Battling Texas’ Worst One-Year Drought: Drought Planning and Response in the Lone Star State

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ABSTRACT

Texas faced the worst single-year drought in its history in 2011, and the battle against dry conditions brought on by that record-setting drought continues in many parts of the state, especially in those areas where water supplies have simply disappeared. Although rains have provided relief to some of the state, Texans are taking steps to have water available for future needs and to fast-track water supply projects desperately needed now. This paper features case studies of Texas cities and water suppliers who are responding to existing drought conditions and who are planning for potential droughts in the future. Response measures include water conservation, drought measures (including rationing in some cases), priority water right calls to protect senior water rights, fast-tracked implementation of new water supplies, water reuse, and close monitoring of the status of raw water systems using models and decision support tools.

INTRODUCTION

Texas experienced the worst single-year drought in its history in 2011. At the beginning of October 2011, the United States Drought Monitor map (Figure 1) indicated that 97 percent of Texas was in extreme or exceptional drought, with drought conditions present in every county in Texas.

State agencies and water suppliers in Texas faced new, previously unseen challenges. Some water supply reservoirs reached all-time lows, and large water supply projects required fast-tracked schedules. The Texas Commission on Environmental Quality (TCEQ) received 15 senior water right calls resulting in the suspension of more than 1,200 water rights. TCEQ sent letters to approximately 6,000 public water systems across Texas, encouraging implementation of drought contingency plans. It also began working with the Texas Department of Emergency Management and other state agency partners to develop the “Emergency Drinking Water Annex,” which details management and response for public water systems with 180 days or less of water supply (TCEQ, 2012). The drought had devastating impacts to water systems and agricultural resources across the state.
Much-needed rainfall brought relief to many areas of Texas in 2012. However, during 2012, long-term forecasts changed from predicting El Niño conditions (which typically means more rainfall) back to neutral conditions, meaning average rainfall for most of the state. Drought conditions are now moving back into most areas of Texas, leading the TCEQ to announce on November 21, 2012 that water rights in the Upper Brazos River Basin will be administered on a priority basis because a senior water right call was made.

PRIORITY WATER RIGHT CALLS

In Texas, TCEQ administers surface water rights by priority doctrine (first in time, first in right). When a senior water right holder is not getting the water to which it is entitled, it can make a senior water right call and request TCEQ enforcement of the priority doctrine.

In 2011, TCEQ received 15 senior water right calls resulting in the suspension of approximately 1,200 water right permits. Senior water right calls were made in the Brazos, Guadalupe, Colorado, Sabine, and Neches River Basins for the following types of water users: municipal, industrial, irrigation, recreation, and domestic and livestock. Until the drought of 2011, the TCEQ had never received senior water right calls from municipalities or domestic and livestock users.

Before 2011, TCEQ had not received a priority call on an interstate river compact. (Texas is party to five interstate river compacts and two international treaties that impact water supplies available to Texas.) In August 2011, New Mexico took action in federal district court to invalidate the 2008 operating agreement in the Rio Grande Compact. TCEQ, in coordination with the Legislative Budget Board and the Attorney General’s Office, hired outside council with specialized experience in interstate water litigation to protect Texas’ share of the water supply (TCEQ, 2012).

The water right permits suspended in 2011 were primarily irrigation water rights. TCEQ did not suspend municipal water rights or power generation water rights because of concerns about public health and safety. While TCEQ did not curtail junior municipal water rights, the agency did ask for increased stages of drought contingency plans in senior call areas, asking junior municipal water right holders to implement mandatory water restrictions that limit outdoor water use (TCEQ, 2012).

Because of the intensity and duration of the 2011 drought, the TCEQ was forced to respond to several new issues. As previously mentioned, junior municipal and power generation water rights were not suspended when senior calls were made, so the priority doctrine was not completely enforced in all situations. Consequently, the TCEQ began the process to develop a new rule regarding the suspension of water rights during drought conditions. The rule-making process included stakeholder meetings and an opportunity for public comment. TCEQ adopted Chapter 36 of the
Texas Administrative Code, Suspension or Adjustment of Water Rights during Water Shortage on April 11, 2012.

As of January 7, 2013, one water right priority call suspension order is in place in Texas. In November 2012, Dow Chemical Company made a senior water right priority call in the Brazos River Basin. In response, TCEQ has suspended junior water rights on the Brazos River Basin with the exception of municipal, power generation, and non-exempt domestic use water rights that were determined necessary to protect public health, safety and welfare (TCEQ, 2012). Most of the suspended water rights are for irrigation users. In response to the curtailment of only selected junior water rights, the Texas Farm Bureau filed a lawsuit in December 2012 against TCEQ for failure to follow the priority doctrine.

WATER CONSERVATION

At all times, but especially in times of drought, water conservation is critical to sustainable water supplies in Texas. Note the clear distinction between “water conservation” and “drought management.” Conservation involves ongoing water management practices intended to reduce the consumption, loss, or waste of water; to improve the efficient use of water; and to increase the recycling and reuse of water. In contrast, drought management practices are temporary measures implemented only in times of drought that are over and above normal conservation practices and that will cease when drought conditions subside. Conservation efforts in Texas are highlighted in this section of the paper. Drought management efforts are detailed in a later section.

Understanding that demand from Texas’ rapidly expanding population could eventually eclipse available water resources, the Texas Water Development Board (TWDB) requires large water suppliers to develop Water Conservation Plans. Many water suppliers have turned this requirement into an opportunity to develop conservation programs that could extend the life of their current supplies and push back the mammoth costs of developing new water supplies.

Case Study – Dallas Water Utilities. One such water supplier is Dallas Water Utilities (DWU). DWU serves 1.2 million residents of Dallas and provides wholesale water supply to all or portions of more than 30 surrounding cities and water supply districts. DWU’s current supply comes from seven reservoirs. DWU’s ability to respond to the recent drought began many years ago with its foresight in conservation planning. Dallas began its conservation program in the early 1980s with public education. The program was taken to the next level in 2001 with the adoption of an irrigation ordinance that included time-of-day watering restrictions. Since 2001, DWU has been able to reduce its per-capita water use by 22 percent, and has saved more than 165 billion gallons of water and 493.3 million kilowatt hours of electricity. It also has reduced its greenhouse gas emissions by 304,657 tons (Dallas Water Utilities, 2012). DWU’s FY 2013 budget for their Conservation Program is just under $6.8 million (Davis, 2012).

Major elements of the conservation program are (Dallas Water Utilities, 2012):

- **Permanent twice-weekly lawn watering restrictions implemented in April 2012**
• Other irrigation restrictions including restrictions on daytime watering from April to October.
• Joint public education program co-sponsored with Tarrant Regional Water District, which serves approximately two million residents in north Texas. The current program features the popular character the “Lawn Whisperer” (Figure 2) seen on television, billboards, Facebook, and even on pop-up ads when streaming music on your mobile device.
• Free irrigation system check-ups
• Free toilet replacement program – “New Throne for Your Home”
• Minor Plumbing Repair Program (free to qualified low-income residents)
• Hospitality Industry Program, a voluntary conservation effort designed to help hotels and restaurants increase water use efficiency in their operations
• Industrial, Commercial and Institutional (ICI) Water Conservation Program, which includes a free water-efficiency assessment (Dallas Water Utilities, 2012) and rebates.

DROUGHT CONTINGENCY PLANS

As previously mentioned, drought management practices are *temporary* measures implemented only in times of drought that are over and above normal conservation practices and that will cease when drought conditions subside. To safeguard public health and prepare for the inevitable Texas droughts, Texas state agencies require certain large water suppliers to develop and submit Drought Contingency Plans. These plans require certain elements (triggers, actions, and water savings goals for Drought Stage) and must be updated every five years. TCEQ has made a model drought plan template and handbook available to assist entities in developing these plans. For public water suppliers, the basic goal of drought contingency planning is to identify and support an uninterrupted supply of water in an amount sufficient to satisfy essential human needs. Secondary objectives are to minimize adverse impacts on quality of life, the economy and the environment. In 2011, TCEQ sent letters to approximately 6,000 public water systems in Texas encouraging Drought Contingency Plan implementation (TCEQ, 2012).

**Case Study – North Texas Municipal Water District.** The North Texas Municipal Water District (NTMWD) is a water supplier that has initiated various stages of its Drought Contingency and Water Emergency Response Plan in recent years, due to the drought and in response to an emergency situation (contamination by invasive species) that rendered approximately 25 percent of its current supply unavailable for an extended period of time (three years and counting). NTMWD serves a population of 1.5 million in the area just northeast of Dallas and supplies wholesale treated water
to over 70 cities and water districts. NTMWD’s Drought Contingency Plan, last updated in 2008, consists of four stages.

During the last two years, NTMWD has initiated Stages 1 through 3 of its 4-stage drought plan. Stage 1 was initiated in April 2011, Stage 2 in August 2011, and Stage 3 at the beginning of November 2011. Due to a very dry fall in 2011, reservoir levels dropped to within a few feet of the trigger for initiating Stage 4; however, rainfall events in early December brought reservoir levels up significantly. Further rainfall events in the spring of 2012 allowed NTMWD to step down to Stage 2.

Figure 3 shows NTMWD’s 2011 and 2012 actual usage as compared to the demand that would have been expected if drought measures had not been in place. The green shaded area demonstrates water savings that can be attributed to drought restrictions being in place. The drought measures significantly reduced summer peaking, sometimes up to 300 million gallons per day (MGD). These water savings were critical to sustaining available water supply, particularly since NTMWD’s available supply has been reduced by 25 percent due to the presence of invasive species.

Figure 3. NTMWD Actual Usage Compared to Dry-Year Demand with no Drought Measures

**MONITORING OF RAW WATER SYSTEM STATUS**

During a drought, the status of a water supply system is always changing. Rain comes and supplies increase; demands are higher or lower than expected; new supplies become available; and supplies are lost due to facility failure, contamination or other causes. A water supplier must monitor the status of the water supply system regularly to respond appropriately to changing conditions.

**Case Study – North Texas Municipal Water District.** In the last decade, drought and the temporary loss of previously available supplies have placed stress on NTMWD’s water supply system. Freese and Nichols developed a RiverWare model
to help NTMWD monitor and project performance of NTMWD’s raw water supply system. The district gets water from five reservoirs and two indirect reuse projects. Input for the NTMWD model includes operating policies, reservoir area and capacity characteristics, raw water transmission capacities, projected demands and projected availability of new supplies. Using these inputs, the model is run using over 70 seven-year sequences of historical streamflow and evaporation. The use of multiple hydrologic sequences allows NTMWD to test operating policies against a range of potential future conditions. The model determines lake elevations, supply availability, shortages and other information for multiple hydrologic sequences given the selected demands, operating policies and additional supply development.

A model run in October 2012, with initial conditions based on actual conditions at the end of September 2012, gave a range of elevations that might occur in Lake Lavon, NTMWD’s primary water supply reservoir, with a potential program of new water supply development. Figure 4 summarizes the same model runs by showing the minimum elevation that would be reached in each month based on historical hydrology and the 5th percentile, 10th percentile, 25th percentile and median elevations.

This model can be used to examine the impacts of variations in demand and the desirability of potential water supply programs. Since the model is rerun every month (and more frequently if there is a major inflow), NTMWD remains aware of how changing conditions affect the security of its water supply. Figure 5 shows the minimum elevations for several alternative sets of water supply measures that NTMWD was considering in the current drought. (This model run was also conducted in October 2012, and the initial conditions are based on actual conditions at the end of September 2012.) Model output also includes water supply shortages, if there are shortages with historical hydrologic conditions. This kind of analysis helps NTMWD compare the benefits of alternative water supply strategies and the risks it faces as the drought continues. The information helps NTMWD make informed responses to a changing situation. (It is important to remember that historical hydrologic conditions do not represent the full range of conditions that might occur and to make allowance for the possibility of lower inflows than are in the historical record.)
FAST-TRACKED WATER SUPPLY PROJECTS

In addition to the drought measures and water system monitoring NTMWD put in place, it also began a fast-tracked design and construction project (the Texoma pipeline) to reclaim some of the 25 percent of supply lost due to invasive species. NTMWD was not the only entity to fast-track water supply projects in 2011. The drought of 2011 was particularly brutal to surface water supplies across Texas. In most of the state, the combination of high temperatures and lack of rainfall led to high evaporation, dry soil conditions, and very little runoff for supply reservoirs. Water districts, river authorities, and municipalities began facing a severe water supply crisis and were forced to build emergency projects to supply water to their customers.

Project Schedules – Fast-tracked Versus Typical Water Transmission Projects.

Design and construction of water supply projects are challenging in normal times. When projects must be accelerated to meet emergencies, many additional challenges are presented for the owner, engineer, and contractor. The normal processes for design and construction will not be effective for an accelerated schedule.

The engineer should do a detailed evaluation of the design and construction schedule to identify means for acceleration. The schedule for an accelerated project should be controlled by the planning, land and permit acquisition, bidding, and construction phases. Accelerated schedules may require splitting the project into small manageable components.

The use of alternate delivery methods, especially a construction manager at risk (CMAR), may allow the owner to expedite construction, order long-delivery items early, and still maintain control of the design. Competitive sealed proposals (CSP) allow owners to use a value-based selection of vendors and contractors, which can decrease construction time and increase quality.

For a normal water supply and transmission project, the planning phase typically includes a brief study of alternative conveyance systems, treatment methods, funding, phasing, ownership and operations structure, and permitting requirements.
The planning phase often includes political decisions and buy-in of the rate payers. For these reasons, it is difficult to accelerate the planning phase. To the extent feasible, water suppliers should identify future water supplies and lay the groundwork for project development before an emergency arises. By doing so, critical time and money may be saved.

During the conceptual design phase, the size, capacity, location and operations protocol are determined for the water supply. These items are needed to further define the project scope and cost, and to permit land and permit acquisition. Land acquisition requires right-of-entry, surveying, appraisals, and real estate negotiations. Permitting may include United States Army Corps of Engineers (USACE) Section 10 and 404, National Environmental Policy Act (NEPA), water rights, and many other state and local permits. After the land and permits are acquired, the final design phase, bidding, construction and system commissioning occur.

In an accelerated water supply and transmission project, the conceptual design phase overlaps the planning phase. Many conceptual design activities can begin as soon as major political decisions are made. For instance, desktop pipeline route studies and conceptual intake design studies can begin when the starting and ending points for a conveyance system are determined. Also, note that the land acquisition and permitting phase can begin as soon as the planning phase is complete and the conceptual design phase is underway. Right-of-entry, boundary surveying, aerial topographic surveys and environmental studies can begin as soon as a major portion of the project footprint is determined. The final design phase can be concurrent with the land acquisition and permitting phase, once the project footprint is finalized and the critical design features such as wetland crossings and water intakes are established. Again, bidding and construction follow the final design phase for a typical design-bid-build delivery method.

**Case Study – North Texas Municipal Water District – Texoma Pipeline.** The NTMWD Texoma Pipeline project includes the following metrics:

- 47 miles of 96-inch and 84-inch transmission pipeline
- Connection to an existing 78-inch pipeline
- Connections to the existing water treatment plant (WTP) headworks
- Water treatment plant upgrades
- 250-million-gallon balancing reservoir
- Original schedule – 30 months from start of planning and design to water delivery
- Actual schedule – currently under construction and on schedule for February 2014

The following concepts were used to expedite this project:

- The pipeline was routed along existing oil and gas easements and roads to expedite easement acquisition.
- A CMAR was used for the project. Long delivery items were purchased through the CMAR, including pipe and valves. CSP were used for the CMAR selection and all equipment and construction contracts.
Pipe was purchased at 30-percent plan design to allow easement acquisition to be concurrent with bidding, raw steel delivery for pipe production, processing of pipe shop drawings and mobilization.

Valves were purchased at 60-percent plan design.

Five pipeline contracts were bid with a provision that the bidders could offer a deduction if awarded multiple contracts.

Easements were written and property acquisition began at 30-percent plan design.

**Case Study – Colorado River Municipal Water District -- Ward County.** The Colorado River Municipal Water District (CRMWD) -- Ward County project includes the following metrics:

- 42 miles of 48-inch and 42-inch transmission pipeline
- 20 miles of 10-36-inch well collection pipelines
- 21 groundwater wells
- 3 booster pump stations at 25-30 MGD each
- 2 ground storage tanks – 2-million-gallon capacity each
- $130-million construction (2012)
- Original schedule – 18 months from start of planning and design to water delivery
- Actual schedule – currently under construction and on schedule for January 2013

The following concepts were used to expedite this project:

- The pipeline was routed along existing pipelines and roads to expedite easement acquisition.
- The pipeline was bid early to allow easement acquisition to be concurrent with bidding, raw steel delivery for pipe production, processing of pipe shop drawings, and mobilization.
- Two pipeline contracts were bid with a provision that the bidders could offer a deduction if awarded both contracts. The successful bidder offered a $3.6-million deduction.
- A CMAR was used for the pump stations. Long-delivery items were purchased through the CMAR, including pumps, valves, and variable frequency drives. CSPs were used for the CMAR selection and all equipment and construction contracts.
- The pump stations were split into slab and below- and above-slab contracts to allow the underground construction to be concurrent with design of the above-grade facilities.
- The pipeline was designed to use native materials for bedding and backfill to expedite construction. One four-mile segment of the pipeline crossed through shifting sand dunes. On-site mixed flowable fill with native materials, flyash and cement was specified for this segment.
WATER REUSE

The increasing difficulty of obtaining new reliable water supplies in Texas has water suppliers looking to less traditional water supply sources. Texas has built few major reservoirs during the past 25 years, and many water suppliers in Texas are turning to the reuse of treated wastewater as a viable option. Reuse can either be indirect or direct. Indirect reuse occurs when treated wastewater is discharged into a natural water body (stream or reservoir) and mixed with raw water before being diverted, treated and used again. Direct reuse occurs when treated effluent from a wastewater treatment plant is piped directly to an end-user without entering a natural water body. Indirect reuse for potable supply is common in Texas, and direct reuse is commonly used as a source for non-potable supply, mostly for irrigation or industrial uses. Until now, direct reuse for potable supply is only recognized to occur at one place in the world (Windhoek, Namibia). The recent Texas droughts have changed this approach.

Case Study – Colorado River Municipal Water District. Parched West Texas has seen its surface water supplies dwindle in recent years due to the prolonged drought and intense heat. The Colorado River Municipal Water District (CRMWD), headquartered in Big Spring, Texas, serves numerous cities with a combined population of approximately 450,000 (CRMWD, 2012). CRMWD serves these customers from its three major reservoirs along with four groundwater well fields, which are used to supplement surface water deliveries during the summer (CRMWD, 2012). As of the summer of 2012, two of those three reservoirs were at less than 1 percent capacity, and the third was down to 16 percent capacity (Water Data for Texas, 2012). As a result, CRMWD was forced to severely restrict its supplies to customer cities. This critical situation only highlighted the need for additional sources of supply – in this case a direct potable reuse project that was already in the construction stage. This project is expected to come on-line in early 2013.

Freese and Nichols performed planning, permitting, design, and construction phase services for CRMWD’s new Raw Water Production Facility located in Big Spring, Texas (Figure 6). This plant will receive treated wastewater effluent directly from Big Spring’s Wastewater Treatment Plant. A series of treatment processes (detailed below) will bring this water up to near drinking water standards. The water will then be piped directly into CRMWD’s raw water supply line that delivers raw water from their reservoirs to their largest customers, the cities of Big Spring, Odessa, and Midland, Texas. The reuse water will account for 5-15% of the water flowing through the raw water delivery pipe. This new Raw Water Production Facility will be the first plant in North America that receives and treats wastewater effluent and blends the reclaimed water directly in a raw water distribution pipeline for potable supply.
The CRMWD Raw Water Production Facility consists of three main treatment phases to bring the treated wastewater effluent up to drinking water standards. The first phase is Membrane Filtration, which removes small suspended particles including protozoa and some bacteria. This same process is frequently used in food production/processing. The second phase of treatment is Reverse Osmosis (RO), which directs water under high pressure through membranes that extract salts, viruses, pesticides, and most organic compounds, creating near-distilled quality water. RO is typically used by companies to purify bottled water. The last step in treatment is Ultraviolet Oxidation, which disinfects and breaks down organic compounds. After this step the water meets almost all state and federal standards for drinking water quality.

**Case Studies – Wetland Water Reuse Projects.** Two recent indirect reuse projects of note in Texas are Tarrant Regional Water District’s (TRWD’s) 56-MGD George W. Shannon Wetland Water Reuse Project and NTMWD’s 91-MGD East Fork Reuse Project.

TRWD began operation of the constructed George Shannon Wetlands in 2002. Treated effluent from the Trinity River (originating from TRWD’s customers in North Texas) is passed through these wetlands and then into TRWD’s Richland Chambers Reservoir where it is pumped approximately 90 miles back to TRWD’s two million customers in the Fort Worth area.
NTMWD operates numerous wastewater plants that return treated water into the East Fork of the Trinity River. Downstream, this water is diverted from the East Fork into the John Bunker Sands Wetlands (Figure 7). The water is then pumped 43 miles back to NTMWD’s primary supply reservoir (Lavon Lake).

CONCLUSION

The 2011 drought and on-going drought conditions in Texas have prompted state agencies and water suppliers to take additional steps to have water available for future needs and to fast-track water supply projects desperately needed now. Response measures underway include water conservation, drought measures (including rationing in some cases), priority water right calls to protect senior water rights, fast-tracked implementation of new water supplies, water reuse, and close monitoring of raw water system status using models and decision-support tools. These are challenging times for many water suppliers in Texas. The message is getting across to the people in Texas: Conserve water, optimize the use of current water supplies, and plan ahead to develop new water supplies. “Save water. Nothing can replace it.” (Save Tarrant Water, 2012)

REFERENCES


Dallas Water Utilities (DWU). 2012. Save Water Nothing Can Replace It—How We’re Doing <http://savedallaswater.com/how-were-doing/>


