Drinking Water

**Ozone** and other oxidants

QUALIFICATIONS

[Image of industrial equipment]

Carollo

Engineers...Working Wonders With Water®
Carollo Engineers is an environmental consulting firm with more than 1,050 employees in 44 offices throughout the United States. All of our work is performed in the areas of water and wastewater, resulting in a level of understanding of key project issues that few can match. Carollo strives to maintain the tradition of using sound and proven engineering principles while moving progressively forward to keep abreast of changing times and new technologies.

This is a specialty Statement of Qualifications (SOQ) for Carollo Engineers detailing some of our experience and expertise in the field of water treatment specific to this topic.

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Carollo is a leader in the full-scale application of advanced drinking water technology, including ozonation. This work began over two decades ago with the design of the ozone system for the City of Tucson, AZ, and is on-going today.

Carollo’s dedication to providing innovative and cost-effective solutions is demonstrated by numerous projects, including:

- Design of pre- and intermediate ozonation facilities for the City of Arlington, TX. This project incorporated the use of our computational fluid dynamic (CFD) models.
- Design of the Alfred Merritt Smith Water Treatment Facility (WTF) expansion for the Southern Nevada Water Authority. Carollo, in joint venture, designed an expansion of this facility from 400 to 624 mgd, making it the largest ozone generation system in the world at the time of construction.
- Use of ozone and UV disinfection for the Weber Basin Water Conservancy District, where we designed an expansion of the Davis North Water Treatment Plant (WTP) from 26 to 46 mgd. The use of ozone and UV resulted in a significant cost savings over the next-lowest-cost alternative.

These are just a few examples of Carollo’s ozone experience. We have highlighted these and additional relevant ozone-related projects in the table on the next page and the project profiles that follow.
### Carollo Engineers Ozone Design Experience

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<th>Client/Project</th>
<th>Capacity (mgd)</th>
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<tr>
<td><strong>Southern Nevada Water Authority, Las Vegas, Nevada - Alfred Merritt Smith WTF</strong></td>
<td>624</td>
<td>20,000</td>
</tr>
<tr>
<td><strong>Metropolitan Water District of Southern California - F.E. Weymouth Filtration Plant</strong></td>
<td>520</td>
<td>13,000</td>
</tr>
<tr>
<td><strong>City of Fort Worth, Texas - North and South Holly WTPs</strong></td>
<td>210</td>
<td>9,750</td>
</tr>
<tr>
<td><strong>City of Tucson, Arizona - Central Arizona Project (CAP) WTP</strong></td>
<td>150</td>
<td>6,000</td>
</tr>
<tr>
<td><strong>City of Arlington, Texas - John Kubala WTP</strong></td>
<td>97.5</td>
<td>5,500</td>
</tr>
<tr>
<td><strong>Metropolitan Water District of Salt Lake and Sandy, Utah - Point of the Mountain WTP</strong></td>
<td>70</td>
<td>1,750</td>
</tr>
<tr>
<td><strong>City of Arlington, Texas - Pierce Burch WTP</strong></td>
<td>68</td>
<td>3,000</td>
</tr>
<tr>
<td><strong>Weber Basin Water Conservancy District, Layton, Utah - Davis North WTP</strong></td>
<td>46</td>
<td>1,200</td>
</tr>
<tr>
<td><strong>Santa Clara Valley Water District, San José, California - Penitencia WTP</strong></td>
<td>42</td>
<td>960</td>
</tr>
<tr>
<td><strong>City of Vallejo, California - Fleming Hill WTP</strong></td>
<td>42</td>
<td>1,875</td>
</tr>
<tr>
<td><strong>Town of Gilbert, Arizona - Gilbert WTP</strong></td>
<td>40</td>
<td>2,500</td>
</tr>
<tr>
<td><strong>Tampa Bay Water, Florida - Lithia Hydrogen Sulfide Removal Facility Utilizing Ozone Treatment - Predesign, EPCM Selection, Design and Construction Support Services</strong></td>
<td>24</td>
<td>3,000</td>
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<tr>
<td><strong>City of Peoria, Arizona - Greenway WTP</strong></td>
<td>16</td>
<td>1,450</td>
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<td>1,500</td>
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The project profiles on the following pages present highlights of Carollo’s key achievements in drinking water treatment using ozone and other oxidants. These examples illustrate our ability to:

- Implement innovative technologies to improve process design and performance.
- Integrate engineering and research to achieve practical solutions tailored to specific client needs.
- Involve project participants early in the process to “demystify” advanced technology and fully understand each other’s needs.
- Offer advanced solutions that are practical, affordable, and reliable.

We would be happy to provide client references that can attest to the quality and responsiveness of Carollo’s services upon request.
Tampa Bay Water is tasked with developing, storing, and supplying water to Hillsborough, Pasco, and Pinellas counties; and the cities of New Port Richey, St. Petersburg, and Tampa. Groundwater from the South Central Hillsborough Regional Wellfield is treated at the Hillsborough County Lithia WTP. The finished water from the WTP currently meets the hydrogen sulfide removal requirements, as specified in their master water supply contract, through tray aeration and biological oxidation of the remnant hydrogen sulfide. As described in a Memorandum of Understanding (2004), Tampa Bay Water will replace the current hydrogen sulfide removal facility with a new, more reliable process, and will own and operate the new facility.

Tampa Bay Water determined through on-site pilot testing that the best process for this new facility is ozonation. Furthermore, the project delivery was approved by the Tampa Bay Water Board of Directors to proceed using an Engineer-Procure-Construction Management (EPCM) approach. As such, the overall goal was to develop a robust, best-value facility that meets master water supply contract requirements and achieves operational status in accordance with the schedule.

Tampa Bay Water selected Carollo as the Owner’s engineer for the treatment improvements at the Lithia WTP. Project tasks included:

- Assisted Tampa Bay Water in acquiring property for the project, and assisted the EPCM team in acquiring the permits necessary to support the project.
- Prepared a Preliminary Design Package (i.e., 30-percent complete drawings, specifications, and details) to establish the baseline prescriptive and performance requirements for the EPCM’s design.
- Prepared the requisite procurement documents necessary to secure a qualified EPCM team to design and construct a 45-mgd hydrogen sulfide removal system using ozone.
- Assisted Tampa Bay Water in negotiating a guaranteed maximum price and final EPCM contract agreement.
- Provided design-phase oversight services to assure the EPCM fulfills the requirements of the preliminary design package.
- Provided construction-phase services to assure the EPCM team fulfills the requirement of the procurement documents, and secured a qualified contractor operator.
As part of the $8.4-billion Comprehensive Everglades Restoration Program (CERP), the U.S. Army Corps of Engineers and the South Florida Water Management District selected Carollo to perform the first pilot testing and engineering analysis of water treatment technologies on Lake Okeechobee. This pilot study provided the basis for design and cost estimates for treatment systems with an ultimate capacity of approximately 1.5 billion gallons per day (bgd).

The CERP presents a framework for Everglades restoration and contains 68 specific components to restore more natural flows of water and improve water quality in the south Florida ecosystem. The plan will restore the habitat of threatened and endangered species and improve fresh water supply in the region. This study evaluated alternatives for treating Lake Okeechobee water prior to injection in aquifer storage and recovery (ASR) wells.

The alternatives proposed by Carollo applied the latest proven treatment technologies leveraged with a global analysis of all goals and constraints surrounding the project. The selected treatment train consisted of bank filtration (BF), ozonation, and UV disinfection. BF addressed microbial, total organic carbon (TOC), color, taste, odor, and turbidity goals cost-effectively with minimal operational and maintenance requirements. Ozonation provided additional treatment for microbial and organic contaminants and also substantially increased the UV transmittance of the water, thereby reducing the capital and operational costs of the UV disinfection process. UV disinfection provided a final barrier to pathogens, particularly disinfectant-resistant pathogens such as Cryptosporidium. The treatment train (BF/ozonation/UV) provided multiple barriers to target water quality impairments. As treatment may be applied at up to 300 individual sites across rural central and south Florida, other key attributes of the treatment train included: no waste stream disposal, minimal chemical delivery requirements, and low operational and maintenance costs.
The Southern Nevada Water Authority contracted Carollo, in joint venture, to design the $145-million Southern Nevada Water System Improvements Project. The project consisted of the following components:

- Expansion of the Alfred Merritt Smith WTF from 400 mgd to 624 mgd.
- Four miles of 12-foot-diameter tunnel through the River Mountains.
- A 55-million-gallon reservoir.
- 33,000 feet of 60-inch transmission pipeline.
- 2,500 feet of 96-inch inlet/outlet piping.
- A flood control detention basin and flow dissipation structure.
- Modifications to the existing Twin Lakes pumping plant.
- A 2,000-cfs flood control channel.
- Seven hot tap connections to steel and prestressed concrete pipe, ranging in size from 24 inches to 72 inches in diameter.
- Micro-tunneling and bored-and-cased crossings of highways and major arterials within the metropolitan area.

Combined, these projects have increased water delivery capacity and reliability to customers in the cities of North Las Vegas, Henderson, and Boulder City, as well as the Las Vegas Valley Water District service area.

The joint venture team designed ozone treatment units at the head of the treatment plant for primary disinfection purposes. The construction cost of these improvements was in excess of $50 million. Carollo was responsible for the hydraulic design (using computational fluid dynamic modeling), the site utilities relocation, mass grading, and design of contactor basins. The plant has the world’s largest ozone generation system at a water treatment plant. A total of 20,000 pounds per day of ozone are provided from five medium-frequency generators producing up to 12 percent ozone, by weight.
Built in 1939, the Metropolitan Water District of Southern California's (MWD) 520-mgd F.E. Weymouth Filtration Plant is one of the largest conventional treatment/filtration plants in the United States. This facility treats water delivered from the Colorado River Aqueduct and the State Water Project’s California Aqueduct. As a result of the Stage 2 Disinfectant/Disinfection By-Products Rule (D/DBPR), the U.S. EPA essentially requires the use of ozone or other alternative (non-chlorine) disinfection at all plants treating significant amounts of State Project Water due to elevated levels of DBP precursors. The blended water at the Weymouth plant currently undergoes primary disinfection using chlorine gas and secondary disinfection using chloramines for residual preservation. MWD has been preparing for the conversion of disinfection facilities at several of its filtration plants through extensive pilot testing and other applied research, including the 5.5-mgd oxidation demonstration plant at Weymouth. The result of this research led to the planned Oxidation Retrofit Program (ORP).

In early 2003, MWD selected Carollo to perform a Site Engineering Study for the Weymouth plant. This study essentially determined a site master plan that incorporated near-term and possible future projects, including the ORP facilities. Subsequently, MWD contracted with Carollo to perform preliminary and final design of the ORP facilities at Weymouth. The following components provide a design ozone dosage of 2.0 mg/L for up to 520 mgd, or nearly 8,700 ppd of on-site generated ozone to the Weymouth facility. With redundancy, the ozone generation system will be capable of producing up to 13,000 ppd.

- Liquid oxygen storage and ozone generation, with possible future oxygen separation facilities.
- Four ozone contactors with ten chambers each for a design contact time of 10 minutes.
- An off-gas ozone destruction system and effluent ozone quenching system.
- pH adjustment upstream of the contactors to minimize bromate formation, with readjustment downstream of the contactors.
- Standby primary disinfection with sodium hypochlorite or gaseous chlorine.
- Taste and odor control with hydrogen peroxide.
- Relocation and replacement of the plant flow meter and rapid mix unit, and rerouting of the filter backwash return upstream of the ozone contactors.

The final design was completed in September 2006 with the facilities operational by 2010.
Carollo, in association with others, completed the design of preozonation and intermediate ozonation facilities and filtration improvements for two water treatment plants for the City of Arlington. The design team used computational fluid dynamic (CFD) models to optimize the ozone contactor design. The ozonation improvements include 3,000 pounds per day of generation capacity at the 68-mgd Pierce-Burch WTP and 5,500 pounds per day generation capacity at the 97.5-mgd John F. Kubala WTP. Liquid oxygen (LOX) is stored in LOX tanks and fed to the medium-frequency generators where ozone is produced at a concentration of up to 10 percent by weight. The design provides for both preozonation and intermediate ozonation contactors at each plant to obtain the maximum benefits for microflocculation and disinfection. Filter improvements involved replacing the existing underdrains with porous-plate air/water underdrains and replacing the filter media with granular activated carbon (GAC) over sand.

These improvements were the result of a year-long treatability study conducted by Carollo, in association with others, to determine Arlington’s best course to comply with impending regulations and address taste and odor problems occurring during the warmer months. The study involved bench-scale and pilot-scale testing of enhanced coagulation, ozonation/sand filtration, and ozonation with GAC contactors. The study concluded that two-stage ozone with GAC/sand filters was the most cost-effective method of meeting Arlington’s water quality goals of eliminating taste and odor problems, reducing trihalomethanes and providing another barrier against potential Cryptosporidium contamination.
Carollo designed an expansion and upgrade for the Weber Basin Water Conservancy District’s Davis North WTP in Layton, Utah. The project, which increases capacity from 26 mgd to 46 mgd, includes UV disinfection for the full 46-mgd capacity using 20-mgd reactors. It is the first such system for treatment of potable water in the State of Utah and one of the first large-scale drinking water facilities in the country utilizing UV disinfection.

The design also included new conventional flocculation and sedimentation basins, and pre- and intermediate ozone designed for taste and odor control, and enhanced particle removal. An evaluation of disinfection and taste and odor control strategies showed that the synergistic combination of ozone and UV disinfection resulted in a facility cost reduction of approximately 50 percent compared to the next cost alternative.
SCVWD Water Treatment Improvement Project

Carollo is currently involved in Stage 2 of the Santa Clara Valley Water District (SCVWD) Water Treatment Improvement Project, which includes detailed design of GAC filter caps, settled water ozonation, washwater treatment improvements, additional chemical feed facilities, and filter-to-waste enhancements at the Penitencia WTP. The plant will use ozone to meet the multiple objectives of primary disinfection and taste and odor.

SCVWD was concerned that a failure in any portion of the ozone disinfection system would render the plant without primary disinfection. Therefore, the project team evaluated UV disinfection with standby power to provide backup primary disinfection downstream of the biologically-active GAC filters, and to meet future regulatory requirements at the 42-mgd Penitencia, 75-mgd Rinconada, and 100-mgd Santa Teresa WTPs. Carollo participated in expert panel workshops and prepared a technical memorandum that provided layouts and cost estimates for UV disinfection. SCVWD will consider implementing this technology when it is needed.

**HIGHLIGHTS**

- Ozonation for primary disinfection and taste and odor control.
- Washwater treatment improvements.
- Filter-to-waste enhancements.
- Evaluation of UV disinfection with standby power to provide backup primary disinfection downstream of the biologically-active GAC filters.

Carollo provided pre-design for 242 mgd of UV disinfection facilities for the Santa Clara Valley Water District’s three water treatment plants.
Carollo completed a comprehensive plant evaluation that identified the necessary process upgrades and expansion for the City of Vallejo Fleming Hill WTP. The Fleming Hill facility is a conventional plant that treats water from the Sacramento/San Joaquin River Delta. It is located on the top of a hill bounded by steep terrain on one side, a 10-million-gallon reservoir on another side, and single family homes on the other two sides. Upgrades were needed for improved control of water quality to meet stringent new drinking water regulations and to improve plant reliability. Increasing demand also required a capacity increase. Vallejo retained Carollo to design process upgrades to bring the plant capacity from 27 to 42 mgd. Carollo also provided construction support, start-up, and training services.

Major treatment plant features and facilities included in the design were:
- Complete chemical systems redesign including secondary containment of all chemical facilities and pre-ammonia addition for control of brominated DBPs.
- Flash and rapid coagulant chemical mixing.
- Horizontal turbine, three-stage flocculation and improved sedimentation.
- Pre- and intermediate ozonation.
- Both upgraded and new filters with dual GAC/sand media.
- Washwater reclamation.
- A new vertical turbine pump station.
- A new chlorine scrubber for the new chlorine gas facilities.
- A new backwash clearwell and chlorine contact chamber.
- Seismic upgrade of 10-million-gallon clearwell and other plant facilities.

Carollo designed the upgrades as well as the new processes to fit within the existing, constrained residential site. The project team worked closely with the State Water Board Division of Drinking Water (DDW) to ensure that their concerns were met as the design progressed. When the construction phase was nearing completion, the Carollo team conducted training sessions with the operators so that they would be brought up to speed and feel confident about operating the new facilities. Since the plant is the only source of water for Vallejo, Carollo’s design included special considerations to allow the plant to stay in service during construction.
In the early 1980s, the Town of Gilbert recognized the need to plan for future growth, and that an alternative to pumping groundwater was necessary. At the same time, Arizona enacted the state’s progressive Groundwater Code, which addressed the groundwater overdraft problem and provided a means for allocating Arizona’s limited groundwater resources. In 1984, Gilbert selected Carollo to develop a water resource plan. Four years later, Gilbert passed the water system improvement bond election that authorized the funding for the development of its first water treatment plant. Gilbert retained Carollo to provide planning, design, and construction of the 15-mgd Gilbert WTP.

In a subsequent project, Carollo performed a study to evaluate Gilbert’s current water treatment process and completed design and construction to expand the plant from 15 to 40 mgd. The expansion design included a pilot study to examine ozonation and biological filtration to meet Gilbert’s long-term finished water quality goals. The main objectives of the work were to comply with future regulations, to minimize the public health risk associated with chlorine-resistant microbial pathogens, and to improve the aesthetic quality of water, mostly in terms of taste and odor. Based on the results of the pilot study investigations, Gilbert included ozone for the 30-mgd water treatment plant in the 15-mgd expansion.

Construction of the 15-mgd expansion and new ozone facilities was complete in 2002. In addition, Carollo also reviewed Gilbert’s current master plan to determine if the plant’s ultimate capacity could be increased from 40 to 60 mgd. The results of the study helped town officials determine what improvements/changes were needed to meet Gilbert’s future needs.
Carollo recently completed the site master plan and design for the City of Peoria’s new water treatment plant. Carollo also provided construction management with on-site resident engineering services. Construction of this 16-mgd facility was completed in Summer 2002. Phase I of the Greenway WTP design included a 5-million-gallon storage reservoir, a finished water pump station, and treatment processes that utilize conventional treatment combined with ozonation and BAF.

The conventional treatment process utilizes chemical addition, rapid-flash mixing, pre- and final sedimentation, and flocculation. Ozone is used as a primary disinfectant with chlorine added as the secondary disinfectant. BAF is added for the reduction of taste and odor. The facility design also provides for finished water storage and pumping, used water recovery, and solids handling.

The facility treats Salt River Project and Central Arizona Project water from the end of the Arizona Canal. The project satisfies many significant statewide goals such as:

- Meeting regulatory requirements.
- Decreasing dependence on groundwater.
- Increasing the use of surface water.

The Greenway WTP satisfies many significant and statewide goals, such as meeting regulatory requirements, decreasing dependence on groundwater, and increasing dependence on surface water.
Mesa Consolidated Water District (Mesa Water) selected Carollo to prepare design/build plans and specifications for a new treatment facility to remove natural color from groundwater. Carollo prepared a design/build request for proposals package to approximately the 30-percent design level. This package included a number of drawings including conceptual layouts, building requirements, a process flow diagram, a basic SCADA system design, and several detailed process and instrumentation diagrams (P&IDs). Carollo tailored a design criteria report and detailed specifications to meet the client’s specific requirements in terms of equipment and control/monitoring capabilities for the new facility. We also prepared a bidding requirements package specific to the project, which included the contractual forms such as the agreement and the customized design/build conditions of contract.

Based upon our experience with other design/build projects, we prepared design/build documentation which provided for a high level of input by the design/build teams during the bid stage. This enabled Carollo to carry out a detailed evaluation of the bids to ensure that the facility offered by the successful bidder would meet the client’s expectations.

Carollo’s scope of work included the prequalification of suitable design/build teams and major equipment manufacturers acceptable to Mesa Water and facilitated award of the $11-million Phase I contract to the successful design/build team. Our preliminary design effort also included an assessment of nanofiltration as an alternative treatment approach.

Mesa Water retained Carollo to provide engineering services during the final design, construction, and start-up phases of the project. Our scope also included the preparation of an operational plan for the plant, and assistance to Mesa Water in discussions with the DDW to obtain a permit to operate the new facility.
CITY OF MANKATO, MINNESOTA

Water Treatment Plant Evaluation Project

The City of Mankato hired Carollo to assess the challenges that its water treatment facility could face from increasingly stringent water quality regulations and heightened consumer awareness, and to determine existing/emerging technologies to meet or exceed Mankato water customer expectations and increase the treatment capacity. Water treatment challenges included seasonal fluctuations in the levels of nitrates, total organic carbon, and DBP precursors.

The water treatment plant evaluation project involved two phases. Phase 1 consisted of a regulatory analysis and a water treatment plant process evaluation. The regulatory analysis involved a summary of existing and future regulations, an overview of the compliance of the Mankato plant, a comprehensive filter evaluation, and confirmation of the CT available in the on-site reservoir.

Phase 2 involved surveying and evaluating new technologies, including ozone, ultra and/or nanofiltration membranes, and UV disinfection, to determine if they hold promise for future application at the plant. Softened water shipped to Carollo’s water research laboratory provided a basis for developing ozone demand and decay data using Carollo’s unique bench-scale equipment. Carollo presented and discussed the investigative results with Mankato staff in a series of workshops and summarized the findings in a project report which detailed the conclusions, recommendations, and preliminary costs of optimizing the existing facility, increasing plant capacity, and adding other technologies to enhance water quality.

Faced with increasingly stringent water quality regulations and growing public awareness, Mankato retained Carollo to recommend alternatives, including ozonation facilities, to optimize its water treatment plant and increase capacity.
Carollo led the effort to conduct a pilot study for the Metropolitan Water District of Salt Lake and Sandy. The purpose of the study was to evaluate three potential treatment trains for the new 70-mgd Point of the Mountain WTP:

- **Treatment Train No. 1.** Low-pressure membrane filtration with conventional pretreatment.
- **Treatment Train No. 2.** Low-pressure membrane filtration and granular activated carbon adsorption with presedimentation.
- **Treatment Train No. 3.** Ozonation, biologically active filtration, and ultraviolet disinfection with conventional pretreatment.

Carollo conducted bench- and pilot-scale evaluations at a testing facility near the future site of the treatment plant. This involved constructing a metal building for this purpose close to the raw water intake location of the future plant. This dedicated facility housed nine pilot skids and related equipment and included an on-site laboratory and office space for project meetings. Carollo maximized on-site testing capabilities to reduce external analytical costs during piloting.

For the pilot-scale evaluations, Carollo provided a new 7-gpm conventional treatment train, complete with pre- and intermediate ozonation and six filters, as well as a 100-gpm pretreatment unit for the membrane systems.

Carollo used a combination of bench- and pilot-scale ozone evaluations to optimize testing costs. This involved refining viable ozone operating conditions at the bench-scale, such as dose and contact time, for subsequent pilot-scale tests. Carollo developed design criteria for the ozonation facilities, based on the results of the pilot evaluations.

The piloting effort demonstrated that all three trains achieve the operational and finished water quality goals established for the Point of the Mountain WTP.

Carollo determined that Treatment Train No. 3, which included pre- and intermediate ozonation, would be most cost effective and robust to meet future challenges, such as taste and odor treatment and more stringent DBP goals.
Carollo, in association with others, conducted an extensive study to develop the best treatment process to meet future regulations for the proposed Lake Pleasant WTP. The study included both a bench-scale evaluation and pilot studies.

The bench-scale testing included assessment of raw water quality, development of finished water quality goals, and the evaluation of current and future treatment technologies. Focus group meetings with client staff and national experts resulted in recommendations for developing the bench-scale testing program. Bench-scale testing covered pre-oxidation, pretreatment, and advanced treatment processes for several key test waters. Pre-oxidation included ozone, chlorine dioxide, and peroxone. Treatment processes included dissolved air flotation (DAF), ballasted flocculation, and GAC filtration. Advanced treatment processes included a range of presently available membrane options. The team compared these to conventional treatment. The testing focused on two primary parameters: turbidity removal and dissolved organic carbon (DOC) removal. Additional parameters included arsenic removal.

Based on the bench-scale testing, the team developed select treatment options for pilot-scale testing. The key objective of this phase was to narrow the treatment options that would meet the water quality goals and select the best treatment options for the proposed new treatment plant. The result was the construction of a total of six pilot plants.

In addition to the treatment trains at each of the pilot plants, work included feeding effluent from select filter media columns and microfiltration to rapid small-scale column test (RSSCT) equipment to evaluate the effectiveness of GAC post-contactors for TOC removal and bed life. The team also conditioned microfiltration effluent with acid and anti-scalant as a pretreatment for nanofiltration and reverse osmosis testing. Pilot trailer systems allowed short-term pretreatment testing with DAF and ballasted flocculation on Central Arizona Project (CAP) water, algae-spiked CAP water, and high-turbidity CAP water.

Colorado Springs Utilities selected Carollo, teamed with a national contractor, to design and construct the new 50-mgd Southern Delivery System WTP. A progressive design-build alternative delivery approach is being used. The process includes conventional pretreatment, intermediate ozone, biological filtration, and support facilities, including a raw water tank, finished water tank and pump station, and all required chemical facilities.

The intermediate ozone process is designed to apply a maximum dose of 1.5 mg/L, primarily for the control of taste and odor causing compounds. The system will utilize injection equipment to dissolve up to 650 pounds per day of ozone into a small side-stream flow of settled water that is then flash mixed into the overall process stream. The total process flow then enters two ozone contact chambers that provide a minimum of 10 minutes of hydraulic contact time, designed with a dual level, end around baffle design that will provide an estimated $T_{10}/t$ of 0.65.

This design-build project will be completed by July 2012. Construction is planned to begin in late 2012 or early 2013.

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**HIGHLIGHTS**

- All design for this fast-paced design-build project is being performed using 3D CAD
- Value engineering was incorporated in all phases of design
- Ozone will enhance the effectiveness of the biologically-active GAC filters

This 3-dimensional (3D) rendering shows the main process facility at the Southern Delivery System WTP. This facility will include conventional pretreatment, ozone, filtration, chemical storage and feed, and maintenance and administration facilities.
Changes to regulations with respect to the D/DBPR resulted in the City of Santa Barbara evaluating alternative treatment processes for the reduction of DBP precursors. The 37-mgd William B. Cater WTP utilized free chlorine for pre-oxidation for proper sedimentation and filtration and wanted to maintain the practice of free chlorine as a residual disinfectant. Subsequent fires in the watershed increased raw water TOC levels by 50 percent and necessitated the use of powder activated carbon (PAC) for TOC removal. Bench- and pilot-scale testing had shown that ozone and pH reduction could significantly reduce DBP levels to meet the changing regulations and water quality goals.

Carollo completed the design for a new ozone facility as part of the Advanced Treatment Solutions project that included a 13,000-gallon LOX storage tank and vaporizers, two 630-ppd generators that produce ozone at concentrations up to 12 percent by weight, side-stream injection into a 42-inch raw water pipe, and a 10-minute ozone contactor. The ozone contactor was designed in an under-over configuration that utilized available space to provide a more hydraulically efficient ozone contactor.

Carollo also worked with City agencies, such as the Planning Commission and Architecture Board of Review, and local home owners to minimize impacts of the new facilities. In addition, the State of California requested a fast-track schedule to allocate unused State Revolving Funds before the end of the fiscal year.

The design also included a new carbonic acid storage and feed system, new chemical feed and storage for caustic soda, sludge thickening, and mechanical dewatering facilities.
Central Utah Water Conservancy District selected Carollo to provide engineering services for the Process Improvement Project at the Utah Valley WTP (UVWTP). The UVWTP is an 80-mgd direct filtration plant that has plans to expand to 120 mgd in the future. Water quality challenges and changing regulations required the plant to evaluate alternative methods for TOC removal to lower subsequent DBPs. Bench- and pilot-scale testing has shown that ozone and/or enhanced coagulation can adequately remove TOC to significantly reduce subsequent DBPs to meet treatment goals and water quality regulations.

Design components of the ozone facility include a 13,000-gallon LOX storage and vaporization system, three 590-ppd generators, side-stream injection system, two 12-minute ozone contactors with associated destruct units, and chemical storage and feed for ozone quenching. The facility will provide provisions for future expansion to 120 mgd as well as considerations for ozone augmented biofiltration. The scope of work also included pre-selection of an ozone system supplier to facilitate in the design of the facilities.

Challenges of the project included site constraints that required addition of the new ozone facilities, additional flocculation and new sedimentation basins while maintaining space for future expansion.

Other design efforts included hydraulic evaluation and improvements to plant filters, modifications to the waste washwater and filter-to-waste handling facilities, upgraded chemical feed and storage areas, and solids handling facilities.

In addition to preliminary and final design services, Carollo will provide assistance for pre-selection of contractors and bidding, as well as engineering services for construction and startup phases of the project.
The Carollo Research Group (CRG), founded in 1997, provides research, process evaluation, and plant optimization services. Early in the design process, the CRG often performs testing to develop design criteria for new treatment facilities. The CRG also conducts evaluations as part of our applied research projects that are funded by associations such as the Water Research Foundation.

The CRG combines the use of bench- and pilot-scale testing capabilities to meet the specific objectives of each study. We have developed a flow-through bench-scale ozone contactor and a modular 10-gpm pilot-scale ozonation skid to collect data representative of full-scale processes in the most efficient manner.

CONTINUOUS-FLOW BENCH-SCALE OZONE SYSTEM

The information required to develop design criteria for ozone facilities includes ozone demand, ozone decay, and screening of ozone application points. Traditionally, this information has been developed using pilot-scale facilities, semi-batch bench-scale testing units, or modeling techniques. The major drawbacks of ozonation pilot studies include the tendency to overestimate the hydraulic efficiency and the
high cost and time commitment required to mobilize the equipment. Semi-batch reactors and the use of mathematical models do not provide sufficiently reliable data for extrapolation to full-scale design.

To address these drawbacks, Carollo has developed a continuous-flow bench-scale ozone testing unit which combines the reliability of pilot-scale testing and cost-effectiveness of bench-scale methods. This testing unit offers several benefits, including:

- Providing data representative of full-scale ozone systems.
- Determining key design parameters using a 5-gallon sample.
- Offering quick mobilization (half day) to allow ozone treatment options to be evaluated for transient water quality episodes.
- Easily simulating a wide range of water quality and operating conditions.

**PILOT-SCALE OZONE SKID**

Carollo’s pilot-scale ozone skid may be operated independently or easily integrated with other skids to evaluate the impact of ozonation on other treatment processes. This type of skid is generally used to evaluate intermediate ozonation.

The skid comes fully equipped for complete ozone evaluations and includes the following components:

- Air compressors to provide feed gas.
- Complete air preparation, including drying and filtration.
- Ozone generation equipment.
- Ozone contacting.
- Ozone quenching.
- Off-gas ozone destruction.
- Instrumentation and control.

Major benefits of this pilot-scale ozone skid include the ability to:

- Mimic full-scale hydraulics, allowing for ozone demand, disinfection assessment, and by-product formation testing.
- Offer capacity for a wide range of ozone dosages.
- Quench residuals using a quenching agent, such as calcium thiosulfate.
- Destroying ozone in the off-gas using an integrated ozone destruct unit.
SELECT OZONE AND ALTERNATIVE OXIDANT PUBLICATIONS - PEER-REVIEWED


SELECT OZONE AND ALTERNATIVE OXIDANT PUBLICATIONS/PRESENTATIONS - OTHER


CAROLLO IS CURRENTLY RANKED WITHIN ENGINEERING NEWS RECORD'S TOP 500 DESIGN FIRMS ... ENR'S ANNUAL SOURCE BOOK RANKS CAROLLO AMONG THE TOP 10 FIRMS FOR WATER AND WASTEWATER TREATMENT PLANT DESIGN.

WATER AND WASTEWATER EXPERTS

Carollo is an environmental engineering firm specializing in the planning, design, and construction of water and wastewater facilities and infrastructure. Carollo’s reputation is based upon client service, a continual commitment to quality, and technical leadership.

During our 86-year history, Carollo has successfully completed more than 25,000 projects for public sector clients. Carollo is currently ranked within Engineering News Record’s top 500 design firms. More importantly, ENR’s annual Source Book ranks Carollo among the top 10 firms for water and wastewater treatment plant design. Unlike many of our competitors, Carollo provides only water and wastewater engineering services.

With our focus on water and wastewater, we recruit nationwide and hire technical staff who have the extensive background and training specific to this field. For that reason, the quality and professional standing of our core group of water and wastewater professionals equals or exceeds that provided by some of the largest engineering firms in the U.S.

Resources

Carollo’s staff numbers more than 1,050 employees, including more than 500 registered engineers. We are a full-service water and wastewater engineering company with the experience and qualified professionals to successfully manage projects of any size. Our staff includes civil, sanitary, electrical, environmental, mechanical, chemical, structural, instrumentation, and corrosion control engineers, as well as architects, planners and specialists in other areas. These individuals perform work solely on water and wastewater related facilities.
Carollo provides only water and wastewater engineering services, resulting in a level of understanding of key project issues that few can match.

MANAGEMENT PHILOSOPHY

Carollo’s management philosophy and the success of our company are founded on simple precepts:

- **Seek out, hire, and hold onto the best people in the business.** We recognize that the most critical element for a successful project is the project team. Carollo aggressively recruits the top candidates from the leading engineering schools across the country. We train and mentor these engineers to become the next generation of leaders for Carollo and the industry. This long-term commitment to developing excellent engineers has resulted in a depth of talent unmatched by other consulting firms.

- **Specialize in the planning, design and construction management of water and wastewater projects.** This is our business. Our success hinges solely upon our ability to provide responsive service to our municipal clients.

- **Commit our partners to an active role in every project.** This provides our clients with top management interest, clear accountability, responsiveness, and talent—and helps to ensure that the necessary staff and resources are committed to each assignment.

- **Focus on client service.** Carollo knows the value of listening to our clients and recognizes that successful projects result from the combined expertise of our staff and the client’s staff. This commitment to understanding client needs and valuing their input is one of the cornerstones of Carollo’s success.

LEADERS IN WATER ENGINEERING

Carollo has provided design and construction management services for more than 100 water treatment plants with a total capacity of more than 3.5 billion gallons per day, more than 1,000 miles of water pipeline ranging in size from 6 to 108 inches in diameter, and more than 100 water pumping stations with capacities as high as 600 mgd. We have recently completed or are performing ongoing water projects for many of the country’s major municipalities or special districts. A few examples of Carollo’s achievements include:

- Conceiving and developing the custom design approach for low-pressure membrane water treatment plant design. Carollo developed our own custom, nonproprietary, non-packaged pilot plant unit, which has been successfully tested in Kansas City, MO.
Engineering the fast-paced design/build expansion of the Palm Coast, FL, reverse osmosis (RO) water treatment plant from 3.2 to 9.6 mgd. Carollo completed preliminary design and obtained all permits just eight weeks after beginning work to help facilitate successful completion of this project in just 15 months.

Conducting the first U.S. testing and evaluation of electrodialysis reversal (EDR) for perchlorate treatment.

Achieving leadership in ultraviolet (UV) disinfection, first for wastewater applications in the western United States and now for UV drinking water applications. Carollo was the primary author of the USEPA UV Disinfection Guidance manual. We also developed and operate the world’s largest UV validation facility in Portland, OR.

Designing the preozonation and intermediate ozonation at two water treatment facilities for the City of Arlington, TX, using our computational fluid dynamic (CFD) modeling to optimize ozone contactor design. Carollo also conducted a joint research project with various utilities in the Phoenix, AZ, area to evaluate ozonation and biological filtration to meet long-term finished water quality goals, leading to design and construction of ozonation facilities in Gilbert and Peoria, AZ.

Designing, in a joint venture, the world’s largest ozone generation system at a water treatment facility in Las Vegas, NV.

**FORMULA FOR SUCCESS**

Much of our success as an industry leader is based on our ability to offer advanced solutions that are practical, affordable, and reliable. We strive to maximize the use of existing infrastructure whenever possible, promote environmental conservation, and make the best technologies available at a competitive cost.

A major factor in maintaining Carollo’s ability to integrate new technology is the Carollo Water Research Group (CWRG). The relationship between our design engineers and the CWRG is unique in the industry and serves as a company-wide resource for evaluating water quality and treatability data, performing pilot studies, developing design criteria, tailoring design solutions to water quality issues, and addressing regulatory compliance concerns.

Our firm takes pride in the large number of clients with whom we have maintained continuing working relationships. We have worked with some clients for more than 80 years—a clear indication of the quality of our service.
work, our control of costs, and our ability to meet schedules. This dedication to quality has resulted in a long list of successful projects and satisfied clients, some of which are highlighted in the table below.

<table>
<thead>
<tr>
<th>Client/Project</th>
<th>Capacity (mgd)</th>
<th>Conventional Treatment</th>
<th>Membranes</th>
<th>Ozone</th>
<th>UV Disinfection</th>
<th>Automation</th>
<th>Solids Handling</th>
<th>Chemical Handling</th>
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