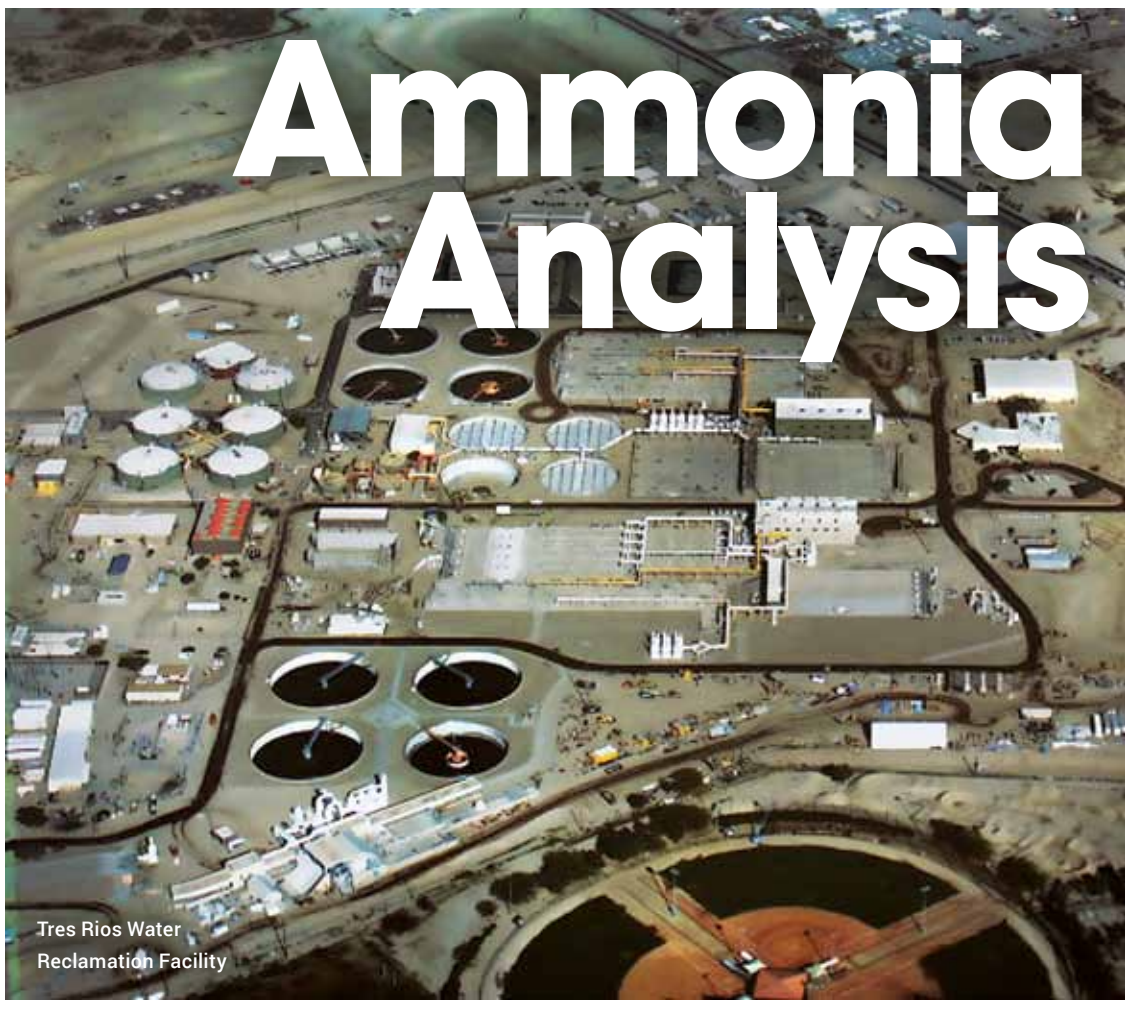
Ammonia Analysis


Tres Rios Water Reclamation Facility

By Jeff Prevatt

Arizona facility employs ammonia-laden centrate for THM control

In 2007, the Pima County Regional Wastewater Reclamation Department (RWRD) embarked on a $720 million Regional Optimization Master Plan (ROMP) to improve the quality of its effluent. The ROMP was initiated after the Arizona Department of Environmental Quality (DEQ) ruled that ammonia effluent levels from regional treatment facilities were too high. In accordance with federal requirements, DEQ set permissible nitrogen and ammonia limits to a range of 8 to 10 mg/L, and imposed a Jan. 1, 2014, compliance deadline for the Tres Rios Water Reclamation Facility (WRF), formerly known as the Ina Road WRF.

The Tres Rios WRF primarily receives domestic wastewater from 380,000 Tucson, Ariz., residents at an average flow of 25 to 35 mgd. However, there are 48 categorical and significant industrial users in the Tucson area also discharging to the facility. Typical loading rates at the facility include ammonia at 35 mg/L, suspended solids ranging from 250 to 500 mg/L and influent biological oxygen demand ranging from 200 to 450 mg/L.

The Upgrade Process

The RWRD expanded and upgraded the 37.5-mgd Tres Rios WRF to 50 mgd. The project included the construction of a new 25-mgd ammonia-, nitrogen- and nutrient-removal process system to replace an existing 25-mgd high-purity oxygen train; the upgrade of an existing 12.5-mgd biological nutrient-activated-sludge process train for additional nutrient removal; and the construction of another 12.5-mgd capacity ammonia-, nitrogen- and nutrient-removal process system. For nitrogen removal, a five-stage Bardenpho process was employed to pass the flow through an anaerobic zone and then through alternating anoxic and aerobic zones. Step-feed and simultaneous nitrification and denitrification features also were incorporated into the Bardenpho process.

The fully expanded Tres Rios WRF went online in December 2013. Prior to the optimization, the facility was releasing wastewater with nitrogen levels between 30 to 35 mg/L, well above the 10-mg/L maximum requirement. Following the completion of the upgraded facility, effluent nitrogen levels remained below 3 mg/L.

In fact, the nitrogen removal system was so effective at reducing nitrogen and ammonia levels that it posed an unforeseen problem for operators: With reduced levels of ammonia in the effluent, the chlorine disinfectant injected prior to discharge began producing lower levels of chloramines, thus elevating total trihalomethane (TTHM) values beyond the 100-µg/L regulatory limit and increasing the potential for disinfection byproduct (DBP) formation.

Controlling THM Formation

To address the elevated levels of TTHM, operational staff began evaluating options to control and reduce THM formation. Initial calculations showed aeration—specifically air stripping—could have a significant reduction in THM concentration.

As volatile organic compounds, THMs can be removed from water through volatilization given sufficient gas transfer opportunities. There are four primary species of THMs: chloroform ($CHCl_3$), bromodichloromethane ($CHBrCl_2$), dibromochloromethane ($CHBr_2Cl$) and bromoform ($CHBr_3$). Chloroform is the most volatile of the primary THMs and the most prevalent at Tres Rios WRF. The TTHM concentration at the facility was composed of $CHCl_3$ at 40% to 60%, $CHBrCl_2$ at 30% to 40%, $CHBr_2Cl$ at 10% to 15% and $CHBr_3$ at 0% to 2%.

Packed towers, or spray, diffused or tray aeration all are methods of THM removal through air stripping. Each method has associated costs and gas transfer efficiencies. Air stripping using a combination of mixing and spray nozzles was the most applicable aeration approach to pilot at the Tres Rios WRF because of its ability to be easily retrofitted to the chlorine contact basin at a minimal cost and construction time.

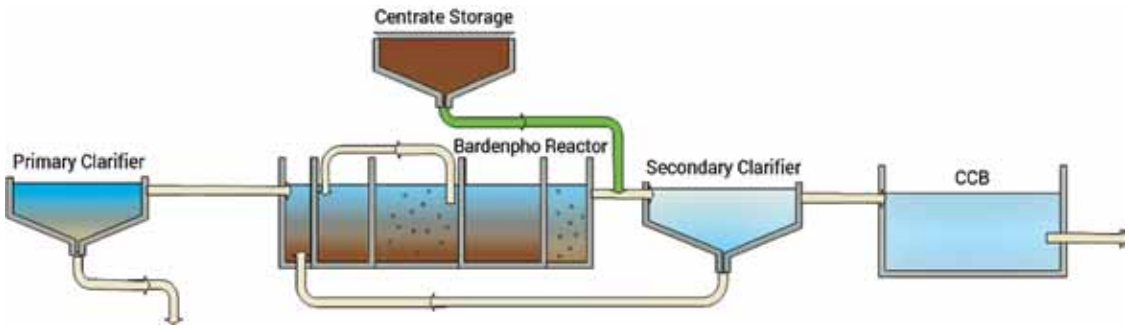
The aeration pilot, managed in-house with collaboration from Greeley and Hansen, was undertaken June 5 to 28, 2014. While the specific flow rate from the spray heads was not determined, the flow rate through the contact basins was variable and ranged from 15 to 55 mgd. A maximum nozzle pressure of 32 psi was achieved with the equipment used in the pilot. Samples collected pre- and post-spray nozzles showed significant reduction in THMs—greater than 60%. However, the impact to the in-stream THM concentration was not significant enough to warrant additional testing or full-scale implementation of the technology.

After the aeration study failed to provide a viable means to bring the Tres Rios WRF into regulatory compliance with the 100 µg/L effluent TTHM limit, an ammonia additive was proposed to reduce the formation of DBPs and preclude the formation of THMs through the creation of monochloramines. Instead of using costly chemical additives, operational staff focused on two internal sources of ammonia—primary effluent and centrate—for addition to the secondary effluent stream. The secondary effluent typically contained less than 1 mg/L of ammonia and would require ammonia concentration levels of 1 to 2 mg/L to aid in the formation of monochloramines.

Upon closer review, the primary effluent contained low ammonia concentrations and would require pumping of large volumes that could possibly alter the quality of the effluent stream in order to create the levels necessary for ammonia addition. Conversely, the ammonia-laden centrate containing approximately 1,000 mg/L of ammonia would require small volumes to bring the secondary effluent ammonia concentration to the levels necessary to aid in the formation of monochloramines.

Testing Technology

As a result, a bench test was conducted to determine the viability of centrate as an ammonia additive. During jar testing, spikes of centrate resulted



Centrate added to prior secondary clarification

in ammonia concentrations that held relatively constant over several hours. Following the successful bench study, a full-scale centrate addition pilot study was undertaken in July 2014.

During the centrate pilot, operators wanted to characterize THM values and measure levels pre- and post-chlorine injection. At the time, commercially available online THM water quality monitors were specific to potable water applications, not wastewater. Nonetheless, a leading online THM monitor for potable water applications was evaluated at Tres Rios WRF. A comparison of laboratory THM results with several daily measurements taken from the online meter showed the instrument to have poor correlation of data.

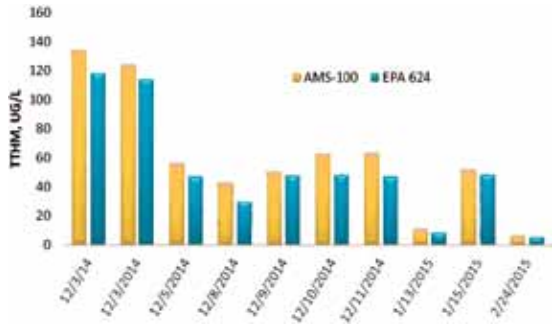
Operators then evaluated the THM-100 online THM analyzer manufactured by Aqua Metrology Systems, and the instrument showed excellent comparative results with external laboratory data. In December 2014, a full-scale pilot of the fully automated and online THM-100 was undertaken and integrated with the centrate pilot study to characterize and monitor THM levels.

Plant flow was split into two trains, and the THM-100 instrument was placed on one train treating between 26 to 30 mgd. The instrument was calibrated to laboratory results and run under split sampling and laboratory analysis test conditions. THM values ranged between 50 to 100 µg/L and the instrument consistently read within 5 to 10 µg/L of the laboratory results. The validation of the monitor found the instrument to be consistent and highly reproducible, with a standard error of deviation as low as 2%.

The THM-100 analyzer uses an approved "purge-and-trap" sampling method, followed by desorption into a chemical mixture that generates a colored product and time-resolved spectrophotometric analysis for detection and determination of THM levels. The online sampling method is automatic and does not require manual intervention. Multi-point analysis can be achieved with a single unit by manually collecting "grab" samples from other locations to analyze alongside samples taken automatically by the monitor in its online mode. The self-calibrating instrument was easily integrated into operations at Tres Rios WRF. THM levels were measured every four hours; however, more frequent measurements could be programmed if necessary. The online analyzer uses three reagents and two on-board calibration standards.

The THM-100 monitor enabled the facility to optimize its chlorine injection process and minimize the formation of THMs in its effluent water by providing the operational staff with immediate and accurate daily reports on THM levels. System performance of the unit also was remotely monitored 24/7 by the manufacturer to ensure that the instrument was operating within pre-determined parameters, enabling the factory to notify the operational staff of deviations if required.

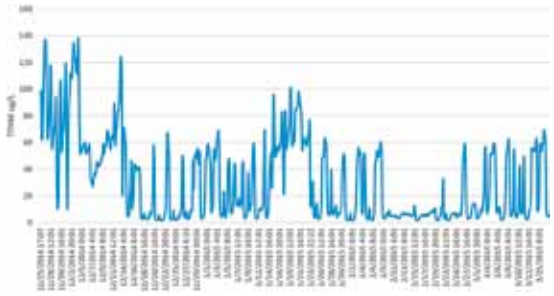
Diurnal flow and THM concentrations change throughout the day at Tres Rios WRF, like any wastewater facility. The instrument helped operational staff to monitor fluctuations in THM values resulting from changing flow rate, chlorine contact time and treatment efficiency over the daily cycle. Temperature and seasonal fluctuations affecting the



TTHM analyzer performance

THM formation rate also could be characterized with the instrument. The pilot typically only ran during standard business hours in order to maintain tank levels. As a result, THM concentrations dropped to single-digit values during operation and peaked at 40 to 60 µg/L when the pilot was offline. The THM-100 instrument adequately captured the on/off cycles of the pilot system.

Although THM shows an inverse correlation to flow in the diurnal cycle at Tres Rios WRF, a fixed centrate flow was used when adding ammonia to the secondary clarifier during the pilot testing. Concerns of whether the centrate feed would dramatically increase chlorine demand were abated when results showed no significant increase in chemical demand following centrate addition. Over a two-month pilot period, there was a dramatic decrease in THM concentrations, resulting from centrate addition.



TTHM reduction

To ensure that effluent THM and ammonia concentrations remain within regulatory permit limits following the conclusion of the pilot study, a permanent centrate feed tank with flow pacing to mimic the diurnal cycle will be implemented at the Tres Rios WRF. Additionally, the online instrument will be incorporated into daily full-scale plant operations to continuously, accurately and reliably monitor THM values in real time. W&WD

Jeff Prevatt, Ph.D., is manager of the Pima County Regional Wastewater Reclamation Department. Prevatt can be reached at jeff.prevatt@pima.gov or 520.724.6040.