WHAT'S**NEW**

New Water Research Group Members

David Gaithuma

Mr. David Gaithuma earned a B.S. in Environmental and Resource Economics in 2000 and a M.S. in Environmental Engineering in 2004 from the University of New Hampshire.

Mr. Gaithuma's graduate research at UNH focused on assessing alternative surrogates for UV reactor validation and UV dose-monitoring.

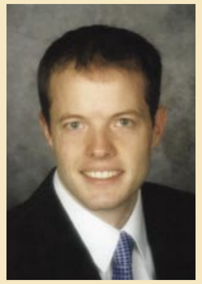
Since joining Carollo, David has validated five large-scale UV reactors (flow rates up to 44 mgd) at the Portland, Oregon UV Validation Facility. He oversees testing, conducts data analysis, and prepares validation reports. Mr. Gaithuma is also involved in research evaluating UV system operations and reliability funded by the New York State Energy Research and Development Authority (NYSERDA) and AwwaRF. David will serve as a technical advisor on future Carollo UV designs.

Thomas E.T. Gillogly, Ph.D.

Dr. Thomas E.T. Gillogly received his M.S. and Ph.D. in Environmental Engineering from the University of Illinois at Urbana-Champaign. He joins Carollo with over 12 years of experience in environmental engineering and has authored or co-authored over 40 conference proceedings papers and peer-reviewed papers. Tom is the Vice-Chair of the AWWA Inorganics Committee.

Tom has had the opportunity to support a wide variety of clients with an equally diverse set of challenges. Some of his recent activities have taken him abroad to Morocco, Costa Rica, and Fiji to address ozonation-related issues for facilities ranging in size from 0.2 to 320 mgd. His domestic project base spans the country, dealing with disinfection by-product control, as well as trace inorganic and synthetic organic contaminant mitigation.

Patrick Carlson



Mr. Patrick Carlson earned his B.S. in Civil Engineering from the University of Utah. His graduate research focused on an advanced sedimentation process for post remediation placement of decontaminated underwater sediments.

During Patrick's graduate studies, he worked as an intern at Metropolitan Water District of Salt Lake & Sandy, Utah. Over the course of 1 ½ years, he participated in several pilot studies to determine the design parameters of a planned ozone retrofit to the 113-MGD Little Cottonwood Water Treatment Plant. He was also involved in several process chemical optimization pilot studies and multiple fluoride tracer studies.

Since joining Carollo, Patrick has been involved in a number of research projects including a coupled ion-exchange ceramic membrane pilot study to assess the removal capabilities of the process on disinfection byproduct precursors in Palmdale, California, an AwwaRF research project to evaluate non-interruptive filter-bed assessment methods, and a UF membrane certification study for the CA DHS.

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COMMENTARY

Standardizing Performance Monitoring with UV Disinfection

By Harold Wright (HWright@Carollo.com)

With the discovery that UV light inactivates *Cryptosporidium* oocysts at low, cost-effective doses, USEPA had the foundation for developing the Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR). To support the rule, USEPA funded the development of the UV Disinfection Guidance Manual (UVDGM). It provides guidance for implementing UV disinfection at drinking water treatment plants (WTPs), and includes sections on planning, design, operation, and validation.

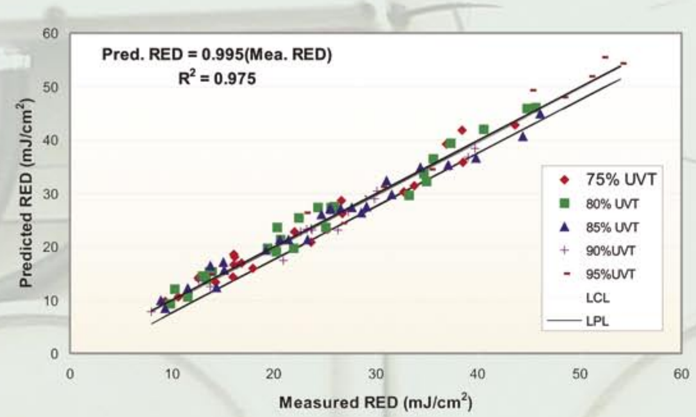


Figure 1.
Predicted vs. measured RED for Calgon 36" reactor.

The UVDGM and the LT2ESWTR are expected to be finalized in late 2005. A challenge in preparing the UVDGM was understanding and resolving differences between the various standards and guidance documents for implementing UV disinfection and the commercial products that were being provided by UV system manufacturers. In particular, there are significant differences in the UV dose delivery monitoring systems.

The Austrian and German standards and guidance define how UV disinfection systems should monitor dose delivery. These documents specify a target UV dose of 40 mJ/cm² to achieve 4-log inactivation of virus and other waterborne pathogens. This level of UV dose delivery is indicated when the UV intensity, measured by one or more UV sensors, is greater than some alarm level defined as a function of flow rate. The properties of the UV sensor are defined. In principle, by standardizing UV sensor properties, a "universal" reference could be used to check the performance of UV sensor systems from different manufacturers. The Austrian and German standards and guidance specifies that the UV intensity alarm level used to indicate a UV dose of 40 mJ/cm2 be verified using validation testing and include a safety factor to account for the measurement uncertainty of the UV sensor. Validation involves measuring UV dose delivery by the reactor using *Bacillus subtilis* spores as the test microbe.

Validation of the Calgon 36" reactor.

In comparison to the Austrian and German standards and guidance, the proposed LT2ESWTR specifies UV doses required to receive inactivation credit for *Cryptosporidium* oocysts, *Giardia* cysts, and viruses. UV doses for 0.5- to 3-log inactivation of *Cryptosporidium* and *Giardia* range from 1.5 to 12 mJ/cm², while UV doses for 0.5- to 4.0-log virus inactivation range from 39 to 186 mJ/cm². Commercial UV systems sold in the U.S. market used various approaches for monitoring UV dose delivery. Many UV vendors used complex and proprietary mathematical algorithms programmed into the PLC of the UV system, which calculate a UV dose value as a function of the measured flow rate, UV intensity, and UV transmittance of the water at 254 nm (UVT). Other UV vendors followed the German and Austrian standards. UV sensor systems also varied significantly among UV vendors. Multiple UV vendors used a UV sensor mounted behind a polarized window (to screen out non-germicidal light); one vendor used a wet sensor in direct contact with the water, another used a silicon carbide sensor with a spectral response that included a significant proportion of light outside of the germicidal range of UV light. In all cases, UV vendors had convincing arguments for justifying their monitoring approach.

Understanding and resolving the differences between these approaches was hampered by a lack of data on whether or not UV sensor systems could meet the tight German and Austrian provisions and no data was available on the field performance of UV systems using these approaches.

To resolve these issues, the draft UVDGM provides flexible instead of prescriptive guidance for UV dose-monitoring. In particular, it identifies and describes issues with current approaches used by the industry and provides a method for calculating an "equipment factor" that accounts for these issues.

For example, instead of prescribing the spectral response of UV sensors, the guidance describes the errors that occur when spectral response is non-germicidal and accounts for those errors using an uncertainty factor termed the "polychromatic bias." Instead of specifying a single equation to be used for monitoring UV dose delivery, the UVDGM describes several possible algorithms and how they should be applied and validated. While this flexibility comes at the cost of increased complexity, the guidance does not exclude any one commercial technology and provides opportunities for innovation.

Also, a new approach for UV dose-monitoring has been developed that involves calibrating the following equation to UV validation test data (1,2):

$$RED = 10^{A} \times UVA^{B} \times (S/S_0)^{C} \times Q^{D} \times Banks^{E}$$

where RED is the Reduction Equivalent Dose delivered by the UV reactor, UVA is the UV absorbance of the water at 254 nm, S is the measured UV intensity, S_0 is the UV intensity expected with a new lamp in a new sleeve, Q is the flow rate through the reactor, and Banks is the number of banks of lamps operating in the reactor. A, B, C, D, and E are model coefficients obtained by fitting the equation to validation data using multi-variate regression.

This provides a simple, efficient, transparent approach for UV dose-monitoring. This equation has been successfully applied to validation data for ten different commercial UV reactors from four UV vendors. Figure 1 compares the RED predicted by the equation to the RED measured for a 36" Calgon Sentinel reactor validated at the Portland UV Validation Facility. With this dataset, the equation gives a RED within ± 3 mJ/cm² of the value over a flow rate ranging from 3 to 26 mgd, a UVT ranging from 75 to 95%, and REDs ranging from 8 to 54 mJ/cm². The engineer, utility, and regulator can easily check calibration of the equation to the validation dataset and verify calculations by the PLC. Overall, the approach represents a significant advancement in UV dose-monitoring and holds great promise as a standard method for the industry.

1. Gaithuma et al., 2005
2. Wright et al., 2005

WHAT'S NEW

Carollo Awarded
Two Breakthrough Desalination Projects

Carollo was recently selected to implement two significant water desalination and concentrate (brine) management research projects. The first of the awards is from AwwaRF and will focus on the important issues of desalination recovery enhancement and minimization of concentrate volume. The project, *Desalination Product Water Recovery and Concentrate Volume Minimization,* taps Carollo's desalination and concentrate management experience to explore promising and innovative solutions.

"Locating new water sources is difficult. Frequently, desalination technology must be implemented to treat water that was previously considered unusable," said Carollo's Dr. Sandeep Sethi, principal investigator (PI) of the project.

"In real world applications, concentrate disposal can be a deal-breaker," said Carollo partner Dr. Gil Crozes. "We can readily solve most desalination treatment objectives with technology, but concentrate disposal can often be the barrier to project implementation because it involves environmental, institutional, and political concerns."

Along with Dr. Sethi, the research team includes Dr. Jörg Drewes as co-PI, several technical advisors, and 18 participating utilities and agencies spanning several states (California, Arizona, Nevada, Colorado, Virginia, and Florida).

The second project, awarded by the Joint Water Reuse & Desalination Task Force (WateReuse Foundation, AwwaRF, Water Environment Research Foundation and the U.S. Bureau of Reclamation), will develop a decision methodology to help water utilities evaluate their brine disposal options on a local level. This project, *Regional Solutions for Concentrate Disposal*, addresses the significant, geographically diverse issues associated with concentrate disposal and requires Carollo's longstanding knowledge of the complexities of regional and state environmental planning processes.

"Desalination projects often fail to be implemented because concentrate disposal adversely impacts the environment and does not adequately address stakeholder values," said Carollo's Dr. Erin Mackey. "This study will help identify what concentrate disposal options are feasible and viable for various regions."

The Regional Solutions team, led by PI Tom Seacord, includes the following utilities: City of Phoenix, Southern Nevada Water Authority, Santa Ana Watershed Project Authority, and Irvine Ranch Water District.

The outcome of these projects is extremely pertinent to industry decision makers who need to determine a sound, just basis for pursuing desalination. Carollo's research will provide important information to aid project planners in assessing the efforts required to implement a water resource portfolio that may include desalination.

PALMDALE PILOT STUDY PROJECT

Complying with DBP Rules while Maintaining Free Chlorine during Distribution: Evaluating Advanced Processes for Precursor Removal

By Stephen Booth (SBooth@carollo.com),
Justin Sutherland,
A. Cristina Fonseca,
Jim Meyerhofer, Bo Labisi,
Dennis LaMoreaux, and
Curtis Paxton

The Palmdale Water District (Palmdale) treats California State Project Water at its treatment plant, northeast of Los Angeles. The nature of the organic matter in the raw water (3 to 5 mg/L as total organic carbon, or TOC), and high concentrations of bromide (up to 0.45 mg/L) tend to promote the formation of halogenated disinfection by-products (DBPs), such as the regulated groups of these compounds: the sum of four trihalomethanes (TTHM), and of five haloacetic acids (HAA5). Currently, the TTHM and HAA5 MCLs are 80 μg/L and 60 μg/L, respectively.

Palmdale has struggled to comply with the Stage-1 Disinfectants/Disinfection Byproducts Rule (D/DBP1R) since it became effective in January 2002, and anticipates further difficulty with implementation of the more stringent Stage-2 Rule. Although the MCLs will remain the same, once the Stage-2 Rule is fully implemented, each sampling location in the distribution system will be required to comply with these MCLs.

Chloramines is Not the Preferred Solution

One option for complying with the D/DBP rules is to switch from free chlorine to chloramines. Chloramines tend to form less THMs and HAAs, compared to free chlorine. However, this option is not attractive for Palmdale, which operates about 2-dozen wells in addition to the surface water treatment plant. Chloramine conversion would require modification of the existing well sites. Further complicating matters, the distribution system is comprised of seven pressure zones, with a varying mixture of ground and surface waters, which would make control of the chlorine-to-ammonia ratio exceedingly complex. Extensive distribution system monitoring would be needed to avoid loss of residual and nitrification. Palmdale is also concerned about the potential formation of other disinfection by-products, such as NDMA and NDEA, which have been linked to chloramines, and are being considered for regulation by California (possibly at the low ng/L level).

Pilot GAC columns at Palmdale.

Investigation of Alternative Processes

Palmdale is currently investigating treatment processes to reduce DBP precursors (*i.e.*, organic matter and bromide) levels. This would allow it to continue to use free chlorine in the distribution system. This approach would also lower the chlorine demand of the finished water, making chlorine residuals more stable, simplifying distribution system operation and reducing chlorine usage.

Currently, Palmdale's conventional treatment plant does not remove sufficient DBP precursor material to reliably comply with the D/DBP rules. A first step is the implementation of Carollo-recommended plant modifications, including carbon dioxide for pH suppression, and switching from alum to ferric chloride to allow enhanced coagulation. Even with these improvements, a new process will be required at the plant to further optimize the removal of organic matter and bromide to limit DBP formation.

In a preliminary study, Carollo identified five processes that could potentially meet Palmdale's treatment goals:

- NF/RO treatment of a side-stream
- Fixed-bed ion exchange
- GAC
- The MIEX® process (water is contacted with a proprietary magnetic ion exchange resin, and the resin is subsequently recovered downstream)
- Ceramic membranes in combination with MIEX® resin

The latter four processes were further evaluated in a pilot study at Palmdale, funded by Palmdale and AwwaRF. The NF/RO option was eliminated due to the high volume of concentrate that would be produced (>65,000 gal/MG).

Pilot Study to Evaluate Process Performance

The goal of the pilot study was to demonstrate performance in achieving the finished water goals, and then to determine design criteria and costs for feasible processes.

Carollo evaluated GAC columns with an empty bed contact time (EBCT) of 15 minutes for TOC removal on conventionally treated and filtered water. The performance of GAC was better than expected. The run-time to breakthrough for a single contactor was roughly 60 days. Based on these data, a full-scale facility, with multiple contactors, could achieve a GAC replacement interval of greater than 4 months (Figure 1).

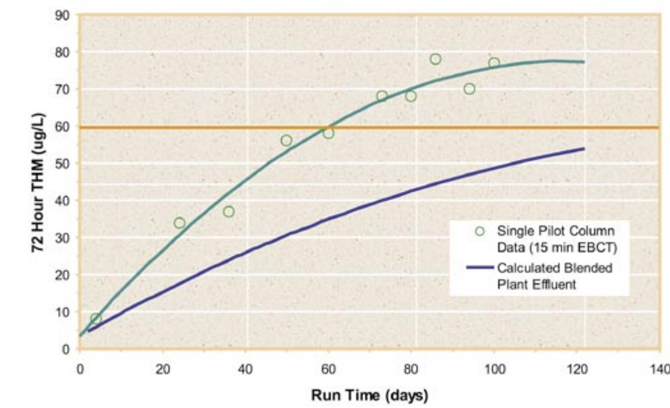


Figure 1. THM breakthrough curves for GAC column with 15 minutes EBCT.

The fixed-bed ion-exchange testing included two resins. A bromide-specific resin achieved run times of greater than 800 bed volumes (Figure 2), whereas a TOC-specific resin achieved run times of 200 to 300 bed volumes. Removals ranging from 40 to 60% of TOC and up to 80% of bromide could be achieved with fixed-bed ion exchange. The presence of sulfate in the water was a significant limiting factor for TOC exchange with the TOC-specific resin, but not with the bromide-specific resin.

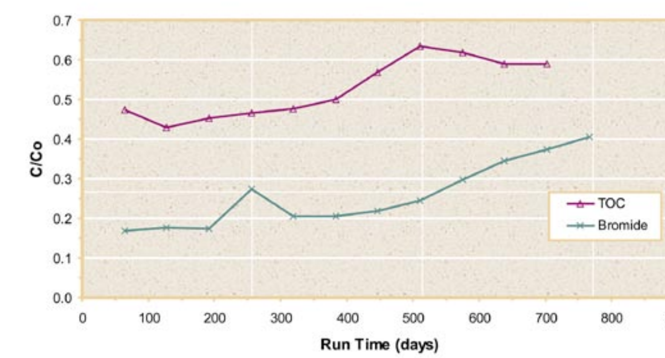


Figure 2. TOC and bromide breakthrough curves for a bromide-specific fixed-bed ion exchange resin (after 8 regeneration cycles).

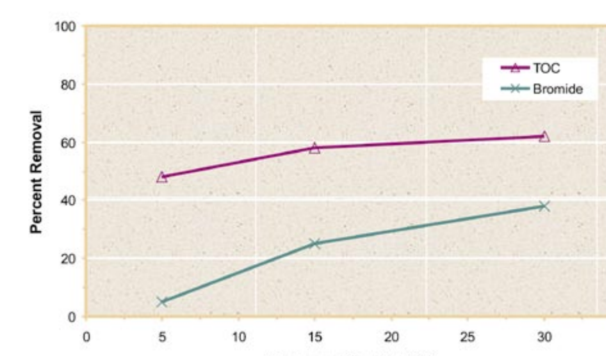


Figure 3. Average TOC and bromide removal for the MIEX® process for 7.5 minutes contact time.

MIEX® process pilot plant.

Key operating parameters for the MIEX® process are the resin concentration, the contact time, and the resin regeneration rate. Under the conditions tested (20 mL/L resin concentration and a contact time of 7.5 to 25 minutes), TOC removal varied only slightly, averaging ~ 60%, whereas bromide removal was strongly dependent on the regeneration rate, and varied from 5% to 40% (Figure 3).

Carollo has completed the data analysis and cost estimates. Construction cost estimates ranged from $12M to $23M for a 30-mgd facility. Operations and maintenance cost estimates ranged from $0.7M to $2.6M on an annual basis.

Schedule

Carollo has submitted the draft final report to both Palmdale and AwwaRF. The final report will be published in late 2005. Carollo is continuing to work closely with Palmdale to make a final process recommendation and to proceed with design and construction of the selected process.

PROJECT**UPDATES**

California DHS Approves

Carollo's New Perchlorate Treatment Process

By Jess Brown, (JBrown@carollo.com)

Fixed-bed bioreactors were pilot tested at the Castaic Lake Water Agency.

As part of a six-month pilot study at the Castaic Lake Water Agency, California, Carollo evaluated the use of fixed-bed bioreactors to treat perchlorate-contaminated groundwater. While "conventional" treatment processes (*e.g.*, ion exchange, NF, RO) separate perchlorate from the bulk solution, a fixed-bed bioreactor converts perchlorate to innocuous chloride and oxygen, eliminating the generation of a perchlorate-laden concentrate that must be further treated or disposed of. The pilot data showed that perchlorate-reducing fixed-bed bioreactors can be acclimated using organisms indigenous to the local aquifer, can achieve sustained perchlorate removal to below the analytical detection limit using reasonable contact times and electron donor doses, can produce biologically stable effluent, do not foster the growth of pathogenic bacteria, and are robust with respect to system upsets. Associated preliminary designs and cost estimates also indicated that fixed-bed biological treatment can be a simple and relatively inexpensive approach for removing perchlorate from drinking water.

> Carollo received conditional approval from CA DHS for using fixed-bed biological reactors to treat perchlorate contaminated drinking water.

Based on the results of this pilot study, CA DHS granted Carollo conditional approval of fixed-bed biological treatment for producing drinking water from perchlorate-contaminated water. The first approval of its kind for a non-proprietary perchlorate treatment technology. Fixed-bed biological reactors are a new full-scale option for removing perchlorate from drinking water.

Computational Fluid Dynamics

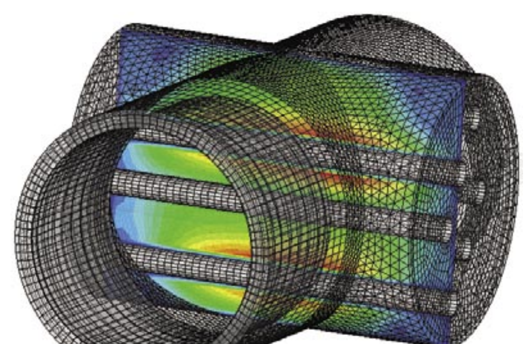
Carollo has successfully applied computational fluid dynamics (CFD) to improve water and wastewater facility designs since 1996

CFD is a state-of-the-art numerical modeling technique used to predict 3-D, high-resolution flow patterns in process vessels. This approach has been used to optimize chlorine and ozone contactors, UV reactors, flocculation/sedimentation basins, pump station wet wells, and flow distribution structures. CFD allows us to fully understand the flow streams within these facilities in an effort to minimize short-circuiting, reduce vortex formation, and maximize process efficiency.

CFD models can be used to improve the design of many elements of a water/wastewater treatment system, from intake structures, through the treatment train and finished water storage. At the base level, these models can resolve flow-field characteristics and can be integrated with sub-models to predict the overall process performance of a given system. This approach allows operators and engineers to look inside the "black box" to:

- Gain an understanding of critical factors that influence process efficiency
- Optimize water quality
- Reduce capital and operating costs

For more information, please contact Dennis Greene (DGreene@carollo.com).



Using CFD, a 3-D mesh of a 6-lamp MP Trojan Technologies UVSwift™ reactor defines microbe trajectories through the unit.

CAROLLO AWARDED PROJECT ON PRELIMINARY DESIGN OF

Brackish Water Desalting Facilities

Carollo was recently awarded a project for preliminary design of brackish water desalting facilities by Indian Wells Valley Water District (District), California.

To further on-going efforts to optimize use of the existing water supply, the District is dedicated to exploring various alternative water sources, including treatment of the poorer quality water from within the Indian Wells Valley, such as the Northwest Well Field (NWWF).

This project has regional, as well as national importance, as it involves treatment of brackish waters and associated concentrate disposal for an inland facility. Concentrate disposal will be the critical step in the project. Alternatives with reasonable costs will need to be identified to make the project economically viable. Preliminary analyses of the well waters indicate that potentially multiple contaminants (in addition to salinity) will require removal, adding a further challenge to selection of the treatment technologies.

The overall goal of the preliminary design is to investigate potential desalination treatment alternatives and their costs, and develop the recommended treatment train for desalting brackish groundwater to potable standards. Key project elements include: characterization of the groundwater quality in four wells, establishing treatment goals and design criteria, preliminary screening of treatment alternatives, detailed evaluation of three treatment alternatives, preparation of budget cost estimates, and conceptual design.

> **FUNDING AGENCY/LOCATION**
> Indian Wells Valley Water District, Ridgecrest, CA
>
> **KEY TEAM CONTACTS**
> Graham Juby
> Sandeep Sethi
> Adam Zacheis

Identification and consideration of site conditions and constraints will be included.

A preliminary screening of potential treatment combinations will be performed. Various concentrate disposal alternatives will be evaluated and up to three most viable treatment alternatives will be identified and further developed. Based on comparisons and evaluations, one alternative will be selected for which a conceptual design will be generated.

Two AwwaRF reports published

Carollo is pleased to announce the publication of AwwaRF report 2681, *Assessment and Development of Low-Pressure Membrane Integrity Monitoring Tools*, authored by Sandeep Sethi, Gil Crozes, Dan Hugaboom, Baoxia Mi, Jason Curl, and Benito Mariñas.

Carollo is also pleased to announce the publication of AwwaRF report 2591, *Bridging Pilot Testing to Full-Scale Design of UV Disinfection Systems*, authored by Erin D. Mackey, Robert Cushing, Marie-Laure Janex-Habibi, Nicolas Picard, Jean-Michel Lainé, and Jim Malley, Jr.

These reports are available in the AWWA Bookstore.

WHAT'S**NEW**

DIRECTOR OF WATER PRACTICE, Rocky Mountain Region

E. Marco Aieta, Ph.D.

Dr. Marco Aieta has joined our Denver office as Director of Water Practice for the Rocky Mountain Region. Marco will assist Carollo in the planning and implementation of water projects including developing strategies to help clients achieve cost-effective solutions, realize water quality goals, comply with regulations, and gain public acceptance.

Marco comes to Carollo with over 25 years of experience in environmental engineering. His background includes 18 years of leadership and growth of the drinking water business for Montgomery Watson Harza, where he consolidated applied research, engineering design, and laboratory services into a complete client-focused service package for municipalities. Most recently, as a senior vice president for Metcalf and Eddy, he was responsible for developing and managing all environmental practices and design-build activities.

Marco holds a Ph.D. (from Stanford University in Environmental Engineering), has published over 30 peer-reviewed articles, and made numerous presentations. A widely sought expert in the water and reuse industry, Marco has served on technical advisory panels for major water projects and provided expert witness testimony on water quality issues.

Contact Marco at 303-635-1220 or MAieta@carollo.com