

**Dry Atmospheric Deposition
of Nitrogen, Phosphorus, and Particulate Matter to Lake Tahoe**
(estimates¹ from the Lake Tahoe Atmospheric Deposition Study)

Technical Memorandum

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¹ Note: The air quality and meteorological data comprising the foundation of the deposition estimates contained herein are based on the initial review (Level I review for temporal consistency) of the data. To improve the detection of phosphorus additional laboratory analysis has been conducted and results are expected soon. Data are continuously undergoing additional review as they are summarized and analyzed. Some data are still undergoing review for Level II validation (consistency with other measurements at the monitoring site). Any future refinement of the deposition estimates after all the input data have been thoroughly validated would likely result in similar estimates to those presented here.

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1. Executive Summary

Between the mid-1960s and the mid-1990s, the water clarity of Lake Tahoe decreased from 100 feet to 65 feet. To address this concern California's Lahontan Regional Water Quality Board (LRWQCB) and the Nevada Division of Environmental Protection (NDEP) are developing a Total Maximum Daily Load (TMDL) for Lake Tahoe. A TMDL is a water quality restoration plan designed to determine the ability of a body of water to accept contaminants without resulting in a reduction in water quality. Materials that can adversely impact water clarity enter the Lake via water runoff, groundwater seepage, and direct atmospheric deposition.

To meet the need of the TMDL for estimates of atmospheric deposition to Lake Tahoe, the California Air Resources Board (CARB) conducted the Lake Tahoe Atmospheric Deposition Study (LTADS). The primary goal of this study is to quantify the contribution of atmospheric deposition to the nitrogen, phosphorus, and particulate matter loading of Lake Tahoe. This entails measurement of optically and biologically significant materials in the air over the Lake and estimation of the airborne material that deposits directly onto the lake surface. This deposition memo presents CARB's dry deposition estimates but wet deposition estimates will also be provided in the final LTADS report. The information resulting from LTADS will be used by the LRWQCB and the Tahoe Regional Planning Agency (TRPA) to develop programs to restore the clarity of Lake Tahoe.

LTADS is a multi-million dollar effort with contributions of funds and effort by the United States Environmental Protection Agency, USDA Forest Service, Tahoe Research Group (TRG), NDEP, LRWQCB, and TRPA, as well as CARB's Monitoring & Laboratory, Planning & Technical Support, and Research Divisions. Research groups from the Berkeley, Davis, Riverside, and San Diego campuses of the University of California, the Desert Research Institute (DRI), and the National Oceanic & Atmospheric Administration contributed their expertise. Planning for the study began in the Fall of 2001. By the end of 2002 several new monitoring and meteorological sites had been set up in the Lake Tahoe Basin and at Big Hill, a site south of Union Valley Reservoir. Collection of gaseous and particulate ambient air quality and meteorological data continued through the end of 2003 at all sites and some parameters into the spring of 2004 at most sites. Although air quality and meteorological measurements have been routinely collected for many years at a limited number of locations in the Tahoe Basin and although enhanced sampling has also occurred during short-term field studies, the combined sampling efforts of the ARB, TRG, the TRPA, the DRI, etc. during LTADS will result in the most comprehensive database of atmospheric data ever assembled for the Lake Tahoe region. In addition, to support the development of an improved emission inventory for critical sources, studies were undertaken to measure emission and activities factors for residential and prescribed burning, road dust and motor vehicle emissions.

To meet the atmospheric deposition input needs of the Lake Tahoe Water Clarity model, the initial data analysis task of LTADS during the summer of 2004 has been to

provide refined estimates of the atmospheric deposition of nutrients (primarily, nitrogen and phosphorus) and particulate matter that contribute to the on-going degradation of water clarity in Lake Tahoe. This technical memo transmits a summary of the measurements and analyses (including assumptions and bounding/uncertainty estimates) of the LTADS. These numbers will be incorporated into the Water Clarity Model for Lake Tahoe with inputs from other aquatic and terrestrial sources of nitrogen (N), phosphorus (P), and particulate matter (PM) to estimate the relative contributions of the various sources to the declining water clarity.

The LTADS approach for estimating atmospheric deposition to Lake Tahoe is based on seasonal-average N, P, and PM mass concentrations being apportioned, based on mass, to hourly concentrations, which then are merged with day- and hour-specific deposition velocities to provide deposition estimates. The estimates from LTADS of the annual atmospheric dry deposition of N, P, and PM to Lake Tahoe are presented, with upper and lower bounds, in the following table. Background information, approaches, assumptions, and analyses leading to these estimates are presented in the main body of this memorandum.

LTADS Estimate of Dry Atmospheric Deposition of N, P, & PM to Lake Tahoe
(metric tons/year)

Pollutant	Lower Estimate	Best Estimate	Upper Estimate
N (NH ₃ , NH ₄ ⁺ , HNO ₃ , NO ₃ ⁻)	110	160	230
P (P, PO ₄ ⁻³)	0.7	1	6
PM (fine, coarse, large)	850	1300	1800

While the LTADS dry deposition estimates for nitrogen species are consistent with previous deposition estimates; previous estimates of phosphorus deposition to the Lake are higher than the best estimate from LTADS. However, wet deposition will increase the estimate of total phosphorus deposition. Due to difficulties associated with the measurement of phosphorus in particulate matter, the analysis in this document provides upper and lower bounds estimates based on phosphorus concentrations observed at CARB's Toxics Air Contaminant (TAC) Monitoring Network and the operational limit of detection for phosphorus in ambient particulate matter samples. Filters collected as part of the Toxics Air Contaminant monitoring program are analyzed with the X-ray fluorescence (XRF) technique which reports results for 40 elements including phosphorus. Thus, phosphorus data are available for several urban but also some rural locations, including Truckee, which is just northwest of the Tahoe Basin. It should be noted that the Upper Estimate of P deposition to Lake Tahoe is very conservative, as it is based on worst case assumptions for P concentrations and deposition velocities.