

PROVIDING FOR AURORA

Faced with population growth and frequent droughts, the City of Aurora, Colorado, sought to improve its water reliability by tapping into a new source, the South Platte River. The resulting Prairie Waters Project features alluvial well fields, an aquifer treatment basin, more than 30 mi of conveyance pipeline, and a new, 50 mgd drinking water treatment facility. Completed in under six years, the roughly \$660-million project ensures that Aurora will enjoy adequate supplies of high-quality water for decades to come.

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**By Jonathan Diebel, P.E., and
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IN THE WESTERN UNITED STATES, where drought and population growth have made reliable water resources more critical than ever, a new water project has combined innovation with sustainability to provide high-quality drinking water for Aurora, Colorado. The Prairie Waters Project, the largest project of this type to be completed in Colorado in more than 30 years, provides an innovative, creative response to dwindling water resources in an arid location. By using a sustainable approach to maximize existing water rights and local water sources, the project is delivering drinking water of outstanding quality to the City of Aurora's customers.

Like other western cities, Aurora is faced with increasing water demands and dwindling water supplies. The complex nature of this situation was vividly demonstrated by a period of extreme drought from 2002 to 2004 that, at one point, left Aurora with only a nine-month supply of water in its reservoir

Biological activated carbon filtration is just one step in the multiple-barrier, advanced treatment process employed by the Peter D. Binney Water Purification Facility. In conjunction with the project's natural treatment elements, the facility ensures state-of-the-art treatment for a challenging source of supply.





AURORA WATER, ALL

system. As a result, city leaders recognized the need for additional water supplies and initiated a comprehensive study of alternatives. More than 40 options were considered, including importing additional water from across the Continental Divide.

After careful review, the city decided to carry out what is now known as the Prairie Waters Project, a sustainable approach that involves extracting water from the South Platte River by means of an alluvial well field and pretreating it through natural purification processes before pumping it 34 mi to a new water treatment plant, the 50 mgd Peter D. Binney Water Purification Facility. (The facility is named for a former director of the city department Aurora Water who was a driving force in developing the Prairie Waters Project.) The treated water is then delivered to the zones of higher pressure within Aurora's potable water distribution system.

The key elements of the Prairie Waters Project include the following:

- 17 alluvial riverbank wells with well field piping;
- A 200-acre basin used to cleanse water naturally by means of aquifer recharge and recovery, as well as 27 extraction wells;
- 34 mi of 60 in. diameter steel pipe;
- Three raw water pump stations having an ultimate capacity of 50 mgd;
- The 50 mgd Peter D. Binney facility, which can be expanded in the future;
- One pump station for potable water.

To quickly provide the growing community with a more drought-resistant water supply, the city determined that the project should be operational with an initial capacity of 10,000 acre-ft per year by the end of 2010. The ultimate capacity, however, was to be 50,000 acre-ft per year, and much of the infrastructure was constructed for the ultimate capacity. The aggressive deadline for completing the Prairie Waters Project allowed less than six years for project planning, design, and construction at an initially estimated cost of \$854 million.

To meet this fast-track schedule, the city hired CH2M HILL, of Englewood, Colorado, in 2005 as the designer of the Binney facility and of what is called the North Campus Collection Facility, which comprises the alluvial wells, the recharge basin, and the extraction wells. In 2006 the city hired the firm to serve as the program manager to oversee implementation of the Prairie Waters Project. CH2M HILL's program management staff worked as part of an integrated project delivery team that included many City of Aurora program and project staff members, and the integrated team managed, supervised, and controlled all aspects of the program. The team was also responsible for public information, business and contract management, program controls, permitting, environmental protection, project delivery, and regulatory agency coordination.

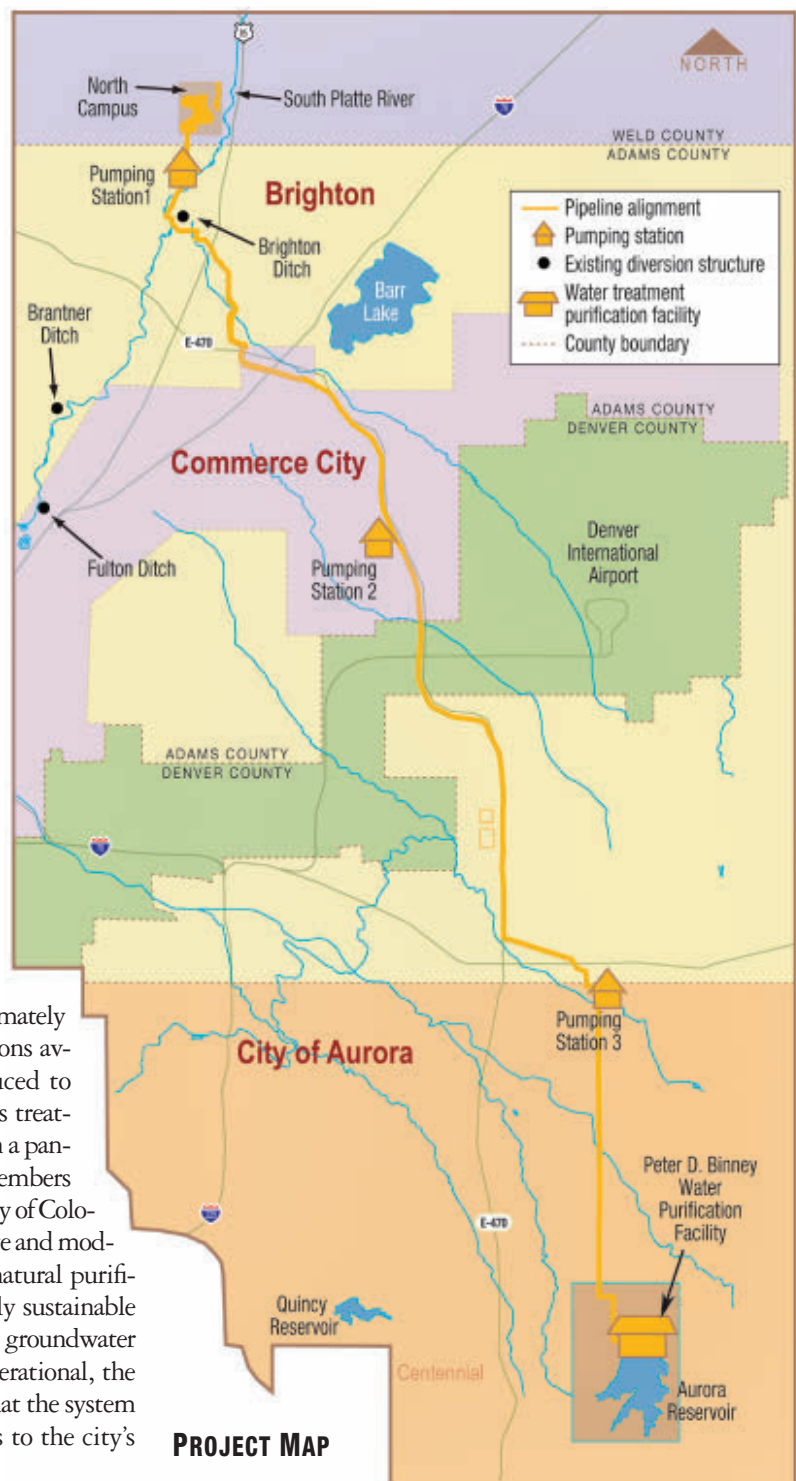
As established by CH2M HILL, the Prairie Waters Project looked to the future and used a sustainable water source, the South Platte River, to meet Aurora's needs and protect it from drought for decades to come. The project features natural

cleansing processes and state-of-the-art purification technology to deliver an additional 3.3 billion gal of water per year.

This new source begins in Brighton, Colorado, nearly 35 mi away, at the North Campus Collection Facility. There a series of alluvial wells along the South Platte River withdraw the water through sand and gravel to begin the purification process. Water extracted by the wells has spent a period of roughly 10 days passing through the river alluvium, a process that naturally reduces the concentrations of pathogens, nitrogen, dissolved organic carbon, and “micropollutants,” a class of emerging contaminants that includes endocrine-disrupting compounds, pharmaceuticals, and personal care products. The water is then conveyed to the 200-acre basin, where it undergoes additional treatment for approximately 20 days. This natural basin includes subsurface gravel alluvium capable of further removing carbon-based pollutants and micropollutants.

Natural water purification systems have been used by water providers for decades. However, the Prairie Waters Project represents a unique application of the science on a large scale. Pilot- and demonstration-scale testing confirmed the effectiveness of the natural treatment system: during a 10-day period, nitrates were reduced from a range of 7 to 10 mg/L to approximately 2 mg/L, while total organic carbon concentrations averaging 8 mg/L in the river water were reduced to 3.5 mg/L after natural treatment. CH2M HILL’s treatment experts collaborated with the city and with a panel of independent scientists and with faculty members from the Colorado School of Mines, the University of Colorado, and Colorado State University to investigate and model the system. This effort established that the natural purification process is both biologically and physically sustainable and avoids any untoward effects on the river and groundwater system around the South Platte River. Now operational, the project is being carefully monitored to ensure that the system continues to operate sustainably and conforms to the city’s high standards.

From the basin the water is piped to the Peter D. Binney facility through a series of three pump stations and 34 mi of 60 in. diameter steel pipeline that is lined with cement mortar and coated with polyurethane. Water is delivered to a 6 million gal forebay at what is referred to as pump station 1 before being conveyed successively to pump stations 2 and 3 and finally to the Binney facility. Pump stations 2 and 3 each have a 1.5 million gal forebay, and all three pump stations have surge protection systems. Each pump station was initially constructed with one 12.5 mgd pump and one 8 mgd pump. The ultimate capacity of each station is to be 50 mgd. This system was also designed to be expandable; as demand increases, additional pumps can be added at each



PROJECT MAP

station. The pump stations were designed and constructed to appeal to the community, their architecture reflecting a rural, prairie aesthetic sensibility and their systems generating a minimum amount of noise.

The Binney facility is the centerpiece of the Prairie Waters Project. Located on an 80-acre site north of the Aurora Reservoir, the facility uses ultraviolet advanced oxidation as well as an innovative treatment process that includes a number of steps. With an initial treatment capacity of 50 mgd and an ultimate capacity of 83.3 mgd, the facility is the largest in the United States using ultraviolet advanced oxidation to treat surface water.

The conceptual design began in March 2004 with the assessment of potential systems for treating the water that was available through Aurora's existing water rights in the South Platte basin. Candidate treatment systems were developed and evaluated against the following requirements of the city:

- Multiple-barrier purification;
- Thoroughgoing removal of traditional and emerging contaminants;
- Sustainability with respect to maximizing the use of existing water rights and minimizing power needs and brine waste;
- Finished water indistinguishable from current supplies.

In early water quality testing, *n*-nitrosodimethylamine, an industrial by-product suspected of being a carcinogen, was detected in the source water, along with other contaminants. Although *n*-nitrosodimethylamine is resistant to many treatment processes, photolysis with ultraviolet light is widely recognized as being able to remove not only this contaminant but also a broad spectrum of other emerging contaminants

the extent to which varying levels of TDS affected customers' perceptions of water quality. Participants sampled water with varying TDS levels and scored the water on the basis of taste. The study determined that taste scores began to drop at TDS concentrations of about 400 mg/L, so the city established this as the target TDS level; it also set a target hardness goal of 150 mg/L.

The design team determined that the hardness of the South Platte supply could be reduced by means of a softening process at the Binney facility. To meet the TDS goal of 400 mg/L, the team established a blending ratio of 33 percent South Platte supply to 67 percent Aurora Reservoir supply. To improve water quality further, the new facility employs not only the advanced ultraviolet oxidation described above but also biological activated carbon filtration and activated carbon adsorption. This multiple-barrier advanced purification process, in conjunction with the project's natural treatment elements, ensures state-of-the-art treatment for this challenging supply source.

The treatment process at the Binney facility addresses all of these water quality concerns while also acting as a good neighbor. The purification process destroys contaminants present in the source water rather than transferring them to another medium, which might affect the downstream environment or create hazardous by-products for disposal.

The Binney plant itself is a "greenfield" facility located in parkland surrounding Aurora Reservoir, the city's largest park and open space. With a campus-style layout in which the buildings follow natural landforms, the design complements the park's ecological and aesthetic characteristics. Exterior architectural treatments adhere to the Prairie style, popularized by Frank Lloyd Wright. Along with conveying water by gravity through the facility's treatment processes, the design used buried structures and existing landforms to minimize the visibility of the Binney facility and enable it to blend into the park environment.

With much of the facility underground, the remaining buildings are oriented to minimize heat gain in occupied spaces; insulation and special window glazing minimize heat loss and energy consumption.

Where possible, locally produced materials were used in an effort to reduce energy consumption related to transportation. In occupied spaces, natural light is maximized through extensive use of clerestories.

The first construction contract for the project covered the Binney facility, and work began in May 2007. During construction the design team took great pains to identify and protect wildlife and fragile habitat areas. Multiple wildlife species, including prairie dogs, burrowing owls, red-tailed hawks,



and a variety of more common compounds. For these reasons and because it can accomplish all of this without producing a waste stream, the team selected ultraviolet advanced oxidation.

Aurora customers have come to expect high-quality, good-tasting water, so water quality figured prominently in the Prairie Waters Project. The characteristics of the water in the South Platte River are markedly different from those of Aurora's existing supply, which originates mainly as mountain snowmelt delivered by the Arkansas and Colorado rivers. The concentrations of total dissolved solids (TDS) and the level of hardness found in the South Platte supply exceed the city's target goals. To address these differences, the city established a goal of producing finished water that would be indistinguishable from Aurora Water's existing supplies with respect to taste and odor. To this end CH2M HILL conducted two taste tests to determine

The 50 mgd Peter D. Binney Water Purification Facility, the centerpiece of the Prairie Waters Project, is the largest installation in the United States using ultraviolet advanced oxidation to treat surface water. The building's design is in keeping with the locally popular Prairie style of architecture.

and bald eagles, inhabited the construction area. The team's regulatory staff worked with the contractors to ensure that fences, signs, and other appropriate controls were in place before construction began to avoid untoward effects on environmentally important areas. Moreover, an employee with the Colorado Division of Wildlife built an artificial nest and placed it at the North Campus Collection Facility to encourage raptors to nest away from dangerous construction areas. As a result, project construction proceeded on schedule with minimal effect on the environment.

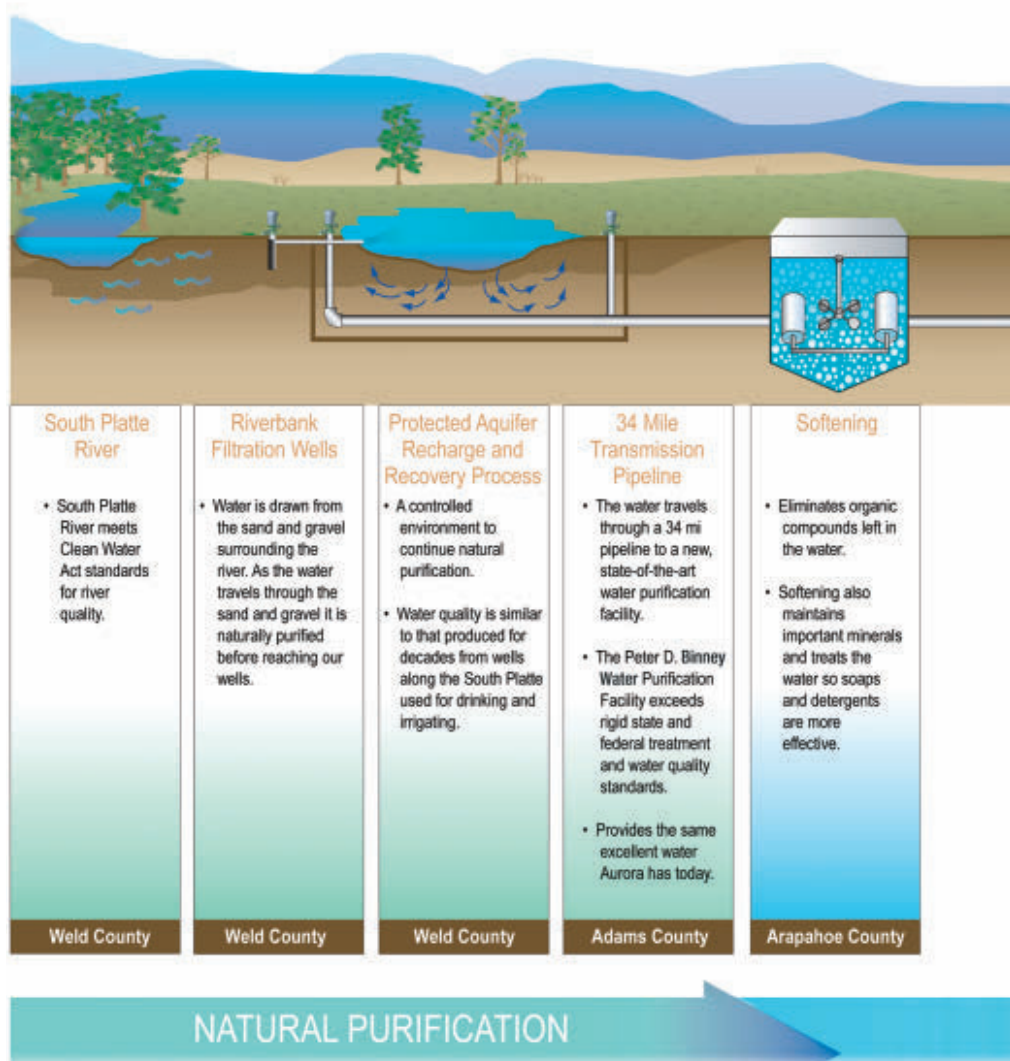
Funded through a combination of bonds, connection fees, and water rates paid by Aurora Water's customers, the project is part of that department's approximately \$1.1-billion, 10-year capital improvement program to improve the reliability of the existing water system while increasing supplies and expanding water conservation efforts.

Many successes were realized on this project in the areas of program, budget, and schedule management. A dynamic program management team, which included personnel from CH2M HILL and the City of Aurora, successfully delivered the project more than two months ahead of schedule and \$200 million under the original budget.

Because of the critical nature of the drought and the city's dwindling water supplies, meeting the project's fast-track schedule was of paramount importance. The design of project facilities began in early 2005, and project completion was originally set for December 2010. As a result, the project management team had only five and a half years to complete a project of a size and scale that elsewhere in Colorado had sometimes taken decades to complete. On October 9, 2010, the city formally dedicated the Binney facility, which by then was substantially complete.

In 2005, when CH2M HILL was selected as the program manager, the \$854-million budget for the project exceeded the city's intended funding by \$100 million. Through a series of value engineering activities managed by CH2M HILL, the budget was reduced from \$854 million to \$754 million, including all activities related to planning, engineering, construction, and land acquisition. Each construction bid package was evaluated to determine possible savings. Among all the bid packages, nearly 100 items were highlighted as sources of potential cuts to produce savings.

As the program progressed, CH2M HILL found numerous other ways to help the city save money. A cost management



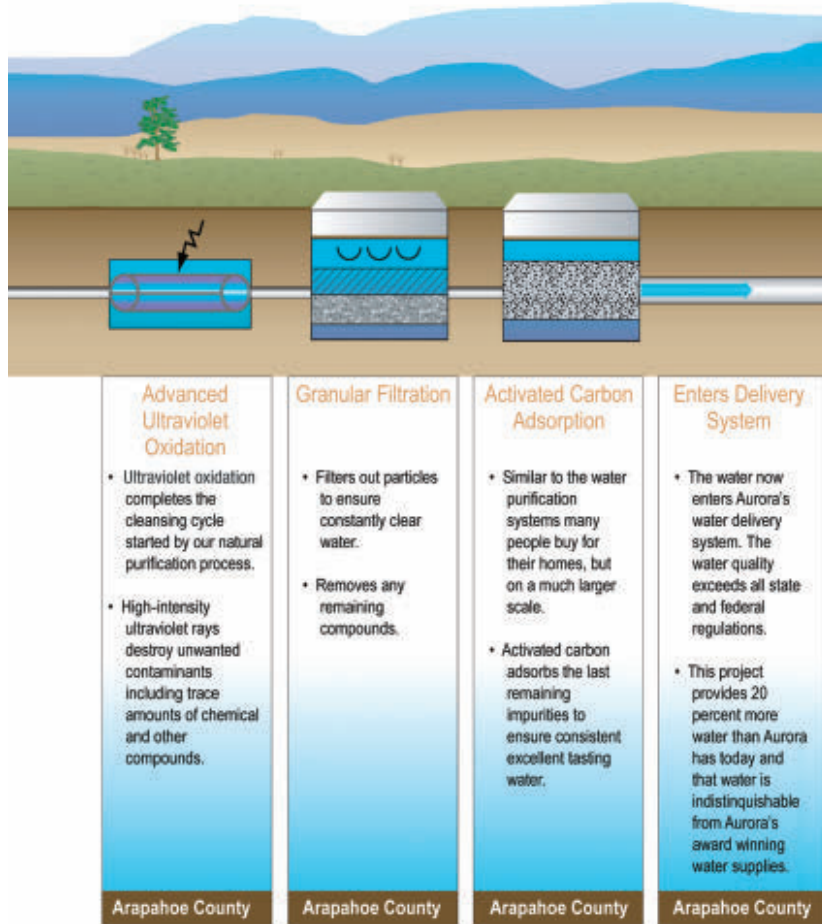
TREATMENT PROCESS

strategy was employed that offered contractors incentives for proposing changes that would reduce costs. Ultimately, the value engineering process and quality control efforts associated with various elements of the conveyance facilities shaved nearly \$200 million from the original budget, resulting in actual completion costs closer to \$660 million.

The overall responsibilities of the program management team included awarding and negotiating design contracts, obtaining permits on behalf of the owner as well as overseeing permits to be obtained by the construction contractors, acquiring the land and easements required for the project, negotiating agreements with multiple governmental entities, selecting and contracting with firms to perform construction management, and preparing general contract documents and administering the bidding and contract award process.

To streamline the permitting process, CH2M HILL used an advanced permitting tool that tracked the weekly status of every permit needed for each bid package. This approach facilitated the integration of permit scheduling within bid packages and streamlined construction and completion of the project by essentially "flagging" the particular permit needs for each project component.

Because of the geographic distribution of the project, construction required activity in the jurisdictions of eight local governments. Obtaining permission to carry out



STATE-OF-THE-ART PURIFICATION

construction in these areas required 18 months of complex governmental negotiations, to say nothing of the work required to manage more than 400 permits. By early 2007 the project had obtained all of the major agreements and permits without affecting the fast-track schedule.

To facilitate communication between the members of the integrated project team, CH2M HILL and city staff worked together in the city's offices. Just as important, the engineers developed a Web-based project management information system, known as PrairieNet, using commercial software known as SharePoint (a product of Microsoft, of Redmond, Washington). This tool optimized the performance of the various groups responsible for certain functions, including land acquisition, permitting, construction management, environmental protection, cost control, project delivery studies, program management, and document management. It did this by promoting coordination and facilitating the exchange of information and knowledge. The Web-based portal enabled each group to function effectively within its own area of expertise and to easily interact with other groups to work collaboratively.

The power of PrairieNet was best exemplified in the construction management process. In tracking project schedules and costs, certain factors weighed heavily, including special permit requirements, environmental factors, and safety performance. To efficiently track these performance indicators, a

specialized "dashboard view" was created that showed the status of information submitted by contractors, requests for information, budgeted versus actual expenditures, and other information critical to effective management. A total of 10 individual contracts totaling nearly \$500 million worth of construction were tracked and managed through this tool.

PrairieNet also offered an environmental protection feature that interactively engaged project managers, contractors, and others involved in specialized environmental approaches for the project. The team also used a mapping feature that linked land acquisition records and permits to acquired land or easements, along with tools related to program delivery, public involvement, and permitting. PrairieNet also helped to integrate the actions of the various groups related to project closeout. A separate closeout page unified all of the activities required for the successful completion of the project. Specialized views enabled members from each area of expertise to track and update the status of the 75 closeout activities.

During construction, the Prairie Waters Project compiled an impressive safety record. More than 3,400 construction workers put in approximately 2.5 million hours over the project's five years. During that time, only 23 injuries occurred that were defined as recordable under the rules of the U.S. Occupational Safety and Health Administration, well below the national average for similar construction projects. Furthermore, only five "lost time" incidents occurred, which is also well below the national average. An owner-controlled insurance program, along with rigorous contractor safety programs, directly led to this outstanding safety record. Not only did the attention to safety by the project's contractors and workers maintain a safe work environment, but the commitment boosted the project's success in quality and productivity by keeping workers focused on their daily activities.

Maintaining momentum for the fast-track project required a robust public affairs program to meet stakeholders' needs for information and to address community concerns. The project involved a diverse group of stakeholders, including farmers, businesses, residents in rural and urban areas, regulators, individuals and groups directly affected by construction, and vigilant environmental groups. Successful communication strategies to create stakeholder support helped to streamline the permit approvals, maintain positive relations with the community, and foster favorable media coverage. During the project, more than 150 events to educate stakeholders were conducted, and more than 270 news articles were written about the Prairie Waters Project.

For addressing its pressing water use issues and determining the feasibility of a large-scale natural purification approach, the city has been commended by local news organizations and citizens. The project has also served as an example for other water utilities in the western United States and across the country. Its focus on natural, sustainable engineering techniques demonstrates the city's (Continued on Page 74)

Providing for Aurora

(Continued from Page 63) commitment to finding solutions that are technologically innovative, provide a level of treatment equivalent to more expensive, advanced treatment processes, and remain sustainable over the long term. No other surface water treatment system in the United States incorporates this innovative level of purification capability. The Prairie Waters Project has clearly shown itself to be the most cost-effective, environmentally sustainable, and expeditious way to meet Aurora's needs today and in the future. **CE**

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PROJECT CREDITS **Owner:** City of Aurora, Colorado **Designer, civil engineer, and program manager:** CH2M HILL, Englewood, Colorado **Construction managers:** HDR Engineering, Inc., Englewood, Colorado; Carollo Engineers, Broomfield, Colorado; and Brown and Caldwell, Golden, Colorado **Conveyance system and pump station design:** MWH Americas, Broomfield, Colorado **Construction of Peter D. Binney Water Purification Facility and conveyance system pump stations:** Western Summit Constructors, Inc., Denver **Construction of North Campus Collection Facility, conveyance system pipeline, and potable water pump station:** Garney Construction, Denver **Construction of conveyance system pipeline:** Reynolds-Tierdael Construction, Denver, and S.J. Louis, Rockville, Minnesota

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