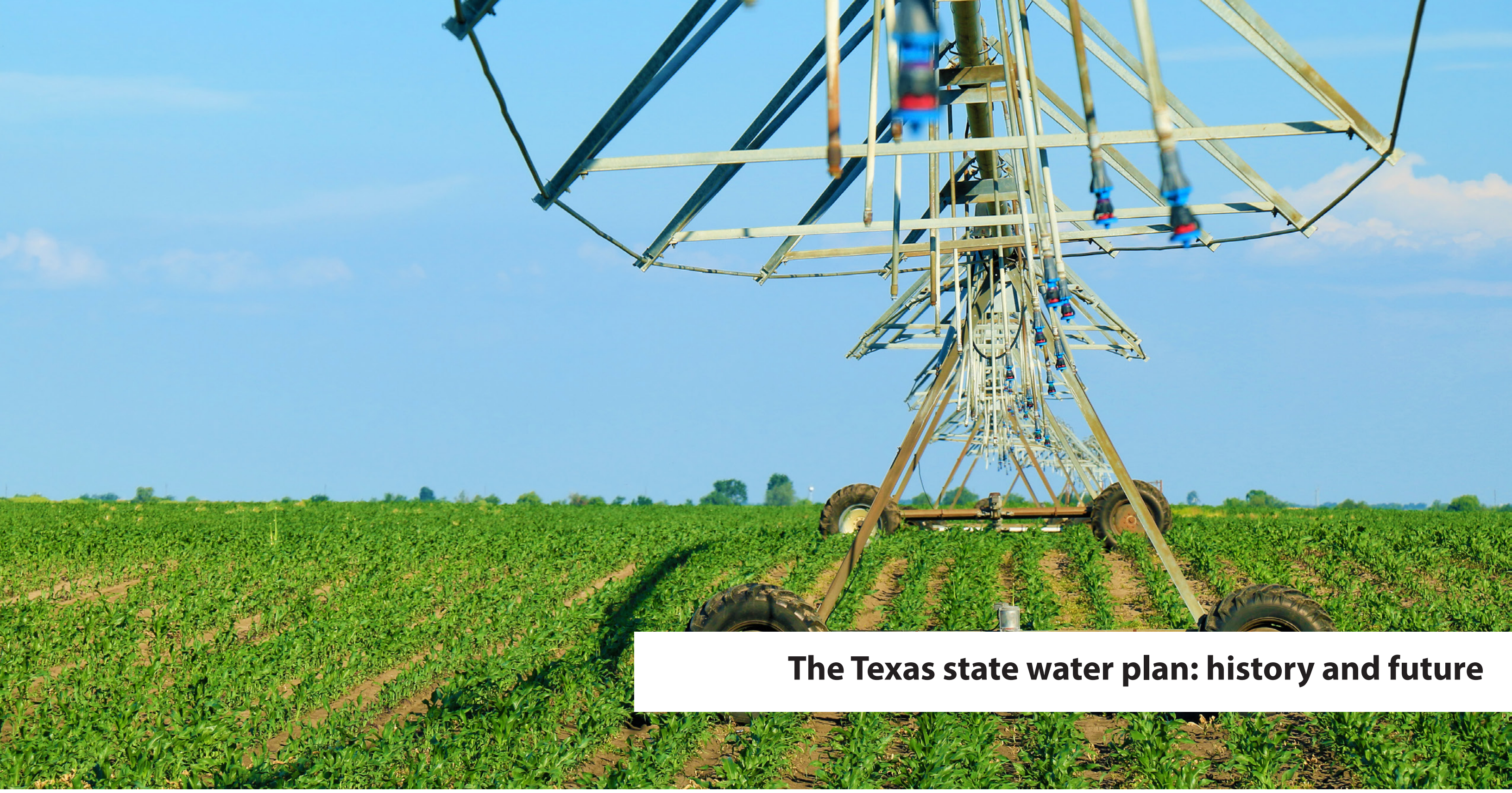

The Texas state water plan: history and future

By Gregory Torrell[1] and Reid Stevens[2]

Abstract

The severe Texas droughts of the 1950s prompted the development of a comprehensive planning framework to guide the state's water policy and investments. The Texas State Water Plan has been regularly updated since the first plan in 1961 and has developed into a system of regional water plans that define the statewide strategies to mitigate the impact of future severe droughts. In this paper, we describe the history of the Texas State Water Plan, some of its shortcomings, and provide recommendations for its improvement. We recommend that the plan include linkages between demands and supplies, allow for flexibility in regional planning, and expand its scope to allow a more holistic approach to water management.

Introduction

State-level water planning in Texas has its roots in the reaction to the massive droughts of the 1950s, which continue to be the basis of comparison for all other droughts in the state. Some effects of those droughts were short-lived: overgrazed pastures were more susceptible to noxious weed invasion, agricultural losses were worse than those during the Dust Bowl Era, and 244 of Texas' 254 counties were declared federal disaster areas (Burnett, 2012; Nace & Pluhowski, 1965; Wythe, 2011). In other areas, the legacy of the 1950s drought has left Texas permanently changed: the number of reservoirs more than doubled from 1950 to 1970, and the number of farms and ranches fell by nearly 100,000 between 1950 and 1960 (Wythe, 2011).

Beginning in 1961, plans for meeting future water demands were developed at the state level by the Texas Water Development Board (TWDB), an agency created near the end of the drought in 1957 (Wythe, 2011). From the first plan in 1961, the Texas State Water Plan (TSWP) has evolved in scope and methodology. In 1997, the Texas Legislature created a new process by which plans would be developed. The previous "top-down" approach,

1 Texas A&M AgriLife Research Center at El Paso and Department of Agricultural Economics, College Station.
2 Department of Agricultural Economics, Texas A&M University, College Station, TX 77843, USA

which used state-level water use projections to determine regional needs, was replaced with a “bottom-up” method, where local stakeholders create regional plans for their water needs. Currently, the state is broken into 16 water planning regions. Each planning region is tasked with determining current and future water supplies, demands, and drought contingencies. Each planning region consults with an engineering firm to assess current and future water supplies and demands as well as prepares recommendations and plans for future water management strategies and investments. These regional plans are compiled into a state-wide document that describes the water plan for the state for the next 50 years. This process is repeated every five years, and the latest plan was adopted on May 19, 2016 by the Texas Water Development Board.

Texas experienced a water supply shortfall in 2011 that plunged most of the state into severe drought. The most damaging impacts during the 2011 shortfall rivaled those of the 1950s drought and did not fully abate until 2015. This caused the 2012 TSWP to receive increased attention from policymakers and the press. Two conclusions from the TSWP were the focus of attention. First, Texas would face a gap between supply and demand of 8.3 million acre-feet (10.2 km^3) of water by 2060. Second, the overall cost of meeting water supply strategies would be $53 billion.

These headline-grabbing conclusions led to the passage of House Bill 4, which created the State Water Implementation Fund for Texas (SWIFT) and the State Water Implementation Revenue Fund for Texas (SWIRFT). SWIFT and SWIRFT are designed to finance revolving loan programs for water infrastructure and conservation projects, as well as requiring the 16 regional water planning groups to prioritize water projects in their regional plans through ranked ordering. Voters approved Proposition 6 in November 2013, enabled by House Bill 4, which authorized $2 billion to be drawn from the Texas Economic Stabilization Fund to fund SWIFT.

The TSWP has changed substantially throughout the course of its over 50-year life. This evolution has moved the TSWP towards a system that is more responsive to local issues, allows decision-making under clearer criteria, and creates a funding mechanism for municipalities, counties, and others to borrow at low interest rates to undertake capital improvement projects. While the history of the TSWP has largely been one of maturation, the water planning process lies at a crossroads--its ability to anticipate and continue to provide for the changing needs of Texas citizens. In the rest of this article, we will describe some of the challenges that the near future holds for this plan.

Demand Forecasts

One of the most common critiques of the TSWP is that it has consistently over-stated future water demands (Figure 1). Since 1968, the demand projections have, on average, been 18.1 percent above actual consumption. This upward bias in demand projections is consistent for all but one of the TSWPs. The 1990 TSWP produced projections that underestimated observed water consumption. Indeed, the demand projections used in the TSWP perform worse than a simple naïve prediction where it is assumed that current trends in water use continue. The problem of increasingly inaccurate projections over time is common, particularly in projections of water demands (Bijl, Bogaart, Kram, de Vries, & van Vuuren, 2016). The phenomenon has come to be called “porcupine graphs” by some commentators due to the distinctive shapes of these projections when compared to realized outcomes (Herberger, Donnelly, & Cooley, 2016, p. 6; Cox, 2010).

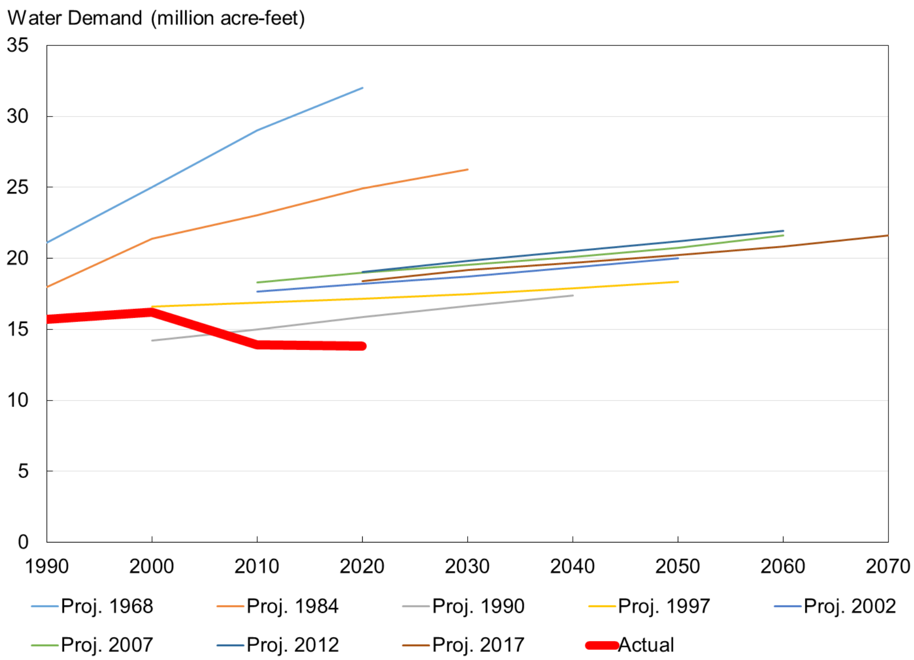

Figure 1: Texas Water Demand Projections

The consistent overestimation of demand by the TSWP is a fact that deserves attention and thought. This is true because of the importance of water demand forecasting in determining the need for supply side maintenance, i.e. for infrastructure building and conservation programs to meet those demands. Currently, demand projections are intended to capture a worst-case scenario by forecasting dry year consumption. However, this may ignore the fact that infrastructure and policies are maintained, and have a cost, in both good and bad water years.

The demand forecasts are estimated by taking population growth predictions and multiplying the current demands by forecasted per capita consumption. The estimates of per capita consumption used are based on a historical dry year by user group, which are adjusted downward slightly for municipal users. This downward adjustment is due to federal and state laws that determine water-use efficiency in fixtures and appliances. Similar to the projections of total water consumption, the projections of per capita water use in past TSWPs have typically overestimated per capita use (Figure 2). In a sense, the per capita water demand forecasts used in the TSWP are an extrapolation of peak demands under drought conditions, with expected population growth. This methodology contains the assumption that water use during dry years is indeed the correct target for the future. However, drought management can be most effective at reducing water use during these dry years, as municipal use is often higher during drought conditions, due to the increased lawn and garden watering during these times. History shows that a third or more of municipal water use during dry periods is used for lawn and garden use (Anderson, Miller, & Washburn, 1980; Kjelgren, Rupp, & Kilgren, 2000).

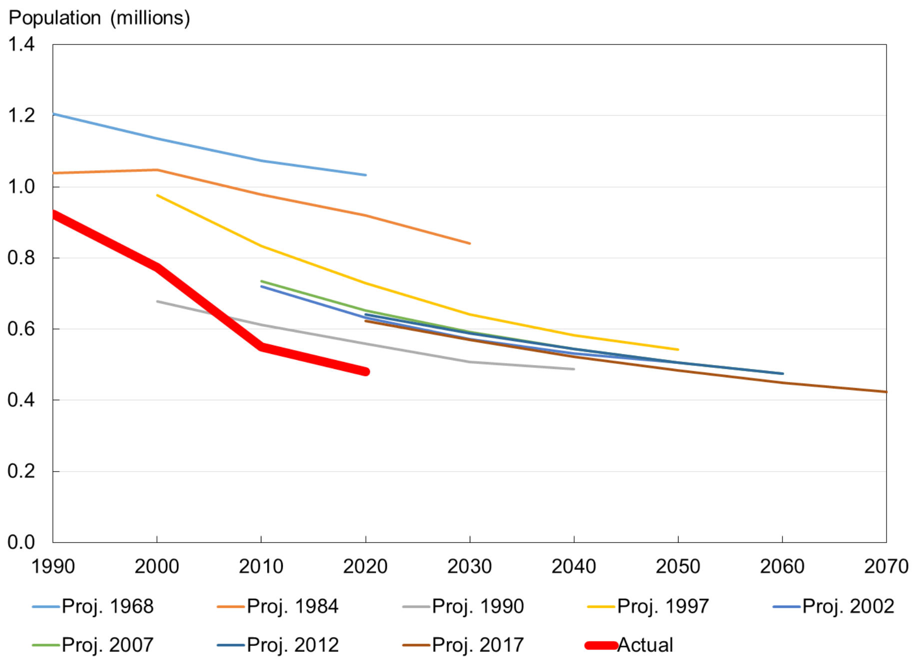

Figure 2: Texas Per Capita Water Use Projections

One area that is not accounted for in the demand projections is a reduction in per capita use that is endogenously precipitated from policy and infrastructure changes. Increasing the costs to water users, changes in attitudes about water use, and conservation campaigns may be able to reduce, delay or eliminate the need for some large water supply projects (Olmstead & Stavins, 2009). Even if the need for water supply projects is taken at face value, and it is assumed that some of these projects will be undertaken, the TSWP fails to encapsulate the effect that these projects will have in increasing costs of management strategies and capital building, resulting in price increases. Water utilities cannot maintain fixed prices in the face of increasing capital costs indefinitely. Meta analyses of the price elasticity of demand for municipal water have shown that a 10 percent increase in the marginal price of water in the urban residential sector can reduce demand by about 3 to 4 percent in the short run (Espey, Espey, & Shaw, 1997; Dalhuisen, Florax, de Groot, & Nijkamp, 2003). Comparable price elasticities have been estimated for other sectors (Ziegler & Bell, 1984). This means in aggregate, even moderate changes in real prices can be as effective as a suite of infrastructure projects.

The viability of using price as a tool to manage water shortages can be strengthened by promoting it. Utilities are often hampered by pricing that disincentivizes utility-wide conservation efforts. In many municipalities, a decline in water use (water conservation) may result in a larger reduction in revenues than in water delivery costs. This is because some utilities charge large marginal prices relative to the share of marginal costs to total costs. Were utilities able to price in a manner where fixed and marginal charges are proportional to fixed and marginal costs, this would reduce the issue. Pricing in a proportional manner has the secondary benefit of giving municipalities the ability to use scarcity surcharges as water becomes scarcer. Policy innovations like this are low cost and effective. Options in pricing such as this are not considered in the TSWP in its current form as a method to promote reductions in water demand.

Supply Modeling

In the current TSWP, when any given water management strategy as well as any associated new water infrastructure projects are considered, strategies are chosen. The TSWP selects strategies using the following criteria: 1) quantity of new water supply provided by each strategy; 2) reliability of the supply under drought of record conditions; 3) cost of the proposed new supply; 4) impacts of each strategy on water quality and natural resources. Each regional water planning group determines a prioritized list of projects for their own region, and these prioritized lists are compiled for the state. These projects and strategies form the basis for the proposed management strategies for ensuring adequate water supplies to meet the projected demands.

Several issues arise with this approach, and the first relates to the previous section. Spending on management strategies and infrastructure are not assumed to influence water prices within the TSWP framework. As a result, the back-and-forth relationship that exists between costs, prices, and price elasticity of demand is ignored. In this case, breaking the linkage between demand and supply is likely to cause an overstatement of not only demand, but also the demand-supply gap that exists given current and proposed management and water infrastructure. Consequently, this causes an overestimation of the infrastructure needed to meet demand.

A more accurate approach to determining the impact of management strategies on the demand-supply gap would be to acknowledge that each proposed management strategy alters the costs of providing water. As a result, prices charged to customers become altered which ultimately changes quantity of water demanded. Even a methodology as simple as levelized costs (net present value of the costs of one unit of water over the expected life of the project) of each proposed asset could serve as a proxy for the average price that the asset would require to break even, and thus each proposed asset's impact on price.

A related issue on the supply side is the timing and magnitude of proposed management strategies and infrastructure projects. The current 2017 TSWP shows that the needed outlay of funds to meet the proposed supply side projects will cost $63 billion in capital costs, with more than 40 percent of those outlays to occur within the next decade. Related to the previous section, these are financial supports sought to meet demands that have been historically overestimated and may not emerge or be delayed for decades. This is further exacerbated by the lack of a proper demand-supply linkage in the current process. Given the uncertainty about future water needs, it would be advantageous for the TSWP to account for the option value of delaying investment and waiting for more information. Because SWIFT is a revolving loan program, these outlays of capital will be repaid by revenues from the borrowers' customers, raising water rates and potentially disincentivizing conservation if demand falls short of projections.

A Move Towards Flexibility and Scenarios

The state can improve the TSWP by increasing the flexibility of its scope, vision, and frequency of preparation at the regional level. More regional flexibility may produce a better water plan, reduce the risk of misallocation of funds, and could be a more robust water plan.

The demand projections are based on water use patterns during dry years and lean towards the worst-case scenario. As a result, the TSWP produces single "headline numbers". These single numbers are easily understood by the press and policymakers but provide little flexibility. However, a more realistic approach to water planning would provide the ability for regions to expand their analysis to consider varying scenarios. Modeling that includes varying scenarios allows for simple "what-if" analyses over a range of potential outcomes, rather than aiming for a single goal that may not describe future conditions. Such planning adds complexity to the analysis performed at the regional level, but allows for robustness in water planning, which would lend credence to plans that "make the cut". Particularly, this is important because management strategies and infrastructure projects are often an either-or prospect. Once an infrastructure project has been undertaken, there is often little ability to return to a world before its existence, particularly in dam construction or aquifer pumping strategies.

Consider, for example, changes in climate or realized population growth that may alter the value of the construction of a new dam. If atmospheric water demand increases due to increased temperature, the value of the dam may be decreased in comparison to an aquifer storage strategy. Although, if realized population growth is lower than predicted by the TSWP, the construction of the dam may come to be an unnecessary expense. The TSWP's singular goal of minimizing the predicted demand-supply gap does not give planning groups a framework to explore the value of water infrastructure under plausible alternative scenarios. Rather than focusing the analysis on a single, dry-year projection, the TSWP could be the source of a set of likely scenarios for the long-term planning. Freedom to consider more complex scenarios on both the demand and supply can be used to create a probability-weighted criterion for proposing management strategies and infrastructure investments.

The TSWP is focused on managing the demand-supply gap 50 years into the future. While this type of medium- to far-term planning is crucial with a resource as critical as water, in some regions, a 50-year plan may be the wrong focus. Texas is vast and diverse, with some regions that are more dynamic in terms of population and land use change, water supply and its stresses, resulting in varying water management challenges. Consider the unexpected water needs of unconventional oil and gas producers in Texas since the late 2000s. This increase in water demand, especially in the sparsely populated Permian Basin, could not have been anticipated even a few years before the shale boom. For much of the state, a more flexible focus on the near term would be more relevant. Allocating limited resources to meet predicted water demand in 50 years may be inefficient when those same resources could be used to meet unanticipated water needs in the short run.

In a similar vein, where regions currently experience little change in the 5-year period between TSWPs, flexibility in the frequency of preparation for the regional water plan can be a welcome prospect. Each region has a limited budget for developing the regional water plan. Were regions flexible in the frequency of regional plan preparation, the time regions would save could be spent on more detailed study and more accurate water planning. The current 5-year time frame between water plans renders this prospect impossible.

Holistic Water Planning

The final area we will discuss is the scope of challenges addressed in future TSWPs. The TSWP is born from a response to severe drought. Preparation for future drought is the focus of the current planning system. While planning for drought is critical, the TSWP has reached a point in which it would be beneficial to incorporate other goals related to water planning. Namely water quality, inter-regional planning, and a comprehensive statewide flood plan.

For instance, it is not clear whether the TSWP is a collection of individual regional water plans, or a cohesive statewide water plan. The TSWP is prepared at the regional level, allowing for direct stakeholder input and the incorporation of local knowledge and concerns. However, the plan has evolved away from a document that defines a comprehensive statewide plan for water management. This is noted by conflicts between regions in the state water planning process.[1]

The issue can be illustrated by a recent example related to flood management, specifically the 2017 flooding in the Houston area due to Hurricane Harvey. Early estimates of the damage caused by the storm were cited up to $108 billion (Quealy, 2017). The TSWP does not currently include a specific task for regional planners to determine a comprehensive flood plan, nor how to manage water quality issues that can result from flood events. In this example, potential gain may exist in both water storage for drought conditions and flash flood mitigation in a project that considers aquifer storage of storm water.

While holistic planning is more complicated and costly to produce, the bottom-up approach of the TSWP provides the needed informational transfer to the state government, policymakers, and water managers to make it possible. This shift in focus could be a gradual goal for the TWDB and could be started at the regional level.

Conclusion

In response to severe droughts in the 1950s, Texas began regularly publishing a state water plan to guide state water policy. The TSWP is a collaborative, good-faith effort by state agencies, stakeholders, academics, and other experts which include projections of future population, water demand, and water supply. Though this plan has evolved since the first plan was published in 1961, its important influence on regional water planning necessitates consideration of additional elements in order to increase its value to Texas.

A principal component of the TSWP is the water demand projection. While the projections of water use within the plan are intended to capture and plan for the worst-case scenario, the current planning process says little about other conditions or scenarios. The demand estimates used most often overshoot actual demand by an average of 18 percent. Also, the common demand estimates have a much higher error rate than simple trend forecasting. As a result, a major critique that the TSWP has faced is that it justifies investment in water infrastructure that exceeds the actual needs because water projections exceed actual demand in most years. This cri-

1 Region C in Northeast Texas proposed the construction of a reservoir. At the same time, Region D to the east and downstream of Region C included specific language opposing the reservoir. The conflict led to a court case, which determined that it is not clear from statute how TWDB should interpret the term "interregional conflict", nor how it should operationalize resolving such conflicts. Definition by statute and a clear definition of how the TSWP defines, plans for, and meets water management goals is a need for the plan.

tique has merit. The demand projections are not a traditional forecast which attempts to minimize forecast error. Rather, the demand projections are the result of an exploratory model which assumes a worst-case outcome in the water market. While this may be a useful scenario to consider, it is not the only relevant scenario for water infrastructure investment. We suggest that the incorporation of other likely scenarios in the analysis would allow for a more flexible and robust plan.

From our perspective, a key shortcoming of the TSWP is the implicit assumption that spending on water management infrastructure does not impact water prices. By leaving out the relationship between water supply and water demand, the water plan likely overestimates the gap between projected demand and projected supply, resulting in a bias towards an over-estimate of the infrastructure needs over time.

We have three recommendations that we feel will help remedy these deficits and improve the TSWP. First, explicitly include the linkage between demand and supply through price mechanisms when considering proposed strategies for water supply. Secondly, allow regional flexibility over the period for which projections are made. Plans currently include a 50-year water demand and supply forecast. For some regions, focusing on a nearer term may be more critical. For other less dynamic regions, the ability to perform more detailed analysis with limited budgets may be welcome. Third, expand the scope of the water plan using a more holistic approach to water management. While drought was the initial focus, there are other areas that could be addressed that provide value to the citizens of Texas, including water quality, interregional water plans, and flood preparation.

References

Anderson, R. L., Miller, T. A., & Washburn, M. C. (1980). Water Savings from Lawn Watering Restrictions During a Drought Year, Fort Collins, Colorado. *Journal of the American Water Resources Association, 16*(4), 642-645.

Bijl, D. L., Bogaart, P. W., Kram, T., de Vries, B. J., & van Vuuren, D. P. (2016). Long-term Water Demand for Electricity, Industry and Households. *Environmental Science & Policy, 55*(1), 75-86.

Burnett, J. (2012, July). When the Sky Ran Dry. *Texas Monthly*.

Cox, A. (2010, February 2). Budget Forecasts, Compared with Reality. *New York Times*. New York, New York, USA. Retrieved February 13, 2018, from http://www.nytimes.com/interactive/2010/02/02/us/politics/20100201-budget-porcupine-graphic.html

Dalhuisen, J. M., Florax, R. J., de Groot, H. L., & Nijkamp, P. (2003). Price and Income Elasticities of Residential Water Demand: A Meta-Analysis. *Land Economics, 79*(2), 292-308.

Espey, M., Espey, J., & Shaw, W. D. (1997). Price Elasticity of Residential Demand for Wtaer: A Meta-analysis. *Water Resources Research, 33*(6), 1369-1374.

Herberger, M., Donnelly, K., & Cooley, H. (2016). *A Community Guide for Evaluating Future Urban Water Demand.* Oakland, CA: Pacific Institute.

Kjelgren, R., Rupp, L., & Kilgren, D. (2000). Water Conservation in Urban Landscapes. *HortScience, 35*(6), 1037-1040.

Nace, R. L., & Pluhowski, E. J. (1965). *Drought of the 1950s with Special Reference to the Midcontinent.* Washington, D.C. : United States Geological Survey.

Olmstead, S. M., & Stavins, R. N. (2009). Comparing Price and Nonprice approaches to Urban Water Conservation. *Water Resources Research, 45*(4), W04301.

Quealy, K. (2017, September 1). The Cost of Hurricane Harvey: Only One Recent Storm Comes Close. *The New York Times*.

Wythe, K. (2011, Fall). The Time it Never Rained: How Texas Water Management has Changed Because of Recurring Droughts. tx H2O, pp. 10-16.

Ziegler, J. A., & Bell, S. E. (1984). Estimating Demand for Intake Wtaer by Self-supplied Firms. Water Resources Research, 20(1), 4-8.