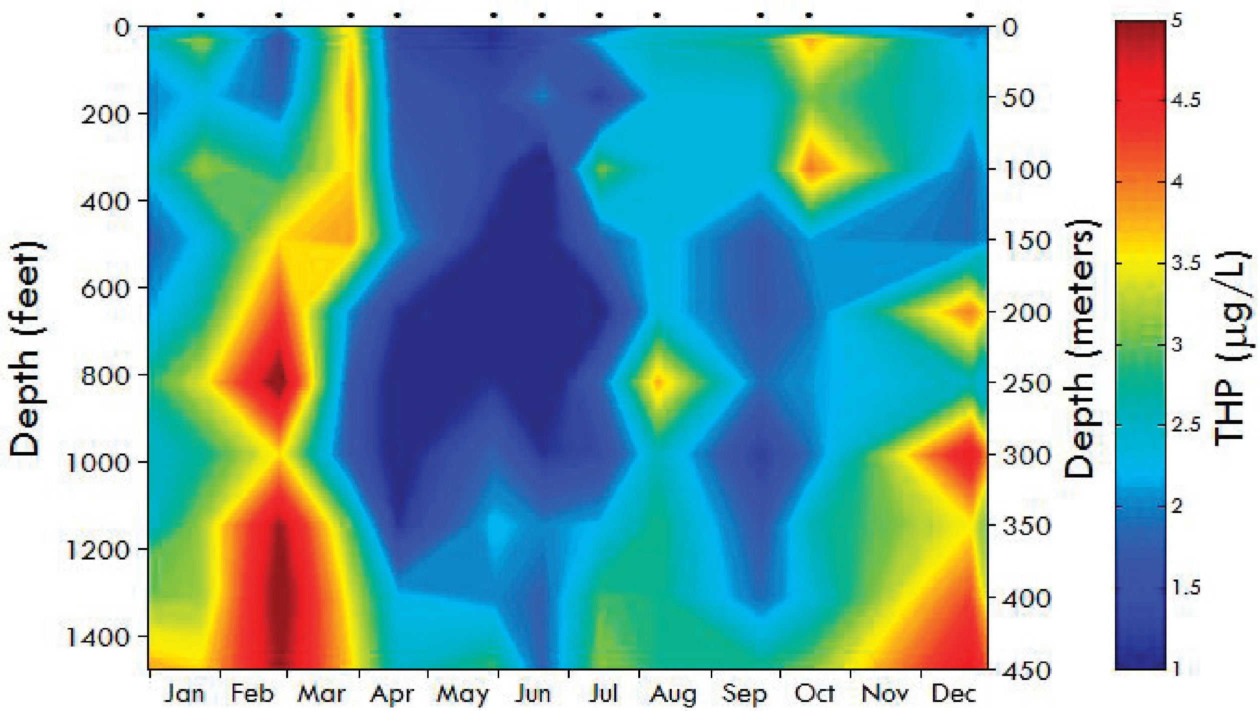
Phosphorus Distribution

In 2013

Water samples are collected approximately monthly (on dates indicated by dots at the top of the figure) at 13 depths at the middle of the lake, and analyzed in the TERC lab for nutrient concentrations. Here the total hydrolyzable phosphorus (THP) concentration (the fraction of the phosphorus that can be most readily used by algae) is shown in the form of color contours.

Unlike the nitrate distribution, there is relatively little vertical distribution of THP. Phosphorus mainly enters the lake in association with fine particles. Because of the low snowmelt volumes and the cold conditions, when snowmelt occurred in March much of the phosphorus was carried with the flow deep into the lake. The phosphorus that remained in the surface was quickly consumed and by April concentrations were extremely low.

Unlike nitrate, which can remain dissolved in the water column, THP is strongly adsorbed to particles, so when algae settle and decompose, the THP is quickly adsorbed to particles which can then settle quickly in the deep water.



NUTRIENTS AND PARTICLES

Fine Particle Distribution

In 2013

Water samples are collected approximately monthly (on dates indicated by dots at the top of the figure) at 13 depths at the middle of the lake, and analyzed in the TERC lab for the concentration of fine particles in 15 different bin sizes. Here the distribution of the finest particles (0.5 to 8 microns) are shown in the form of color contours.

Clearly evident in the figure is that the highest concentrations of fine particles (red tones) are concentrated in the upper part of the lake. In the early part of the year (winter), when clarity is generally highest, surface concentration of particles is the lowest. A reduction in surface particle concentration is also evident in December. In winter there is also the lowest concentrations of fine particles in the deep water. This is due to them aggregating and settling out.

The high concentration values at a depth of about 1300 feet in April and May is believed to be due to some of the very cold snowmelt water plunging to the deep part of the lake on account of its high density.