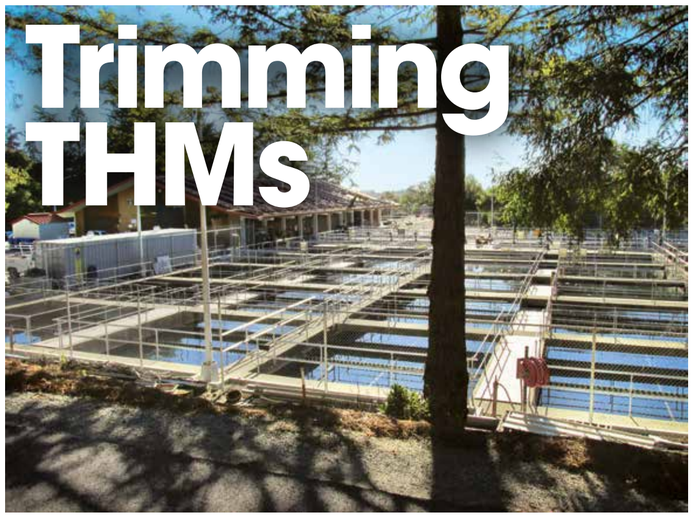


Trimming THMs

By Terrence H. McKinney & Charis Thompson

Online THM analyzer aids mitigation strategies for city of Santa Cruz

In drought-ridden California, water utilities such as the City of Santa Cruz Water Department (SCWD) are tasked with addressing water supply challenges from current and future drought conditions while continuously providing safe drinking water meeting federal and state regulations. With the implementation of the Stage 2 Disinfection Byproducts Rule (DBPR), reducing trihalomethane (THM) formation has been of vital concern to SCWD, which has experienced elevated levels of THM formation potential (THM-FP) since placing a greater reliance on a lake as source water for the Graham Hill Water Treatment Plant (GHWTP). SCWD has undertaken feasibility studies on aeration methodologies, enhanced coagulation, chlorine dioxide and distribution system realignment to reduce distribution system THM levels. An online analyzer has aided SCWD in its daily operations and management of feasibility studies by providing reliable real-time data on THM and THM-FP levels within the WTP and distribution network.

Source Water Situation

The GHWTP is an 18-million-gal-per-day conventional filtration facility serving the needs of more than 66,000 residents in the city of Santa Cruz and the surrounding county. Water comes to the GHWTP from three sources: the San Lorenzo River; North Coast Streams, a series of small dams and spring boxes operated by SCWD; and a large lake in the Santa Cruz Mountains called the Loch Lomond Reservoir.

The quality of SCWD source water varies greatly and has a direct effect on the effluent THM-FP discharged from the GHWTP. When the Loch Lomond Reservoir is the main raw water source, effluent THM-FP levels are at a maximum of 140 ppb. When the San Lorenzo River and other coastal sources are the main raw water sources, effluent THM-FP levels are at a maximum of 70 ppb.

In 2007, in an effort to further protect local aquatic environments and species, the California Department of Fish and Wildlife requested a decrease in water usage from rivers and streams. As a result of this change, SCWD has placed a greater reliance on water from the Loch Lomond Reservoir.

Aeration Study

To ensure regulatory compliance with the Stage 2 DBPR while adhering to new source water requirements, SCWD conducted a feasibility study on commercially available aeration technologies to remove THMs from its reservoirs and complement existing operational THM mitigation efforts. A series of isolated tank experiments were undertaken.

Water quality parameters were monitored throughout the study. Grab samples for THM concentration and chlorine residual were taken three times per day for the first week of the study, after which the frequency was reduced to once per week because it became too costly, time-consuming and labor-intensive to keep the original schedule.

A contract laboratory was hired to test the grab samples for THM concentrations. Analyses took approximately two to three weeks to be returned. As a result, SCWD conservatively operated the aerators while waiting to receive THM results to ensure they remained in regulatory compliance. This approach resulted in increased operational expenses on chemicals, sludge removal, power and other resources used during the aeration feasibility study. Additionally, the long durations between sampling and obtaining the analytical results hindered the timely progression of the study.

Additional Data

In June 2014, SCWD began continuous online monitoring of THM values in the GHWTP effluent with the THM-100 manufactured by Aqua Metrology Systems. The throughput for each THM analysis is approximately two hours. The analyzer allows manually collected grab samples from other locations within the water plant and distribution network to be analyzed alongside samples taken automatically by the monitor in its online mode. It is scheduled to perform six online samples per day, and grab samples are queued to start immediately when the instrument is idle.

Using the new analyzer, grab samples from the aeration study were collected and analyzed along with samples from 11 other locations within the distribution network.

The real-time THM data proved essential in understanding the performance of the aeration systems under the varying test operational conditions. Recognizing that in-network THM-FP values were two times effluent total THM (TTHM) levels measured at the GHWTP, SCWD aimed to consistently limit in-plant TTHM levels to less than 35 µg/L to ensure the GHWTP remained in regulatory compliance with the 80 µg/L limit. The THM and THM-FP profile for the GHWTP and its network are depicted in the graph on page 33.

The online THM analyses aided SCWD in cost-effectively characterizing and monitoring THM levels resulting from aeration, and efficiently managing the study.

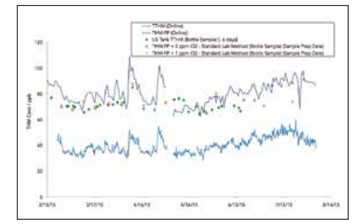
Following the conclusion of the aeration study, SCWD has installed two aeration systems, and the THM-100 continues to be used for daily online analyses of TTHM and THM-FP levels.

Accelerated Online THM-FP

In November 2014 the analyzer was upgraded to a THM-100-FP system capable of providing online THM-FP characterization of the GHWTP effluent. Whereas a standard laboratory method for THM-FP analysis typically requires sample manipulation (Cl_2 adjustment, temperature control and a seven-day incubation period) and an analytical laboratory analysis of THM levels, this new online methodology is automated and returns the THM-FP level within three hours. The analyzer uses software modifications applied to the THM-100 to accelerate the formation of THMs in a water sample acquired inside the heated purge of the THM-100-FP, through the reaction between the residual dissolved organic carbon, bromide and Cl_2, at elevated temperature (approximately 50°C to 70°C) with a reaction time of less than 60 minutes.

Both the THM-forming reaction time and temperature are customizable parameters in the analyzer's software, with the objective of tuning the THM-FP level so that it is similar in magnitude to the TTHM levels at the furthest node in the network (in this case, at "University 5," a storage tank, with an average age of seven days after exiting the GHWTP).

This customization period typically is completed in less than three months, with only a few iterations. It is difficult to precisely correlate water treatment plant THM-FP levels with network TTHM levels because the former is an instantaneous characterization of the water quality leaving the GHWTP, whereas in the network it is a hydrodynamic blend of water of different ages. With the THM-100-FP configuration, the online schedule at the GHWTP was modified to five daily online TTHM samples and one daily online THM-FP sample.



The THM-FP of the GHWTP changed from approximately 68 to 110 µg/L in less than two days, demonstrating the need for high-frequency monitoring.

Online THM and THM-FP analyses provided a high frequency of rapid, reliable DBP data compared to the turnaround from external laboratories. Network TTHM values and lab-based THM-FP values helped drive and refine the experimental conditions, settling on a correlation of online THM-FP values being two times greater than online TTHM effluent values at the plant.

SCWD currently is in negotiations to transfer wintertime water to the Soquel Creek Water District (SQCWD). The transfer would offset groundwater pumping and allow SQCWD's aquifers to recharge, but SQCWD is concerned about the THM levels in SCWD's water. THM-FP results from the analyzer will allow SCWD to ensure the water transferred to SQCWD is in compliance.

Distribution System THM Mitigation

The THM and THM-FP data from the THM-100 have aided SCWD in managing THMs in the distribution system. If THM-FP levels are high, SCWD makes process changes to reduce THM concentrations at the system's end points. For example, when THM-FP is high, SCWD isolates one of the Bay Street Reservoir tanks. The water is held in the tank for a period of seven days and then the aerator in the tank is turned on. When THM values have decreased, the isolated tank is put in service and water is allowed to move through the system up to University 5. This method allows SCWD to manage THM concentrations at one of the end points of the distribution system. Additionally, using the aerators only when necessary allows the SCWD to reduce energy costs.

The analyzer also has helped SCWD optimize flushing flow rates and flushing times at the end points of the distribution system. SCWD flushes the end points of the distribution system weekly. The manually collected bottle sample analysis feature of the analyzer has allowed it to develop baseline THM concentrations for the system's end points.

The online THM and THM-FP analyzer has proved essential to SCWD's daily operations and management by providing real-time and reliable data on THM and THM-FP levels within the water treatment plant and distribution network. W&WD

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