Restoring Clarity to Lake Tahoe

The goal of a Nevada DOT project is clear: Reduce fine sediment runoff

By Brian A. Janes, Daniel L. Stucky & Matthew L. Nussbaumer

Small particles are threatening Lake Tahoe, located in the Sierra Nevada mountains in the western U.S. Lake Tahoe—the world's 26th largest lake by volume and the second-deepest lake in the U.S.—is 99.994% pure and has a surface elevation of 6,223 ft, making it one of the most popular year-round tourist destinations in the country.

But the transportation infrastructure that enables 3 million people to visit the lake each year has an unfortunate side effect: Fine sediment pollutants from roadways, roadway shoulders, cut slopes and embankments, traffic turnout areas, roadside ditches and other sources are slowly but surely flowing into the lake and degrading its legendary clarity.

Small Particles, Big Problem

Fine inorganic sediment particles that are less than 16 µ in diameter (about the size of a red blood cell) comprise the primary factor that has steadily reduced the lake's water clarity since 1968. More than 70% of those particles are from urban runoff associated primarily with seasonal snowmelt and rain. Because of Tahoe's huge volume of water, particles remain in suspension for a long time. Some estimate that it can take a single drop of water entering the lake almost 700 years to travel through and pass out of Tahoe's single outlet: the Truckee River, which drains the lake on its western shore.

When combined with rising levels of nitrogen and phosphorus—primarily by urban storm water—and the increased growth of algae and other aquatic plants, the damage to Lake Tahoe from fine sediment is severe enough to have caused the U.S. Environmental Protection Agency (EPA) to classify the lake under the Clean Water Act Section 303(d) as "impaired."

The good news is that government agencies, environmentalists, commercial enterprises, concerned citizens, scientists and engineers are actively and intentionally collaborating—and spending millions of dollars—to reduce the lake's fine sediment pollutant loading by at least 34% over the next 20 years (compared with levels measured in 2004).

If it can be achieved, a 34% reduction in sediment is expected to increase water clarity (the depth at which a white, 10-in.-diameter Secchi disk can no longer be seen) from today's Secchi depth of approximately 70 ft to a depth of 80 ft. Ultimately, federal and state regulators hope to restore the lake's clarity to its historical Secchi depth standard of about 100 ft—last observed in 1968.

When American writer and humorist Mark Twain visited Lake Tahoe in 1872, he declared it to be "the fairest picture the earth affords." *Photo courtesy of Atkins*

A Solution to FSP Pollution

Working with a wide spectrum of agencies and organizations, the Nevada Department of Transportation (NDOT) set out to develop a solution to the problem that fine sediment particles (FSPs) from storm water runoff are posing to Lake Tahoe's clarity.

Supported by grants from the U.S. Army Corps of Engineers (USACE) and the Nevada Division of Environmental Protection (NDEP), a new software package for Lake Tahoe resource managers was deployed in 2009: the Pollutant Load Reduction Model (PLRM).

Based on predictions in pollutant load reduction, the PRLM enables resource managers to compare the potential effectiveness of alternative methods for improving the quality of storm water flowing into the lake. The PLRM employs algorithms to estimate the lake's pollutant concentrations.

For example, the PLRM can determine the average annual amount of FSPs that are "mobilized" from various runoff areas. The PLRM also can be used to model a variety of FSP reduction strategies for a particular location, such as road shoulder protection, street-sweeping effectiveness and frequency, the connectivity of impervious pavement areas, the application of traction

sand, the construction of infiltration basins, hydrologic dispersion areas and the use of cartridge filters.

NDOT's mission developed new urgency after August 2011, when U.S. Sen. Dianne Feinstein of California, EPA Regional Administrator Jared Blumenfeld, California Gov. Edmund G. Brown and Nevada Gov. Brian Sandoval capped off a decade of collaboration between government agencies and private stakeholders by signing a piece of legislation known as the Lake Tahoe Total Maximum Daily Load (TMDL)—designed to help limit the amount of FSPs that are carried into the lake.

Some of the major challenges faced by NDOT include bare soil vehicle and visitor traffic, the application and removal of traction sand during and after snowstorms, culvert outlets that drain to steep fill slopes, the close proximity of the lake to the roadway, the lack of vegetation on roadway cut slopes and limited right-of-way for improvements.

While the amount of erosion occurring at any given location may seem negligible, the overall impact becomes significant when it is multiplied by millions of visitors, tens of millions of vehicle miles traveled and hundreds of culvert outlets. As a result, the development of drainage features that are compatible with sustainable bikeways, hiking trails and vehicle parking facilities has been a challenge for developers and regulators.

Zeroing In On S.R. 28

NDOT, which is responsible for retrofitting state-managed roadways in the Lake Tahoe basin to meet TMDL requirements, secured the services of the engineering firm Atkins to help complete the planning and design of water quality and erosion control improvements along a heavily traveled, 2.7-mile length of Nevada State Road (S.R.) 28, a national scenic byway that follows the lake's northeast shore.

As a first step toward meeting the objectives of the S.R. 28 Water Quality and Erosion Control Project, Atkins was tasked with:

- Investigating the impact of roadway infrastructure on water quality;
- Assessing the existing drainage facilities to identify storm water drainage problems;
- Performing geotechnical investigations of culvert pipes, soil conditions and existing utilities;
- Determining the baseline conditions of biological and cultural resources; and
- Identifying project constraints and opportunities for implementing water quality improvements.

In February 2012, Atkins submitted its Existing Conditions Analysis Report (S.R. 28 ECA) to NDOT. The multifaceted purpose of S.R. 28 ECA was to determine baseline FSP loading estimates, prioritize project alternatives according to cost/benefit ratio and serve as a basis for developing the Formulation and Evaluation of Alternatives (FEA) Report, from which the project's preferred alternative solutions can be determined.

Another purpose of the FEA Report is to provide a basis for the environmental documentation that is needed before any project-related rights-of-way can be acquired.

FSP Reduction Strategies

In August 2012, Atkins submitted the FEA Report, which describes the findings of its investigations and presents a range of feasible alternatives to handle storm water runoff that is traceable to NDOT rights-of-way.

The FEA Report recommends a multifaceted problem solving approach that delivers the project's desired water quality results while carefully considering key factors such as capital and maintenance costs, public safety concerns, aesthetics and potential right-of-way acquisitions. The plan specifically recommends a wide range of complementary strategies, including:

- Incorporating riprap and/or revegetation to reduce sediment runoff from bare slopes;
- Protecting roadway shoulders with curbs and gutters;
- Paving shoulders and turn-outs with asphalt;
- Stabilizing roadway embankments with timber walls or other erosion-control structures;
- Installing additional drop inlets to reduce storm water overtopping of roadways;
- Constructing surface and subsurface infiltration basins where they are appropriate;
- Installing canister filters where high FSP volumes are indicated;
- Reducing directly connected impervious drainage areas; and
- Limiting concentrated flows and promoting dispersed runoff and energy dissipation.

As of October 2012, the next steps for NDOT are to approve its selection of solution alternatives, finalize a PLRM model of the improvements and develop design plans.

The Future in the Balance Over time, federal, state and local decision-makers hope that their erosion-control measures will be effective and Lake Tahoe will be restored to much of its former pristine condition. But the sheer magnitude of the undertaking presents a daunting—and staggeringly expensive—prospect. Some estimates indicate that the total overall cost of clarifying Lake Tahoe may exceed $1.5 billion, and the ultimate water clarity goals set by the TMDL legislation may not be achieved until 2075. SWS

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