# PIPE DREAM: WHY UTAH'S WATER MANAGERS CONTINUE TO PRIORITIZE SUPPLY-SIDE SOLUTIONS



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ABSTRACT

More than 150 years ago, the Mormon pioneers entered the Salt Lake Valley and immediately set to work digging irrigation ditches and canals to harness what water there was for their farms. Since then, Utah water managers have solved water supply problems by building large infrastructure projects. Today, Utah's population is growing rapidly, but the water supplies that enable its desert oases are not, and climate change is expected to make matters worse. This increasing tension between growing populations and dwindling water supplies is not unique to Utah. However, while other states in the region have implemented aggressive demand-side measures to conserve water, Utah's conservation efforts have been relatively minimal. Utah's history of water engineering, the cultural importance of agriculture, the precedent of federal funding for large water projects, and some of the cheapest water rates in the country make demand-side measures a tough sell for addressing water needs in Utah. However, supply-side projects are costly for taxpayers and for the environment, take decades to complete, and are based on unreliable forecasts of future water demand and uncertain water sources. It is time for Utahns to look past traditional supply-side solutions and embrace water conservation measures, requiring changes to the dominant water planning mindset. In order to do this, the state could take regulatory action, and both the state and LDS Church can act as water efficiency exemplars. It is also time for Utahns to become more involved in Utah's water planning and decide for themselves whether to continue attempting to conquer nature or to live within its bounds.

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## INTRODUCTION

Growing up in Salt Lake City, Utah, I'd frequently hear about how Utah was in a drought; that we were running out of water; that we did, after all, live in a desert. And yet, nothing really changed in our daily lives. Lawns remained green, swimming pools were full, and water never stopped coming out of the tap. In 2015, however, as the population is booming, Utah's water resources are shrinking. Increasing populations and diminishing water supplies are common problems in the West. Though the drought in California is making national headlines, policymakers and residents of many western states, including Utah, are also grappling with water management issues. Climate change will only exacerbate these challenges by decreasing already scarce water supplies. According to the most recent NASA predictions, there is an 80 percent chance that a multidecadal megadrought will plague Utah, and much of the Southwest, in the latter half of the twenty-first century (Cook, Ault, & Smerdon, 2015). To keep water flowing to taps in Utah, there are two basic types of mitigation strategies that water managers and suppliers can implement: increasing water supply and decreasing water demand.

Utah state policymakers continue to support the development of supply-side measures promoted by local water conservancy districts (WCDs) and state agencies, and both the state and WCDs have been slow to institutionalize significant demand-side measures aimed at reducing water use, despite the fact that Utahns have the second highest domestic water use per capita in the nation (Maupin et al., 2015).[1]

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[1] Different states may report water use differently, including or excluding different systems or uses, which can theoretically make it difficult to compare water use across states (T. Adams, 2015). However, the focus of this essay is not highlighting differences in water use comparisons and hence relies on available data.

Prioritizing supply-side projects as necessary solutions for Utahns' future water needs is misguided. Such projects cost billions of dollars, take decades to implement, have negative environmental externalities, and rely on decreasing federal financial support and increasingly unpredictable sources of water due to climate change. In addition, the data the WCDs and state agencies use to justify the need for these projects are erroneous (Office of the Legislative Auditor General, State of Utah, 2015). Meanwhile, in neighboring states such as Colorado and Nevada, state governments and water conservancy districts have robust water conservation measures in place to effectively bolster their water supplies. Demand-side measures can reduce water consumption, delaying or eliminating the need for additional water supply, even with a growing population.

This thesis thus asks: why do Utah state policymakers and water conservancy districts resist instituting water conservation measures, and how might proponents of such initiatives make water conservation a central part of Utah's water planning solutions? Interviews with people in the midst of developing and advocating for water policy in Utah, coupled with study of books, government data and publications, and reports from academic and nonprofit organizations reveal that Utah's distinctive culture, historical reliance on supply-side solutions, and institutionalized disincentives for conservation by water suppliers and users, create an environment in which state policymakers and water conservancy districts prioritize supply-side water management solutions. But by promoting regulatory and voluntary measures that disassemble these structural disincentives to conservation and capitalizing on the state's culture, supporters of demand-side measures can advance water conservation initiatives. In Utah these demand-side measures should include changes to water district revenue structures, regulatory changes allowing for and promoting water efficiency, rebates,

and increasing public education and involvement. Some of the findings of this thesis are particularly relevant to Utah, but many are applicable throughout the region. With water supplies over-allocated and drying up, the continued existence of our western desert societies depends on implementing water conservation measures.

## UTAH'S WATER GOVERNANCE

The history of Utah's settlement by the Mormons is a story of engineering water to suit human needs. Upon entering the Salt Lake Valley on July 24, 1847, Brigham Young and the Mormon pioneers immediately began plowing the land and diverting water to irrigate their farms (Alexander, 2003). Thus, more than 50 years before Utah gained statehood in 1896, its inhabitants were engineering and developing water supplies, reconfiguring nature to suit human needs.

The legal system governing water ownership came about in conjunction with the development and engineering of Utah's water resources, putting in place legal benefits for water use and disincentives for water conservation. Like most western states, the prior appropriation doctrine—first in time, first in right—and beneficial use form the basis of Utah's water rights (Clyde, 2013). The doctrine of prior appropriation determines priority for water distribution. Senior water rights go to those who first started using the water; junior rights holders came later and are allowed to use water after senior rights holders use their allocations (Office of Legislative Research and General Counsel, 2012). Beneficial use is putting water to use for municipal, industrial, commercial, or agricultural purposes, among others (Utah Division of Water Resources, 2010b). Prior appropriation and beneficial use encouraged settlers to put as much water to use for human purposes as possible to claim large water rights; conserving water was not an option and doing so could result in losing some valuable water rights (Clyde,

2013). Though there have been minor modifications over the years, these nineteenth century tenets still largely govern water rights in Utah today (Clyde, 2013; Utah Division of Water Rights, n.d.).

The governing bodies in Utah related to water are many and varied, but those promoting supply-side projects both directly and indirectly include the governor and state policymakers, the Utah Division of Water Resources (DWR), and regional water conservancy districts (WCDs). The relationships among these three entities are complex. The governor and state legislators pass bills and budgets providing funding for water planning and management projects carried out across Utah by the DWR and the regional WCDs. The DWR and the WCDs lobby state policymakers for funding for large water infrastructure projects and maintenance (Utah Rivers Council, 2014). The DWR manages water resources planning and development, including infrastructure and construction programs, monitoring and protecting Utah's interests regarding interstate waters, and forecasting water demand needs (Utah Division of Water Resources, 2015). The DWR is responsible for making sure Utahns have the water they need by fully developing and utilizing water supplies; however, "to some extent promoting the full development and utilization of water in the state is at odds with promoting conservation" (Office of the Legislative Auditor General, State of Utah, 2015, p. 3).

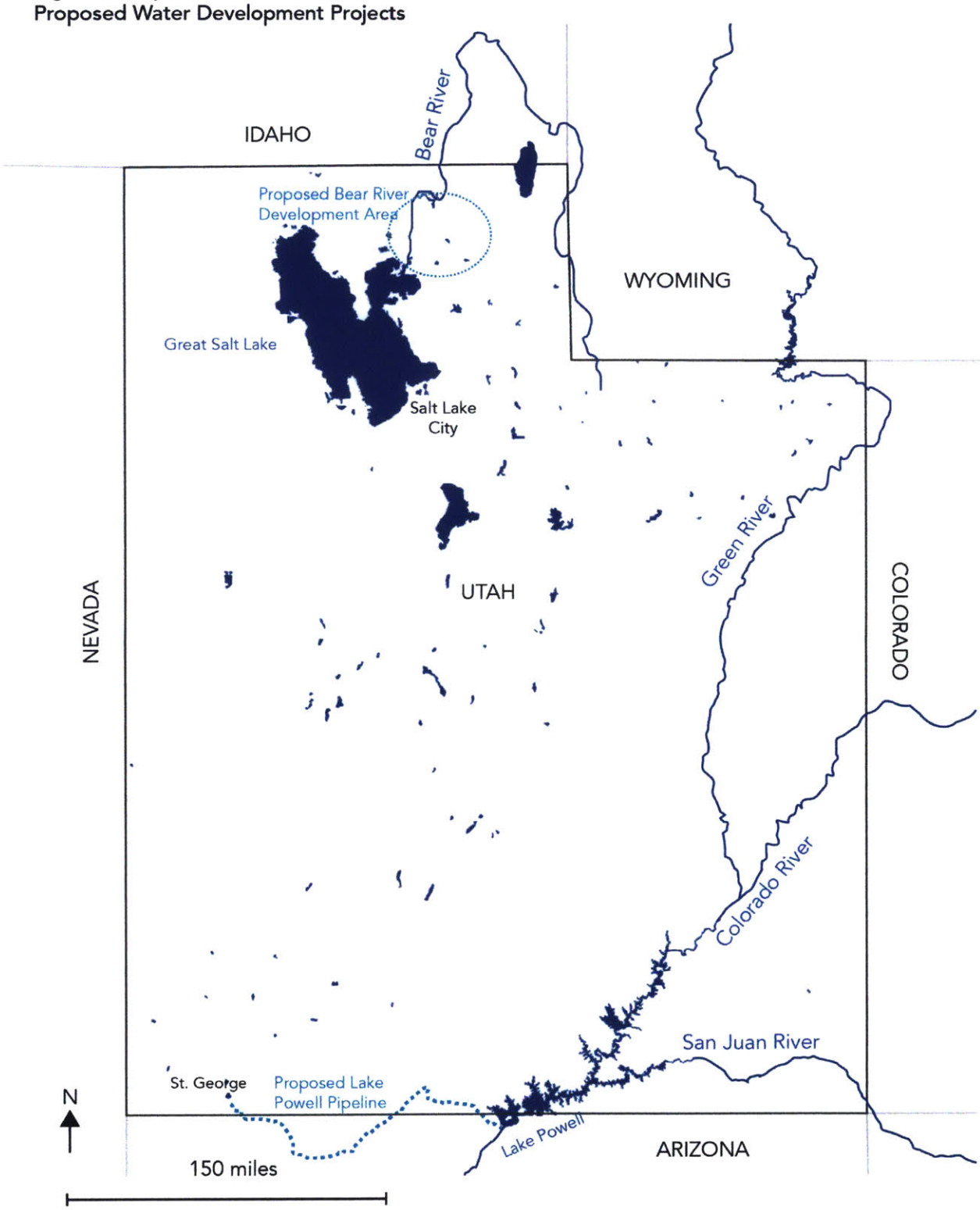
The major water conservancy districts (WCDs) in Utah work with the DWR and operate at a regional level and have broad powers to develop water themselves, as well as to treat and transport water developed by both the state and federal governments (*17B-2a-1004*, 2014). Boards of trustees run the water conservancy and metropolitan water districts, and are either appointed by local elected officials, appointed by the governor, or directly elected (*17B-2a-1004*, 2014). Dozens of smaller municipal and private water utilities and irrigation districts buy water from wholesalers such as the

WCDs and deliver it to end users throughout the state, but they are not powerful in the development of the state's water supply (Frankel, 2015; Office of Legislative Research and General Counsel, 2012). The WCDs collect revenues from a combination of connection fees, property taxes, and water use rates (Office of Legislative Research and General Counsel, 2012). This revenue structure encourages WCDs to seek supply-side projects that allow maintenance of high water use patterns, keeping revenues high (Erickson, 2015; Frankel, 2015).

## UTAH'S WATER SUPPLIES AND DEMANDS

Water managers base the need to develop more water for Utahns on current consumption habits and expected rapid population growth. However, what has worked to meet Utah's water needs for the past century, may not work for the next, especially with changes in water supplies. Utah, the second driest state in the nation after Nevada, relies heavily on snowpack for much of its water supply. The state receives an annual average precipitation of 13 inches, though this figure varies in different areas of Utah (Utah Division of Water Resources, 2001). For example, the southeastern part of the state receives about 10 to 11 inches of precipitation annually, while the mountainous areas in the north receive almost 2 feet (Utah Division of Water Resources, 2001). During the spring and summer, the snow melts and flows into streams and rivers, or seeps into aquifers, recharging Utah's surface and ground water supplies (Utah Division of Water Resources, 2001). Across the Intermountain West, including in Utah, snowmelt between April and July can provide 50 to 80 percent of total annual runoff (Bardsley et al., 2013).

**Figure 1. Major Rivers and Lakes in Utah and Proposed Water Development Projects**




Map is author's illustration adapted from map data from ESRI, DeLorme, MapmyIndia, and OpenStreetMap contributors; Adams, T., Leeflang, B., & Collins, M. (2014, October). Bear River Development Project: Providing Northern Utah's Future Water Supply. Presented at the Great Salt Lake Advisory Council Meeting. Retrieved from http://www.gslcouncil.utah.gov/docs/2014/10Oct/BearRiverPipelineProject.pdf; O'Donoghue, A. J. (2013, February 8). Lake Powell pipeline foes rejoice in delay. Retrieved May 20, 2015, from http://www.deseretnews.com/article/865572677/Lake-Powell-pipeline-foes-rejoice-in-delay.html?pg=all

Surface water is a major component of Utah's water supply, but not all of the surface water in Utah is usable by Utahns. The largest rivers in the state are the highly contested Colorado River and its tributaries the Green and San Juan; other significant rivers in the state include the Bear, and the smaller Weber, Provo, Virgin, Sevier, and Jordan Rivers (see Figure 1) (Utah Division of Water Resources, 2001). The Colorado River in the southern part of the state and the Bear River in the north are subject to interstate compacts, limiting the amount of water in the rivers that is available for use within Utah. The Colorado River is split into the upper and lower basins. The Upper Basin includes Wyoming, Utah, Colorado, and New Mexico and the Lower Basin includes Nevada, Arizona, and California. According to the Colorado River Compact, first written in 1922, Utah can use 23 percent of the water in the Upper Basin after 50,000 acre-feet[2] is allocated to Arizona (Arizona then also receives water from the Lower Basin) (Utah Foundation, 2014). Utah receives a set amount of water from the Bear River, which also provides water to Idaho and Wyoming (Utah Division of Water Resources, 2001; Utah Foundation, 2014).

The numbers presented thus far are based on yearly averages; most years the amount of precipitation and water available for Utahns varies from these numbers (Utah Division of Water Resources, 2001). Some years are wetter than average and some years are drier than average. These changes in water supplies result from short-term variations in weather and long-term climatic changes. Utah water managers have long dealt with the short-term variations in water supplies, using reservoirs and dams to store water for dry periods. However, climate change will likely bring longer-term,

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[2] An acre-foot is the amount of water it takes to cover an acre with water one foot deep; it is approximately 325,850 gallons (Utah Division of Water Resources, 2010b)

more significant changes to the area's weather patterns and water supplies, creating challenges for managing Utah's water supplies in the future (Kirkham & Bardsley, 2013).

### The Monkey Wrench: Climate Change

Although there is always uncertainty when predicting the future, scientists agree with high confidence that human activity has changed the climate globally and in North America (Romero-Lankao et al., 2014). North America as a whole is already experiencing more extreme heat events, fewer frost days, and a higher occurrence of heavy precipitation events (Romero-Lankao et al., 2014). Scientists predict with high confidence that these trends will continue in the future with an increase of 2 degrees Celsius above the baseline of preindustrial global temperatures, straining water resources (Romero-Lankao et al., 2014). A more intense global warming of 4 degrees Celsius above the baseline will likely produce more precipitation in the northern part of North America and drier conditions in the southern half, placing even greater strain on water resources for economic and agricultural centers (Romero-Lankao et al., 2014).

The future climate projections for Utah tell a similar story as those for North America, signaling increased pressure on water resources for Utahns. Higher ambient temperatures and changes in precipitation patterns will likely lead to higher rates of evaporation and evapotranspiration, and more precipitation falling as rain rather than snow, effectively diminishing the state's already unreliable water sources (Bardsley et al., 2013; Kuranz & Kenney, 2014). Utah's climate is already warming, with average temperatures in many areas throughout the state increasing at rates faster than the global average (Bardsley et al., 2013; Gillies, 2014). From 1950 to 2000, Salt Lake City's average temperature increased 0.65 degrees Fahrenheit per decade—twice the global

average (Gillies, 2014). The average temperature in Logan, Utah, in the northern part of the state, has increased 0.56 degrees Fahrenheit per decade—1.7 times the global average (Gillies, 2014).

Models suggest varying changes in precipitation across the state, though the overall average annual precipitation will likely increase (Gillies, 2014; Strong, 2013). Three emissions scenarios from the IPCC AR4 report—low emission (B1), moderate emission (A1B), and high emission (A2)—point to increased precipitation in the northern half of the state and decreased annual precipitation in the southern half between now and 2100 (Strong, 2013). Though precipitation events will increase in intensity, these events will occur less frequently due to changing storm tracks, leading to prolonged dry spells (Georgakakos et al., n.d.; Gillies, Wang, & Booth, 2012; Strong, 2013, 2015). Without infrastructure to capture, transport, and store this infrequent and intense rainfall, water supplies will dwindle leaving the area prone to drought (Bardsley et al., 2013). These droughts could last for decades not just in Utah, but throughout the entire southwestern United States (Cook et al., 2015).

Future climate predictions are not the only uncertain actor in water management planning for Utah; the historical baseline measurements for water supplies for Utah may be based on abnormally wet and bountiful years (DeRose et al., 2015; Tingstad & MacDonald, Glen M., 2010). The twentieth century was an unusually wet century for the Uinta mountains, which provide up to 25 percent of northeastern Utah's water and contribute to the Upper Colorado River Basin streamflows (Tingstad & MacDonald, Glen M., 2010). Using these numbers to forecast water availability into the twenty-first century and beyond may lead to planning based on an overestimation of available supplies, creating shortages in the future.

## Current Water Demands

There are two main factions competing for Utah's fully appropriated water supply: municipal and industrial (M&I) and agricultural (Clyde, 2008).[3] The M&I faction is growing rapidly. In fact, Utah's population is one of the fastest growing in the nation. From 2010 to 2014, Utah's population grew 6.5 percent; the nation as a whole grew 3.3 percent (United States Census Bureau, 2015). The Utah Governor's Office of Management and Budget predicts the statewide population could more than double by 2060 from 2.7 million people in 2010 to almost 6 million in 2060 (2012). Utah is also one of the most urbanized states in the nation, with more than 90 percent of the state's population—more than 2.5 million people as of 2010—living on just over one percent of the state's land (US Census Bureau, 2010). Most of these urban- and suburbanites live in two areas of the state: the Wasatch Front in the northern part and Washington County in the southwestern corner (Utah Governor's Office of Management and Budget, 2012). The populations of some counties such as Utah and Tooele could more than double, and projections for Washington County show the population more than quadrupling (Utah Governor's Office of Management and Budget, 2012).

This anticipated population growth raises concerns about meeting future water demands with current water supplies, especially if current consumption trends continue. Residential use accounts for just over half of all M&I uses, averaging approximately 167 gallons per capita per day (gpcd) statewide for both indoor and outdoor use, or approximately 509,000 acre-feet per year; nationally residential use averages 89 gpcd (T. Adams, 2013; Maupin et al., 2015; Utah Division of Water Resources, 2010a). At home, Utahns use 65 percent of their water outdoors and 35

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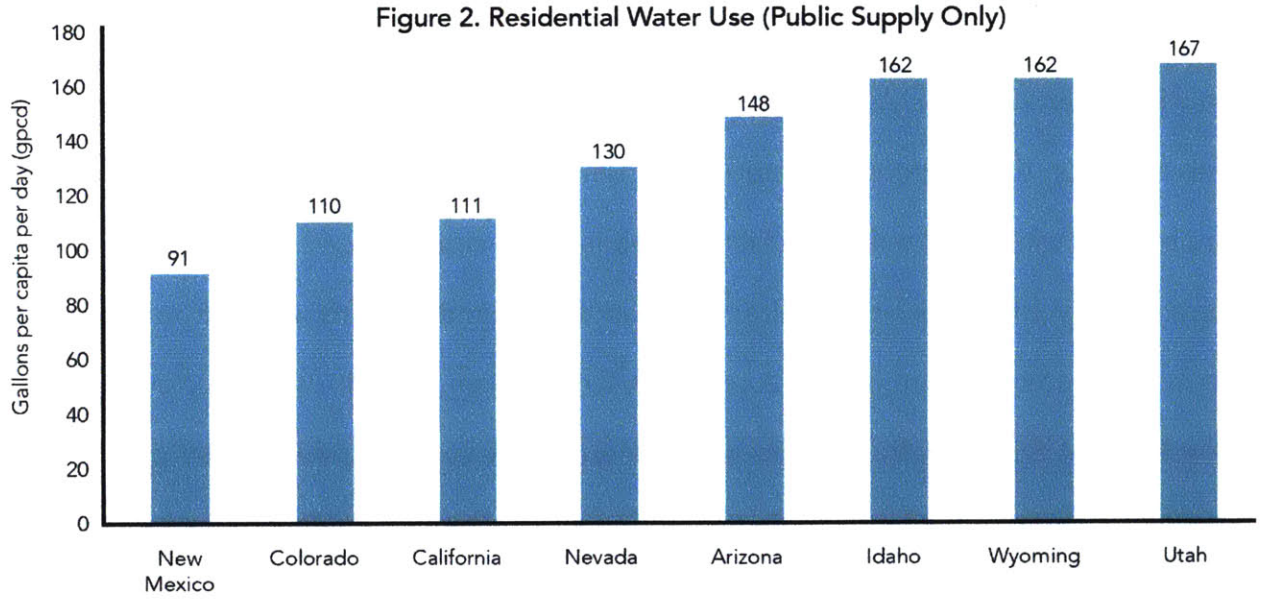
[3] Electricity uses only a small fraction of Utah's water supply (Utah Division of Water Resources, 2012).

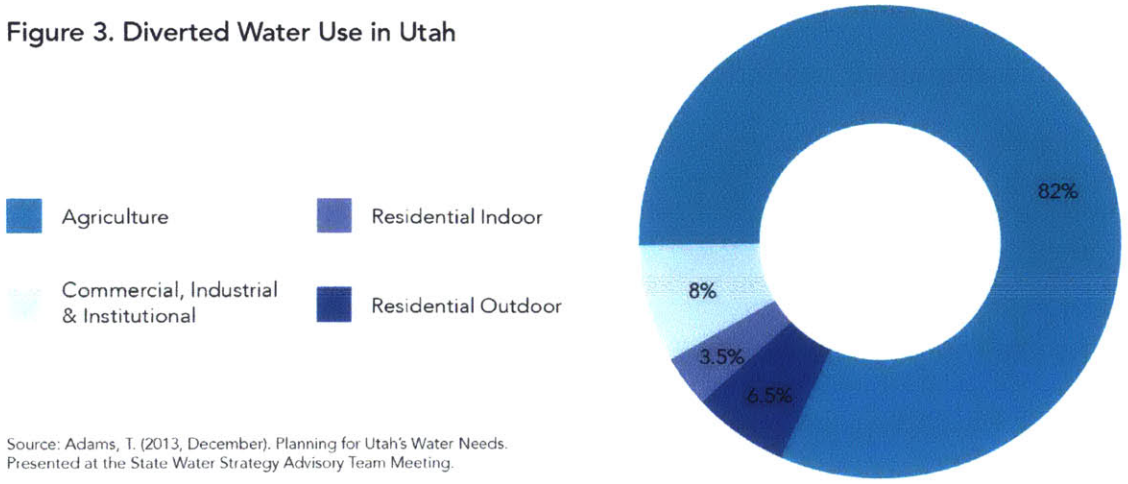
percent indoors (T. Adams, 2013). When considering all M&I uses—including commercial, institutional, and industrial—the statewide average is 241 gpcd, or 952,000 acre-feet per year, which includes both potable and non-potable water (T. Adams, 2013; Utah Division of Water Resources, 2014b). The Utah Division of Water Resources estimates the growing population will require an additional 283,000 to 493,000 acre-feet per year by 2060, depending on whether or not water conservation continues (T. Adams, 2013). But there is little reason to expect these M&I—particularly residential—water consumption rates will continue into the future: these residential water consumption rates are the highest in the West and the nation (public supply only), suggesting Utahns could use water more efficiently (see Figure 2) (Maupin et al., 2015). While an increase of almost 500,000 acre-feet per year may seem like a significant amount relative to the current M&I water use, Figure 3 shows that M&I purposes only account for less than one-fifth—18 percent—of statewide water use (T. Adams, 2013).

**Figure 2. Residential Water Use (Public Supply Only)**




Source: Maupin, M. A., Kenny, J. F., Hutson, S. S., Lovelace, J. K., Barber, N. L., & Linsey, K. S. (2015). Estimated use of water in the United States in 2010. U.S. Geological Survey. Retrieved from http://dx.doi.org/10.3133/cir1405

Figure 3. Diverted Water Use in Utah




Source: Adams, T. (2013, December). Planning for Utah's Water Needs. Presented at the State Water Strategy Advisory Team Meeting.

It is the areas in Utah with the fewest people that use the most water, with agriculture accounting for 82 percent of water use (T. Adams, 2013; Office of Legislative Research and General Counsel, 2012). According to a report for the U.S. Geological Survey, irrigation withdrawals exceed 3 billion gallons of water daily in Utah, while public water supplies (primarily servicing municipalities) withdraw only 673 million gallons of water per day (Maupin et al., 2015). Almost 80 percent of harvested acreage in Utah is for some form of hay or alfalfa, followed by wheat with 13 percent, and then corn with 4 percent (USDA, 2015). The amount of water used to grow alfalfa or hay varies based on the evapotranspiration rate, which depends on the climate and soil of a farm, but one estimate for southwestern Utah is approximately 2.49 acre-feet per acre—approximately 30 inches—for alfalfa, while another estimate is anywhere from 3 to 6 acre-feet of water per acre (Keith, 2008; Reid, Christensen, & Hill, 2008). According to a report by the USDA, alfalfa is the most water-intensive crop relative to other crops commonly grown in the Southwest, estimating a consumption of 70 inches of water per season (Erie, French, Bucks, & Harris, 1982). Almost all of Utah's water "is used to grow grass—either in the form of hay in farmers' fields of bluegrass in our lawns (McCool,

1995, p. 7). With Utahns currently using only a small fraction of their water for basic needs, such as drinking or food preparation, the need for increasing water supplies rather than using water more efficiently is debatable.

### Planning for the Future

Faced with a rapidly growing urban and suburban population, and a water-intensive agricultural sector, the DWR, WCDs, and state lawmakers are promoting the construction of two projects to increase the water supply—development on the Bear River and the Lake Powell Pipeline—and passively promoting water conservation. The Bear River, often called the last undeveloped river in Utah, starts in the northern part of the state, passing through Idaho and Wyoming, before winding up in the Great Salt Lake (Fornataro, 2008). The Bear River Project, which the Utah legislature approved in 1991, remains unbuilt but still on the table as a possible solution to Utah's water woes. The Bear River Project, or development, really consists of several different projects (Fornataro, 2008). The plan includes the identification and potential construction of several different dam sites along the river, as well as pipelines to divert and convey the water (T. Adams, Leeflang, & Collins, 2014). Though two potential sites were removed from the list because they would destroy sacred Shoshone lands and several farms, state policymakers have the power to authorize and fund any proposed site on the river (Fornataro, 2008). With a price tag of over $1 billion, the development would increase annual supply by 220,000 acre-feet, split among Cache County and three WCDs: the Jordan Valley Water Conservancy District, the Weber Basin Water Conservancy District, and the Box Elder Water Conservancy District (Fornataro, 2008; Prepare60, 2014; Utah Foundation, 2014). The Lake Powell pipeline is another billion-dollar project that would convey approximately 86,000 acre-feet of water (estimates vary) more than

100 miles from Lake Powell to Washington and Kane Counties in southern Utah, primarily to serve the desert city of St. George (Ewert, 2014; Prepare60, 2014; Utah Foundation, 2014). Four of the largest water conservancy districts in the state—Central Utah Water Conservancy District, Jordan Valley Water Conservancy District, Washington County Water Conservancy District, and Weber Basin Water Conservancy District—formed a marketing campaign, Prepare 60, to promote these projects at opposite ends of the state as essential to maintaining Utahns' way of life and economic success (Erickson, 2015; Prepare60, 2014).

The WCDs also lobby the state legislators to support these projects, and in 2015 these efforts paid off. The Utah State Legislature passed S.B. 281 in the last few days of the 2015 legislative session, appropriating $5 million from the state's general fund surplus for these projects as part of a water infrastructure fund (S. J. Adams, 2015; Erickson, 2015). The law states the funds can be used for two purposes: for the Bear River and Lake Powell projects and for existing infrastructure maintenance (S. J. Adams, 2015). The original passage of the Bear River and Lake Powell Pipeline Acts stipulated that the users of the water from these developments would pay for these projects, but this money is coming from all Utahns (Erickson, 2015). While the $5 million is a drop in the bucket for these billion dollar projects, the passage of the bill and appropriation of money symbolizes legislative support and fiscal commitment for the Bear River and Lake Powell Pipeline developments (de Freitas, 2015; Erickson, 2015; Frankel, 2015).

Utah's water conservancy districts and state level water managers acknowledge the role water conservation could play in helping to satisfy future water demand, but this amounts to little more than public awareness campaigns. The DWR even goes so far as to say that conservation "represents the single most significant strategy to help

meet Utah's future water needs" (Utah Division of Water Resources, 2012, 2014a, p. 3). Indeed, conservation programs are generally the most cost-effective measure for addressing water supply and demand imbalances (Kenney, 2014). The DWR agrees, stating that water conservation as the least expensive way to address demand (Utah Division of Water Resources, 2012, 2014a). Yet there are a few rebate programs run by WCDs to financially motivate behavior change. The Weber Basin and Central Utah WCDs offer rebates for improved irrigation and Washington County WCD offers rebates for low-flow toilets and some commercial appliances. And some water districts, such as Weber, limit the hours for irrigation. So far, however, most conservation efforts on the part of the DWR and the WCDs are voluntary programs for M&I customers.

The state government's contribution to conservation is a public awareness campaign. In 2000, on the heels of a drought, the governor formed the Governor's Water Conservation Team (GWCT), with members from the DWR, the Central Utah WCD, the Jordan Valley WCD, Metropolitan Water District of Salt Lake & Sandy, Washington County WCD, and Weber Basin WCD (Slow the Flow, 2011). The GWCT funds a public awareness campaign, Slow the Flow, to promote more water-wise behavior for M&I water users and a goal to reduce per capita water use by 25 percent by 2025 (initially 25 percent by 2050) (T. Adams, 2013; Utah Division of Water Resources, 2014a). The Slow the Flow program does not provide any monetary incentives or institute regulatory requirements for participants, instead focusing on increasing public education, providing lists of less water-intensive plants, or linking interested parties to other resources. Statewide per capita use is already down 15 to 18 percent since the program's inception, though critics question whether this is due to the program (T. Adams, 2013; Utah Rivers Council, 2014). Water conservation advocates think the Slow the Flow numbers are inflated, showing higher numbers of savings due

to selection of an unusually high water use baseline year; some question whether the numbers are simply part of the natural fluctuation in water use (Utah Rivers Council, 2014). There is also no planning for conservation beyond 2025 or beyond 25 percent, but there is reason to think more savings could be achieved (Ewert, 2014).

The state also does seemingly little to address agricultural water use efficiency. There is only one easily identifiable conservation program in Utah aimed at agriculture. Farmers within the Central Utah WCD may apply for grants covering up to half of the equipment cost for measures that will reduce water use by at least 25 percent, however this is an involved process and funding is not necessarily guaranteed (Central Utah Water Conservancy District, 2011). There are also some opportunities for federal funding for larger scale projects increasing agricultural water use efficiency (USDA Natural Resources Conservation Service, n.d.). Overall, however, according to the DWR, agricultural water efficiency does not necessarily free up water; the main benefits are increased crop production or better water quality (2001). Water planning in Utah can perhaps best be summed up by the following statistic: the state government spends approximately $250,000 annually on the Slow the Flow campaign, but over the past ten years the DWR has spent $25 million on the Lake Powell Pipeline, which is still embroiled in environmental impact assessments (Utah Rivers Council, 2014).

## WHY UTAH CONTINUES TO OPT FOR SUPPLY-SIDE SOLUTIONS

Utah water managers and policymakers continue to pump money into these large infrastructural water projects due to the state's cultural and agricultural history, the historical precedent of engineering solutions to water problems with the use of federal funding, and the structural disincentives to conservation for water districts and users. Water development is an integral part of the history and culture of Utah and its

settlement by the Mormon pioneers (Handley, Ball, & Peck, 2006; Reisner, 1993). Agriculture currently enjoys sympathetic public opinion, and there are not strong economic reasons for farmers to save water, but there are economic reasons for agricultural support of supply-side measures (Clyde, 2013; McCool, 1995; Peterson, 2013). Historical trends also matter and for the past century or more Utahns have been able to build their way out of water problems, with the help of federal funds (McCool, 1995, 2015). The water pricing structure in Utah keeps rates low, providing suppliers and consumers with little financial incentive to save water (Office of the Legislative Auditor General, State of Utah, 2015). All of these factors combined, lead water managers to seek additional supplies rather than demand-side measures.

### The Mormon Influence

The path Utah water managers are following today to meet water supply shortages was established more than a 150 years ago, with the settlement of the Mormons in Utah. When the Mormons arrived in the Salt Lake Valley, they irrigated the land not just to feed themselves, but also to fulfill a religious prophecy "to make the desert blossom as a rose" (Handley, 2014, p. 63). The Mormons succeeded,

> "laying the foundation of the most ambitious desert civilization the world has seen…the Mormons attacked the desert full-bore, flooded it, subverted its dreadful indifference—moralized it—until they had made a Mesopotamia in America between the valleys of the Green River and the middle Snake." (Reisner, 1993, p. 2)

Though the impetus for irrigating what is now Utah may have been partly spiritual, the methods were anything but (Handley, 2014). Technological feats such as dams and canals transformed the landscape and straightened rivers, setting a precedent for

improving upon nature, for engineering nature to serve human purposes (Handley, 2014). The Mormons were so successful in engineering and irrigating the landscape, the U.S. Bureau of Reclamation employed several Mormons upon its founding, looking to them for guidance in developing a national irrigation program to develop and populate the West (McCool, 1995; Reisner, 1993). As the Mormons made the arid West blossom, the history of Utah's water establishment and the Church of Jesus Christ of Latter-day Saints (the LDS Church) became inextricably linked (Handley et al., 2006; Reisner, 1993).

The LDS Church continues to play a large role in Utah's culture and politics. Today, the majority of residents and policymakers in Utah belong to the LDS Church: 58 percent of the state's population identify as Mormons (The Pew Forum on Religion & Public Life, 2008; Davidson & Canham, 2015). The influence of the Church in Utah is overwhelming both in public and private life, "which leads some Utahns to remark, only half-jokingly, that they live in a theocracy..." (Foltz, 2000, p. 2). For example, in 2015, the LDS Church not only endorsed a nondiscrimination law for Utah, but church attorneys actually helped draft the bill, which provides widespread exemptions for religious institutions (Gehrke & Dobner, 2015). Though the church is more likely to take an explicit political stance on moral issues, it has also historically spoken out on issues of water policy (Davidson & Canham, 2015; Miller, 1995). During the 1970s, Mormon leaders criticized public figures who spoke out against the Central Utah Project, a large federally funded water development project (Miller, 1995). The criticism was so harsh, it prompted those public figures not to run for reelection (Miller, 1995).

Today, the LDS Church is not publicly admonishing proponents of water conservation, but Mormon attitudes toward the environment can indirectly support supply-side projects. LDS doctrine can technically be interpreted either to support or oppose environmentalism (Handley, 2014). For example, Mormons who use their

doctrine to promote environmentalism, may highlight the beliefs that: everything—plants, animals, and people—is valuable; humans should not act selfishly and appreciate God's creations; and nature serves our aesthetic and spiritual desires and thus should be preserved (Handley, 2014). Conversely, when Mormons use the Church's doctrine to promote economic development and oppose environmentalism, they may emphasize the following beliefs: not using natural resources is an affront to God; humans' time on Earth is temporary and it is the eternal afterlife that matters; procreation is a divine mandate; and the end is near, so people should not worry about the distant future (Handley, 2014). Though Mormon doctrine can support or oppose environmental interests, most Mormons tend toward the latter. According to a 2012 survey of Mormons throughout the United States, 77 percent opposed stricter environmental laws, with 49 percent in strong opposition (Campbell, Green, & Monson, 2014). In the case of water in the West and making the desert blossom, the Mormon scholar George Handley stated: "There is no doubt that such a doctrine [the words of Isaiah (35:1-2, 6-7)] has been misused to justify a passive Panglossian attitude that the environment is on automatic pilot and that it matters little how we treat it, as long as we are good to one another" (Handley et al., 2006).

### Agriculture

Agriculture is also deeply engrained in the state's history and culture, which can make it difficult to fight politically. Even though most Utahns now live in cities and suburbs, public opinion of agriculture in Utah is highly favorable; people still want to think of themselves as pioneers or cowboys (Erickson, 2015; McCool, 2015; Peterson, 2013). Comments from public meetings and online submissions during a statewide water planning process initiated by the governor support maintaining Utah agriculture,

and a public opinion poll carried out by the Utah Department of Food and Agriculture showed 95 percent of Wasatch Front residents believe agriculture is important to the state's future (Peterson, 2013; Utah Department of Agriculture and Food, 2014). This is partly for misperceived reasons of food security. A report from the governor's office states that "A decrease in food production at a time of rapid population growth seems imprudent" (Peterson, 2013, p. 17). Yet only a few pages earlier the report acknowledges that Utah imports most of its food (Peterson, 2013). Utahns also view agriculture as important to the economy, but most people are not farmers and there are several other sectors, such as manufacturing and financial activities that are larger contributors to the state's GDP (Peterson, 2013; Utah Economic Council, 2015). Although it is difficult to completely isolate one sector from another, the agriculture, natural resources, and mining industry accounted for an estimated 3.8 percent of Utah's GDP (Utah Economic Council, 2015). Farmers are not only seen as important for feeding the state and helping the economy, but also for protecting Utah's environment. According to a public opinion poll, 84 percent of residents along the urbanized Wasatch Front think farmers act as responsible stewards of the land (Utah Department of Agriculture and Food, 2014).

Though the public may view farmers as stewards of the land, farmers are provided little opportunity or incentive to act as stewards of water. Built into the water rights law in Utah, and the tenets of beneficial use and prior appropriation doctrine, is the concept of "use it or lose it" (Clyde, 2013). Use it or lose it means that any allocated portion of a water right that goes unused for seven years may be reallocated to someone else, deterring conservation (Clyde, 2013; Utah Division of Water Rights, n.d.). The set up of senior and junior water rights can also render agricultural efficiency measures on a single farm moot (Office of Legislative Research and General Counsel, 2012). If a

senior water rights holder uses less water, the return flow downstream may be less, decreasing the amount of water junior water rights holders have available to use (Office of Legislative Research and General Counsel, 2012). In a different scenario, if the senior water rights holder uses less water but the return flow downstream is the normal amount, the junior water rights holders downstream may still use just as much water as before (Utah Division of Water Resources, 2001). This network of users means improving agricultural water efficiency for individual farms may not result in an overall reduction of water diversions (Utah Division of Water Resources, 2001).

The complexities of agricultural irrigation mean increases in irrigation efficiency on individual farms may not necessarily lead to greater water availability, and even if a farmer increases water use efficiency, it may be difficult to transfer the saved water to an M&I water supplier (Utah Division of Water Resources, 2001). Though it is certainly possible to purchase a water right, Utah does not actively promote the transfer of water rights alone (without selling land) from agriculture to M&I uses (Office of the Legislative Auditor General, State of Utah, 2015). When this does happen, the agricultural land is usually retired (Utah Division of Water Resources, 2001). Thus, it may be difficult to actually convert that water to M&I use, unless the agricultural land itself is being developed, even if it made economical sense to cut back on agricultural water use.

In addition to an archaic legal system disincentivizing agricultural water conservation, farmers have little economic reason to save water. For those farms in Utah that pay for water from irrigation districts or other off-farm sources, water is cheap. Across all farm sizes, the price in Utah for off-farm water—used by more than 78 percent of Utah farms is only $9.69/acre-foot, compared to $25.52/acre-foot across the West (USDA Economic Research Service, 2013). As one informant noted, some Utah

farmers, were they paying M&I rates for water, are "using thousands of dollars of water to make hundreds of dollars of hay" (McCool, 2015). Indeed, a very rough back of the envelope calculation using a conservative consumption based water rate of $1.61 per 748 gallons shows that water would cost more than $700 per acre-foot; requiring anywhere from 3 to 6 acre-feet of water to grow alfalfa means water alone would cost $2100 or more per acre, but alfalfa and hay currently generates approximately $350 to $750 per acre (Reid et al., 2008; Salt Lake City Department of Public Utilities, 2014; USDA, 2015). With water so inexpensive, it is not surprising that only 16 percent of the gravity-irrigated acres in Utah (representing more than half of Utah's irrigated farmland) use efficient delivery systems, such as lined canals or pipes (USDA Economic Research Service, 2013).

Farmers have also supported supply-side projects not only because these concrete mega-structures enable the irrigation and agricultural production of Utah, but because farmers pay only a fraction of the cost for such projects (McCool, 1995). For the irrigation part of the Bonneville Unit of the Central Utah Project, farmers needed to pay back only $16.4 million of over $950 million (Vedder, 1995). This subsidy for irrigation comes from combining irrigation projects with water delivery for M&I users and the production of hydropower (McCool, 1995). The political support from farmers for such projects continues today. In 2015, the Utah Farm Bureau, which lobbies on behalf of its 29,000 member families, supported the passage of S.B. 281, which set aside $5 million for the Bear River and Lake Powell Pipeline projects (Utah Farm Bureau Federation, 2015). With no precedent or economic reason to change agricultural farm use patterns, water has traveled cheaply through farmers' irrigation canals for the past 150 years.

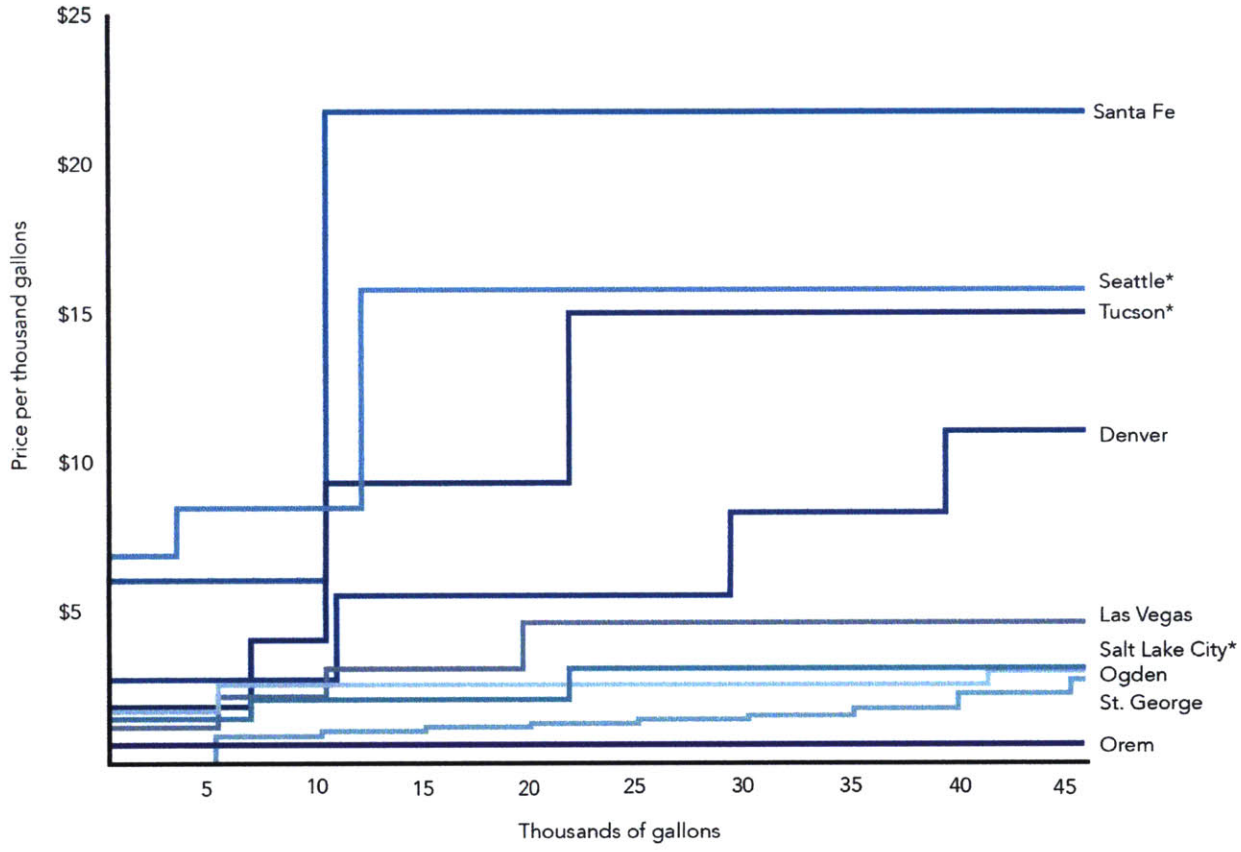
Precedent + Monetary Disincentives

Historical precedent also leads water managers and policymakers to turn to supply-side projects as solutions. The construction of major water development projects is how water agencies in Utah solved problems for their first 100 years of existence (McCool, 2015). Engineers continue to make many of the water planning decisions in Utah and still seek engineering solutions (Frankel, 2015). These projects are tried and true, and they have historically been cheap for Utahns. For the past century, the federal government funded these projects through the Bureau of Reclamation, bringing inexpensive water and jobs to the state, while national taxpayers footed the bill (McCool, 1995). However, the days of federal funding for and construction of large infrastructural projects through the Army Corps of Engineers and the Bureau of Reclamation are likely over (Denton, 2014). The two more recently proposed projects, the Bear River and Lake Powell Pipeline projects, are not federally funded and will require Utahns to pay for them, either through water rates or taxes (Utah Rivers Council, 2014).

Not only is a propensity for large supply-side projects built into Utah's culture and history, but water suppliers and users are economically disincentivized from conserving water. Water suppliers like low consumption based water rates because they keep water consumption high, bringing in higher levels of revenues (Erickson, 2015; Frankel, 2015; McCool, 2015). Fortunately for water suppliers in Utah, urban Utahns enjoy some of the cheapest water rates not only in the west, but also in the country as shown in Figures 4 and 5. One study by the Utah Division of Water Resources found the average cost of water per 1,000 gallons in the Jordan River Basin (Salt Lake County) was 34 percent less than the national average (Utah Division of Water Resources,

2010b). For some Utahns, water is beyond cheap: it's unmetered. Approximately 23 percent of water use is secondary, much of which is unmetered (Office of the Legislative Auditor General, State of Utah, 2015). Thus for a flat fee, or included in their monthly

**Figure 4. Consumption Based Water Rates for Select Western Cities**

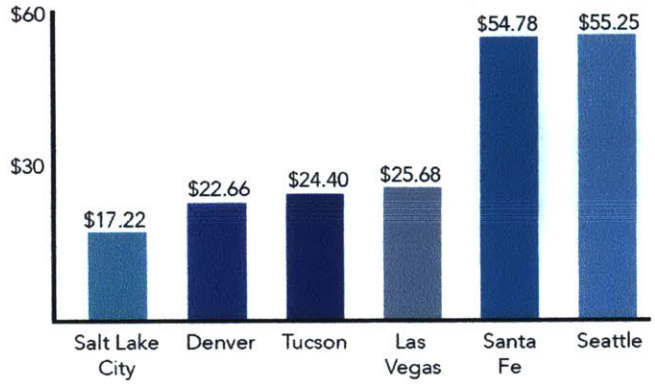



Source: Rates collected from each city's website, accessed May 2015. Rates are for summer for single-family, residential customers and based on the smallest meter where that determines consumption based rates. These prices do not include the monthly base rate charged by most cities.

*Denotes that a city's blocks are based on CCF rather than 1,000 gallons. In those cases, the price per CCF has been converted to price per thousand gallons using the following formula: price per CCF/748*1000.

bill, a resident can use an unlimited amount of secondary water—typically used for landscaping (Office of the Legislative Auditor General, State of Utah, 2015). Unmetered water use also adds to high water use; one study of the Weber Basin showed that in areas with unmetered secondary water, per capita use was 47 percent higher than in metered areas (Office of the Legislative Auditor General, State of Utah, 2015). With water seemingly so cheap, there is little reason for M&I users to conserve water.

**Figure 5. Average Monthly Water Bill for a Family of Four Using 50 gpcd**




Source: Circle of Blue. (2014). Circle of Blue's 2014 water pricing survey. Circle of Blue. Retrieved from http://www.circleofblue.org/waternews/2014/world/price-water-2014-6-percent-30-major-u-s-cities-33-percent-rise-since-2010/

There are two reasons for these low rates: snowpack and property taxes (Utah Division of Water Resources, 2010c; Ward, 2015). Snowpack is an inexpensive source of water storage, transportation, and treatment, reducing the cost of supplying water (Bardsley et al., 2013; Utah Division of Water Resources, 2010c; Ward, 2015). In addition to lower operating costs, many of Utah's major water conservancy districts and suppliers receive a significant portion of revenues from property taxes—hundreds of millions of dollars annually—an unusual practice among western water suppliers (Office of Legislative Research and General Counsel, 2012; Utah Rivers Council, 2001). In 2012 property taxes accounted for almost 70 percent of the Central Utah WCD's revenues and more than 35 percent of Washington County WCD's revenues (Office of the Legislative Auditor General, State of Utah, 2015). For FY 2014, more than 30 percent of Metropolitan Water District of Salt Lake & Sandy's revenues and 24 percent of Jordan Valley WCD's revenues came from property taxes (Jordan Valley WCD & Hansens, Bradshaw, Malmrose & Erickson, 2014; MWDSLS, 2014). This practice dates back to the late nineteenth and early twentieth century and the creation of drainage or water districts in Utah through the Drainage District and Irrigation Acts finalized in 1917 and 1919 respectively, though introduced and initially passed as law earlier (Finlinson, n.d.). In 1935, the Utah legislature passed the Metropolitan Water District Act followed by the Water Conservancy District act in 1941, granting these districts taxing power and

bonding authority (Finlinson, n.d.). These acts gave the districts property taxing and bonding authority to help finance water surveying and development of infrastructure, and also to provide these agencies with their own revenue streams, decreasing the need for state funding (Finlinson, n.d.). With only some modifications, these acts still largely govern the powers of these agencies today—powers the water districts are unlikely to relinquish.

Today, water agencies claim that relying on property taxes helps them receive high bond ratings, but any difference in bond ratings between water districts that collect property taxes and those that don't seem negligible (Utah Rivers Council, 2001). A study by the Utah Rivers Council of more than 50 water suppliers in 11 western states concluded that 75 percent of those that did collect property taxes had high or highest category bond ratings compared with 72 percent who did not collect property taxes (2001). This extra revenue stream from property taxes for water providers helps keep consumption based water rates low, obscuring the actual cost of water for most M&I users in Utah (Utah Division of Water Resources, 2010b, 2010c). Large infrastructure projects that augment water supply, allow maintenance of current water use patterns and revenue streams for water suppliers as population grows, whereas demand-side measures could curtail water supplier revenues.

In addition to the cultural and economic precedents for supply-side projects, Utahns have been inculcated with fear of what will happen if these projects aren't completed as part of Utah's water gospel. "Public officials, interest groups, and the public often make assumptions about water that, over time, solidify to become a kind of water gospel, and it is politically risky for anyone to even question their veracity" (McCool, 1995, pp. 20–21). Two of the three elements of Utah's water gospel still factor into water planning in Utah today. One is that Utah should develop its Colorado River

rights before California gets that water, even though this would be illegal (McCool, 1995). The other element is that Utahns have been told for decades that they are running out of water, which "has led to a singular devotion to supply solutions, usually to the exclusion of demand solutions" (McCool, 1995, p. 20).

### PROBLEMS WITH SUPPLY-SIDE SOLUTIONS

While supply-side solutions seem like an obvious answer to "running out of water," such solutions are expensive, take decades to construct, harm the environment, rely on increasingly unstable water sources, and are of questionable necessity. Dams, reservoirs, and water conveyance systems often have price tags of billions of dollars, paid for by national or local taxpayers (McCool, 1995). The Bear River and Lake Powell Pipeline projects are no exception. The price tag for the Bear River and Lake Powell Pipeline projects is now $2.5 billion; and the nearly completed Central Utah Project is likely to cost over $3 billion when finished (Central Utah Project Completion Act Office, n.d.; Office of the Legislative Auditor General, State of Utah, 2015). Previously these types of projects were paid for by the federal government, but now Utahns are going to foot the bill (McCool, 2015). Funding these projects through user fees will require huge increases in water rates, rate increases that will likely curtail demand and could potentially render these projects unnecessary (Utah Rivers Council, 2014). However, by the time an increase in water prices reduces demand, these projects could be well under way.

These projects also take decades to implement. The Bear River Act, authorizing development of the river, dates back over 20 years, but nothing has been built yet. The Lake Powell Pipeline Act is almost 10 years old and nothing has been built, with the DWR still carrying out environmental impact assessments (Utah Rivers Council, 2014).

The Central Utah Project dates back more than 50 years and is still not finished (Central Utah Project Completion Act Office, n.d.). With a timeline of decades from inception to completion, supply-side projects are not capable of bringing supply in line with demand in a relatively short timeframe of years, which may be necessary in the face of more sudden changes in water supply such as droughts.

Large-scale water development projects, especially dams, are also environmentally degrading. Development of the Bear River, the last undeveloped river in Utah, could significantly impact the ecosystem of the Great Salt Lake (de Freitas, 2015). The Bear River is one of the Great Salt Lake's largest tributaries; developing the river can lower the levels of the Great Salt Lake, having detrimental effects both on the animals and the people in the area (T. Adams, 2015; de Freitas, 2015). A decrease in water levels increases the salinity of the lake, making it inhospitable for animals that depend on it. Brine shrimp, the most prevalent animal in the Great Salt Lake, can only survive at certain levels of salinity; increased concentrations of salt can harm the brine shrimp population and the industry that depends on it (Capener, 2015; de Freitas, 2015). Declining lake levels can also exacerbate an already serious air pollution problem in the Salt Lake Valley by increasing heavy metals in the air (Capener, 2015; de Freitas, 2015; McCool, 2015).

The Lake Powell Pipeline relies on water from Lake Powell, formed by the Glen Canyon Dam. Since its inception, environmentalists have fought the construction and continued existence of the Glen Canyon Dam (Glen Canyon Institute, n.d.; Powell, 2008). Downstream ecosystems, particularly fish, suffer because sediment carrying nutrients piles up behind the dam at a rate of approximately 120,000 tons per day (Palmer, 2014; Powell, 2008). Beyond the dam, the fast flow of the river erodes riverbanks and riparian habitats (Palmer, 2014). The temperature of water released from

the dam also remains uniform throughout the year, rather than changing seasonally, creating environments where invasive species thrive (Glen Canyon Institute, 2000). In 2014, the Natural Resources Defense Council listed the Glen Canyon Dam as one of the top five most environmentally degrading dams in America (Palmer, 2014). Investing over a billion dollars on a pipeline dependent on the Glen Canyon Dam could make decommissioning of the dam even more unlikely, perpetuating these negative environmental impacts.

The future reliability of the water sources for these billion-dollar projects is uncertain. Water sources such as the Bear River and the Colorado River are already at the whim of nature and no amount of precipitation and water is ever certain, but more importantly, studies show that current trends for water supply from these two rivers are higher than what can be expected in the future (DeRose et al., 2015; Powell, 2008). For the Bear River, a study of the past 1,200 years shows the latter half of the twentieth century to be an abnormally wet period, "strongly suggesting that current water management impression of available Bear River flow is biased toward higher flow...[and] maintaining high expectations for future availability of Bear River flow could have catastrophic consequence" (DeRose et al., 2015, pp. 9–10). This is not only true for the Bear River; the twentieth century was also the wettest for the Colorado River, according to tree ring studies of the past five centuries (Powell, 2008). Believing these rivers will provide such abundant water in the future as in the recent past is misguided.

Climate change will only exacerbate the natural variability of these water resources, increasing extreme conditions and likely diminishing water supplies (Melillo, Richmond, & Yohe, 2014). Already, the Colorado River's over-appropriated streamflow is decreasing (Melillo et al., 2014; Romero-Lankao et al., 2014). Projected stream flows

for the Colorado River in the 2050s are approximately 10 percent less than today's averages (Melillo et al., 2014). Even though less water will enter Lake Powell, the same amount of sediment or possibly more will continue to accumulate in the lake, effectively reducing the amount of water the dam can hold and hence the lifetime of the lake (Powell, 2008). Lake Powell is currently 45 percent full and may be dry by the end of the century (McCool, 2015; Taylor, 2015). With little or no water, these billion-dollar projects will not make a difference in meeting future water needs.

In addition to high economic and environmental costs, the stated need for these projects by water agency and water conservancy districts' is questionable (Fornataro, 2008). The Bear River Project is necessary for providing water during peak times in July and August, water that goes to the watering, or often overwatering, of front lawns in hot summer months, not for fulfilling basic water needs such as bathing or drinking water (Fornataro, 2008; McCool, 2015; Utah Rivers Council, 2014). Indeed, one study by the Utah State University Center for Water-Efficient Landscaping found that Salt Lake residents were overwatering their plants by 100 percent in 2010 (as cited in Office of the Legislative Auditor General, State of Utah, 2015). Likewise, the Lake Powell Pipeline will go to desert towns and cities full of golf courses and green lawns. Critics of the Bear River, Lake Powell Pipeline, and supply-side projects also question the numbers used by state agencies and water conservancy districts to forecast demand (Utah Rivers Council, 2014). A recent audit by the state Office of the Legislative Auditor General supported these claims, expressing concerns about using 2000 as a baseline study year because the data was actually from 1992 through 1999, not 2000 (2015). Because water use declined between 1992 and 2001, using water consumption from 1992, when water use may have been higher, as representative of water use in 2000 may lead to an inflated baseline number (Office of the Legislative Auditor General, State of Utah, 2015).

Indeed, the audit states that the overall accuracy of the data used by the DWR—received from the Division of Water Rights—to forecast water needs contains "significant inaccuracies" (Office of the Legislative Auditor General, State of Utah, 2015, p. ii). One egregious example is that water use data reported by one locality to the Division of Water Rights in 2012 was actually data for a municipality in New York with the same name (Office of the Legislative Auditor General, State of Utah, 2015). The error in these baseline assumptions gets compounded over years in forecasting; due to this, the audit found the 2060 water use projections of 220 gpcd overstated and conservation goals underwhelming (Office of the Legislative Auditor General, State of Utah, 2015).

These forecasts also fail to take into consideration any significant conservation in water use beyond 2025 (Office of the Legislative Auditor General, State of Utah, 2015; Utah Rivers Council, 2014). The DWR touts the Bear River project as necessary for fulfilling future needs in Salt Lake County, but the agency's own graph shows that with conservation, the Bear River Project is not needed for that area (Utah Division of Water Resources, 2010b). The reliability of the population projections is also questionable. The population projections for Washington County from 2006 were high; using the population projections for Washington County from 2012 the need for the Lake Powell Pipeline is not obvious (Utah Rivers Council, 2014). "Hyperbolic statements" about the need for a water project is nothing new; indeed such ideas were used to convince the public the Central Utah Project was necessary (McCool, 1995, p. 6). If the DWR and WCDs added serious conservation efforts to the equation, as well as more accurate forecasting of water use, the need for these supply-side projects becomes debatable (Nuding, n.d.; Utah Rivers Council, 2014).

## TAKING DEMAND-SIDE MEASURES SERIOUSLY: NEARBY EXAMPLES

Many of the problems Utah water planners face are common throughout the West. However, state policymakers and water conservancy districts in Utah are not as proactive in implementing demand-side measures to promote water conservation as other western states, such as Nevada and Colorado. Demand-side measures for increasing water use efficiency can include increasing public awareness, pricing mechanisms, regulations, and incentives. Increasing public awareness generally involves campaigns making water users aware of voluntary behavior changes that will save water. Pricing mechanisms may include increasing rates for increasing blocks of water use, or even charging by the gallon (Goetz, 2013). Regulations can include limits on landscaping, changing plumbing codes to require water-efficient appliances and fixtures, and restricting watering times. Noncompliance with regulations results in penalties of some sort. Incentives may focus on creating similar changes as regulations—for example, plumbing or landscaping—but encourage rather than mandate water efficient behavior, usually through a financial incentive such as rebates or coupons for implementing certain measures. This list is by no means exhaustive, but these are currently some of the primary demand-side measures implemented throughout the West, including in Colorado and Nevada. Colorado and Nevada place water conservation at the forefront of strategies to meet future water needs, though they do not have state-mandated conservation requirements (Colorado Water Conservation Board, 2014; State of Nevada Division of Water Resources, 1999). At the state level, Colorado is more proactive than Nevada and Utah in their approach to water conservation; however, water districts in both Colorado and Nevada implement robust

water conservation programs (Colorado Water Conservation Board, 2014; State of Nevada Division of Water Resources, 1999).

Colorado has several state laws in place to promote water conservation. The Colorado legislature acted to allow greater agricultural efficiency, passing HB 05-133. This bill states a water right owner will not lose their water right if they are using less than appropriated due to a state or other approved conservation program (Colorado Water Conservation Board, 2014). In a state where water law is based on the "use it or lose it" premise, this could open to door for greater agricultural water use efficiency. Colorado also has a state law requiring the phasing in of universal metering as a tool for promoting water conservation (*C.R.S. 37-97-103*, 2014). The state of Colorado is also leading by example. Since January of 1990, Article 96 under Title 37 requires landscaping of state projects and facilities to use drought-resistant or less water-intensive plants and that plumbing be updated to conserve water (*C.R.S. 37-96-103*, 2014).

The Colorado Water Plan, expected to be finalized in December 2015, highlights the water conservation programs of the state's water districts, building upon some of the state requirements and resources already in place to promote water conservation measures (Colorado Water Conservation Board, 2014). Since 2005 Colorado law allocates state funds in the form of grants to water districts for implementation of water conservation plans (*C.R.S. 37-60-126*, 2014). Since 2004 Colorado also requires all water districts selling 2,000 acre-feet of water or more annually to submit a water conservation plan (Colorado Water Conservation Board, n.d.). The water conservation plan must contain minimum required elements including low water landscaping, water reuse systems, pricing to encourage conservation, rebates for customers to install water-

efficient appliances or irrigation fixtures, and estimates of how much water the conservation measures will save (Colorado Water Conservation Board, n.d.).

All of the water districts in Colorado are implementing or developing water conservation programs; one example is Denver Water. Denver Water has a long history of promoting water conservation. Denver Water's official program dates back to 1977 when the city was facing a severe drought, though Denver Water claims as early as 1936 they put advertisements for conservation on street trolleys (Denver Water, 2015a; Gardener & Lively, 2013). For almost 40 years now, Denver Water has promoted conservation through education and, more recently, by offering incentives. Today, Denver Water's conservation program incentivizes switching to water-efficient equipment with rebates, provides tips on how to use less water, offers water audits for both residential and commercial and industrial buildings, and regulates watering lawns and landscapes (Denver Water, 2015b). While much of the conservation program focuses on increasing awareness and voluntary actions, these are coupled with some mandatory restrictions on irrigation and summer watering and aggressive conservation goals (Denver Water, 2015b). Denver Water has a goal of reducing water use by 22 percent from pre-2002 levels by 2016, a goal of M&I use of 165 gpcd (Denver Water, 2015b). In 2001, water use was over 200 gpcd; by 2014 it was well under 150 gpcd, below its 2016 goal (Tejral, 2015). Though perhaps not overtly a part of its conservation program, Denver water rates are also much higher than those for several Utah cities (Denver Water, 2014; Utah Division of Water Resources, 2010b; Utah Foundation, 2014). While some WCDs in Utah implement some of these measures, they are not coupled with high water rates or such ambitious conservation goals.

At the state level, Nevada does not provide as many regulations or incentives for conserving water as Colorado. The most recent available Nevada State Water Plan dates

back to 1999. Since 1991, Nevada state law has required each M&I water supplier adopt a water conservation plan, though the State Water Plan notes the effectiveness of these is not guaranteed (State of Nevada Division of Water Resources, 1999). Despite the seemingly uninspiring state support, some water managers in Nevada, particularly in the Las Vegas area, promote or even require demand-side management strategies. Member agencies of the Southern Nevada Water Authority (SNWA), the wholesaler for water agencies in and around Las Vegas, have had conservation goals and measures in place since the 1990s but in 2009 permanently adopted the demand reduction measures from its Drought Plan (Southern Nevada Water Authority, 2014). SNWA relies on its member agencies to use three mechanisms to curb demand: metering all classes of water, ensuring very little water is lost during the delivery process through high construction standards, and setting multi-tier increasing block rates to encourage residents and businesses to use less water (Southern Nevada Water Authority, 2014).

The SNWA and its members also run public education programs to help elicit buy-in, work with cities and municipalities to implement land-use and water-use regulations, and use incentives to promote conservation (Southern Nevada Water Authority, 2014). Perhaps one of the best known of these incentive programs is the Water Smart Landscaping program. The SNWA uses revenues from higher water rates to fund their Water Smart Landscapes Rebate program, which pays residents to replace lawns with more water-wise landscaping (Erickson, 2015; Southern Nevada Water Authority, 2015). The largest program of its kind in the country, the Water Smart Landscaping program has saved more than 68 billion gallons of water since it began (Southern Nevada Water Authority, 2014).

Other programs instituted by the Southern Nevada Water Authority include coupons and rebates for pool covers, smart irrigation clocks, rain sensors, and water

efficient appliances, meant to increase efficiency for existing customers (Southern Nevada Water Authority, 2014). The SNWA also works to institutionalize conservation initiatives, making them required (Southern Nevada Water Authority, 2014). These mandatory mechanisms include limiting watering times, prohibiting front lawns in new developments, restrictions on ornamental water features, and requiring water efficient plumbing in retrofits or remodeling; violating these codes results in fines (Southern Nevada Water Authority, 2014). In 1991, when SNWA adopted its first conservation goal, total water use was 344 gpcd; in 2012 it was down to 219 gpcd (Southern Nevada Water Authority, 2014). While causality is always difficult to prove, and weather and economic factors can greatly impact water use, this downward trend since implementing conservation measures seems significant (Southern Nevada Water Authority, 2014).

Almost all of the measures discussed focus on M&I water use reduction; only the state law in Colorado touches upon agricultural water use efficiency. There are methods for improving water efficiency such as laser leveling of fields, lining canals or conveyance pipes, and sprinkle or drip irrigation (Utah Division of Water Resources, 2001). Opportunities for financial assistance for increasing agricultural water efficiency were available from the federal government through the Agricultural Water Enhancement Program through the Natural Resources Conservation Service of the USDA, however as of 2014, the program operates somewhat similarly under the Regional Conservation Partnership Program (RCPP) (USDA Natural Resources Conservation Service, n.d.). The RCPP funds large-scale projects and efforts; these are not necessarily rebates an individual farmer is likely to apply and receive funding for. The seeming lack of attention given to agricultural water efficiency and the focus on M&I water conservation by the state governments and individual water districts is not

entirely surprising. M&I water conservation measures can potentially be more prescriptive and straightforward, and done on a smaller scale.

## RECOMMENDATIONS

All of this is not to say water managers in Colorado and Nevada do not consider supply-side measures at all. If more water supplies were readily available in the West, without monetary or political barriers, someone would develop them. Unlike in Utah, however, other states' water districts or governments are investing in demand-side measures and aggressively pursuing water conservation, not just paying conservation "lip service" (Utah Rivers Council, 2014, p. 4). Utah can, and should, follow suit.

Changing the water planning mentality in Utah from one that prioritizes supply-side solutions to one that actively promotes and achieves water conservation first and foremost, will require action from policymakers, water conservancy districts, municipalities, nonprofits, and residents. These actors will need to overcome the historic and structural barriers in place to realize meaningful conservation. Because of this, these recommendations focus on shifts in Utah's policy and culture that will create opportunities for demand-side measures such as those in Colorado or Nevada, rather than detailed explanations of the demand-side measures themselves.

First, Utahns need to pay the true cost of water through their water bills. Without financial ramifications water consumers are unlikely to significantly change their habits (Erickson, 2015; Frankel, 2015; McCool, 2015). Water rates are one of the most effective methods for changing consumer behavior, more effective than voluntary measures (Kenney, 2014; Salvaggio, Futrell, Batson, & Brents, 2014). Key to bringing water rates up and having Utahns see the true cost of water is amending the necessary acts so that water conservancy districts and suppliers cannot levy property taxes. Utah

policymakers should phase out the law that allows water districts to levy and collect property taxes providing an ample transition period. The phasing out of property taxes will likely force water suppliers to collect all of their revenue from connection fees and water rates, increasing the costs consumers see on their water bill and allowing for more responsive consumption based pricing. This increased awareness of how much customers are paying for water—as well as the opportunity to more significantly change how much they pay by changing how much water they use—could make users more inclined to save water. A diverse range of advocacy groups in Utah are already calling for removal of the ability of water suppliers to levy taxes, from the environmentally concerned Utah Rivers Council to the fiscally conservative Utah Taxpayer's Association (The Utah Taxpayers Association, 2011; Utah Rivers Council, 2014). Lowering taxes in Utah seems like a political win, and some bills that would do this have been introduced in previous years, but not passed. State policymakers need to continue to introduce and push such legislation through the House and Senate, but public support on this issue can greatly help. Advocacy groups also need to continue to educate Utahns on this issue, whether through news outlets, campaigns, or their traditional communications methods. If Utahns become vocal on the issue and call for this change, it will be harder for state policymakers to ignore. Citizens can also begin at the local level by calling for changes among smaller metropolitan water districts that levy county taxes. Additionally, there are some WCDs both within Utah and in nearby states operating without property taxes; those collecting taxes could look to them for models on operating without collecting property taxes.

Another regulatory change state policymakers could enact to highlight the true cost of water is requiring metering for all water use, both primary and secondary (Office of the Legislative Auditor General, State of Utah, 2015). This is also something

water districts can do independently, recouping the costs of the meters through delayed water development from decreased water use (Office of the Legislative Auditor General, State of Utah, 2015). Colorado's state law allowed the phasing in of meters over the course of several years and allowed costs to be recouped through water rate increases (Office of the Legislative Auditor General, State of Utah, 2015).

An alternative regulatory model state policymakers can consider that allows WCDs to maintain current or near current revenue levels is decoupling (Kenney, 2014). Decoupling is common among electric utilities facing a similar problem: selling electricity is how electric utilities make money, disincentivizing conservation. With decoupling, a regulating body sets an allowable revenue for the utility based on something other than consumption, for example, the number of residents served (Kenney, 2014). Because the amount of money a utility can collect per resident is limited, the utility will seek to maximize profits by using the most cost-effective ways of supplying the service, which often is conservation measures (Kenney, 2014). Although WCDs are not profit-driven, they must remain solvent while maintaining significant portions of infrastructure. Current estimates for maintenance and repairs to existing infrastructure statewide is in the billions (T. Adams, 2015). If done appropriately, decoupling could provide WCDs with the necessary budgets to maintain infrastructure while encouraging them to seek cost-effective water conservation and efficiency measures as answers to projected supply shortages. This model requires the establishment of a new regulating body to set rates, which could be politically or logistically difficult to implement (Kenney, 2014). Decoupling is also new for the water industry and should be thoroughly investigated before implementation, but it could provide Utah water managers with an opportunity to be on the cutting edge, rather than simply following in the footsteps of others.

Just as Colorado has done, Utah can amend water rights laws to help promote efficiency. Removing the fear that someone will lose their water right if they don't use it could help make water efficiency more appealing and viable for agriculture. State agencies, such as the DWR could also help ease the monetary burden of upgrading irrigation systems either through rebates or through low-interest or revolving loan funds. The DWR already offers a revolving loan fund to public and private entities for infrastructure maintenance and upgrades; it could start targeting these loans more towards farmers requiring larger-scale retrofits or upgrades to increase agricultural irrigation efficiency (Utah Division of Water Resources, 2015). With the vast majority of Utah's water going to agriculture, plans for agricultural water efficiency should be seriously considered, but will require more concerted, customized, and widespread efforts.

The state government should also update the Water Conservation Plan Act. The act has been in place for over 15 years, requiring water suppliers with over 500 connections to submit their own water conservation plan, which is then to be updated every five years (Utah Division of Water Resources, 2001). This is a good start, but the act should be updated to require certain conservation or demand-side measures be incorporated into each supplier's plans, as in Colorado. Requirements for the Utah plans include such elements as the statement of a conservation goal and how to meet it, existing conservation measures, and proposed conservation measures, but there is no language requiring minimum specific conservation program elements. Additionally, even though receipt of state funds is dependent upon completion of a conservation plan, the bill does not specify that such funds go towards water conservation; it simply says "water development" (*73-10-32*, 2007). The act could be updated to prioritize

money for conservation implementation over water development, or could include a minimum conservation goal or requirement.

Another example from Colorado that Utah can follow is leading by example. Whether through regulation or simply through action, the state government should install water-efficient appliances and fixtures in state buildings and landscape state facilities using water-efficient plants. Rather than surrounding buildings such as the state capitol in oceans of grass, these areas can become models of appropriate landscaping for an arid region, demonstrating that a water-wise landscape can still be beautiful. Additionally, ensuring state facilities are adhering to efficient irrigation practices such as watering times and not overwatering could help. If the state facilities do not give up their green lawns, it seems unreasonable to expect residents to do so. This measure could be part of the Slow the Flow program's educational component. Nonprofit groups should call upon the state to serve as an example for residents. Municipalities throughout the state can also lead by example, by promoting water efficiency in and around their own facilities.

The state legislature could also increase funding to the Slow the Flow campaign or potentially require some of the property tax revenues from WCDs be allocated to the campaign to implement demand-side measures such as rebates. Right now the Slow the Flow campaign's rebates section links to a few WCDs providing minimal rebates. The Slow the Flow campaign could be used to provide rebates and incentives statewide, increasing uptake of appliance or fixture upgrades or changes in landscaping and irrigation tools. Public awareness can only do so much; there must be money involved for people to change their habits (Erickson, 2015; Frankel, 2015; McCool, 2015). There is no reason the rebates must come from WCDs, they can be provided by a nonprofit or third party (Kenney, 2014).

Though the state government could decide to take the initiative to implement the above measures, real change will require public support. Nonprofits and advocacy groups should work to better educate Utahns about where their water comes from and how it is funded, whether through media outlets, campaigns, in schools, or other platforms. For example, educating Utahns about how their property taxes are subsidizing water use by other residents or nonprofit institutions such as universities could help bolster public support for getting rid of the property tax subsidy (Utah Rivers Council, 2014). Utahns also need to know more about the costs of the Lake Powell Pipeline and Bear River development—and to understand that Utahns will pay for them, they will not be subsidized by the federal government (McCool, 2015). Having Utahns pay for these projects will either significantly increase water user rates—by 370 percent according to one estimate—or else require significant tax revenues (Ewert, 2014). Residents should know not only how much such projects will cost them, but also what the alternatives are and that in many cases, they could save money without significantly altering their lifestyles and without developing more supply.

The Mormon dominance in Utah can also be used to promote a new water gospel, one that is based on conserving water and natural resources for future generations. Mormons are generally receptive to what their leaders say and are able to mobilize efforts quickly and effectively, as was seen in the case of Proposition 8 in California in 2008 (Campbell et al., 2014). When LDS leaders encouraged members to get involved in the pro-Proposition 8 campaign (in support of banning gay marriage) they jumped into action donating approximately $20 million to the campaign, participating in door-to-door canvassing, and organizing outreach throughout the state (Campbell et al., 2014). If the Mormons mobilized to reduce water use in Utah, by educate each other and the public about water conservation, it could have an impact.

This effort could start with church members or leaders, or even through the various youth groups. The LDS Church leaders are very powerful and have the ear of millions in Utah, and even more globally. Other nonprofits and advocacy organizations could work together with LDS Church members and leaders to craft messages of water conservation, or to even to campaign for removing the property tax authority of WCDs.

The Church can also lead by example. Because the LDS Church is such a large presence in Utah, what they do matters. Church-owned buildings could have water-efficient appliances and low-flow fixtures, and advertise their actions. LDS wards could also become demonstration gardens for water-wise landscaping, providing most neighborhoods in Utah with a demonstration project. Most houses in Utah are likely within walking distance of a ward; this would make most residents in Utah within walking distance of a water-wise demonstration garden. Rather than the few demonstration gardens scattered throughout the state by some of the WCDs, Utahns could see them in their neighborhood regularly, potentially removing biases regarding what a water-wise landscape looks like.

The public also should be more included in the decision making of such projects (Erickson, 2015). Whether through participatory visioning processes such as Envision Utah, or even through the electoral process, Utahns have the right to determine the how to deal with potential water shortages and how much they are willing to pay for solutions. While most of significant water development is carried out at the state level, there are dozens of water suppliers throughout the state. If statewide change is slow to happen, citizens can start with their own water suppliers and work with their city councils and municipalities to put in place ordinances for their communities that will increase water conservation.

## CONCLUSIONS

While Utah water managers and policymakers claim to promote water conservation, when viewed in comparison to nearby states the actual water conservation efforts by the Utah state government and local water districts seem minimal and the water use gluttonous. Rather than devote resources to demand-side management, the state and WCDs are spending money lobbying for supply-side projects that may not be necessary or even viable. Given the history of the state, the cultural significance of agriculture, the traditional reliance on engineered answers to water problems, and the historically low cost of water, the focus on supply-side solutions in Utah is not surprising. However, the era of large water infrastructure projects should be over. The high costs of projects such as developing the Bear River or the Lake Powell Pipeline will be paid by Utah taxpayers, as well as by the environment. These projects will take decades to complete, if they ever begin, but changes in water consumption patterns may be needed sooner. A warmer climate is already affecting the precarious water supplies Utah relies on, and forecasts for the rest of the century look even worse. Indeed, the winter of December 2014 through February 2015 was the warmest on record for Utah, and farmers are already facing drought conditions in April (McFall, 2015). California, just to the west, with state mandated conservation requirements serves as an ominous reminder of drought (Governor's Press Office, 2015). The Utah State Water Plan from 2001 declares that "Utah needs to implement water conservation measures and programs now, rather than wait for a crisis" (Utah Division of Water Resources, 2001, p. 25). Unfortunately, the wait may be over and the day of reckoning may be nigh.

By changing the water pricing structure, amending archaic water rights legislation, and serving as an example, the state government can remove some of the barriers that exist in Utah to promoting demand-side measures. Nonprofit and advocacy organizations need to work to educate the public about the true costs of their water and what the alternatives are. Perhaps the largest advocacy group in the state, the LDS Church can change the perceptions and mentalities of millions. The Mormons can once again be water pioneers, though this time in water conservation.

The path of water conservation is clear, but there is another road much less traveled that Utahns could take to balance water supply and demand. Rather than continuing to bend and alter nature to meet human needs, Utahns could decide to live within its bounds. This could take several different forms. A small step in this direction would be to develop more densely with more regional-appropriate plantings, rather than continuing to develop single-family homes with thirsty yards. A giant leap towards living within the bounds of nature would be to control or limit growth. This is a highly unlikely solution in a state with a booming population like Utah, but it is a solution. At the very least, the puzzle of balancing water supply and demand for in the future should spark a serious conversation among Utahns not only about water but also about the way they live and the resources they rely on.

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## REFERENCES


17B-2a-1004, Utah (2014). Retrieved from http://le.utah.gov/xcode/Title17B/Chapter2A/17B-2a-S1005.html?v=C17B-2a-S1005_2014040320140513

73-10-32, Utah Code (2007). Retrieved from http://le.utah.gov/xcode/Title73/Chapter10/73-10-S32.html?v=C73-10-S32_1800010118000101

Adams, S. J. Water infrastructure funding, Pub. L. No. S.B. 281 (2015). Retrieved from http://le.utah.gov/~2015/bills/static/SB0281.html

Adams, T. (2013, December). *Planning for Utah's water needs*. Presented at the State Water Strategy Advisory Team Meeting.

Adams, T. (2015, January 14). Deputy Director, Utah Division of Water Resources. Personal Communication.

Adams, T., Leeflang, B., & Collins, M. (2014, October). *Bear River Development Project: Providing Northern Utah's Future Water Supply*. Presented at the Great Salt Lake Advisory Council Meeting. Retrieved from http://www.gslcouncil.utah.gov/docs/2014/10Oct/BearRiverPipelineProject.pdf

Alexander, T. G. (2003). Interdependence and change: Mutual irrigation companies in Utah's Wasatch oasis in an age of modernization, 1870-1930. *Utah Historical Quarterly, 71*(4), 292–314.

Bardsley, T., Wood, A., Hobbins, M., Kirkham, T., Briefer, L., Niermeyer, J., & Burian, S. (2013). Planning for an Uncertain Future: Climate Change Sensitivity Assessment toward Adaptation Planning for Public Water Supply. *Earth Interactions, 17*(23), 1–26. http://doi.org/10.1175/2012EI000501.1

Campbell, D. E., Green, J. C., & Monson, J. Q. (2014). *Seeking the promised land: Mormons and American politics*. New York, NY: Cambridge University Press.

Capener, T. (2015). Utah conversations with Ted Capener: Episode 1807. *Utah Conversations with Ted Capener*. KUED. Retrieved from http://www.kued.org/whatson/utah-conversations-with-ted-capener/utah-conversations-with-ted-capener-episode-1807

Central Utah Project Completion Act Office. (n.d.). Frequently asked questions. Retrieved April 26, 2015, from http://www.cupcao.gov/faq.html

Central Utah Water Conservancy District. (2011). 2015 grant program. Retrieved May 17, 2015, from http://cuwcd.com/rebates/grants.html

Clyde, S. E. (2008). Marketplace reallocation in the Colorado River Basin: Better utilization of the West's scarce water resources. *Utah Environmental Law Review, 28*(1), 49–70.

Clyde, S. E. (2013). Water law adaptability: Increasing water use efficiency, meeting the needs of growing population and sustainable agriculture. *The Water Report*, (117), 1–15.

Colorado Water Conservation Board. (2014, December 10). Colorado's water plan. Colorado Water Conservation Board. Retrieved from https://www.colorado.gov/pacific/sites/default/files/2014-Draft-Colorado%27sWaterPlan%28FULL%29.pdf

Colorado Water Conservation Board. (n.d.). Minimum required water conservation plan elements. Retrieved from http://cwcb.state.co.us/water-management/waterEfficiency/Documents/MinReqWaterConservePlanElements.pdf

Cook, B. I., Ault, T. R., & Smerdon, J. E. (2015). Unprecedented 21st century drought risk in the American Southwest and Central Plains. *Science Advances, 1*(1), e1400082–e1400082. http://doi.org/10.1126/sciadv.1400082

C.R.S. 37-60-126, Colorado Revised Statutes (2014). Retrieved from http://www.lexisnexis.com/hottopics/colorado?app=00075&view=full&interface=1&docinfo=off&searchtype=get&search=C.R.S.+37-60-126

C.R.S. 37-96-103, Colorado Revised Statutes (2014). Retrieved from http://www.lexisnexis.com/hottopics/colorado/?app=00075&view=full&interface=1&docinfo=off&searchtype=get&search=C.R.S.+37-96-103

C.R.S. 37-97-103, Colorado Revised Statutes (2014). Retrieved from http://www.lexisnexis.com/hottopics/colorado/?app=00075&view=full&interface=1&docinfo=off&searchtype=get&search=C.R.S.+37-97-103

Davidson, L., & Canham, M. (2015, March 29). Mormon church lobbying in Utah's Capitol -- hardball or light touch? *The Salt Lake Tribune*. Salt Lake City, UT. Retrieved from http://www.sltrib.com/news/2323383-155/mormon-church-lobbying-in-utahs-capitol

De Freitas, L. (2015, March 17). Executive Director, Friends of Great Salt Lake. Personal Communication.

Denton, C. (2014). Bear River: Learning from a river that closes our circle. In H. Crimmel (Ed.), *Desert Water* (pp. 41–58). Salt Lake City, UT: University of Utah Press.

Denver Water. (2014). *2014 cost-of-service rate report*. Retrieved from http://www.denverwater.org/docs/assets/FE5BAAEB-CFAD-9D63-2FE29E3BFA44D172/2014-rate-report.pdf

Denver Water. (2015a). Conservation. Retrieved March 27, 2015, from http://www.denverwater.org/Conservation/

Denver Water. (2015b). Conservation plan. Retrieved March 27, 2015, from http://www.denverwater.org/Conservation/ConservationPlan/

DeRose, R. J., Bekker, M. F., Wang, S.-Y., Buckley, B. M., Kjelgren, R. K., Bardsley, T., ... Allen, E. B. (2015). A millennium-length reconstruction of Bear River stream flow, Utah. *Journal of Hydrology*. http://doi.org/10.1016/j.jhydrol.2015.01.014

Erickson, S. (2015, March 20). Utah Coordinator for the Great Basin Water Network and Policy Advocate for the Utah Audubon Council. Personal Communication.

Erie, L. J., French, O. F., Bucks, D. A., & Harris, K. (1982). *Consumptive use of water by major crops in the southwestern United States* (Conservation Research Report No. 29). United States Department of Agriculture. Retrieved from http://cals.arizona.edu/crop/irrigation/consumuse/conusefinal.pdf

Ewert, E. C. (2014). The coming challenge: Population growth and water decline. In H. Crimmel (Ed.), *Desert Water* (pp. 13–28). Salt Lake City, UT: University of Utah Press.

Finlinson, F. (n.d.). Utah's water history, events and lessons. Washington County Water Conservancy District. Retrieved from http://www.wcwcd.org/wp-content/uploads/2013/04/UtahsWaterHistory1.pdf

Foltz, R. C. (2000). Mormon values and the Utah environment. *Worldviews: Global Religions, Culture & Ecology, 4*(1), 1–19.

Fornataro, E. A. (2008). The last untapped river in Utah: An argument against the development of the Bear River. *Journal of Land, Resources, & Environmental Law, 28*(1), 141–162.

Frankel, Z. (2015, March 25). Executive Director, Utah Rivers Council. Personal Communication.

Gardener, E. V., & Lively, N. Z. (2013). The path of a conservation trailblazer. *Journal: American Water Works Association, 105*(2), 14–18. http://doi.org/10.5942/jawwa.2013.105.0033

Gehrke, R., & Dobner, J. (2015, March 7). Mormon leaders, LGBT groups trumpet new anti-bias bill as a "model." *The Salt Lake Tribune*. Retrieved from http://www.sltrib.com/home/2249270-155/mormon-leaders-lgbt-groups-rally-behind

Georgakakos, A., Fleming, P., Dettinger, M., Peters-Lidard, C., Richmond, T. (T. C. ., Reckhow, K., ... Yates, D. (n.d.). Chapter 3: Water resources. In J. M. Melillo, T. (T. C. . Richmond, & G. W. Yohe (Eds.), *Climate Change Impacts in the United States: The Third National Climate Assessment* (pp. 69–112). U.S. Global Change

Research Program. Retrieved from http://nca2014.globalchange.gov/report/sectors/water

Gillies, R. R. (2014, May). *Utah's climate - Our current understanding of past and current climate and, future prospects.*

Gillies, R. R., Wang, S.-Y., & Booth, M. R. (2012). Observational and synoptic analyses of the winter precipitation regime change over Utah. *Journal of Climate, 25*(13), 4679–4698. http://doi.org/10.1175/JCLI-D-11-00084.1

Glen Canyon Institute. (2000). *Citizens' environmental assessment on the decommissioning of Glen Canyon Dam.* Glen Canyon Institute. Retrieved from http://www.glencanyon.org/pdfs/CEA_Report.pdf

Glen Canyon Institute. (n.d.). Glen Canyon Institute. Retrieved May 19, 2015, from http://www.glencanyon.org/about

Goetz, M. (2013). Defining rates by the gallon makes water worth the price. *Journal: American Water Works Association, 105*(6), 42–44. http://doi.org/10.5942/jawwa.2013.105.0078

Governor's Press Office. (2015, April 1). Top story: California drought. Retrieved May 1, 2015, from http://ca.gov/drought/topstory/top-story-29.html

Handley, G. (2014). The restoration of all things: The case of the Provo River Delta. In H. Crimmel (Ed.), *Desert Water* (pp. 59–79). Salt Lake City, UT: University of Utah Press.

Handley, G., Ball, T. B., & Peck, S. L. (2006). *Stewardship and the creation: LDS perspectives on the environment.* Provo, Utah: Religious Studies Center, Brigham Young University. Retrieved from http://rsc.byu.edu/%5Bfield_status-raw%5D/stewardship-and-creation-lds-perspectives-environment

Jordan Valley WCD, & Hansens, Bradshaw, Malmrose & Erickson. (2014). *Jordan Valley Water Conservancy District: Basic financial statements and independent auditors' report years ended June 30, 2014 and 2013.* Jordan Valley Water Conservancy District. Retrieved from https://jvwcd.org/file/30b50137-cd20-424e-83f4-b1adb657df5c/JVWCD-Basic-Financial-Statements---Signed.pdf

Keith, J. E. (2008). *Final report on the impacts of Beryl-Enterprise groundwater use changes.* Utah State University. Retrieved from http://www.waterrights.utah.gov/groundwater/ManagementReports/BerylEnt/Notes%20on%20Beryl%20Enterprise%20withdrawal%20impactsrev.doc

Kenney, D. S. (2014). Understanding utility disincentives to water conservation as a means of adapting to climate change pressures. *Journal - American Water Works Association, 106*, 36–46. http://doi.org/10.5942/jawwa.2014.106.0008

Kirkham, T., & Bardsley, T. (2013, May). *Climate change and Salt Lake City's water supply: Planning for an uncertain future.* Presented at the American Water Resources

Association Utah Section Annual Conference. Retrieved from http://state.awra.org/utah/sites/default/files/AWRA2013_Bardsley_Kirkham.pdf

Kuranz, A., & Kenney, D. S. (2014). *Media treatment of "climate change" in chaping Colorado River problems and solutions* (Western Water Assessment White Paper). University of Colorado. Retrieved from http://wwa.colorado.edu/publications/reports/WWA_Kenney_Kuranz_Media_Treatment_2014.pdf

Maupin, M. A., Kenny, J. F., Hutson, S. S., Lovelace, J. K., Barber, N. L., & Linsey, K. S. (2015). *Estimated use of water in the United States in 2010*. U.S. Geological Survey. Retrieved from http://dx.doi.org/10.3133/cir1405

McCool, D. (1995). Politics, water, and Utah. In D. McCool (Ed.), *Waters of Zion: the politics of water in Utah* (pp. 3–27). Salt Lake City: University of Utah Press.

McCool, D. (2015, February 4). Director, Environmental and Sustainability Studies Program, Environmental and Sustainability Studies and Professor, Political Science Department, University of Utah. Personal Communication.

McFall, M. (2015, April 7). Drought leaves Utah's farmers wondering what they can grow this summer. *The Salt Lake Tribune*. Retrieved from http://www.sltrib.com/news/2365508-155/drought-leaves-utahs-farmers-wondering-what

Melillo, J. M., Richmond, T. (T. C. ., & Yohe, G. W. (Eds.). (2014). *Climate change impacts in the United States: The third national climate assessment*. U.S. Global Change Research Program. Retrieved from http://purl.fdlp.gov/GPO/gpo48682

Miller, T. (1995). Utah water politics in a national perspective. In D. McCool (Ed.), *Waters of Zion: the politics of water in Utah* (pp. 3–27). Salt Lake City: University of Utah Press.

MWDSLS. (2014, June 17). FY 2015 Metropolitan Water District of Salt Lake & Sandy. Retrieved from http://www.mwdsls.org/pdfs/FY2015_MWDSLS_Final_Budget.pdf

Nuding, A. (n.d.). The local waters alternative to the Lake Powell Pipeline. Western Resource Advocates. Retrieved from http://www.westernresourceadvocates.org/water/pdf/altlakepowellreport.pdf

Office of Legislative Research and General Counsel. (2012). *How Utah water works: An overview of sources, uses, funding, and pricing*. Utah Legislature. Retrieved from http://le.utah.gov/interim/2012/pdf/00002706.pdf

Office of the Legislative Auditor General, State of Utah. (2015). *Report to the Utah Legislature: A performance audit of projections of Utah's water needs* (Performance Audit No. 2015-01). Retrieved from http://le.utah.gov/audit/15_01rpt.pdf

Palmer, B. (2014, December). Dam shame: Five of America's worst. Retrieved May 2, 2015, from http://www.onearth.org/earthwire/dam-shame

Peterson, W. H. (2013). *Water for Utah agriculture: Governor's water initiative.*

Powell, J. L. (2008). *Dead pool: Lake Powell, global warming, and the future of water in the west*. Berkeley: University of California Press.

Prepare60. (2014). *What is Prepare60?*. Retrieved from http://prepare60.com/Content/P60_Presentation.pdf

Reid, C. R., Christensen, K. H., & Hill, R. W. (2008, December). Water rights in Utah. Utah State University Cooperative Extension. Retrieved from http://extension.usu.edu/files/publications/publication/ENGR_WaterManagement_2008-01pr.pdf

Reisner, M. (1993). *Cadillac desert: the American West and its disappearing water* (Rev. and updated). New York, N.Y., U.S.A: Penguin Books.

Romero-Lankao, P., Smith, J. B., Davidson, D. J., Diffenbaugh, N. S., Kinney, P. L., Kirshen, P., ... Villers Ruiz, L. (2014). North America. In V. R. Barros, C. B. Field, D. J. Dokken, M. D. Mastrandrea, K. J. Mach, T. E. Bilir, ... L. L. White (Eds.), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1439–1498). Cambridge, UK and New York, NY, USA: Cambridge University Press. Retrieved from https://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Chap26_FINAL.pdf

Salt Lake City Department of Public Utilities. (2014, July 1). Water rates. Retrieved from http://www.slcdocs.com/utilities/PDF%20Files/UtilityRates/WaterrateswebCurrent.pdf

Salvaggio, M., Futrell, R., Batson, C. D., & Brents, B. G. (2014). Water scarcity in the desert metropolis: how environmental values, knowledge and concern affect Las Vegas residents' support for water conservation policy. *Journal of Environmental Planning and Management, 57*(4), 588–611. http://doi.org/10.1080/09640568.2012.756806

Slow the Flow. (2011). About us. Retrieved May 17, 2015, from http://www.slowtheflow.org/index.php/about-us

Southern Nevada Water Authority. (2014). *Water conservation plan, 2014-2018*. Retrieved from http://www.snwa.com/assets/pdf/about_snwa_conservation_plan_2014.pdf

Southern Nevada Water Authority. (2015). Water smart landscapes rebate. Retrieved March 22, 2015, from http://www.snwa.com/rebates/rebates.html

State of Nevada Division of Water Resources. (1999, March). Nevada state water plan. Retrieved from http://water.nv.gov/programs/planning/stateplan/summary/

Strong, C. (2013, May). *Future precipitation and snowpack along the Wasatch Range.* Presented at the American Water Resources Association Utah Section Annual Conference. Retrieved from http://state.awra.org/utah/sites/default/files/Strong-FutureSupply.pdf

Strong, C. (2015, January 14). Assistant Professor, Department of Atmospheric Sciences, University of Utah. Personal Communication.

Taylor, A. (2015, April 2). The American West dries up. Retrieved April 26, 2015, from http://www.theatlantic.com/photo/2015/04/the-american-west-dries-up/389432/

Tejral, J. (2015, May). *Conservation year in review: 2014.* Presented at the Denver Board of Water Commissioners, Denver Water. Retrieved from http://www.denverwater.org/docs/assets/15510BC7-E518-3FCC-1688F5AB5FB2B299/2014_Conservation_Update.pdf

The Pew Forum on Religion & Public Life. (2008). *U.S. religious landscape survey: Religious affiliation: Diverse and dynamic.* Pew Research Center. Retrieved from http://religions.pewforum.org/pdf/report-religious-landscape-study-full.pdf

The Utah Taxpayers Association. (2011). Eliminate the property tax subsidy for water. *The Utah Taxpayer, 61,* 1–2.

Tingstad, A., & MacDonald, Glen M. (2010). Long-term relationships between ocean variability and water resources in northeastern Utah. *Journal of the American Water Resources Association, 46*(5), 987–1002.

United States Census Bureau. (2015). State & county QuickFacts: Utah [Government]. Retrieved from http://quickfacts.census.gov/qfd/states/49000.html

US Census Bureau. (2010). Census data rural vs. urban. Retrieved from https://www.census.gov/geo/reference/ua/urban-rural-2010.html

USDA. (2015, April 30). 2014 state agricultural overview: Utah. Retrieved April 30, 2015, from http://www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=UTAH

USDA Economic Research Service. (2013, June 7). Western irrigated agriculture. Retrieved April 30, 2015, from http://www.ers.usda.gov/data-products/western-irrigated-agriculture.aspx

USDA Natural Resources Conservation Service. (n.d.). Agricultural water enhancement program. Retrieved May 3, 2015, from http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/awep/

Utah Department of Agriculture and Food. (2014). *2014 Utah agriculture statistics and Utah Department of Agriculture and Food annual report*. Retrieved from http://ag.utah.gov/documents/annualreport2014web.pdf

Utah Division of Water Resources. (2001). *Utah's water resources: Planning for the future.* Utah Division of Water Resources.

Utah Division of Water Resources. (2010a). *2009 residential water use: survey results and analysis of residential water use for seventeen communities in Utah.* Utah Division of Water Resources. Retrieved from http://www.water.utah.gov/OtherReports/RWU_Study.pdf

Utah Division of Water Resources. (2010b). *Jordan River Basin: Planning for the future.* Utah Division of Water Resources.

Utah Division of Water Resources. (2010c). *The cost of water in Utah: "Why are our water costs so low?."* Utah Division of Water Resources.

Utah Division of Water Resources. (2012). *The Water-energy nexus in Utah.* Utah Division of Water Resources. Retrieved from http://www.water.utah.gov/OtherReports/Water%20Energy%20Nexus%20in%20Utah.pdf

Utah Division of Water Resources. (2014a). *Utah's M&I water conservation plan: Investing in the future*. Utah Division of Water Resources. Retrieved from http://www.water.utah.gov/OtherReports/M&IConservation_Revision_2012.pdf

Utah Division of Water Resources. (2014b, October). State of Utah municipal and industrial water supply and use study summary 2010. Utah Division of Water Resources.

Utah Division of Water Resources. (2015). *Water for Utah: A review of duties and funding programs of the Division and Board of Water Resources*. Utah Division of Water Resources. Retrieved from http://www.water.utah.gov/Construction/Water%20for%20Utah/waterforutah.pdf

Utah Division of Water Rights. (n.d.). FAQ's. Retrieved May 2, 2015, from http://www.waterrights.utah.gov/wrinfo/faq.asp

Utah Economic Council. (2015). *2015 economic report to the governor*. David Eccles School of Business and Governor's Office of Management and Budget. Retrieved from https://bebr.business.utah.edu/sites/default/files/2015_erg.pdf

Utah Farm Bureau Federation. (2015, March 13). Final policy watch. *Policy Watch Newsletter*, (8). Retrieved from http://www.utahfarmbureau.org/f/10b1c2aa-c0ed-4d74-99a2-5bed51a73a36/8-final-policy-watch-newsletter-march-13

Utah Foundation. (2014). *Flowing toward 2050: Utah's water outlook* (Research Report No. 723). Utah Foundation. Retrieved from http://www.utahfoundation.org/uploads/rr723.pdf

Utah Governor's Office of Management and Budget. (2012). *Sub-County population projections (data set)*. Retrieved from http://gomb.utah.gov/wp-content/uploads/sites/7/2013/08/Subcounty-Pop-Projections-2013.xlsx

Utah Rivers Council. (2001). *Mirage in the desert: Property tax subsidies for water.*

Utah Rivers Council. (2014, March 24). March '14 Audit Correspondence.

Vedder, K. (1995). Water development in the Salt Lake Valley. In D. McCool (Ed.), *Waters of Zion: the politics of water in Utah* (pp. 3–27). Salt Lake City: University of Utah Press.

Ward, T. (2015, January 16). Deputy Director, Salt Lake City Public Utilities. Personal Communication.