Faced with dwindling surface water supplies, a water provider in western Texas shifted into high gear in 2011 to develop a $130-million system of groundwater wells and transmission pipelines. Completed in only 18 months despite significant logistical challenges, the Ward County Water Supply Project will help ensure adequate supplies for the 500,000 customers of the Colorado River Municipal Water District well into the future.

By Russell Gibson, P.E., M.ASCE, Nicholas Lester, P.E., M.ASCE, John Grant, Mitch Holmes, P.E., M.ASCE, and Jim Coley, P.E.

Although western Texas has experienced sustained drought conditions for more than 10 years, the drought of 2010 and 2011 was particularly brutal to surface water supplies. Soaring temperatures and lack of rainfall led to high evaporation, dry soil conditions, and minimal runoff for supply reservoirs. The Colorado River Municipal Water District (CRMWD) owns and operates three supply reservoirs in western Texas, the combined storage volume of which had dropped to just 5.5 percent by the autumn of 2012. Such conditions represented a severe water supply crisis that forced the CRMWD to build an emergency groundwater supply for the cities of Odessa, Midland, and Big Spring and for other customers. In June 2011 design work began on the $130-million Ward County Water Supply Project, and operations started less than 18 months later, just a few months before the CRMWD’s three surface water supplies were projected to no longer meet customer demand. Because the area served by the CRMWD is experiencing one of the largest oil booms in decades, the Ward County Water Supply Project is critical not only to the economic vitality of the region but also to the nation’s energy independence.

This article presents the challenges and lessons learned during the design, permitting, and construction of the CRMWD’s 30 mgd water supply system, which includes 21 groundwater wells, 65 mi of pipeline, four pump stations, and related facilities. The project’s highlights include the following:

- Measures taken to complete the design and construction in less than 18 months;
- Easement acquisition and permitting challenges;
- New alternative delivery methods to expedite construction, manage risk, and improve quality;
- Pipeline construction using controlled low-strength material mixed on-site with local material;
- Use of new technology tools for designing, constructing, and managing the project;
- Drilling, constructing, and equipping 21 wells in record time.

With solid planning, exemplary teamwork, heroic effort, and a little luck, the new supply began operations before the lakes went dry.

Records from the National Oceanic and Atmospheric Administration’s National Climatic Data Center indicate that 2011 was the driest and second-hottest year in Texas for the 117 years of recorded data. For example, Midland received 5.49 in. of rainfall in 2011, compared with its average of 14.61 in., and had 65 days of temperatures above 100ºF, compared with its average of 14 days. The lack of rain and the high temperatures devastated local water supplies.

Climatologists anticipate that the drought will continue for the foreseeable future. Against this backdrop, the CRMWD has been able to diversify its water supplies in 2010 by purchasing additional groundwater rights in Ward County. Since the 1970s the CRMWD has owned and operated a 16 mgd groundwater supply system in that...
The CRMWD’s goal was to have full operation before January 1, 2013. The CRMWD’s seven pipe-laying crews, and four construction labor and housing during the oil boom, obtaining environmental permits, and acquiring easements. However, the new well system, which would convey water in an east-to-west configuration, would have to move “backward” through the original system.

The project was designed to eliminate elements that required 44 easements through three counties. To accelerate the land acquisition, Freese and Nichols completed the following steps:

• The pipeline was routed along existing pipelines and roads to avoid sewerance.
• Three field survey crews surveyed property boundaries.
• Easements were written by two teams and delivered weekly.
• Land agents worked closely with the surveyor, the title company, and the CRMWD to obtain accurate information on landowners.
• Portions of the pipeline were routed within public streets to decrease the number of easements.

Multiple concepts were employed to accelerate the construction phase. For example, the pipeline was put out for bids early so that easement acquisition could occur concurrently with bidding, raw steel delivery for pipe production, processing of pipe shop drawings, and mobilization. This step saved two to three months. Meanwhile, two pipeline contracts were put out for bids with a provision that the bidders could offer a delivery of piping that could be awarded to both contracts. As a result, the successful bidder offered a $3.6-million delivery. Finally, the pipeline design called for the use of local materials for bedding and backfill to expedite construction. However, for a 4 mi long segment of the pipeline that traversed shifting sand dunes, the design specified the use of controlled low-strength material mixed on-site with local materials, fly ash, and cement. As for the pump stations and tanks, the project delivery method known as construction manager at risk (CMAR) was used, and Garney Companies, Inc., of Kansas City, Missouri, was selected as the construction manager for this project. Items expected to have long delivery times, including pumps, valves, and variable-frequency drives, were purchased through Garney.

The pump stations were split into below-slab and above-slab contracts by Garney so that the underground construction could proceed concurrently with the design of the above-grade facilities. The pump stations were designed and built. To this end, the design minimized the use of below-grade piping and employed prefabricated metal panels for building walls and roofs. Use was also made of skid-mounted equipment and, where possible, local materials and concrete mix designs. The design team modified major equipment specifications, which decreased delivery time by reducing submittal and testing requirements where possible.

With the CMAR approach the owner hires an engineer to design the facilities and a construction manager to act as a general contractor for construction. The construction manager assures the owner and the engineer during the design phase with design reviews, innovations, and the management of cost and schedule. The construction manager hires vendors and subcontractors or carries out construction itself. At any stage of design the owner can require a guaranteed maximum price, which includes a contingency that may or may not be shared by the construction manager and the owner.

The CMAR approach offers many of the advantages of the design/build project delivery method without some of the latter’s disadvantages. Because it enables the design and construction phases to overlap, the CMAR method can reduce project delivery time and spur innovation. Unlike design/build, the CMAR process does not require additional time to select the construction manager, which can be done simultaneously with other activities, and it enables the owner to retain control of the design. The CMAR process should result in a project of higher quality than offered through design/build or the traditional design/bid/build method. Rafael, California—expedited the production of drawings by the Colorado River Municipal Water District.

In 1960 water levels were so high that water easily filled the spillway of Lake J.B. Thomas, one of the three surface water reservoirs relied on by the Colorado River Municipal Water District.

Multiple concepts were employed to accelerate the construction phases. For example, the pipeline was put out for bids early so that easement acquisition could occur concurrently with bidding, raw steel delivery for pipe production, processing of pipe shop drawings, and mobilization. This step saved two to three months. Meanwhile, two pipeline contracts were put out for bids with a provision that the bidders could offer a delivery of piping that could be awarded to both contracts. As a result, the successful bidder offered a $3.6-million delivery. Finally, the pipeline design called for the use of local materials for bedding and backfill to expedite construction. However, for a 4 mi long segment of the pipeline that traversed shifting sand dunes, the design specified the use of controlled low-strength material mixed on-site with local materials, fly ash, and cement. As for the pump stations and tanks, the project delivery method known as construction manager at risk (CMAR) was used, and Garney Companies, Inc., of Kansas City, Missouri, was selected as the construction manager for this project. Items expected to have long delivery times, including pumps, valves, and variable-frequency drives, were purchased through Garney.

The pump stations were split into below-slab and above-slab contracts by Garney so that the underground construction could proceed concurrently with the design of the above-grade facilities. The pump stations were designed and built. For many of the above-slab equipment with long delivery times, this method may extend the overall project completion date. Alternative procurement methods may include preselection and assignment, and in some cases tenant improvements. Preselection calls for solicitation of contracts for items with long delivery times early in the design phase. Purchase orders are awarded to the selected equipment vendors and assigned
to the general contractor after the construction contract is awarded. With owner-furnished equipment, the same process is used, except that the owner retains the purchase order. One disadvantage with both of these methods is that, since the owner is responsible for originally selecting the vendor, the owner retains some of the contractual risk for late delivery or deficient equipment. With the CMAR process, preselection of equipment is handled by the construction manager, reducing contractual risk to the owner associated with late delivery or deficient equipment.

The competitive sealed proposals (CSP) process was used on this project to select the construction manager and all equipment and construction contracts, expediting delivery and increasing the quality of the project. With CSP, the owner makes a value-based selection of the equipment, the construction contractor, or both, rather than selecting among qualified bidders on the basis of price. With CSP the owner can establish selection criteria pertaining to, for example, cost, time, qualifications, experience, claim history, safety, and equipment performance. In this way, CSP enables the owner to select contractors and vendors that have a record of finishing projects on time. CSP also helps to raise the bar within the industry as a whole because owners will tend to limit their use of subpar suppliers and contractors.

The transmission pipeline was separated into two sections: contract A covered 21 mi of 48 in. diameter pipe, while contract B covered 6.1 mi of 48 in. diameter pipe and 14.5 mi of 42 in. diameter pipe. Construction was completed by a joint venture of S.J. Louis Construction of Texas, LTD., of Mansfield, Texas, and Oscar Renda Contracting Inc., Roanoke, Texas. S.J. Louis Construction constructed the contract A pipeline using polyurethane-coated steel pipe manufactured by the Northwest Pipe Company, which has its headquarters in Odessa, Texas.

The pipeline construction encountered many challenges in traversing the 41 mi. The construction passed through sand dunes and hard rock, all during the extreme heat of summer 2012. The pipeline also traversed through multiple oil and gas production fields and crossed hundreds of pipelines.

One of the project’s major challenges involved planning, designing, and constructing the 2.25 mi long section of the transmission pipeline that crossed the Monahans Sandhills State Park and paralleled an existing 33 in. diameter pipeline. The Texas Parks and Wildlife Department manages the park but does not own the property; instead, it has a long-term property lease. As this has its headquarters in Vancouver, Washington, Northwest Pipe manufactured the pipe in two plants to ensure that pipe production would keep pace with the demands of the short schedule. Pipe delivery began in early April 2012 and ended in early October of that year. This time frame made it possible for pipe laying to begin in late April 2012, one crew starting at the beginning of the pipeline and one at the middle. Pipe laying was completed in early November 2012. To facilitate S.J. Louis Construction’s production schedule, welding was allowed on the steel pipe after backfill. S.J. Louis Construction and Frene and Nicholls tested sections of pipeline that had been welded by each welder certified on the project. Upon completion of the test sections, the joints were uncovered and inspected visually, and adhesion pull tests were performed. Each welder was certified using his or her welding equipment with certain settings.

Oscar Renda Contracting constructed the contract B pipeline using bar-wrapped concrete cylinder pipe manufactured by the Water Transmission Group of Ameron International Corporation, a subsidiary of National Oilwell Varco, of Houston, and by Hanson Pipe & Precast, of Irving, Texas. The Water Transmission Group manufactured the pipe in two plants, and Hanson manufactured the pipe in one plant to keep pipe production on schedule. Pipe delivery began in March 2012 and ended in October of that year, allowing pipe laying to begin in early April 2012. With crews starting at each end of the pipeline and working toward the middle, pipe laying was completed in early November 2012.

The pipeline construction encountered many challenges in traversing the 41 mi. The construction passed through sand dunes and hard rock, all during the extreme heat of summer 2012. The pipeline also traversed through multiple oil and gas production fields and crossed hundreds of pipelines.

One of the project’s major challenges involved planning, designing, and constructing the 2.25 mi long section of the transmission pipeline that crossed the Monahans Sandhills State Park and paralleled an existing 33 in. diameter pipeline. The Texas Parks and Wildlife Department manages the park but does not own the property; instead, it has a long-term property lease. As this has its headquarters in Vancouver, Washington, Northwest Pipe manufactured the pipe in two plants to ensure that pipe production would keep pace with the demands of the short schedule. Pipe delivery began in early April 2012 and ended in early October of that year. This time frame made it possible for pipe laying to begin in late April 2012, one crew starting at the beginning of the pipeline and one at the middle. Pipe laying was completed in early November 2012. To facilitate S.J. Louis Construction’s production schedule, welding was allowed on the steel pipe after backfill. S.J. Louis Construction and Frene and Nicholls tested sections of pipeline that had been welded by each welder certified on the project. Upon completion of the test sections, the joints were uncovered and inspected visually, and adhesion pull tests were performed. Each welder was certified using his or her welding equipment with certain settings.

Oscar Renda Contracting constructed the contract B pipeline using bar-wrapped concrete cylinder pipe manufactured by the Water Transmission Group of Ameron International Corporation, a subsidiary of National Oilwell Varco, of Houston, and by Hanson Pipe & Precast, of Irving, Texas. The Water Transmission Group manufactured the pipe in two plants, and Hanson manufactured the pipe in one plant to keep pipe production on schedule. Pipe delivery began in March 2012 and ended in October of that year, allowing pipe laying to begin in early April 2012. With crews starting at each end of the pipeline and working toward the middle, pipe laying was completed in early November 2012.

The pipeline construction encountered many challenges in traversing the 41 mi. The construction passed through sand dunes and hard rock, all during the extreme heat of summer 2012. The pipeline also traversed through multiple oil and gas production fields and crossed hundreds of pipelines.

One of the project’s major challenges involved planning, designing, and constructing the 2.25 mi long section of the transmission pipeline that crossed the Monahans Sandhills State Park and paralleled an existing 33 in. diameter pipeline. The Texas Parks and Wildlife Department manages the park but does not own the property; instead, it has a long-term property lease. As this has its headquarters in Vancouver, Washington, Northwest Pipe manufactured the pipe in two plants to ensure that pipe production would keep pace with the demands of the short schedule. Pipe delivery began in early April 2012 and ended in early October of that year. This time frame made it possible for pipe laying to begin in late April 2012, one crew starting at the beginning of the pipeline and one at the middle. Pipe laying was completed in early November 2012. To facilitate S.J. Louis Construction’s production schedule, welding was allowed on the steel pipe after backfill. S.J. Louis Construction and Frene and Nicholls tested sections of pipeline that had been welded by each welder certified on the project. Upon completion of the test sections, the joints were uncovered and inspected visually, and adhesion pull tests were performed. Each welder was certified using his or her welding equipment with certain settings.

Oscar Renda Contracting constructed the contract B pipeline using bar-wrapped concrete cylinder pipe manufactured by the Water Transmission Group of Ameron International Corporation, a subsidiary of National Oilwell Varco, of Houston, and by Hanson Pipe & Precast, of Irving, Texas. The Water Transmission Group manufactured the pipe in two plants, and Hanson manufactured the pipe in one plant to keep pipe production on schedule. Pipe delivery began in March 2012 and ended in October of that year, allowing pipe laying to begin in early April 2012. With crews starting at each end of the pipeline and working toward the middle, pipe laying was completed in early November 2012.

The pipeline construction encountered many challenges in traversing the 41 mi. The construction passed through sand dunes and hard rock, all during the extreme heat of summer 2012. The pipeline also traversed through multiple oil and gas production fields and crossed hundreds of pipelines.

One of the project’s major challenges involved planning, designing, and constructing the 2.25 mi long section of the transmission pipeline that crossed the Monahans Sandhills State Park and paralleled an existing 33 in. diameter pipeline. The Texas Parks and Wildlife Department manages the park but does not own the property; instead, it has a long-term property lease. As this has its headquarters in Vancouver, Washington, Northwest Pipe manufactured the pipe in two plants to ensure that pipe production would keep pace with the...
Racing against Drought

(Continued from Page 67) involved conducting a schedule analysis to determine the critical path. Delivering a functional project in 18 months required that most of the wells be ready in 16 months to provide testing water for the rest of the system.

Traditionally, a groundwater hydrology study is performed, test wells are drilled, and the well locations are finalized based on estimated well capacity, water quality, and water drawdown. This approach makes it possible for actual production wells to be drilled and tested and for pumps and motors to then be ordered to match each individual well test.

Splitting the project into two design and construction components yielded efficiencies that made it possible for the work to be completed in 16 months. The first component involved drilling the wells and testing them, while the second comprised designing the pump capacity and ordering and installing the pumps. To complete these steps, a hydrogeological design team and a separate design team for well construction developed plans and specifications for the project.

The measures that helped to accelerate the design and construction of the wells included the following:

• Test wells were drilled in the middle of the groundwater hydrology study.
• By using two well-setting crews, the groundwater development firm Hydro Resources, of Sugar Land, Texas, conducted well drilling 24 hours a day seven days a week for six months.
• Well pumps and motors were prepurhased and ordered in the middle of the well-drilling phase based on computer model results for each well.
• A separate contract for the wellhead completion package, which entailed installing pumps and motors, piping, and electrical equipment, was awarded when 60 percent of the wells were completed. The well completion package was handled by the construction manager, Garney Companies.

The design and construction of water supply projects are challenging enough in normal times. When projects must be accelerated to meet emergencies, the owner, the engineer, and the contractor all face many additional challenges. Several concepts expedited the design and construction of the Ward County Water Supply Project, including resource scheduling, the CMAR delivery method, modular construction, simplified equipment specifications, and the use of locally available materials. Technology also expedited the project, including aerial topographic surveys; a geographic information system for route studies, environmental studies, and mapping; three-dimensional software to produce drawings; and Web technology for bidding, electronic file sharing, communication, and the processing of submitted construction documents.

Two keys to meeting an accelerated schedule are having an experienced engineer that is familiar with the owner’s preferences and an owner possessing the leadership that is required to make quick decisions and develop a consensus. With great effort and extensive collaboration on the part of the CRMWD, Freese and Nichols, Daniel B. Stephens & Associates, and the construction contractors, the project began pumping water in late 2012, two weeks ahead of schedule and $10 million under budget. The project was run intermittently during 2013 to meet system demands. The transmission system has operated as designed, and the total well capacity is greater than originally anticipated. In December 2013 the project was honored with a medal by the Texas affiliate of the American Council of Engineering Companies.

Fortunately for the CRMWD and its customers, the lakes that supply surface water to the district’s system received enough rainfall from a rare flood in the autumn of 2012 to meet demands by means of surface water for approximately a year. However, total surface water supplies are currently at just 8.17 percent of full capacity and are dropping. In the absence of significant rainfall in the near future, groundwater from the Ward County Water Supply Project will provide the lion’s share of the water needed to meet demand in 2014 and beyond.

Russell Gibson, P.E., MASCE, is a vice president and Nicholas Lester, P.E., MASCE, a project manager for Freese and Nichols, Inc., of Fort Worth, Texas. John Grant is the general manager of the Colorado River Municipal Water District; Mitch Holmes, P.E., MASCE, is the district’s assistant general manager, and Jim Coley, P.E., is a project manager there. This article is based on a paper the authors presented at ASCE’s Pipelines 2013 Conference, which was held in Fort Worth, Texas, in June.