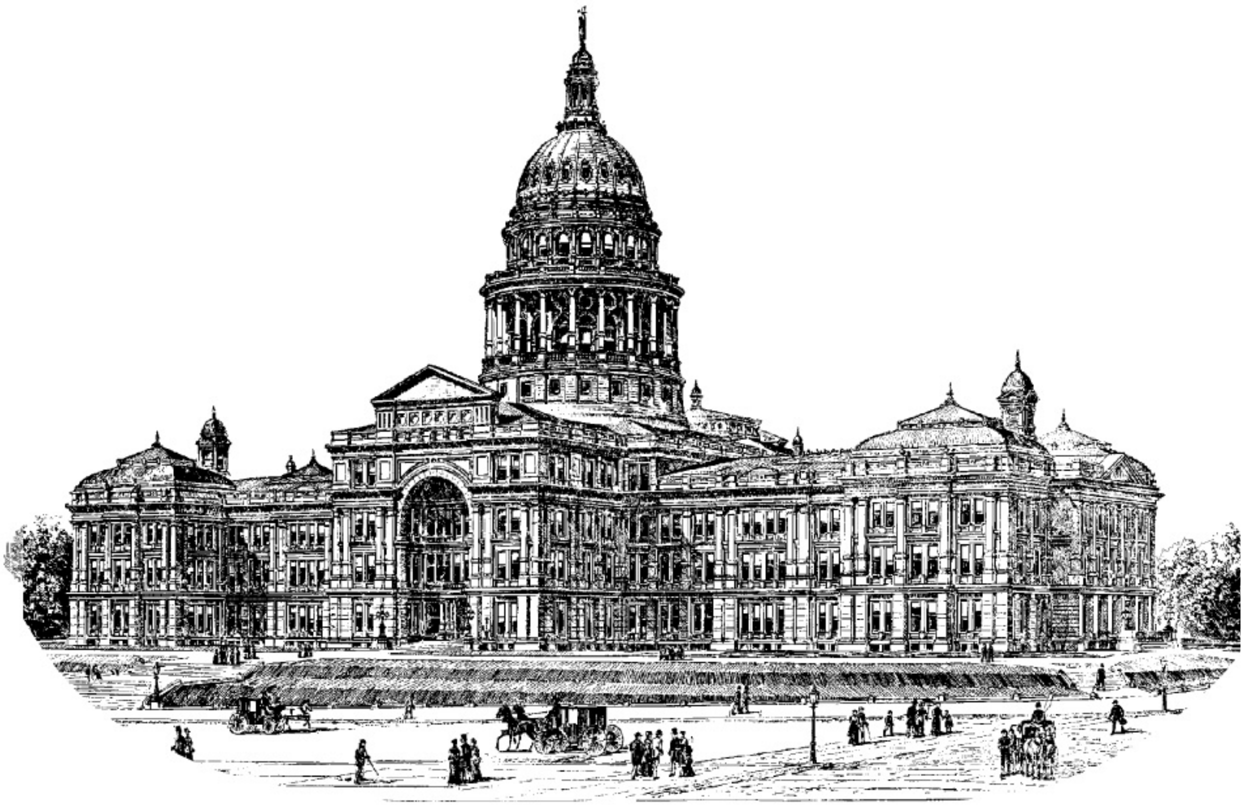
Interim Report
to the 83rd Texas Legislature



House Committee on
Natural Resources
January 2013

HOUSE COMMITTEE ON NATURAL RESOURCES
TEXAS HOUSE OF REPRESENTATIVES
INTERIM REPORT 2012

A REPORT TO THE
HOUSE OF REPRESENTATIVES
83RD TEXAS LEGISLATURE

ALLAN B. RITTER
CHAIRMAN

COMMITTEE DIRECTOR
ELIZABETH A. FAZIO

ACKNOWLEDGMENTS

The Chairman and House Committee on Natural Resources would like to acknowledge and thank several individuals whose hard work made this report possible. The work contained in this report could not have been completed without the diligence and commitment of the following individuals who served the House Committee on Natural Resources this interim:

Senior Editor and Co-Author

Elizabeth Fazio (Committee Director) − Co-authored Interim Charge Number 1 related to drought; Interim Charge Number 2 related to the interplay of water and energy resources, PART I and II; Interim Charge Number 3 related to desalination; and Interim Charge Number 4 related to agricultural irrigation conservation. Served as Senior Editor in all aspects of this report.

Co-Authors

Martha Landwehr (Legal Analyst) − Co-authored Interim Charge Number 1 related to drought, Interim Charge Number 3 related to desalination, and Interim Charge Number 4 related to agricultural irrigation conservation. Served as an Editor in all aspects of this report.

Kevin Kyte (Intern) − Co-authored and provided significant support in the drafting of the report on Interim Charge Number 2, PART I related to the interplay of water and energy resources in the oil and gas industry including hydraulic fracturing.

Hilary Turner (Intern) − Co-authored and provided significant support in the drafting of the report on Interim Charge Number 2, PART II related to the interplay of water and energy resources in electric generation.

Research Assistants

Heidi Kluber (Intern) − Provided initial research on Interim Charge Number 2 related to the interplay of water and energy resources.

Matthew Fiorillo (Intern) − Provided substantial research and preparation for hearings on Interim Charge 1 related to drought; Interim Charge Number 3 related to desalination; and Interim Charge Number 4 related to agricultural irrigation conservation.

House Committee on Natural Resources

January 2, 2013

Allan B. Ritter
Chairman

P.O. Box 2910
Austin, Texas 78768-2910

The Honorable Joe Straus
Speaker, Texas House of Representatives
Members of the Texas House of Representatives
Texas State Capitol, Rm. 2W.13
Austin, Texas 78701

Dear Mr. Speaker and Fellow Members:

The House Committee on Natural Resources of the Eighty-Second Legislature hereby submits its interim report including recommendations and drafted legislation for consideration by the Eighty-Third Legislature.

Respectfully submitted,

Allan B. Ritter

Tracy O. King | Marva Beck
Brandon Creighton | Chuck Hopson
James L. "Jim" Keffer | Lyle Larson
Eddie Lucio III | Trey Martinez Fischer
Doug Miller | Walter "Four" Price

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HOUSE COMMITTEE ON NATURAL RESOURCES

INTRODUCTION

At the beginning of the 82nd Legislature, the Honorable Joe Straus, Speaker of the Texas House of Representatives, appointed eleven members to the House Committee on Natural Resources (the "committee"). The committee membership included the following: Representatives Allan B. Ritter (Chairman), Tracy O. King (Vice-Chairman), Marva Beck, Brandon Creighton, Chuck Hopson, James L. "Jim" Keffer, Lyle Larson, Eddie Lucio III, Trey Martinez Fischer, Doug Miller, and Walter "Four" Price.

During the interim, the committee was assigned five charges by the Speaker:

1. Monitor the ongoing statewide drought and the performance of state, regional, and local entities in addressing it. Examine the impact of the drought on the state water plan, including an evaluation of how well the state's existing water resources can meet demand, the need for additional funding sources to implement the plan, and the effectiveness of current drought planning and drought management policies. Identify short-term and long-term strategies to help the state better cope with drought and assess any obstacles, including state and federal regulations, to implementation of these strategies.
2. Examine the interplay of water and energy resources and needs in the state. Study the economic, environmental, and social impacts of water use in energy production and exploration, including the impacts of this use on regional and state water planning. Determine the current and likely future water needs of power generation and energy production, and evaluate options to develop new or alternative supplies. Include an evaluation of current issues involving water use for oil and gas production and related water quality issues.
3. Evaluate the status of desalination projects in Texas. Include an evaluation of the regulation of brackish groundwater and whether opportunities exist to facilitate better utilization of this groundwater to meet future needs.
4. Study ways to enhance incentives for water conservation in agricultural irrigation.
5. Monitor the agencies and programs under the committee's jurisdiction and the implementation of relevant legislation passed by the 82nd Legislature.

The committee has completed its hearings and investigations and has issued the following final report and recommendations. All interim charges including the charge monitor the agencies and programs under the committee's jurisdiction were undertaken by the committee as a whole and no subcommittees were appointed.

Finally, the committee wishes to express its appreciation to the federal and state agencies, local governments, public and private interests, and concerned citizens who testified at the public hearings for their time and efforts on behalf of the committee.

INTERIM STUDY CHARGES

Committee of the Whole

CHARGE #1: Monitor the ongoing statewide drought and the performance of state, regional, and local entities in addressing it. Examine the impact of the drought on the state water plan, including an evaluation of how well the state's existing water resources can meet demand, the need for additional funding sources to implement the plan, and the effectiveness of current drought planning and drought management policies. Identify short-term and long-term strategies to help the state better cope with drought and assess any obstacles, including state and federal regulations, to implementation of these strategies.

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Committee of the Whole

CHARGE #2: Examine the interplay of water and energy resources and needs in the state. Study the economic, environmental, and social impacts of water use in energy production and exploration, including the impacts of this use on regional and state water planning. Determine the current and likely future water needs of power generation and energy production, and evaluate options to develop new or alternative supplies. Include an evaluation of current issues involving water use for oil and gas production and related water quality issues.

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Committee of the Whole

CHARGE #3: Evaluate the status of desalination projects in Texas. Include an evaluation of the regulation of brackish groundwater and whether opportunities exist to facilitate better utilization of this groundwater to meet future needs.

Allan B. Ritter
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Committee on the Whole

CHARGE #4: Study ways to enhance incentives for water conservation in agricultural irrigation.

Allan B. Ritter
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Lyle Larson
Eddie Lucio III
Trey Martinez Fischer
Doug Miller
Walter "Four" Price

DROUGHT

PUBLIC HEARING

The House Committee on Natural Resources held two public hearings on its Interim Charge #1 related to drought. The first public hearing held on Interim Charge #1 related to drought was held on November 2, 2011 at 9:00 a.m. in Austin, Texas in the Capitol Extension, Room E2.010. The following individuals testified on the charge:

Tom Boggus, Texas Forest Service
Brad Brunett, Brazos River Authority
Melanie Callahan, Texas Water Development Board
Jerry Clark, Sabine River Authority, Texas
Jim Conkwright, High Plains UWCD No.1, Texas Alliance of Groundwater Districts
Finley DeGraffenried, City of Llano
Karl Dreher, Edwards Aquifer Authority
Gregory Ellis, Harris-Galveston Subsidence District
John Grant, Colorado River Municipal Water District
Scott Hall, Lower Neches Valley Authority
Brent Leisure, Texas Parks and Wildlife Department
Jackie Levingston, City of Groesbeck, Texas Municipal League
Robert Mace, Texas Water Development Board
Dave McMurry, Aqua Water Supply Corporation
Greg Meszaros, City of Austin Water Utility
Becky Motal, Lower Colorado River Authority
Ronald Neighbors, Harris-Galveston Subsidence District
John Nielsen-Gammon, Office of the State Climatologist, Texas
Jim Parks, North Texas Municipal Water District
Chuck Phinney, Texas Division of Emergency Management, Texas DPS
Dean Robbins, Texas Water Conservation Association
Bob Rose, Lower Colorado River Authority
Carlos Rubinstein, Texas Commission on Environmental Quality
Charles Smith, Aransas County
Stacey Steinbach, Texas Alliance of Groundwater Districts
L'Oreal Stepney, Texas Commission on Environmental Quality
Kathy Turner Jones, Lone Star GCD, Texas Alliance of Groundwater Districts
Mark Vickery, Texas Commission on Environmental Quality
Matt Wagner, Texas Parks and Wildlife Department
William “Bill” West, Guadalupe-Blanco River Authority

The second public hearing held on Interim Charge #1 related to drought was held on March 22 at 9:00 a.m. in Austin, Texas in the Capitol Extension, Room E2.010. The following individuals testified on the charge:

Russell Boenig Texas Farm Bureau
Carolyn Brittin, Texas Water Development Board
Robby Cook, Lakeside Irrigation District Water Management
Tom Currah, Office of Texas Comptroller
Drew DeBerry, Texas Department of Agriculture
Jay Evans, Texas Southwestern Cattle Raisers Association
Mitchell Harris, Texas Farm Credit
Ken Kramer, Sierra Club
Michael Lemonds, Texas General Land Office
Travis Miller, Texas AgriLife Extension Service, Texas A&M University
Becky Motal, Lower Colorado River Authority
John Nielsen-Gammon, Office of the State Climatologist
Chuck Phinney, Texas Division of Emergency Management
L'Oreal Stepney, Texas Commission on Environmental Quality

The following section of this report related to drought is produced in large part from the oral and written testimony of the individuals listed on the previous page and above.

INTRODUCTION

The committee was charged with monitoring the ongoing statewide drought and the performance of state, regional, and local entities in addressing it. This included the examination of the impact of the drought on the state water plan, including an evaluation of how well the state's existing water resources can meet demand, the need for additional funding sources to implement the plan, and the effectiveness of current drought planning and drought management policies. Additionally, the committee was charged with identifying short-term and long-term strategies to help the state better cope with drought and assessing any obstacles, including state and federal regulations, to implementation of these strategies.

The Drought of 2011 was the worst one-year drought recorded in Texas history and in recent memory since the 1950s. Thankfully, the state's current water resources were able to ultimately withstand the drought and perform as planned under the Senate Bill 1 planning process. Under this process and in planning for drought, an entity plans for every each and every last drop of water to be used, supplying enough water to meet its needs through the last day of the worst drought at hand. This report provides for a summary of the devastating impact that drought causes on all sectors of our economy. The news, while startling, is not all bad. This report also outlines how drought can provide for the opportunity to gain knowledge and make greater strides in the development of our water resources, championing Texas as a leader for the most progressive, comprehensive State Water Plan in the country.

BACKGROUND

Descriptions of droughts come in many forms: worst drought in recent years, driest year on record, driest spell in memory, lowest water supply to date, and so on. Drought is a term not easily defined and even harder to determine until the damage is well underway. In actuality, drought is a term loosely defined because whether a drought exists is dependent on so many variables, including the climate, region, supply, and ultimately the need. Texas water plans have traditionally defined drought as a period of less than average precipitation over a period of time that results in a shortage of water. Other characteristics include above average temperatures, increased evaporation rates, and low relative humidity.[1]

These periods can be measured in years, months, or even weeks. Further, the effects on rural areas versus urban areas can be totally different. In terms of agriculture, a deficiency in rainfall results in drought when crops are lost. In "city" terms, a deficiency in rainfall becomes significant when water supply is so depleted that mandatory water restrictions apply.[2] Simply put, drought is difficult to define objectively. Of course for any population, "drought conditions may be said to prevail whenever precipitation is insufficient to meet the needs of established human activities."[3] Droughts, unlike other natural disasters that strike suddenly, subtly appear. The results, however, are just as, if not more, catastrophic. Aptly referred to by Ivan Ray Tannehill, "[Drought] creeps upon us gradually, almost mysteriously, but its consequences are a terrible reality."[4]

Overview of Texas' Significant Droughts

To put the Drought of 2011 into perspective requires a little historical review. Droughts go back before recorded history. Incredibly, tree-ring chronologies in the Southwest extend back almost 4,000 years.[5] Records of rainfall in Texas begin around 1889, with a few recordings beginning in the 1850s. Historical droughts since 1889 varied from one to four years in length and on average occurred at least once a decade up until the Drought of the 1950s.

No one can consider droughts in the United States without discussing the "Dust Bowl" drought of the 1930s, which came as three events: 1934, 1936, and 1939 – 40. This is a well-documented drought that had the most impact on Oklahoma and the High Plains, but it was so severe that we saw a significant migration of population from the plains to California as farmers could not produce enough crops to pay off loans. Farms were abandoned and many were lost to the wind erosion that produced the infamous dust clouds which turned day into night.[6]

While dollar figures are not comparable due to vast differences in the value of currency and commodities, the drought to which we compare all others in Texas lasted from 1950 – 1957. A drought of this extent and duration had major implications to agriculture, economy, and demographics of the state and its water supplies. Many of the major reservoirs of the state were constructed in a 20-year period following the Drought of the 1950s, with 69 dams constructed between 1957 – 1970. Further, it was primarily responsible for the development of much of the financial safety net currently protecting U.S. agriculture. It also heralded a significant change in Texas demographics and a diversification of the economy as many rural Texans moved to urban areas in the face of the prolonged losses to the agricultural economy.[7]

The Drought of the 1950s

In the recorded history of Texas, the worst drought occurred from 1950 – 1957. This drought was the driest, longest, and most widespread period on record for the state: a whopping seven years. Today, the Drought of the 1950s is still considered Texas' "Drought of Record" upon which supply and demand for state water planning is based.[8] Beginning in 1953, most of central Texas and all of west and southwest Texas experienced deficiencies in rainfall. By 1957, half of the state had accumulated deficiencies in excess of 20 inches and half of those deficiencies were over 30 inches with a small, inland stretch of land at over 40 inches deficient.[9]

Agricultural losses resulting from the drought between 1950 –1957 were devastating. Farmers in some regions planted crops for three consecutive years without harvesting a single crop. Ranchers were forced to provide supplemental rations to their herds, and even after the drought ended, the cattle capacity of the rangeland took years to recover. By the end of the drought, 244 of 254 counties in Texas were classified as disaster areas. In total, agricultural losses during the seven-year drought were estimated to exceed $3 billion.[10] In today's dollars that would be over $23.6 billion.[11]

The effect on municipalities in the 1950s was harder to measure. Some of the factors considered in attempting to quantify the monetary effects of the drought included: the cost of emergency supply, shortages to industry, unfavorable publicity, and an increase in future cost of water. Many smaller communities did not have the financial resources to handle the drought. With a rapid increase in population and per capita water usage, the drought resulted in water rationing for some cities. Very early in the Drought of the 1950s, eight communities were hauling water, 28 towns were using emergency sources of supply, and 77 municipalities were rationing water. [12]

Irrigation from surface water supplies was greatly curtailed and supplemental irrigation from groundwater supplies continued with an increased cost of operations. Pumps were lowered, additional wells were dug, distribution systems were installed, and water pump operations worked overtime. Several hundred thousand acre-feet of releases from the northern portion of the Brazos River were even sent south in order to save a multi-million dollar rice crop at the mouth of the river.[13] Another serious effect of the drought was the reduction in run-off and stream flow. Comal Springs stopped flowing out of the Edwards Aquifer for the first and only time in recorded history.[14]

As a result of the drought, the Texas Water Development Board was formed in 1957 to measure and plan for future water supply demands and provide funding for water supply projects that would meet that growing demand. That same year, Texans authorized through a constitutional amendment the issuance of $200 million in general revenue bonds.[15] In the following two decades, more than 126 reservoirs were constructed in the state.[16]

The Drought of 1996[17]

At the onset of the 1996 drought, Texas was “suffering through a drought [with] the potential to be as damaging as any in the state’s history.” Mid-year 1996, a study by Texas A&M projected that the total agricultural loss would be $2.4 billion unless drought conditions lessened. At the same time, all of the state’s 10 climatic regions were in a stage of drought ranging from moderate to extreme. The Rio Grande Valley region was in its fourth consecutive year of drought. In South Texas, the year was recorded as having tied for the second driest first quarter since records were kept. Amarillo reported that it was the driest six months on record dating back to the Dust Bowl days of the 1930s.

According to projections, agriculture earnings in 1996 were hit especially hard. From wheat harvest to cotton fields, farmers’ production was down nearly 24%. Cattle raisers were in even worse shape. Livestock production for the year fell approximately 12.5%. Out of 254 counties in the state, over half were eligible for some type of emergency drought assistance through the U.S. Department of Agriculture. Federal, state, and local initiatives poured out program dollars to help save agricultural and livestock production throughout the state.

Response techniques generally varied across the state with some rural regions continuing to explore unconventional technologies through weather modification like cloud seeding. Urban areas established emergency water management strategies, and more than 200 Texas cities and/ or counties developed plans. A variety of cities such as Dallas, San Antonio, Austin, Harlingen, Lubbock, and El Paso had water management or conservation plans that all dictated varying levels of stages and responses during times of emergency shortages. Still, nearly every recommendation for handling the drought involved making more funding available.

All told, the Drought of 1996 was difficult to define because it depended on the normal climate of the region. "Severe drought conditions in East Texas [were considered] a wet season in West Texas." Recovery from the drought, was equally as varied and unpredictable. This drought resulted in Senate Bill 1 that created a bottom-up planning process, whereby 16 regional planning groups worked together with local interests and suppliers to develop a statewide plan based on projections of a 50-year planning horizon. Now required every five years, this comprehensive planning process was the beginning of an unprecedented way of planning and thinking for the state. Regional and local stakeholders not only determined their needs, they also requested specific funding needs in their areas.

The Drought of 2007 − 2009[18]

Another short-term drought that affected localized areas of Texas occurred around 2009. The Drought of 2007 − 2009, for some locations in Texas, may well have been the worst drought on record up until 2011. The Drought of 2007 − 2009 was most severe in South Central and South Texas. The short-term dryness was most acute in the Coastal Bend area, where at least one county experienced a total failure of its cotton crop, while longer-term drought was most intense along and just southeast of the Balcones Escarpment in Central and South Central Texas. Extreme drought conditions in the Lower Valley and East Texas were largely mitigated by the rainfall from hurricanes Dolly and Ike, as well as tropical storm Edouard.

Overview of Texas' Drought of 2011

> "The drought we are experiencing today is currently exceptional for most of Texas, and it has only increased in recent months. Due to dry conditions existing before the drought even began, the lack of rainfall only added insult to injury for Texas during this past year." – John Nielson-Gammon, Texas State Climatologist

The Drought of 2011 began for much of the state in September 2010. Much of the Gulf Coast, Central, West Texas, and the High Plains had seen abundant moisture in the summer of 2010 from tropical storm Hermine and other rainfall events. An unusually strong La Niña pattern moved into place in the fall of 2010 which had an impact comparable to turning off the "rainfall switch" for most of Texas and its surrounding states. The year 2011 was easily the hottest and driest year recorded in Texas history, topping any previous year since records were initiated in the late 1800s. No region of the state was spared.[19]

La Niña

La Niña is a coupled atmosphere-ocean weather pattern involving unusually cool temperatures in the tropical Pacific Ocean, which has such a strong effect on jet streams and weather patterns. Most La Niña events induce changes in weather patterns that lead to dry late-fall to early-spring conditions for Texas and surrounding parts of the southern United States.[20]

Four out of five times, a La Niña weather pattern will result in Texas wintertime precipitation that is below normal.[21] This was certainly the case for the La Niña pattern that began during mid-2010 and resulted in Texas' driest one year on record.

Chronology

At the beginning of the drought in October of 2010, the dry conditions in eastern Texas were becoming increasingly dire.[22] The two-month precipitation index showed a combination of a wet September with multiple tropical disturbances bringing rain to the central and southern areas of Texas, yet an October that was eighth-driest on record for the state as a whole.[23] During November of 2010, the fall dryness was exceptional in parts of Central and South Texas. The Panhandle had actually received above-normal precipitation for the two-month period, due almost entirely to rain from a single storm system on the 11th – 12th of November.[24] December marked the third consecutive drier-than-normal month for Texas.[25] As of December 2010, just three months into what would become the Drought of 2011, the U.S. Drought Monitor was indicating short-term drought across most of Texas. Already, 69.4% of the state was classified as in at least a moderate drought.[26] Both short-term and long-term drought were also present in East Central Texas in an area centered on Bryan/ College Station and in the southwestern area of Texas just east of Del Rio.[27] In the rest of the state, the wet summer was still substantially reducing the potential impact of the dry fall.[28] Exceptional drought, the most serious stage, had not yet made an appearance, and only 9.6% of the state was in extreme drought, the second-most serious stage.[29]

January 2011 was the only month within the period in which statewide average rainfall barely exceeded its long-term average. The precipitation was sufficient to bring the two-month and six-month totals to above normal in the Coastal Bend area. This rain was extremely beneficial for establishing suitable conditions for crop planting and seed germination. Most of the rest of the state also benefited temporarily from the rainfall. However, less than a tenth of an inch of precipitation was recorded in most of western Texas, and the lack of mid-season precipitation and snow cover would have serious implications for much of the winter wheat crop.[30] By the end of January, the area around Bryan/ College Station had crossed into the exceptional drought threshold at the six-month accumulation period. Terrell County in southwestern Texas had also crept into exceptional drought on the basis of six-month precipitation.[31]

Texas was already in serious drought at the end of February 2011, and the upcoming months were disastrous for farmers and ranchers. March 2011 was the driest March on record for the State of Texas as a whole. Below-normal precipitation for the February – March period occurred everywhere except parts of western Texas, where rainfall in February and March is normally light.[32] The record dry March combined with the removal of September from the six-month precipitation accumulation period showed terrible drought conditions across the state. Many counties in East Central, South, and West Texas had a lack of cool-season rainfall that was unprecedented in the historical record.[33] Aside from the Panhandle, the remarkable lack of rainfall combined with springtime warmth to dry out the previous year's growth of grasses. By early April, wildfires were burning in many parts of western and West-Central Texas.[34] Over 43% of the state was classified as in extreme drought.[35]

According to the U.S. Drought Monitor in April, the 2011 drought was already the most severe Texas drought in recent memory.[36] Statewide, May averages more precipitation than any other month, however, May 2011 turned out to be the ninth-driest May on record. The three-month period from March – May was the driest March – May on record.[37] For all of the state except parts of North Central and Northeast Texas, the dry March – May, on the heels of an already dry winter, guaranteed very low to nonexistent dryland crop yields for the 2011 growing season, irrespective of potential future rainfall.[38]

The U.S. Drought Monitor showed that drought conditions had rapidly worsened during the April – June 2011 period because the lack of rainfall occurred at precisely the time of year when rain was most needed.[39] By the end of June, 72% of the state was depicted as being in exceptional drought.[40] The only portion of the state not shown as abnormally dry was the region near and north of Dallas, where several counties received adequate rain during May and June.[41] Amplifying the severity of the drought was the excessive heat that had developed across the state. June was the warmest June on record and the fourth warmest month on record so far.[42] Temperatures continued to set records and July was not just the warmest July on record for Texas, but the warmest month ever in the state.[43] Records for days with triple-digit temperatures were threatened.

In August, scattered rains in parts of West Texas had reduced the severity of drought conditions in some areas, but elsewhere conditions worsened. July and August had been especially dry almost precisely where the previous summer's rainfall had been most beneficial: along a line from Corpus Christi through Austin and nearly to Dallas. Over the six months from March through August, rainfall in that area was so small that the six-month standard precipitation index was below -3.0, and similar conditions were found near Houston, in much of the Hill Country, and almost the entire region north and west of Abilene.[44]

By the end of September, the drought was one year old, and the twelve consecutive months of precipitation from October 2010 through September 2011 were the driest twelve consecutive months on record for the state. Texas averaged slightly more than 11" for the twelve months, much less than the 27" average value and roughly 2.5" less than the previous 12-month record set during the Drought of the 1950s.[45]

The record for warmest month in Texas, set during July, was surpassed by more than one degree Fahrenheit (°F) in August.[46] The June – August average temperature across Texas was roughly 2.5 °F warmer than any previous Texas summer and over 5 °F above the long-term average. The public's attention was captured by the unusually high number of days reaching or exceeding 100 °F.[47] Many parts of the state achieved the "double-triple", or in other words at least 100 days of at least 100 degrees. Such areas included a large portion of South Texas surrounding Laredo, parts of North Texas near and west of Wichita Falls, and weather stations along the Rio Grande upstream at least as far as Big Bend. Much easier to count were the four stations that did not have a single day reach 100 °F: two of them along the Gulf Coast, while the other two were in far West Texas at altitudes exceeding 5000' above sea level.[48]

Regional Impacts

Drought is no stranger to Texas and the Southwest. On any given year, it is more likely to have drought in at least one climatic division of the state than to have the whole state in favorable moisture conditions.[49] The drought in the Panhandle created sub-desert conditions. Typically, it rains 11 inches in the desert, and most of the Panhandle received less than 60% of that amount. In fact, some areas had not received 6 inches of rainfall in 18 months. For instance, Amarillo received less than 7 inches of rain in 2011, the lowest level of rainfall ever recorded in that locale. Lubbock received less than 6 inches during that same period, representing the driest period on record for Lubbock, as well.[50] Furthermore, river basins that stretched from Northwest Texas near Lubbock, all the way down to Southeast Texas' Allens Creek outside of Houston were also impacted.[51] As of December 31, 2011, it was projected that all the reservoirs in the Brazos River Authority system totaled to only 57% full.[52]

Similarly, West Texas also had little to no rainfall during the Drought of 2011. Big Spring, Odessa, Snyder, Abilene, and San Angelo all experienced their own unique challenges. For example, three of their main water supply reservoirs, J.B. Thomas, E.V. Spence, and O.H. Ivie, were only at 9.16% water capacity combined.[53] Then, due to significant distances and varying elevations, transportation of water between sources proved difficult. By carefully managing resources, Colorado River Municipal Water District continued to supply about 18 billion gallons through the driest months from January-September of 2011.[54]

In addition to drought, North Texas struggled with another one of mother nature's challenges: the Zebra Mussel, an invasive species of mussel that impacts the water quality in raw water/ reservoir supplies, as well as treated water supplies.[55] These mussels disturb the natural ecosystems and are also responsible for fouling pumps, pipelines, intakes, trash bars, screen houses, and steam condensers inside of water and power plant structures,[56] as well as completely stopping water pumping from a local reservoir supply.[57] North Texas Municipal Water District (NTMWD) estimated that an additional 28% of its water supply was restricted because of this invasive species, making it even harder to manage through the drought.[58] In order to effectively manage its water supply for over 1.6 million customers, NTMWD initiated its Drought Management Plan, Stage 1 in April 2011. Due to extended drought conditions and the loss of access to Lake Texoma, the district moved to Stage 3 in November 2011. Although some relief from drought occurred in 2012, the restriction still remains at in place at Stage 2 due to impediments derived from the invasive species.[59] NTMWD is spending over $300 million to construct a new pipeline in order to resume use of its Lake Texoma supplies by early 2014.

Central Texas was no exception to devastation resulting from the drought. Prior to significant drought conditions of 2011 within the region, the Lower Colorado River Authority (LCRA) had implemented outreach and compliance efforts for more than 5,500 domestic diversions around the Highland Lakes, requiring diverters to obtain contracts with the LCRA.[60] By the time the 2011 drought peaked at its worst, the LCRA began preparations for a drought worse than the Drought of Record in the event that specific criteria were met, the most critical one being a trigger for whether the combined storage of Lake Buchanan and Lake Travis dropped below 600,000 acre-feet.[61] For raw water customers, mostly cities, industries, and irrigation customers who pay firm water rates, this meant the possibility of a pro rata curtailment of water use. Additionally, if a drought worse than the Drought of Record was declared, firm water customers would have to reduce water use by 20%.[62] Luckily, by March 2012, rainfall pushed the combined storage of the Highland Lakes past 933,000 acre-feet, significantly delaying the need for any last resort measures.[63]

The Guadalupe-Blanco River Authority (GBRA) also considered taking precautionary measures in the event that the Drought of 2011 surpassed the Drought of Record. Created in 1933 to provide "conservation and reclamation" on the Guadalupe River, the authority's main "firm" water supply on the Guadalupe River is Canyon Reservoir.[64] During the Drought of 2011, GBRA avoided curtailment of water to firm customers by undergoing an "on the road" campaign to educate commissioners' courts and city councils about the importance of conservation measures. Additionally, GBRA worked closely with regional watermasters to protect senior water rights.

Continuing across the state, East Texas was one of the first areas of Texas to experience the effects of the Drought of 2011.[65] The normal rainfall pattern was disrupted by La Niña conditions in 2010 such that the basin ended the year with a rainfall total 25 inches below normal.[66] For East Texas, the drought began in April 2010 when Sam Rayburn Reservoir dropped below a full pool. Moderate drought conditions over the basin developed as early as May 2010.[67] Through the spring of 2011, Rayburn only slightly recovered and summer demands on the reservoir, coupled with high evaporation rates and virtually no rainfall runoff, left the conservation storage at 10% of capacity at the end of October.[68] The Lower Neches Valley Authority (LNVA) is the local sponsor for this reservoir, along with two other federal projects including Dam B - Lake B.A. Steinhagen and the Neches River Saltwater Barrier.[69] The water supplied by these projects and run-of-river diversions by LNVA account for a permitted water supply of 1.2 million acre-feet per year.[70] While the area served by the authority includes a population of 250,000 and 27,000 acres of rice production, the largest water user group is industry.[71] A vital sector of the economy, the refining and petrochemical complex in Jefferson County generates $7.9 billion in annual gross product and 79,532 jobs according to a study conducted by Ray Perryman.[72] Simply put, the economy of Southeast Texas is dependent upon a reliable water supply[73] and during drought that reliability becomes increasingly important.

Finally, 2011 offered yet another interesting trial in Texas: how to manage subsidence issues through significant periods of drought. The Harris-Galveston Subsidence District (HGSD) was created by the Texas Legislature as a special purpose district in 1975 to provide for the regulation of groundwater withdrawals throughout Harris and Galveston counties. Its purpose is the prevention of land subsidence, which leads to increased flooding.[74] Subsidence most affects land along the Galveston Bay. Since 1906, land surface in this area has sunk as much as 10 feet.[75] With each passing year, more hurricanes and longer lasting droughts only make this subsidence issue more pressing. Hurricanes directly contribute to subsidence by flooding sensitive lands, while long-term droughts indirectly affect subsidence due to the required water conservation planning that is used to combat the problem.

During the Drought of 2011, higher prices and drought restrictions led to more requests at the HGSD for individual wells on properties already served by public water systems.[76] The HGSD already provides an exemption for homeowners who have a well that serves the homestead, where no access to a water utility or some other alternative water supply existed.[77] The requests by homeowners for new wells already being served by a system, created a long-term problem for HGSD. Drilling new wells inside subdivisions in response to a drought (or higher water prices) exacerbated the problem: first, the new wells allowed unlimited withdrawals by homeowners, whereas utility customers have to follow drought restrictions; and the utility, which is participating in purchasing surface water supplies to replace their groundwater withdrawals, risked loss of customers.[78] Moreover, once the drought was over, the wells still remained.[79]

Overview of the Drought of 2011 Impact on Texas

Agriculture and Livestock

A full understanding of the implications of the drought came too-little, too-late for Texas agriculture and livestock. In March 2011 seeds were placed in the ground in southern Texas as well as northern Texas, despite the fact that soil moisture was at critical levels. In July 2011, it was the peak of the growing season for most crops and forage. Crop abandonment decisions began, and livestock sell-offs were well underway. In October 2011, small harvest realities set-in, and the remaining livestock were fed hay from hundreds or thousands of miles away.[80] The drought ruined crops, the price of hay increased 200%, corn outputs fell by 40%, and water supplies were cut off to rice farmers.[81] This broad timeline, and the general statistics accompanying it, provide the most basic example of how difficult life was for farmers and ranchers during the Drought of 2011.

Agriculture Irrigation

Surprisingly, the trending decline in agricultural irrigation played an important role in sustaining the agricultural output during the drought. As of the 2007 Agriculture Census, only 3.8% of agricultural lands were found to be irrigated, and the 10-year snapshot showed that the amount of irrigated acres had declined 13% from 1997. According to the Texas Water Development Board, irrigated agriculture acres declined 26% from 1979 to 2000. Although the urgency to conserve played a key role in the decline, it is important to note that technology advancements helped to save water, while still improving yields. For example, corn yields increased from 30 bushels per acre during the 1960s to 150 bushels per acre today. Additionally, cotton yields today are twice the amount of cotton than in the 1960s. Similarly, the amount of beef per cow is now twice the amount of beef then. In just the past 10 years, Texas milk productivity per cow increased 30%.[82]

Perhaps the most telling thing about the 2011 drought was that even irrigated farmers were not spared. While most Texas irrigation systems work well in normal or even below normal rainfall, many irrigators found that water supplies were not able to provide all of the water requirements of the crop in the absence of any rain and presence of excessive heat.[83] Farmers and ranchers invested an unusual amount of dollars, time, and labor to produce crops in 2011, but production was off in every phase of operation. Simply put, the drought was too severe and too long. In the end, dry land crops failed and irrigated crop yields were about 75% – 80% of normal, even after pumping twice the amount of water in a normal year. In some areas of the state, the outcome was even worse.[84]

In West and North Texas, producers had to abandon half-circles of irrigated crops just to try and keep the other half-circle irrigated. Even then, the half-circles were not always successful.[85] By mid-July, farmers began to try to stop losses, dedicating all of their water supplies to a reduced number of acres, as water demand from the crops was higher than the ability to supply it. Many corn acres were abandoned to divert water to cotton, which is more heat and stress tolerant.[86]

Corn, Cotton, and Other Commodities

This destructive climatic pattern took a huge toll on crops and forages and the timing could not have been worse for Texas producers, as many of the major agricultural commodities were previously enjoying strong prices. Corn production declined 55% from 2010 and had a 46% decline from a five-year average. Of the 7.55 million cotton acres planted, 57.5% would be abandoned, much of it never having enough rain to germinate planting seed, resulting in a loss of 4.34 million bales. Due to unusually high cotton prices in the 2011 growing season, this loss was greater than the $1.8 billion 10-year average value of the Texas cotton crop.[87]

There were fewer statistics available on the Texas hay crop than on traditional commodities. Hay is typically the second or third highest value crop. While exact estimates are not available, it appears that Texas producers made less than 10% of a normal crop, leaving ranchers without a local hay supply and adding significantly to the price of hay, most of which was shipped great distances from out of state, with costs escalating due to high diesel prices. The loss of the 2011 hay crop to drought was key to the disaster that befell the livestock industry. One Montana rancher gave an account of a stream of Texas cattle trucks coming into his state with loads of cattle and leaving with loads of Montana hay.[88]

Other commodities were down, as well. Only 35% of the Texas wheat crop was harvested, with production down 59% from 2010 and 47% from a five-year average. Sorghum production was down 60% from a five-year average. Peanut production was down 60.3%, and soybeans were down 69.2% from 2010 production levels.[89]

Economic Impact on Agriculture

The Drought of 2011 dealt a devastating financial blow to all agricultural producers in the state. Many producers went from a positive operating income in 2010 to a substantial negative operating income in 2011.[90] Normal operating expenses included payments for land, equipment, fuel, fertilizer, irrigation, seed, and herbicides. Then, due to the early onslaught of hot, dry and windy conditions in the spring, irrigation began earlier than planned, which piled on additional expenses. The cost to produce crops and feed livestock from irrigation alone increased about 80%.[91] This resulted in depleting cash reserves, which further postponed needed improvements.[92] In total, estimated losses by commodity were the following: cotton − $2.2 billion; hay − $750 million; corn − $736 million; wheat − $314 million; and sorghum − $385 million. The total was a whopping loss estimate of $7.58 billion.[93] While crop insurance was helpful in offsetting the loss, it unfortunately only provided 40% of the earning from a normal harvest. These losses, coupled with other tough years, reduced yield histories, which in turn lowered the level of protection provided by crop insurance.[94]

Livestock

The drought dealt a similar timeline and more disheartening statistics to livestock producers. Most went into 2011 with the prospect of unusually high prices. The weather was too dry to produce any significant wheat pastures or ryegrass, so feeding was heavy during the winter with a lack of green pastures in the spring. By May, most of the state's hay supplies were depleted and water supplies were rapidly declining. Cattle, sheep, and goat producers began the process of culling. By July, the liquidation of herds began in earnest, with sale rings hitting record numbers of stock as ranchers began to give up hope on being saved by rain. Ranchers continued to liquidate herds through the fall with many selling all of their livestock, while others opted to move herds to leased pastures in the Northern United States, where rainfall and grass were abundant. Hay prices were at record levels, often selling for more than twice that of normal prices. Hay quality and feed value were typically very poor as many ranchers and dairies turned to low quality feeds such as corn stalks, and, even in a few cases, cotton stalks.[95]

A lack of adequate forage and surface water were the key factors affecting the livestock industry. The drought was compounded by extreme summer heat that caused evaporation and contributed to the degradation of range conditions and forage quality.[96] Due to the drought being statewide (and a continuation of what ranchers might argue is really a 15-year drought in some areas of the state), [97] very little local hay was available at any price. Producers had to go out of state to find supplies, sometimes as far as the Dakotas or even into Canada. As a result, transportation costs more than tripled from what they would have normally been.[98] Feed costs also increased due to having to purchase supplemental feed for livestock because hay alone could not meet the nutritional requirements.[99]

The next alternative was relocation. The drought was not only severe, it was widespread with few economical alternatives for relocation due to lack of available alternate range and high freight. In order to preserve the home turf and maintain long-term genetics, however, many herds did go north to Kansas, Nebraska, South Dakota, Wyoming, and Montana. The economic goal here was to sustain good markets for the product and be able to return to home range in a reasonable time frame. Extreme heat and high winds from May − September, wild fires that destroyed almost 4 million acres of range land, and continued low hay and grain production left little more alternative, leading to substantial reductions in production.[100] The long-term impact related to production is yet to be determined, but production may suffer for 12 − 18 months even with improved range conditions.[101]

The most obvious impact of the Drought of 2011 on livestock was herd liquidation.[102] All producers made considerable herd reductions to minimize the number of livestock needing feed.[103] Members of Texas Southwestern Cattle Raisers Association overall reduced their herd numbers (cows and bred heifers) by 35% and over 10% were forced into complete liquidation.[104] The year 2011 saw the largest beef cow herd reduction in Texas history. Over 600,000 beef cows were reduced by January 2012. This was the largest percentage decline since the 1934 and 1935 reduction. This left a beef cow inventory of 4.4 million head during the same month, the lowest inventory since 1961.[105] Ultimately, the result of the Drought of 2011 will be felt for many years to come, due to the fact that many young, high quality livestock had to be sold.[106]

Economic Impact on Livestock

The economic impact on livestock cannot be understated. Producers will most likely be faced with additional liquidation in certain areas, like South and West Texas. Economic challenges linger with respect high operating costs and low productivity of 2011. Due to reduced numbers and high values, restocking will require substantial capital.[107] Moreover, resource recovery and preservation of our natural resources cannot be overlooked. Under the circumstances, producers support the need to do the right thing long term for the range and habitat, ensuring that things are looked at "from the ground up and not just the cow down."[108]

Economic Impact Totals

The Drought of 2011 imposed an incredible financial blow to the agriculture industry in Texas. Where agriculture has a $100 billion impact on the state economy and one in seven Texans are involved in agriculture in one way or another,[109] over $7.6 billion was reported lost in 2011. This equates to 38% of the 2010 cash receipt total. Moreover, the timber industry suffered a $3.4 billion economic loss due to the wildfires and severe drought. Furthermore, a December 2012 economic analysis by BBVA Compass Bank found that indirect losses to Texas agriculture due to the drought would likely add another $3.5 billion to the toll.[110]

In August 2011, the Texas AgriLife Extension Service estimated Texas' direct agricultural losses from the year's drought at $5.2 billion. The total annual losses were later estimated at $7.62 billion, nearly twice the highest previously recorded loss of $4.1 billion attributed to the 2006 drought. The August estimate included the following losses: livestock − $2.06 billion, hay production − $750 million, cotton − $1.8 billion, corn − $327 million, wheat − $243 million, and sorghum − $63 million. In addition to losses from fruit and vegetable producers, horticultural crops, nursery crops, and other grain and row crops suffered losses.[111] As the drought continued without relief in large areas of the western and the plains regions, some suggested that Texas would enter into a multi-year drought that will further compound these estimates.[112]

Lending and Insurance[113]

As business owners, farmers and cattle ranchers normally insure their investments against losses, including from natural disasters and catastrophic events. The Drought of 2011 substantially effected agriculture assets, which in turn negatively impacted the lending community. If agricultural losses remain at a level of $5 billion per year as suggested by an AgriLife Extension study, all parties will face tough decisions. Agricultural producers and the credit lending industry both have safeguards in place, such as building a strong financial base over three to five years, that would provide the necessary resources to work through such challenges. Nevertheless, a continued drought, especially one over the next five years, would impose a harsh negative impact.

Farm lending was also impacted by the drought. Lenders typically require multi-peril crop insurance coverage on eligible crops in Texas. Although the level of protection afforded to farmers was significant in 2011, providing farmers the opportunity to retain their asset base and to farm another production cycle, the premiums paid by farmers were at all-time highs. This coverage enabled bankers to effectively manage risk, but it did not ensure profits to farmers. The 2012 price protections are estimated to be 30% less than in 2011, and production guarantees, which are based on 10-year production averages, will also decrease. Cotton infrastructure, however, remains in sound condition and is well-positioned for 2012, and the majority of grain infrastructure is reasonably well-positioned given the stockpiled working capital that can off-set the volatility in the grain industry.

Fortunately, many of the sales liquidating cattle were conducted at relatively high prices that reduced the risk to both the lender and borrower. Lender portfolios ultimately suffered negative earnings, but strengthened capitalization due to the lack of normal outlays. Although loan losses have not been significant thus far, the most significant industry effects may have yet to be felt. The substantial herd liquidations, which typically ranged from 20% − 60%, coupled with up to 20% less calving in 2012 in some areas, dictated a struggle for ranchers to maintain production in order to meet export demand and retain export markets.

In response to farmers' and ranchers' lending needs, the farm credit lending community remains financially secure to effectively manage the risks associated with serving the agriculture industry. If the drought extends beyond 2012, however, lenders will be required to evaluate their approach to bringing additional capital to rural communities. Most of the lenders in the state have recovered from the impacts of the 2008 recession and have the resources to meet the needs of rural communities, but an extended drought and/ or a double dip recession would create nearly insurmountable economic challenges.

Municipalities

The 2011 drought caused considerable damage to infrastructure across the state, especially within municipalities. Much of Texas is covered in clay-rich soils that swell when wet and shrink when soil moisture evaporates. In extreme weather conditions, this expansive character causes the soil to buckle, damaging foundations, roads, and water and sewer lines. For example, Williamson County had around 100 road and bridge employees working full-time to fix pavement cracks in the summer.[114] Dallas closed more than two dozen athletic fields due to cracks in the soil up to two feet deep.[115] Similarly, the drought adversely impacted water infrastructure. Austin repaired 103 leaking pipes in the last week of July alone. In July, Fort Worth reported more than 200 breaks in its water mains, including 20 discovered on a single day.[116] At the end of August, Houston had 1,033 active leaks in its water system.[117] All of these repairs required significant capital expenses.

Soil Moisture and Tree Mortality

The prolonged Drought of 2011 also seriously impacted soil moisture and caused tree mortality. Normally, trees are able to tolerate short-term drought because their root systems penetrate deeper into the soil. By the end of July of 2011, the 12 months of remarkably dry and hot weather across Central and East Texas caused even deep soil moisture to become seriously depleted.[118] Without deep soil moisture, Texas became vulnerable to an extended dry period, which caused widespread tree mortality. Tree mortality and all around dry conditions ultimately led to a very high fire danger in Texas.[119]

Wildfires

The long-lasting drought and high temperatures cumulatively amplified suitable conditions for wildfires across the state. The resulting breakout became the worst wildfire season in Texas history. The fires destroyed 7,809 homes and structures, but Texas firefighters, 90% of whom were from Volunteer Fire Departments, saved 36,763 homes and 12,555 other structures from destruction.[120] Although only 27,517 fires had taken place throughout the state by November of 2011,[121] a total of 31,557 fires had burned nearly 4 million acres of land and 3,947 homes by March of 2012.[122] Approximately 81% of those fires occurred within 2 miles of a community.[123] The total land destroyed amounts to an area larger than the combined areas of Delaware, Rhode Island, Washington, D.C., and half of Connecticut.[124] Moreover, the wide scope of the fires required firefighters to respond to an area of 640 miles wide and 660 miles tall throughout Texas.[125] During the 2011 fire season, 13,925 persons, 98 crews, 227 dozers, 954 engines, and 196 aircraft were mobilized through the Texas Interagency Coordination Center to fight fires across the United States,[126] many of which were located within the state. Ultimately in Texas, state parks, timber lands, agriculture, and related infrastructure were all affected by the wildfires.

Texas state parks were severely affected by the wildfires. The fires in the Davis Mountains, near Possum Kingdom Lake, and in Bastrop directly impacted three state parks, Davis Mountains State Park, Possum Kingdom State Park, and Bastrop State Park, consuming close to 8,300 acres of state park land.[127] All of these sites saw a stark decrease in revenue, totaling $100,429; $72,925; and $175,000, respectively, with Bastrop State Park incurring the worst damage.[128] In fact, 96% of the park burned.[129] Recovery estimates required to rebuild this park are estimated at $8.5 million dollars.[130]

The estimate for total loss of commercial timber (merchantable trees) to fire was $558 million, with an additional loss estimate of $111 million in tree seedlings and saplings.[131] In East Texas alone, the timber industry suffered over a $97 million hit when trees were destroyed.[132] The eastern region fell victim to 2,298 wildfires and lost 207,763 acres, or 175 million cubic feet of timber.[133] Ultimately, the land area in East Texas affected by these fires could have produced $1.6 billion in forest products, amounting to a $3.4 billion economic impact.[134]

The wildfires produced a double impact on agriculture. The summer rains of 2010 caused prolific grass growth which provided fuel for the unprecedented fire season, destroying over $150 million in agricultural value,[135] including property such as fences, agriculture related structures, hay, grass, livestock, and equipment.[136] The estimated 6,200 miles of fence lost has an average replacement cost of $10,000 a mile.[137]

Agency Oversight/ Statutory Regulation over Drought

Texas Water Development Board

<u>Monitoring Surface Water Levels</u>

During the Drought of 2011, the Texas Water Development Board (TWDB) worked with a number of other state agencies to monitor the effects of the drought, particularly on surface water storage. TWDB used information from river flows, reservoir levels, and aquifer levels to determine the status of several areas. Many river flows showed low flows associated with moderate to severe drought conditions, and a number of flows were at new lows.[138]

As of November 2011, the TWDB tracked conditions at 109 of the state's 175 major water supply reservoirs (reservoirs greater than 5,000 acre-feet).[139] These 109 reservoirs represent 96% of the state's total conservation storage capacity.[140] At the end of September, statewide conservation storage was at 60%, the lowest it had been since January 1978.[141] The TWDB also reported conservation storage for various regions of the state, tracked since April 1996. East Texas, High Plains, North Central Texas, South Central Texas, Trans Pecos Texas, and Upper Coast set new lows in 2011.[142] The only part of the state with above median conditions was the Southern Region, which included Lake Amistad, then at 87% capacity.[143] Also, Elephant Butte, a shared reservoir between Texas and New Mexico, was not included in the overall numbers but registered at 10% capacity.[144]

As of March 2012, the total storage in 109 of the state's major water supply reservoirs was at 24.19 million acre-feet, or 78% of their total conservation storage capacity.[145] This was 2.25 million acre-feet more than in February 2012 and 20% higher than the record lowest total storage of 58% set November 2011, yet still 0.44 million acre-feet below storage levels in March 2011.[146] Forty-six reservoirs located primarily in the north central and eastern regions of the state held 100% of conservation storage capacity. Ten reservoirs were at or below 10% full. Lakes E.V. Spence, O.C. Fisher, Twin Buttes, Hords Creek, and Meredith were effectively empty. Electra and J.B. Thomas were at 1% capacity. Palo Duro was at 5%, Red Bluff was at

8%, and Mackenzie was at 9% full.[147] Total combined storage increased to greater than 70% in the north central (94%), eastern (96%), and upper coast (100%) regions.[148] The regions with the lowest percentage storage were the High Plains (2%) and Trans-Pecos regions (8%). Also, by March of 2012, storage had declined in the last month in the High Plains and Low Rolling Plains regions and increased in the remaining seven regions.[149] Elephant Butte reservoir held 387,519 acre-feet, or 20% of storage capacity.[150] This was 22,700 acre-feet more than the previous month.[151]

Monitoring Aquifer Levels[152]

The TWDB also monitored aquifer levels throughout the state. Many of the state's aquifers were impacted more by pumping during the drought than a lack of recharge. Due to an increase in pumping during drought, especially in the agricultural sector, water levels often decline at a faster rate and to a deeper level. Recent water levels are rebounding in several of the wells due to the end of the irrigation season. Contrarily, the Edwards Aquifer, where pumping is regulated, was impacted more during the drought due to a decrease in recharge.

Texas Commission on Environmental Quality

Senior Priority Calls[153]

In managing surface water supply for the state, the actions of Texas Commission on Environmental Quality (TCEQ) are guided by the priority doctrine. Domestic and livestock users have superior rights to any permitted surface water right holders. Between permitted water right holders, those permit holders that received an authorization first (senior water rights) are entitled to receive their water before those water right holders that received an authorization later (junior water rights). If a senior water right holder does not receive the authorized water entitled to them, the TCEQ must take action to enforce the priority doctrine under a senior call.

In responding to senior calls during the Drought of 2011, TCEQ took steps that attempted to minimize impacts to junior water right holders. The TCEQ field staff enforced suspensions and curtailments through ground and aerial investigations. Field staff also conducted stream flow monitoring to help the agency make informed decisions regarding suspensions and management of senior calls. In some cases, field investigation revealed that suspensions and/ or curtailments would not produce additional water. In these futile calls, TCEQ weighed whether to take further action because water might not be available even if junior water rights were suspended.

Public Water Systems[154]

The TCEQ also closely monitored the status of public water systems (PWSs). Public water systems self-report and a PWSs' status may be updated through an online form or by contacting staff at the TCEQ. The TCEQ strongly encouraged all PWSs to provide regular status updates, allowing TCEQ to offer assistance to those experiencing critical conditions. Targeted outreach and assistance for PWSs included: sending letters to approximately 6,000 statewide to

PWSs, contacting PWSs to determine the condition of water systems, surveying PWSs' implementation of Drought Contingency Plans (DCPs), and encouraging DCP implementation. In addition, The TCEQ's Drought Information Webpage included guidance on emergency interconnections, emergency use of wells for public water supply, and a current list of companies that haul drinking water.

Moreover, the TCEQ intensively monitored a targeted list of PWSs that have either an unknown or fewer than 180 days of water supply. These entities were placed on a "Priority Watch List." The TCEQ offered these systems financial, managerial, and technical assistance that included: identifying alternative water sources, coordination of emergency drinking water planning, and identification of possible funding sources for alternative sources of water.

Texas Parks and Wildlife Department

The drought has not only dried up a significant amount of lakes and rivers, it is also to blame for drying up the activity at state parks. Due to the hot summer and low amounts of precipitation, state parks saw a 32% decline in August visitation when compared to the previous two years.[155] Overall in the FY 2011, state parks generated $1,230,813 less in revenue compared to the previous FY 2010.[156] Reduced inflows and high temperatures led to algae blooms that made some water contact unsafe.[157] Lower lake levels resulted in unusable boat ramps and swimming areas in many of the parks' lakes.[158] Finally, the factor most responsible for the decrease in visitors to state parks was the likely fact that many counties were in burn bans, leaving campers unable to have campfires or cook on open grills, activities that many visitors view as essential activities for camping.[159]

The drought also adversely affected many areas of wildlife across the state. Many federally listed fish species were re-located from drying rivers and streams to federal fish hatcheries.[160] For the most part, white-tailed deer populations remained good, although fawn survival in 2011 was much lower than in the past.[161] Hunters were encouraged to help reduce the deer population in order to ease pressure on the habitat for the following year.[162] Specifically, mule deer populations were stable, although antler production was poor.[163] Pronghorn populations were fairly good in the Panhandle, although this declined precipitously in the Trans-Pecos, primarily due to disease.[164] Fawn survival was down to 10% and the Texas Parks and Wildlife Department (TPWD) issued the lowest number of permits in the Trans-Pecos since 1953.[165] Desert Bighorn Sheep numbers were also down.[166] With the exception of the Gulf Coastal Prairies, there were big declines in quail, as well as lower turkey numbers due to lower reproduction rates.[167] The TPWD was also concerned about some rare and endangered species such as the Houston Toad. In these rare cases the TPWD worked with U.S. Fish and Wildlife Service, as well as other partners, to hold and propagate species in captivity to ensure that there was no catastrophic loss.[168] The ultimate goal was to use the captive bred animals to restock into suitable habitat when conditions allowed.[169]

Texas General Land Office[170]

The General Land Office (GLO) manages the real estate inventory of the Permanent

School Fund (PSF), created by the Texas Constitution in 1854 with a $2 million appropriation. With a present inventory of over 710,000 acres of surface land holdings, 4,000,000 acres of submerged land holdings, and 13,000,000 acres of mineral holdings, the GLO is one of the largest surface and mineral owners in the State of Texas. As such, the agency monitored drought conditions of 2011 and impacts on the PSF lands, particularly relating to how future investment strategies may be shaped. Ultimately, the cumulative impacts of the drought significantly altered the long-term management strategies and will have a decades-long impact to the 50-year timber management plans.

PSF land holdings are concentrated in West Texas, Central Texas, and East Texas, which are all facing harsh drought conditions. One area in West Texas that consists of 600,000 acres concentrated in the Trans-Pecos region generally thrives with very little rainfall. While the area receives an average annual rainfall of 7 – 8 inches, the absolute lack of rainfall has left landowners and lessees with few options to utilize the land. The GLO traditionally leased these properties for hunting and grazing, but the number of recorded cattle grazing on PSF property decreased significantly, or was completely eliminated, due to a severe lack of available surface water and dry stock tanks. Those lessees who continued grazing cattle were forced to lower existing well pumps to reach the lowered water table. Currently, the PSF has experienced minimal rental impacts from these events, but if similar drought conditions continue through 2012, the GLO anticipates noticeable impacts. The Trans-Pecos region also experienced significant wildfires during the 2011 drought. Hundreds of thousands of acres were consumed by the wildfires, and although portions of the PSF holdings were impacted, most areas largely avoided destruction.

In addition to the drought impacts of West Texas, the GLO closely monitors investment properties in Central Texas. The 9,700 acres, much of which is located between Austin and San Antonio, consist of large tracts with high potential for future development and were acquired for the purpose of future disposition for a return on investment. These properties were strategically acquired in areas where land would be critical to meet future commercial and residential population needs. The interim uses of these properties have been significantly limited by depleting surface water stock tanks, and the wildfires of 2011 will have a significant effect on the overall aesthetic value of nearly 1,000 acres of Hill Country property.

Finally, the Drought of 2011 impacted the PSF's timber properties in East Texas. Of the 5,500 acres of timber in East Texas managed by the GLO, an estimated 350 acres were lost to drought last year, and the 50-year timber management plan was compromised. Essentially all timber holdings were stressed over the past two years, so if drought conditions continued through 2012, the timber mortality rate was anticipated to be exponential. Moreover, the remaining timber was severely susceptible to disease and insects in its current distressed condition. Economically, the drought conditions have both reduced the market value of timber, as it must be sold at salvage prices rather than full harvest value, and the market inundation with salvage timber further results in significantly lower prices than normal. Many timber owners were determining that the cost to deliver the timber to market is not financially feasible, clearing the timber but leaving the logs at the site for eventual breakdown. Drought-fueled wildfires have additionally impacted 375 acres of timber land, and continuing drought conditions placed all timber holdings, especially the western-most located, at a greater risk of wildfire.

DISCUSSION AND CHALLENGES

Water Use and Demand[171]

Since the last multi-year drought of the 1950s, the population of the state has grown from about 7 million people to about 25 million people. This increase similarly creates a much greater demand in water for agriculture, industrial, and urban use. The TWDB is charged with planning for the state's future water needs based on population projections. The planning statutes require that a state water plan be created based on approved regional water plans from major regions of Texas. The regional planning groups and TWDB use a 50-year planning horizon and a 5-year planning cycle. The plan is strategically based off of the Drought of Record of the 1950s.

The last "State Water Plan" was developed and released in 2012. The TWDB involved many interest groups in the regional water planning process. These groups quantified current and projected future population and water demand; evaluated and quantified existing and future water supplies; identified surpluses and needs; evaluated and recommended water management strategies; made regulatory, administrative, and legislative policy recommendations; and adopted the plan, all while maintaining the required level of public participation. The groups that are typically represented during the regional water planning process included agriculture, industry, environment, public, municipalities, business, water districts, river authorities, water utilities, counties, power generation and groundwater management areas.

The greater need for additional water resources goes hand-in-hand with the projected population growth in Texas. The population in Texas is expected to increase 82% from 2010 to 2060, growing from 25.4 million to 46.3 million people. Despite this dramatic increase in population, water demand in Texas is projected to increase by only 22%, from about 18 million acre-feet per year in 2010 to about 22 million acre-feet per year in 2060. Existing water supplies, the amount of water that can be produced with current permits, contracts, and existing infrastructure during drought, are projected to decrease about 10%, from about 17 million acre-feet in 2010 to about 15.3 million acre-feet in 2060.

In times of drought, if Texas does not implement new water supply projects or management strategies, then homes, businesses, and agricultural enterprises throughout the state are projected to need 8.3 million acre-feet of additional water supply by 2060. Currently, irrigation accounts for the largest percentage of projected water supply needs under drought conditions at 3.1 million acre-feet, or 86% of the total in 2010, which is projected to increase to 3.8 million acre-feet by 2060. Municipal water use accounts for about 9% of total identified needs, or roughly 315,000 acre-feet in 2010, increasing to 41% or 3.4 million acre-feet by 2060. The regional planning process resulted in a recommendation of 562 unique water supply projects designed to meet needs for additional water supplies for Texas during drought. If implemented, this plan would add 9 million acre-feet per year of water supplies by 2060.

A Drought Worse Than the Drought of Record

Based on tree-ring studies dating back to 1648, some believe that it would be imprudent for the state to assume that the Drought of the 1950s represents the worst case scenario.[172] A study conducted by Malcolm K. Cleaveland, Professor of Geography at the Tree-Ring Laboratory at the University of Arkansas, found that a combination of years in the 1600s and 1700s includes three of the worst decadal droughts.[173] In the event of a drought worse than the Drought of Record, the Texas Water Code requires that all users of a water source must "share and share alike" the remainder of the supply.[174] When supply is depleted by 50%, or when half of the supply is remaining, mandatory curtailment of firm contract customers must be initiated.[175] As drought continues and becomes more severe, the level of curtailment must also increase so as to protect the remaining supply as long as possible.[176]

Agency Oversight/ Statutory Regulation over the Drought of 2011

Texas Commission on Environmental Quality

Senior Priority Calls

In times of extreme drought, water availability wanes and water rights permit holders come into conflict. By November 2011, the TCEQ received 14 senior calls, including calls on surface water in the Brazos, Guadalupe, Colorado, Sabine, and Neches River Basins.[177] By the close of severe drought conditions, however, the TCEQ suspended or curtailed more than a thousand junior water right permits in response to senior calls.[178] The TCEQ additionally stopped issuing temporary water right permits in basins affected by these calls.[179] This entire process was new for the TCEQ, as these drought conditions had not occurred during the agency's existence, and senior calls had only been handled previously in 2009. The TCEQ was able to work with stakeholders and other agencies to improve the drought response process.

One such call came by the Lower Neches Valley Authority (LNVA). By November 2011, LNVA experienced increased demand across all customer classes due to the persistent drought.[180] These demands were met after issuing a Moderate Water Shortage Condition in April 2011, elevated to a Severe Water Shortage Condition in September 2011.[181] Although LNVA did not have to invoke allocation of the water supply as provided for under its contracts and Drought Contingency Plan,[182] with the initiation of the Severe Water Shortage Condition, LNVA did have to place a senior call on its water rights in the Neches Basin.[183]

In order to protect general public water uses, however, the TCEQ did not curtail junior municipal water right holders or power generation uses,[184] so that municipalities could continue providing water to their residents and power generation companies could continue to operate. Some senior rights holders argued that a failure to enforce a senior call such as this undermines the reliability of the senior water rights and the prior appropriation system as a whole, but others believed that it was necessary to continue furnishing water to the general public and for public purposes.[185]

By April 2012, after significant rain, senior calls were rescinded and junior rights were reinstated.[186] Unfortunately, the state has seen a return to drier times, and senior calls in the Brazos River Basin began to resurface in November of 2012.

Public Water Systems

Public Water Systems (PWSs) provide potable water for the public's use and must comply with various state and federal regulations. There are approximately 6,000 PWSs in Texas. During times of drought, many PWSs imposed water use restrictions such as voluntary and mandatory watering schedules. In fact, during the 2011 drought, these types of restrictions were pervasively implemented in responding to mass water shortages. As of October 28, 2011, 956 PWSs asked customers to follow outdoor water use restrictions. Of these systems, 319 asked customers to follow a voluntary watering schedule, and 637 implemented mandatory watering schedules, with 55 prohibiting all outside watering.[187] This number only increased as the drought continued. As of March 16, 2012, 1,007 PWSs asked customers to follow outdoor water use restrictions. Of these systems, 367 asked customers to follow a voluntary watering schedule, and 640 implemented mandatory watering schedules, with 47 prohibiting all outside watering.[188]

Priority Watch List

As previously mentioned, the TCEQ compiles and manages a Priority Watch List, composed of all of the high priority water systems that have an unknown amount or less than 180 days of water supply.[189] For PWSs on this list, the TCEQ provided financial, technical, and managerial assistance, identifying alternative water sources, coordinating emergency drinking water planning, and identifying possible funding sources for alternative sources of water.[190] The TCEQ also worked with other state agencies, including the Texas Department of Emergency Management and the TWDB, to provide state-level emergency assistance to these water systems.[191]

Since December, the TCEQ has provided these services successfully in areas such as Robert Lee, Groesbeck, and Pendleton Harbor.[192] The City of Robert Lee was prioritized through the TCEQ's Intended Use Plan, enabling them to receive funding from the TWDB to construct an interconnect, which secured the city's water supply.[193] Further, the TCEQ worked with the City of Groesbeck to identify water sources and technical equipment.[194] The City of Groesbeck located an alternative water source and installed a pipeline and equipment, extending their water supply.[195] Finally, Pendleton Harbor, with TCEQ assistance, evaluated and identified solutions when their intake, located in an inlet, went dry.[196] Pendleton Harbor was able to reset the pump and supply water through a deeper intake structure.[197]

Rural Towns Running Out of Water

Many areas felt the effects of the drought, but none quite like the toll it took on rural communities. Because it was a difficult growing season, it left little income for cotton gins, grain elevators, farm input suppliers, and many other businesses. Some farmers even stopped farming and left town. In addition, municipal water needs in these areas were in serious shortage. There were 14 communities within 180 days of running out of water, including the town of Spicewood Beach, which has approximately 1,100 residents. Moreover, Robert Lee, Texas, almost completely ran out of water, and the city only obtained additional water from a pipeline that was constructed by a volunteer labor force and funded by the USDA and the TWDB.[198]

2011 Sunset Review of Texas Commission on Environmental Quality

As a result of TCEQ's Sunset Review, the Executive Director was provided with the authority to suspend or curtail water rights during times of drought or emergency shortage of water.[199] TCEQ proposed and adopted rules that define drought or other emergency shortage of water, as well as specify conditions and terms under which the Executive Director may exercise this authority.[200]

The Sunset Bill, House Bill 2694, also required the TCEQ's Executive Director to assess the need for watermaster programs at least once every five years in basins where programs do not currently exist.[201] At the September 28, 2011 agenda, the TCEQ approved the criteria, process, and schedule for watermaster program evaluation.[202] The Executive Director evaluated the Brazos, Brazos-Colorado Coastal, Colorado, and Colorado-Lavaca Coastal Basins in 2012.[203]

Texas Division of Emergency Management

Drought Council

The Texas Department of Emergency Management (TDEM) is a division of the Texas Department of Public Safety that manages the state emergency management program. It is intended to ensure that the state and its local governments respond to and recover from emergencies/ disasters, and implement plans/ programs to help prevent or lessen the impact of such emergencies and disasters.[204] Furthermore, the TDEM State Preparedness Drought Council (Drought Council) was authorized and established by the 76th Legislature in 1999 to manage and coordinate the drought response component of the State Water Plan, as well as to develop and implement a comprehensive state drought preparedness plan for mitigating the effects of drought in the state.[205]

Collaboration[206]

Once the Drought of 2011 hit in full force, TDEM met with the Federal Emergency Management Agency (FEMA) Region 6 Incident Management Assistance Team (IMAT) Planning Section and the Federal Coordinating Officer to discuss contingency planning. Representatives from TCEQ, TWDB, and Texas Department of Transportation were also present. FEMA assessed how it could provide available federal resources to assist during the drought. These particular drought conditions presented a novel situation for TDEM and the state. As a result of the unique drought conditions and the consequential contingency planning, the Drought Council learned that drought management touches many entities across the board.

Therefore, it is important to continue to expand input into the Drought Council by inviting more state agencies, federal agencies, water systems/ providers and members of the private sector. This process broadens the information flowing into and out of the Drought Council.

By anticipating drought declaration, the agency was able to identify state and federal regulations that could impact emergency response to be waived as a part of a declaration. Additionally, more categories were identified for local jurisdictions and state agencies to track drought cost. By working with FEMA Region 6, TDEM could find answers to questions that would be asked when requesting declaration.

In addition, the Homeland Security Infrastructure Threat and Risk Analysis Center (HITRAC) offered the assistance of Los Alamos Laboratory and Sandia National Laboratory to compile a report of the impacts of the drought on critical infrastructure. The results of HITRAC's analysis helped Texas to understand the vulnerability of the electric power generation and distribution systems to the drought, identify particularly vulnerable points in the system, identify scenarios that could cause catastrophic failure, model areas of potential low voltage, and propose alternate strategies to mitigate the impact of rolling blackouts.

TDEM also participated in Drought Outreach workshops sponsored by TCEQ. These workshops in West Texas educated citizens on state drought and wildfire response plans with subsequent facilitated discussions. It was critical that these programs and other Drought Council activities provided an increase in visibility by moving meetings around the state.

Strategies for Managing Future Droughts

Rising water demands and the grim prospect of extended drought require Texas water planners to consider innovative responses. The 2012 State Water Plan indicates that nearly 40% of the water supplies to be developed by 2060 will be the result of conservation and unconventional water sources.[207] One strategy includes rainwater harvesting, which typically involves funneling rainwater runoff from roofs or other surfaces into cisterns for storage. Some Texas municipal water systems already provide rebates toward the purchase of rain barrels for capturing runoff.[208] Such systems can lower residential water bills, as well as lower the demand for municipal water.

A second strategy includes exploring the option of aquifer storage and recovery (ASR), the storage of water in an aquifer for later use.[209] ASR allows providers to collect surface water and rainwater when it is abundant and store it underground until needed. The San Antonio Water System's ASR system is one of the nation's largest, delivering 40 million gallons a day at the peak of the 2011 drought.[210] TWDB proposes that ASR projects produce 81,000 acre-feet of water annually by 2060.[211]

A third option includes water reuse, chiefly the use of treated wastewater, otherwise known as reclaimed water. In West Texas, reclaimed water has been used in agricultural irrigation for many years. Other uses can include landscaping irrigation, industrial cooling, hydraulic fracturing in natural gas drilling, and with appropriate treatment, drinking water.[212]

The 2012 State Water Plan proposes a major expansion in reuse, from 100,600 acre-feet in 2010 to 915,600 acre-feet in 2060.[213]

A fourth option includes brackish water desalination, the conversion of brackish groundwater into drinking water. Texas has an estimated 2.7 billion acre-feet of brackish groundwater and 44 active groundwater desalination plants, including the world's largest inland facility, the Kay Bailey Hutchison Desalination Plant in El Paso, which produces almost 85 acre-feet of fresh water daily.[214] In all, Texas' groundwater desalination plants have a current capacity of about 70,560 acre-feet annually; the State Water Plan proposes expanding this total to 181,568 acre-feet by 2060.[215]

One final option is seawater desalination. It is roughly two to three times more expensive than brackish groundwater desalination.[216] Although Texas does not yet have a municipal seawater desalination plant, in May 2011 voters in Port Isabel's Laguna Madre Water District voted to build one on South Padre Island. The plant is expected to cost $13.2 million and will generate about 3 acre-feet of fresh water daily.[217] TWDB proposes a major expansion of the state's seawater desalination capacity, to 125,514 acre-feet annually by 2060.[218]

<u>Drought Contingency Plans</u>

Texas law requires certain water rights holders to prepare and submit a drought contingency plan (DCP) that includes quantifiable water use reduction targets.[219] The rules requiring the submittal of DCPs also require that affected parties submit an annual report regarding any implementation of the plan.[220] The TCEQ requires all wholesale public water suppliers, retail public water suppliers serving 3,300 connections or more, and irrigation districts to submit these plans.[221] DCPs are intended to plan for the effect that droughts have on the use, allocation, and conservation of water in the state.[222]

Although these plans are helpful in planning for drought emergencies, there remain some criticisms regarding implementation and practical effects. For one, the triggers chosen to implement different stages of a DCP, as well as the actions to be taken that are tied to those stages, could delay effective responses to drought long after a drought has reached a critical point.[223] This delayed response time may require taking an action that could potentially have been avoided with a more gradual implementation of water use reductions.[224] Essentially, it is argued that if action were taken earlier in the process, it is possible that the implementation of even voluntary measures would not be necessary until months into an exceptional drought.[225]

Furthermore, there is often a lack of consistency in drought management plans and implementation of those plans within the same geographic area, even when water suppliers are using the same water source.[226] This can cause confusion among citizens in that area about different water use reductions required by different water suppliers and raises issues of effectiveness and equity.[227] In some areas of the state, however, neighboring water systems are beginning to coordinate their drought response measures.[228]

Finally, revenue concerns by water suppliers may provide a disincentive for imposing water use reductions during a drought.[229] The failure to require water use reductions puts unnecessary strains on local or regional water supplies.[230]

The state puts a high priority on meeting current and future challenges by maximizing efficient use of existing water resources. This includes improving the ability of managing water demand during drought. Therefore, to address these concerns, some suggest it might be appropriate to encourage or require municipal water suppliers and other entities submitting DCPs to incorporate additional information in their plans or implement additional management strategies. For instance, entities could incorporate meteorological conditions or factors into the triggers for various stages of their DCPs, with water use reductions tied to those stages.[231] A state agency such as the TCEQ or TWDB could provide guidance on best practices for incorporating these factors.[232] A second example might be developing a coordinated approach to drought contingency planning and management in a congruent area, such as including consistent triggers and stages in the plans, as well as common media messaging and materials and sharing of information.[233] Finally, DCPs could establish water rate structures that add a drought period "surcharge" for water use by customers that would be graduated based on the volume of water used.[234] This would allow suppliers to maintain or stabilize revenues during times of drought, and would effectively reward efficient water users.[235]

These suggestions, however, would likely require a greater commitment of resources to the state agencies, namely TWDB and TCEQ.[236] For example, implementation of these actions would necessitate a more substantive review of DCPs required to be submitted to the state, and an enhanced review of those plans will require more state agency resources.[237]

A Case Study: Managing Limited Supplies in the Lower Colorado River Basin

Lower Colorado River Authority

The Lower Colorado River Authority (LCRA) was created by the Texas Legislature in 1934 to provide flood control, water supply, and electric generation, mainly along the Highland Lakes of the Colorado River.[238] It encompasses 35 counties in its water service area and 58 counties in its electric service area.[239] LCRA's transmission affiliate, LCRA Transmission Services Corporation, owns or operates more than 4,000 miles of transmission lines.[240] More than 70% of the authority's revenues come from electricity generation, 22% from transmission services, and about 3% from sale of raw water.[241] Currently, a very small percentage of revenue for LCRA also comes from operation of retail water/ wastewater services and parks fees.[242] The exceptional drought has been devastating to the LCRA service area, plaguing business and tourism in and around the Highland Lakes.[243]

Water Management Plan

In order to manage through a Drought of Record, LCRA heavily relies on its Water Management Plan (WMP). LCRA is required by a 1989 court settlement to produce a WMP.[244] This WMP is the only one of its kind in the state and must be approved by the TCEQ.[245] The

WMP governs LCRA's operation of the Highland Lakes to meet the needs of major water users throughout the Colorado River basin.[246] Specifically, the WMP prescribes how to allocate water during water supply shortages.[247] During severe drought, the plan directs the curtailment of Highland Lakes water for downstream agriculture so that water will be available for the basic needs of cities, businesses, and industries.[248] Under the plan, LCRA and its customers take actions at designated "trigger points" as water storage levels drop.[249] The plan also prescribes how LCRA must provide water from the lakes to help meet the environmental needs of the Lower Colorado River and Matagorda Bay at these various trigger points.[250] The state approved the first WMP in 1989, and updates have since been approved in 1992, 1999, and 2010.[251]

It is important to note that the WMP depends solely on reductions in water availability to agriculture to meet the demands of growing cities and industries. According to some concerned rice farmers, this spells disaster for irrigated agriculture. The average individual in this state uses just over 100 gallons of water per day for domestic uses, but more importantly, the food that this same person will eat in one day takes 600 gallons of water to produce.[252]

Water Management Plan Process

The TCEQ order approving LCRA's WMP revisions in January 2010 required that the revision process be "reasonably calculated … to achieve regional consensus, where possible."[253] Therefore, in July 2010, LCRA began a new stakeholder process to further update the WMP, by forming a 16-member Water Management Plan Advisory Committee, comprised of various interests including agriculture, environment, industry, cities, and lakeside residents/ businesses.[254] This water management planning involved the first consensus-based stakeholder process used in this context, which presented a new set of challenges, while also providing an opportunity to improve the process as a whole.[255] For more than a year, the committee held 16 stakeholder meetings, numerous workshops, and smaller technical meetings.[256] Some 40 – 50 stakeholders and staff attended each meeting, as did members of various state agencies.[257]

In December 2011, LCRA sought and received an emergency order from the TCEQ to restrict releases for rice and other farmers if Lake Buchanan and Lake Travis did not hold at least 850,000 acre-feet of stored water on March 1, 2012.[258] That was the amount agreed upon by the group of stakeholders representing lakeside residents/ businesses, cities, industry, environmentalists, and farmers.[259] Although February rainfall raised the combined storage significantly, it did not reach the agreed-upon 850,000 acre-feet.[260] Instead, the maximum level at the March 1 deadline was 847,324 acre-feet.[261] The Highland Lakes reservoirs were only 46% full as of March 2012, and for the first time in its 77-year history, LCRA withdrew delivering stored water to most downstream agriculture.[262]

LCRA released a draft WMP revision in January of 2012, which received a tremendous amount of public interest.[263] LCRA received more than 450 comments, and its Board heard from more than 40 stakeholders at the February Board meetings.[264] The WMP revision process is complex, and at times contentious, especially when occurring during the midst of the worst one-year drought on record.[265] The stakeholders, however, heard the perspectives of water users throughout the basin and learned about the technical complexity of a WMP.[266] Eventually, the advisory committee reached consensus or near consensus on every area where LCRA staff requested input.[267]

LCRA's Board of Directors approved the revised WMP on February 22, 2012, and filed it with TCEQ for consideration on March 12, 2012.[268] The resulting proposed revision would give LCRA, among other things, more flexibility in determining how much stored water is to be available for agriculture in wet periods and in drought.[269] Another key change would be to set two decision points for releasing water for agriculture instead of the one, on January 1, in the current plan.[270] Under the proposed plan, there would have to be at least 1.4 million acre-feet in the lakes on January 1 for downstream farmers to receive their full allotment of water for first crop, and at least 1.55 million acre-feet in the lakes on June 1 for farmers to receive their full allotment for a second crop.[271] Full allotment would not exceed 273,500 acre-feet a year from the Highland Lakes.[272] Also, minimum combined storage and irrigation cut-off triggers would be raised in order to protect the water supply for cities and industry in times of extreme drought.[273]

An additional proposed change is that LCRA would not request that its firm water customers implement any stages in their Drought Contingency Plans unless interruptible customers are actually being curtailed.[274] In 2011, LCRA requested its raw water customers to conserve 5% of their water use when the lakes' combined storage hit 1.4 million acre-feet.[275] On August 23, 2011, combined storage fell to 900,000 acre-feet, and LCRA asked its customers to implement mandatory drought response measures with a goal of reducing water use by 10% −20%.[276] If the combined storage in Lake Buchanan and Lake Travis drops to 600,000 acre-feet, the LCRA Board will declare a drought worse than the Drought of Record, and water from the Highland Lakes for farmers would immediately be cut off.[277] LCRA would also begin pro rata curtailment for its firm water customers.[278] Initially, that would require firm customers to reduce their use of water by 20%.[279]

The severe drought conditions of 2011 and into 2012 provided pressure on the LCRA Board to complete the WMP revision process quickly, which some argue may have led to an imperfect result.[280] Therefore, some stakeholder groups, such as the rice industry, are continuing to review the plan as well as the process.[281] The TCEQ declared the proposed WMP administratively complete on April 19, 2012 and has been conducting technical review since that time.[282] The technical review is ongoing and LCRA continues to work with TCEQ on finalizing the WMP.[283]

Stakeholders

<u>Rice Farmers</u>

In December of 2011, the TCEQ approved an emergency order allowing the LCRA Board to discontinue the provision of water to downstream rice farmers.[284] LCRA sought the advice of a group of stakeholders in September 2011, including several members of the rice industry, before making the decision of curtailment.[285] LCRA, however, ultimately determined that curtailment was necessary and cut off many rice farmers beginning March 1, 2012. This historic decision was unsettling to the farmers, but many expressed an understanding that agricultural water rights were subordinate to LCRA's firm water customers and could thus be interrupted during times of extreme drought.[286]

The economic impact of this curtailment does not go unnoticed. Articles have appeared in the Houston Chronicle, Dallas Morning News, Wall Street Journal, and NY Times, pointing out losses to the agriculture industry, as previously mentioned in the Background portion of this report on Drought.[287] The additional losses to the rice industry in the Lower Colorado River Basin alone were estimated by an agricultural economist with Texas A&M Corpus Christi, noting that rice production and related businesses contributed about $460 million a year to the local economy.[288] Moreover, the estimated impact on the state's ecotourism and hunting, which is a direct byproduct of rice farming, also sustained an economic blow.[289]

Lakeside Interests

The Highland Lakes primarily exist as working water supply reservoirs. They also, however, provide aesthetic and scenic value to the Central Texas area and its residents. Although some have promoted the idea of instituting constant lake levels, most recognize that this is not a practical way to address the various interests in light of the multi-faceted role these important water bodies play.[290] The Central Texas Water Coalition has advocated for an increase in overall water supply that will allow some reasonable operating range for lake levels. Such operating ranges would allow Lake Travis and Lake Buchanan to serve as water supply reservoirs while at the same time account for the critical role they play in the economy of the Upper Basin and Texas as a whole.[291] This is important to support not only the economic growth dependent on the lakes but also to maintain property values and tax revenues around the lakes.

In 2010, Llano County estimated waterfront property market values around Lake LBJ at $1.878 billion, Lake Buchanan at $162 million, and Inks Lake at $35 million. These three lakes alone hold a total waterfront value of $2.075 billion. The Lake Travis area boasts more than four times this amount at $8.4 billion in property value.[292] In addition to the obvious value of realty income that directly affects the Highland Lakes, the tax revenue collected in these areas provides a significant monetary contribution to other areas of Texas. The Lake Travis area provided state and local governments with $158.4 million in property tax revenue, $45.2 million in sales tax revenue, and $3.6 million in hotel/ mixed beverage tax revenue, totaling $207.2 million in tax revenue. Additionally, marina businesses on Lake Travis paid LCRA $580,656.27 in surface water permit fees in 2010.[293]

Developing New Water Supplies

During LCRA's WMP revision process, it was consistently discussed that stakeholders should be developing new water supplies instead of merely managing the current dwindling supplies.[294] This reflects the 2012 State Water Plan as it pertains to the water shortages throughout the various regions of the state.[295] LCRA is also taking steps to improve its water supply management and planning, including revising the WMP and pursuing other supplies.[296]

Although water development must occur in a separate process from the WMP process, LCRA General Manager Becky Motal announced that the LCRA Board resolved at its February 2012 meeting to find an additional 100,000 acre-feet of new firm water supplies by 2017.[297] Moreover, the Board has approved a Water Supply Resource Plan to serve as a roadmap for developing other water supplies to meet the demands of a growing region through the year 2100, in which LCRA staff is studying supply options such as off-channel storage, aquifer recharge and recovery, groundwater, and desalination.[298] Stakeholders appreciate LCRA's leadership in moving forward, but also understand the need to do so in a responsible manner that benefits the entire basin.[299]

RECOMMENDATIONS

State Water Plan Funding

Provide for the establishment of a dedicated fund and funding source for the implementation of the State Water Plan in order to offer meaningful funding alternatives and incentives to local entities.

Drought Planning

Continue to monitor the performance of state, regional, and local entities in addressing current and future drought conditions, as well as planning to meet the growing demand on existing water supplies and to find ways to exceed current water resource availability.

Continue identifying and assisting public water systems and rural water suppliers that appear on the Priority Watch List. Encourage these systems/ suppliers to become more involved in the regional planning process for future needs and more effectively manage water supplies to meet current needs.

Drought Management

Further evaluate drought contingency plans to consider including consistent statewide drought stages and other baseline standards.

Monitor water management plans with respect to certain river basins in the state. Work with the appropriate agencies to ensure that a variety of needs are met for the protection of all of the state's resources and best benefit for the state's economic development.

Strategies for Managing Future Droughts

Encourage local and regional entities to better develop and more strongly consider identifying short-term and long-term strategies in order to be more prepared for drought conditions. These strategies should include research and development of new innovative water technologies.

Define appropriate conservation measures for state water planning and funding. Clarify that conservation measures should be longstanding goals implemented not only during times of drought but also as daily best management practices.

PUBLIC HEARING

The House Committee on Natural Resources held a public hearing on its Interim Charge #2 related to the interplay of water and energy resources in the state on June 27, 2012 at 9:00 a.m. in Austin, Texas in the Capitol Extension, Room E1.030. The following individuals testified on the charge:

Michael Altavilla, Texas Westmoreland Coal Company
Harry Anthony, Uranium Energy Corporation
Phil Berry, North American Coal Corporation
Teddy Carter, Texas Independent Producers & Royalty Owners Association
Ricky Clifton, Gulf Coast Waste Disposal Authority
Jay Ewing, Devon Energy Corporation
Davis Ford, Self; Environmental Engineer
Nellie Frisbee, San Miguel Electric Coop
Buddy Garcia, Railroad Commission of Texas
Ronald Green, Wintergarden Groundwater Conservation District, Ed Walker, General Manager
Joey Hall, Pioneer Natural Resources
Brent Halldorson, Fountain Quail Water Management, LLC
Ben Hambleton, Superior Solutions International
Dan Hardin, Texas Water Development Board
Mark Homer, America's Natural Gas Alliance
Stephen Jester, ConocoPhillips
Steve King, Weatherford International
Ken Kramer, Lone Star Chapter, Sierra Club
Matt Mantell, Chesapeake Energy
Barbara Mayfield, Pinnergy, Ltd.
Luke Metzger, Environment Texas
Drew Nelson, Self; Clean Energy Project Manager, Environmental Defense Fund
Jean-Phillipe Nicot, Bureau of Economic Geology, The University of Texas at Austin
Michael Parker, Exxon Mobil Production Company/ XTO Energy
Mark Pelizza, Texas Mining and Reclamation Association, Uranium Resources, Inc.
Cory Pomeroy, Texas Oil & Gas Association
David Porter, Railroad Commission of Texas
Trey Powers, Texas Mining & Reclamation Association
Neil Richardson, Purestream
Lance Robertson, Marathon Oil Company
John Rogers, Union of Concerned Scientists
Robert Ryan, Stallion Oilfield Services, Inc.
Leslie Savage, Railroad Commission of Texas
Jerome Schubert, Texas A&M College of Engineering, Petroleum Engineering Department
Tom "Smitty" Smith, Public Citizen, Inc.

Barry Smitherman, Railroad Commission of Texas
L'Oreal Stepney, Texas Commission on Environmental Quality
Bill Stevens, Texas Alliance of Energy Producers
William Ward, GASFRAC, Inc.
John Warkentin, Superior Products International, Superior Solutions International
William Weathersby, Energy Water Solutions
David Weinburg, Texas League of Conservation Voters

The following section of this report on the interplay of water and energy resources is produced in large part from the oral and written testimony of the individuals listed above.

INTRODUCTION

The committee was charged with examining the interplay of water and energy resources of the state: Study the economic, environmental, and social impacts of water use in energy production and exploration, including the impacts of this use on regional and state water planning; determine the current and likely future of water needs of power generation and energy production and evaluate options to develop new or alternative supplies; and include an evaluation of current issues involving water use for oil and gas production and related water quality issues.

This charge has been separated into two parts: water usage in mining and oil/ gas production and water usage in electric generation. In both cases, the production and generation of energy is of significant importance to the State of Texas. Equally important is the management of water resources in these processes. Arguably, the two are inextricably linked together. This report outlines the background of process and provides vital analysis/ discussion of issues current to the supply of both water and energy.

PART I: ENERGY PRODUCTION

Through the decades, significant strides have been made to increase the exploration of our natural resources and improve efficiency in the production these resources. At the same time, the protection of water, our most precious resource, has been at the forefront of advancing the development of our natural resources. Obviously, with an increase in demand for energy, there is subsequently an increase in demand for water; thus, the interplay of water and energy for the state is born. Furthermore, from Spindletop to Santa Rita to the East Texas Field to the Barnett and Eagle Ford, oil and natural gas exploration and production has been synonymous with the state of business in Texas and prosperity in the United States. Today, Texas produces 20% of the crude oil produced in the United States and 31% of the natural gas.[300]

BACKGROUND

Overview of the Development of Texas Oil and Gas Production

Since the days of Texas' first great oil gusher at Spindletop in 1901, Texas has held a rich history of harvesting oil and gas and supporting that industry for over a century. Starting in 1866, the first producing well in Texas was drilled at Melrose, Nacogdoches County. Six years later, the first known gas production well was drilled by the Graham brothers near Graham, Texas.[301] In 1972, just before the Organization of the Petroleum Exporting Countries (OPEC) embargo, Texas crude oil production peaked at approximately 3.45 million barrels of oil per day (BOPD) for 365 days a year, producing at maximum capacity. This not so coincidentally prefaced the 1973 OPEC oil embargo and began a 37 year decline in Texas daily deliverability at an average of 2.5% per year.[302]

The very first hydraulic fracturing job took place in July of 1947[303] with limestone rock as the source rock, but it was an ineffective technique due to the lack of efficient technology at the time. In 1997 with the advent of newer, more effective technology, ground was broken in the Barnett Shale region which began the modern-day age of hydraulic fracturing. Today, there is an increase in production with up to 1.4 million BOPD, and production is projected to grow for years to come.[304]

In 2002 for the first time in decades, Texas crude oil production fell below the 1,000,000 BOPD mark to 978,000 BOPD, and production bottomed out in 2007 with 921,000 BOPD. With the drilling switch from gas to liquids in the Eagle Ford Shale and Permian Basin, production began increasing and reached 1,100,000 BOPD in 2011. Barring a major price slash or worldwide recession, that upward trend should continue for years to come.[305]

If 1973 and the OPEC embargo is a defining date for crude oil, then 1978 is a year to remember for its effect on Texas natural gas production. President Carter, convinced that supplies of natural gas were running low, supported the Natural Gas Policy Act of 1978, which created 32 different pricing categories. If the confusion over pricing were not enough, the Fuel Use Act of that same year began killing the market as it banned the building of natural gas fired boilers for electric generation. Indeed, it was a self-fulfilling prophecy, and Texas natural gas well production dropped from a peak in 1972 of 7.2 trillion cubic feet (tcf) per year to a low of 4.2 tcf per year by 1983. Eventually, these two acts of market interference were repealed. By then, it was too little too late, and it took the Texas industry another decade to begin to recover.[306]

From this point of recovery, the economic outlook of the industry has overall been positive but not without some notable exceptions. The upward trend from the 1995 baseline of 100.00 rose to the peak value of 285.4 in September – October 2008, a near tripling of the economic effect in a period for the industry of generally rising prices and stable regulation.[307] The notable exceptions to the upward trend and resultant troughs in the Petro Index Graph (Index)[308] were each accompanied by a price collapse, either in natural gas or crude oil or both. Particularly, Texans may remember in 1998 – 1999 when crude oil fell to $6 – $8 per barrel. The phenomenon of Barnett Shale was only beginning, and the huge increase in natural gas production and price had yet to occur. Ultimately, oil field workers marched up Congress Avenue in Austin, Texas, and the industry petitioned the legislature for severance tax relief in the Legislative Session of 1999.[309]

More recently in 2009, the falling price of natural gas threatened to erase the gains of the prior decade. The peak in September – October 2008 was followed by a precipitous decline triggered by the financial collapse and resulting decline in demand. The decline halted in December 2009 and improvement began again, but the Index had lost 35% of its value.[310] Today, after 27 months of increases in the Index since the 2009 recession, there has been a plateau with March, April, and May being virtually flat. Overall, natural gas has improved slightly from the frightfully low prices below $2 per thousand cubic feet to today's prices at $2.50. However, the price of crude oil which fueled the recovery has lost $28 a barrel or 26% of its value since April 2011.[311]

Clearly, the up and down trend in the price of crude oil creates a fluctuating market and ultimately plays into the overall Texas gross domestic product (gdp), as does upstream production reflected in the Texas mining industry. Fifteen percent or more of the Texas gdp is derived from the State's oil and gas production. [312] One hundred dollar a barrel crude oil has been driving this extraordinary activity, but further decline in crude oil prices could dampen, if not arrest, some of the growth. A sub-$65 barrel on the world trade index could have a chilling effect on the fever pitch of drilling $4 – 8 million wells.[313] Four dollar gasoline, although hurtful to pay, is great for the Texas economy.[314]

Overview of Texas Economy in Mining and Production

Coal and Lignite Mining

TMRA's lignite mining members play a vital role in the Texas economy. Lignite mining alone contributes $2.5 billion to the Texas economy and accounts for more than 50% of the local tax base for many of our state's rural communities. The Texas lignite mining industry alone spends in excess of $100 million each year on land reclamation and protection of water, air and other environmental resources.[315]

Moreover, Texas lignite mines are important to the economies of the counties in which they are located. According to an April 2004 study by the Perryman Group,[316] for every person directly employed by a lignite mine in Texas another four permanent, indirect jobs are created.[317] Lignite mining and electric generation from coal creates over 33,000 permanent jobs and has an overall economic impact of $10.5 billion.[318] San Miguel Mine employs 232 people with an annual payroll of over $17,800,000 for labor and benefits.[319] Not counting power plant jobs, periodic construction activities, or indirect consultant and contractor jobs, Sabine Mine has more than 260 full-time employees, with more than 126 of those employees serving for more than 10 years and 87 employees with additionally 20 years of service for the company. Sabine Mine has an annual payroll of over $22 million dollars and paid over $2.8 million in property taxes last year.[320]

Westmoreland is another mining company in Texas. It employs close to 1,400 people in seven states and is producing approximately 30 million tons of coal annually.[321] In Texas, the mine employs 450 people and has been in production since 1985. Approximately 90% of these people reside in the three counties where the mines are located in. Westmoreland Mine has an annual payroll of $27 million.[322]

Uranium Mining

In terms of the economic impact that the uranium mining industry has in Texas, the University of North Texas, Center for Economic Development and Research, completed a study in 2011 that found that the uranium mining operations provide more than 1,160 jobs in what are typically rural and economically distressed areas of Texas. The study also found that the industry has an annual payroll of over $127 million and paid over $23 million in state and local taxes.[323]

Oil and Gas Production

In addition to the Texas mining industry, the State of Texas has a considerable economic stake in the oil and gas industry from the generation of revenue through job creation, wages, and taxes. According to the most recent data, the oil and gas industry provides more than 345,000 high-quality, high-paying jobs in Texas.[324] The Marathon Company employs approximately 4,300 people in Texas, directly or indirectly, including 1,400 employees and 400 contractors in Houston, and 200 employees and 2,200 contactors in San Antonio.[325] In addition, Texas plays host to a variety of different multinational companies that choose to do their business in the state. Weatherford International Ltd. is a Swiss-based, multinational oilfield service and technology company and currently has more than 150 locations with more than 7,800 employees in the State of Texas; more than 1,000 of those employees are based in the Eagle Ford Shale area.[326] Another company, Stallion Oilfield Services, employs more than 2,000 people nationwide with offices stretching from the North Slope of Alaska to the Bakken Shale and Marcellus Shale, as well as historic oil producing grounds of Oklahoma, Louisiana, and Texas; more than 800 of those jobs are in Texas.[327] Over 1,700 full-time Chesapeake employees live in Texas and pay taxes every day helping the Texas economy.[328]

Overall, oil and gas jobs are some of the highest average wages in the state.[329] The average oil and gas worker earns $119,368 annually, and last year the industry's payroll was over $41 billion. Stallion Oilfield Services paid its Texas employees over $44 million in payroll in 2011 (not including $812,500 in unemployment tax).[330]

The oil and gas industry fuels not only the state economy jobs and wages, it also contributes $9.25 billion in state and local taxes, as well as royalties.[331] For example, Stallion averaged $1.3 million in franchise tax over the past three years, nearly $5 million in sales tax, approximately $1.25 million in use tax, and almost $2.4 million in property taxes to the State of Texas. [332] In 2010, Chesapeake paid $37 million in ad valorem and property taxes. Furthermore, industry revenues contribute hundreds of millions of dollars to the Permanent University Fund and Permanent School Fund, while being the near 100% basis for the Rainy Day Fund.[333]

Overview of Texas Mining

Coal and Lignite Mining

Coal and lignite mining accounts for about 36% of Texas power generation. In 2011, 45 million tons of Texas lignite was mined and turned into electricity, enough to power over 4.2 million homes.[334] For instance, Sabine Mining Company (Sabine Mine) operates the South Marshall and Rusk Mines which supply Texas lignite to the adjacent Pirkey Power Plant, which is owned and operated by AEP/ SWEPCO and encompasses over 66,000 acres under permit. Sabine delivered its first mined lignite to AEP/ SWEPCO in August of 1984, and since that time has reliably delivered over 98 million tons of Texas lignite, delivering reliable and affordable electricity to its over 520,000 customers for more than 28 years. [335] Additionally, the San Miguel Lignite Mine (San Miguel Mine) currently encompasses more than 20,000 acres and provides 3.2 million tons of lignite per year to the power plant. To date, more than 93.1 million tons of lignite have been delivered to the power plant and more than 8,000 acres have been mined and reclaimed.[336]

Another company, the Westmoreland Coal Company (Westmoreland) has provided the Limestone Electric Generation Station with 188 million tons of lignite over the last 27 years, and in turn NRG has been a provider of low cost, reliable electricity to the citizens of Texas. Founded in 1854, Westmoreland is the oldest, independent coal company in the United States and is one of the nation's top 10 coal producers.[337] Within the last 10 years, NRG also purchased subbituminous coal from the Powder River Basin in Wyoming to blend with Texas lignite. The particular blend of lignite-to-subbituminous coal is based on numerous factors determined by the power plants personnel and how their facilities are to be operated at any given time.[338]

Uranium Mining

Uranium mining has occurred in Texas for over 60 years and more than 80 million pounds of uranium have been produced in Texas. With the increased emphasis placed on nuclear power generation by countries with rapidly developing economies, such as China and India, and the search for clean energy by countries such as the United States, the price of uranium has increased over the last decade and increased mining activity has occurred in Texas. For example, the Texas Railroad Commission staff has stated that more uranium mining exploration permits were filed in 2011 than in any year since the beginning of the resurgence of the industry earlier in the century[339] Another boost for the uranium mining industry in Texas is that Cameco, the largest uranium mining company in the world, recently started a mining project in Kenedy County.[340]

Uranium is a fuel source for the nuclear power industry and uranium mining operations are located all over the world, including right here in Texas. There are currently five uranium mining companies in Texas that are members of the Texas Mining and Reclamation Association. The uranium region of Texas extends about 300 miles from East Central Texas through the Coastal Plains to South Texas and includes 11 counties.[341]

The uranium mining companies in Texas all use a mining technique called In-Situ Recovery (ISR) to mine uranium. ISR mining has been used in Texas since the 1970s and is an advanced mining technique that is now used all over the world. ISR is sometimes referred to as solution mining. Regardless of the name, it is the process of recovering uranium from a water-saturated, underground ore body in a manner which leaves overlying rock strata and the land surface intact. A typical in-situ mining project would consume approximately 30 acre-feet of water per year based on a mining rate of 1,500 gallons per minute operating capacity.[342] Companies in Texas were some of the first companies in the world to use this advanced mining technique.[343]

The drilling procedure involves the installation of a series of wells through which a chemical solution (oxygen and bicarbonate), also known as lixiviant, is injected into the uranium-bearing formation. This solution passes through the formation and is pumped back to the surface through a recovery well. The uranium-bearing solution is piped to a surface plant, where a series of conventional chemical processes extract uranium from the solution and dry it into “yellow cake.” This is the final product. This yellow cake is then shipped to conversion facilities for sale to nuclear power plants.[344]

Overview of Hydraulic Fracturing in Oil and Gas Production

Chesapeake is the largest leaseholder owner in Texas with approximately 3.2 million acres, currently operating 52 rigs in Texas as of June 2012. It owns over 4,500 producing wells with an average daily production in Texas of 75,000 bbl in oil and 1.7 million cubic feet in gas.[345]

Hydraulic fracturing is a proven exploration technology used for more than 60 years to safely enhance the production of oil and natural gas. With advances in drilling and exploration technology, like fracturing, operators can produce oil and natural gas from formations that were once thought to be unrecoverable. Hydraulic fracturing occurs at great depths, generally a mile or more underground and thousands of feet below freshwater supplies. With the safety system of steel casing and cement in place, operators drill vertically thousands of feet down then drill horizontally into targeted rock formations.[346]

Horizontal drilling combined with fracturing technology has greatly enhanced the opportunity to commercially produce hydrocarbons from unconventional reservoirs, such as shales. This technology was first developed in the Barnett Shale field in North Texas.[347] The primary application of hydraulic fracturing is where the natural or non-stimulated production is not at sufficient levels to be economically feasible.[348] In most cases, thousands of feet of impervious rock separate the aquifer from the oil and gas reservoir. Typical water aquifers occur within 1,000 feet of the surface and most fracturing operations occur at much greater depths.[349] The process can be summarized as injecting fluids, primarily water, into the oil or gas reservoir to create fractures and/ or open natural fractures. The created fractures are propped open to create a highly conductive path, which increases production. With the safety system of steel casing and cement in place, operators drill vertically thousands of feet down then drill horizontally into targeted rock formations. Then a mixture of pressurized water, sand, and specifically formulated fracturing compound is pumped thousands of feet down into the formation to create tiny, millimeter-thick, fissures in carefully targeted sections of the host rock. Operations typically use a fracturing compound that is more than 99% water and sand, and less than a half percent of additives. The tiny fractures free the trapped oil or natural gas allowing the operator to determine if there is adequate reserve for economic recovery, and if so, the production process begins.[350] Following the fracture stimulation of a well, production is initiated from the well to recover the water used during the stimulation. This initial stage of production is known as the “flowback process.” The water produced during the flowback process is typically much lower in total dissolved solids (TDS) than the water produced during later stages of production.[351]

Hydraulic fracturing technology is applied to many areas around the State of Texas. There are a couple of primary plays that many companies choose to drill because of the quality and quantity of oil and gas; notably, the Barnett Shale and the Eagle Ford Shale are top areas of production. For instance, XTO Energy has their primary areas of operation in the Haynesville Shale, Barnett Shale, and Freestone Tight Gas plays.[352]

Overview of Water Use and Demand in Mining and Production

Coal and Lignite Mining

Some lignite mining companies operate mines that cross into multiple Regional Water Planning Areas. For example, the San Miguel Electric Cooperative owns the San Miguel Mine located on the border of the Region L and Region N.[353] According to the Texas Water Development Board's Water for Texas 2012 State Water Plan, demand for all types of mining accounted for 29,674 acre-feet per year. This is compared to water demands for irrigation and livestock at 439,702 acre-feet and manufacturing, which requires 183,130 acre-feet.[354] Additionally, the plan projects a decline in the total demand for water in traditional mining operations.[355]

For surface water, the impact area encompasses the watersheds to be disturbed. All downstream users and water rights permits are identified. Water quality and quantity are documented upstream and downstream of the proposed mine area for 12 months prior to any disturbance in order to identify any seasonal variations. Historic rainfall, rainfall/ run-off relationships, and evaporation rates are determined. Impact predictions must include chemical changes that can occur in surface water due to contact with disturbed land and changes in the nature of stream flow due to temporary and permanent impoundments. Surface mining regulations further require that a cumulative hydrologic impact assessment of proposed mine areas be included in the permit application that is submitted to the Texas Railroad Commission. The development of the impact assessment involves defining an impact area for surface water and groundwater, collecting baseline data, then modeling the impact to the hydrologic system due to the anticipated mining and reclamation activities.[356]

In the mining process, every drop of water that falls within a permitted mining area must be captured in retention and settling ponds prior to being released into waters of the state. The quality of that water is monitored and reported to the Texas Commission on Environmental Quality and, as required by Texas Pollution Discharge Elimination System permits, is released as equal to or better in quality than the stream into which it flows.[357]

Some mines also dewater or depressurize aquifer water underlying the mining area. This ensures the mine pit is safe and workable.[358] Groundwater is the second water source that coal mining operations encounter and account for in the process. Groundwater is based on the geologic strata, types of water-bearing sands, and depths of the principal aquifers within the immediate mining area. The quality and quantity of this resource varies for every coal mining operation. As is the case at the Jewett Mines, groundwater within individual reserve areas can be quite different and impact the operations significantly.[359]

The purpose of dewatering/ depressurization is to provide a safe and stable work environment for employees and mining equipment that operate in the "active pit" areas of the mine. By dewatering the overburden, material directly above the coal seam, it is possible to maintain a safe highwall and spoil configurations with the proper safety factors. This prevents stability failures of either material, which could potentially injure employees and/ or damage mining equipment. In the case of depressurization, it is decreasing the forces under the lowest coal seam to prevent the pit floor from heaving upwards and again minimizing the chance of injury or equipment damage.[360]

Groundwater resources are also documented. Guidelines to the regulations require a description of the geology, geometry, and general hydrology of the principal aquifers within the impact area. This description includes whether the aquifer is confined or unconfined, as well as the nature of the water-bearing sands. Data collected includes geophysical logs, cores, aquifer tests, and an inventory of water wells within the impact area. For 12 months prior to any disturbance, a network of monitoring wells is sampled and water levels are taken to determine the quality and quantity of water and any seasonal fluctuations in the aquifers in the impact area. The model predictions, as well as all of the baseline data, are included in the permit application.[361]

The permit application includes a groundwater control plan. Shallow groundwater overlying the lignite must be removed prior to mining in order to stabilize the pit walls and prevent saturated spoil material from sliding into the pit; this would endanger people and equipment. Aquifers below the lignite seam can contain enough pressure or “head” to result in seepage or to even “heave” or buckle the floor of an open pit, causing serious safety concerns. These underlying aquifers must be depressurized prior to mining. In 2011, the San Miguel Mine pumped 274 acre-feet from a shallow aquifer in order to stabilize the pit. The groundwater in this shallow aquifer is unsuitable for agriculture, livestock, or drinking water due to TDS concentrations that are greater than 10,000 mg/L. High TDS concentrations in shallow groundwater is a natural condition in this area due to the saline sediments. This groundwater is treated in a sedimentation pond to reduce the TDS concentrations and is injected in a deeper aquifer of similar water quality which is regulated by the Texas Commission on Environmental Quality.[362]

The permit application also includes a surface water protection plan. This plan details how surface runoff will be diverted around mining operations in order to protect the water resources and the open pits. The plan details how surface run-off from disturbed areas will be captured in sedimentation ponds and checked for quality prior to release.[363] The permit details the amount of groundwater that must be removed to depressurize under burden aquifers and to reach safety target levels. Groundwater from dewatering and depressurization is pumped to sedimentation ponds, the quality is checked and the water is released as surface water or treated for injection back into deeper aquifers. The sedimentation ponds also provide a source of water for dust suppression.[364]

Uranium Mining

When looking at the water use associated with uranium mining operations in Texas, the typical mining operation consumes about 250 acre-feet of groundwater per year. To put that in perspective, this is less than the water demands of a one-fourth section, or 160 acres, field of cotton. In addition, uranium mining operations in Texas recirculate the groundwater that they use into the aquifer.[365]

Oil and Gas Production

A survey in the 1990s estimated water use in the oil and gas industry at approximately 30 thousand acre-feet.[366] Under Chapter 36 of the Texas Water Code, if an oil and gas water supply well is located in a groundwater conservation district, the water well must register, comply with the rules of the district, and report usage if required by district rule. Under Section 36.117, there is an exception to permitting for water wells used to supply water for drilling or exploration operations.[367]

With the increased popularity of hydraulic fracturing operations, companies such as XTO Energy anticipate a rise in the consumption of water for shale and tight gas development. The use of water in oil and gas operations can occur in advanced recovery or reservoir management with things like water plugs, pressure maintenance, and fluid management within reservoirs. Oil and gas production operations also use water as their base fluid in drilling. Other water usage within upstream operations is at far lower levels, including significant usage in equipment cooling and process cooling, steam generation for oil and gas processing systems, and facility maintenance.[368]

Hydraulic Fracturing in Oil and Gas Production

Quantity

Chesapeake Energy estimates that it takes 4 million gallons of water to hydraulically fracture a single gas well.[369] In 2008, Jean P. Nicot of the University of Texas estimated that the industry used about 36 thousand acre-feet of water, nearly all over the state. In 2011, the numbers have gone up to 82 thousand acre-feet. Those numbers represent water taken from aquifers and surface water bodies, as there is currently little recycling in the state.[370]

As industries have further developed the Barnett Shale, technology has enabled the industry to drill longer laterals ultimately reducing the total number of wells drilled. For instance, in just two years Devon’s average lateral lengths have increased 26% from 3,390 feet to 4,300 feet. Early horizontals were approximately 2,000 feet.[371] Water use for the hydraulic fracturing of shale gas wells was dominated by the Barnett Shale in 2008 at approximately 25,500 acre-feet, whereas all tight formations across the state totaled approximately 10,400 acre-feet.[372] The Barnett Shale requires fracture stimulation to be productive. Fracture stimulation involves the use of 4 – 6 million gallons of water dependent on the length of horizontal lateral.[373] Sources of water for fracture stimulation in the Barnett Shale can include the following: groundwater, surface water (rivers and streams, lakes, local impoundments, waste water effluent), municipalities, brackish water sources (limitations on surface storage and fluid transportation where TDS content exceeds 3,000 parts per million), and recycled water.[374]

Alternatively, in the Eagle Ford Shale there are over 4,000 wells drilled with the water demand being around 85,000 – 100,000 bbls.[375] The projected oil and gas industry water demand in Eagle Ford Shale is approximately 5.5 – 6.7% of the total water demand.[376] Currently, Chesapeake Energy in the Eagle Ford Shale, drilled, completed, and is now producing from 177 wells.[377] Their total water use is an estimated 877 million gallons with the average use around 4.95 million gallons per well.[378]

Quality

Before drilling a water source must be selected. Once an optimal volume of water is established, the type of treatment and target water quality will be reviewed to determine if non-potable, recycled, or non-aquifer water sources can be used. One such example is the Fort Worth Basin. Domestic and municipal wells are supplied by The Upper Trinity Aquifer while operators can access the non-potable Lower Trinity Aquifer for Barnett Shale applications.[379]

In the planning phase prior to drilling, every effort must be made for the protection of groundwater during oil and gas production. The primary means of protecting from contamination during the fracturing process is proper isolation of the potable water aquifers. This is accomplished with proper drilling, casing, and cementing techniques which are engineered and state regulated to meet local requirements.[380]

During the drilling phase, drilling additives are used to minimize drilling fluid loss as formations are penetrated. During the fracturing process, injection pressures are monitored during the treatment and any breach of the treating string would result in immediately stopping the process. In addition, pressure relief valves and monitoring of subsequent strings ensures structural integrity and aquifer isolation is maintained. Treating string breaches can then be isolated and repaired.[381]

Furthermore, protection from spills during and after the drilling phase is another important component in the quality protection of water resources in oil and gas production. The industry strives to follow state and federal regulations for the safe storage, transport, and use of chemicals necessary for the process. In this sense, the industry is like any other industry that transports and uses chemicals. Spill containments, absorbent materials, proper disposal, reporting, and remediation are all important in minimizing and eliminating contamination from surface spills when they do occur.[382]

Lastly, there are over 120,000 abandoned wells in Texas. Some wells are old and were constructed with material now considered inferior. Although the Texas Railroad Commission maintains an inventory of oil and gas wells in the state, many older wells have no documentation and their mere existence is not known. Most abandoned wells that were drilled for oil and gas production are located in "oil and gas" zones which are some of the same zones now used for liquid waste injection.[383]

Agency Oversight/ Statutory Regulation over Mining and Production

Texas Railroad Commission

The task of regulation in regards to mining and oil and gas production falls under the purview of several agencies, primarily the Texas Railroad Commission (RRC) and the Texas Commission for Environmental Quality. Article 2 of House Bill 2694, passed by the 82nd Texas

Legislature and signed into law by the Governor, transferred from the Texas Commission for Environmental Quality to the RRC duties relating to the protection of groundwater resources from oil and gas associated activities. Specifically, the law transfers from the Texas Commission for Environmental Quality to the RRC those duties pertaining to the responsibility of preparing groundwater protection advisory/ recommendation letters. After the transfer, the RRC is responsible for providing surface casing and/ or groundwater protection recommendations for oil and gas activities under the jurisdiction of the RRC.[384]

Well Construction and Disposal Wells

Prior to drilling, regulations require multiple layers of steel casing and cement between a well-bore and water supply, with casing running as deep as 10,000 feet below the surface. These casings and cement jobs all must meet certain pressure thresholds and safety tests, as well as pass stipulations with the RRC to ensure accurate and appropriate protectiveness.[385]

In order to operate a disposal well in Texas, an operator must get a permit from the RRC, as well as maintain a status as a registered operator and maintain a $25,000 financial assurance. The conditions of the permit are very strict and designed to ensure that the proposed well will not operate in a manner that could jeopardize useable quality water or an underground source of drinking water.[386] Disposal wells are oil and gas wells in reverse. They are constructed in the same way and by the same drillers as oil and gas wells, and contain three layers of protections and the same casing and cementing requirements as oil and gas wells.[387]

Disclosure of the Composition of Hydraulic Fracturing Fluids

In the 82nd Legislative Session, the Texas Legislature enacted House Bill 3328 (H.B. 3328).[388] H.B. 3328 amended Chapter 91 of the Texas Natural Resources Code to add a new Subchapter S, Section 91.851, Disclosure of Composition of Hydraulic Fracturing Fluids. H.B. 3328 required the RRC to adopt regulations relating to the disclosure of the chemical ingredients of hydraulic fracturing fluids used on oil and gas wells in the state by July 1, 2013.[389] Texas is the first state to require oil and gas operators to disclose the chemicals used in hydraulic fracturing fluid on a well-by-well basis.[390]

In response to H.B. 3328, the RRC enacted new Rule 29, Hydraulic Fracturing Chemical Disclosure Requirements. In accordance with H.B. 3328, Rule 29 provides for the protection of trade secret information. It also provides for any challenges to a claim of trade secret protection to the landowner on whose property the relevant wellhead is located, the landowner who owns property adjacent to that property, or a Texas department or agency with jurisdiction over a matter to which the claimed trade secret information is relevant and includes the procedure for such a challenge. The rule does not require the owner of trade secret information to disclose that information, unless the Office of the Attorney General or an appropriate court determines that the information is not entitled to trade secret protection under Texas Government Code, Chapter 551.

In addition to requiring operators to disclose chemicals used in hydraulic fracturing treatments, Rule 29 requires operators to indicate the amount of water used in each treatment.

Therefore, future estimates of water use in hydraulic fracturing will be more definitive.[391] The RRC made the rule requirements effective for a hydraulic fracturing treatment performed on a well in the State of Texas for which the RRC has issued an initial drilling permit on or after February 1, 2012, in order to allow sufficient time for all operators and their authorized agents to register with the appropriate website.[392] Under the RRC's hydraulic fracturing disclosure rule, operators are required to disclose chemicals and total water usage on the FracFocus Chemical Disclosure Registry website.[393] In addition, operators are required to report water volumes used to hydraulically fracture wells in Texas.[394] FracFocus was created to provide the public access to reported chemicals used for hydraulic fracturing within their area and to help users put this information into perspective. The registry is managed by the Groundwater Protection Council and the Interstate Oil and Gas Compact Commission (IOGCC).[395] The Groundwater Protection Council and the IOGCC are the entities representing state regulators who are charged with protecting local water and overseeing our operations. The web-based registry stores and publishes information concerning chemicals used in the hydraulic fracturing process on a per-well basis. The rules, requiring full disclosure of the chemicals used in hydraulic fracturing, went into effect in February 2012. The three members of the RRC unanimously approved the new rules requiring the disclosure of the chemicals on the public website.[396]

Texas Commission on Environmental Quality

The Texas Commission on Environmental Quality (TCEQ) is authorized to establish the level of water quality to be maintained and to control sources of pollutants that may affect the quality of surface water and groundwater in the state.[397] Surface waters, reclaimed water (e.g. wastewater or direct reuse), and groundwater may be used in oil and gas production and related activities. The TCEQ is the state agency with the authority to manage surface water and authorize the use of reclaimed water.[398] However, the TCEQ does not issue or regulate the use of groundwater. Under Chapter 36, groundwater management is locally controlled by groundwater conservation districts.

The TCEQ is also the agency with the primary regulatory authority for air emissions in the state, including those from oil and gas facilities. The TCEQ strives to base their rules and permits on sound science and common sense. The TCEQ has developed new rules and updates to existing rules.[399] The use of surface water for municipal, industrial, and agricultural uses requires an authorization from the TCEQ. Under Chapter 11 of the Water Code, the TCEQ issues water use permits for a variety of uses, including oil and gas production (categorized as a "mining" use). The TCEQ issues perpetual, term, and temporary water use permits. Perpetual permits do not expire, term permits are issued for a term of up to 10 years, and temporary permits expire after a term of no longer than three years.[400]

The TCEQ Clean Rivers and Surface Water Quality Monitoring Programs routinely monitor the quality of rivers, lakes, bays, and the Gulf of Mexico to determine if established state water quality standards are being met. The Texas Clean Rivers Program is a partnership between the TCEQ and 15 regional water authorities to perform strategic and comprehensive surface water quality monitoring, evaluation of water quality conditions, and local stakeholder involvement.[401]

For some time the TCEQ has authorized the direct reuse of wastewater, although the interest in direct reuse has increased significantly as a result of the drought and with the development of additional gas production in the state. Primarily, authorizations for the reuse wastewater are issued under Texas Administrative Code Section 210. Authorizations may also be obtained under a Texas Pollutant Discharge Elimination System Permit, or a Texas Land Application Permit. In 2011, the TCEQ issued 32 domestic/ municipal reclaimed water authorizations and 15 industrial reclaimed water authorizations.[402]

Ultimately, the TCEQ has an exemplary record regulating the oil and gas exploration and production in this state and to date there has not been a single known incidence of groundwater contamination as a result of properly administered hydraulic fracturing activities in Texas.[403]

Groundwater Management and Regulation

Under Chapter 36 of the Texas Water Code, if an oil and gas water supply well is located in a groundwater conservation district, the water well must be registered, must comply with the rules of the district and usage must be reported if required by district rule. Under Section 36.117, there is an exception to permitting for water wells used to supply water for drilling or exploration operations but the well must be registered and comply with district rules and reporting requirements.[404]

There are a lot of engineering, geology, regulatory, construction, and operations standards to which these wells are subject.[405] First, there is the "Water Board Letter." Previously provided by TCEQ, but now provided by the RRC, the letter is a determination that groundwater is adequately separated from the injection zone by impervious rock formations, and it establishes where surface casings must be set, usually 20 – 50 feet below base of usable quality water. The applicant must demonstrate that abandoned wells within a one-fourth mile radius and penetrating the injection zone are plugged, as well as it must provide an electrical log to prove the zone. The RRC requires at least 250 feet of impervious rock or strata between the injection zone and the base of useable quality water in order to receive a permit. Finally, there must also be notice published in a paper of general circulation in the county to any "affected person" or any person who has suffered or will suffer actual injury or economic damage and who may protest the permit application. If the permit application is protected, the RRC will conduct a hearing with evidence and expert testimony.

DISCUSSION AND CHALLENGES

As outlined in the Background portion of this report, energy production through oil and gas, as well as mining, is extremely important in the State of Texas. The state, and its many entities, is committed to safely developing these resources in a progressive manner to benefit the growing population and its growing demands. Balancing all interests in the management of the state's natural resources does not come without challenges, especially in water and times of drought.

Challenges of Texas Mining

Oil and gas wells produce more than just oil and gas. They also produce saltwater, which must be disposed of or else the producing well must be shut-in. The only component routinely requiring treatment in surface water is suspended soil particles related to the mining disturbance. At the Sabine Mine, these are easily removed with a benign flocculent, and the water released from the mine is consistently the cleanest water to enter this particular stretch of the Sabine River. In fact, due to the large geographic scope of mining operations, the water management and water quality protection effectively cover many non-mining related activities that are conducted within the boundaries of many mine permits, such as farming, ranching, timber production, and oil and gas development.[406]

Environmental Stewardship in Mining[407]

Another criticism of the mining industry is that the process disturbs the surface of the land. It can create large "craters" and "holes" in the earth. Movement of the dirt during the process can also disturb natural habitats and landscapes, leaving the mined areas "stripped."

In order to better address these concerns, environmental stewardship and water management have moved to the top of the mining industry's priorities. The Texas lignite mining industry alone spends in excess of $100 million each year on land reclamation and protection of water, air, and other environmental resources. Companies like North American Coal Corporation's Sabine Mine take pride in their environmental stewardship and water management. Like their fellow Texas lignite mining companies, a significant amount of time and resources are spent ensuring that the land is left in as good as or better shape than when the projects began. At Sabine Mine alone, more than $10 million a year are spent on environmental protection and reclamation. Sabine Mine has also been the recipient of numerous reclamation awards throughout the years, most recently the Texas Parks and Wildlife Lone Star Land Steward Award in 2011 for the development of high quality quail habitat in reclamation.

Further, water management is crucial to environmental stewardship efforts in the mining process. "Water resources are developed, not wasted, in the operations as all groundwater withdrawals and surface water collections are either used for environmental and safety uses (e.g., dust and fire suppression) or directly contribute to in-stream flows in the Sabine River Basin." Sabine Mine produces less than 1.5 million gallons of groundwater annually that is primarily used for office and shop facilities. All surface water flowing from disturbed areas of the mine is required to pass through sedimentation ponds to ensure water quality prior to discharge. While this water may be held for several days prior to discharge, it is then passed downstream and available for other users.

Water Use and Reuse in Uranium Mining

Part of the permitting process for uranium mining operations requires companies to apply for an aquifer exemption under the Safe Water Drinking Act for the area in which they will mine.[408] Because of the state and federal regulations that the industry must comply with, uranium mining operations in Texas are only allowed to use non-potable water.

Uranium Energy Corporation utilizes only water that is recycled and used over and over again in the process. The reuse process and final restoration makes in-situ recovery highly conservative of water resources. In return, this process results in a tremendous amount of clean electrical energy. It is important to note that because the groundwater in a uranium ore body contains uranium and radium-226 in excess of the drinking water standards, the use of this water for energy development makes sense.[409]

Groundwater Quality and Uranium Mining

In mining, much attention is focused around protecting groundwater resources. Specifically with regards to uranium mining, there is significant concern that disturbing uranium ore deposits contaminates groundwater resources. Some believe that the groundwater, even in an area with uranium deposits, is pure in form and meets drinking water standards. They argue that it is not until the disruption of the uranium deposits through the exploration process that the groundwater is contaminated.

On the other hand, there is evidence to suggest that the groundwater as it exists in its natural state is already saturated with many minerals, including uranium and radium-226. In its natural state, the water in a uranium mining zone already does not meet minimum federal water quality standards and should not be used for agriculture, domestic consumption, municipal, or industrial purposes.[410] In fact, “the industry has not contaminated an underground source of drinking water in the 40 years of operating in Texas.”[411] Generally, uranium operators establish baseline groundwater quality conditions for the ore-bearing aquifer. Once mining has concluded, the groundwater is processed using reverse osmosis technology, the same technology that turns seawater into drinking water. The water is then reintroduced back into the mined area until the water quality being pumped is consistent with baseline quality. Ultimately, the groundwater is restored to baseline quality, and the surface is returned for unrestricted use back to the surface owner.[412]

Challenges of Hydraulic Fracturing

Environmental Protection and Impact in Hydraulic Fracturing

<u>Protection During Drilling</u>

Typical water aquifers occur within 1,000 feet of the surface and most hydraulic fracturing operations occur at much greater depths. In most cases, thousands of feet of impervious rock separate the aquifer from the oil and gas reservoir.[413] Protection of groundwater can be divided into categories. The first and most obvious protection category is not contaminating the potable aquifer(s). This occurs through proper isolation of the potable water sources. It is accomplished with proper drilling, casing, and cementing techniques which are engineered and state regulated to meet local requirements. In the drilling phase, drilling additives are used to minimize drilling fluid loss as formations are penetrated.[414] Further, natural gas released by hydraulic fracturing at thousands of feet below drinking water sources has not ever caused contamination to those sources in over forty years of advanced hydraulic fracturing activities.[415] The industry believes that it is impractical to generate enough energy or pump enough volume to breach this separation.[416]

Disposal/ Injection Wells

The second category of protection arises from activities associated with the disposal of waste fluids, or flowback, from hydraulic fracturing activities. This concern has the potential for inadvertent contamination resulting from disposal of liquid drilling wastes by deep-well injection. There are over 12,600 disposal wells in Texas (of which 7,300 are active) used to inject liquid wastes at greater depths, while 3,900 disposal wells inject wastes into former oil and gas formations.[417] This concern is not only relevant in South Texas, but throughout the state.

In the past, the most common method of disposal[418] and most cost effective options for producers to handle flowback and produced wastewater were limited to injection wells or, in some limited instances, to evaporation ponds.[419] Oil and gas producers have been sourcing freshwater and disposing of produced water since the inception of their drilling programs.[420] Now there are new major challenges facing producers, especially in areas with intense shale drilling activity as they attempt to manage their water issues (e.g. limited disposal capacity, long hauling distances, limited freshwater supplies, increased regulatory scrutiny, and rising public concerns).[421]

For example, the primary function in the oilfield that Pinnergy operates is to haul off and dispose of this flowback produced saltwater into disposal wells, which they own and operate or which may be owned and operated by others. The disposal process involves injecting the flowback or produced wastewater into a deeper formation. This process is carefully monitored and regulated by the RRC to ensure protection of water supplies.[422] Among the nine disposal wells, Pinnergy injects 1,200,000 barrels on average per month.[423]

In addition, the Texas Water Code requires the Texas Groundwater Protection Committee to compile and publish a joint groundwater monitoring and contamination report that contains, among other information, a description of each case of groundwater contamination documented during the previous calendar year. The probability of shallow water well contamination (less than 1,000 – 2,000 feet) during drilling and completion activities could come from improper surface casing and/ or cementing or could come from surface leaks from diesel storage tanks, tank batteries, or surface spills.[424] For calendar year 2010, there were 4,268 documented cases of groundwater contamination described in the report. None of the causes of contamination documented in this report, nor the 21 prior editions of the report, have been attributed to hydraulic fracturing.[425] In fact:

> "In its review of incidents of drinking water well contamination believed to be associated with hydraulic fracturing, the EPA found no confirmed cases that are linked to fracturing fluid injection into coal bed methane (CBM) wells or subsequent underground movement of fracturing fluids. Further, although thousands of CBM wells are fractured annually, EPA did not find confirmed evidence that drinking water wells have been contaminated by hydraulic fracturing fluid injection into CBM wells."[426]

Spill Containment[427]

Protection from spills is the third category for the protection of aquifers. The industry follows state and federal regulations for the safe storage, transport, and use of chemicals necessary for the process. In this sense, the industry is like any other that transports and uses chemicals. Spill containments, absorbent materials, proper disposal, reporting, and remediation are all important in minimizing and eliminating contamination from surface spills when they do occur.

Water Use and Demand in Hydraulic Fracturing

As the most recent regional water plans were being completed, the potential impact of increased activity in hydraulic fracturing operations on the demand for water led the TWDB to devote research funding to a study of freshwater use in all sectors of the mining industry in Texas.[428] Surface water is used mostly in the eastern part of the state. Overall, operators used between 20 – 30 thousand acre-feet of surface water in 2011.[429] Although the study projects that the demand for water in hydraulic fracturing will nearly triple over the next decade, that amount will still represent less than 1% of the state's total water use.[430]

The Upper Trinity Groundwater District estimates that drilling uses 40% of the district's water. This water, contaminated with the toxic chemicals used in releasing the gas, is then usually pumped deep underground, entirely removed from the hydrological cycle.[431]

There are some who have also been encouraging the oil and gas industry to reduce its water footprint and consumption of freshwater. Some environmentalists believe that Texas needs to set standards to encourage alternatives to the use of freshwater in hydraulic fracturing, including recycling fracture water and more use of brackish water. Recycling fracture water saves about 20% of water used in the process, which means that 6 billion gallons of water could have been saved in 2011 (conservatively assuming just a single use of fracture well).[432]

The Environmental Defense Fund argues that some of the heaviest oil and gas producing areas of the state are the most susceptible to extreme drought conditions. As of June 19th 2012, almost 90% of the state was in drought-like conditions, but 100% of the counties that comprise the Eagle Ford play and 100% of the counties that comprise the Permian Basin are in drought-like conditions ranging from abnormally dry to extreme drought.[433]

In the 2012 State Water Plan, water for the production of oil and gas, as well as the extraction of minerals (and overall generation of electric power), is projected to represent about 9% of the state's total water demand in 2060. However, the consequences of facing water shortages in these industries in the event of drought of record conditions would be serious. Under such conditions, water shortages of about 30% of demand in mining and nearly 40% of demand in thermal electric generation would be expected. If not met, these shortages would be expected to cause an annual loss of over $30 billion in income, about $4.25 billion in lost state and local tax revenue, and over 110 thousand jobs. As much as one-third of the state's generation of electricity could potentially be threatened.[434] Using best available information, water use by Texas coal plants is 279,451 acre-feet per year, based on 2005 electrical generation rates.[435] During the same 50-year period that water demand is projected to increase, water available during drought, based on the State Water Plan Methodology, is projected to decrease from 17 to about 15.3 million acre-feet. State water planners say that current water supplies in Texas are 3.6 million acre-feet per year short of meeting Texas water demands during a reoccurrence of the "drought of record." The gap between available supply and demand is projected to grow to 8.3 million acre-feet by 2060.[436]

Natural gas, like all fossil fuels, produces water when it is combusted. For every 1 million cubic feet of natural gas that is burned, about 10,675 gallons of water are produced. In the Barnett, which is expected to produce for 30 or more years, each well contributes far more water to the hydrologic cycle than it uses.[437]

An issue that arises in regards to hydraulic fracturing is the quantity of the water being used. Oil and gas drilling uses a significant amount of water – an estimated 30 billion gallons in 2011 alone.[438] Oil and gas activities accounted for only 2% of water used statewide in 2010, and that percentage is expected to remain constant through 2060.[439] This is relatively small compared to other uses. For instance, municipal use of water accounted for 27% of the water used in Texas in 2010, and that percentage is projected to reach 38% by 2060.[440] The 2012 Texas State Water Plan projects water demand in Texas to increase over the next 50 years from 18 million acre-feet per year in 2010 to about 22 million acre-feet per year in 2060. Water is critically important to meet the needs of Texans to grow food, run businesses, wash, cook, and drink now and in the future. Texans must carefully manage every drop of our water supply to meet these needs, and steps should be taken now to decrease water demands wherever possible.[441]

Water has always been the most common fluid for drilling and fracturing treatments. Although produced and refined hydrocarbons, acids, nitrogen, and carbon dioxide have been used in specific fracturing applications, water remains the most economical fluid available. While one service provider, Weatherford, works with the operator or customer to select the fluid and optimize the volume, it is the responsibility of the operator to acquire, transport, store and manage the water. Waste, more so than use or water mismanagement, has rarely been a problem primarily because of the costs associated with acquisition, treatment, pumping, recovering and disposal. From the operator's standpoint, every gallon of waste or mismanaged water is an additional cost. In addition, the drilling services industry is very competitive and strives to provide the oil and gas operator the best economic value, which includes using less to do more.[442]

<u>Wells Drilled/ Amounts of Water Per Well</u>

Oil production has been in parts of Texas for generations, but the widespread usage of hydraulic fracturing is fairly new. Some believe that the hydraulic fracturing process is putting severe demands on the water supply in parts of the state.[443] For example, in the Eagle Ford Shale almost 3,000 permits were issued last year.[444] About half of those were drilled and each well drilled used about 6.1 million gallons of water for a total of almost 9 billion gallons of water used.[445] In the Permian Basin, 9,347 permits were issued last year. About half of those permits resulted in wells drilled, using on average 1.9 million gallons of water for an additional 9 billion gallons of water.[446] If you include the water used for wells drilled in the Haynesville Shale and Barnett Shale last year, that adds about another 7 billion gallons of water used. This means that hydraulic fracturing in Texas used about 25 billion gallons of water last year alone,[447] equivalent to every Texan taking 38 showers a day. Over the next 20 years 25,000 wells are projected to be drilled in the Eagle Ford,[448] which is equivalent to every Texan taking about 240 showers a day. In areas already hit hard by the drought where water is scarce, 25 billion gallons can feel like much more and using it for hydraulic fracturing can have an outsized impact on water supplies.[449] Last year, oil companies drilled 2,232 new water wells throughout Texas, about three times as many as five years earlier according to a Wall Street Journal analysis of TWDB records, and more oil wells are expected to be developed in the coming years.[450]

Aquifer Availability

The amount of water available for oil and gas hydraulic fracturing depends on the underlying aquifers in the area, the geology of the proposed site, as well as the size of the project. Due to the size and area of the Eagle Ford Shale, comparisons have been made as to the range of water availability between the northern and southern areas. The northern portion uses Gulf Coast Aquifer water, while the southern portion uses Carrizo-Wilcox Aquifer water.[451] The northern portion has a groundwater availability model of about 620,000 acre-feet annual flow with around 420,000 acre-feet pumped in 1999, while the southern area has a ground availability model of 370,000 acre-feet annual flow and pumped nearly 190,000 acre-feet in 1999.[452] The difference in water availability within the Eagle Ford Shale alone makes it very difficult to predict and manage the groundwater supply.

Another consideration in the use of groundwater for the production of oil and gas is how quickly or how slowly the local aquifer recharges. The Wintergarden Groundwater Conservation District (WGCD) believes that the impact on water supply should be recognized in terms of its percentage of usage of local recharge. Water requirements to develop the Eagle Ford Shale in the Wintergarden area over the Carrizo-Wilcox Aquifer are estimated to be approximately one-third of the average annual recharge. WGCD feels that the impact of this water demand on the local water resources is compounded by the fact that the area has been mining groundwater for most of the past century and continues to pump water at rates significantly greater than natural recharge rates.[453]

WGCD suggests that a potential alternative is drilling deeper and pumping from the poorer quality, less prolific Wilcox portion of the Carrizo-Wilcox Aquifer.[454] This process would leave the better quality, more accessible water from the Carrizo portion for agricultural and municipal users. Although using water from the Wilcox Aquifer to support development of the Eagle Ford Shale would increase costs, WGCD believes that the alternative of depleting the slow-to-recharge Carrizo Aquifer could be even more costly and damaging in the long term.[455]

Alternatively, the RRC Eagle Ford Task Force issued a press release on January 26, 2012 titled "Eagle Ford Task Force Finds South Texas Water Supply Sufficient, Data shows Carrizo-Wilcox Aquifer contains enough water to support oil and gas development." The press release noted the following:

> "The data presented to the group indicated that drilling and completions in the Eagle Ford Shale account for approximately 6% of the water demand in South Texas, while irrigation accounts for 64% and municipal uses account for 17%."[456]

Additionally,

> "Industry experts informed the task force that approximately 2,600 to 2,800 new wells are expected to be completed annually in the Eagle Ford Shale at peak demand, which translates into about 30,000 acre-feet of water per year during the heaviest point of development of the Eagle Ford Shale. In 2008, the Carrizo Wilcox Aquifer contained 540,000 acre-feet of available water."[457]

Overall, conservation of water is first accomplished by working with the operator to optimize the treatment volumes to provide the greatest return on investment. The oil and gas operator will use the least volume of water possible to accomplish their economic goal. The economics of finding, drilling, and producing oil and gas cannot support wasteful, overuse, or mismanaged water usage.[458]

Water Source Alternatives

Aside from freshwater, several water source alternatives are being examined for further use in the hydraulic fracturing process. Brackish groundwater and wastewater reuse are being predominantly considered as compared to potable groundwater and water currently appropriated to other uses that might instead be used for power production.[459]

Brackish Groundwater

Texas agencies are encouraging the oil and gas industry to reduce its water footprint and consumption of freshwater. Currently, brackish water used in hydraulic fracturing is mostly groundwater. Brackish water, or water of lesser quality, includes about 12 thousand acre-feet or 15% of total water use mostly in West and South Texas.[460] The industry is actively testing the use of brackish water to replace freshwater in their drilling and completion operations.[461] Some companies have already begun using brackish water instead of freshwater, and as technology evolves, hydraulic fracturing will be less dependent on freshwater.[462]

There are challenges, however, to the greater use of brackish water and the reuse of produced water including: reliability and economic feasibility of treatment technology, regulatory impediments, transportation and infrastructure issues, disposal of solid wastes, and landowner objections.[463] Furthermore, the use of brackish water may require more effort. For instance, brackish water requires its own set of chemicals to render the water usable.[464]

Nevertheless, newly emerging technologies, such as that which Purestream has developed, now exist for reclamation and treatment of these wastewaters, i.e. practical solutions for overcoming many of these issues, while at the same time providing very pure water that can be used for a multitude of purposes.[465] Purestream is also working with producers in Texas and elsewhere to explore how their technology can be applied for the treatment of brackish, high saline, and other non-potable waters in order to provide fracture make-up water or streams that can be put to other beneficial uses. This, of course, could serve to lessen the stress that intense drilling activity might place on limited potable water supplies in certain areas.[466]

Industrial Wastewater

Gulf Coast Waste Disposal Authority (GCWDA) has been approached by several entities to provide treated wastewater for reuse in the hydraulic fracturing process. In most cases, the quantity of treated wastewater is too small to be cost effective. In keeping with their future goals, GCWDA recognizes the water supply challenges that the state's industry and business sectors are facing today. GCWDA believes that the time is now to explore opportunities for the utilization of non-traditional sources of water such as non-potable and brackish waters to meet future water needs. One specific legislative step towards this goal that GCWDA recommends is to amend Subchapter H of Chapter 49 of the Texas Water Code to specifically provide that all districts treating for potable water or treating wastewaters for reuse shall also be authorized to use non-potable surface water, brackish groundwater, or coastal marine water for augmentation.[467]

Unique in Texas, GCWDA operates the specially designed industrial wastewater treatment plants under an exemption from federal categorical pretreatment standards for industrial wastewater, Public Law 102-389. The exemption allows GCWDA to treat wastewater from diverse industrial customers without requiring them to install and operate costly, redundant pretreatment equipment. Their industrial customers benefit from foregoing the capital and operating expenditures of unnecessary pretreatment systems; environmental regulators benefit from a reduction in the number of individual permits they must manage; and the communities GCWDA serve benefit from economic development and cleaner water resources.[468]

In keeping with goals for the future, GCWDA recognizes the water supply challenges the state's industry and business sectors are facing in an era of limited water availability. Steps must be taken to ensure the future of Texas economic viability is not hindered by the growing demands for water. It is the opinion of some that the addition of such authority will prove to be one significant step towards enhancing the prospects for expanding our water supply to meet present and future needs for all sectors (agriculture, business, environmental, industrial, and the public at large) without any detrimental impacts on the environment or public welfare.[469]

Other "Restrictive" Freshwater Sources[470]

Additional alternative sources, such as potable groundwater and currently appropriated water, are less straightforward and more restricted. Ongoing studies reflect that potable groundwater is considered to be available only where recharge exceeds current pumping and where the area is not under administrative control. This eliminates significant areas of Texas, such as the Ogallala Aquifer and the Edwards Aquifer Authority area.

Next, currently appropriated water is represented by the quantity of water currently used to irrigate pasture. Presumably, this water could be reallocated under the assumption that the water would have greater value if used to generate power. While potable groundwater and currently appropriated water sources are being examined and are considered to be available over at least a small geographic area of the state, brackish groundwater and wastewater still remain at the forefront of availability over the broadest geographic range.

New Technologies

Industry is currently testing new technologies that could further decrease the need for freshwater in hydraulic fracturing. These include reuse and recycling, as well as other waterless techniques with special drilling tools. Recycling is estimated at about 2 thousand acre-feet or 3% of the total water use overall but is somewhat variable across operators and plays.[471] As the cost of water increases, these more expensive technologies become more attractive.[472]

Reuse and Recycling

Many companies are looking at on-site water treatment and recycling technologies which allow them to treat and reuse water at the drilling site. Energy Water Solutions uses a unique technology based on ceramic microfiltration as the core process to remove dissolved solids. The process includes additional key technologies to remove the salts, hardness, and other impurities to provide EPA certified freshwater. This technology is a multi-stage process, utilizing passive filtration and generating minimal solid waste.[473] On-site recycling capabilities are offered in two options: an immobile recycling facility and a portable recycling skid. In this case, recycling facilities are offered in four standard sizes, scalable from 1,000 bbl/day to well over 100,000 bbl/day. Recycling skids are offered in two standard sizes, capable of 1,000 bbls/day up to 5,000 bbls/day. Recycling skids are based on standard ISO 40-foot-shipping containers.[474] The freshwater component becomes part of the freshwater infrastructure, the brine is concentrated for use as a 10-pound brine replacement, and the remaining brine is trucked to a Class II injection facility.[475] The benefits from on-site recycling are three-fold: a reduction in trucking and disposal by more than 60%; a reduction in a producer's total cost of ownership for freshwater and produced water by over 25%; and an additional benefit in the augmentation of recycled water into freshwater, allowing the producer to be less intrusive in the local ecosystem.[476] Ultimately, this process has the capability of turning up to 90% of the produced water they recycle into water that meets EPA freshwater standards to offset freshwater needs in drought stricken areas. With over 8 billion barrels annually of produced water in Texas, the technology can make a significant difference in offsetting freshwater needs in drought stricken areas.[477]

Another technology in recycling hydraulic fracturing fluids is Mechanical Vapor Recompression (MVR). This technology is a low energy, low pressure, and low cost technology that allows oil and gas producers to clean-up and recycle produced water and flowback water from hydraulic fracturing activities.[478] Devon Energy, in collaboration with Fountain Quail Water Management, uses this technology in the Barnett Shale. First approved and implemented by the RRC in 2005, this process vaporizes wastewater to remove salts, metals, chemicals and other solids, producing a stream of fresh, distilled water that can be economically reused for hydraulic fracturing or other beneficial uses.[479] The remaining concentrated brine is then removed for disposal. This process is capable of generating 105,000 gallons per day with approximately 84,000 gallons per day of freshwater generated by a single unit.[480]

Another company, Purestream Technology, utilizes a slightly enhanced and accelerated version of MVR called AVARA technology, originally designed for the U.S. space program.[481] Its unique design allows large volumes of water to be processed with very little energy cost because the energy expelled during vapor condensation is utilized in the evaporation of brine-laden feed water. AVARA pushes the efficiency envelope, taking theory and the practice of vapor recompression to new, more effective levels. For example, its proprietary, lighter core boasts one of the best overall heat transfer coefficients per unit area in the world of saline water reclamation. Its advanced design requires less energy per unit volume of output (distilled water) than any conventional tube and shell recompression system. In fact, because it operates at such a low pressure, it does not require tube and shell elements or pressure vessel containments. This means AVARA is lighter by design, and due to advanced thermal engineering, more efficient in operation.[482]

Reuse and recycling technologies are not without significant challenges. One challenge related to recycling hydraulic fracturing fluids is the handling, treatment, and storage of recycled water which increases risks associated with spillage. The treatment of hydraulic fluids is essentially the treatment of contaminated water; the more it is dealt with it, the more the risk for contamination and spillage go up. When looking at this from a broad perspective, it is an overall important consideration.[483]

Another challenge associated with recycling hydraulic fracturing fluids is related to a cost-benefit analysis. The economics of recycling is heavily dependent on several factors ranging from trucking and disposal costs, to the costs of treatment and freshwater, and ultimately the proximity of recycled water to future wells.[484] Recycling is currently 50% – 75% more expensive than the current practice of deep well disposal.[485] The difficulty in bringing the practice online faster is that the cost of cleaning produced water can be significant enough to be prohibitive, particularly for the smaller independents that operate most of the wells in the state.[486] It is important that the state provide support for both consumers and producers to better encourage cost effective recycling and reuse technologies.[487] Therefore, incentives for operators are needed to further expand recycling.[488]

As with all technology, water recycling methods and technologies are advancing all of the time. Assuming it follows the same trajectory as other advances, as time passes the process will continue to improve in efficiency and decrease in cost, thereby pushing it closer and closer to being common practice.[489] Through this advancement, other challenges will need to be addressed. For example, produced water quality and composition is highly variable, thus creating difficulty in water treatment.[490] Additionally, as recycling expands, more freshwater may be generated than needed for fracture stimulations, thus requiring alternative options to the release of water and possible freshwater credits.[491] Ultimately, the need for additional options for the reuse of recycled water exists beyond reuse within the oil and gas industry.[492]

<u>“Water-less” Fracturing</u>

Some companies have opted to go with a technology that does not include any water. For example, GASFRAC has developed an innovative closed stimulation process, utilizing gelled Liquified Petroleum Gas (LPG) rather than conventional fracturing fluids. GASFRAC operates an advanced sealed system to ensure that the fracturing process is completely controlled, and its patented LPG gel maintains its fluid state, unexposed to the atmosphere and thereby preventing vapor buildup.[493]

There are two primary benefits to using GAFRAC's LPG gel: one, its fracture length can be maximized for longer use in the process; and two, the gel's sustainability allows for it to be returned to the normal flowback and recovery process. Practically 100% of the propped fracture length created contributes to producing the oil and gas reserves it contacts. Nearly 100% of the fluid can be recovered in a much shorter time than a traditional treatment. This greatly increases the opportunity to hit peak initial production much sooner than with traditional fracturing fluids.[494] GASFRAC's waterless LPG gel stimulation process is sustainable, and it is able to recover all of the fluid through recapturing or recycling processes. This greatly reduces the need for any post fracturing clean-up or disposal, creating a backside cost benefit.[495]

Heat Reduction and Corrosion Control[496]

Another innovative technology that the oil and gas industry, as well as other industries including transportation and water supply, should consider is thermal coating and corrosion protection. The Super Thermo technology can block initial heat load from ever happening. It is not an insulator but an actual heat reflector. Thermal coating when applied to an entire building can stop heat load dramatically and further provide fire protection. Additionally, corrosion protection can be applied to actual water supply and production facilities, where the potential for rust and contaminants in the atmosphere can be greater. These technologies have been applied to airports, large facilities like industrial containers, tanks, and pipelines. By applying these technologies, energy usage and costs can be reduced by 20% – 60%. A reduced cost in energy savings and maintenance invariably reduces water usage.

Agency Oversight/ Statutory Regulation over Mining and Production

Texas Railroad Commission

Public Outreach/ Education

When dealing with policy in regards to hydraulic fracturing, the importance of the public outreach and education cannot be overstated. In some cases, anti-industry media efforts can cause unwarranted public concern for the protection of groundwater from the hydraulic fracturing process.[497] Industry education efforts have begun to find a foothold and turn the public perception tide through presentation of factual information and increased transparency.[498] Various efforts to tie groundwater contamination to hydraulic fracturing have been proven to be premature, unfounded misstatements. When examined in concert, these indicate goals that are less concerned with the actual protection of water resources and more concerned with the fundamental opposition to oil and natural gas development.[499] On June 21, 2010, a film entitled *Gasland* premiered on HBO. In an infamous scene, a gentleman is shown turning on his kitchen faucet and lighting his water on fire. The filmmaker blames this occurrence on hydraulic fracturing operations in the area. This, needless to say, caused some concern, even prompting an investigation by the Colorado Oil and Gas Conservation Commission, who determined that, "Dissolved methane in well water appears to be biogenic [naturally occurring] in origin…there are no indications of oil and gas related impacts to the water well."[500] Industry has presented a long-term solution that many believe is seeing some success in healing some of the superficial wounds inflicted by fallacious claims of water contamination. People fear what they do not understand, and the best way to combat misunderstanding is through presentation of the facts and responsible transparency.[501]

For example, proactive education efforts that reach out to citizens, state legislators, local elected officials, and media have produced an increased understanding of the hydraulic fracturing process, and therefore, increased confidence in its protectiveness. Furthermore, there has been a successful increase in transparency brought about by recent legislative measures,[502] resulting in a public armed with the facts, allowing them to better identify misinformation.[503]

Further Disclosure/ Transparency

Alternatively, there are some who believe there is always room for improvement, and the Texas League of Conservation Voters (TLCV) would like to highlight just some of the ways the state can further strengthen its laws and policies related to hydraulic fracturing practices in natural gas production. One example TLCV points to comes from Ohio. Governor John Kasich led a recent effort to seek a level of transparency and disclosure from "spud-to-plug," otherwise known as disclosures of chemicals used in drilling, producing, servicing and shutting down wells. Though the more comprehensive version of the Ohio Governor's bill failed to reach his desk, even the scaled-back version provides an instructive example of where Texas should head next. Most notable and laudatory is that Ohio's disclosure policy now requires disclosure of the chemicals used in stimulating a well but its application goes beyond hydraulic fracturing to other stimulation techniques, something most other states, including Texas, have failed thus far to address.[504]

TLCV also feels strongly that while the Texas Legislature may lack the direct authority to improve the FracFocus website, it is hopeful that the state leaders and representatives on the IOGCC might hold sufficient sway to press for improvements to make FracFocus more user friendly for the benefit of Texans and users across the country. If disclosure rules and legislation are to direct or require producers to publish on FracFocus, the site must adopt a format and function that ensures it can serve as a truer tool of public disclosure. Improved search capability, better use of online databases, and increased data format availability should be employed.[505]

Varying Definitions of Groundwater Resources[506]

In the administration of its programs, the RRC applies a variety of standards in order to protect groundwater resources. Although the RRC does a good job distinguishing among varying standards, there is no statewide, nor agency-wide, standard of water quality zones. This can cause some confusion among applicants and cross-agency administration. In an effort to standardize the varying standards of water quality zones, the Groundwater Advisory Unit (GAU) provides geological interpretation for identifying freshwater zones and base usable-quality water.

When possible, the GAU identifies the following water quality zones:

- Superior (0-500 mg/l TDS).
- Freshwater (0-1,000 mg/l TDS).
- Base of usable-quality water (3,000 mg/l TDS and water of any concentration of TDS that is being used in the area. Generally, the TDS is less than 7,000 mg/l).
- Base of the underground source of drinking water (10,000 mg/l TDS).

Further statutory language clarifying the different zones and uses of standards could be helpful in future protection of water quality zones.

Texas Commission on Environmental Quality

Defining "Public Interest"

The TCEQ has oversight of the environmental regulations relating to mining operations and the extraction of mineral resources. At the June 27, 2012 hearing, the uranium mining industry shared a few concerns about current regulatory obstacles. These concerns stem largely from ambiguous statutory language and potentially duplicative regulatory standards.[507] For instance, Section 27.051(a), Texas Water Code authorizes the TCEQ to grant an injection well permit if, among other matters, the agency finds that the injection well is in the "public interest." Representatives of the uranium mining industry argue that this term is ambiguous and presents an occasionally varying standard.[508] The term "public interest" has not been defined by either the legislature or the TCEQ. Further, the uranium mining industry also believes that a standard like "public interest" is really no standard at all; it is much too subjective.[509] Arguably, the TCEQ already has sufficient rules that provide for the protection of public health, safety, and environment. The provisions of Section 27.051 largely constitute what some might consider public interest, while not impairing existing rights. These provisions include protecting mineral rights, providing proper safeguards for both surface water and groundwater quality, showing sufficient financial responsibility, and reviewing an applicant's compliance history, among others. Removing the "public interest" requirement would provide a more consistent standard for applicants and the public while still maintaining the legislature's directive to protect human health and the environment.[510]

Contested Case Hearings

Another significant concern revolves around the contested case hearing process. Currently, the Area Permits that the uranium mining industry must obtain from the TCEQ are subject to contested case hearings, while Production Area Authorizations (PAA) are also subject to contested case hearings. An Area Permit covers a larger area than a PAA. Each contested case hearing can take 18 – 24 months, and the costs can range from $300,000 to $1 million. By having both an Area Permit and a PAA subject to contested case hearings, mining operations can be delayed for substantial periods of time and significant amounts of funds must be spent by uranium mining companies to participate in contested case hearings for both sets of applications. Section 27.0513, Texas Water Code should be reviewed and amended to create a more balanced and fair regulatory process for the uranium mining companies that operate in Texas.[511] This would allow individual uranium production areas to proceed without subjecting each individual and secondary area to redundant contested case hearing requirements. Applicants would still be required to meet environmental standards, subject to TCEQ.[512]

Groundwater Management and Regulation[513]

Water is used in a number of oil and gas activities including drilling, enhanced recovery and hydraulic fracturing. The use of surface water is regulated by the TCEQ, river authorities, municipalities and other local water management entities. However, no state agency has the authority to manage or regulate the use of groundwater. Under state statute, local groundwater conservation districts are designated as the preferred entities to regulate and manage groundwater. In Texas, nearly 100 groundwater conservation districts fulfill this role, making it difficult for the mining industry, as well as the oil and gas industry to comply with the various district rules and reporting requirements.

Federal Oversight and Regulation

The federal government also plays an active and important role in the mining industry, as well as the oil and gas industry. With respect to uranium mining, there is a significant concern about the delay in granting aquifer exemption approvals by the Environmental Protection Agency (EPA), specifically by the EPA Region 6 Office. In the past, the EPA has granted over 35 aquifer exemption requests in Texas. In contrast, since 2010 the EPA Region 6 Office has refused to approve aquifer exemption requests for three uranium mining projects in Texas, including a URI project, even though the TCEQ has granted similar aquifer exemption requests using stringent regulatory requirements and review processes.[514]

Federal regulatory creep is also an ongoing area of concern for the Texas oil and gas industry.[515] Some are under the opinion that the biggest challenge the state is facing is keeping Texas regulated by Texas. Many feel that the federal government certainly would like to draw industry further under their regulatory umbrella and are attempting to do so by accusing state regulators of not being able to handle the job of protecting the public and the environment. The RRC has unparalleled expertise on all things oil and natural gas, and has successfully regulated the industry for many decades.[516] Overall, Texas agencies do a great job of managing the state's water, air, and environment.[517]

<u>RECOMMENDATIONS</u>

Disclosure and Water Use Reporting Requirements

Continue to monitor the implementation of House Bill 3328 from the 82nd Legislative Session. Improve the access and ease of which the public interacts with information collected and disclosed through the FracFocus website. Evaluate the impacts of water use in energy exploration and production through reporting requirements and integrate these numbers into regional and state water planning.

Groundwater Management

Examine uniformity of statutory language for complying with groundwater conservation district rules and reporting requirements for energy exploration and production.

Mining Regulation

Evaluate ambiguous requirements in the regulatory oversight of the mining industry and consider clarifying or eliminating any subjective standards. Consider streamlining administrative procedures related to contested case hearings in the permitting process of the mining industry.

Reuse/ Recycling Technologies

Strongly encourage the reuse and recycling of freshwater used in fracturing work performed at onshore oil and gas wells. Alternatively, strengthen existing incentives to encourage greater reuse and recycling in order to reduce the overall impact on freshwater supplies.

Statutory Definitions of Groundwater

Consider standardizing existing statutory definitions for water, subsurface water, fresh groundwater, underground water, brackish groundwater, usable quality groundwater, etc. among the various state regulatory codes especially as they relate to energy exploration and production, and environmental protection.

THE INTERPLAY OF WATER AND ENERGY

PUBLIC HEARING

The House Committee on Natural Resources held a public hearing on its Interim Charge #2 related to the interplay of water and energy resources in the state on June 28, 2012 at 9:00 a.m. in Austin, Texas in the Capitol Extension, Room E1.030. The following individuals testified on the charge:

Carole Baker, Texas Water Foundation
Ben Carmine, NRG Energy, Inc.
Jun Chang, Department of Public Works and Engineering, City of Houston
Barbara Clemenhagen, Topaz Power Group
Trip Doggett, Electric Reliability Council of Texas
Chris Eugster, CPS Energy
John Fainter Jr., Association of Electric Companies Texas, Inc.
Jorge Garcia, Toyota Motor Manufacturing, Texas
Gary Gibbs, America Electric Power
Shawn Glacken, Luminant
Scott Hambrick, Exelon Power
Bob Holt, General Electric Water and Process Technologies
Lairy Johnson, MillerCoors
Carey King, Jackson School of Geosciences, The University of Texas at Austin
Matt Langley, The Wind Coalition
Ron Lemons, H204Texas Coalition
Brian Lloyd, Public Utility Commission of Texas
Christa Lopez-Reynolds, City of Fort Worth
Dean Metcalf, Xcel Energy
William "Skip" Mills, Texas Engineering Experiment Station
Becky Motal, Lower Colorado River Authority
Raymond Orbach, Energy Institute, The University of Texas At Austin
Jody Puckett, City of Dallas Water Utilities
William Sarni, Deloitte Consulting, LLP
Bryan Shaw, Texas Commission on Environmental Quality
Howard Wenger, Sunpower Corporation
Doug Whipple, The Dow Chemical Company
Kent Zammit, Electric Power Research Institute

The following section of the report related to water and energy is produced in large part from the oral and written testimony of the individuals listed above.

PART II: ELECTRIC GENERATION

We use water for energy; we also use energy for water.[518] These two resources are inextricably linked. We need water to produce electricity, and electricity to produce, deliver, heat, and treat water supplies.[519] It is in electric generation that the energy-water nexus continues. A study conducted in 2010 estimated that 507,000 acre-feet of water consumed generates 426 terawatt-hours of electricity.[520] Water availability and supply is critical to power generation resources in both the near and long-term reliable generation in the State of Texas.[521]

This report is the second portion of a broader charge that the committee was tasked with examining the interplay of water and energy resources of the state. This portion of the report is centered around the discussion of water and generation issues in the State of Texas.

BACKGROUND

Overview of Texas Energy Generation

In Texas, companies generate power from natural gas, coal, nuclear, and wind generation. Certain generation plants around Texas use natural gas as the fuel for the majority of generation due to its increasing availability and low cost.[522] Most energy in Texas comes from steam turbines, making water a critical component in electric generation.[523] The Association of Electric Companies of Texas (AECT) member companies own over 38,000 megawatts (MW) of generation in Texas.[524] At a snapshot, the second largest power producer in Texas is NRG Energy, owning and operating 13 generating facilities, mostly located in Southeast Texas with several wind farms in West Texas.[525] NR''s fleet has a combined capacity of 12,600 MW, representing 12% of the state's total generating capacity.[526] To put this in perspective, the Electric Reliability Council of Texas (ERCOT) calculates that 1 MW is enough power to supply roughly 200 Texas homes during a hot summer day.[527] Exelon owns six natural gas fired plants, producing a little more than 4,000 MW of electricity, all within the ERCOT market.[528] In addition to natural gas power plants, Exelon operates 12 small wind farms generating 190 MW in the Texas Panhandle. Exelon yields roughly 5% of ERCOT's generating capacity.[529]

At the wholesale and retail levels, providers deliver substantial contributions to Texas power generation. City Public Service of San Antonio (CPS) is "one of the largest municipally-owned utilities in the United States."[530] With a total generation capacity of 6,626 MW, it is a fully integrated utility comprising 7% of the ERCOT market.[531] The Lower Colorado River Authority (LCRA) generates a total of 3,347 MW of power for wholesale consumption. The LCRA currently sells electric power to 43 wholesale customers.[532] A majority of LCRA's generation, at least 50%, comes from natural gas producing 1,711 MW. Forty-six percent of LCRA's generation comes from coal generating 1,035 MW. The other 4% comes from renewable resources such as hydroelectric and wind sources.[533] LCRA owns 13 hydroelectric units at six dams that produce 295 MW of energy. Additionally, LCRA purchases 316 MW of wind power from West Texas and Gulf Coast wind facilities.[534]

At the manufacturing level, a great deal of Texas' electric consumption drives the production of goods used across America and around the world. In fact, much of the electricity consumed by Texas industries is used to produce the fuel needed to generate energy and electricity in other states.[535] Increased costs are reflected in all products that require electricity to manufacture, transport, store, and distribute them to consumers. Industrial users account for 50% of all energy consumed in Texas.[536]

At the municipal level, Houston consumes electricity generated by a mix of coal, gas, and wind. Houston has an energy contract with CenterPoint that to produce 77 billion kilowatt hours (kWh) for the Houston/ Galveston area, and 1.2 billion kWh for the City of Houston.[537] Due to Houston's LEED certification, 5% of energy must come from renewable resources, which has earned them a #1 ranking among U.S. municipalities from the EPA.[538] The City of Dallas, Texas' second largest city, has a contract with TXU Energy to provide electricity, as well as a co-generation contract with one wastewater treatment plant that currently uses biogas to produce 26 – 30 million kWh annually.[539] This contract has saved 40 million gallons of water daily.[540]

The average American household also consumes 29 kWh of electricity each day.[541] "The average American household consumes 300 gallons of water each day. In that household, 92 gallons of water are consumed for bathing, and the average Texas household flushes 76 gallons of water down the toilet each day."[542] It is evident that domestic electric consumers rely on a steady supply of water and energy to meet their needs.

Ultimately, as our population continues to grow, the importance of reliable and affordable electricity will also continue to grow. Texas' demand for electricity is projected to continue to increase more than 2% per year on average for the next decade, even after accounting for greater energy efficiency and demand response initiatives.[543] This increase in demand makes water exceptionally important for maintaining the reliability of Texas' generation.[544] It is of great importance that the state takes necessary action to meet the growing demands of our increasing population and the growing businesses that fuel our state's economy.[545]

Overview of Texas Economy in Energy Generation

Electricity is vital to Texas' economic development.[546] Electricity powers the economy, and affordable and reliable electricity is increasingly critical for electronics and manufacturing processes.[547] These uses include serving farms, chip manufacturing, recycling facilities, metal and gas processing plants, and refrigeration storage.[548] Additionally, power plants that are located on large tracts of land provide leased farmland to local farmers and ranchers.[549] This produces billions in feedstock and natural gas purchases, furthering the positive impact that the electric industry has on our economy.[550]

Wholesale and retail providers also have a positive economic impact on the community from power generation. CPS proceeds stay in the community of San Antonio, where the company is located.[551] These revenues go to support general municipal facilities like parks, libraries, schools, and roads.[552]

In addition, power generation has a positive impact on job creation in Texas. Electric companies provide steady jobs, career opportunities, and savings for the employees working in power generation.[553] According to the Texas Workforce Commission, electric power generation in Texas provides 13,570 jobs with $1.3 billion in annual wages.[554] Including retail, wholesale, and regulated sectors, AECT member companies provide employment to over 19,000 Texans.[555] General Electric (GE) provides jobs for 9,500 Texans in manufacturing and service support services for various GE sectors: GE Aviation, GE Aeroderivates, GE Energy Services, GE Oil and Gas, GE Water and Process Technologies, GE Healthcare, and GE Capital.[556] Wholesale and municipal providers, like CPS Energy and the LCRA, create employment in the San Antonio and Austin areas. CPS currently employs 3,600 residents of San Antonio. Since 1975, CPS has created over 58,000 jobs.[557]

Texas' electric industry and industrial companies provide indirect job creation. According to Doug Whipple, "[The Dow] Chemical [Company] is a job creator; for every one direct job created, seven indirect jobs are created."[558] Electric companies invest billions of dollars in new infrastructure. Investing in construction projects for new power plant facilities also generates employment for thousands of construction workers.[559] The completed plants and mines provide high-quality jobs for many rural residents of the state.[560] Rural residents are not the only Texans that benefit from electric generation; NRG employs nearly 3,000 individuals in generation, retail, and energy related business all across the state.[561] Overall, private electric generation companies are committed to a successful and reliable economy and market in Texas through their employment of thousands of Texans across the state.[562]

Electric generation companies not only provide Texans with steady jobs and incomes, they also provide substantial tax bases and revenues that benefit all residents of the state can benefit from. AECT member companies pay nearly $2 billion in state and local taxes and fees per year.[563] Private electric generation companies are the largest taxpayers by a wide margin in virtually all the communities where they operate plants.[564] In Corpus Christi alone, the local economic activity associated with Topaz Power Group creates approximately $11.1 million per year in tax revenues and provides $920 million in payroll benefits.[565] American Electric Power and Luminant Power Company together pay $173 million in property taxes in Texas. Topaz Power Group also generates over $120 million per year in economic impact in South Texas.[566] In wholesale, the LCRA is a large contributor in tax revenue, paying $2.7 million in property taxes last year, and $50,284 in sales taxes.[567] The Dow Chemical Company alone pays $112.5 million in state and local taxes.[568] These taxes and revenues contribute an important portion of Texas' tax base that allows the state to provide vital services to people all across the state.

Overview of Texas Energy Generation: Efficiency, Capacity, and Types

Texas needs all different types of generation and abundant water resources for that generation. As previously mentioned in this report, power generation can come from a variety of primary energy sources such as coal, uranium, natural gas, biomass, sun, water, or wind.[569] The generated electricity is distributed to commercial, industrial, and municipal customers.[570] Power generation plants in Texas vary in source water, water quality, and different water treatment processes.[571] In Texas, the typical coal-fired power plant has an average efficiency of 35%.[572] In some cases efficiency can be increased by using waste gas from combustion turbines that boil water for a steam generator.[573] Moreover, if fans are installed to cool the steam, the plant will use 90% less water than plants with similar cooling technology.[574] Nuclear fueled plants have a slightly lower efficiency at 33%[575] because of a lower peak steam temperature and pressure.[576] Natural gas efficiency varies depending on the type of generator, ranging from 26% – 39%.[577]

Each fuel source has a different capacity depending on how efficiently it can produce electricity. Coal-fired power plants account for 35% of Texas electrical generation, and in 2009, coal-generated power plants produced 21,056 MW of electricity.[578] Out of the 10 largest power plants in Texas, six are fueled by coal.[579] Nuclear accounts for a much smaller portion of electricity production in Texas, but it generates one-fifth of the energy used in the United States.[580] Natural gas fuels 49% of the electricity generated in Texas.[581] For example, the Winchester Power Park is a four-unit natural gas fueled facility in Fayette County that can produce 176 MW of energy during peak demands.[582]

Thermoelectric Power Generation

The most common way to produce electricity is through thermoelectric power generation. Thermoelectric power generation uses heat created most often by coal, nuclear, or natural gas sources which in turn creates electricity; however, each plant differs in how it utilizes its resources. Coal-generated power plants burn coal to convert boiler water into pressurized steam, the steam then drives the turbines.[583] Nuclear plants use nuclear energy to heat steam and spin the turbines.[584] Natural gas can be used to create steam for the turbine or can be used as fuel for combustion which creates the steam.[585]

<u>Steam Electric Generation</u>

In Texas, thermoelectric power generation is most commonly achieved through the use of steam turbines. Steam electric power plants may use coal, nuclear, or natural gas to heat high purity water into steam, which turns a turbine connected to a generator.[586] The turbine spins a large shaft called a rotor inside a chamber lined with magnets, which create the electric current.[587] The spent steam is routed into a condenser, where the steam is exposed to cool water and condensed.[588] The transformation from gas to liquid shrinks the volume of the steam, pulling more steam from the turbine into the condenser and making the turbine move faster.[589] The condensed water cycles through the process again or is discharged into the nearest water source, depending on what kind of cooling technology the plant utilizes.[590] Condensing is a key component in maintaining effective electric generation.[591] Waste heat must to be cooled, and water is the cheapest and most readily available method.[592]

<u>Natural Gas Generation</u>

Natural gas generation is another way to achieve thermoelectric power generation. These power plants burn natural gas as a fuel source like an engine to turn the turbines. Although less water is used in the generation process, water is needed in the cooling process in order to eliminate or reduce nitrogen oxide emissions. For example, the Laredo Energy Center uses the water from the Rio Grande to cool the air pulled into a gas-fired turbine, which helps to make the production of electricity more efficient and reduces plant emissions. In 2012, with significantly lower fuel costs and an increasing demand due to the continuing growth in the Texas economy, Topaz Power Group's natural gas fueled plants in Texas have been operating significantly more than in previous years.[593]

Combined Cycle Generation

Combined cycle plants for natural gas are another option for generation in the state. "Combined cycle plants will produce about two-thirds of their power from combustion turbines, which require no cooling systems, and one-third of their power from the steam turbines."[594] In the combined cycle process, a natural gas turbine generates power, creating a by-product of heat. The exhaust or waste heat of the natural gas turbine is then used to create steam, which combines to provide additional power. These plants use water in the steam phase for cooling and condensing.[595]

A similar process can also be used for integrated gasification combined cycle (IGCC) plants; IGCC plants use coal, petroleum coke, or biomass as fuel sources.[596] In this process, fuel is not combusted; rather, it is gasified with steam and controlled oxygen at high temperature and pressure.[597] The result of gasification is syngas. It is reformed over a catalyst and converted into carbon dioxide, which fuels a combustion turbine producing electricity. IGCC plants require extra water for cooling of the air separation units, but use less water than conventional coal and nuclear plants, or about 30 – 60 gal/MWh.[598]

Alternative Sources for Generation: Renewable Energy

Texas has a diverse portfolio of renewable energy resources for the production of electricity. Hydroelectric generation made its largest impact in Texas in the mid-1930s.[599] Today, Texas is currently the leader in wind and biofuel generation.[600] Many more companies have plans to invest in additional solar, wind, and geothermal energy products as technology becomes more efficient and cheaper. These alternative sources of energy harness solar and wind power that convert energy into electricity.

Hydroelectric Generation

A less common source of electric generation in Texas is hydroelectric generation. Hydroelectric generation uses the force of surface water in a variety of forms to power a turbine. In Texas, less than 1% of power generation comes from hydroelectric generation.[601] LCRA has 13 hydroelectric units at six dams that can produce 295 MW in emergency situations or when releases are being made to meet downstream water demands.[602]

Photovoltaic Solar Power

Photovoltaic (PV) panels convert sunlight's radiant energy directly into electricity.[603] When sunlight hits phosphorus and boron atoms, the energy is turned into electricity. PV panels are made of the same material used to carry electric current in semiconductors, so the energy is captured and transported efficiently.[604] A 50 MW PV system could power a desalinization plant that would be large enough to supply about 10,000,000 gallons per day of potable water to supply 50,000 homes.[605] For example, in Arizona a 7.5 MW PV system at a 40 million gallon water treatment plant provides municipal water to Phoenix, Arizona. The average price of photovoltaic panels dropped by 50% in 2011. The technology is becoming cheaper to implement, and the 20 year savings for the Phoenix plant are projected to be $4,485,000. NRG is one of the nation's largest developers of solar power products, and they plan to start building solar energy plants in Texas since the cost is comparable to natural gas.[606] Not only is cost going down for solar energy in Texas, but the state also has some of the highest "solar insulation" in the country.[607] For example, a water treatment plant in Phoenix, AZ produced 15,962,040 kWh of electricity in one year though PV technology.[608] This same technology offset grid consumption by 75% in Arizona.[609]

<u>Concentrated Solar Power</u>

An alternative to photovoltaic solar generated electricity is Concentrated Solar Power (CSP), or solar thermal generated electricity, which collects and concentrates radiant solar energy as a power plant fuel source. CSP generates electricity with steam, similar to thermoelectric power plants. CSP uses mirrors to concentrate the heat in order to create steam through a heat exchanger.[610] The steam is converted into energy through turbines; then the steam is condensed using a cooling technology.[611]

<u>Wind Power</u>

The United States currently leads the world in wind capacity, and Texas leads the nation in total wind capacity.[612] In fact, Texas alone generated over 12 terawatt hours of electricity last year, more than the total combined renewable generation in 2006.[613] The wind generation process works by converting the wind's kinetic energy into mechanical energy through the rotation of the wind tower's blades.[614] A generator then converts the energy from the rotating blades. Wind generation does not require fuel or water resources.

Overview of Texas Water Use and Demand in Electric Generation

The Importance of Water and Water Resources

Water is more than a quality of life issue; life cannot exist without it, nor can our economy.[615] Water is the foundation upon which everything in Texas is built: public health, economic development, energy, industry, agriculture, residential development, and recreation all would collapse without water.[616] Coincidentally, Texas' electricity provides energy to pump water to farms, clean drinking water for cities, and treatment for sewage.[617] Electricity also allows our hospitals, schools, emergency services, and airports to provide necessary and vital services to our citizens.[618] Therefore, generating dependable electricity and providing an ample supply of water is of great importance.[619]

Water and electricity are inextricably linked. While it takes electricity to supply water, it also takes water to supply energy. Water is used in almost every part of electric generation. Water must be extracted from sources and brought to the plant. Conveyance systems are in place across Texas to deliver water from its source to water treatment plants. These systems can range from a few hundred feet to 150 miles.[620] Electricity is needed to extract the water from the source and to power the conveyance systems.[621]

In Texas, obtaining a reliable water supply depends on the location and available water resources.[622] The power plants' surrounding geography in relation to water is the most important consideration; this becomes especially critical during drought periods.[623] In order to ensure and safeguard an adequate, long-term and reliable water supply, water rights and contracts are usually secured decades before a plant is in use.

The water source for power plants varies depending on what is physically available.[624] Some use surface water lakes, while others use deep water wells.[625] Some plants located near the ocean intake seawater,[626] while other plants located near large cities can utilize municipal water supplies.[627] Natural water sources can include lakes, rivers, and streams.[628] Alternatively, many power plants in Texas build off-channel cooling reservoirs that provide cooling and process water to the plant.[629] There are approximately 190 reservoirs in Texas, each holding more than 5,000 acre-feet of water.[630] Twenty-one million acre-feet of surface water was used for electric generation in 2011, and of this figure, 390,000 acre-feet was consumed in power generation.[631] Due to an increasing strain in surface water resources especially during drought, however,[632] groundwater is increasingly being viewed as a "buffer" to improve water reliability.[633]

Plants located by an ocean can use seawater as a source water for electric generation, preserving surface water and groundwater resources. For instance, Topaz Power Group facilities in Corpus Christi use water from a nearby ship channel to power generation.[634] The seawater that is used as cooling water is non-contact water when used for power generation, so it is returned to its source with the same purity as when it was withdrawn.[635] Additionally, drought conditions have little or no impact on evaporating seawater, and sites by the ocean can utilize desalinization plants to help with water needs.[636]

Finally, treated effluent water is a viable alternative to surface water, groundwater, and sea water. Effluent is treated wastewater that meets clean water standards.[637] Under the Texas Administrative Code Section 210, the Texas Pollutant Discharge Elimination System issues authorization for the reuse and treatment of domestic and industrial wastewater.[638] Wastewater uses less energy to withdraw because parts of the system are handled through the flow of gravity, although electricity is used to transport or pump wastewater through lift stations.[639] In a 50-year span, an average commercial plant can conserve 163.5 billion gallons of water by using treated effluent water.[640] In addition, treated water has numerous uses besides fueling power plants. Industrial reclaimed water may be used for landscape irrigation, soil compaction, fire protection, dust suppression, impoundment maintenance, and irrigation for non-food crops.[641] Some of the contaminants are a valued resource such as salt and metals that can be used as energy.

Water Use in Generation

Water "use" in generation can sometimes be hard to define. Due to its rather broad definition, "use" can define a number of tasks such as drinking, cooling, and even flushing. "Use" can be considered consumptive in some cases and non-consumptive in others. It is possible that water "use" in the generation process makes the plant run smoothly without actually consuming much water. Therefore, it is important to understand these definitions when understanding water's role in electric generation.

Water "use" may be relative to water "consumption" in electric generation. Understanding the true meaning of water "consumption" can ultimately lead to a correct understanding that the continual circulation of water results in a significant amount of water being "used" but a very small portion of water being "consumed" for power generation.[642] Water is consumed when it can no longer be available for other uses.[643] Consumption should be considered the "big picture measure of impact on water resources."[644] In most cases of consumption, water is most significantly consumed through evaporation.[645] Evaporation can be seen on cool mornings as white clouds of evaporation billow from the cooling towers at electric generation plants.[646] Overall, although water use may be quite high, consumption is minimal at electric generation power plants. According to a 2009 survey by the Texas Water Development Board, only 3% of the water in the state is consumed for generation, which equates to less than 10 gallons per day per person. This is compared to the 60% of water that is used for irrigation in the state.[647]

Process water is an example of consumptive water in power generation. Cooling water condenses steam while process water is used to make steam. Process water accounts for less than 15% of the water consumed to produce power.[648] Plants use process water in the boiler and steam cycle, scrubbing, ash handling, dust suppression, and plant service water.[649]

An additional distinction must be made between water that is consumed and water that is "withdrawn" for generating electricity. Water that is "withdrawn" is water that is needed to produce electricity.[650] Withdrawn water used to cool the condenser is considered non-contact water, and can be recycled back into its water source. The water will eventually be used again, or can be directly recycled back into the process.[651] Withdrawn water that is impounded and then recirculated for cooling purposes in power plants is usually returned back to the source at a slightly elevated temperature.[652] Whereas, consumed water must be treated or replaced before it is returned to the original water source.[653]

Water Development and Management in Generation

Companies started generating electricity in Texas in the 1880s. By the early 1900s, those companies were helping financially to develop water resources. These efforts have continued today with increased efficiency in water management.[654] Electric generation companies capture, monitor, treat, reuse, or release water at generating facilities to ensure good water quality and regulatory compliance.[655] Luminant is the largest private owner of reservoirs in Texas. The company owns and operates 14 lakes, making it one of the largest water managers in the state.[656] Another electric provider that develops and manages water resources is NRG. Under established water rights and contracts, NRG uses surface water from the surrounding Houston area. These sources include the Sabine, Trinity, San Jacinto, Navasota, Brazos, and Colorado Rivers, as well as Galveston Bay.[657] Accordingly, most Texas power plants utilize cooling water for plant operations, making these companies the largest private water rights holders in Texas.[658]

Industrial water users also develop and manage water resources in Texas. For example, The Dow Chemical Company owns and operates two freshwater reservoirs with a combined usable capacity of 29,000 acre-feet. It also holds senior water rights on the Brazos River, one of the last significant freshwater intakes before flowing into the Gulf of Mexico.[659] Finally, it manages the freshwater supply to local industries and the Brazosport Water Authority, which supplies water to seven municipalities.[660]

Water Use in Thermoelectric Generation

Thermoelectric power plants that employ heat to generate power are the largest users of water in the United States.[661] An average Texas steam electric plant consumes about .4 gallons per kWh produced.[662] The largest use of water in thermoelectric power generation is cooling heat that is not utilized in energy production. While water is a necessary component to create steam, the cooling process more importantly functions to retain efficiency at the plant. The cooling system is an integral part of the power generation process and greatly influences plant performance.[663] Today, there are a variety of cooling technologies available in electric generation process. In Texas, the three most popular technologies used to cool water in electric generation are open-loop, closed-loop, and dry cooling.

Water Use in Alternative Sources for Generation

Photovoltaic solar and wind electric generation sources use little or no water. For example, the most efficient PV solar cells operate at a 24% efficiency.[664] The little amount of water consumed in solar generation comes from cleaning PV panels. This consumes 30 gal/MWh.[665] Alternatively, wind power is even more efficient, operating at a 50% efficiency.[666] Wind requires no water to produce electricity. In Texas, 30 TWh of wind generation can offset 39,000 acre-feet of water consumption.[667]

A Further Look at Water Use and Demand in Cooling Technologies

Open-Loop Cooling

The most prevalent type of cooling technology used in thermoelectric power generation in Texas is once-through cooling, otherwise known as open-loop cooling. In open-loop cooling, power plants withdraw water from a source, which flows through condensers to compress the steam in a single pass. The water circulates through the power plant once before it is returned to its source. A majority of the water withdrawn is returned to its source.

The two most common sources for once-through cooling are streams and reservoirs. Water is only consumed through forced evaporation. Water used for open-loop cooling can be withdrawn from numerous sources with a wide range of qualities. Water can come from a reservoir, river, bay, or groundwater source, and even treated sewage effluent can be utilized.[668] The water never comes into direct contact with pollutants, which contributes to the flexibility of sources.[669] Even saline water can be used in open-loop cooling because large amounts of water are not evaporated during the process.

A typical open-loop cooling system generally withdraws about 448,000 acre-feet of water per year or 10 – 40 gallons per kWh.[670] This depends on the size of the plant and how much water is consumed through forced evaporation.[671] Open-loop cooling withdraws 40 – 80 times more water than other cooling technologies, but consumes far less. Once-through cooling actually only consumes approximately .33 of a gallon of the withdrawn water to produce 1 kWh of electricity.[672] Average water consumption ranges from 50 – 350 gal/MWh, which is 1% of total withdrawal.[673] This means that Texas plants that use once through cooling consume at most 9.5 gallons of water to produce enough electricity to power an average household for a day.[674] To put that in perspective, less than two orange Home Depot buckets are consumed to provide power to a home for a day.[675] Open-loop cooling is the most cost efficient cooling technology; water can be recirculated over and over again without degradation in quality,[676] which means using more water while consuming less.[677]

Closed-Loop Cooling

Another cooling technology is wet cooling, also known as closed-loop cooling. Closed-loop cooling, is a popular method in the United States, accounting for about 85% of electricity produced nationally.[678] Cooling towers are an integral part of the closed-loop cooling process. Cooling towers are large evaporative coolers that cool and condense steam as it is passed through the electric generation cycle.[679] Water is withdrawn from a source and then pumped through heat exchangers. Water is recirculated continuously between the condenser and the cooling tower. As the water is recirculated through the cooling tower, the heat from the water dissipates as it comes into contact with air and evaporates.[680] The remaining water is then directly recycled back through the condenser.[681] After water has cycled through the towers about four to five times,[682] the evaporation of water in the cooling tower leaves behind contaminants. The contaminants must be removed, or "blown-down," from the water and replaced with freshwater.[683] The blowdown water is treated and recycled through the plant. The remaining contaminant water is not harmful and can be redistributed to the land through irrigation systems.[684]

Closed-loop systems are the second most efficient behind open-loop cooling.[685] An average closed-loop system withdraws about 9,000 acre-feet of water per year, which is continuously cooled and recycled.[686] With each cycle (not including nuclear), about 230 – 700 gal/MWh, is consumed via evaporation.[687] The water that is lost to evaporation must be replaced, consuming 80% of the water that is withdrawn,[688] almost twice as much than once-through cooling.[689] Closed-loop cooling uses significantly less water, but consumes more water to produce electricity.[690] Cooling towers are generally built where access to surface water is limited. Water sources typically come from groundwater, brackish surface water, and treated municipal effluent, or some combination.[691]

Dry Cooling

Another cooling technology is dry cooling. Dry cooling can be used in areas of the state where water availability is severely limited, and power plants can be specifically designed to use it.[692] In the dry cooling process, steam is directly condensed in an air-cooled condenser that collects the steam into small metal tubes that stop water from evaporating while heat is dispersed. Cool air is blown across the tubes using fans, condensing the steam into water. This process works similarly to a car radiator.[693]

Dry cooling uses approximately 220 acre-feet of water per year to produce electricity. Dry cooling eliminates the need for large amounts water, which allows for plants to be built in arid locations.[694] This technology uses about 70% less water than other dry cooling technologies but requires six times more power to cool the steam.[695] Dry cooling requires more power because a cubic foot of air has a lower ability to dissipate heat compared to other cooling technologies that use water.[696] Dry cooling plants require larger cooling structures which increase capital costs.[697] Currently, dry cooling is the most expensive and least efficient cooling technology.[698]

Overview of Water Use and Demand in Municipalities

Municipalities oversee natural resource management for their cities and surrounding areas. The City of Houston's primary surface water source is Lake Livingston. Currently, the city has 1.2 billion gallons of available surface water to meet water needs.[699] The City of Houston also oversees 115 water wells, 65 pumping stations, and 98 storage tanks, and oversees 65 groundwater plants, a decrease from 114 in 1985 due to a reduction in groundwater use because of policy decisions related to subsidence.[700] Houston maintains 7,480 miles of water lines throughout the city and surrounding areas.[701] Currently, Dallas only utilizes surface water to meet the city's water needs. The City of Dallas developed six connected surface waters: Lakes Ray Roberts, Lewisville, Ray Hubbard, Grapevine, Tawakoni, and Fork.[702]

In addition to surface water and groundwater resources, municipalities use effluent water or reclaimed water to help reduce reliance on natural sources that can be otherwise limited in supply during drought. Municipal reclaimed water is treated water that is primarily derived from sewage treatment plants. The wastewater is treated where it is safe and suitable for reuse as reclaimed water. Reuse of untreated wastewater is prohibited.[703] For example, recycled water from the City of Amarillo accounts for about 98% of the water needs at the Harrington-Nichols generation plant .[704]

The largest cities in Texas have a consumer base that needs water for basic domestic functions. The City of Fort Worth is a municipal water utility serving 222,585 accounts with a population of 750,000.[705] Additionally, the City of Dallas owns its own regional water and wastewater utility that provides water to Dallas and 23 surrounding suburban cities with a total population of 2.3 million people.[706] Recent statistics show that the population of Dallas will increase to 4.5 million people by the year 2060, increasing water use to 850 million gallons per day. On a daily basis, Dallas currently consumes about 400 – 425 million gallons of water.[707] The City of Houston services 470,000 customer accounts and 2,940,000 residents.[708] Statistics show the population of Houston will increase to 11.3 million people by 2060.[709]

Overview of Water Technology in Electric Generation

Power generation companies play a crucial role in furthering continued efforts to conserve Texas water. One of the state's leading companies in water conservation is Xcel

Energy. Xcel Energy conserves water by treating wastewater, recycling water multiple times though the plants, and utilizing the available land around the plants by giving excess water to farmers and ranchers.[710]

Texas industrial companies have also made a commitment to implementing water technology to conserve water. For example, the Toyota plant in San Antonio understood that the Edwards Aquifer, the city's sole source of drinking water, is in limited supply, so they designed the plant around conservation.[711] Toyota invested in water treatment and filtering systems to make recycling water part of the plant's processes.[712] Toyota purchases close to one million gallons of recyclable water per production day from the San Antonio Water System. This water is effluent from San Antonio's Wastewater Treatment (sewer) plant.[713] Water that is not bought by Toyota would otherwise be disposed into a nearby river.[714] The water goes through several filtering processes and chemical treatments before it can be used in Toyota's processes. After Toyota uses the water, it goes through an internal industrial wastewater treatment plant to remove contaminants, and then is discharged back to San Antonio's Wastewater Treatment Plant.[715] MillerCoors is another company that has made a strong commitment to conservation. "The brewery has saved more than 190 million gallons of water per year through improvements in package line lubrication, the brewery's pasteurizer reclaim system, and fermenter foam traps."[716] Sixty-one percent of the water that MillerCoors purchased from the City of Fort Worth was returned after being processed through the brewery's water treatment facility.[717] The water is reused for irrigation or dispersed into the Trinity River.[718]

Agency Oversight/ Statutory Regulation over Electric Generation

There are three main regulatory entities that oversee water resource management and generation regulation in Texas. These agencies are the Electric Reliability Council of Texas, the Public Utility Commission, and the Texas Commission on Environmental Quality. Each are tasked with responsibilities to oversee and manage water resources and electric generation in Texas.

Electric Reliability Council of Texas[719]

The Electric Reliability Council of Texas (ERCOT) oversees the deregulated and competitive market in Texas power generation. The ERCOT region comprises about 85% of the state. ERCOT has 74,000 MW in capacity for peak demand, generated by privately held independent power producers, publicly held independent power producers, municipalities/ co-ops, retail electric providers, and large customers. ERCOT's generating capacity comes from a number of different resources to power its plants, including: 26 natural gas units that generate 5,110 MW; 12 coal units that generate 5,110 MW; and 2 nuclear units that generate 2,300MW. Companies only receive revenue when they are able to produce power.

Public Utility Commission[720]

The Public Utility Commission (PUC) systematically reviews the ERCOT market design, and PUC rules ensure that Texas will be a favorable place for electric companies to build new power plants, which includes geographic location, as well as the type of utility the plant will provide. Utilities are required to obtain PUC approval of new power plants. The PUC bases their approval on factors including cost, environmental issues, and community values. The PUC is tasked with examining emergency operations plans of electric utilities and power generation companies. The PUC examines the ability of generation plants to withstand extreme weather conditions and compiles a list of best practices for generation during difficult weather months.

Texas Commission on Environmental Quality

The Texas Commission on Environmental Quality (TCEQ) is the state's environmental regulatory agency responsible for clean air, clean water, and safe disposal of waste. In its duties to regulate water, it is responsible for managing, securing, and authorizing surface water rights in Texas. The TCEQ authorizes the direct reuse of wastewater. The TCEQ is tasked with managing surface water rights in Texas. The TCEQ primarily accomplishes this duty through issuing and enforcing water right permits.[721] Surface water in Texas is "owned by the state and held in trust for the citizens of the state."[722] Surface water rights in Texas are dictated by the concept of prior appropriation.[723] Surface water use that is governed through water rights and contracts are measured by self-reported uses in the Water Use Report. Government entities rely on the water right holders to report their use accurately.[724]

Although the TCEQ oversees the protection of groundwater resources, groundwater in Texas is actually owned by the landowners and managed by local groundwater conservation districts (GCDs).[725] GCDs manage water by mointoring conservation, preservation, protection, and recharge of groundwater sources.[726] While the TCEQ does not directly manage groundwater, it lends support to the GCDs. Currently, 98 GCDs are established in Texas and oversee the management of groundwater in accordance with Chapter 36 of the Texas Water Code.

According to Chapter 11 of the Texas Water Code, water use permits are issued for power generation, which are classified as "industrial use."[727] There are three different types of permits the TCEQ issues: perpetual permits that do not expire, term permits that are valid up to 10 years, and temporary permits that are valid for a maximum of three years.[728] Currently, there are 113 industrial water right permits and 40 water supply contracts for power generation in the state, as well as 55 mining perpetual water rights and 76 temporary water rights being used for oil and gas production.[729] Water rights permits are enforced by TCEQ field staff in areas without watermasters. Watermasters ensure compliance with water rights by monitoring stream flows, reservoir levels, and water use that is within the quantities of the user's right. Field staff conduct on-the-ground and aerial investigations and also conduct stream flow monitoring to ensure appropriate use and adequate supply.[730]

The TCEQ also assists with water conservation practices through the regulation and distribution of water rights permits. Currently the TCEQ, in conjunction with the Water Conservation Advisory Council (WCAC), is in the process of developing guidelines to support the requirements of Senate Bill 181 and Senate Bill 660 of the 82nd Legislative Session. These bills required a sector based approach to water use reporting for water conservation plans and implementation reports. The TCEQ and the TWDB are currently undergoing rulemaking to comply with the bill. The rules and guidance will be effective January 1, 2013.[731]

In addition, the TCEQ, WCAC, and TWDB are in the process of revising the Water Conservation Best Management Practices Guide originally developed by the Water Conservation Implementation Task Force. The Best Management Practice Guide is offered to the state's regional water providers and water users as a tool for planning and designing effective conservation programs.[732] Water conservation plans meeting 30 Texas Administrative Code Chapter 288, subchapter A, are required to be submitted to the TCEQ every five years for non-irrigation (municipal or industrial) water rights holders of 1,000 acre-feet per year or more and for irrigation water rights holders of 10,000 acre-feet per year or more.[733] Water conservation plans are also required for all municipal, industrial, and irrigation water rights applications.[734]

DISCUSSION AND CHALLENGES

Water Use and Demand in Electric Generation

State Water Plan Future Projections

Earlier this year, the TWDB issued its third version of the State Water Plan under the Senate Bill 1 process.[735] The *Water For Texas 2012 State Water Plan* provides recommendations on different water management strategies that could be considered for augmenting current water resources.[736] This plan aggregates estimates for current and future water demand for 16 regions of the state and six major categories of demand, including municipalities, steam-electric generation, manufacturing, mining, irrigation, and livestock.[737] According to the State Water Plan, the current water supplies in Texas are 3.6 million acre-feet short of meeting water demands, if Texas suffers another severe drought of record like the Drought of the 1950s.[738] By 2060 if we do not implement the State Water Plan, Texas will be short 8.3 million acre-feet to meet the state's water demands.[739]

Representatives of power generators are active members of the regional water planning process.[740] The State Water Plan, and the regional plans from which it is drawn, estimate water demand and future unmet demands for steam-electric power generation in Texas for each decade from 2010 through 2060.[741] Water demand for electric generation makes up a minute portion of Texas' overall water demand. Currently, water consumption in electric generation comprises 4%, or 700,000 acre-feet of Texas' total water demand,[742] whereas livestock and irrigation make up 58%, and municipalities 27%.[743]

The tides will turn by the year 2060. Overall demand for electric generation is projected to grow 38.3%.[744] According to the TWDB, water withdrawals for electric generation will increase to 7.4%,[745] or equal 1.6 million acre-feet of water consumed annually.[746] To put this in perspective of projected increases, "the total municipal water usage for Houston in 2009 was 287,000 acre-feet per year. Water usage for steam electric power generation is projected to increase over the 50-year planning period from 2.4 to 5.6 times the total amount of municipal water used in Houston."[747]

Municipalities also face adversity in achieving an adequate water supply due to an increase in population and demand. In Houston, the current population of 6 million people is projected to double by 2060.[748] By 2060, Houston will have increased use from 1,020,860 acre-feet per year to 1,556,151 acre-feet per year. And in Dallas, the expected population by 2060 of 4.5 million people will consume more than 850 million gallons a day.[749] The cities are looking into plans that include extensive conservation and reuse, as well as developing new reservoirs in order to provide water for the cities' growing populations.[750]

Improving the State Water Plan

Alternatively, the Sierra Club, as well as other environmental organizations, have some concern about the estimates used in the plan for water usage in electric generation. For example, the estimates in the 2012 State Water Plan for steam electric water demand are higher than those reported directly to the TCEQ and TWDB.[751] The Sierra Club believes that if the steam electric sector consumes as much water as indicated in the 2012 State Water Plan, then it should to be reported to these regulatory agencies.[752] Additionally, the data provided through the existing pathways could be used as the basis for the State Water Plan.

Moreover, Carey King, a research assistant at Jackson School of Geosciences, argues that a more detailed accounting of the water usage should be taken into consideration when drafting the 2017 State Water Plan.[753] He suggests that in order to estimate annual water consumption for a power plant, one needs to estimate (1) the amount of power generated during the year, (2) the type of fuel and prime mover (e.g. steam turbine), and (3) the type of cooling configuration (if applicable). This information is not currently included the plan.[754] Overall, accuracy and consistency should be a priority when developing data for water supply projections.[755]

In response to the discrepancies among estimates for steam electric water demand reported in the 2012 State Water Plan versus those actually reported directly to state agencies, the planning numbers are indeed, purposefully larger projections. The State Water Plan is intended to reflect water use under the Drought of Record condition, as well as any additional water demand related to new electric generation capacity anticipated to be added in the next decade. In fact, the decadal projections in the State Water Plan based off of the Drought of Record are expected to exceed the actual use for a specific, normal precipitation year such as 2010.[756]

Implementing the State Water Plan

The public health and economic consequences of ignoring the water shortage problems in many areas would be harsh. If the state does not fully implement the State Water Plan by 2050, 50% of Texans will lack an adequate supply of water during times of drought.[757] It will cause an annual loss of $116 billion in income, a $9.8 billion lost in state and local revenue, and 1.1 million Texans will lose jobs.[758]

In order to secure the state's future water supply, action is needed now.[759] Action and implementation can most readily be accomplished by fully funding the State Water Plan. Many electric generation companies, including the AECT and its member companies, support the full funding of the State Water Plan.[760] A meaningful, adequate source of funding will provide incentives for local entities to accomplish the different water management strategies within the plan, in turn developing water resources for the future.

In addition, the state should review and analyze the existing regulations and permitting processes in place. For example, some argue that the state should move forward with obtaining land for legislatively designated reservoir sites and permitting these unique reservoir sites as identified in the State Water Plan.[761] Achieving the water strategies, goals, and objectives outlined in the State Water Plan will prepare Texas for a stronger future.

Overview of Drought Conditions on Electric Generation

In 2011, the State of Texas experienced the hottest summer in Texas history, and with it came one of the worst droughts in history.[762] In October 2011, 97% of Texas was experiencing extreme or exceptional drought with 85% of the state at the highest level of an "exceptional drought."[763] Generation units in the Brazos River and Sabine River Basins were hit the hardest, which greatly affected the ability of power plants' in these regions to maintain adequate levels of generation.[764] Fortunately, as of October 2011, only 24 MW of capacity was unavailable due to drought. Unfortunately, however, long-term drought forecasts suggest drought conditions like the ones Texas experienced in 2011 will be repeated in upcoming summers.

Drought Impact: Incidentals from Dry Climate Conditions

The drought caused available surface water supplies across Texas to be substantially reduced, and reservoir storage fell to levels not experienced in previous decades.[765] Surface water reservoirs throughout Texas, especially in East and Central Texas, were at 10-year lows.[766] Lake Buchanan and Lake Travis, water supply reservoirs, were only 51% full in June 2012.[767] This occurrence was the first of its kind in 77 years.[768] In fact, in every region of the state, precipitation was the lowest on record, especially near the Brazos, Colorado, and Sabine Rivers.[769] As parts of the Brazos and Guadalupe Rivers ran dry,[770] power generation plants were luckily able to produce historic amounts of electricity with very little amounts of rain.[771]

Additionally, the dwindling supply of water contributed to inefficient plant operations at a time when efficiency needed to be maximized. For example, the temperatures in cooling reservoirs were not able to decrease enough to cool the water coming from the generation plants.[772] This led to increased withdrawal and consumption of water from already low reservoirs, because more water had to be used to sufficiently cool the plants.

The dry climate conditions also led to an increase of air-borne contaminants, such as sea salt and dust on transmission and distribution facilities.[773] These contaminants and other debris landed on insulator brushing and peripheral line equipment.[774] Although rainwater normally washes the debris away from the insulators, this did not happen because of lack of rain.[775] Moreover, flashovers, or spontaneous electric fires, occurred from the contamination of the insulators. In one instance, these flashovers not only endangered the structure of the plant and its ability to provide electricity, but these instantaneous fires were extremely dangerous for employees at the plant.

Lastly, the dry climate conditions contributed to Texas' wildfire problem. These wildfires threatened multiple electric generation plants. For instance, there was a large fire near a major transmission line that brings power into the Houston area.[776] This fire threatened power supply to residents during the hottest months of the summer, and also led to situations where companies had to de-energize transmission lines to allow firefighter equipment, such as airplanes, to operate.[777]

Agency Oversight/ Statutory Regulation over Electric Generation during Drought

The Texas drought from late 2010 – 2011 made it apparent to many that the regulatory framework of the state could affect the availability of water and energy to Texans. In fact, the Governor has continued to reissue an Emergency Disaster Proclamation originally issued in July of 2011 relating to drought. The Governor's Proclamation suspended all rules and regulations that inhibit or prevent prompt response and allowed enforcement discretion at power plants so that regulatory and permitting burdens did not contribute to a loss of power.[778] This gave priority to power generation and water use to serve the needs of public safety, health, and quality of life.[779]

Electric Reliability Council of Texas

As water levels decreased, electric generation was increasingly put at risk. As a result of these conditions and the subsequent effects across the state, the Electric Reliability Council of Texas (ERCOT) solicited support from corporate leaders of several Texas generating operators to initiate a review of their current water management programs for dealing with extreme drought conditions. The drought contingency plans included permitting and drilling extensive and expensive groundwater fields that supplemented dwindling surface water supplies.[780] In addition to drought contingency plans, companies agreed that continued investment in electric power infrastructure must be made to meet growing demand for power, especially in the summer months when water runs low and usage peaks. This led ERCOT to adopt protocols that allowed mothballed plants to be temporarily returned to service, which created additional options to replace power from plants in water constrained areas of the state that became expectantly unable to provide sufficient amounts of power.[781]

In addition, ERCOT increased communication with water permitting entities, users, and stakeholders. The agency identified water sources used by electric generation operations that were at historically low levels and provided regular updates on water resources to ERCOT's Board of Directors.[782] ERCOT also provided communication and education to a number of state entities and consumers throughout Texas. For example, ERCOT held several workshops to share best practices and possible mitigation strategies relevant to drought conditions. Generation companies discussed measures like lowering intake structures and identified existing opportunities for alternative sources that could provide additional water to keep the plants running at full capacity. ERCOT also worked to identify opportunities for moving consumption off of peak demand hours, like pumping at night.[783] Additionally, ERCOT also launched a mobile app to help educate consumers about the conservation of electricity.[784]

Texas Commission on Environmental Quality

The TCEQ oversaw and managed drought impact across the state.[785] The TCEQ primarily focused on minimizing the impacts of drought on public health and safety, managing public surface water systems, and coordinating with other agencies for available power generation.[786] Public health and safety priorities included drinking water, fire protection, hospital use, tree preservation, and necessary domestic uses.[787] The TCEQ organized a TCEQ Drought Team that began meeting in February 2010 to work with various stakeholders, including power plants and surface water users. This was necessary in order to manage lake levels and temperature, as well as to offset additional suspensions.[788] The TCEQ Drought Team communicated information about the status of on-going drought conditions, response activities, and other resources through regular meetings and the TCEQ's Drought Information Webpage.[789]

Requests for more information about drought conditions and permit suspensions began in early 2011. The TCEQ responded to these calls and communicated to state leadership, legislative officials, county judges, county extension agents, water rights permit holds, and the media.[790] The TCEQ received 15 senior calls on surface water in the Brazos, Guadalupe, Colorado, Sabine, and Neches River Basins, which resulted in the suspension or curtailment of over 1,200 water rights permits, as well as to a temporary halt on issuing provisional water rights permits.[791] Due to the persistent drought, the TCEQ was forced to curtail junior priority water rights in certain river basins.[792] Junior municipal, or power generation uses, were not suspended because of public health and safety concerns.[793] As the drought intensified however, water rights for municipal and power generators were the next in line for suspension from the TCEQ.[794]

In addition to suspending water rights, the TCEQ utilized its watermaster program for those basins where watermasters are in place. The TCEQ watermaster worked with South Texas Electrical Cooperative to coordinate releases of water to meet emergency requests for power from ERCOT.[795] A watermaster holds permittees accountable for their misuse of water, thus helping curtail over-pumping which hinders the state's ability to meet its water needs.

Although the TCEQ did a phenomenal job managing all of the competing interests during one of the driest years on record, the agency must continue to consider outlying variables, such as the effect that suspending water rights can have on competition and operation within the electric market.[796] For instance, some believe that when the TCEQ allowed electric generators access to water, even though the subordinate status of their water rights would have dictated otherwise, it effectively intervened in the competitive electric market.[797] This caused a market distortion, albeit for a societal benefit, ultimately effecting competiveness because it directly impacted the cost of operating in severe drought.[798]

Regulatory Coordination

Ultimately, the most effective way that Texas can deal with drought conditions is through regulatory coordination. All entities, both private and public, must come together in order to safeguard our water supply. This was evident through the Drought of 2011. For instance, the TCEQ worked with the TWDB, the Texas Division of Emergency Management (TDEM), ERCOT, and the PUC on a number of items. All agencies attended weekly and bi-weekly TCEQ drought meetings in order to be fully informed on current drought conditions. In February 2011 and again in August 2011, ERCOT and TCEQ collaborated together in order to establish a framework for guidance that would best support and uphold the grid. Additionally, in October 2011, TDEM organized a meeting with Texas' water regulatory agencies – TCEQ, ERCOT, and PUC – to discuss the potential impact of drought on electric generation in the state. Furthermore, the TCEQ published procedures for ERCOT and other electric generation companies on how to request and exercise enforcement discretion for a power emergency. The TCEQ also provided ERCOT with information on water rights for power generators as well as survey questions to help identify the water supply needs of power companies during the drought.[799]

In coordination with one another, every agency's top priority is to ensure that Texas has adequate and reliable power. Today, the agencies continue to work collaboratively with one another to address the issue of water needs in Texas, especially during times of drought.

Power generation companies also need to work together to ensure a successful economic future in Texas. Energy and water are the building blocks for Texas' economic future. The electric industry worked very closely with the TCEQ throughout the drought to ensure adequate generation during times of limited water supply. For example, companies offset water concerns by purchasing water from water reserves held by river authorities.[800] Although companies are severely impacted by drought, it is up to the TCEQ to ensure that an adequate water supply is available to meet the needs of the state.

Environmental Stewardship and Reservoir Creation

The creation of reservoirs for the cooling process should respect the environment, protect the long-term integrity of the ecological system, and expand the purposes of use beyond the energy generation process so that multiple goals can be accomplished simultaneously. Environmentalists are concerned that thermal pollution from the water returned at high temperatures removes oxygen in the water that is necessary for aquatic life to survive.[801] On the other hand, there is evidence to suggest that the warmed, returned water allows many species to spawn and survive through the cold winter months, which otherwise would not be possible.[802] For example, Topaz Power Group's Barney Davis Plant returns sea water to the Oso Creek, creating new habitats for fish and wildlife, which would otherwise not be able to survive there.[803] Even more care is given during the summer months to ensure that temperatures are no more than 10 degrees above natural ambient water temperature.[804]

Additionally, cooling reservoirs can serve numerous purposes outside the electric generation plant. Cooling water from reservoirs can be used in emissions control, sanitation systems, and municipal water systems. Moreover, reservoirs serve a number of useful roles to the surrounding area. For example, some reservoirs provide drinking water to nearby municipalities.[805] Reservoirs also provide and sustain thousands of acres of aquatic habitat for wildlife.[806] These reservoirs can also be used as recreational parks that provide fishing, boating, and other outdoor activities to the public, further enhancing local tourism and tax revenues.[807]

Furthermore, industry has also seen a benefit in reservoir creation and the need to create more water supply by repurposing public land for beneficial use. For example, The Dow

Chemical Company recently purchased 2,200 acres of land from the Texas Department of Criminal Justice as a site for a new freshwater storage reservoir.[808] This reservoir will triple stored reserves available for use in drought conditions, benefiting both the community and industry in Brazoria County.[809]

Conservation

Converting raw energy resources into electricity requires the use of water, and conversely, the treatment and distribution of water consumes energy, usually in the form of electricity. It is imperative that Texans take the necessary steps to conserve our water resources. The keys to enabling water conservation stem from technology, economics, and policy.[810] Various conservation measures improve the efficiency of electricity production, which ultimately leads to a reduction in water use.[811] Because it is feasible to reduce the amount of water per unit of energy created through the adoption of conservation practices, Texas' major water users must employ them.[812]

Industrial Conservation

Although there have been a few innovative industry leaders who have put conservation measures in place, some private industries do not view water scarcity as a concern. Only 36% of industries surveyed said that they have in place "board-level oversight of water-related policies, strategies, or plans."[813] One of the obstacles that Texas faces when planning for conservation is knowing the exact amounts of water used in electric generation. As previously mentioned, this inhibits a company's ability to plan for future water needs, which in turn disrupts the statewide planning process. A plant cannot become more efficient and reduce its water consumption if it does not know the precise amounts of water consumed.[814]

Municipal Conservation

Conservation among the largest municipalities in Texas is on the rise. Many municipal water supply plans call for a heavy reliance on conservation and reuse strategies in order to meet the growing population demands and many already have these strategies in place. In fact, Dallas estimates that 25% of its future water supply strategies will be met through conservation and reuse.[815] Dallas also adopted more aggressive water conservation measures in 2001 that included regulating time of day watering and "water and freeze sensors" that detect and alert users of water leaks.[816] It is estimated that Dallas has saved 146 billion gallons of water since implementing these programs in 2001.[817] During the drought of 2011, Dallas was also able to save 30 – 35 MGD of water by limiting domestic watering to twice a week.[818]

The City of Houston has also implemented similar strategies. Due to the persistent drought in 2011, Houston entered Stage Two Water Conservation Measures, which included requiring consumers to repair leaks within 72 hours of detection, regulating time of day watering, and implementing a 10% water reduction goal from all city departments.[819] Furthermore, the City of Houston's Public Works Department maintained a reduction goal of 18%, saving the city 859,265 gallons of water per day though limiting the use of water for golf course watering and public pool facilities.[820] The city continues its conservation measures: in July of 2012, Houston announced the creation of a Water Conservation Task Force.[821] The Task Force will review water supply options and conservation measures for Houston, and will look at other ideas to diversify the City's water supply, including recycled water for irrigation, greywater use, and rainwater capture.[822] San Antonio has also adopted a number of mandatory and incentive-based conservation measures. Its conservation ordinance alone includes provisions to save up to 1.3 billion gallons of water annually, or about 3 gallons per person per day, even when the city is not suffering from drought conditions.[823] Other programs aimed at both residential and commercial users, include consumer based water efficient programs and rebate that encourage indoor conservation.[824]

Conservation Education and Incentives

Much more can be done to strengthen conservation efforts by educating the public. Research suggests that people do not really have a concern for water conservation.[825] Although the drought made citizens more aware of water shortages, this awareness dissipated with rainfall.[826] Conservation should not just be a short-term solution during drought only. The state must make a better effort to communicate the long-term shortages and strategies in the State Water Plan by informing citizens through outreach efforts on ways to provide water saving alternatives and ensuring that water is being used in a responsible manner.[827]

The state should also consider several other policy options that exist to improve conservation. These include updating and strengthening building energy codes, providing tax rebates to homeowners who undertake certain efficiency improvements, expanding utility programs to encourage energy efficiency, and providing rebates or other incentives for energy efficient appliances. Likewise, generation companies and municipalities should maximize efficiency potential by adding programs and continuously strengthening existing ones.[828] For example, incentives to homeowners and businesses for the installation of small renewable generators, like solar panels or wind turbines, could help alleviate some of the demand during peak hours.[829] Moreover, the City of Houston has already implemented a Multi-Family Rebate Program that educates residents on water savings, which gives rebates to families who install water saving devices.[830]

Alternative Water Sources

Wastewater Reuse

Municipal Wastewater Reuse

Companies are currently evaluating and expanding the use of alternative water sources in order to safeguard existing supplies. For instance, municipal wastewater reuse provides the most immediate and best return on investment per gallon due to its proximity, availability, predictability, and ease of treatment.[831] Municipal wastewater reuse becomes especially important during Texas drought conditions when other water sources become limited.

Industrial Wastewater Reuse: Internal Programs

Another example of reuse techniques occur within the actual facilities themselves. Power generation companies that implemented a number of recycle and water reuse measures found that water use could be reduced by 10%.[832] Some industrial facilities even incorporate these reuse strategies into the initial design of the whole facility. For example, the Toyota manufacturing plant had the benefit of being designed around conservation. This allowed the plant to implement creative water recycle and reuse strategies that capture 1.7 million gallons of water per month from its sources.[833] Some plants recycle all waste streams within a facility to maximize efficiency. Wastewater from one process can be used as source water for another process.[834] Plants can also capture and use storm water for landscape maintenance and floor drain/ sump systems.[835] In addition, companies can capture condensation from air conditioning systems.[836] These ideas allow plants to utilize wastewater within plant operations in order to uphold their commitment to water reuse and reduce their overall consumption. Ultimately, future water reuse companies will be the drivers to provide a greater understanding, appreciation, and value of water.[837]

Industry Wastewater Reuse: External Programs

Industry is also expanding opportunities for water conservation outside of their facilities. One way that companies are implementing programs to promote water conservation is through private-public partnerships. This can be illustrated by MillerCoors' program, "Water as a Crop." The program combines water conservation strategies of large industrial companies with local landowners. Water as a Crop provides incentives to nearby farmers to improve surface erosion and infiltration of precipitation that will improve water quality and quantity.[838] This program served as a catalyst for the United States Department of Agriculture National Resource Conservation Service to provide a grant of $2.88 million aimed at expanding water conservation programs.[839] Water as a Crop is an ideal model of incentive based private-public partnerships that foster innovative water conservation strategies.

Other Initiatives

One Technology Cooling

The Environmental Protection Agency (EPA) has recently proposed a one technology cooling mandate. The proposed EPA regulations effecting new and existing power plants would require the retrofit of cooling towers.[840] This mandate is intended to reduce water consumption and provide a cleaner approach to electric generation; however, this federal regulation could impose more harmful than helpful effects. "A one technology cooling mandate would impede the industry's ability to employ water conservation measures that are appropriate for the particular location. Such a mandate would also reduce power generators' ability to remain viable in the competitive Texas market and would, therefore, be a disincentive to build new power plants in Texas at a time when the lack of new power plant starts is already a major concern with ERCOT."[841] Additionally, the mandate might force existing power plants to shut down if compliance with those regulations imposes sufficient costs to make the plants uneconomic, or if plants simply cannot physically install adequate controls in the time allowed for compliance.[842]

Mandating the technology statewide could also result in very expensive retrofits leading to electric rate increases, which would have a profound ripple effect on the entire Texas economy.[843] As the cost of electricity increases, it would be more expensive to treat and distribute water to homes, hospitals, and businesses, and the increased expense of getting water to crops would result in higher food prices.[844]

Hybrid Wet-Dry Cooling

An alternative to the one technology cooling mandate is hybrid wet-dry cooling. Hybrid wet-dry cooling is a combination of wet and dry cooling towers. Hybrid cooling allows facilities to bypass the use of water on cool days, and on hot days the plant can resort to wet cooling.[845] This technology is more energy efficient than dry cooling alone, and consumes less water.[846]

Unfortunately, hybrid cooling has many drawbacks. First, it is expensive to implement and is currently only used in Europe.[847] Further, and more important to Texas' climate, most of the water is cooled in the wet-cooling tower during hot days, which means the system will use the most water when water supplies are the most strained.[848] While it appears to be more efficient, it ends up using just as much water as closed-loop cooling.

New Technologies

Industry is currently exploring new technologies that could help Texas become more energy and water efficient. Implementing new technologies can also have a positive effect on business. Studies show that a $10 billion investment in increasing water efficiency can create between 150 – 250 thousand new jobs.[849] Moreover, this kind of investment can save almost 2 trillion gallons of water.[850]

The Power and Water Division of GE developed a new technology that allows industry to achieve "zero liquid discharge" by converting dissolved substances in water into solids.[851] The ZeeWeed MBR technology uses an immersed hollow fiber ultrafiltration membrane, which produces high quality effluent suitable for direct reuse.[852] The benefits of the MBR over conventional wastewater treatment include a higher quality of water, which creates greater reuse options, greater simplicity, and a smaller environmental footprint.[853] The ZeeWeed MBR technology has generated over $250 million in annual revenues since 2006.[854]

Another technology recently implemented by electric generators is flue-gas desulfurization controls, also known as scrubbers. Scrubbers remove more than 95% of sulfur dioxide from power plant emissions,[855] but the water required in the flue-gas desulfurization process is equal to the amount of water needed to produce electricity.[856] By implementing this technology, the power plant's withdrawal and consumption rates doubles.[857]

On the other hand, new technology is not the only way to increase productivity. Some electric generators have increased power plant efficiency by simply repairing and maintaining equipment in order to minimize water loss.[858] Companies are also using chemical additives to help minimize water usage and enhance pumping capacity at plants.[859] Additionally, electric generators are making small upgrades in their existing cooling technology. For example, generators have changed certain cooling tower arrangements, using computer controlled systems that adjust for certain climatic conditions.[860] These computer controlled systems ultimately minimize cooling water consumption.[861]

Renewable Energy Resources

Texas' Renewable Portfolio Standard has been very successful in reducing water use by encouraging alternative, renewable energy resources such as wind, solar, geothermal, and biomass energy.[862] Many of these resources require essentially no water to operate. These "zero water" renewables accounted for 12.8% of Texas' generation in 2011. [863] Integrating renewable energy resources into Texas generation not only reduces water consumption, it also improves the reliability of the Texas electrical power supply system.[864] These resources can reduce water consumption directly and avoid more severe water scarcity problems in the future.

The integration of renewable energy resources can be seen today in the construction of Competitive Renewable Energy Zone (CREZ) transmission projects. The expansion out of the ERCOT grid will allow for greater development and utilization of the state's wind capacity as well as greater conservation of water resources.[865]

In fact, the competition of CREZ is predicted to conserve approximately 17 billion gallons of water annually. In addition to the substantial water savings, the CREZ project has economic benefits. The total ongoing effect of the CREZ transmission investment includes $1.6 billion in additional revenues for the state and 383,972 new jobs for Texans.[866] The $5 billion investment will help solidify Texas' position at the forefront of the renewable energy industry.[867]

RECOMMENDATIONS

Interplay of Water and Energy

Continue to examine and monitor the interplay of water and energy resources in Texas, especially focusing on the use of water and electric generation.

Drought Management and Energy Generation

Continue to coordinate and enhance communications between regulatory agencies and electric generators, so that implementation of drought contingency measures and state emergency actions do not inadvertently effect electric supply and availability.

Other Initiatives in Electric Generation

Continue to evaluate the economic impact and overall effectiveness of other initiatives, such as one technology cooling and hybrid we-dry cooling, in relation to Texas' climate and demography.

Conservation and Electric Generation

Enhance conservation efforts in the public, private, and utility sectors, by creating and implementing more incentives that encourage generators, users, and consumers to conserve water and electricity.

DESALINATION

PUBLIC HEARING

The House Committee on Natural Resources held a public hearing on its Interim Charge #3 related to desalination on March 22, 2012 at 9:00 a.m. in Austin, Texas in the Capitol Extension, Room E2.010. The following individuals testified on the charge:

Chuck Ahrens, San Antonio Water Systems
Tyson Broad, Sierra Club
Genoveva Gomez, Brownsville Public Utilities
Hector Gonzales, El Paso Water Utility
Kirk Holland, Barton Springs/ Edwards Aquifer Conservation District
Michael Irlbeck, NRS and Abengoa Water
Les Lampe, Black and Veatch
Robert Mace, Texas Water Development Board
Tom Pankratz, Water Desalination Report
Ken Rainwater, City of Seminole/ Texas Tech University
L'Oreal Stepney, Texas Commission on Environmental Quality
William "Bill" West, Guadalupe-Blanco River Authority

The following section of this report related to desalination is produced in large part from the oral and written testimony of the individuals listed above.

INTRODUCTION

The committee was charged with evaluating the status of desalination projects in Texas, including an evaluation of the regulation of brackish groundwater and whether opportunities exist to facilitate better utilization of this groundwater to meet future needs.

There exists a growing trend towards advancing desalination as a water supply source for the state. The trend is predominantly due to the progress of new desalination technologies, as well as the growing need for the development of new water resources. Desalination is a viable solution to immediate needs, especially during a time of drought with few or no other alternatives. For long-term planning, however, high cost remains an obstacle to widespread implementation of desalination. This report outlines the background of desalination technologies and current projects, as well as presents discussions and challenges related to the energy requirements, cost, environmental, and regulatory issues associated with desalination projects.

BACKGROUND

Overview of Desalination in Texas

Texas has historically undertaken innovative strategies to support the state's water demand and advance desalination technology. In fact, Texas was part of the first seawater desalination demonstration project in the United States.[868] In 1958, Congress authorized the U.S. Department of Interior's Office of Saline Water to implement five desalination plants in order to demonstrate the engineering, operation, and economic potential of the most promising water conversion processes.[869] The first of those plants was installed in Freeport, Texas. It operated from 1961 to 1969 and produced 1 million gallons per day (MGD) or approximately 1,100 acre-feet per year.[870] The Dow Chemical Company assisted with the project, consuming half of the water produced and reserving the rest for use by the City of Freeport.[871] In 1965, the first non-demonstration community desalination plant was constructed and began producing 0.25 MGD or approximately 280 acre-feet per year, via seawater electrodialysis.[872]

Desalination continued to be an intricate part of state water planning.[873] In 1997, the Texas Legislature passed Senate Bill 1 to encourage the consideration of alternative water supply options such as reuse and desalination in addressing the future water needs of the state.[874] Today, this is reflected in the 2012 State Water Plan, which calls for increasing the total installed desalination capacity by 309,782 acre-feet per year by 2060.[875] The State Water Plan includes four seawater desalination plants scheduled for completion by the termination of the 50-year planning cycle.[876]

Overview of Technologies in Desalination

The concept of desalination can be effectively summarized as a process by which some device separates saline water into two streams: one stream that is almost free of dissolved salts (the freshwater stream or permeate) and the other stream containing most of the dissolved salts (the concentrated stream or concentrate).[877] The device, regardless of the technology used, requires energy to operate,[878] and the more dissolved solids in the water, the more energy required to separate the minerals from the water.

The two most common types of technology used to remove salts from water are thermal and membrane.[879] Other desalination technologies that have not achieved the same commercial success as thermal or membrane applications include freezing by removing salts during the initial formation of ice crystals, membrane distillation by combining both processes, and solar humidification by using direct solar energy for distillation.[880] Moreover, chemical approaches, such as ice exchange, have been developed but are still impractical for application in waters with high total dissolved solids (TDS).[881]

Thermal/ Evaporation Technologies

One available technology for desalting brackish water or seawater is through thermal technologies, or an evaporation process that uses distillation to produce freshwater.[882] Distillation mimics the natural water cycle whereby salt water is heated to a boiling point, producing water vapor that is condensed to form freshwater.[883] This kind of process requires large amounts of energy[884] and generally results in relatively small recovery rates with large waste streams.[885] Thus, evaporation-based methods are most commonly used for large-scale, seawater desalination where the source water is very salty and energy is relatively abundant and inexpensive.[886] For example, it has been widely utilized in Middle Eastern countries, largely due to the relative availability of inexpensive energy.[887]

Membrane Technologies

<u>Electrical-Driven Technologies</u>

Membrane treatment processes generally use either electrical-driven or pressure-driven technologies.[888] With a pressure of 70 – 90 psi, electrolysis, also known as electrodialysis, attracts sodium and chloride ions, removing 75% – 98% of the total dissolved solids.[889] Treatment costs for electrical-driven technologies are directly related to the TDS concentration. Therefore, these technologies are best used for brackish waters with a TDS of up to 3,000 parts per million.[890]

<u>Pressure-Driven Technologies</u>

Pressure-driven membrane technologies use osmotic pressure to force freshwater through the membrane, leaving the salts behind.[891] These applications are categorized in terms of the relative size of the membrane pores and include: reverse osmosis, nano-filtration, ultra-filtration, and micro-filtration (from smallest to largest pore size).[892] The most widely used desalination technology is reverse osmosis (RO).[893] To date, brackish groundwater desalination plants in Texas have almost exclusively used reverse osmosis.[894] The last fifteen years have seen an unbelievable growth in RO capacity, with advances in membrane technology and energy efficiency fueling the growth.[895] Internationally, more than 12,600 units now produce over 65 million m^3/d (17.1 billion gallons per day), and it will likely be difficult to displace RO for most new or existing municipal applications.[896]

The essential components of an RO system include the ocean intake, the pretreatment system, the reverse osmosis system, the post treatment system, and the residuals handling system.[897] Intake systems must be specially designed to minimize adverse environmental impacts on marine life in order to avoid impingement on intake screens or entrainment in the withdrawn water.[898] Pretreatment is used to remove turbidity and other undesirable constituents such as organics and microbiological organisms from the water that would otherwise clog the RO membranes.[899] Post treatment of the desalted water is used to disinfect the water and to minimize the corrosive nature of the water.[900]

Overview of Water Sources Used in Desalination[901]

There are three major sources of water used in desalination facilities: brackish surface water, brackish groundwater, and seawater. The major distinguishing factor between brackish waters and seawater is the concentration of TDS. The concentration of brackish waters ranges from 1,000 to 10,000 mg/L TDS, whereas seawater breaches 22,000 mg/L TDS. Desalination requires energy to separate the particulate matter from the water molecules, so it will inherently cost more in energy consumption to desalinate seawater than brackish.

Brackish Desalination

Most of the state's progress in desalination has been among brackish surface water and brackish groundwater. By 1999, 12 brackish desalination facilities were in operation, producing a total of 12 MGD or 13,500 acre-feet per year.[902] Within the past decade, Texas has increased its production capacity by 75% and now boasts more than 90 desalination plants across the state. Of the over 90 plants, 44 are large-scale facilities capable of producing 134,500 acre-feet per year: 56,000 acre-feet per year comes from brackish surface water (12 plants) and the remaining 78,500 acre-feet per year comes from brackish groundwater (32 plants).

Brackish desalination plants are located across the state and every planning region has at least some desalination production.[903] Out of the 16 state water planning regions, the following contain the highest percentages by volume of brackish water produced: Region L in South Central Texas; Region M along the Rio Grande; Region F in West Texas; and Region N in the Coastal Bend area.[904] Although production remains highest in the southern part of the state, El Paso contains the single most productive brackish facility in the country.[905]

Brownsville[906]

Approximately 10 years ago, during severe drought conditions on the Rio Grande that caused the river supply to be in jeopardy, Brownsville undertook the development of a desalination project to diversify its sources of water supply. The Brownsville Public Utilities Board (BPUB) provides water, wastewater, and electrical services to approximately 47,000 households and businesses within the city. Potable water is distributed to these customers from three water treatment plants: two surface water plants which are owned and operated by the BPUB; and a brackish desalination plant, which is owned by the Southmost Regional Water Authority (SRWA) and operated by the BPUB.

During the drought of 2011, BPUB fully utilized its Rio Grande water rights of 29,200 acre-feet of water per year, which has a municipal priority – the highest priority among Rio Grande water rights classifications. BPUB distributed an average of about 6.2 MGD of treated water from this plant to its customers. The desalination plant played an essential role in fulfilling the BPUB's obligations for supplying water to its customers. Although all of Texas suffered from extreme drought in 2011, the City of Brownsville never succumbed to a water shortage. The plant is now undergoing expansion and modification. The SRWA Regional Desalination Plant, completed in 2004, has a current capacity of 7.5 MGD and uses membrane-technology to process brackish groundwater pumped from nearby water well fields. Currently, this plant operates at about 80% capacity. It is expected to operate at its full design capacity of 10 MGD within the next two years.

El Paso[907]

El Paso Water Utility (EPWU) has also been a leader in desalination and reclamation efforts by effectively incorporating these technologies in El Paso County. The Kay Bailey Hutchison Brackish Groundwater Desalination Plant has a current capacity of 18 MGD. In addition to desalinating brackish groundwater, the plant has the ability to blend other groundwater and can produce 27.5 MGD of product water, making it the largest inland desalination plant in the world. The total cost for the desalination plant was $91 million, including $26 million from federal grants. This supply of water provides up to 25% of the city's current annual demand, which in 2010 totaled 37.4 billion gallons of water. Furthermore, EPWU plans to pursue more desalination projects within the next 20 years and expects to begin developing new water infrastructure projects during the upcoming legislative session.

Other Locations[908]

The North Alamo Water Supply Corporation is the largest water supply corporation in the state, encompassing 973 square miles and serving more than 33,000 meter connections and an estimated 140,000 people. It operates three brackish desalination facilities: the Donna Brackish Desalination Facility in Donna, Texas; the Owassa Brackish Water Reverse Osmosis Water Treatment Plant; and Doolittle Brackish Water Reverse Osmosis Water Treatment Plant in Edinburg, Texas. The Donna facility was the first water supply project completed in Texas under a design-build contract and has a capacity of 2.5 MGD. The Owassa and Doolittle facilities are co-located with existing surface water treatment plants and currently save approximately $18 million in surface water rights. They individually produce 3 MGD of desalinated brackish water, which is blended to produce a total output of 3.5 MGD per plant.

The North Cameron Regional Water Authority was created in 2004 by the North Alamo Water Supply Corporation, the East Rio Hondo Water Supply Corporation, and the City of Primera to provide an alternative water supply to the Rio Grande by developing a brackish desalination plant.[909] It currently operates two facilities: the La Sara Brackish Desalination Facility in Lasara, Texas and the North Cameron Regional BWRO WTP in Harlingen, Texas.[910] The La Sara desalination facility replaced the existing surface water treatment plant, allowing the facility to make use of existing infrastructure and reducing capital costs.[911]The North Cameron Regional facility has a capacity of 2.25 MGD and saves 2,800 acre-feet in water rights at a capital value of $5.8 million.[912]

Seawater Desalination

Texas is still further exploring the idea of using seawater in desalination plants, as it is an abundant source of water and has lower disposal costs – both financially and environmentally. There are several plants expected to be constructed in the coming decades primarily as recommended water management strategies, including in South Padre Island, in the Brownsville Ship Channel, in Freeport-Brazos River Authority, in Seadrift-San Antonio, and in the City of Corpus Christi.[913]

South Padre Island

The Laguna Madre Water District (LMWD) in South Padre Island, Texas has completed a seawater desalination feasibility and pilot study.[914] In 2008, LMWD, with financial assistance from the Texas Water Development Board, contracted with NRS to conduct a pilot study on South Padre Island to evaluate available treatment technologies under site-specific conditions.[915] Having demonstrated the feasibility of seawater desalination, NRS is currently working with LMWD to develop a full scale 1 MGD seawater reverse osmosis facility in the same area, providing LMWD customers a more secure long-term water supply.[916] This facility is expected to have a capacity of 1,121 acre-feet per year and will cost $1,561 per acre-foot.[917]

Brownsville

BPUB has also undertaken a seawater desalination demonstration project. In 2003, the Texas Water Development Board selected BPUB as one of these initial projects to demonstrate the feasibility of seawater desalination in the state.[918] Based on the feasibility of the report, this project was the only project selected to move forward to the piloting phase in 2006.[919] The pilot project ran from February 2007 to July 2008 and provided an opportunity to evaluate actual performance of proposed water treatment systems under site-specific conditions.[920] After initiating the pilot project, BPUB determined that it would be most beneficial to implement a variety of technologies at the facility in order to conduct a side-by-side comparison.[921] Therefore, they added two additional membrane-based pretreatment units on top of the ultrafiltration and conventional systems in place, increasing the project budget by $1 million.[922] The highly complex results of the project and technological comparisons were used to refine the design and cost estimates for a full-scale 25 MGD seawater desalination facility.[923] The new plant is expected to have a capacity of 2,803 acre-feet per year, costing approximately $1,170 per acre-foot.[924]

Other Locations[925]

Three additional seawater desalination plants are expected to be completed at other locations by 2060. The City of Corpus Christi plant, expected to be completed in 2040, will have a capacity of 28,000 acre-feet per year and is projected to cost $1,696 per acre-foot. The Freeport plant, expected to be completed in 2050, will have a capacity of 33,600 acre-feet per year and is projected to cost between $1,730 and $2,376 per acre-foot. The Seadrift-San Antonio plant, expected to be completed in 2060, will have a capacity of 84,075 acre-feet per year and is projected to cost $2,284 per acre-foot.

Agency Oversight/ Statutory Regulation over Desalination

Texas Water Development Board[926]

The Texas Water Development Board (TWDB) is the state agency with the primary responsibility for providing state water planning and financial assistance to local entities for the completion of projects listed in the State Water Plan. To accomplish its goals of planning for the state's water resources and providing affordable financing for water and wastewater services, the TWDB provides overall water planning, data collection and dissemination, financial assistance, and technical assistance services to the citizens of Texas. The continual threat of severe drought and the tremendous population growth that the state continues to experience, intensifies the need for the TWDB to accomplish its mission under the current Senate Bill 1 planning process and to further provide financial support to local water providers in an effective and efficient manner. In this role, TWDB serves as a resource, both through research and financial assistance, for the continued development of desalination in the state.

Texas Commission on Environmental Quality

The Texas Commission on Environmental Quality (TCEQ) is the environmental agency of the state that oversees the regulatory compliance of water produced and water disposed during the desalination process. Several authorizations are required for desalination facilities: regulating drinking water standards, piloting studies, permitting injection wells, and permitting wastewater discharges.[927] The TCEQ recognizes the need for and importance of desalination projects and works with public water systems (PWSs) and other desalination facilities through pre-application meetings to facilitate the authorization process.[928]

Drinking Water Standards and Pilot Studies

The desalination treatment process is used by PWSs to convert brackish surface water, brackish groundwater, or seawater to safe quality drinking water by reducing TDS and other dissolved salts.[929] Desalination treatment also removes other primary and secondary drinking water constituents of concern.[930] The maximum contaminant level for TDS is established as 1,000 milligrams per liter.[931]

Chapter 290 of the Texas Administrative Code establishes rules and regulations for a PWS related to minimum design, operating, monitoring, and reporting criteria.[932] Where no minimum design, operating, monitoring, or reporting criteria are specifically established for a treatment process, that process is approved through an exception. Innovative or alternative treatment processes, such as those used for desalination, do not have established criteria and are thus approved through exceptions.[933]

The TCEQ also requires that PWSs using the desalination process provide a site-specific pilot study report or a report from an alternate treatment facility with a similar raw water quality report in order to determine compliance with drinking water standards. A plan review is then required following pilot study approval. For desalination plants, the plan review process includes review of the engineering plans and specifications to verify that the design will meet the criteria conditions of the granted exception and design criteria.

Injection Wells

An inherent byproduct of the desalination process is waste brine. The use of injection wells under the state's federally authorized Underground Injection Control (UIC) program is the most common option for managing nonhazardous desalination concentrate or nonhazardous drinking water treatment residuals (DWTR).[934] Chapter 27 of the Texas Water Code, the Injection Well Act, classifies injection wells into five different types.[935] Class I wells are the most commonly used for deep injection.[936] Since 2008, the UIC program has authorized the use of a Class I well to inject nonhazardous desalination concentrate (brine) or nonhazardous water treatment residuals from public water systems.[937] For example, in preparation of implementing their brackish water desalination project, the San Antonio Water System (SAWS) has been approved for five Class I injection wells under their general permit.[938] Construction of SAWS' first Class I disposal well was completed this year.[939]

Furthermore, the TCEQ UIC program has permitted some Class I wells that are dually permitted as Class II wells by the Texas Railroad Commission, an option that is available under the UIC general permit for existing Class II wells that meet Class I standards.[940] In these cases, the owner or operator must comply with the provisions of both permits, with the more stringent requirements prevailing for overlapping permit conditions.[941] Lastly, another option for disposal of nonhazardous desalination brine and nonhazardous DWTR may be disposal through a Class V well.[942] Class V wells inject nonhazardous fluids into or above formations that contain underground sources of drinking water.[943]

Wastewater Discharge[944]

Section 26.121 of the Texas Water Code requires an authorization (permit) from the TCEQ prior to the discharge of wastes into or adjacent to any water in the state. Disposal of wastewater generated by desalination treatment equipment requires either a Texas Pollutant Discharge Elimination System permit if discharge will be to waters in the state or a Texas Land Application permit if disposal is by evaporation or irrigation. The permitting process is site specific and requires two public notices.

DISCUSSION AND CHALLENGES

Water Use and Demand[945]

As a consequence of Texas' prevailing weather patterns, main-stem reservoirs have been an attractive and efficient water supply strategy for the state: water stored during the wet periods can be used to get through the dry ones. During the 20th century, this strategy served Texas well. In response to major drought events, Texas made an unprecedented investment in reservoir construction that ensured water supplies kept pace with population growth, despite recurring periods of little rainfall. In the 21st century, reservoir construction slowed because either most of the state's dependable freshwater resources have been developed or other challenges impede the development of currently designated reservoir sites.

This has resulted in an increased awareness that Texas should implement new approaches to ensure adequate water supplies for a continually expanding population in a drought-prone climate. Desalination is one of those strategies because it essentially taps into an unutilized and abundant water resource. The State Water Plan has considered desalination to be a vital strategy to ensure the future of Texas water supplies. Recent technological advances have made construction and operation of desalination facilities much more feasible than before; however, various challenges and impediments to this innovative strategy still remain.

Drought

Texas suffers from sporadic yet severe drought conditions. Although the state has not suffered a drought of such intensity and duration since the 1950s, Texas does regularly experience serious dry spells of short duration, as exemplified by the 2011 drought.[946] If severe dry climatic trends continue, the worst one-year drought on record of 2011 could eclipse the drought of the 1950s and become the new drought of record.[947] Moreover, Texas' water supply is exacerbated by its rapidly growing population. As the state's population increases, so does the state's vulnerability to drought conditions.[948] The hard reality that current water supplies will not be enough to meet growing demands means that Texas and its local water providers must aggressively plan, fund, and pursue a rich portfolio of water projects.

Around the world, progressive water purveyors are using a portfolio of supplies to ensure resilience against prolonged droughts.[949] These utilities are continuing to use conventional surface and ground water supplies, but are supplementing these supplies with desalination facilities.[950] For example, the drought and lack of water supplies that Texas is currently experiencing can be compared to the conditions Australia went through from 2000 − 2010. Black and Veatch, an engineering firm that focuses on constructing desalination plants globally, assisted water suppliers in Australia respond to this severe drought, where the storage levels of multiple reservoirs in Australia fell to between 15% – 30% capacity.[951] In the midst of its significant drought, major water providers in Australia increasingly turned to seawater desalination as a drought-proof source of water supply.[952] With two additional major desalination plants scheduled to go online during 2012, the total capacity of ocean desalination facilities serving major cities in Australia will be almost 390 MGD.[953] These will provide 38% of the water supply for Perth, 27% of the water supply for Brisbane, 30% of the water supply for Sydney, 33% of the water supply for Melbourne, and 50% of the water supply for Adelaide.[954]

Nevertheless, aggressive implementation should never be a complete substitute for smart, cost-effective planning. Although desalination facilities came alive quickly and curbed a lack of water supplies, some plants now lay dormant costing the taxpayers significant sums of money. Once the drought ended and reservoirs filled, the more costly water produced by the desalination plants became superfluous and unnecessary. Therefore, as technology advances and desalination becomes more viable, a number of valuable lessons from Australia's drought should be considered.[955] First, a portfolio of supplies is more reliable than a single source of supply. Second, the large cost of infrastructure to provide reliable water supplies led to water rate increases for major utilities of two and three times what the rates were before the drought. Lastly, the urgency with which some large water supply infrastructure projects were completed led to construction costs that were much greater than if a more orderly process could have been followed.[956]

Challenges of Desalination

Energy Intensive

One of the biggest concerns related to implementing brackish water, and especially seawater, desalination plants is the high amount of energy used in the desalination process.[957] For instance, the energy usage for seawater desalination is 44 – 75 times that of fresh surface water treatment alone (not including transport costs), and energy usage for brackish desalination is 18 – 44 times that of fresh surface water treatment.[958] Energy requirements for seawater desalination are usually around 12 – 16 kWh per thousand gallons of product, and those for brackish water desalting are usually in the range of 1 – 3 kWh per thousand gallons of product.[959] It takes approximately 800 kWh to produce enough desalinated water for one person on an annual basis, which is 6% of the average electricity a Texan currently uses on an annual basis.[960]

Moreover, traditional energy production also requires the use of some water for cooling purposes. Desalination plants require high amounts of energy, so when using traditional electricity generation, the plant will also require additional water sources to keep it running.[961]

For instance, a 25 MGD desalination facility must withdraw an additional 4 – 17 MGD to provide the electricity to the plant.[962]

Environmental Impacts

Waste Disposal of Brine

An inherent byproduct of the desalination process is waste brine. Brine is the concentrated dissolved solids separated and removed from the sourcewater during desalination. Seawater generally produces 55 gallons of waste brine for every 100 gallons of seawater put into the desalination process. Brackish water, on the other hand, produces between 10 – 25 gallons of waste brine for every 100 gallons of brackish water withdrawn from the source. [963]

Brine can be disposed of in a number of ways, many of which involve disposal away from the facilities. Disposal most commonly occurs through injection into a deep well or by a surface discharge via a wastewater treatment plant. Alternatively, zero liquid discharge can be used to convert the waste salts to a solid form for disposal.[964] Coastal desalination plants usually dispose of brine into the ocean.[965] The process for all of these disposal methods is quite rigorous in Texas.

Environmental advocates enumerate the various potential environmental concerns related to these disposal methods. Disposing brine into streams and sewer treatment plants may cause problems from the changing salinity levels, as well as from contaminants from the sourcewater, especially hydrogen sulfide and low levels of dissolved oxygen.[966] Further, residual chemicals used to prevent fouling and scaling are 4 – 10 times the original concentrations after the reverse osmosis process.[967]

In addition, disposal into injection wells also has inherent downfalls. For instance, the receiving aquifer has a limited capacity to assimilate brine over the long term.[968] Thus, there is a need to identify alternative locations for disposal.[969] Further, a 2008 Texas Water Resources Institute (TWRI) study noted the need to identify specific groundwater quality traits that may influence the extent to which concentrates from brackish desalination may be treated as a hazardous waste: parameters include naturally occurring metals (arsenic) and naturally occurring radionuclides.[970]

Other Environmental Impacts[971]

Other environmental impacts of implementing desalination projects include the potential for the entrapment or entrainment of aquatic species and potential impacts to aquifers. Brackish groundwater use is fairly new, so the hydrologic impacts of pumping from these saline aquifers is not necessarily well known or well modeled. Therefore, it would be beneficial to continue refinement of groundwater models for brackish aquifers, especially where there is potential to impact freshwater aquifers, such as the Carrizo-Wilcox Aquifer. Furthermore, it would be worthwhile to properly locate projects that have sufficient confining layers, such as in areas of the Carrizo-Wilcox Aquifer, to prevent impacts from brackish pumping. Ultimately, it is important for brackish desalination projects to work closely with local groundwater districts in properly siting desalination projects.

Cost

Overall costs for desalination plants include the capital costs of the facilities and the life-cycle expenses, including energy costs.[972] These costs can vary widely depending on a variety of factors, such as the source of water, permitting requirements, energy costs, and facility costs needed to integrate the desalted water into the municipal or industrial water supply system.[973] Additional considerations that increase overall costs include: the raw water quality; the brine disposal method; the number and depth of production wells; the facility size or production capacity; the existing finished water storage and distribution facilities;[974] and the funding and project procurement method.[975] Finally, a major cost component to consider is the ultimate transportation cost of the desalted water.[976]

The Sierra Club estimates that desalinated brackish water costs about $1,200 – $1,300 per acre-foot or about $4 per 1,000 gallons.[977] This number is reflected in the State Water Plan. NRS, however, also provided general data on brackish desalination costs, finding that all-in unit costs range from $1 – $3 per 1,000 gallons of finished water, or $325 – $1,000 per acre-foot.[978] Texas brackish desalination facilities generally fall within this cost average. The capital costs in 2011 dollar equivalents of three major desalination facilities in Texas averages around $3.8 million per million gallons of installed capacity, and the operation and maintenance costs range from $0.65 to $1.16 per 1,000 gallons of water produced.[979] The Kay Bailey Hutchison Brackish Groundwater Desalination Plant in El Paso produces 27.5 MGD (~ 31,000 acre-feet per year) and cost $91 million.[980] The operation and maintenance costs of the Kay Bailey plant results in $212 per acre-foot.[981] The Southmost Regional Water Authority (SRWA) Brackish Groundwater Desalination Plant in Cameron County produces 7.5 MGD and cost $23 million. The operation and maintenance costs of the SRWA plant results in $378 per acre-foot.[982] The North Cameron Regional Water Supply Corporation is currently being equipped to produce its final capacity of 2.5 MGD (~ 2,800 acre-feet per year), and is projected to cost $8 million.[983] The operation and maintenance costs of the plant will result in $310 per acre-foot.[984]

Seawater desalination facilities, on the other hand, generally have higher costs than brackish desalination facilities due to higher levels of TDS, higher energy requirements, different brine disposal locations and practices, and longer transport distances. Recent global unit capital costs for ocean desalting facilities with capacities of 25 – 90 MGD have ranged from $2 – $8 per gallon of capacity.[985] NRS also provided general data on seawater facility costs, estimating that small-scale seawater facilities (<10 MGD) range from $4 – $6 per 1,000 gallons of finished water; and large-scale seawater facilities (>10 MGD) range from $2 – $12 per 1,000 gallons produced.[986]

Although Texas currently has no operating seawater desalination facilities, local water providers have completed seawater desalination pilot plants, and the State Water Plan incorporates data-driven cost estimates for seawater desalination facilities. For instance, the South Padre Island seawater pilot plant was estimated to cost $4.79 per 1,000 gallons.[987]

Additionally, the Region L and State Water Plans estimate that seawater desalination projects cost almost $2,300 per acre-foot, or $7 per 1,000 gallons of desalinated water produced, where 52% is treatment cost and the remainder is transport cost.[988]

Proponents of desalination argue that despite high costs, there are various reasons to continue developing desalination technologies and implementing new desalination facilities. For one, the performance of brackish water and seawater reverse osmosis membrane technology is predictable and can be accurately modeled,[989] thus providing a solid approach to alleviating water shortages. Moreover, membrane technology is continually improving[990] and will likely decrease in cost in the near future. Modeling approaches can also be used to estimate treatment performance as well as the cost differences between treating brackish water of varied concentrations.[991] Finally, water conservation, which is an alternative strategy to desalination, is expensive, generally costing $600 per acre-foot, or nearly twice as much as a brackish desalination facility costs to operate.[992] Therefore, the costs of desalination should not impose an absolute barrier to implementing these new options because Texas needs to develop a rich portfolio of water projects.

Financing[993]

Local funding for water supply projects usually comes from the rates and charges that water utilities assess customers in support of the capital and operational portions of projects. The total cost to operate any water treatment project includes the capital costs of infrastructure and the operational costs of electricity, chemicals, and labor. Both capital and operating costs can be significant. If traditional 20-year debt financing assumptions were applied to a project, the local contribution through operation and maintenance revenues alone would amount to 40% – 50% of total project costs.

Texas has traditionally supported the development of water resources through financial assistance programs. Following the Drought of the 1950s, a number of Texas communities embarked on developing major water supply projects. These projects were funded through a combination of federal, state, and local resources. The TWDB actively participated in many of these projects, primarily through the Storage Acquisition Program, the forerunner of today's State Participation Program. The State Participation Program is ideally suited to support a state interest in local projects that are not sustainable at the current customer base. Low interest loans through the Drinking Water State Revolving Fund also appear to be a viable alternative, but funding is limited in total amount and competitive in an annual funding cycle. There are numerous other fund options, however, that may be used to develop water supply projects, including the Water Infrastructure Fund, Economically Distressed Areas Program, Rural Water Assistance Fund, and Development Fund II.

Agency Oversight/ Statutory Regulation over Desalination

Texas Water Development Board

Funding for Desalination[994]

The TWDB participates in both seawater and brackish groundwater desalination funding, awarding nearly $7 million in the last 10 years alone for various desalination initiatives. Since 2003, the TWDB has awarded approximately $3.3 million in grants related to research and development of seawater desalination. These grants supported seawater desalination projects in Brownsville, Laguna Madre River Authority, Corpus Christi, Brazos River Authority, and South Padre Island, as well as other initiatives. In addition, since 2002, the TWDB has awarded approximately $3.7 million in grants for 21 separate brackish groundwater desalination projects.

The types of projects funded by TWDB vary for seawater and brackish water desalination because the stage of research and development, as well as technologies for each type of sourcewater, are significantly different. Projects associated with seawater desalination include: feasibility studies; seawater pilot plant studies; drafting permitting guidelines; and scoping permitting issues. Projects associated with brackish desalination include: preparing guidelines for implementing desalination projects; improving the economics of desalination by reducing and optimizing energy use; demonstrating methods for reducing the volume of concentrate; seeking cost-effective methods for disposing of the concentrate; and increasing the knowledge of the brackish portion of the aquifers of the state to facilitate the planning and engineering of brackish groundwater desalination projects.

Moreover, the TWDB has sought funding and partnering opportunities to advance desalination issues, including several projects with the U.S. Bureau of Reclamation. The following initiatives have been funded: pilot and assess the feasibility of variable salinity processes, and preparing guidance for rapid assessment and implementation of temporary emergency supplies using desalination. The following initiative is pending: developing desalination cost curves to assist in the cost estimating of brackish groundwater desalination projects.

Texas Commission on Environmental Quality

Pilot Studies for Desalination

Although this process is generally lengthy and requires immense amounts of expertise, pilot studies also provide engineering companies practical opportunities to work through the challenges associated with implementing their innovative technologies on a full scale.[995] Most desalination technology is extremely complex, so the process of moving from a feasibility report to a pilot project to full scale operation can easily become frustrated, and complications can arise. Therefore, the pilot process is generally welcomed by most companies.

On the other hand, some companies, such as Abengoa, have already constructed and operated numerous desalination facilities and find the pilot study requirement costly and unnecessary.[996] Even companies that might find the general process useful believe it could be abbreviated. In an effort to reduce the costs and time required to conduct these pilot studies, the TCEQ is participating in a TWDB project to find practical alternatives to the pilot testing process.[997] Currently, the project is in the first of three stages that will eventually result in a revised TCEQ guidance document for the development of brackish groundwater. The project is scheduled to be completed by the first quarter of 2014.In some instances, the state can eliminate pilot testing and reduce the time required to implement a project by 6 – 12 months.[998] This can also reduce the costs for implementing a project by as much as $500,000 to $1 million.[999]

Moreover, desalination is stilled as an "alternative technology" with no firm design standards. This requires a preliminary "process review" by the TCEQ's technical review group. This process may take a month or more, discounting the time and expense involved in preparing the documentation for the TCEQ's review. The Texas Desalination Association recommends streamlining this review process into a single review, which is the second step in TCEQ's plan review process.[1000]

Injection Wells for Desalination

As previously discussed in the Background, TCEQ authorizes the use of injection wells for the disposal of wastes generated by desalination.[1001] The permitted authorizations for injection wells may be limited in some instances, however. The Barton Springs/ Edwards Aquifer Conservation District (BSEACD) claims that there are statutory barriers to practically and cost-effectively disposing of concentrate in feasible locations.[1002] Whereas both deep injection wells and long-distance transmission of concentrate for disposal can be prohibitively costly for some water suppliers, disposal of brine into the saline zone of an aquifer, such as the Edwards, could provide a feasible and less expensive option for brackish desalination facilities. Under current law, only Edwards water that has not been chemically, biologically, or physically altered can be injected into or through the Edwards freshwater zone. Although this prohibition was intended to protect the freshwater Edwards resource, it was not envisioned to apply to the large saline zone, and thus presents a potentially unnecessary barrier to development of brackish groundwater desalination facilities in the area.[1003]

Wastewater Discharge for Desalination[1004]

When discharged to a surface water or a wastewater plant discharging to a surface water, disposal of desalination brine water may impact the quality and sustainability of waters of the state. As such, it has become increasingly difficult to discharge these brine wastewater flows to both surface waters and wastewater plants that discharge to waters of the state. Alternative disposal methods are needed and additional research and development is this area is warranted.

Groundwater Conservation Districts

Landowners in Texas own the groundwater below their property.[1005] The state retains police power, however, to reasonably regulate groundwater withdrawals through local groundwater conservation districts (GCDs).[1006] GCDs are required to develop and implement plans for the effective management of groundwater, and separate GCDs may have different requirements for complying with well registration and production permits.[1007] Therefore, permitting requirements for developing groundwater depend largely on where the potential water well field is located.[1008] Although this regulatory scheme can encourage local control and responsibility, it can also create obstacles to untapped resources.

Another issue related to GCDs is whether they have the regulatory authority to manage brackish groundwater along with fresh groundwater. GCDs are required to determine available water supply through a modeled available groundwater (MAG). These MAGs are created through desired future conditions and scientific models of available fresh groundwater. MAGs are then used to determine the availability of water resources for permitting in a GCD. Currently, it is unclear whether these MAGs must also include brackish groundwater supplies. Moreover, many GCDs already have limited access to science that might help determine a MAG for fresh groundwater resources. If GCDs are further required to determine MAGs for brackish water resources, access to more science and standardized methodologies for determining brackish groundwater will be necessary.

One example that illustrates the inconsistencies in groundwater management related to water type can be found in the Edwards Aquifer Authority Act (EAAA). There is no distinction between fresh groundwater and brackish groundwater in the statutorily defined maximum withdrawal limitations of 572,000 acre-feet per year and related curtailment limits.[1009] These withdrawal limits were established to maintain freshwater aquifer levels during drought, to protect springflows and endangered species at the spring outlets, and to maintain base flows downstream.[1010] While these goals are critically important, appropriately designed water well fields and withdrawal rates in the saline zone of the aquifer, at least at some specified minimum distance away from the saline-freshwater interface, will not hydrogeologically or materially affect the freshwater aquifer levels and springflows.[1011]

Currently, brackish groundwater withdrawals count against those statutory limits in the EAA jurisdiction exactly the same as fresh groundwater withdrawals.[1012] Brackish groundwater supplies are also priced as a resource exactly the same as freshwater resources, and that price is currently very steep for a saline water supply that then needs considerably more expensive treatment.[1013] BSEACD purports that there is no scientific or other reason that brackish Edwards water should be included in the statutory and regulatory ceilings of the EAAA.[1014] Overall, clarifying whether there is a distinction between fresh groundwater and brackish groundwater in the EAAA and more generally, and removing impediments to accessing brackish groundwater resources would both make desalination available in places that could benefit from in the most.

RECOMMENDATIONS

Pilot Studies and Permitting

Consider the effectiveness of pilot studies and testing requirements in the development of desalination projects.

Continue streamlining the process review for planning in order to expedite the permitting process for a desalination plant.

Local and Regional Planning

Encourage local and regional entities to further consider desalination as an available alternative water supply to meet immediate demands, especially in times of drought.

Waste Disposal of Brine

Continue studying the environmental impacts of brine disposal, while continuing to improve and advance more cost-effective disposal methods.

Distinguishing Between Fresh Groundwater and Brackish Groundwater

Consider clarifying statutory language in order to distinguish fresh groundwater from brackish groundwater in the management and development of groundwater resources.

AGRICULTURAL IRRIGATION CONSERVATION

PUBLIC HEARING

The House Committee on Natural Resources held a public hearing on its Interim Charge #4 related to agricultural irrigation conservation on March 22, 2012 at 9:00 a.m. in Austin, Texas in the Capitol Extension, Room E2.010. The following individuals testified on the charge:

Vivien Allen, Texas Tech University
Wayne Halbert, Harlingen Irrigation District
Laura Huffman, The Nature Conservancy
Robert Mace, Texas Water Development Board
Garry McCauley, Texas AgriLife Research
L'Oreal Stepney, Texas Commission on Environmental Quality
C.E. Williams, Panhandle Groundwater Conservation District

The following section of this report related to agricultural irrigation conservation is produced in large part from the oral and written testimony of the individuals listed above.

INTRODUCTION

The committee was charged with studying ways to enhance incentives for water conservation in agricultural irrigation. Agriculture is a vital industry to the State of Texas, employing 14% of the state's workers and covering over 130 million acres with farms and ranches that span from the High Plains of the Panhandle to the Rio Grande Valley and down to the coastal plains.[1015] Agricultural irrigation consumes a generous portion of the state's water, nearly 56% of water used in 2010,[1016] for the production of crops such as cotton, corn, and rice. The small decrease in irrigation demand and the large increase in municipal demand means for the future that the development of water resources and continued advancement of conservation methods are imperative. This report outlines the background of agricultural irrigation practices and discusses the strategies and new technologies used in the industry today.

BACKGROUND

Overview of Agricultural Irrigation

In Texas, 60% of water consumed is used to grow food,[1017] and in certain areas of the state, such as in the Panhandle where agriculture is the predominant industry, that number reaches up to 88%.[1018] Compared to domestic and industrial uses, where only 10% − 20% of the water that can be used is lost, as much as 50% − 60% of water used in agriculture is lost to direct evaporation from ditches and the soil or through plant use or "evapotranspiration" by crops.[1019] Therefore, the potential benefits of water conservation in agriculture are tremendous.

Although Texas is a highly productive agricultural state, it also suffers from sporadic rainfall and periods of severe drought. Water users across the state, including state and local governmental entities, communities, and especially individuals and farmers, should learn about and implement agricultural irrigation conservation strategies. These strategies can come in the forms of best management practices, mechanical retrofits, and new technological innovations.

History of Irrigation Districts in Texas

The Texas Legislature adopted Article III, Section 52 of the Texas Constitution in 1904, authorizing the formation of special districts.[1020] The first legislative action to create "drainage districts" and "irrigation districts" occurred one year later.[1021] Irrigation districts developed and transitioned over time through legislative acts and by addition of other special districts.[1022] For instance, in 1917, the Legislature passed the Conservation Amendment to expand special district purposes by authorizing the formation of conservation and reclamation districts and providing for more liberal provisions related to their powers.[1023] The purpose of irrigation districts, however, has essentially remained unchanged: to deliver irrigation water for agriculture.[1024] Some districts also deliver raw water to cities for treatment, such as those located along the Rio Grande.[1025] There are several types and countless numbers of special purpose districts currently found across the state, but irrigation districts are located predominantly in the Rio Grande

Basin.[1026] The remaining irrigation districts are generally scattered across the state, including in Tom Green County and Wichita Falls.[1027] There are approximately 25 irrigation districts in Texas.[1028]

Overview of Economy in Texas Agriculture and Agricultural Irrigation

Texas is one of the nation's largest producers of agricultural crops with the economic impact of the food and fiber sector totaling more than $100 billion.[1029] As the nation's leader in number of farms and ranches, Texas encompasses 247,000 farms and ranches covering 130.4 million acres.[1030] Further, one out of every seven working Texans, or 14%, is in an agriculture-related job.[1031] The extensive agricultural industry is especially pronounced in the Texas Panhandle. The Texas High Plains currently generates a combined annual economic value of crops and livestock that exceeds $5.6 billion ($1.1 B in crops; $4.5 B in livestock).[1032] Overall, there are 4 million acres of irrigated crops in the High Plains, which produces 70% of the total net crop revenue of the state.[1033] The region also produces 25% − 30% of cotton and feed cattle in the United States.[1034]

In response to a growing dairy industry and to current U.S. policy placing emphasis on renewable fuels, especially ethanol, agriculture is also changing in the Texas High Plains.[1035] Both the dairy and ethanol industries are increasing demands for grain crops, primarily corn.[1036] Feeds demanded by the dairy industry also include corn for silage and alfalfa, both of which require irrigation at levels above the current major cropping systems in this region.[1037] Increasing grain prices, fertilizer costs, and uncertain energy costs are driving changes in this region, as well as increasing water scarcity.[1038]

Overview of Water Use and Demand in Agricultural Irrigation

Agricultural irrigation consumes drastically high quantities of water. The amount of water required for consumption depends on the type of crop, location of planting, irrigation method, and climate. Irrigated agriculture uses over half of the water in Texas, much of the irrigation taking place in the Texas panhandle, along the southern portion of the Rio Grande, and along the rice producing areas along the coast.[1039] Irrigation demand is expected to decline over the planning horizon by 17%, from 10 million acre-feet in 2010 to 8.3 million acre-feet in 2060, largely due to anticipated natural improvements in irrigation efficiency, the loss of irrigated farm land to urban development in some regions, and the economics of pumping water from increasingly greater depths.[1040]

In the Texas High Plains region, irrigators of the 4 million acres of crops are highly dependent on water from the Ogallala Aquifer.[1041] Over 95% of the water pumped is for irrigated agriculture.[1042] Groundwater supplies are declining in this region.[1043] In fact, the use drastically exceeds the recharge rate.[1044] The Ogallala is declining at a rate of over one foot per year with a negligible recharge rate and a water demand that is expected to continue exceeding supply for the next 10 − 20 years.[1045] The aquifer spans several states and groundwater conservation districts in Texas.

Types of Irrigation Systems

Across Texas, farmers employ three types of irrigation systems.[1046] The first system is a surface-gravity system. The methods associated with gravity are flood, furrow, border, and surge.[1047] Flood irrigation diverts water from ditches to fields or pastures; furrow irrigation channels water down furrows for row crops or fruit trees; border irrigation applies water to sloping strips of fields bordered by ridges; and surge irrigation uses valves that control delivery of water to fields in intermittent surges.[1048] The second irrigation system is a sprinkler-pressurized system.[1049] The methods associated with sprinkler-pressurized systems are pivot and linear systems, side rolls, and solid sets. Pivot and linear systems use high, medium, or low pressure water nozzles; side rolls use mobile pipelines to deliver water across fields using sprinklers; and solid sets user pipes placed on fields to deliver water from raised sprinkler heads.[1050] The third system is a micro-irrigation-pressurized system.[1051] The methods associated with micro-irrigation are surface, sub-surface, and micro-sprinklers. Surface irrigation uses emitters along pipes or hoses to deliver water directly to the soil surface; sub-surface irrigation uses emitters along pipes or hoses to deliver water below the soil surface; and micro-sprinklers use emitters on short risers or suspended by drop tubes to sprinkle or spray water above the soil surface.[1052]

To irrigate effectively, the right amount of water has to reach the right place at the right time.[1053] Generally, greater amounts of water are applied with gravity systems than with sprinkler and micro-irrigation systems.[1054] The various types of agricultural irrigation methods are heavily dependent on the soil and crop. For instance, rice is normally flood irrigated using contour levees.[1055] Traditionally, fields use one inlet depending on the high spots in the field and one or more drains depending on the number of low point near the field parameter.[1056] A rice irrigator will use approximately 4.47 acre-feet per acre per year, calculated over a 10-year diversion.[1057]

Agency Oversight/ Statutory Regulation over Agricultural Irrigation

Texas Water Development Board[1058]

In addition to providing state water planning and financial assistance to local entities, the Texas Water Development Board (TWDB) also provides support for the development of conservation initiatives. They conduct numerous water conservation programs, and help finance the implementation of water conservation research and development by local governmental entities through both loans and grants.

<u>Agricultural Water Conservation Program</u>[1059]

In 1985, House Bill 2 authorized the $10 million Agricultural Trust Fund as a source of financial assistance to promote agricultural soil and water conservation. In 1985, the Texas Legislature also created a $5 million Pilot Loan Program (later renamed the Agricultural Conservation Fund) to loan money to groundwater conservation districts who in turn loan money to producers to install more efficient irrigation systems.

In 2003, Senate Bill 1053 created the Agricultural Water Conservation Program. It is codified in Texas Water Code, Sections 17.897 – 17.912. The associated rules are found in Chapter 367.5 of the Texas Administrative Code. Senate Bill 1053 combined the balances from the previous Agricultural Trust Fund and Agricultural Conservation Fund to create a starting balance of $26,306,650.

The program is used for a number of purposes including: providing loans to groundwater conservation districts who in turn loan the money to irrigators to install more efficient irrigation systems; providing grants to support water conservation demonstration projects; providing grants to local political subdivisions and state agencies to implement local programs of conservation education, irrigation metering, ad irrigation system audits; estimating annual irrigation water for all 254 counties in Texas (as used in water planning and groundwater modeling); developing education materials, distributing literature, and conducting outreach activities at farm and ranch shows, water festivals, and other public events and on the agency's website; and coordinating with the Texas State Soil and Water Conservation Board and U.S. Department of Agriculture-Natural Resources Conservation Science on cooperative activities. Under the program, $7.5 million in loans have been issued, and the program's remaining balance going into fiscal year (FY) 2012 was $17.4 million.[1060] The program estimates that during FY 2007 through 2011, 226,390 acre-feet have been saved through water conservation grants, and 33,406 acre-feet have been saved through water conservation loans.[1061]

In addition to the Agricultural Water Conservation Program, the TWDB also houses the Agricultural Water Conservation Bond Program, created in 1989 to provide bonding authority. The $200 million bond program was authorized by legislation and approved by voters. There is currently $164,840,000 of authority remaining; however, the bond program is not as attractive because repayment has a higher interest rate.

Texas Alliance for Water Conservation[1062]

In 1997, Texas Tech University and its partners began to replicate long-term whole-farm systems research to define more sustainable agricultural systems for Texas' semi-arid region in the Southern High Plains. This project is called the Texas Coalition for Sustainable Integrated Systems, or TeCSIS. The results of this research led to an eight-year, $6.2 million grant in 2004 from the TWDB to create the Texas Alliance for Water Conservation. This project is a demonstration of 30 producer-managed farms engrossing over 4,500 acres that examine all aspects of water, energy, and profitability with the objective of water conservation and economic viability. In this unique project, producers and researchers learn how to collect real-world data.

Texas Commission on Environmental Quality[1063]

The Texas Commission on Environmental Quality (TCEQ) is the environmental regulatory entity of the state. The TCEQ issues water rights permits to individuals, including agricultural irrigation users across the state. Section 11.1271 of the Texas Water Code requires Water Conservation Plans (WCPs) for new and amended agricultural water right authorizations and all agricultural water right holders authorized to use 10,000 or more acre-feet of water per year. WCPs incorporate a strategy or combination of strategies that aim at reducing the volume of water withdrawn from a water supply source, reducing the loss or waste of water, maintaining or improving the efficiency in the use of water, increasing the recycling and reuse of water, and preventing the pollution of water.

DISCUSSION AND CHALLENGES

Drought Impact on Agricultural Irrigation

The amount of water that must be applied by the irrigator is dependent on the amount of annual rainfall. In times of drought, water management conservation can be difficult for agricultural irrigation. For instance, in East Texas the long-term average rainfall has been over 40 inches.[1064] More recently, however, rainfall has been low. In 2008 the amount of rainfall was just under 20 inches. Rainfall was less than normal in 2009, and another record was set in 2011 when the rainfall was just over 18 inches.[1065] This has caused extreme production problems for Texas farmers, especially in the western parts of the state.[1066]

Agricultural Water Conservation Methods

Agricultural water conservation focuses on the efficiency of use and the reduction of demands on existing water supplies.[1067] Many agricultural irrigators achieve water conservation through a variety of conservation methods. In general, programs designed to reduce water usage, as well as educational initiatives, achieve the most savings.[1068]

Conservation methods designed to reduce water usage utilize various strategies and techniques, as well as new technologies. Strategies and techniques include improvement in soil cultivation, integration of agricultural systems, implementation of best management practices, and installation of mechanical retrofits. Agriculture conservation methods through new technologies primarily center around data collection and irrigation management, as well as some automated canal management. It is imperative to realize, however, that water conservation cannot be attained solely by implementing a single strategy or technology.[1069] Incorporation of a variety of strategies can reduce water demand, optimize water use and value, and maintain an appropriate level of productivity and profitability.[1070]

Strategies and Techniques

Conservation Tillage and Sod Based Rotation - Soil Cultivation

One conservation strategy that can improve the efficiency of agricultural water use is the enhancement of soil cultivation through conservation tillage and sod based rotation. A study conducted in partnership with The Nature Conservancy in the Lower Flint River Basin in southwest Georgia, which has many corollaries to Texas in terms of irrigated row-crop agriculture, found that conservation tillage and sod based rotation both positively affected water consumption.[1071] In fact, conservation tillage generates savings by using a cover crop and leaving plant residue in the field, which modifies plant rooting structure and physiology to enable more efficient water use by crops, improves water holding capacity in the soil, increases water infiltration rates, and reduces soil temperature, evaporative loss, and field runoff.[1072] This method reduces water use by up to 15%.[1073] Sod based rotation, on the other hand, generates savings by incorporating a rotation of a warm season perennial grass into a conservation tillage based production system which yields improved soil quality and water holding capacity, and increases water infiltration and retention.[1074] This method reduces water use by up to 30%.[1075]

Integration of Agriculture Systems

Another conservation strategy that can positively improve the efficiency of agricultural water use is the integration of agriculture systems. A 10-year study conducted by Texas Tech University in the High Plains of the Texas Panhandle examined how water consumption is effected by utilizing diversified or integrated systems, such as farming units that incorporate both crops and livestock.[1076] A system that integrates cotton, forage, and beef cattle reduces irrigated water use by 25%, compared to cotton monoculture system.[1077] An integrated system also increases profitability per unit of water invested, diversifies income sources, and reduces soil erosion. Moreover, an integrated system reduces nitrogen fertilizer use by about 40% and decreases the need for other chemicals, all while maintaining similar cotton yields per acre between the two systems.[1078]

Best Management Practices for Rice Farming[1079]

One other conservation strategy that can improve the efficiency of agricultural water use is the implementation of best management practices. Another substantial study performed by Texas A&M AgriLife Research for over 25 years documented numerous best management practices (BMPs) and farming methods related to rice farming in Texas. Interestingly, the daily water use requirements among the different varieties of rice does not fluctuate, but the number of days until maturity does effect the total water use. Additionally, the management unit or field size is important in relation to water use with the optimum field size somewhere between 80 − 100 acres. These factors, along with a number of other considerations, help determine the BMPs for an individual agriculture irrigator.

According to Texas A&M AgriLife Research, one of the most inefficient irrigation practices in rice farming is flushing, or pre-flood irrigation. The average irrigation inflow is 3.3 acre-inches per acre with 42% of this water flowing as run-off after the flush. Developing BMPs can be especially helpful in this case for determining when and how much to flush. For instance, an irrigator should develop BMPs that consider the following: clay soil fields require more flush irrigation than lighter textured soils; stale seedbed planting, or reduced tillage, can reduce the number of flushes required; and flooding early can reduce the number of flushes with no harm to the rice. Other BMPs might include constructing optimal levee spacing to ensure that the largest cut is not at the bottom of the field; utilizing multiple inlets through the use of an earthen lateral down the water source side of the field; conducting shallow flooding during the first part of the season; employing land forming or precision leveling; and maintaining water delivery systems, including transitioning from earthen canals to underground pipe.

Ultimately, implementing agricultural irrigation conservation BMPs saves immense quantities of water. Specific practices and methods have already been proven to ensure higher water savings, but incentives are needed to encourage the use of those practices, as well as to research and develop newer and better methods. For instance, an individual farmer that uses at least two BMPs will result in a 40% water savings. Currently, between 20% and 60% of farmers use at least two BMPs. Assuming there are approximately 180,000 acres of rice being farmed in Texas, irrigated at a rate of 4.47 acre-feet of water per year, the use of two BMPs will save 129,000 acre-feet of water per year. Therefore, it is extremely important to encourage and educate farmers on using BMPs.

Mechanical Retrofits[1080]

One last conservation strategy that can improve the efficiency of agricultural water use is the installation of mechanical retrofits such as low pressure, drop nozzle retrofits with an end gun shut-off. Savings are generated by installing new nozzles that apply irrigation water at a lower pressure nearer the soil surface reducing evaporation and wind drift losses. Furthermore, high-powered "end-guns" that spray water on the edges of a field can be fitted with controls keeping irrigation inside the field boundary by shutting them off over non-planted areas like roads. These retrofits reduce water use by up to 22.5%.

New Technologies

Automated Data Collection and Irrigation Management

Technological advances constitute an important part of furthering conservation potential in agricultural irrigation. One example of how local government has utilized technology to advance community conservation efforts is in the Harlingen Irrigation District, which has designed and installed a telemetry system with Supervisory Control And Data Acquisition (SCADA). This system is the backbone of all other projects throughout the district.[1081] The telemetry system transmits data from remote sites to a central place. Then, it collects, analyzes, and archives the information, displaying it in an easily understood format.

Similarly, other automated data collection and irrigation management systems exist and result in significant water savings. For example, variable rate irrigation (VRI) allows a farmer to refine irrigation patterns through GPS-based software, allowing them to remove non-crop areas from irrigation.[1082] VRI reduces water use by an average of 15%.[1083] In addition, advanced irrigation scheduling (AIS) works in conjunction with VRI by relaying data such as temperature, soil moisture, crop growth stage, and localized evapotranspiration from sensors in the field to the farmers.[1084] Savings are generated by identifying precise periods of time in which a farmer can irrigate less by using this objective field data.[1085] AIS also reduces water use by up to 15%.[1086]

The Panhandle Groundwater Conservation District (PGCD) also utilizes these automated data collection and irrigation technologies, including net irrigate tracking and soil moisture probes.[1087] Data was recorded from 2010 and 2011 on a corn field in Moore County, Texas, both with and without utilizing the technologies.[1088] In 2011, the technologies helped save 10 inches of water pumped, produced 3.8 more bushels per inch of water used, and the total savings amounted to $94.64 per acre.[1089] Revenue in this case increased $192.63.[1090] Overall, these technologies caused the production of more crop utilizing less water.[1091]

Automated Canal Management

An increase in available technologies also enables better management of canal systems for the further conservation of water. Common practices for increasing agriculture water conservation among the canal systems include: converting from canals to pipeline, lining irrigation canals, replacing pipelines, and more efficient irrigation systems.[1092] More innovative solutions also consider the actual operation of the canal system. For instance, the Harlingen Irrigation District developed an automated gate system, which allows the district to control the water in the canal system. This innovative device operates with 12 or 24 volt battery power, charged with wind or solar generators, allowing for the continual operation of systems in remote areas where traditional power is either unavailable or too expensive.[1093] This automated canal management also allows inspectors, otherwise known as canal riders, to view both canal levels and water usage on portable electronic devices, as well as allowing operators make adjustments remotely when necessary.[1094]

Conservation Education[1095]

Furthermore, the opportunity exists across the state for furthering educational initiatives. With each drought recorded and census measured, Texans realize the importance of conservation and the dire need for development of more resources. Water conservation is not only a community effort, however, it must also be an individual goal. Educational outreach programs must be cultivated at all levels in order to raise awareness about the impact that water conservation can have on regional stability. This can include the economic advantages of conservation, as well as the available technologies to accomplish it. In some instances, a major event spurs these initiatives. For example, in the late 1990s and early 2000s, irrigation districts in the Rio Grande Valley experienced devastating agricultural and financial losses due to water shortages mostly brought on by the refusal of Mexico to meet Treaty obligations. The realization that this was not a one-time issue, plus a recognition that rain alone would not meet their needs, has spurred districts to take action on water conservation projects.

Cost Share Programs[1096]

Cost share programs act as an incentive for furthering agricultural water conservation. For instance, in 2000, the Rio Grande Valley irrigation districts worked with local U.S. Congressmen and Senators to pass federal legislation that authorized $80 million in 50% cost share projects. The Harlingen Irrigation District completed a $4.2 million project in 2005 from this legislation. Valley districts combined have completed nearly $70 million in conservation work from this legislation. Although much of these funds have yet to be appropriated, the districts have sponsored new legislation for an additional $80 million, which is currently pending. Cost share programs assist districts in implementing numerous water conservation projects, including pipelines, canal lining projects, improved pumping stations and the automated data systems. Cost share programs should be expanded so that conservation methods become good practices and ethical standards for the whole community.

Agency Oversight/ Statutory Regulation over Agricultural Irrigation

Texas Water Development Board

Texas High Plains Agricultural Water Enhancement Program[1097]

In 2009 the U.S. Department of Agriculture-Natural Resources Conservation Service chose the TWDB as a partner for the Agricultural Water Enhancement Program. The purpose of this project is to encourage irrigated agriculture producers on the Texas High Plains to implement agricultural water conservation practices for more efficient irrigation water use and the eventual reduction in use of irrigation water supplied from the Ogallala Aquifer. To date the federal funding for this program has been $7.2 million in FY 2009, $4.2 million in FY 2010, $5 million in FY 2011, and $5.4 million in FY 2012. Funding for Fiscal Year 2013 is pending under the five-year agreement. Texas has received a total benefit of $21.8 million, thus far. The TWDB should maximize the state's potential for receiving future funds and continue to make available these federal funds for the furtherance of agriculture water conservation measures.

Demonstration Projects[1098]

For the most part, agricultural water conservation efforts are advanced through demonstration projects. In fact, many of the conservation strategies and new technologies such as integrated agriculture systems and automated canal management actually develop through demonstrations. For instance, the Harlingen Irrigation District conducted a demonstration project that used different methods of irrigation on actual farms, as well as provided information to farmers, districts, and management to promote water conservation at every level. Other demonstration projects include: center pivot, side-roll, drip, emitters, flood and combinations of each. Farmers were invited to interact and critique the sites to determine the practicability of each practice on their own operations.

Further, the Texas AgriLife Extension – Farm Assist Program used demonstration projects to determine the cost effectiveness of best management practices, evaluating each demonstrator's operation regarding yield and expense as it pertained to the particular practice. This continues to allow farmers the ability to determine how bottom lines are affected and whether changes in their operations are justified. Moreover, innovative combinations of practices can be analyzed for further recommendations. Demonstration projects funded through the TWDB ultimately provide that management itself is the most important component to any practice. Funds should continue to be made available through the TWDB for demonstration projects on various conservation methods.

Texas Commission on Environmental Quality[1099]

Water Conservation Plans

The TCEQ rules outline requirements for an agricultural water right Water Conservation Plan (WCP). The TCEQ establishes and administers WCP rule requirements for agricultural water rights holders, including individual irrigation use and systems providing irrigation water to more than one user, like an irrigation district. These rules require water-conserving irrigation equipment, leak-detection, repair, and water-loss control, and require irrigation districts to incorporate programs to assist customers in developing on-farm WCPs and system efficiency measures. The rules also require specific, quantified five-year and 10-year targets for water savings. Further, the rules require that agricultural water rights holders submit an updated WCP and implementation report to the TCEQ every five years.

RECOMMENDATIONS

Continue to monitor the advancements of water conservation and agricultural irrigation.

Continue to encourage and support the use of grant and loan programs through state and federal agencies.

Consider ways to enhance incentives for furthering agricultural irrigation conservation efforts through demonstration projects and cost share programs.

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[526] *Id.*

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[530] Oral and Written Testimony of Chris Eugster, CPS of San Antonio, Public Hearing, Texas House of Representatives Committee on Natural Resources, Austin, Texas, June 28, 2012.

[531] *Id.*

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[533] *Id.*

[534] *Id.*

[535] Oral and Written Testimony of William "Skip" Mills, Environmental and Energy Stability, Public Hearing, Texas House of Representatives Committee on Natural Resources, Austin, Texas, June 28, 2012.

[536] *Id.*

[537] Oral and Written Testimony of Jun Chang, City of Houston, Public Hearing, Texas House of Representatives Committee on Natural Resources, Austin, Texas, June 28, 2012.

[538] *Id.*

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[542] *Id.*

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[545] *Id.*

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[552] *Id.*

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[562] *Id.*

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[566] *Id.*

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[570] *Id.*

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[585] *Id.*

[586] *Id.*

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[600] Oral and Written Testimony of William "Skip" Mills, Environmental and Energy Stability, Public Hearing, Texas House of Representatives Committee on Natural Resources, Austin, Texas, June 28, 2012.

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[604] *Id.*

[605] *Id.*

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[611] *Id.*

[612] Oral and Written Testimony of Matt Langley, The Wind Coalition, Public Hearing, Texas House of Representatives Committee on Natural Resources, Austin, Texas, June 28, 2012.

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[616] *Id.*

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[621] *Id.*

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[623] *Id.*

[624] Oral and Written Testimony of Shawn Glacken, Luminant, Public Hearing, Texas House of Representatives Committee on Natural Resources, Austin, Texas, June 28, 2012.

[625] *Id.*

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[631] Oral and Written Testimony of Carey King, Jackson School of Geosciences, The University of Texas at Austin, Public Hearing, Texas House of Representatives Committee on Natural Resources, Austin, Texas, June 28, 2012.

[632] Yun Huang, Bridget R. Scalon, Jean-Philippe Nicot, Robert C. Reedy, Alan R, Dutton, Van A. Kelly, and Neil E. Deeds, Sources of Groundwater Pumpage in Layered Unconfined-Confined Aquifer System in the US Gulf Coast. Aug, 21, 2011.

[633] *Id.*

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[635] *Id.*

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644 *Id.*

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649 *Id.*

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655 *Id.*

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[669] *Id.*

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[697] *Id.*

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[712] *Id.*

[713] *Id.*

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[715] *Id.*

[716] Oral and Written Testimony of Lairy Johnson, Jr., MillerCoors, Public Hearing, Texas House of Representatives Committee on Natural Resources, Austin, Texas, June 28, 2012.

[717] *Id.*

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[719] Oral and Written Testimony of Trip Doggett, Electric Reliability Council of Texas, Public Hearing, Texas House of Representatives Committee on Natural Resources, Austin, Texas, June 28, 2012.

[720] Oral and Written Testimony of Brian Lloyd, Public Utility Commission, Public Hearing, Texas House of Representatives Committee on Natural Resources, Austin, Texas, June 28, 2012. See S.B. 1133, 82nd Leg., R.S. (Tex. 2011).

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[722]*Id.*

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[724]*Id.*

[725] Oral and Written Testimony of Brian Shaw, Texas Commission of Environmental Quality, Public Hearing, Texas House of Representatives Committee on Natural Resources, Austin, Texas, June 28, 2012.

[726] *Id.*

[727] *Id.*

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[729] *Id.*

[730] *Id.*

[731] *Id.*

[732] *Id.*

[733] *Id.*

[734] *Id.*

[735] S.B. 1, 75th Leg., Reg. Sess., (Tex. 1997) (implementing a bottom-up approach to water planning in the state).

[736] Oral and Written Testimony of Bob Holt, GE Power and Water, Public Hearing, Texas House of Representatives Committee on Natural Resources, Austin, Texas, June 28, 2012.

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[739] *Id.*

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[741] *Id.*

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[743] Oral and Written Testimony of John Fainter, Association of Electric Companies of Texas, Public Hearing, Texas House of Representatives Committee on Natural Resources, Austin, Texas, June 28, 2012.

[744] *Id.*

[745] *Id.* (noting that this minor increase in water usage is sufficient to provide electricity for a population projected to grow over the same time frame by 82%).

[746] Oral and Written Testimony of Luke Metzger, Environment Texas, Public Hearing, Texas House of Representatives Committee on Natural Resources, Austin, Texas, June 27, 2012.

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[752] *Id.*

[753] *Id.*

[754] *Id.*

[755] *Id.*

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[758] Texas Water Development Board, Water for Texas 2012 State Water Plan, 6 (2012).

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[1070] *Id.*

[1071] Written Testimony of Laura Huffman, The Nature Conservancy, Texas House of Representatives Committee on Natural Resources, Austin, Texas, Mar. 22, 2012.

[1072] *Id.*

[1073] *Id.*

[1074] *Id.*

[1075] *Id.*

[1076] Oral and Written Testimony of Vivien Allen, Texas Tech University, Texas House of Representatives Committee on Natural Resources, Austin, Texas, Mar. 22, 2012. This research was selected by the USDA as a national model of successful research.

[1077] Texas Alliance of Water Conservation, *2011/ 2012 Site Research Report*, TEXAS TECH UNIVERSITY (2012), http://www.depts.ttu.edu/tawc/ResearchSummaries/Year_7_FinalAnnualReport%20pdf.pdf.

[1078] *Id.*

[1079] Oral and Written Testimony of Garry McCauley, Texas AgriLife Research, Texas A&M University, Texas House of Representatives Committee on Natural Resources, Austin, Texas, Mar. 22, 2012.

[1080] Written Testimony of Laura Huffman, The Nature Conservancy, Texas House of Representatives Committee on Natural Resources, Austin, Texas, Mar. 22, 2012.

[1081] Oral and Written Testimony of Wayne Halbert, Harlingen Irrigation District, Texas House of Representatives Committee on Natural Resources, Austin, Texas, Mar. 22, 2012.

[1082] *Id.*

[1083] *Id.*

[1084] *Id.*

[1085] *Id.*

[1086] *Id.*

[1087] Oral and Written Testimony of C.E. Williams, Panhandle Groundwater Conservation District, Texas House of Representatives Committee on Natural Resources, Austin, Texas, Mar. 22, 2012.

[1088] *Id.*

[1089] *Id.*

[1090] *Id.*

[1091] *Id.*

[1092] Oral and Written Testimony of L'Oreal Stepney, Texas Commission on Environmental Quality, Texas House of Representatives Committee on Natural Resources, Austin, Texas, Mar. 22, 2012.

[1093] *Id.*

[1094] *Id.*

[1095] Oral and Written Testimony of Wayne Halbert, Harlingen Irrigation District, Texas House of Representatives Committee on Natural Resources, Austin, Texas, Mar. 22, 2012.

[1096] *Id.*

[1097] *Id.*

[1098] *Id.*

[1099] Oral and Written Testimony of L'Oreal Stepney, Texas Commission on Environmental Quality, Texas House of Representatives Committee on Natural Resources, Austin, Texas, Mar. 22, 2012.