



water treatment

*Carollo has provided
planning and design services
for more than 100 water
treatment plants with
a total capacity of over
3.5 billion gallons per day.*

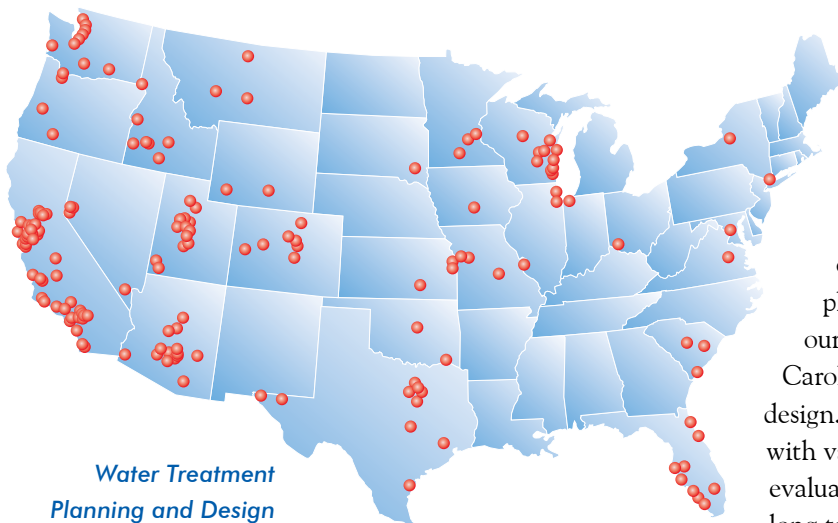
Carollo's water treatment experience includes more than 100 water treatment plants ranging in size from less than 1 mgd to more than 600 mgd. We are a proven leader in applying innovative technologies to achieve the production of high-quality finished water at a reasonable cost. Examples of our achievements include:

- ▶ Pioneering a custom design approach for membrane water treatment plant design using our own custom pilot plant unit.
- ▶ Developing a water treatment master plan for United Water Florida that defined the most cost-effective solution to treat their brackish deep well supply and preserve local wetlands. Low-pressure reverse osmosis (RO) shows promise for this application.
- ▶ Conducting the first testing and evaluation of electro dialysis reversal (EDR) for perchlorate treatment.
- ▶ Pioneering the use of ultraviolet light (UV) disinfection technology for both wastewater applications in the West and now for drinking water applications. Carollo is leading the team in charge of a Water Research

Foundation project that is evaluating UV disinfection systems for the inactivation of *Cryptosporidium*. We are also co-principal investigator for a Water Research Foundation project focused on inactivation of pathogens by innovative UV technologies.

- ▶ Designing pre-ozonation and intermediate ozonation facilities at the two water treatment plants for the City of Arlington, Texas. Using our computational fluid dynamic (CFD) models, Carollo optimized Arlington's ozone contactor design. We are also conducting a joint research project with various utilities in the Phoenix, Arizona, area to evaluate ozonation and biological filtration to meet long-term finished water quality goals.

- ▶ Designing (in joint venture) the world's largest ozone generation system at a water treatment plant in Las Vegas, Nevada.



**Water Treatment
Planning and Design
Projects**

Carollo takes pride in our proven track record of applying innovative solutions that are both practical and reliable.

Representative Projects - Water Treatment Plants

Client/Project	Project Elements							
	Capacity (million gallons)	Conventional Treatment	Membranes	Ozone	UV Disinfection	Automation	Solids Handling	Chemical Handling
Southern Nevada Water Authority, Las Vegas, Nevada - Southern Nevada Water System Improvements Project	624	●		●		●	●	●
Metropolitan Water District of Southern California, La Verne, California - F.E. Weymouth Water Treatment Plant	520	●		●		●		●
City of Phoenix, Arizona - Val Vista Water Treatment Plant	220	●				●	●	●
City of Phoenix, Arizona - Union Hills Water Treatment Plant	160	●				●	●	●
City of Sacramento, California - E.A. Fairbairn Water Treatment Plant	160	●				●	●	●
City of Sacramento, California - Sacramento River Water Treatment Plant	160	●				●	●	●
Metropolitan Water District of Salt Lake City and Sandy, Utah - Point of the Mountain Water Treatment Plant	150	●		●	●	●	●	●
City of Oklahoma City, Oklahoma - Draper Water Treatment Plant	150		●				●	●
East Bay Municipal Utility District, California - Walnut Creek Water Treatment Plant	120	●			●	●	●	●
Santa Clara Valley Water District, California - Santa Teresa Water Treatment Plant	100	●		●		●		●
Santa Clara Valley Water District, California - Rinconada Water Treatment Plant	75	●		●		●		●
City of Arlington, Texas - Pierce-Burch Water Treatment Plant	68	●		●		●		●
City of Arlington, Texas - John F. Kubala Water Treatment Plant	65	●		●		●		●
City of Austin, Texas - Water Treatment Plant	50	●				●	●	●
Santa Clara Valley Water District, California - Penitencia Water Treatment Plant	42	●		●		●		●
City of Vallejo, California - Fleming Hill Water Treatment Plant	42	●		●		●	●	●
Town of Gilbert, Arizona - Gilbert Water Treatment Plant	30	●		●		●		●
City of Olathe, Kansas - Water Treatment Plant No. 2	30		●					●
Upper Trinity Regional Water District, Texas - Tom Harpool Water Treatment Plant	20		●	●		●		●
North Shore Water Commission, Wisconsin - North Shore Water Filtration Plant	18	●			●			
City of Peoria, Arizona - Greenway Water Treatment Plant	16	●		●		●	●	●
Brazos River Authority, Texas - Brazos River Authority Water Treatment Plant	15		●			●		●
City of Lake Forest, Illinois - Lake Forest Water Treatment Plant	14		●			●	●	●
United Water Missouri - United Water Missouri Treatment Plant	8					●		●
City of South Bend, Washington - South Bend Water Treatment Plant	2		●			●		●

METROPOLITAN WATER DISTRICT OF SALT LAKE AND SANDY, UTAH

Point of the Mountain Water Treatment Plant Design and Construction

HIGHLIGHTS

Design, construction, and startup of a 70-mgd (150-mgd ultimate) water treatment plant with UV disinfection.

Optimized UV system validation, dose monitoring, and control.

On time and within budget project completion.

Carollo was the lead consultant for the design and construction of the Point of the Mountain Water Treatment Plant for the Metropolitan Water District of Salt Lake and Sandy, located near Salt Lake City, Utah. The plant was designed for an initial capacity of 70 mgd, expandable to 150 mgd. This greenfield project included flash mix, flocculation, sedimentation, intermediate ozone, biologically active filters, UV disinfection, and on-site chlorine generation. Other plant facilities included a finished water pump station, a 20-MG finished water reservoir, solids settling basins, a 6-megawatt standby power generation facility, and a maintenance facility. Total construction costs were \$90 million (2004 dollars). Project construction was completed in 2007.

Carollo designed the disinfection facilities to provide complementary use of ozone, chlorine, and UV disinfection. UV provided 2.5-log *Cryptosporidium* and *Giardia* inactivation credit. Ozone provided 0.5-log *Giardia* credit, T&O treatment, and process enhancement. Chlorine provided 2.0-log virus credit.

While the UV system was designed to accommodate seven reactors, only four reactors are installed to treat an interim capacity of 70 mgd. With the optimization of UV validation using new test microbes, the implementation of the 2006 UVDGM, and the increase in UVT caused by ozonation, the four installed reactors have capacity to treat the 150-mgd design flow, thereby providing capital and operation and maintenance cost savings. Each UV reactor was validated for 40-mgd of flow capacity.



Carollo provided construction services for the installation of large-scale WEDECO K143 reactors validated to flows of 40 mgd.



HIGHLIGHTS

Design includes several miles of new tunnels, including a raw water tunnel more than 350 feet deep.

Use of lime softening takes advantage of an abundant local resource.

Occupied buildings using "green" technology to achieve a LEED rating of Silver.

Rainwater harvesting reduces runoff and maximizes efficient water use.

Water Treatment Plant No. 4 Predesign and Design

The City of Austin hired Carollo to perform the preliminary design, final design, and construction management services of a new water treatment plant (WTP4). The initial plant capacity will be 50 mgd, and the facilities will be sized and configured for an ultimate capacity of 300 mgd.

A submerged intake in nearby Lake Travis will draw water from the lake, which will then flow through a 350-foot deep, two-mile tunnel to a raw water pump station and then be lifted to the WTP4 site. The water will be treated using lime softening, granular media filtration, UV disinfection (at ultimate capacity), and chloramination. WTP4 will be built on a challenging hillside site in a sensitive environmental area, requiring the implementation of a rigorous process to implement best management practices and environmental mitigation measures.

Carollo completed preliminary engineering and moved into final detailed design of the facility in 2008. Initial phases of roadway and pump station construction were started in 2009, with construction of the water plant facilities scheduled to begin in 2011.

Specifically, Carollo's services consist of the following tasks:

- ▶ Develop and conduct a broad-based communications plan to involve key stakeholders.
- ▶ Develop mitigation measures and environmental enhancements for construction of the new WTP4.
- ▶ Assist in alternative site assessments conducted by the City and others.
- ▶ Perform additional environmental surveys and monitoring to enhance the existing database of information and secure permits for the various phases of the work.
- ▶ Develop alternative layouts for the potential sites that reflect current concepts for mitigation and plant size.
- ▶ Benchmark this project to other projects developed in environmentally sensitive areas.
- ▶ Perform hydraulic modeling and distribution system analysis.
- ▶ Complete design phase services, including multiple hydraulic structures and buildings, new roadways and piping systems, environmental protection features, a new electrical substation, and security improvements.
- ▶ Follow-through with construction and startup phase services.



Water from nearby Lake Travis will be used for the new treatment facilities to provide drinking water to the growing population of Austin.

METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA, LA VERNE, CALIFORNIA

Weymouth Water Filtration Plant Oxidation Retrofit Preliminary Design

HIGHLIGHTS

520-mgd water treatment plant.

Preliminary design of preozonation for primary disinfection.

DBP abatement for compliance with Stage 2 D/DBP Rule.

pH adjustment upstream of ozonation to minimize bromate formation.

Built in 1939, Metropolitan's 520-mgd F.E. Weymouth Water Treatment Plant is one of the largest conventional treatment plants in the United States. This facility treats water delivered from the Colorado River Aqueduct and the State Project Water (SPW) California Aqueduct. As a result of the upcoming Stage 2 D/DBP Rule, the U.S. EPA essentially requires the use of ozone or other alternative (non-chlorine) disinfection at all plants treating significant amounts of SPW 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. Metropolitan 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 these applications led to the planned Oxidation Retrofit Program (ORP).



Implementing ozonation at MWDSC's F.E. Weymouth Filtration Plant will allow unrestricted blending of Colorado River Water and State Project Water, and optimize source water usage.

In early 2003, Metropolitan 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. As the Site Engineering Study task neared completion, Metropolitan selected Carollo to perform preliminary 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. The project includes:

- ▶ Liquid oxygen storage, with subsequent oxygen separation and ozone generation.
- ▶ Four ozone contactors with ten chambers each for a design contact time of 10 minutes.
- ▶ An off-gas ozone destruction system and an 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.

Southern Nevada Water System Improvements Project

The Southern Nevada Water Authority retained Carollo, in joint venture, to design and provide construction management services for the \$124 million Southern Nevada Water System Improvements Project. The project included the following major components:

- ▶ Expansion of the Alfred Merritt Smith (AMS) Water Treatment Plant from 400 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.
- ▶ A 2,000-cfs flood control channel.
- ▶ Seven hot tap connections to steel and prestressed concrete pipe ranging in size from 24 to 72 inches in diameter.

- ▶ Micro-tunneled and bored-and-cased crossings of highways/major arterials.

The joint venture team was also responsible for design and construction of the world's largest ozone generation system. With a construction cost in excess of \$60 million, the AMS system provides preozonation in advance of flocculation and filtration. Carollo was responsible for the planning, design, resident engineering, and construction support services. A total of 20,000 pounds per day of ozone will be provided from five medium-frequency generators producing up to 12 percent ozone by weight.

HIGHLIGHTS

624-mgd water treatment facility; one of the largest direct filtration plants in the world.

World's largest ozone generation system at a treatment plant.

Successful resolution of complex construction sequencing issues.

“An additional characteristic of the company is its dedication and commitment to meeting the plant operators’ needs. Carollo met with the operators on a regular basis to gain mutual understanding in regard to the plant’s new treatment and process chain. In addition, the firm demonstrated its comprehension of new technology.”

*— J.T. Monscvitz, Former Director of Operations,
Southern Nevada Water System*



Carollo’s experience includes designing water treatment plants ranging in size from less than 1 mgd in capacity to the 624-mgd Alfred Merritt Smith Water Treatment Plant in Las Vegas, Nevada.

Val Vista Water Treatment Plant

HIGHLIGHTS

Water treatment plant expansion to 220 mgd.

Hydraulic and instrumentation upgrades.

Solids handling facility.

Dechlorination facility.

Existing facility modification to comply with UBC and UFC requirements.

Conformance with State of Arizona water treatment guidelines and federal water quality targets.

Carollo provided predesign, design, and construction services for the expansion of the Val Vista Water Treatment Plant to 220 mgd. Preceding the expansion project, Carollo designed a \$25 million plant hydraulic and instrumentation upgrade project that also included chemical facilities and a remodeled administration building.

The plant, which is jointly owned by the cities of Phoenix and Mesa, was first placed into service in 1975 with a treatment capacity of 80 mgd. An expansion increased capacity to 140 mgd in 1982. Carollo completed the 80-mgd expansion to 220 mgd in 1998. This expansion included:

- ▶ A new water inlet facility and raw water pump station.
- ▶ Presedimentation, flocculation, and final sedimentation basins.
- ▶ Eight mono medium filters.
- ▶ Expanded chemical handling facilities to include alum and coagulant-aid polymer.
- ▶ A chlorine disinfection and scrubber facility.
- ▶ An expanded distributed control instrumentation system and new electrical service.

Carollo also completed the preliminary and final design of the solids handling facility that converts the plant to near-zero discharge. This facility, which treats waste streams from the newly expanded plant, includes waste backwash water equalization and clarification, blow down sludge thickening, thickened sludge storage, modifications to the used water recovery system, and addition of a permanent dewatering facility. The project included new facilities to dechlorinate discharge from the solids handling facility or overflow from the existing finished water reservoirs. In order to achieve compliance with NPDES permit requirements, Carollo prepared a best management practice (BMP) plan to

explain operating procedures for the treatment plant, solids handling, and dechlorination facilities.



The Val Vista Water Treatment Plant expansion to 220 mgd is just one example of Carollo's work at this facility, which spans more than 10 years.



E.A. Fairbairn and Sacramento River Water Treatment Plant Expansions

HIGHLIGHTS

Capacity increase to 160 mgd at both facilities.

Design which provides for future implementation of ozone or ultraviolet disinfection.

Seismic considerations for soils with high liquefaction potential.

Carollo, in association with others, recently completed the design of an expansion of the City of Sacramento's E. A. Fairbairn and Sacramento River Water Treatment Plants. Both existing facilities were aging conventional treatment plants. The project involved providing an integrated package of improvements based on Sacramento's values, operational preferences, flexibility, reliability, and the continued use of the existing facilities.

The project involved increasing the capacity from 100 mgd to 160 mgd at both plants while reducing the demands on aging treatment processes. Upgrades provided by Carollo include:

- ▶ Common automatic grit removal facilities replacing existing individual manually-cleaned basins.
 - ▶ Pump diffusion flash mix for 160-mgd of flow.
 - ▶ Four-stage, 30-minute flocculation with vertical shaft units.
 - ▶ Rectangular horizontal sedimentation basins with automatic sludge collection equipment.
 - ▶ Dual-media filters with air/water wash underdrains and filter-to-waste capabilities.
 - ▶ CT basin/clearwell upgrades to provide flexibility in meeting future regulatory disinfection requirements downstream of the filters.
 - ▶ Engineered lagoons to provide inexpensive solids handling.
- The design allows existing and new facilities to be isolated for maintenance. The expansion is designed for future implementation of ozone or ultraviolet disinfection. The design also includes special considerations, such as pile foundation supports, for the Sacramento River Water Treatment Plant due to soils in the area with extremely low bearing capacities and high-liquefaction potential during an earthquake.



The expansion designs for Sacramento's water treatment facilities incorporated the clients values and operational preferences, flexibility, reliability, and continued use of existing facilities.



Draper Water Treatment Plant

Carollo is expanding the Oklahoma City's Draper Water Treatment Plant. This expansion increases plant capacity from 90 mgd to 150 mgd for the treatment plant and from 90 mgd to 124 mgd for the pumping stations. It also incorporates hydraulic improvements that will allow Oklahoma City to eliminate sustained use of the existing low lift pump station that has been in operation since 1969. Oklahoma City will save approximately \$7.1 million through reduced usage and avoided expansion of the low lift pump station by allowing gravity flow from the two separate water sources (Lake Draper and the Atoka Pipeline). The project also includes novel process solutions for total organic carbon (TOC) removal for both interim and long-term compliance with the disinfection by-products rules.

Major improvements related to this project include modifying the coagulant addition process, upgrading existing flocculation facilities, and modifying the sedimentation facilities, including a new solids collection system. The design will incorporate new chemical feed systems, such as carbon dioxide, in the expanded facility to provide the flexibility required to meet TOC requirements and still produce non-aggressive finished water. Upgrading existing chemical feed facilities such as coagulant and chlorine gas will provide improved flexibility as well as safer, more reliable, and secure facilities. The project will include the construction/upgrade of seven chemical feed systems.

The upgraded facility will easily accommodate the unit processes desired by Oklahoma City in the future. Providing facilities that can incorporate baffle walls and plate settlers for more basin settling capacity, and an

ultraviolet disinfection system will produce a water treatment plant that can easily be expanded to handle changing raw water quality as well as future anticipated regulations.



The expansion of Oklahoma City's Draper Water Treatment Plant will result in a savings of \$7.1 million through hydraulic improvements and reduced use of existing facilities.

HIGHLIGHTS

- 150-mgd water treatment capacity and 124-mgd pumping capacity.
- Novel process solution for TOC removal.
- Modifications to flocculation and sedimentation facilities.
- Construction/upgrade of seven chemical feed systems to provide improved flexibility as well as safer, more reliable, and secure facilities.
- Design to accommodate future process improvements.

EAST BAY MUNICIPAL UTILITY DISTRICT, CALIFORNIA

Walnut Creek Water Treatment Plant

Carollo provided preliminary design and is currently providing final design services for the East Bay Municipal Utility District's (EBMUD) Walnut Creek Water Treatment Plant Improvements Project. The primary objective of the project is to increase the plant's treatment capacity to 120 mgd and provides for approximately \$85 million in planned improvements to the facility.

During preliminary design, Carollo also developed a master plan to upgrade the plant from an in-line process to full conventional treatment to address future regulatory requirements and/or treatment of American River water. The master plan also included layout and hydraulic modifications to allow future addition of ozone and/or UV disinfection.

Plant improvements will include completely new chemical facilities to improve reliability and increase storage and feed capacity; two new filters totaling 40 mgd in capacity; new washwater treatment facilities including flow equalization, sedimentation and UV disinfection; new 16-million-gallon and 5-million-gallon clearwell tanks; upgrade to the plant instrumentation and control system; seismic improvements to plant buildings; and measures to address operations staff work space, plant security, and landscaping needs. Carollo is performing final design of UV for the washwater recycling system—an innovative response to the unique treatment needs at the site.

The improvements will be constructed on a congested hillside site, requiring extensive earthwork to move up to 100,000 cubic yards of soil. Construction of the facilities will also involve significant neighborhood issues and require a phasing plan to keep existing facilities in operation during construction.

HIGHLIGHTS

\$85 million in planned improvements.

Completely new chemical facilities.

Design of UV treatment following sedimentation of recycled washwater.

Use of computational fluid dynamics to assist with design of clearwell for improved chlorine contact efficiency.

Extensive mitigation requirements to protect the environment and minimize impact on neighbors.

Construction of improvements to the East Bay Municipal Utility District's Walnut Creek Water Treatment Plant will involve significant neighborhood issues given the facility's proximity to surrounding homes.



SANTA CLARA VALLEY WATER DISTRICT, SAN JOSÉ, CALIFORNIA

Penitencia, Rinconada, and Santa Teresa Water Treatment Plants

HIGHLIGHTS

Chemical handling facilities at three treatment facilities.

Evaluation of UV disinfection and membrane treatment as alternatives to the proposed addition of ozone.

Washwater treatment improvements.

Settled water ozonation.

Biologically-active GAC filters.

The Santa Clara Valley Water District (SCVWD) retained Carollo to provide engineering services for Stage 1 and Stage 2 of its Water Treatment Improvement Project (WTIP). The project involves improvements at three water treatment facilities: the 42-mgd Penitencia Water Treatment Plant, the 75-mgd Rinconada Water Treatment Plant, and the 100-mgd Santa Teresa Water Treatment Plant. These improvements will allow SCVWD to meet its customers' needs in the 21st century and provide the operational tools to produce finished water that complies with Stage 1 of the D/DBP Rule and Interim Enhanced Surface Water Treatment Rule (IESWTR).

WTIP Stage 1 included the design of new chemical facilities at all three water treatment facilities and the design of significant structural improvements to the Penitencia plant's flocculation, sedimentation, and filter basins.

WTIP Stage 2 improvements include design of washwater treatment improvements, additional chemical feed facilities, filter-to-waste enhancements, GAC filter caps, and settled water ozonation at the Penitencia

plant. Stage 2 also involves evaluating alternatives to the proposed addition of ozone at all three treatment facilities. Alternatives include membrane treatment and UV disinfection. Carollo participated in expert panel workshops and prepared a technical memorandum that detailed layouts and cost estimates for UV disinfection.

Carollo's services also include providing support to SCVWD's construction management group for all three Stage 1 facilities and for the Penitencia plant for Stage 2.



Carollo's work for the Santa Clara Valley Water District (left to right; Santa Teresa Water Treatment Plant, Rinconada Water Treatment Plant, Penitencia Water Treatment Plant) includes improvements to three water treatment facilities with a combined capacity of 217 mgd.

Pierce-Burch and John F. Kubala Water Treatment Plants

HIGHLIGHTS

First community in Texas to have its entire water supply treated with ozone.

68-mgd and 65-mgd water treatment facilities.

Design of \$20 million in preozonation and intermediate ozonation facilities at two water treatment plants.

Computational fluid dynamic models used to optimize ozone contactor design.

Reduction in tastes and odors, trihalomethanes, and potential *Cryptosporidium* contamination.

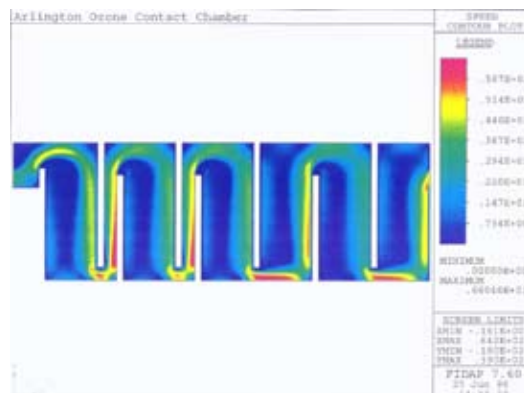
Carollo, in association with others, completed the design of preozonation and intermediate ozonation facilities and filtration improvements for two water treatment plants for the City of Arlington. The design team used computational fluid dynamic models to optimize the ozone contactor design. The ozonation improvements include 3,000 pounds per day of generation capacity at the 68-mgd Pierce-Burch Water Treatment Plant and 2,000 pounds per day generation capacity at the 32.5-mgd John F. Kubala Water Treatment Plant. Liquid oxygen 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. The filter improvements involve 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 to determine Arlington's best course to comply with pending 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 to less than 40 mg/L, and providing another barrier against potential *Cryptosporidium* contamination.

In a subsequent project, Arlington retained Carollo, in association with others, to expand the current treatment capacity of the John F. Kubala plant from 32.5 to 65 mgd. The project includes expansions to the plant's basin complex, filter complex, finished water clearwells, high-service pump station, chemical facilities, and electrical/instrumentation facilities.



Carollo used computational fluid dynamic modeling at two Arlington water treatment facilities to increase ozone reactor efficiency by 20 percent and significantly reduce construction costs.



Conceptual Design of UV Disinfection Facility

The water supply for the City of Syracuse is Skaneateles Lake, a high-quality supply with low turbidity and low organics. The supply is of such high quality that Syracuse currently maintains filtration avoidance. Water flows from the lake through two intakes, enters a gatehouse where it splits into three conduits, and then exits the gatehouse where it is dosed with chlorine. The water then travels over 20 miles into open reservoirs or a standpipe to feed two pressure zones within the City. Sodium hypochlorite is added to the water as it leaves the reservoirs and standpipe and enters the distribution system. The entire system flows by gravity from the lake intake to the consumer's tap.

To maintain filtration avoidance, Syracuse is investigating ultraviolet (UV) disinfection for the Skaneateles Lake supply. Carollo is part of the team that is providing conceptual design of a UV disinfection facility. The conceptual design consists of some unique features. Because the system flows completely by gravity, any hydraulic head used in the UV facility reduces the overall capacity of the conduits that carry water to Syracuse's reservoirs. This required careful hydraulic design to minimize headloss through the facility. In addition, two separate pipelines carry water to two separate pressure zones within the City. To provide ultimate flexibility, each UV reactor can treat water from either of the two sources. The ultimate treatment capacity of the facility will be 60 mgd. The facility includes three reactors and an additional reactor for redundancy. Because a complete water treatment plant may eventually be located on the site, the UV facility design allows stand-alone operation or operation as part of the future water treatment facility.

HIGHLIGHTS

Conceptual design of a 60-mgd UV disinfection facility.

Flexibility to treat and deliver water to two pressure zones.

Design that allows stand-alone operation or operation as part of a future water treatment facility.



Carollo is part of a team assisting Syracuse with design of a UV disinfection facility. The facility will help Syracuse maintain the current filtration avoidance of its Skaneateles Lake water supply.

WEBER BASIN WATER CONSERVANCY DISTRICT, LAYTON, UTAH

Davis North Water Treatment Plant

Carollo designed an expansion and upgrade for the Weber Basin Water Conservancy District's Davis North Water Treatment Plant in Layton, Utah. The project increases capacity from 26 mgd to 46 mgd and 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.

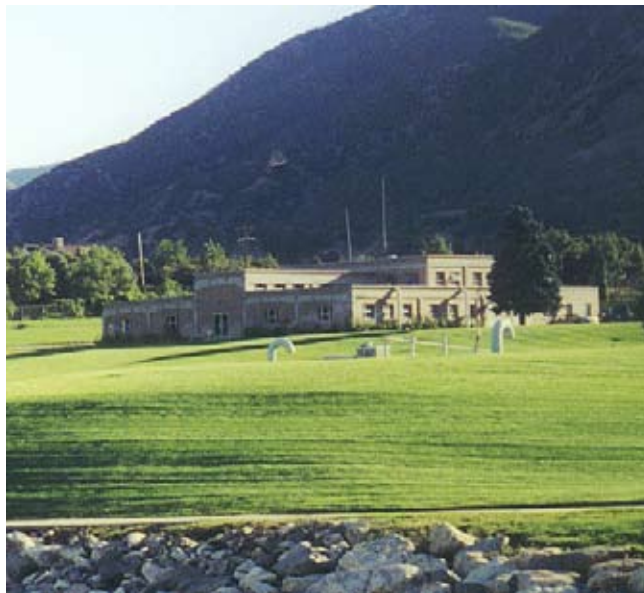
HIGHLIGHTS

Plant expansion to 46 mgd.

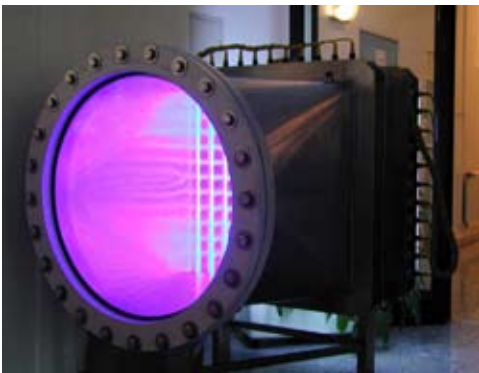
Pre- and intermediate ozone designed for taste and odor control and enhanced particle removal.

One of the country's first large-scale UV disinfection drinking water installation.

Conjunctive use of ozone and UV resulted in a facility cost approximately 50 percent of the next-lowest-cost alternative.



Carollo designed an expansion of Weber Basin's Davis North Water Treatment Plant from 26 to 46 mgd. Facilities include ozonation and UV disinfection.



HIGHLIGHTS

- Water treatment expansion to 42 mgd.
- Small challenging site in a residential area.
- Facilities kept in service during construction.
- Successful resolution of complex delivery/sequencing issues.

Fleming Hill Water Treatment Plant Expansion

Carollo completed a comprehensive plant evaluation that identified the necessary process upgrades and expansion for the City of Vallejo Fleming Hill Water Treatment Plant. The plant 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 necessitated a capacity increase. Vallejo retained Carollo to design process upgrades to bring the plant capacity from 27 mgd 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.
- ▶ 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.

"The effort clearly demonstrates a commitment to quality and constructability."

—Exequiel Ganding, Jr., Water Superintendent, City of Vallejo



Carollo successfully delivered the \$35 million Fleming Hill Water Treatment Plant in a residential neighborhood without interruption to Vallejo's water supply.

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 environmental subconsultant to provide a smooth EIR stage of the project. They also worked closely with the California Department of Health Services 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.

Gilbert Water Treatment Plant Expansion

In the early 1980s, the Town of Gilbert recognized the need to plan for future growth and that an alternative to pumping groundwater to supply the community's water needs was necessary. At this same time, Arizona enacted its progressive Groundwater Code, which addressed the groundwater overdraft problem and provided a means for allocating Arizona's limited groundwater resources. To meet its water supply needs, Gilbert selected Carollo to develop a water resource plan and then to provide planning, design, and construction services for its first water treatment plant. The construction of the 15-mgd Gilbert Water Treatment plant was completed in 1997.

In a subsequent project, Carollo performed a study to evaluate Gilbert's water treatment process and completed the design of a 15-mgd expansion of the plant to 30 mgd. This project included a pilot study to examine the use of ozonation and biological filtration to meet Gilbert's long-term finished water quality goals. Work included reviewing current and anticipated water quality regulations, evaluating available treatment technologies, investigating the Roosevelt Conservation District as a second raw water supply, and assessing alternative energy resources for the plant. The project's objectives included complying with future regulations, minimizing the public health risk associated with chlorine-resistant microbial pathogens, and addressing taste and odor issues. Based on the pilot study results, the 15-mgd expansion design includes ozonation facilities.

Carollo also reviewed Gilbert's current master plan to determine if the plant's ultimate capacity could be increased from 45 mgd to 60 mgd. Study results assisted town officials in determining if adjustments were necessary to meet Gilbert's future water needs.

HIGHLIGHTS

- Client relationship spanning nearly 20 years.
- Design of new 15-mgd water treatment facility and subsequent expansion to 30 mgd.
- Pilot testing to examine the use of ozone and biological filtration to meet long-term finished water quality goals.
- Design of ozonation facilities.



Carollo's design of Gilbert's water treatment facility includes the addition of ozonation to provide primary disinfection and meet future regulatory requirements.

Water Treatment Plant No. 2

The City of Olathe had two water treatment facilities. Water Treatment Plant No. 1 was a surface water treatment plant with a capacity of 4 mgd. Water Treatment Plant No. 2 treated groundwater under the influence of surface water and had a capacity of 17 mgd.

High growth source water over the past six years, coupled with limited firm yield of Water Treatment Plant No. 1, drove Olathe to seek additional treatment capacity at Water Treatment Plant No. 2. Olathe selected Carollo to assess the expansion of this facility. The study included:

- ▶ Investigating the changes in source water quality as Olathe transitions from groundwater wells to a horizontal collector well system.
- ▶ Performing a regulatory evaluation and identifying available treatment technologies to meet current and proposed regulations.
- ▶ Conducting a process evaluation to determine the necessary improvements to increase the firm capacity from 17 mgd to 30 mgd.
- ▶ Conducting a hydraulic evaluation including field calibration of the hydraulic model.
- ▶ Developing a series of process alternatives that satisfy future regulatory and water capacity issues (including membranes and UV disinfection).
- ▶ Conducting an operational impacts evaluation/constructability review with input from a selected contractor.

The study recommended increases in pretreatment and softening capacity through innovative modifications to existing infrastructure involving the addition of filtration capacity through low-pressure membranes. The expansion increased the overall capacity to 30 mgd, with provisions in the hydraulic system and building structures to supply up to 52 mgd in the future.

Due to a tight schedule that required the improvements to be complete by the peak demand season in 2005, Olathe opted for project delivery via design/build. Carollo maintained a leadership role as engineer and produced a 30 percent set of plans and specifications. The 30 percent design effort included membrane piloting for a three-month period in order to produce reasonable design criteria for four prequalified membrane manufacturers. The 30 percent design bid package included two alternative building designs so that Olathe could receive comprehensive competitive pricing on both submerged and module membrane systems. Carollo delivered the 30 percent plans and specifications on time to meet the project's aggressive schedule, and continued meeting the schedule through the final design and construction of the project.

HIGHLIGHTS

Design/build delivery of water treatment plant expansion to 30 mgd.

Evaluation of process alternatives including membrane filtration and UV disinfection.

30 percent design that includes two alternative building layouts to obtain competitive pricing for submerged and module membrane systems.

Innovative approach to meet peak season demand requirements on a tight schedule and at a reasonable cost.



Utilizing existing plant infrastructure at Olathe's Water Treatment Plant No. 2, Carollo developed an innovative plan to meet peak demand without bringing membrane facilities online until months later. This eased a tight schedule and reduced construction costs.

Tom Harpool Water Treatment Plant

HIGHLIGHTS

Conceptual design study evaluating conventional versus membrane treatment.

Consideration of treatment facility life-cycle costs, remote operations, and operational staff.

Design of 20-mgd membrane treatment facility.

Designed to accommodate the addition of ozone and UV disinfection pretreatment for taste and odors.

Design of raw water and finished water lines.

Carollo provided a site selection study, conceptual process evaluation, membrane pilot testing, preliminary design, final design, and engineering services during construction for the new \$33.3 million 20-mgd Tom Harpool Water Treatment Plant (WTP), located in the rapidly growing northeast part of Denton County. Additional services that were provided include complete design services for both the raw water line and finished water lines for this new treatment plant.

Conceptual Design. The conceptual design study included an evaluation of a conventional treatment facility with ozone versus a membrane treatment facility. As part of this study, life-cycle costing for both options was investigated. In addition to cost, other factors included the applicability for remote operations and sensitivity for operational manning of the plant. The recommended treatment process for this facility was a membrane plant.

Pilot Study. A membrane pilot testing study was conducted to determine the design parameters applicable for this new plant. Three membrane manufacturer units were tested at the Sulphur Springs WTP since that plant receives the same raw water. The raw water is relatively high in TOC (6 to 7 mg/L) and has an average turbidity of 20 NTU. The pilot testing confirmed that membrane treatment is a viable and cost-effective process that provides high quality water.

Design. The final design included a membrane building to house the membrane system and pretreatment processes (screening, rapid mix, and flocculation), a chemical/control building, sodium hypochlorite / ferric facilities, finished water pump station, 4-MG clearwell, backwash recovery ponds, and a recovery / emergency return pumping station along with miscellaneous yard structures and piping. The disinfection process includes sodium hypochlorite followed by liquid ammonium sulfate to form chloramines in the transmission system. This initial phase of the plant design laid out the site facilities and piping to accommodate an ultimate 240-mgd plant while minimizing the initial plant construction cost.



Carollo is designing a second water treatment plant for the Upper Trinity Regional Water District. The new facility will provide additional treatment capacity to UTRWD's service area, which is currently served by the existing regional treatment facility, shown here.

Engineering Services During Construction. Construction began in December 2004. Carollo is providing office construction-phase services. UTRWD is providing the resident engineering and construction inspection.

Raw and Finished Water Pipelines. Carollo also provided design services for five miles of 48-inch raw water pipeline and five miles of 36-inch finished water transmission pipeline.

NORTH SHORE WATER COMMISSION, MILWAUKEE, WISCONSIN

North Shore Water Filtration Plant

The North Shore Water Filtration Plant was placed in service in 1963 and has a current capacity of 18 mgd. Because of the age of the plant and changes in water quality regulations, the North Shore Water Commission retained Carollo to perform an optimization study prior to commencing the next round of modification and upgrade projects for the plant. The optimization study's purpose was to determine the operating methods and physical modifications necessary to eliminate deficiencies and improve the operation of the plant to meet current and future water quality standards. Work included:

- ▶ Preparing a regulatory analysis to determine the plant's compliance with existing regulations and projected compliance with future regulations.
- ▶ Performing bench-scale pretreatment evaluations to optimize chemical pretreatment.
- ▶ Evaluating the existing process facilities and made recommendations to improve deficiencies identified for flash mixing, flocculation, sedimentation, filtration, disinfection, residuals handling, and chemical feed facilities.

Carollo has since assisted North Shore in upgrading their flash mix facilities. This effort involved installing a new pump diffusion flash mix at the plant, which reduced coagulant costs by over 30 percent. Carollo designed UV disinfection facilities for the plant.

HIGHLIGHTS

Optimization study for 18-mgd water treatment facility to improve deficiencies.

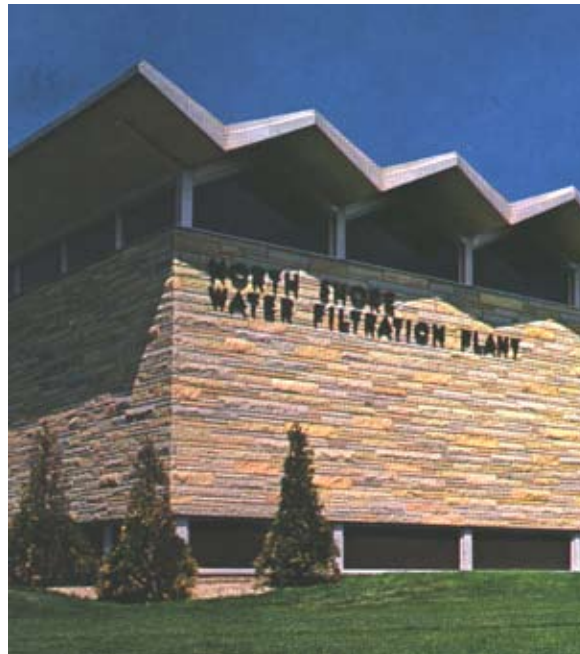
Bench-scale pretreatment evaluations to optimize chemical pretreatment.

New pump diffusion flash mix, reducing coagulant costs by over 30 percent.

UV disinfection design.



Carollo assisted the North Shore Water Filtration Plant in implementing UV disinfection.



Greenway Water Treatment Plant

Carollo's services for the City of Peoria's new Greenway Water Treatment Plant included planning, design, and construction management. The first-phase design provided for a treatment capacity of 16 mgd and utilized conventional treatment processes in combination with ozonation and biologically active filtration (BAF).

The design provided for conventional treatment processes, including chemical addition, rapid flash mixing, pre-sedimentation, final sedimentation, and flocculation. Ozone is used as a primary disinfectant with chlorine added as the secondary disinfectant. BAF reduces taste and odor. Additional facilities included finished water storage and pumping, used water recovery, solids handling, and a PLC-based remote control operation system with SCADA capabilities.

The 20-acre facility included an operations building which houses training rooms, offices, maintenance areas, and a laboratory. Treatment-related buildings, such as the chemical handling facility, a disinfection building, and an ozone generation building, are centrally located in relation to the treatment process structures on the site.

HIGHLIGHTS

\$28 million water treatment facility with a first-phase capacity of 16 mgd.

Designed for conventional treatment in combination with ozonation and biologically active filtration.



The Greenway Water Treatment Plant was designed for conventional treatment in combination with ozonation and biologically active filtration.

Marden Water Treatment Plant Expansion

HIGHLIGHTS

Water treatment plant expansion to 16 mgd.

New pretreatment facilities.

Independent treatment optimization of multiple raw water sources.

Sludge lagoon design.

In 1997, United Water Idaho (UWID) awarded Carollo a contract to design an expansion of the 8-mgd Marden Water Treatment Plant to 16-mgd. The work is a continuation of Carollo's recently completed Expansion Alternatives Study and Predesign Study for UWID.

Members of the Carollo design team previously designed the original Marden plant. The original plant design included high-rate conventional treatment with dual-media granular filters, using Superpulsator® upflow clarifiers. The original design provided for treatment (through a single process) of either surface water from the Boise River or groundwater under the influence of surface water from Ranney collectors.

In expanding the Marden plant, Carollo's design allows for the treatment of either source supply to be optimized independently by providing a second inlet structure with its own metering, flow control, and chemical addition facilities. Pretreated water can be separately applied to the filters or co-mingled prior to filtration, depending on the preference of the operators.

The expansion project also includes the addition of a third sludge lagoon. Carollo designed the lagoon system to dewater Superpulsator® sludge and treat filter waste washwater and filter-to-waste. The engineered sludge lagoons feature a hard bottom and sides (6-inch slabs of fiber-reinforced concrete), sloped bottoms, decant structures with adjustable downward opening weir gates, polymer addition, and constant-rate recycle flow control.



Carollo's design of an expansion of United Water Idaho's Marden Water Treatment Plant allows for separate treatment of multiple raw water sources to reduce overall treatment costs.

BRAZOS RIVER AUTHORITY, GRANBURY, TEXAS

Brazos River Authority Water Treatment Plant

The Brazos River Authority (BRA) owns and operates a water treatment plant near the City of Granbury, Texas. This plant had a finished water treatment capacity of 5 mgd, but was expanded to 15 mgd due to the rapid development in the Dallas-Fort Worth area. The existing plant is a conventional coagulation plant with filtration followed by electro dialysis reversal (EDR) for removal of total dissolved solids (TDS), chloride, and sulfate to meet EPA and State of Texas drinking water standards. Because of problems with the EDR process, BRA decided to pursue reverse osmosis (RO) as the desalting process for the expansion.

Carollo performed a pilot study in the fall of 2000 to evaluate expanded treatment processes that would include RO. The study determined that the expansion flow scheme should involve lime softening to reduce barium ions along with recarbonation and a microfiltration (MF) or ultrafiltration (UF) membrane system to reduce turbidity prior to RO treatment. Barium removal through the lime softening process is important to maximize the RO recovery while preventing barium sulfate scale from forming on the RO membranes.

Carollo, in association with others, provided design services for the 12-mgd UF and the 10-mgd RO facilities along with design of the instrumentation and control system for the entire facility.

HIGHLIGHTS

- State-of-the-art solution to electro dialysis reversal challenges.
- Pilot testing of softening/ ultrafiltration/reverse osmosis.
- Design of 12-mgd ultrafiltration facilities.
- Design of 10-mgd reverse osmosis facilities.
- Instrumentation/control system design.



To meet water quality objectives, the upgrade of the Brazos River Authority Water Treatment Plant included new low-pressure membranes and reverse osmosis.

Lake Forest Water Treatment Plant

The City of Lake Forest had concerns about the ability of its water treatment facility to meet existing and future water quality standards. In addition, physical limitations prevented the plant from achieving its 18-mgd design capacity. To address these issues, Lake Forest hired Carollo to evaluate improvements needed at the treatment facility and to design an upgrade. Project elements included:

Water treatment facility upgrade.

Hydraulic capacity analysis using Carollo's hydraulic model.

Phased, prioritized schedule of plant improvements.

New low-pressure membranes with an initial capacity of 14 mgd.

HIGHLIGHTS

- ▶ A hydraulic capacity analysis of the individual treatment processes using Carollo's hydraulic model. The project team developed solutions to hydraulic bottlenecks using the hydraulic model and calibrated the model results with field survey measurements.
- ▶ An evaluation of process capacity and treatment upgrade needs. This included defining optimal chemical pretreatment conditions using bench-scale equipment.
- ▶ An evaluation of process facilities based on process design criteria.
- ▶ Preparation of a pre-design report to establish a phased, prioritized schedule of plant improvements.

Based on this evaluation, Lake Forest hired Carollo to design the necessary improvements at the plant. These upgrades included the addition of low-pressure membranes with an initial capacity of 14 mgd, a new 18-mgd finished water pump station, and replacement of the existing electrical and instrumentation control system.



The City of Lake Forest retained Carollo to design new ultrafiltration membranes at its water treatment facility to protect consumers from water-borne pathogens.

UNITED WATER MISSOURI, JEFFERSON CITY, MISSOURI

United Water Missouri Water Treatment Plant

The United Water Missouri (UWM) Water Treatment Plant is a conventional treatment plant employing lime softening for hardness and turbidity removal. The existing plant was constructed nearly 70 years ago along the shore of the Missouri River. UWM retained Carollo to develop a plan for upgrading and rehabilitating the existing water treatment plant to meet the more stringent water quality requirements of the Safe Water Drinking Act.

Carollo based its recommendations on an exhaustive facility audit assessing the useful life of each treatment process. This included a regulatory compliance analysis to assess existing and future treatment requirements and the development of a facilities improvement plan that included replacement of old and worn-out equipment. Although the study focused primarily on plant upgrade options, it also included developing and analyzing alternative supply and treatment options utilizing alluvial and deep groundwater supplies. Because the proposed treatment plant modifications represented a significant capital expenditure to UWM customers, the study included a phased capital improvements plan (CIP) to implement the necessary upgrades.

UWM retained Carollo to implement the first phase of the CIP. This project included a mechanical, electrical, and instrumentation/control rehabilitation of the existing filter complex. Modifications included the installation of an innovative filter-to-waste process utilizing a backwash supply header and a filter-to-waste control valve and meter to provide a cost-effective solution to improving water quality for the eight existing filters. The project also included the construction of a new chemical handling and feed facilities for ferric chloride, sodium hypochlorite, and powdered activated carbon (PAC). The first project phase also included a new primary electrical feed and distribution system to improve the reliability of service.

HIGHLIGHTS	Upgrades to an 8-mgd conventional water treatment facility.
	Mechanical, electrical, and instrumentation/control rehabilitation of the filter complex.
	Innovative filter-to-waste process.
	New chemical handling and feed facilities for ferric chloride, sodium hypochlorite, and PAC.

Modifications to the United Water Missouri Water Treatment Plant helped the utility meet the future water quality and capacity requirements of its customers.



South Bend Water Treatment Plant

HIGHLIGHTS

New 600-gpm microfiltration plant.

Multiple-barrier approach to water treatment.

First municipal, low-pressure membrane water treatment plant in the State of Washington.

The City of South Bend was operating an aging pressure filtration plant. The Washington State Department of Health determined that the process was not achieving any disinfection/removal credit and deemed South Bend to be out of compliance with the Surface Water Treatment Rule.

South Bend hired Carollo to perform a pilot-testing program to evaluate low-pressure membrane filtration to meet the current and proposed future regulations. Following successful pilot testing and a subsequent predesign report, South Bend retained Carollo to provide planning, design, and construction services for a new 600-gpm microfiltration plant on a site adjacent to the its existing water treatment facility.

The new treatment plant processes included:

- ▶ Pre-filtration.
- ▶ A raw water pumping station.
- ▶ Skid-mounted microfiltration units.
- ▶ A CT basin and clearwell.
- ▶ A finished water pumping station.

This new plant provides a multiple-barrier approach to treatment. Designed for a future expansion capacity of up to 900-gpm, the South Bend Water Treatment Plant is the first municipal low-pressure membrane water treatment plant in the State of Washington.



Carollo provided pilot testing, planning design, and construction services to the City of South Bend for the first low-pressure membrane water treatment plant in the State of Washington.

