LAKE TAHOE NUTRIENT AND SEDIMENT TOTAL MAXIMUM DAILY LOAD

WINTER 2003-04 NEWSLETTER

Nevada Division of Environmental Protection   Lahontan Regional Water Quality Control Board

This edition highlights two additional research projects contributing to development of the Lake Tahoe Total Maximum Daily Load (TMDL) for sediment and nutrients, which has the objective of restoring the lake's clarity to its exceptional historic levels. The first article below describes a project that is characterizing the impacts of air pollution on lake clarity, the sources of atmospheric pollutants, and whether they originate within or outside the Lake Tahoe Basin. Study coordinators and researchers are introduced briefly in a separate piece following the project description. The second research effort described is called the Near Shore Clarity study. This project examines in detail the clarity of waters along the shoreline of Lake Tahoe and which pollutants are affecting clarity. Both these projects will provide information key to development and implementation of the TMDL.

LAKE TAHOE ATMOSPHERIC DEPOSITION STUDY

The numerous parties collaborating on the development of the Lake Tahoe TMDL require, to the extent possible, a comprehensive and accurate account of the most significant and controllable sources of pollution that impact lake clarity. Therefore, the researchers must consider a source not normally associated with water quality assessments: direct deposition of pollutants from the air to the lake surface. It has been demonstrated, based on a 20-year period of monitoring in a single watershed within Lake Tahoe Basin, that air deposition could be a major contributor of both fine sediment (or dust) and nutrients (phosphorus and nitrogen) directly to the lake. Air deposition appears to be a major pollutant source because the lake itself occupies such a large surface area (500 km^2) relative to its drainage basin (800 km^2).

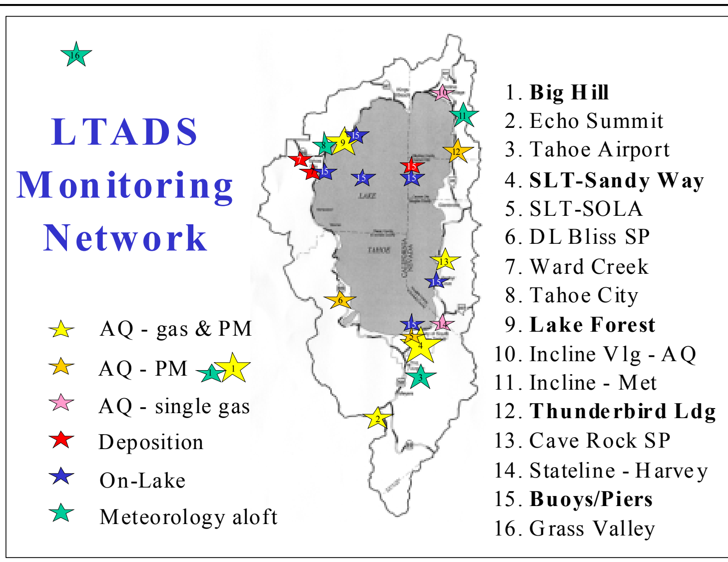

Figure 1. The Lake Tahoe Atmospheric Deposition Study monitoring network. Sites in bold have Two-Week Samplers (see Figure 3) or Mini-Volume Samplers that provide critical data for the atmospheric deposition analyses. AQ =Air Quality monitoring station, where gas and/or particulate matter (PM) samples are taken.

To quantify atmospheric loading to the lake, the Lahontan Regional Water Quality Control Board (RWQCB) and the Nevada Division of Environmental Protection (NDEP) are fortunate to benefit from the expertise and resources of the California Air Resources Board (CARB), a highly regarded scientific and regulatory authority with extensive expertise in characterizing and controlling air pollution. CARB is currently completing over a year of intensive monitoring of air pollution and meteorology in and near the Lake Tahoe Basin to provide refined estimates of the inputs of various pollutants that can impact water clarity. During the coming year, CARB staff will continue to validate and analyze the data being collected to provide the most up-to-date assessment of the magnitude and origins of atmospheric deposition to the lake. This information, in combination with our assessment of pollutant loading from the watershed, will be a key input to the Lake Clarity Model (see Spring 2003 edition), which will determine the mix of phosphorus, nitrogen and fine sediment load reductions necessary to achieve the desired lake clarity.

Prior Research

Based upon air deposition sampling prior to the current monitoring program, air pollutants reaching Lake Tahoe have been estimated to represent nearly one quarter of the Lake's total phosphorus inputs, and over one half its nitrogen load. Monitoring of nutrient deposition on the watershed and the lake by the UC Davis-Tahoe Research Group first identified atmospheric deposition as a potentially major source for both phosphorus and nitrogen (Jassby et al., 1994). Recent work at the Desert Research Institute has further characterized nitrogen deposition (Tarnay et al., 2001). While acknowledging the limited amount of field data, the Lake Tahoe Watershed Assessment (Reuter and Miller, 2000) hypothesized that atmospheric nitrogen is largely associated with automobiles while phosphorus is most likely associated with wood smoke from various sources and with road dust.

Figure 2. Measurements of particulate matter and meteorology on piers is important for refining deposition estimates to Lake Tahoe. Note the inversion layer in the distance. The complex meteorology of the Tahoe Basin often traps smoke and other pollution in layers above the Lake.

New Research

Thus, air pollution may be considered among the most critical, if also challenging, pollutant sources to characterize and to control. The potential importance of air deposition prompted CARB to design a ~$2 million study of air quality and deposition in the Lake Tahoe Basin, entitled "Lake Tahoe Atmospheric Deposition Study," or LTADS, to contribute to the TMDL research program. This study has the objectives of better characterizing atmospheric deposition of nitrogen, phosphorus, and particulate matter (see Figures 1 & 2), emission sources in the Tahoe Basin, and transport of pollutants from outside the Tahoe Basin.

Figure 3. The Two Week Sampler (TWS) is the cornerstone of the LTADS monitoring program for nitrogen and phosphorus compounds that deposit to the Lake and contribute to algal growth. TWS measurements represent ambient conditions during every minute of the more than 1-year field study portion of LTADS.

Specifically the study approach includes:

- Enhancing the ambient monitoring network (air quality and meteorology) to better characterize the spatial variations in conditions (see Figure 1 for map of monitoring network);
- Conducting a year-long enhanced monitoring program to capture temporal variations in deposition and to quantify total annual air pollutant loadings to the Lake (see Figure 3);
- Conducting special short-term field experiments to better characterize atmospheric processes such as transport of pollutants from the shoreline to mid-lake locations;
- Characterizing pollutant emission sources (e.g., analyzing their chemical composition and the extent and nature of the activities that produce them) in order to determine the relative contributions from various potential stationary and mobile sources such as wood burning, vehicle exhaust, and road dust; and
- Analyzing the data obtained during the field study to estimate ranges of atmospheric deposition and the associated uncertainties.

Figure 4. Data from six monitoring sites in the Sierra Nevada and southern Cascade mountain chain are being used to evaluate the relative importance of particulate air pollution transport into Lake Tahoe Basin versus what is locally-generated. (CRLA: Crater Lake; LAVO: Lassen Volcanic National Park; BLIS: D. L. Bliss State Park; SOLA: South Lake Tahoe; YOSE: Yosemite National Park; SEQU: Sequoia National Park.)

Using inferential models adapted to extrapolate measurements into basin-wide deposition calculations, short-term (daily, weekly, seasonal) LTADS observations will be used in concert with other existing information to refine historical estimates of atmospheric deposition to the lake. Together with existing data and published reports, this study will also include an evaluation of the impacts of in-basin versus out-of-basin emission sources.

CARB is finalizing an Interim Report, which will be viewable by clicking on the Lake Tahoe link at http://www.arb.ca.gov/research/ecosys/ecosys.htm (currently, the website contains slides summarizing the report and monitoring results to date). The report describes the field research program currently underway and analysis of existing data, both from within Lake Tahoe Basin and from a series of comparable monitoring stations located throughout the

Sierra Nevada and southern Cascade mountain ranges (see Figure 4). CARB will use data from these stations to estimate the role of long range transport of aerosols (or air-borne particles) on particulate matter concentrations. Lastly, the report explains how the deposition of nitrogen, phosphorus and particulate matter on the lake will be estimated, taking into account spatial and temporal dynamics of pollutant transport to and within the basin. For additional information, please contact Leon Dolislager of CARB at ldolisla@arb.ca.gov.

AIR DEPOSITION RESEARCH TEAM

The Lake Tahoe Atmospheric Deposition Study is spearheaded by the Atmospheric Processes Research Section of the California Air Resources Board (see Figure 5 below) and includes a supporting cast of over 50 employees, collaborators, and contractors, providing thousands of hours of dedicated efforts and hundreds of thousands of dollars in funding. Besides CARB, funding sources include the U.S. Environmental Protection Agency, the Tahoe Regional Planning Agency (TRPA), NDEP, and Lahontan RWQCB. Peer review of the LTADS workplan, reports, and other work products are provided by the University of California. LTADS contractors and associates making field measurements include CARB's Monitoring & Laboratory Division, UC Berkeley, UC Davis, UC Riverside, Desert Research Institute, Tahoe Research Group, TRPA, Lahontan RWQCB, and the National Oceanic and Atmospheric Administration.

Figure 5. LTADS staff from CARB's Atmospheric Processes Research Section include, from left to right: Dongmin Luo, Leon Dolislager, Ash Lashgari, Eileen McCauley, Tony VanCuren, William Vance, and Jim Pedersen.

The Atmospheric Processes Research Section, headed by Eileen McCauley, includes Tony VanCuren, William Vance, Jim Pederson, Dongmin Luo, Ash Lashgari, and Leon Dolislager. All members of the section have doctoral degrees except Mr. Pederson and Mr. Dolislager, who have master's degrees. McCauley, Luo, and Vance have chemistry degrees; Pederson, and Dolislager have meteorology degrees; VanCuren has geography degrees, and Lashgari has engineering and environmental degrees. In addition, Dr. Lashgari recently earned his law degree. The section has been greatly aided by the office and field assistance of students Sarah Connelly and Charles Cozad.

Water Quality Near the Shore of Lake Tahoe

Lake Tahoe may be considered to consist of two regions, the deep middle portion of the lake and the shallow areas near the shore. The near shore zones of Lake Tahoe are the areas less than 30 meters deep or within 100 meters of shore, whichever extends further from shore. Although most of our current research and modeling are focused on the mid-lake region, the Lake Tahoe TMDL will address all areas of the lake, including the near-shore areas most visible to residents and visitors. Consequently, Lahontan RWQCB, NDEP, and the Tahoe Regional Planning Agency (TRPA) funded a TMDL research project by the Desert Research Institute (DRI) to assess variations in near-shore clarity and to determine the constituents that reduce clarity.

Fig. 6 The Desert Research Institute used a boat to measure the water quality near the shore of Lake Tahoe. The boat and water quality instruments inside can operate in poor and cold weather. The boat can also operate in very shallow water because it is equipped with a jet drive instead of a propeller. A probe on the bow was used to collect water samples while the boat was moving.

Management actions will influence the near-shore zone years before their effect may be detected in the middle of the lake because water quality near the shore responds faster to on-shore activities and to land use changes than does the middle of the lake. Furthermore, near-shore water quality along any particular section of the lakeshore is most significantly influenced activities in close proximity to the affected area of the lake. By mapping the water quality near the shore it is possible to identify neighborhood sized areas that are contributing undesirable material to the lake. Near-shore water quality may therefore be considered a short-term, immediate indicator of both the effectiveness of on-shore pollution control activities and expected future deep lake quality. This characteristic could be used to track our progress toward restoring clarity during TMDL implementation.

Mid-lake clarity is measured with a Secchi disk, but this method cannot be used close to shore because the water is usually not deep enough for the disk to fade from view before it rests on the bottom. Instead, the clarity of the near-shore zone is commonly described in terms of the turbidity of the water, which is a measure of how the water scatters light. High turbidity water is murky and scatters light more than low turbidity water, which is clear.

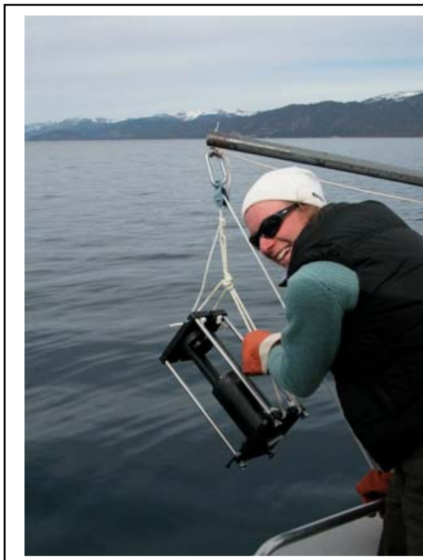

Fig. 7 Margaret Shanafield of DRI prepares an instrument used to measure how the turbidity of the water changes with depth.

To study the near shore zone the DRI outfitted a boat for year round research (see Figures 6 and 7). A water-sampling probe was mounted on the bow to collect water from a foot below the surface. The water was pumped through instruments on the boat that measured the concentration of turbidity and chlorophyll (which indicates the presence of organic matter such as algae) and the temperature of the water. Measurements were made every 20 feet while the boat was moving at speeds of up to 15 miles an hour. The boat operators were guided by a computer display that showed the measurement results and location of the boat. This made it possible to quickly measure near shore turbidity. Between July 2002 and July 2003 turbidity and chlorophyll surveys were conducted every few weeks along the south shore of the lake. Water samples were also collected to determine if the particles in the water were minerals or organic material (i.e. fine sediments or algae, see Figure 8). These surveys showed which near shore areas had the greatest turbidity and if the elevated turbidity was caused by mineral or organic material. High levels of organic material are likely caused by excessive nutrient inputs to that part of the lake.

Several surveys were done around the entire perimeter of the lake to identify sections of the shore that persistently have high turbidity. The south shore has the highest turbidity water. To a much lesser extent, there is occasionally elevated turbidity in waters near Lake Forest, Kings Beach, and Tahoe Vista. The waters near the shore of Bliss State Park and the undeveloped portions the east shore have turbidity as low as the middle of the lake.

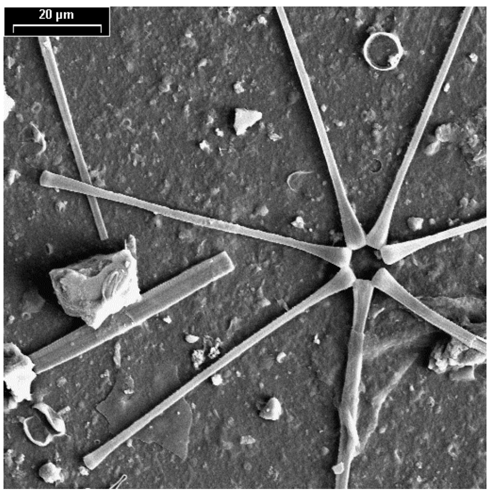

Fig. 8 A scanning electron microscope image of the particles in a water sample collected 100 feet off Nevada Beach. The image shows a star shaped diatom formed by a type of algae, and on the left there is a block like mineral grain. The background of the filter is covered with a continuous mat of algae.

The near shore surveys showed (see Figure 9) that the Upper Truckee River, which enters the lake at its southernmost point, is the largest cause of increased turbidity in the near shore zone. Nearby Bijou Creek was also a major problem area. Smaller but still significant problem areas were the Ski Run Marina and Al Tahoe areas. This increased turbidity was always caused by mineral particles. It is tempting to attribute the high turbidity water quality to the shallow water in these areas. Close examination of the water depth and results of the water quality surveys showed other shallow areas did not have high turbidity, so the near shore turbidity in these areas was not a natural occurrence.

The near shore water quality was good during very cold or dry periods when there was only a small amount of water flowing in the streams and storm drains. The near shore waters became more turbid when storms or spring runoff filled the streams and storm drains with moving water. With the exception of the west side of Al Tahoe neighborhood, all the near shore areas with high turbidity had an obvious cause such as a stream or storm drain. The higher turbidity area off western Al Tahoe may have been caused by outflow from the Upper Truckee River that moved along the shore in water that was too shallow to survey.

A report on this project will be available on line at http://tahoenearshore.dri.edu in March 2004. The project is led by Ken Taylor, with Rick Susfalk and Margaret Shanafield (all with DRI) assisting with data collection and analysis. Geoff Schladow with the University of California at Davis also provided analytical support. Funding for this project comes from the Lahontan RWQCB, the Nevada Department of State Lands (using funds from the sale of vehicle license plates with a Lake Tahoe motif), TRPA, and DRI. Tahoe Keys Marina and Sand Harbor State Park provided logistical support.

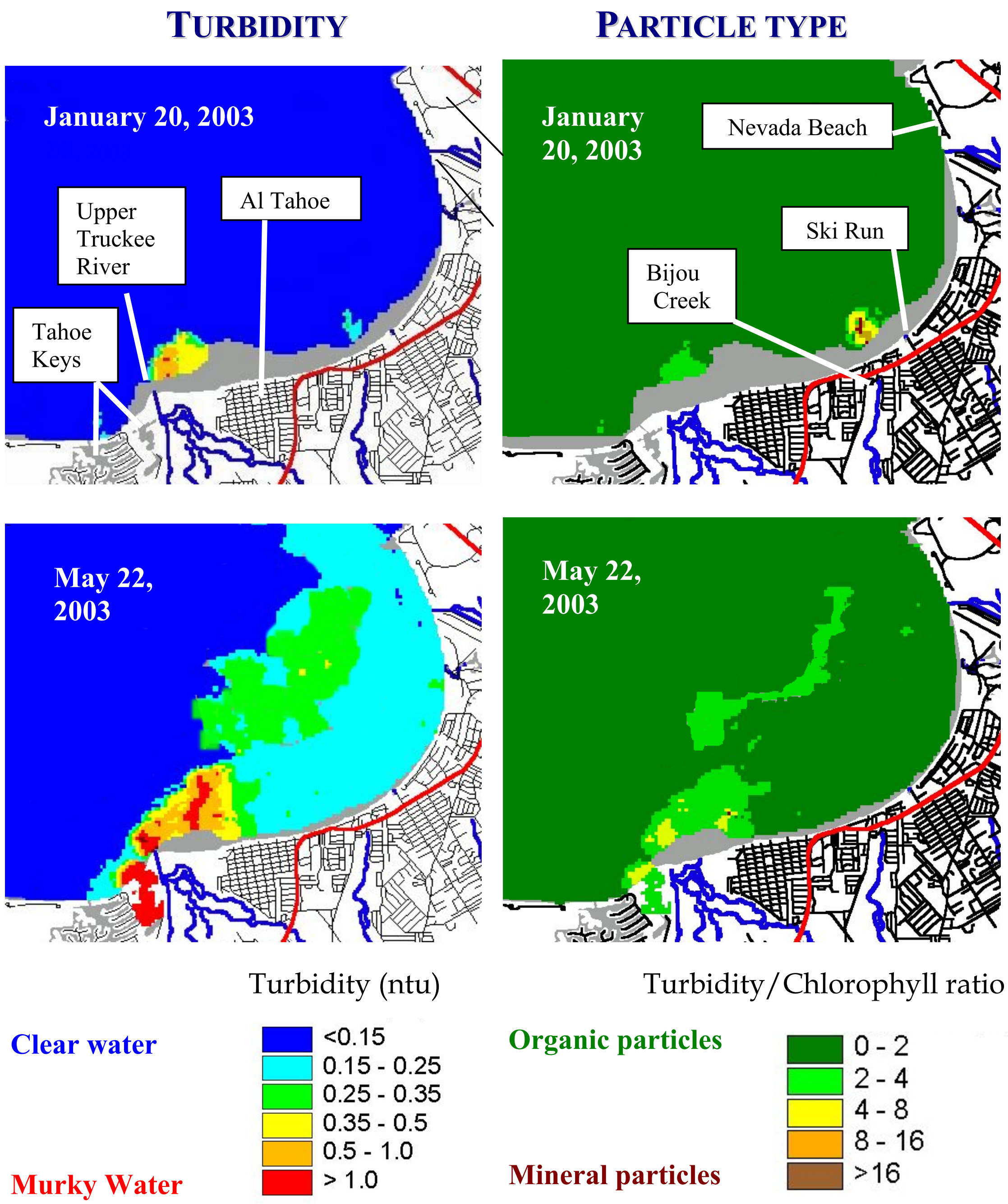

Fig. 9 The examples above show survey results from January 20, 2003 (top) and May 22, 2003 (bottom). Overall, 23 surveys of the south shore were done between July 2002 and August 2003. The colors in the left figures show the turbidity of the water. Red areas were murky and had high turbidity, blue areas were clear and had low turbidity. Areas with other colors had intermediate values. The colors in the right figures show what type of particles were in the water. Brown, orange and yellow areas had mostly mineral particles, green areas had mostly organic particles. The particle type was determined by using a scanning electron microscope and measurements of chlorophyll and turbidity. In January the near shore zone had mostly clear water except at the outlet of the Upper Truckee River and Bijou Creek. In May during the spring run off murky water from the Upper Truckee was spread by currents along the whole southeast shore.

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