California Regional Water Quality Control Board
Lahontan Region

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FACT SHEET

Questions and Answers about Water Sampling Conducted at Lake Tahoe on the Fourth of July

Why did the California Water Quality Control Board-Lahontan Region (Regional Board) collect water samples during the Fourth of July fireworks display?

During the Spring of 2001, the Regional Board was copied a letter addressed to Tahoe Regional Planning Agency (TRPA) concerning the effect of the fireworks displays on the purity and clarity of Lake Tahoe. The Regional Board decided to conduct a preliminary investigation by collecting water samples before, during, and after the July Fourth 2001 Fireworks Display. This limited sampling would determine if levels of certain chemicals used in pyrotechnic shows were elevated after the fireworks event and if more research was needed to determine if these chemicals were impacting the purity and clarity of Lake Tahoe.

What constituents were analyzed in the water samples?

Regional Board staff consulted Dr. Glenn C. Miller from the University of Nevada, Reno regarding fireworks chemistry and the appropriate analyses to run on the water samples. The dominant component of fireworks is an oxidizer such as potassium perchlorate, ammonium perchlorate, or potassium nitrate which helps create a controlled explosion. Color effects (i.e., white sparks, red and blue flames) are created by the high temperature oxidation of various metals (barium, copper, strontium) and salts (magnesium and sodium). The constituents of most concern because of their stimulating effect on algae growth were the nitrogen containing species including nitrate and ammonia. Though phosphorus also stimulates algae growth, water samples were not analyzed for phosphorus because there is no phosphorus content in fireworks.

What chemicals appeared elevated after the fireworks display?

The only constituent that appeared elevated over background levels after the fireworks display was perchlorate. Perchlorate concentrations that were measured ranged from non-detectable levels before the fireworks show to 63 µg/L after the fireworks were deployed. On July 5, a water sample was collected from approximately the same location as the July 4 samples. The July 5 sample, collected 12 hours after the July 4 samples, contained non-detectable levels of perchlorate. Separate but similar sampling conducted on the evening of Independence Day by

Dr. Glenn C. Miller, however, did show elevated levels of nitrate (< 0.001 mg/L pre-fireworks to 0.061 mg/L post-fireworks) as well as perchlorate. Discrepancies in nitrate results may be attributed to the different laboratories that analyzed the water samples or the different sampling locations (Regional Board samples were collected approximately 600 feet from the fireworks barge whereas the UNR samples were collected approximately 25 feet from the barge). Samples collected by the Regional Board were analyzed by Nevada Environmental Laboratories whereas samples collected by Dr. Glenn Miller were analyzed at the Analytical and Trace Laboratories at the Desert Research Institute.

What is perchlorate?

One chlorine and four oxygen molecules (ClO_4^-) make up the ion known as perchlorate. Perchlorate is an oxidizer that helps create a controlled explosion in solid propellants for rockets missiles, matches, and fireworks. Perchlorate also originates as a contaminant in ground and surface waters from the dissolution of ammonium, potassium, magnesium, or sodium salts. Perchlorate salts have a variety of industrial uses where perchlorate is used in air bag inflators and in nuclear reactors and electronic tubes. Perchlorate salts are used as additives in lubricating oils, in tanning and finishing leather, as a mordant for fabrics and dyes, and in electroplating, aluminum refining, rubber manufacture, and the production of paints and enamels. Perchlorate also appears to be associated with certain types of fertilizers.

How much perchlorate is contained in the fireworks and how much perchlorate is entering Lake Tahoe during the fireworks events?

Oxidizers such as potassium perchlorate, potassium chlorate, and ammonium perchlorate are the dominant components of fireworks compositions and, potassium nitrate is the largest bulk ingredient of the black powder in fireworks. The amount of perchlorate contained in an individual firework varies depending on the color and effect produced by the firework. Typical compositions may contain up to 38 % by weight potassium perchlorate for a blue star, 50 % by weight ammonium perchlorate for a green fire, and 64 % by weight potassium chlorate for a red star [1].

At this time, we are unable to calculate the approximate perchlorate load to the Lake that results from the pyrotechnic displays occurring on Lake Tahoe during the Fourth of July and Labor Day. Information regarding pounds of fireworks deployed and information regarding the fate and transport of perchlorate in the water column are not yet known. Regional Board have learned Pyrodigital Consultants out of Sacramento organizes the fireworks shows occurring during Fourth of July and Labor Day. Assuming Pyrodigital Consultants can provide information on the total pounds of fireworks deployed during each fireworks event and Regional Board staff or other agencies can determine the depth and area distribution of perchlorate, we can estimate the

[1] McLain, J.H., "Pyrotechnics," Franklin Institute Press, Philadelphia, 1980 and Lancaster, R., "Fireworks Principles and Practice," Chemical Publishing Co., New York 1972: manufacturer's information.

total load of perchlorate, associated with the fireworks displays, that are discharged to Lake Tahoe.

Where has perchlorate been detected in the United States?

The U.S. EPA Office of Water reports that there has not been a systematic national survey of perchlorate occurrence. Since 1997, a sensitive analytical procedure has helped detect perchlorate in surface or groundwater at 14 states including California, Texas, Nevada, Utah, Arkansas, Maryland, and New York. The majority of locations where perchlorate has been detected in the groundwater are in California, associated with twelve facilities which have manufactured or tested solid rocket fuels for the Department of Defense (DOD) or the National Aeronautics and Space Administration (NASA). In Nevada, two facilities which manufactured ammonium perchlorate released perchlorate to groundwater resulting in low levels (4 to 16 ppb) in Lake Mead and the Colorado River. This water is used for drinking water supply, irrigation and recreation for millions of people in Nevada, California, Arizona, and Native American Tribes (http://www.epa.gov/safewater/ccl/perchlor/perchlo.html#overview). The Nevada Division of Environmental Protection is working with Kerr-McGee Chemical Company to intercept and treat contaminated surface flows entering the Las Vegas Wash. This effort has significantly reduced the amount of perchlorate entering the Las Vegas Wash which supplies less than two percent of the water in Lake Mead.

In February 1997, the California Department of Health Services (DHS) sampled several hundred drinking water wells for perchlorate after perchlorate was first found in drinking water wells in eastern Sacramento County (up to 260 µg/L), near Aerojet General Corporation's facility. As of April 2002, perchlorate has been detected in 246 drinking water sources (principally wells), most of them in southern California. (For more information about perchlorate detections, see http://www.dhs.ca.gov/ps/ddwem/chemicals/perchl/perchlindex.htm).

How does perchlorate behave in the environment?

The perchlorate ion is nonvolatile and highly soluble in the environment. Because perchlorate is not very reactive chemically, degradation of perchlorate through sorption or natural chemical reduction in the environment is not significant. Perchlorate is mobile in aqueous systems and can persist for many decades under typical ground and surface water conditions because of its resistance to react with other available constituents.

In a lake setting, the compound is very stable especially if it remains under aerobic conditions. Because perchlorate has a density nearly twice that of water, the chemical will sink. Reductions in initial concentrations are likely caused by dispersion throughout the water column and dilution by the waterbody. However, if perchlorate is buried in the bottom lake sediments, breakdown of perchlorate can be rapid under anaerobic biological conditions.

Though the fate and transport of perchlorate in Lake Tahoe has not been studied, because we know perchlorate is nonvolatile, highly soluble, and not likely to sorb to sediments, we can speculate perchlorate introduced to Lake Tahoe may remain suspended in the water column or in

bottom sediments for long periods of time. Studies suggest perchlorate is rapidly broken down under anaerobic conditions. However, because Lake Tahoe is an oligotropic water (low nutrient input compared to other nutrient rich lakes) the lake contains less organic matter and planktonic algae. With less algae and organic matter to decompose, the oxygen content of Lake Tahoe's water column and the top layers of the bottom sediments is maintained. Since Lake Tahoe's top bottom sediments are well oxygenated, perchlorate breakdown by means of anaerobic bacterial action will not be significant unless perchlorate is buried to the deeper, oxygen depleted sediments.

Are there any health advisories regarding safe levels of perchlorate?

Currently, perchlorate is an unregulated chemical for which monitoring is required (Title 22, CCR § 64450). The DHS has developed an action level for perchlorate of 4 µg/L (ppb), based mainly on health effects (see below for details on health effects). The DHS website explains that action levels are health-based advisory levels established for chemicals in drinking water for which primary maximum contaminant levels (MCLs) have not been adopted. An MCL is an enforceable standard, adopted by DHS, that must be met by all water purveyors providing drinking water to the public.

Action levels are advisory to water suppliers. If water is served that contains perchlorate above the action level, the DHS recommends the water supplier notify its consumers. If the water supply is a well, water suppliers must notify the local city council or board of supervisors. According to DHS, an action level is determined "using standard risk assessment methods for non-cancer and cancer endpoints, and typical exposure assumptions, including a 2-liter per day ingestion rate, a 70-kilogram adult body weight, and a 70-year lifetime." (http://www.dhs.ca.gov/ps/ddwem/chemicals/AL/actionlevels.htm). If drinking water contains perchlorate below the action level, it is considered to not pose a significant health risk.

In March 2002 the Office of Environmental Health Hazard Assessment (OEHHA) released a draft public health goal for perchlorate in drinking water of 6 µg/L (http://www.oehha.ca.gov). The United States Environmental Protection Agency's (USEPA's) National Center for Environmental Assessment released in January 2002 a draft risk assessment for perchlorate that suggests an acceptable level for perchlorate of 1 µg/L. (http://www.epa.gov/ncea)

Currently, no water quality limits have been developed for the protection of aquatic life from exposure to perchlorate. The draft USEPA report mentioned above contains information about the ecological effects of perchlorate.

How do unsafe levels of perchlorate affect my health and am I at risk?

The DHS has established an action level of 4 µg/L for perchlorate. DHS believes concentrations at or below 4 µg/L are not considered to pose a health concern for the public, including children and pregnant women and their developing young.

Perchlorate can interfere with the thyroid gland's ability to take up iodine and to produce thyroid hormones, which are needed for normal metabolism in the adult, and for normal pre-and post-natal growth and development. These hormones are especially critical during the gestation period when the brain is developing.

With regard to the perchlorate concentrations measured on the Fourth of July, though the highest concentration measured was 15 times greater than the 4 µg/L action level developed by DHS, it is unlikely any persons who rely on drinking water from Lake Tahoe experienced a health risk from this exposure. A person would need to ingest 8 glasses of water (with each glass containing perchlorate at levels greater than 4 µg/L) over an extended period of time to experience health risks associated with perchlorate effects on the thyroid. Assuming the treatment methods at a drinking water plant did not remove perchlorate, some consumers may have ingested low levels of perchlorate.. However, if consumers were exposed to perchlorate over the action level of 4 µg/L, their exposure was likely a one-time occurrence or for only a short duration of hours or days, not weeks, months, or years.

For more information and links to OEHHA and USEPA perchlorate documents, see http://www.dhs.ca.gov/ps/ddwem/chemicals/perchl/actionlevel.htm.

What Are Other Local Agencies Doing to Address Water Pollution Associated with Firework Displays?

In their 2001 Threshold Evaluation, the Tahoe Regional Planning Agency (TRPA) committed to cooperating with the Nevada Department of Environmental Protection and the Regional Board to research the impacts of fireworks on Lake Tahoe. Approximately $20,000 in funding is associated with research to investigate impacts to water clarity, water quality, and biological processes. If monitoring results indicate significant water quality problems are associated with fireworks displays, the TRPA may regulate pyrotechnic displays as necessary (TRPA 2001).

The sponsors of the Lake Tahoe fireworks displays which include the Lake Tahoe Gaming Alliance, the Lake Tahoe Visitors Authority, and members of Labor Day Lake Tahoe fund an aggressive clean-up effort following the Fourth of July and Labor Day fireworks displays. Clean-up efforts involve the retrieval of physical debris on the lake surface immediately following the show, and a clean-up of below the surface and on the lake bottom by divers the following day. Beginning this year, the technicians who handle the fireworks shows will deploy a new vessel specifically designed to improve the efficiency and effectiveness of the clean-up program.

Technicians from the Lake Tahoe Gaming Alliance who assist with the Lake Tahoe fireworks shows are committed to working with staff from the Lahontan Regional Board to coordinate a sampling plan to evaluate the impacts of future pyrotechnic displays.

Recommendations for the future

1. Encourage water utilities including Lakeside Water Company and other water companies with lake intakes near areas where pyrotechnics are displayed to sample for perchlorate in the days prior to and immediately following fireworks shows. If monitoring by water purveyors indicates intake water does contain perchlorate, water purveyors should consider implementing management measures to minimize public exposure to perchlorate.

   If perchlorate is found to be impacting water intakes, the pyrotechnics company could relocate the fireworks barge to an area farther from intake pipes.

2. Determine if the fall-out debris associated with fireworks impacts water quality and fish habitat including feed and cover.

3. Implement long-term ambient monitoring to ensure perchlorate concentrations do not increase in Lake Tahoe.

4. Implement sampling that includes water analysis for Total Kjeldahl Nitrogen (TKN). Water quality samples collected during 2001 do not indicate significant increases in nitrate levels following fireworks displays; however, the algae present in the water column may be utilizing the nitrate and converting it to TKN so quickly that little nitrate remains in the water. A measure of nitrate plus TKN will provide regulators with a Total Nitrogen concentration. Total Nitrogen is a more useful comparative number when determining impacts to Lake Tahoe. The Lake Tahoe water quality objective for Total Nitrogen has been established at 0.15 mg/L.

5. Implement management measures to reduce the impacts related to fireworks displays (e.g., limit the number of pyrotechnic displays/year, move the fireworks display farther from the drinking water intake at Lakeside Water Company, remove the fireworks debris immediately following the fireworks event, etc.). Ensure all entities coordinating fireworks shows, including those in Tahoe City, Kings Beach, Incline Village, et al., commit to cleanup of fireworks debris after the show.

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