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LONG-RANGE WATER SUPPLY PLAN

Prepared for:

Wichita Falls

Wichita Falls TEXAS
BLUE SKIES. GOLDEN OPPORTUNITIES

January 2015
Revised January 2016

Prepared by:

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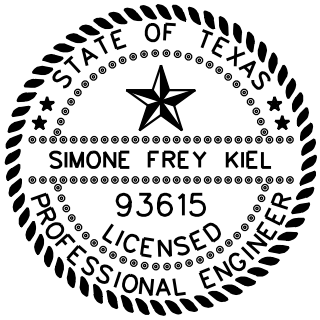

Long Range Water Supply Plan

January 2015
Revised January 2016

Prepared for:

City of Wichita Falls

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EXECUTIVE SUMMARY

Between 2011 and 2015 the City of Wichita Falls experienced a severe drought which expedited the need for additional water supplies and highlighted the challenges with securing new supplies in the short-term. This Long Range Water Supply Plan evaluates the water needs for Wichita Falls and provides the analyses necessary for the City to identify and secure water supplies for Wichita Falls' future. The Plan was updated in January 2016 to reflect the full impact of the 2011-2015 drought.

A critical aspect of this study is the amount of existing supply that Wichita Falls can rely on for future water needs. Wichita Falls' existing water supplies were greatly impacted during the recent drought, and several supply analyses were performed as part of this study to quantify immediate short-term impacts and long-term reliability of existing supplies. With staff input, the hydrology was extended through June 2015. The reliable supply for Wichita Falls assumes there is a 20% reserve in each reservoir at the end of the 2011-2015 drought of record. This represents similar conditions to those the City experienced at the end of the recent drought, which triggered the implementation of emergency drought stages and the direct potable reuse project. This analysis results in a reliable supply of about 18.5 million gallons per day (MGD) from the City's existing lakes in 2020. The projected demands on the City, including wholesale customers, total about 30 MGD. A comparison of the supply and demands in Figure ES-1 shows an expected immediate water shortage of about 11.3 MGD. The shortage is shown to increase over time to about 19.3 MGD due to increases in demands and reductions in supplies from reduced storage capacities associated with sediment accumulation.

To address these shortages, potential water management strategies were systematically evaluated through an initial screening process, followed by a more thorough assessment of the retained strategies. The initial screening analysis considered twenty-two potential strategies. Each of the identified potential strategies were assessed based on water quantity, water quality, reliability, regulatory requirements, environmental impacts, potential cost, time to implement, development obstacles, supply independence and competition for water supply. Of the ten criteria, water quantity, reliability and potential cost were selected to have a greater weight in the analysis. Twelve strategies were selected for further analysis and are shown in Table ES-1.

Figure ES-1: Reliable Supply versus Demand

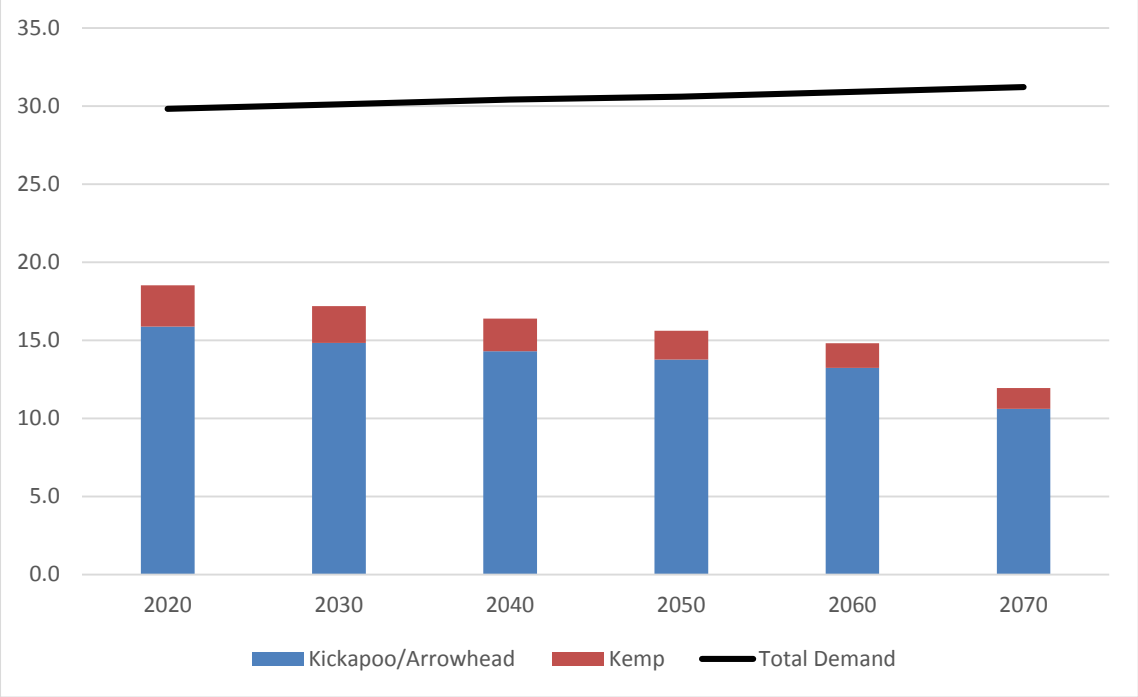


Table ES-1: Selected Strategies for Further Evaluation

Alternative	Composite Score (max 80)	Rank
Indirect Reuse	72	1
Water Conservation	67	2
Lake Ringgold Water	58	3
Groundwater HFSJ	50	4
Groundwater From Wilbarger County	49	5
Groundwater From Roberts County	47	6
Groundwater From Donley & Gray County	45	7
Wichita River Supply	45	7
Lake Kemp Water Right Amendment	43	9
Groundwater From Denton County	41	10
Lake Texoma Water	41	10
Lake Bridgeport Water	40	12

The twelve selected strategies were broken into two categories, short-term strategies and long-term strategies. The short-term strategies were those which could be implemented within two to four

years included indirect reuse, water conservation, local groundwater (HFSJ), Wichita River supplies, and a conjunctive use project of local groundwater and Wichita River supplies. The remaining eight strategies were evaluated as long-term strategies.

Based on the strategy evaluations and consultation with City staff, the strategies that provide the greatest potential for reliable water supply to Wichita Falls include water conservation, indirect reuse, Lake Ringgold, Lake Texoma and one of the Panhandle groundwater strategies. Short term strategies that could potentially provide supplies in the near-term until a long-term strategy could be implemented include Groundwater from Wichita County (HFSJ), Wichita River diversions and/or Conjunctive Use of these two strategies. However, further evaluations will be needed to confirm the quantities, quality and reliability of these sources. Preliminary studies indicate these near-term strategies provide small quantities of water with unproven reliability. The City also requested further consideration of Groundwater from Wilbarger County as a potential short-term supply and a potential interconnection with Tarrant Regional Water District through Lake Bridgeport.

To better assess the potential direction for water supply development, four scenarios were developed to meet Wichita Falls' water needs. Since the City is moving forward with its water conservation program and indirect reuse project, which both were ranked very highly, all scenarios include both conservation and indirect reuse. Each scenario considered the quantity of water that could be developed, the timing of when the supply would be online and cost to the City and rate payers. Each scenario has beneficial aspects and potential drawback which are discussed briefly.

- Scenario 1 - HFSJ groundwater, Wichita River and Lake Ringgold. Scenario 1 is the lowest cost scenario with both short and long-term supplies in close proximity to Wichita Falls. The potential drawbacks are the uncertainty of short-term supplies (groundwater and Wichita River), potential reduction in supplies in an extended drought worse than the drought of record and limiting supply independence to the current Wichita River and Little Wichita River watersheds.

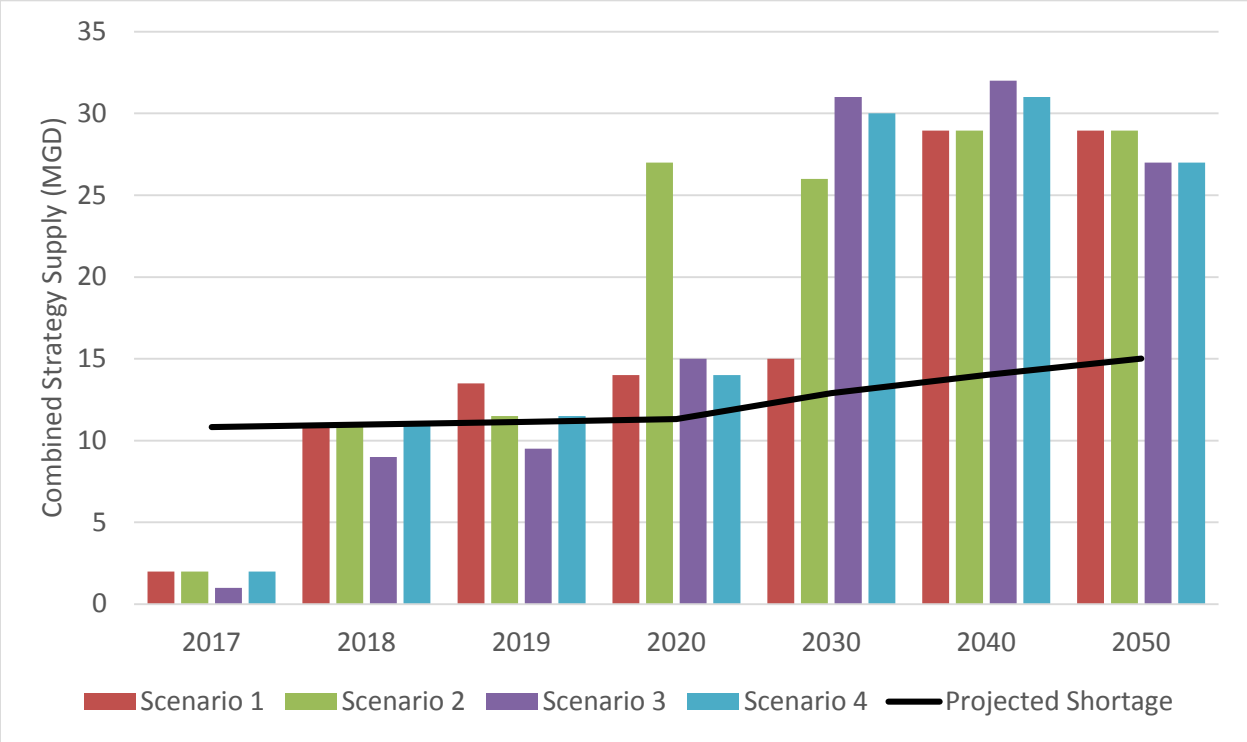
- Scenario 2 –HFSJ groundwater, Lake Bridgeport, Lake Ringgold. Scenario 2 provides a potential interconnection with TRWD which could in the long-term provide increased reliability and cost sharing for Lake Ringgold. However, at this time without an agreement with TRWD this scenario is not feasible.

- Scenario 3 – Wilbarger groundwater, Lake Texoma. Scenario 3 is the scenario that could be developed with the least amount of permitting with potentially the shortest time frame for a long term supply. The potential drawbacks include the treatment of Lake Texoma water, Zebra mussels and competition for groundwater in Wilbarger County.

- Scenario 4 – Conjunctive Use, Donley County groundwater. Scenario 4 offers the greatest independence from current supplies providing a groundwater supply which is not as susceptible to drought conditions. The drawbacks of this scenario include the high cost, uncertainty in negotiations with the Panhandle GCD and landowners, and potential maintenance of a well field and transmission system far from Wichita Falls.

As shown on Figure ES-2, all four scenarios can meet the City's projected shortages by 2020, but not all of the scenarios can fully meet the immediate shortage (prior to 2020).

Figure ES-1.2: Supplies for Scenerios by Decade

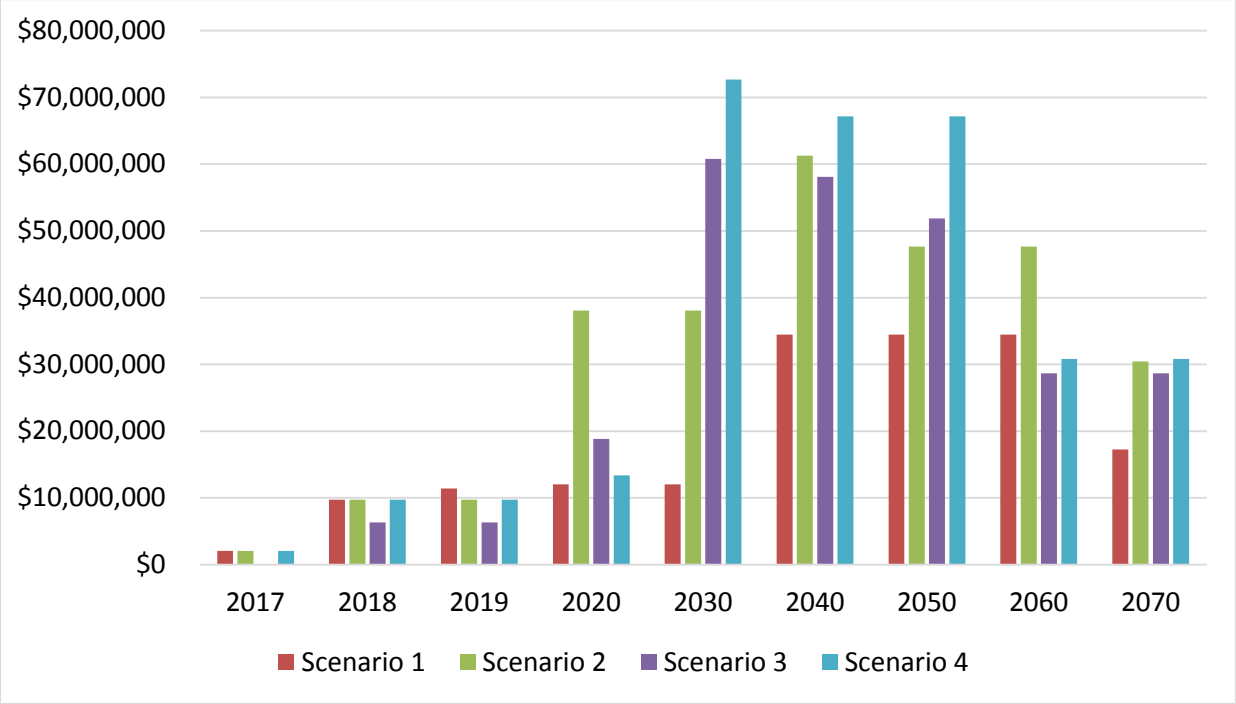


The costs for each scenario are summarized in Table ES-2 and the annual costs by decade are shown on Figure ES-3.

Table ES-2: Scenario Summary Table

Scenario	Components	Total Capital Costs	Unit Cost in $ per 1,000 gallons		
			Minimum	Average	Maximum
1	HFSJ, Wichita River, Lake Ringgold	$364,194,000	$1.78	$3.12	$5.64
2	HFSJ, Lake Bridgeport, Lake Ringgold	$588,984,000	$2.66	$4.25	$6.31
3	Wilbarger, Lake Texoma	$543,810,000	$2.17	$3.83	$5.68
4	Conjunctive Use, Donley County	$701,790,000	$2.61	$4.55	$7.36

Figure ES-1.3: Annual Costs for Scenarios by Decade



Considering all of the evaluation criteria and the City's increased importance for water quantity, reliability and potential cost of the strategies, it is recommended that the City pursue Scenario 1 (Indirect Reuse, Conservation, Local Groundwater, Wichita River and Lake Ringgold). This scenario will have the least impact to rate payers while providing supplies to meet the projected needs.

This study did note that the short-term strategies have considerable uncertainties regarding the reliability of the supplies during drought and the City should carefully monitor the supplies associated

with these strategies prior to major financial commitments. The other recommended strategies (conservation, indirect reuse and Lake Ringgold) can collectively meet the City's projected demands, but these strategies do not provide a margin of safety for future droughts worse than the 2011-2015 drought.

To provide the supplies within the timeframe shown in Figure ES-2, the City will need to initiate and/or continue the following actions:

- Continue permitting, design and construction of the indirect reuse project.
- Initiate permitting for the surface water supplies. This includes the Wichita River supply and Lake Ringgold.
- Continue negotiations with the HFSJ groundwater interests and pursue possible additional groundwater development on City-owned property.

Other recommendations to secure the City's future water supplies include:

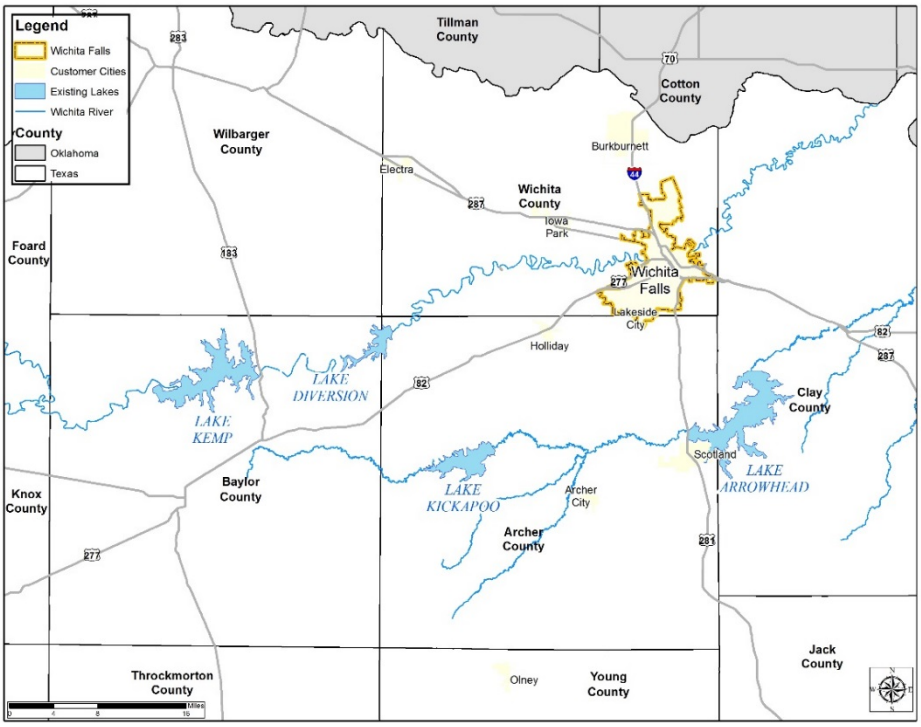
- Continue to monitor flows in the Wichita River to assess whether the drought and reduction in irrigation water use continue to impact flows in the Wichita River.
- Review current wholesale contracts to ensure the contract is an accurate reflection of water demand on the City and compensation is adequately assessed.
- Initiate discussions with the Wichita County WID #2 regarding a comprehensive operation plan for Lake Kemp.
- As opportunities arise Wichita Falls may seek to purchase additional supplies from Lake Kemp. This would provide the City with a greater percentage of supplies in the Lake Kemp/Diversion system.
- If and/or when other water supply studies are completed, review the findings and consider appropriate adjustments to this water supply plan.

1.0 INTRODUCTION

The City of Wichita Falls is located in Wichita County in North Texas near the Red River. It supports a population of 105,000 and is home to the Shepard Air Force Base and Midwestern State University. The City has a long history of developing water supplies to sustain its growth and support the industrial and institutional users within the community. Wichita Falls also is a regional water provider to local cities and water supply corporations within a 40-mile radius of the City.

The City's main water sources include Lakes Arrowhead, Kickapoo and Kemp shown in Figure 1-1. In 2011 the state of Texas experienced an extreme drought year and the Wichita Falls area was especially hard hit. High temperatures and little rainfall contributed to falling lake levels at each of the City's water sources. The drought continued through May 2015 when the lakes began to refill, with Lakes Arrowhead and Kickapoo having since both spilled and Lake Kemp reaching 84 percent of capacity. During the drought, the City implemented its drought plan and substantially reduced its water use. The City also implemented a temporary direct potable reuse project to utilize treated wastewater effluent. This allowed the City to reduce diversions from its surface water sources but it was not a permanent solution for long-term water needs and is now offline.

Figure 1.1: Wichita Falls Water Supplies



Wichita Falls recognizes that the recent drought has impacted the reliability of its current water sources and the City will need to develop additional supplies to meet the future needs of its customers. In June 2014, Wichita Falls contracted with Freese and Nichols and Biggs and Mathews to prepare a long-range water supply plan. This plan is a compilation of previous studies conducted for the City of Wichita Falls to help address the immediate need for water and the review and development of potential long-term water supplies.

The report is organized by chapter with an initial discussion of existing water supplies, water requirements, and a comparison of supply and demand in Chapters 2 through 4. Chapter 5 includes a detailed discussion of potential water sources, including the screening process used by the City to identify strategies, and descriptions of short term and long term strategies. The most promising strategies are developed into scenarios, which are discussed in Chapter 6. The report concludes with a summary of the findings, recommendations for implementation of water supply scenarios, and other recommendations to improve operations for a sustainable water supply.

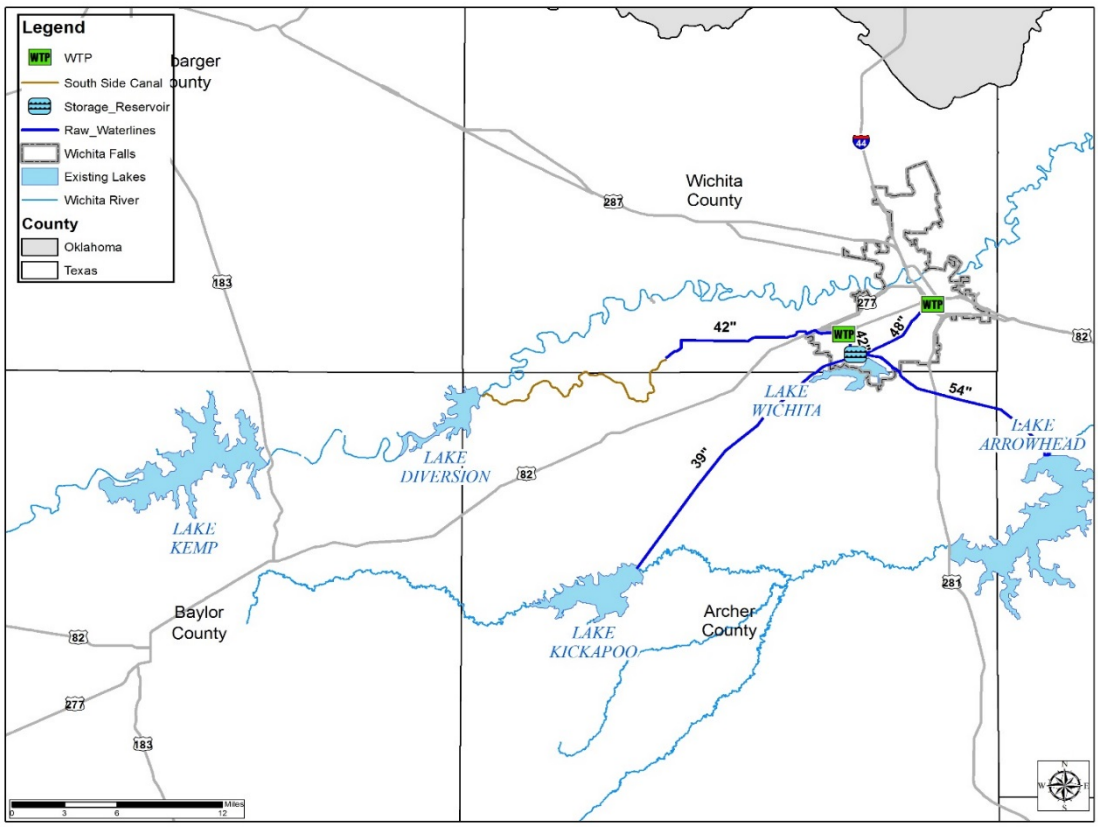
Freese and Nichols and Biggs and Mathews would like to acknowledge the guidance and input from City staff and Mayor Glenn Barham as we worked together in developing the assumptions for existing water supplies and the identification and evaluations of potential water strategies.

2.0 EXISTING WATER SUPPLIES

The City of Wichita Falls owns and operates Lake Kickapoo and Lake Arrowhead on the Little Wichita River, and co-owns the Lake Kemp-Diversion system on the Wichita River. In 2014 and early 2015, the City also used 5 million gallons per day (MGD) of treated wastewater effluent through an emergency direct potable reuse project. This project was an interim water supply to help the City reduce its reliance on its surface water sources. As of January 1, 2016, Lakes Arrowhead and Kickapoo were full and Lake Kemp was 84 percent full. Both Lakes Kickapoo and Arrowhead (the City's primary sources of water), experienced the lowest water elevations since initial filling during the drought. For the Lake Kemp-Diversion system, lake elevations were the lowest sustained elevations over a five year period beginning in 2011. During the drought of the 1950's Lake Kemp's elevation was lower, but the lake recovered within two years.

The following sections present a brief description of each of the City's water sources followed by supply evaluations. Figure 2-1 shows the locations of the Wichita Falls' surface water sources and raw water transmission system to the City.

Figure 2.1: Wichita Falls Raw Water Supply System



2.1 LAKE KICKAPOO – ARROWHEAD SYSTEM

Lakes Arrowhead and Kickapoo are operated as a system. Water from the lakes is transported to Wichita Falls' water treatment plants for treatment and distribution. Some raw water is sold directly to wholesale customers. Water from both lakes is of good quality and can be treated with conventional treatment.

Lake Kickapoo

Lake Kickapoo was built by the City of Wichita Falls in 1946 for municipal water supply with an initial conservation storage capacity of 106,000 acre-feet. The reservoir is located on the North Fork of the Little Wichita River in Archer County. The diversion rights from the lake total 40,000 acre-feet per year (35.7 MGD). The current storage capacity of the lake is estimated at 86,345 acre-feet (TWDB Volumetric Survey, 2014). In addition to the water that is transported to the City for treatment, raw water is sold from the lake to Archer City, the City of Olney and the Wichita Valley Water Supply Corporation.

Lake Arrowhead

Lake Arrowhead was built in 1966 by the City of Wichita Falls for municipal, industrial and recreational use. The lake is located on Little Wichita River in Clay County, about 12 miles southeast of Wichita Falls. The diversion rights from Lake Arrowhead total 45,000 acre-feet per year (40.14 MGD); however, the maximum diversion from both Lakes Arrowhead and Kickapoo cannot exceed 65,000 acre-feet per year (58.0 MGD). The storage capacity of the lake is currently estimated at 230,359 acre-feet (TWDB Volumetric Survey, 2014). In addition to Wichita Falls, direct customers from Lake Arrowhead include the Red River Authority (Lake Arrowhead Area, Arrowhead Ranch Estates Area, and Lake Arrowhead State Park). In addition, water is periodically released downstream to the City of Henrietta in fulfillment of its senior water right.

2.2 LAKE KEMP – DIVERSION SYSTEM

Lake Kemp is located on the Wichita River, immediately upstream of State Highway 183 in Baylor County. The lake is authorized to store 318,000 acre-feet of water. Lake Diversion was constructed approximately 20 miles downstream of Lake Kemp for secondary storage with an authorized capacity of 45,000 acre-feet. The reservoir lies in both Archer and Baylor Counties.

Lake Diversion is operated in conjunction with Lake Kemp to provide water supply for municipal, industrial, irrigation, mining and recreational purposes. The City of Wichita Falls and Wichita County Water Control and Improvement District (WCID) No. 2 own the water rights in Lake Kemp and Lake Diversion. Water released from Lake Kemp travels to Lake Diversion for distribution. Irrigation water is diverted into canal systems that distribute water to customers in Archer, Clay and Wichita Counties. Municipal water is diverted from the canal system to a pipe for transmission to Wichita Falls. American Electric Power has a contract to divert up to 20,000 acre-feet per year (17.84 MGD) for the Oklaunion Power Plant in Wilbarger County. This water is diverted directly from Lake Diversion. Water from Lake Diversion also is used to provide water to the Dundee Fish Hatchery during the spring spawning season. However, due to the drought and low water elevations, the Fish Hatchery is temporarily closed.

Historically, most of the water use from Lake Kemp has been limited to irrigation and industrial purposes because of the high salinity loads in the tributaries that flow to Lake Kemp. In 2008 the City of Wichita Falls completed a reverse osmosis system at the Cypress Water Treatment Plant (WTP) to more fully utilize water from Lake Kemp for municipal purposes.

To improve the water quality of the Wichita River, the Red River Authority sponsors a chloride control project that diverts saline water from the South Wichita River above Lake Kemp to Truscott Brine Reservoir in Knox County. Evaluations of the effectiveness of the project found these diversions reduce the total chloride load to Lake Kemp by approximately 25 percent. This results in a lower chloride concentration in the reservoir. However, a significant chloride load to the reservoir system from the North and Middle Wichita Rivers remains. Also during periods with low inflows, the quality of the water diminishes as salts become concentrated due to evaporation. As of October 2014, the total dissolved solid concentration in Lake Kemp is about 4,000 mg/l. This has limited the City's ability to treat and use Lake Kemp water. The low water content and high salinity levels have also impacted its use for irrigation. In 2012, irrigation deliveries were suspended. Deliveries to the irrigators resumed in 2015 and it is anticipated that the Dundee Fish Hatchery will reopen in 2016.

2.3 INTERIM SUPPLY – DIRECT REUSE

In response to continuing falling water elevations in 2013, Wichita Falls initiated a Direct Potable Reuse (DPR) project to supplement its current supplies with treated wastewater effluent. This project

came on-line in July 2014 and was producing 5 MGD of additional water supply for the City. This allowed the City to reduce its diversions from Lakes Kickapoo and Arrowhead.

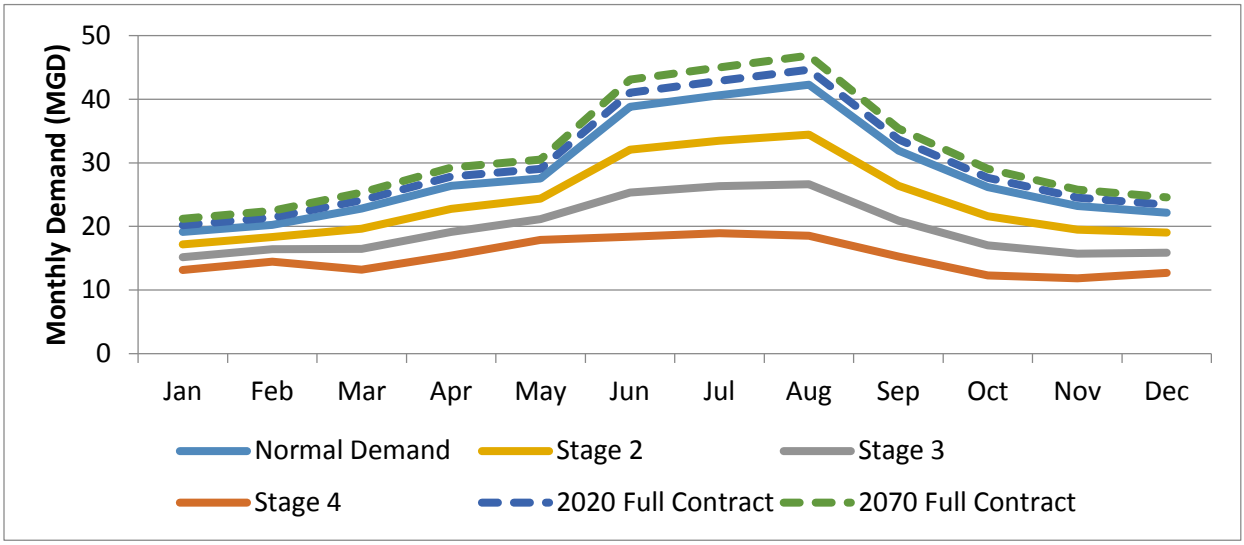
The DPR project included 12.5 miles of 32-inch pipeline that transported treated effluent from the River Road Wastewater Treatment Plant (WWTP) to the Cypress Water Treatment Plant (WTP) for advanced treatment by reverse osmosis. The treated water was then blended with raw water from the City's other sources and treated by conventional surface water treatment. Under the City's permit, the treated wastewater was limited to 50% of the total water production with a maximum amount of 5 MGD. Beginning in February 2015, the DPR began using ultraviolent disinfection of the treated effluent prior to blending with the raw surface water. This system remained in operation until July 2015. Wichita Falls intends to utilize its wastewater effluent as supplies through the development of a permanent indirect reuse project in the near future, which is discussed in further detail in section 5.2.1.

2.4 DEMAND PATTERN

Seasonal water demand patterns are considered during the evaluation of supplies. These patterns can impact the availability of supplies during higher use months. As is the case with many utilities in Texas, Wichita Falls experiences peak usage during the summer due to outdoor watering with reduced usage during the winter months. Drought restrictions tend to reduce the summer peaks by restricting outdoor usage. In the case of Wichita Falls, which restricted all outdoor watering between November 2013 and June 2015, the seasonal use pattern has been nearly flat over the past year. Figure 2-2 shows the normal year demand (pre-drought), full contract demand with the normal demand pattern applied, and varying drought restriction levels. While future peaks may be somewhat reduced due to continued conservation practices implemented during the recent drought, some level of peaking will still occur.

The demand patterns shown in Figure 2-2 were used in the modeling of supply discussed later in this chapter.

Figure 2.2: Wichita Falls Demand Pattern with Various Demand Conditions



2.5 SUPPLY EVALUATIONS

Surface water supplies are commonly defined by the yield of the reservoir, which is evaluated with a hydrologic model. For the model results to be representative of the reliable supply, the hydrologic record should include the period with the lowest historical inflows to the reservoir, followed by a period of recovery (inflows). This is referred to as the "drought of record".

When this study was initiated, the City was in the midst of the drought of record. Due to the uncertainty of the length of drought and its severity, the reliable supply for Wichita Falls was evaluated using multiple approaches. These approaches included a conditional reliability model which evaluated possible lake levels given lake levels during the drought. The next two modeling approaches, referred to as a firm and safe yield analyses, are commonly used to determine water supply in Texas and were completed with hydrology through June 2015. The fourth approach leaves more water in reserve during severe drought than the traditional safe yield analysis. This approach also recognizes the operational considerations of the City's water sources and the need for a reserve supply. The last approach, which was conducted in 2014 during the drought, was to extend the hydrology from the end of 2013 with two or three subsequent years of extreme drought. This approach attempted to characterize the expected reliable supply with droughts continuing through 2015 and 2016. While the drought has ended, the findings from this analysis provide an estimate of

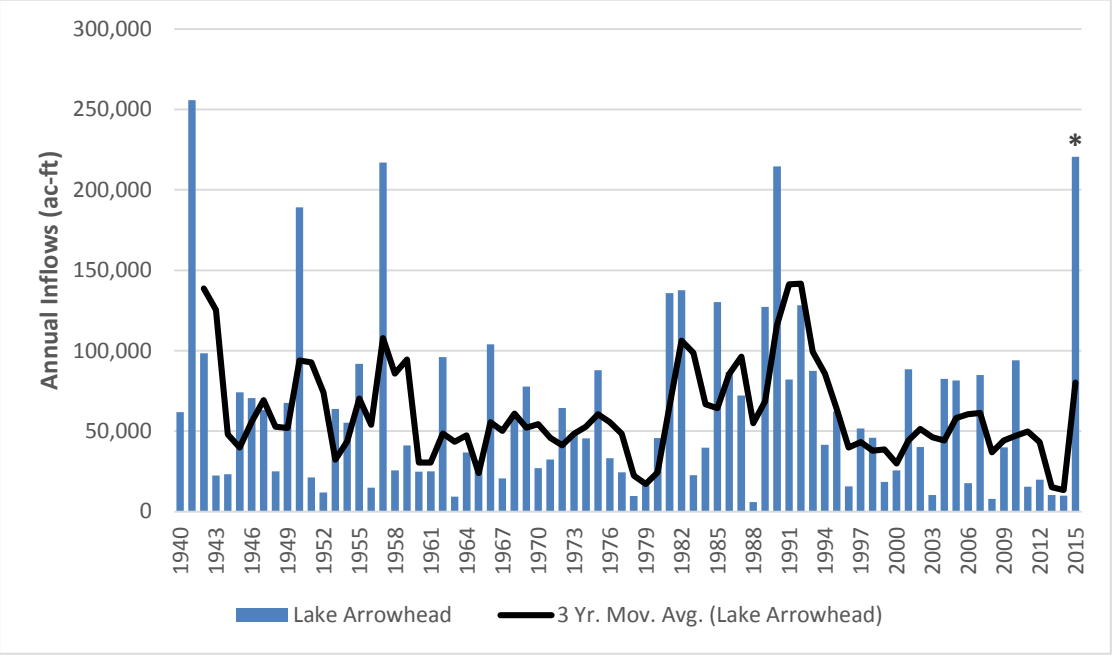
reliable supply to Wichita Falls if a drought worse than the drought of 2011-2015 should occur. The following subsections discuss these approaches in more detail.

2.5.1 Hydrology

The Wichita Falls area and the Wichita River and Little Wichita River watersheds recently experienced drought of record conditions. The year 2011 was one of the hottest and driest years on record from January through September. There was very little inflow into the City's reservoirs during this period and there were record setting evaporative losses. In 2013, inflows in the Little Wichita watershed were the lowest recorded over the past 75 years. Year 2014 was similar to 2013. It was not until May 2015 that the City's water sources received significant inflows.

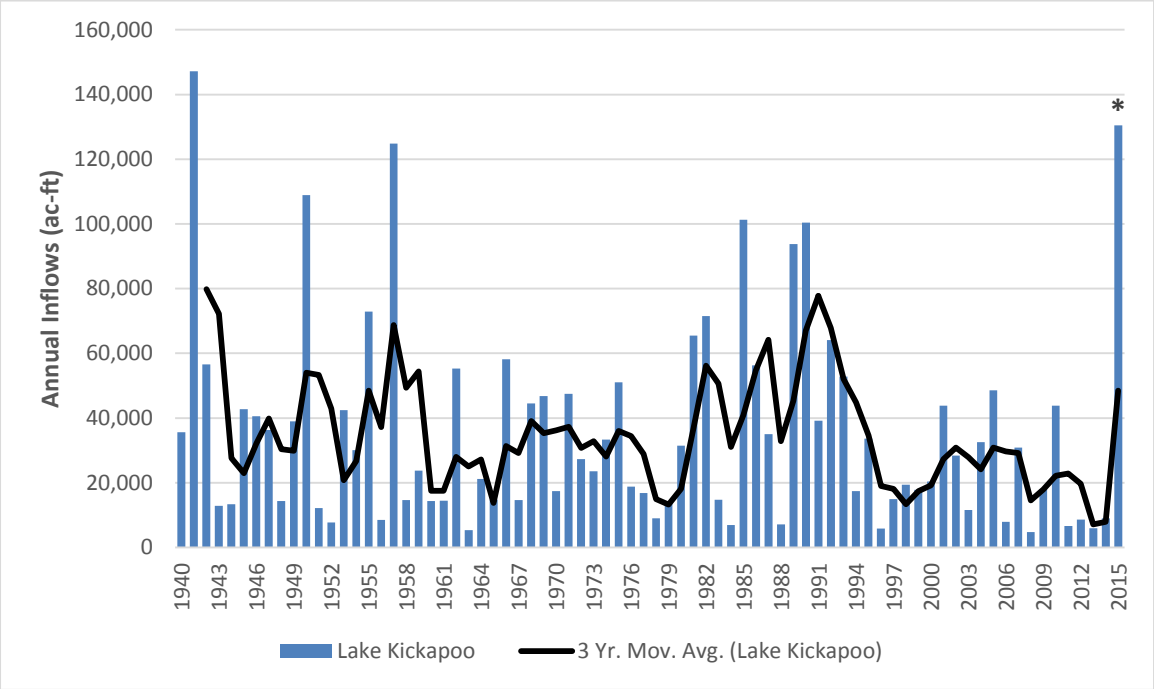
Inflows over the hydrologic record of 1940 to June 2015 were developed for Lakes Kickapoo and Arrowhead using flow data from Red River Water Availability Model (WAM), the Archer City gage, TWDB quadrangle data for evaporation and precipitation, and historical lake operating records. Figures 2-3 and 2-4 show the historical inflows to Lakes Arrowhead and Kickapoo, respectively. The black lines on these graphs represent a 3-year moving average, which indicates trends over time. For both these lakes, the period from 2011 through 2014 are the lowest inflows on record.

Figure 2.3: Lake Arrowhead Inflows



*The inflow for 2015 only includes the inflow through June 2015

Figure 2.4: Lake Kickapoo Inflows



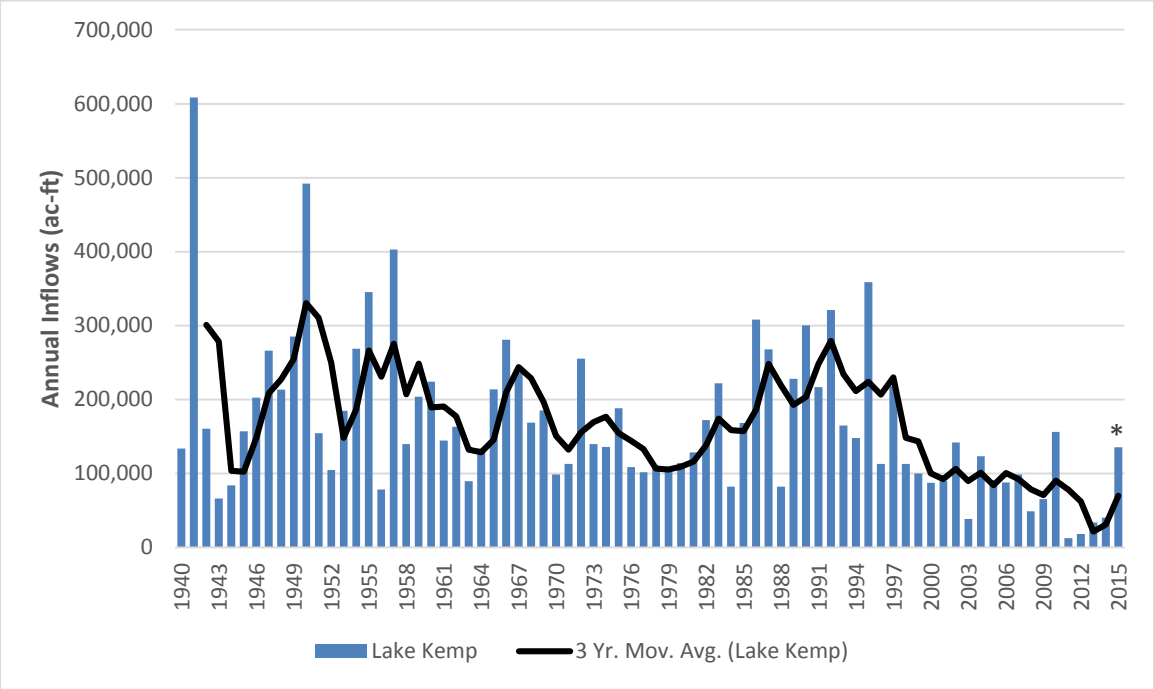
*The inflow for 2015 only includes the inflow through June 2015

As shown on the previous inflow graphs, both Lakes Arrowhead and Kickapoo have experienced periods of very low inflows, but these periods have generally lasted only one to two years. The period from 2011 through 2013 is the lowest consecutive three-year period in the historical record. The low inflows continued through early 2015.

Inflows to Lake Kemp were developed in a similar manner over the hydrologic record of 1940 to June 2015 using flow data from Red River WAM, the Mabelle gage, TWDB quadrangle data for evaporation and precipitation, and historical lake operating records. Figure 2-5 shows the inflows to Lake Kemp.

The graph for Lake Kemp shows a significant downward trend of inflows since 1997. This has impacted the reservoir yield and could continue to impact the availability of water from the lake. As shown on Figure 2-5, Lake Kemp had unprecedented low inflows from 2011 through 2014.

Figure 2.5: Lake Kemp Inflows



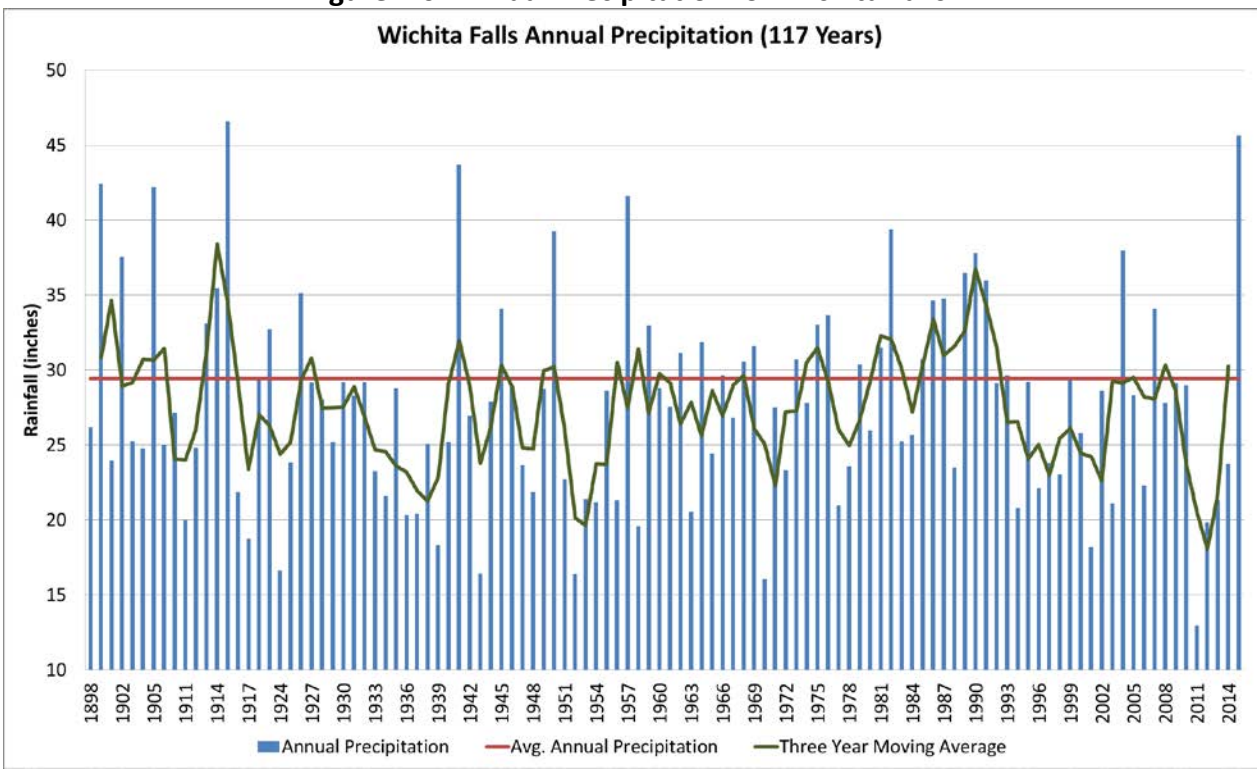
*The inflow for 2015 only includes the inflow through June 2015

2.5.2 Precipitation

Consistent with the findings of the inflows to area lakes, the Wichita Falls area has experienced below average rainfall over the last several years. As shown on Figure 2-6, 2011 recorded the lowest annual precipitation over the past 116 years at Wichita Falls at just under 13 inches. Rainfall in 2012 through 2014 was also below average. Above average rainfall in 2015 associated with an El Nino has led to substantial inflow. The only other period showing similar rainfall patterns was during the 1950s drought from 1952 through 1954. Typically other low rainfall years are followed by a year with average or above average rainfall. This did not happen in the Wichita Falls area during the recent drought which was longer than previous dry periods.

The three-year moving average shown on Figure 2-6 indicates that the City has experienced multi-year periods of below average rainfall with nearly a ten-year period occurring in the 1930s. It is difficult to assess whether the latest period of low rainfall is a new trend associated with changes in climate patterns or whether it is simply another cyclic period of low rainfall.

Figure 2.6: Annual Precipitation for Wichita Falls



2.5.3 Conditional Reliability

During the drought, a conditional reliability assessment was conducted for Wichita Falls' supply reservoirs to provide a statistical estimate of reservoir supply for planning purposes. A conditional reliability assessment starts with current lake conditions and an expected demand level, and then analyzes the reservoir response under all sequences of available historical hydrology. Based on statistics of the output, a level of risk for each possible outcome is assigned. This method provides a means to assess future reservoir conditions under specific demand levels.

A critical component of this method is establishing future demand levels on the reservoir. Unlike yield analyses that determine the demands that can be met through a critical drought, this approach sets the demands and then sees how the reservoir responds. Since the City had aggressive demand reduction in response to drought, the demands were defined based on the drought stage. The drought stage triggers are based on the combined storage of lakes Arrowhead and Kickapoo or the demand as a percentage of system capacity. Table 2-1 shows the demands that were used for each reservoir for this analysis.

Table 2-1: Demands Used in Model Runs
-Values in Million Gallons per Day-

	Drought Stage				
Reservoir	**Normal**	**1**	**2**	**3**	**4**
Combined Reservoir Storage Trigger		*60%*	*50%*	*40%*	*30%*
Arrowhead					
Wichita Falls	14.3	14.3	12.1	9.7	7.6
Windthorst/Henrietta	1.0	1.0	1.0	1.0	1.0
Total	*15.3*	*15.3*	*13.2*	*10.7*	*8.6*
Kickapoo					
Wichita Falls	7.1	7.1	6.1	4.9	2.7
Archer City	0.2	0.2	0.2	0.2	0.2
Olney	0.2	0.2	0.2	0.2	0.2
Wichita Valley	0.1	0.1	0.1	0.1	0.1
Total	*7.7*	*7.7*	*6.6*	*5.4*	*3.2*
Kemp					
Wichita Falls	8.9	8.9	7.6	0.0	0.0
AEP	5.4	5.4	5.4	5.4	5.4
WCID #2	40.1	40.1	40.1	0.0	0.0
Total	*54.4*	*54.4*	*53.1*	*5.4*	*5.4*

For the conditional reliability analysis, the hydrologic model is executed multiple times, and statistics taken from the model output give an indication of the relative probability of future conditions. For this analysis, future water levels were projected over a 5-year period with the initial reservoir storage as of February 28, 2014. All historical 5-year sequences of hydrology with demands varying according to drought stage were used. For example, the first model run projects future lake levels with hydrology from 1940 through 1945, the second model run uses the hydrology from 1941 through 1946, etc. For 5-year periods starting after 2009 (where a full five years of data would not be available), the model uses only the data available. The result is a set of 74 possible lake level projections based on historical data. These projections allow an estimate of the probability of being at a given elevation at a given time in the near future. However, the estimated probabilities are based on historical hydrological conditions and would not be indicative of future conditions if the underlying hydrologic conditions have substantially changed.

In the models, each reservoir was evaluated separately and drought triggers were based on individual reservoir contents. Because each reservoir was modeled separately, potential future spills from Lake

Kickapoo were not included in Lake Arrowhead inflows. While this may underestimate Lake Arrowhead's content during wet periods, it is unlikely that Lake Kickapoo would spill under dry and very dry conditions. This was considered acceptable since the analysis is focused on the reservoirs' responses during dry periods. The evaporation from Lake Diversion was modeled as an extra demand on Lake Kemp. For the purposes of determining evaporation from Lake Diversion, Lake Diversion was assumed to be relatively full. Even during dry conditions, Lake Diversion is generally kept relatively full.

Figure 2-7 shows the results of the conditional reliability analysis for Lake Arrowhead. The different colored lines represent lines of equal probability. Hydrologic condition (wet, normal-dry, dry and very dry) were assigned to the different probabilities. For a given hydrologic condition, future storage in the reservoir should be somewhere in this range. For continued dry conditions, the analyses show lake elevations declining before recovering. Under all historical hydrological conditions lake elevations begin to increase from the projected lowest level by the end of the 5-year period modeled. Actual response during 2014 showed a trend between the dry (5%) and normal –dry (25%) conditions.

Figure 2.7: Lake Arrowhead Risk Analysis

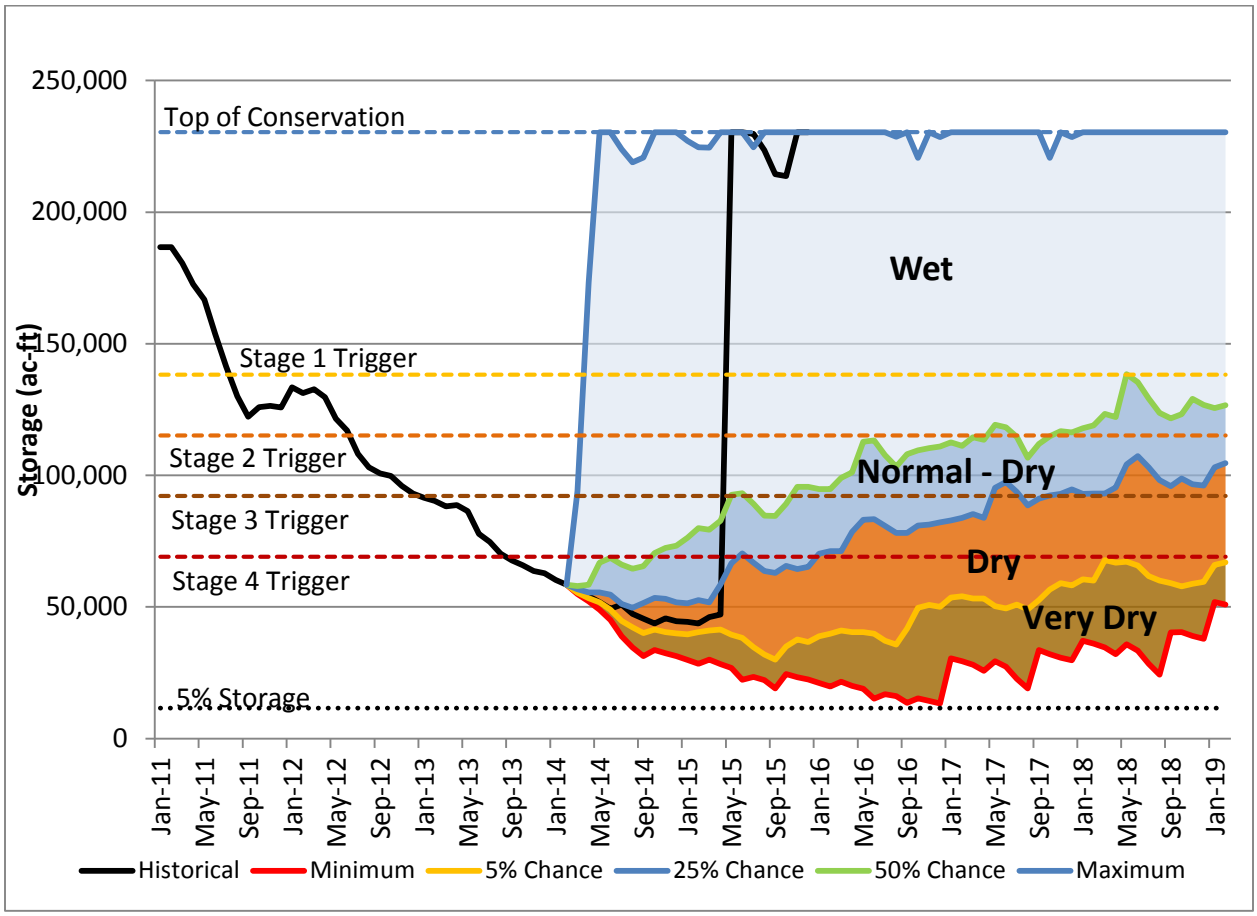
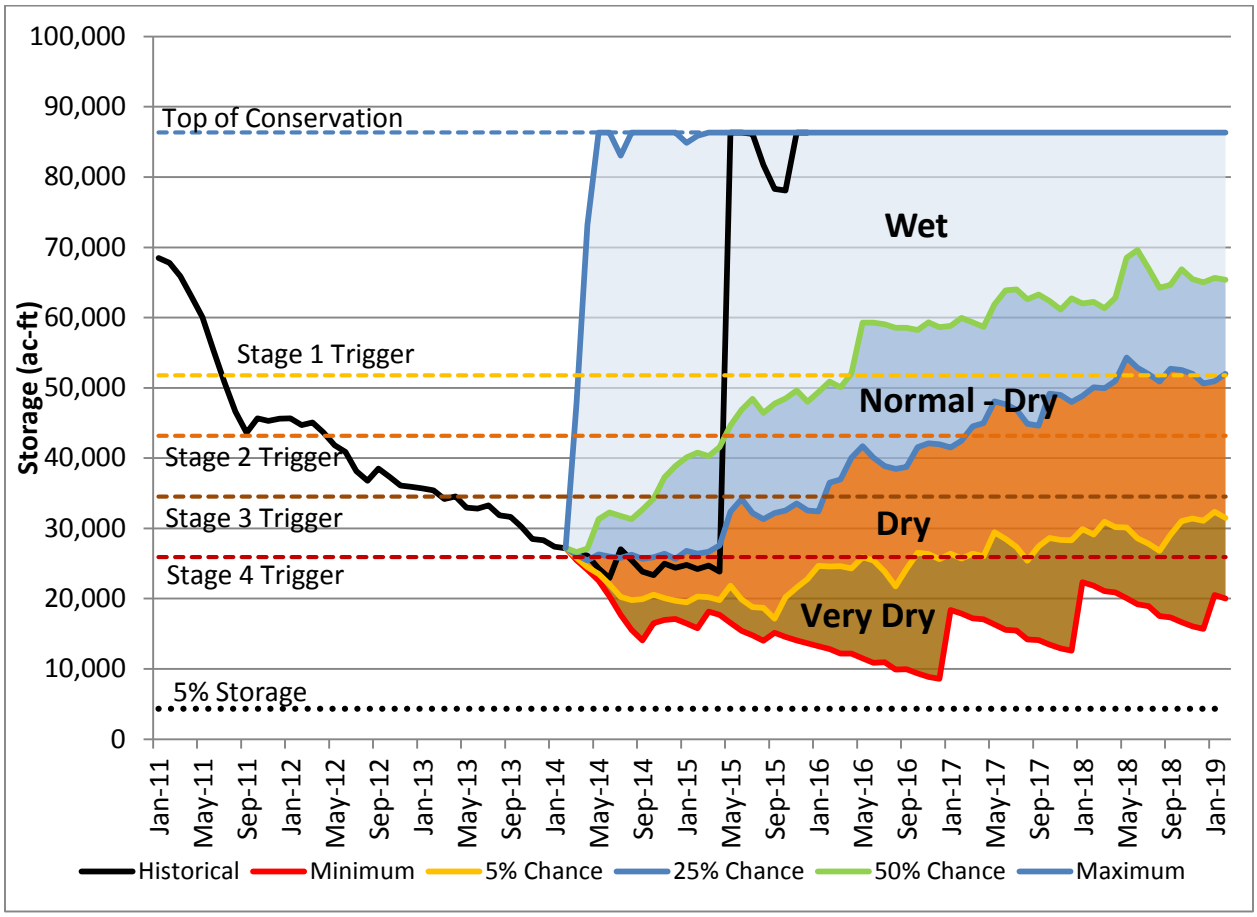


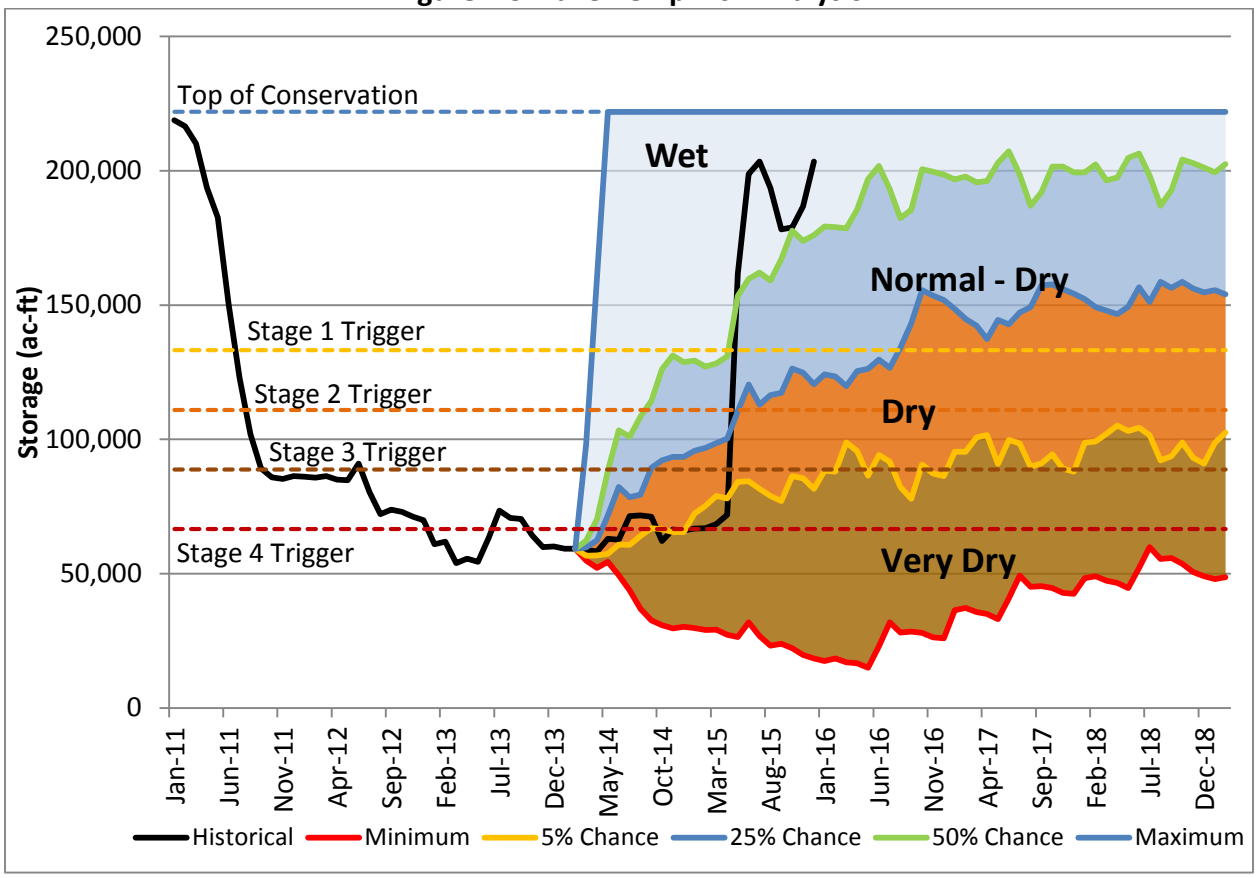
Figure 2-8 shows the conditional reliability analysis for Lake Kickapoo. For Kickapoo, there is a 50 percent chance that storage in the reservoir will be about 75 percent full in five years. The minimum historical hydrology shows slight recovery but still shows only about 23 percent of available storage in five years. Lake levels from February 2014 through December 2015 showed Lake Kickapoo continuing to trend in dry conditions. By May 2015, the lake is full and spilling.

Figure 2.8: Lake Kickapoo Risk Analysis



A similar analysis was performed for Lake Kemp. As seen in Figure 2-9, there is a 50 percent chance the reservoir will start to recover and be about 90 percent full within five years. The minimum line shows that the reservoir would reach a low of about 7 percent in June of 2016 under worst case historical hydrology. Lake Kemp water levels continued to fall within the dry to very dry probability conditions through 2014. During this time, very little water is being used from Lake Kemp.

Figure 2.9: Lake Kemp Risk Analysis



The conditional reliability analysis shows that under continued drought the minimum expected content for Lake Arrowhead would occur at the end of 2016 and that the lake then begins to recover through the rest of the simulation under the worst historical hydrologic conditions. Lake Kickapoo exhibits a similar pattern. At the demand levels used for this study, Lake Arrowhead approaches the 5 percent minimum level at its lowest point, while Lake Kickapoo never reaches the 5 percent level. Both lakes show that with continued extreme drought the lake levels will decline before they recover. All of the conditional reliability simulations show both lakes recovering within three to four years.

The analyses for Lake Kemp shows that under continued drought the lake reaches its minimum level by summer of 2016. This assumes that only 6,000 acre-feet are being diverted from the lake by AEP. Increased demands on the lake could accelerate the water level declines. The City of Wichita Falls has the exclusive rights to the last 50,000 acre-feet in the Kemp-Diversion system. The analysis assumes that Lake Diversion is kept at or near full for diversions (30,000 acre-feet) as long as AEP is diverting. Operationally, higher levels in Diversion are conducive to operating the system of canals.

2.5.4 Yield Evaluations with Hydrology Through June 2015

The amount of supply that can be reliably used during drought of record conditions is often referred to as "firm yield." A firm yield analysis assumes that the reservoir never goes completely empty during the historical hydrological record, but there is little to no reserve supply at the end of the critical period. Most reservoirs are operated with some level of reserve storage to account for minimum intake elevations, reduced water quality or future droughts worse than the historical drought. Safe yield is the amount of water that can be used during the critical drought while leaving a minimum one-year supply in reserve.

Both firm and safe yields were calculated for each reservoir. Lakes Kickapoo and Arrowhead were modeled as a system such that spills from Lake Kickapoo are captured in Lake Arrowhead. The yield of Lake Kemp and Lake Diversion was evaluated as a system with releases made to Lake Diversion and target minimum elevations in Lake Diversion of 1,050.0 feet msl in March and 1,046.0 feet msl the remainder of the year. The elevation of 1,050.0 feet msl is to allow the Dundee Fish Hatchery to divert water during the spring spawning season. The 1,046.0 feet target is based in the intake constraints for American Electric Power.

The firm and safe yields of each reservoir is presented in Table 2-2 for current sediment conditions. For Lake Kemp, the amount of supply that would be available to Wichita Falls is also shown. As shown on the graphs of the reservoir storage for the safe yield analyses (Figures 2-10 through 2-12) the reservoir content is the lowest at the end of 2014 or early 2015 with the lakes filling or nearly filling by June 2015.

Table 2-2: Summary of Yield Analyses with Hydrology through June 2015

Reservoir	Firm Yield (MGD)	Safe Yield (MGD)
Kickapoo	9.8	7.5
Arrowhead	19.4	15.8
Kemp-Diversion Total	39.3	29.3
Kemp-Wichita Falls	5.8	4.0
Wichita Falls - Treated	*4.4*	*3.0*

Yield is given as the annual average daily diversion in million gallons per day (MGD)

Figure 2.10: Kickapoo Safe Yield Analysis Through June 2015

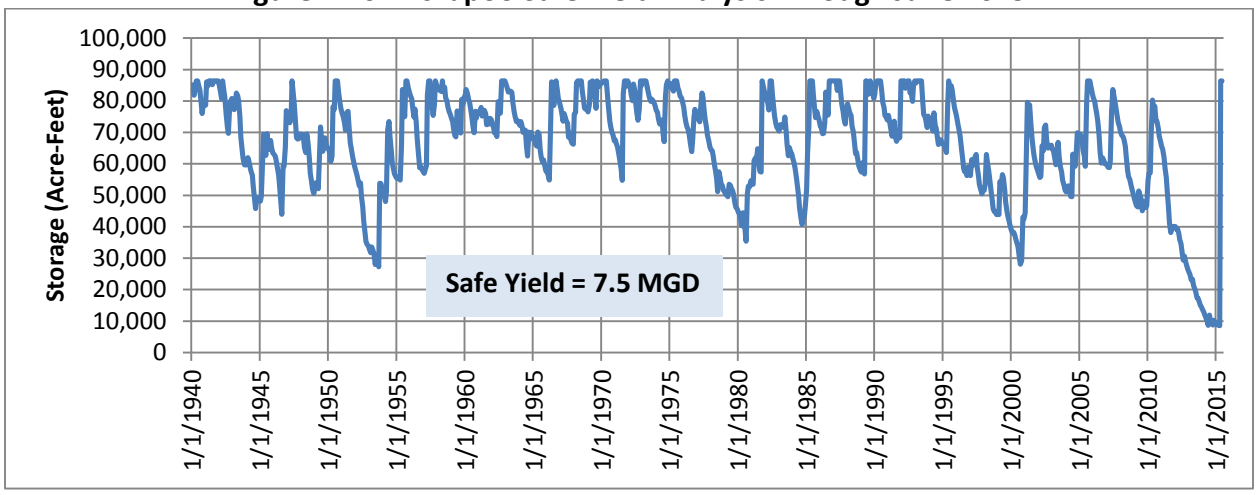


Figure 2.11: Arrowhead Safe Yield Analysis Through June 2015

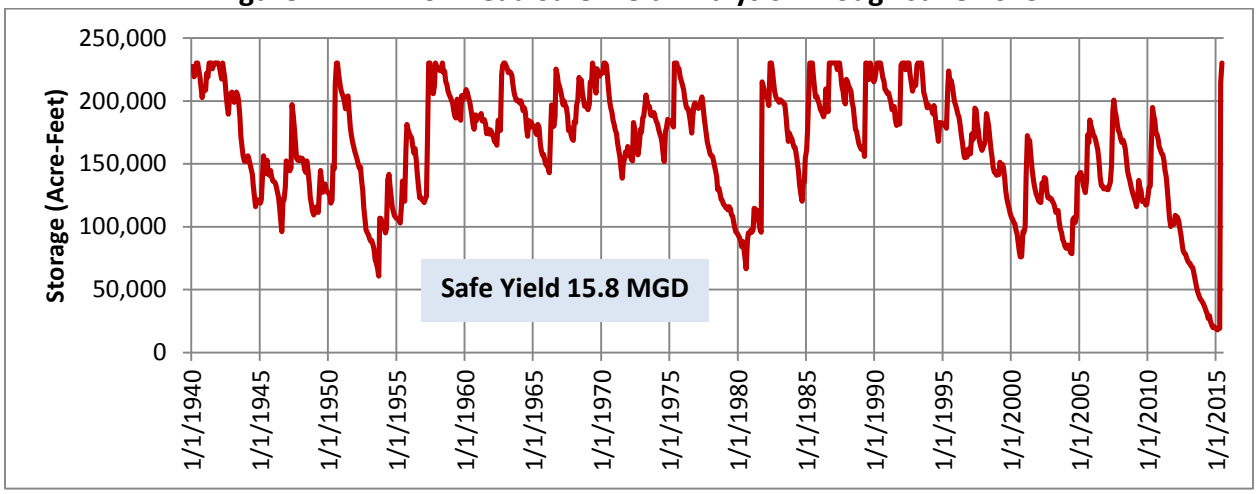
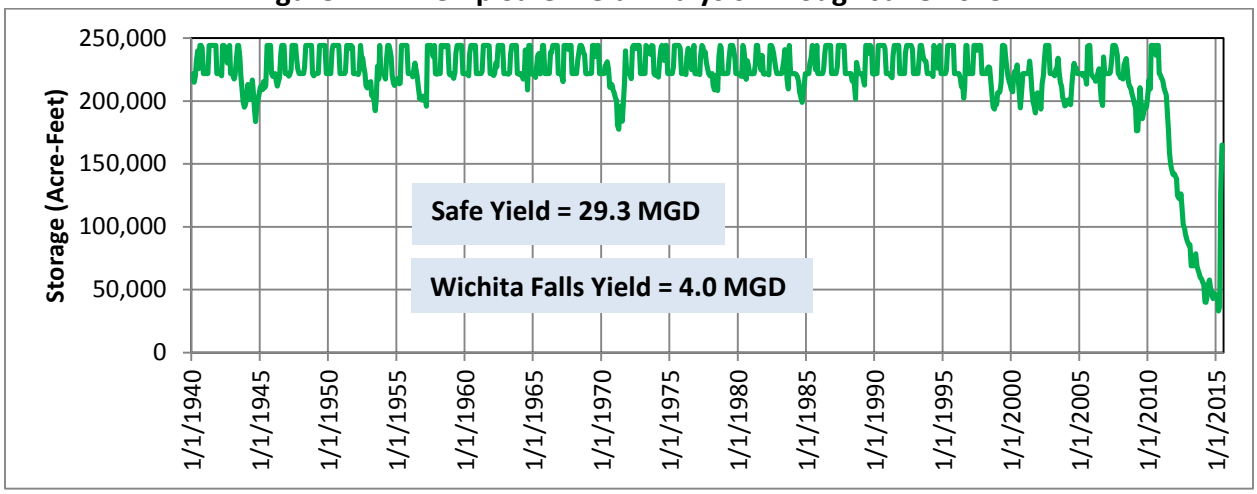


Figure 2.12: Kemp Safe Yield Analysis Through June 2015



2.5.5 Yield With 20 Percent Reserve Supply

During the most recent drought the minimum combined storage of Lakes Arrowhead and Kickapoo hovered near 20 percent for most of 2014 into early 2015. This low storage level caused Wichita Falls to implement significant drought management strategies to reduce demand and initiate the implementation of an emergency direct potable reuse project. The low levels in lakes also impacted the ability of some customers to divert from the lakes. In discussions with the City of Wichita Falls, a reserve of about two years supply would provide the City with appropriate reserves for emergencies and/or droughts worse than the 2011-2015 drought. This equates to about a 20 percent reserve storage in Lakes Arrowhead and Kickapoo, the City's primary water sources. For Lake Kemp, a minimum of 20 percent reserve storage is needed due to the impaired water quality of the water when lake levels decline. At low capacity levels, the salts and total dissolved solids in Lake Kemp create treatability issues. Therefore, a yield analysis was conducted to reserve 20 percent of the storage in Lakes Arrowhead, Kemp and Kickapoo at the end of the critical period. The storage traces for Lakes Arrowhead, Kemp and Kickapoo with the 20 percent reserve are shown in Figure 2.13 through Figure 2.15. The results of this analysis are presented in Table 2-3.

Table 2-3: Summary of Safe Yield Analyses with 20 % Reserve

Reservoir	Lowest Storage (acre-feet)	Safe Yield 20% Reserve (MGD)
Kickapoo	17,435	5.0
Arrowhead	46,260	10.9
Kemp-Diversion Total	44,607	25.9
Kemp-Wichita Falls	-	3.5
Wichita Falls - Treated	-	*2.6*

Yield is given as the annual average daily diversion in million gallons per day (MGD)

Figure 2.13: Kickapoo Yield Analysis with 20% Reserve Through June 2015

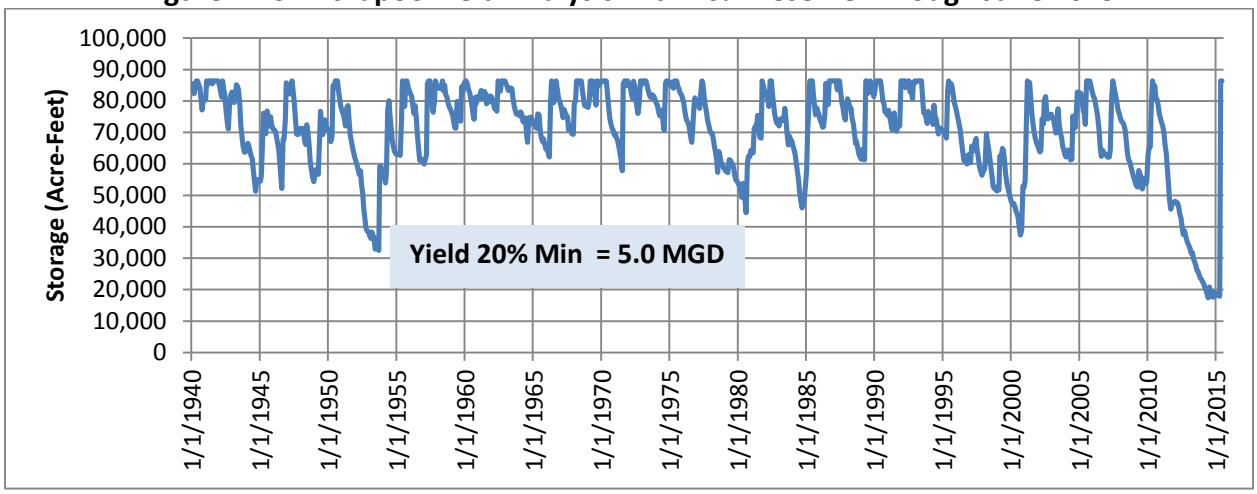


Figure 2.14: Arrowhead Yield Analysis with 20% Reserve Through June 2015

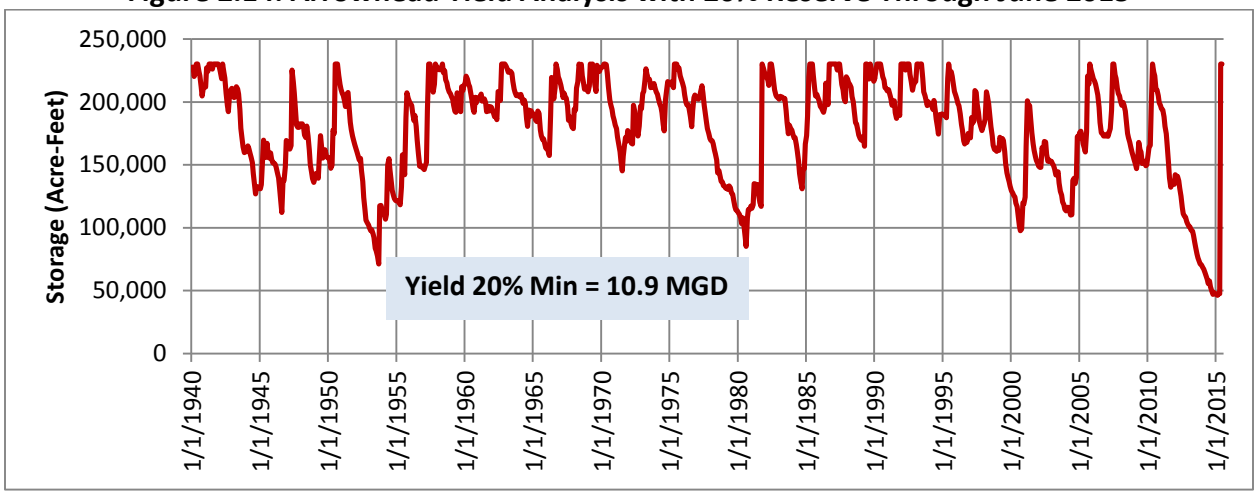
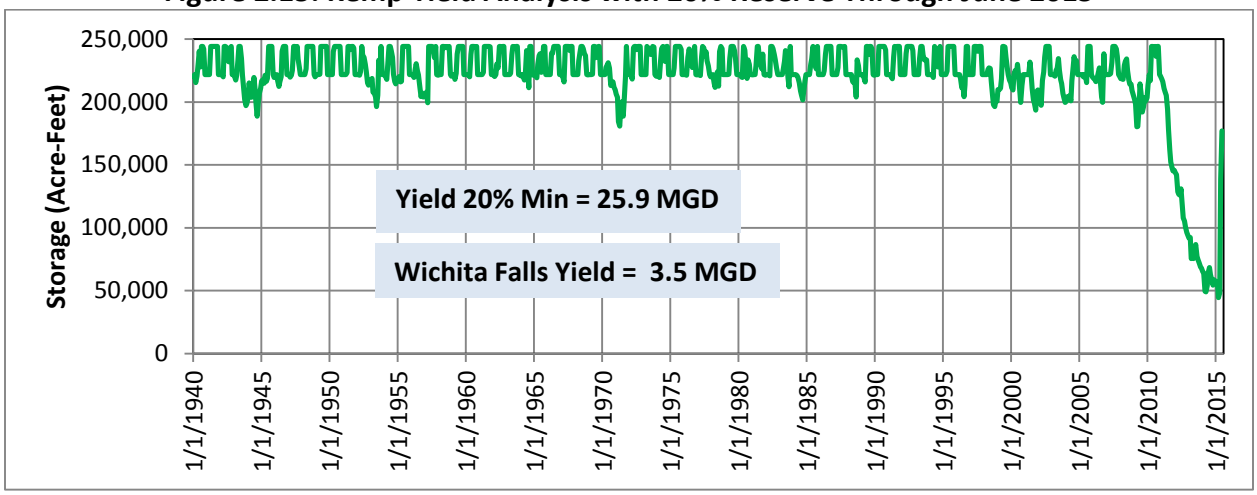


Figure 2.15: Kemp Yield Analysis with 20% Reserve Through June 2015



2.5.6 Extended Drought Yield Evaluations

This analysis was conducted in 2014 when Wichita Falls was in the midst of the 2011-2015 drought. While the drought is now over, these analyses provide an assessment of supplies if the drought were to extend through 2015 or through 2016. This is still relevant because the City could experience another drought that may be worse than the drought of record. For this analysis, a series of yield evaluations were conducted by extending the hydrology from 2013 by two and three years based on the inflows from 2011 through 2013. The first scenario evaluated the safe yield of lakes Kemp, Kickapoo, and Arrowhead repeating the 2011-2012 hydrology at the end of the simulation in 2013 (these two years represent the worst two consecutive inflow years). At the end of the two years, it is assumed that the reservoirs receive a significant inflow, ending the drought. This assumption estimates the safe yields if severe drought conditions continue through 2015.

The second scenario calculated the safe yield of Kemp, Kickapoo, and Arrowhead repeating the 2011-2013 hydrology at the end of the simulation in 2013 (represents extended hydrology with the worst three consecutive inflow years). This analysis estimates the safe yield if extreme drought conditions persist through 2016. The results of these analyses are shown in Table 2-4 and are compared against results with the hydrology through June 2015.

Table 2-4: Summary of Safe Yield Analyses with Extended Hydrology

Reservoir	June 2015 Yield	June 2015 Yield 20% Reserve	2-Year Extended Drought	3-Year Extended Drought
Kickapoo	7.5	5.0	5.6	4.2
Arrowhead	15.8	10.9	14.2	10.9
Kemp-Diversion Total	29.3	25.9	15.9	14.2
Kemp-Wichita Falls	4.0	3.5	2.2	1.9
Wichita Falls Treated	*3.0*	*2.6*	*1.6*	*1.4*

Yield is given as the annual average daily diversion in million gallons per day (MGD)

2.5.7 Existing Supply Used for Long-Range Water Supply Plan

Given the recent drought, the assumptions used in developing the available supplies for use in the Long Range Water Supply Plan are critical for identifying the amount of water the City currently has available and the amount of new supplies that the City will need to develop.

With input from City staff, it was decided to use the safe yield supplies through June 2015 while maintaining a 20 percent reserve. This represents the worst recorded drought encountered for the Wichita River and Little Wichita River watersheds. The existing water supplies that will be used in this plan are shown in Table 2-5. The reduction in available supply over time is due to reduced storage capacity associated with sediment accumulation in the lakes. Sedimentation rates were estimated from the most recent volumetric surveys.

Table 2-5: Reliable Water Supplies for Wichita Falls

Average Annual Supply in MGD						
	2020	**2030**	**2040**	**2050**	**2060**	**2070**
Kickapoo	5.0	4.7	4.4	4.2	4.0	3.3
Arrowhead	10.9	10.2	9.9	9.6	9.3	7.3
Subtotal	*15.9*	*14.8*	*14.3*	*13.8*	*13.2*	*10.6*
Kemp Total	*25.9*	*23.3*	*20.7*	*18.1*	*15.5*	*12.9*
Kemp Industrial	5.4	4.8	4.3	3.8	3.2	2.7
Kemp Mining	0.0	0.0	0.0	0.0	0.0	0.0
Kemp Recreation	0.8	0.7	0.6	0.5	0.5	0.4
Kemp Irrigation	16.2	14.6	13.0	11.4	9.7	8.1
Kemp Wichita Falls	3.5	3.2	2.8	2.5	2.1	1.8
Treated water	*2.6*	*2.4*	*2.1*	*1.8*	*1.6*	*1.3*
Total reliable supply available to Wichita Falls	**18.5**	**17.2**	**16.4**	**15.6**	**14.8**	**11.9**

3.0 WATER REQUIREMENTS

The water requirement is the amount of water that Wichita Falls will need to meet current and future demands. Projected requirements include the demands for the City, its treated water customers and raw water contracts, and potential future customers.

Current water demands are based on the City's non-restrictive water use during dry periods and contractual obligations to other entities. This typically represents the highest expected water demand during a drought. Future municipal water demands are developed based on projected population growth and per capita water use. Future demands also consider potential future customers of the City.

The State of Texas, through the regional water planning process, has developed population and water demand projections for Wichita Falls and its customers. These projections provided an initial basis for developing the water demands for the City.

3.1 POPULATION

The baseline population is based on the 2010 Census which the Texas State Data Center used to develop county-level population projections for 2011-2050. The TWDB staff extended the projections to 2060-2070 by using the average annual growth rates from 2011-2050. The county level population was then allocated down to the water user groups[1] based on their city limit boundaries and utility service areas. Any remaining population in each county was placed in the county-other category. Figure 3-1 shows the historic and projected population for the City of Wichita Falls. Table 3-1 shows the population for Wichita Falls and all of the customers it serves. While some of this population may be served by water supplies other than those provided by Wichita Falls, the total population for each customer was included in Table 3-1.

[1] Water User Groups (WUGs) are defined by the TWDB as municipalities with a population of 500 people or more and utilities providing at least 0.25 million gallons per day (MGD).

Figure 3.1: Wichita Falls Historical and Projected Population

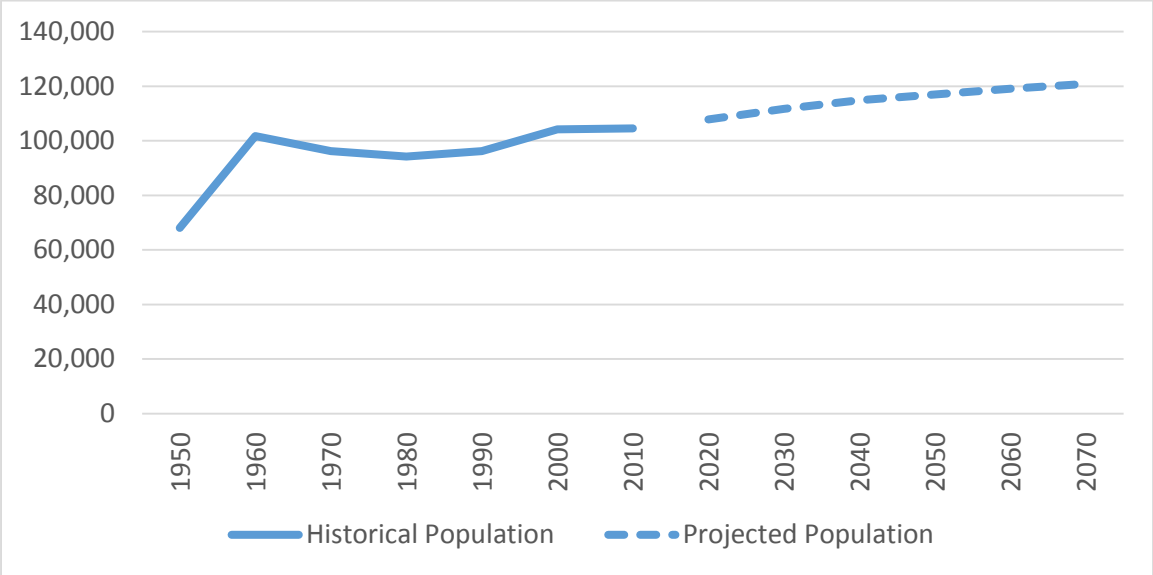


Table 3-1: Wichita Falls Customer Population

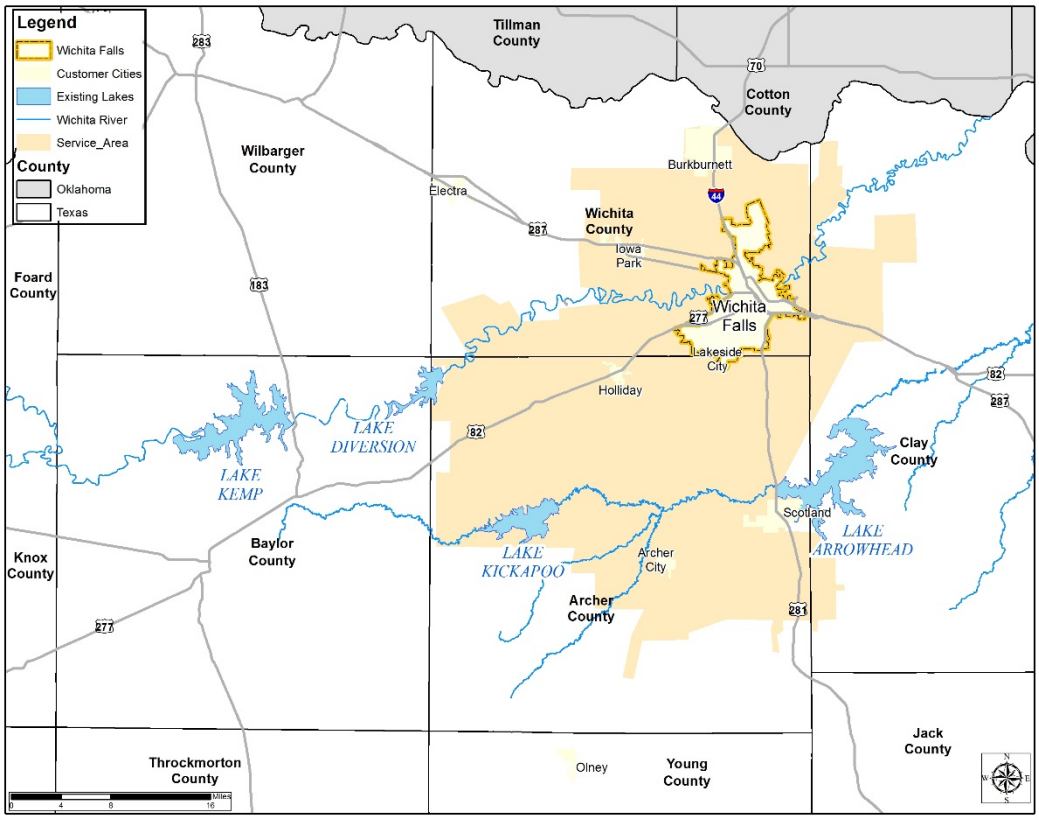
Customer	Recipient	Population					
		2020	2030	2040	2050	2060	2070
Wichita Falls	Wichita Falls	107,835	111,767	114,848	117,013	119,080	120,838
Archer City	Archer City	1,834	1,834	1,834	1,834	1,834	1,834
Archer Co. MUD #1	Archer County - Other	424	255	208	208	208	208
Holliday	Holliday	1,982	2,257	2,330	2,330	2,330	2,330
Lakeside City	Lakeside City	1,021	1,050	1,058	1,058	1,058	1,058
Scotland	Scotland	613	751	788	788	788	788
Windthorst WSC	Windthorst WSC	1,295	1,351	1,364	1,364	1,364	1,364
Dean Dale WSC	Clay County	2,262	2,333	2,333	2,333	2,333	2,333
Red River Auth.	Clay County Other	4,688	4,835	4,835	4,835	4,835	4,835
Burkburnett	Burkburnett	11,151	11,557	11,876	12,100	12,314	12,495
Dean Dale WSC	Wichita County	1,121	1,161	1,193	1,216	1,237	1,256
Friberg-Cooper WSC.	Wichita County Other	2,691	2,791	2,868	2,921	2,974	3,018
Iowa Park	Iowa Park	6,555	6,794	6,981	7,113	7,238	7,345
Electra	Electra	2,879	2,984	3,066	3,124	3,179	3,226
Pleasant Valley	Pleasant Valley	part of Wichita County Other population (see Friberg-Cooper WSC)					
Sheppard A.F.B.	Wichita Falls	part of Wichita Falls population					
Wichita Valley WSC.	Wichita Valley WSC.	5,868	6,106	6,234	6,302	6,367	6,422
Olney	Olney	3,370	3,485	3,568	3,655	3,740	3,822
TOTAL		**155,589**	**161,311**	**165,384**	**168,194**	**170,879**	**173,172**

3.2 WATER DEMANDS

The water demands used for the Long Range Water Supply Plan are based on the Region B projected water demands. The water demands for the current round of water planning (2016 Region B Water Plan) were developed by the TWDB for municipalities of 500 people or more and water supply corporations that provide at least 0.25 million gallons per day (MGD). Water for smaller municipal water users and industrial water use were estimated on a county basis. The projected water demands were developed for years 2020 through 2070. The TWDB took the water use for 2011 and the 2010 Census data as its starting point for municipal water demands. An expected amount of reduction in demands was also considered due to water efficiencies associated with replacements of older plumbing fixtures.

The expected demand on Wichita Falls by its customers was estimated based on contractual obligations. During the review of these demands, it was noted that some customers have contracts with Wichita Falls in excess of their demands and some customers have projected demands in excess of the contract amounts. In an effort to better estimate the potential future demands on Wichita Falls, FNI performed an analysis to project the actual demand of the customers on Wichita Falls. The net difference between the current contractual demands and Region B projected demands with a safety factor of 1.2 was small. Therefore, it was decided to use the contractual demands for planning purposes. Lastly, FNI also reviewed the projected demands for future customers (not currently under contract with Wichita Falls) based on the projected water needs for entities in Region B. Figure 3-2 shows the service area for Wichita Falls which covers portions of Archer, Clay, Wichita, and Young Counties.

Figure 3.2: Wichita Falls Service Area Map



As previously discussed, the TWDB demands consider dry year water use and an expected level of future water efficiency based on the replacement of high water use plumbing fixtures. To account for potential uncertainties in these projections, a safety factor of 1.2 was applied to the City of Wichita Falls' demands and direct customers that do not have specified contract limits (such as the City of Holliday). The demands for Wichita Falls' other customers are based on the contractual obligation with Wichita Falls. The customer contracts specify a daily consumptive amount (expressed in MGD) or average annual contract amounts. For those customers with only a maximum daily contract amount, the average annual demands on Wichita Falls were estimated based on a peaking factor of 2. This results in an average annual demand of half of their maximum daily contractual amount. Figure 3-3 shows the average annual contractual demand for Wichita Falls, treated and raw water customers, and future customers. Table 3-2 shows the demand on Wichita Falls in MGD. These demands are approximately 30 to 31 MGD.

Figure 3.3 : Average Annual Contractual Demand

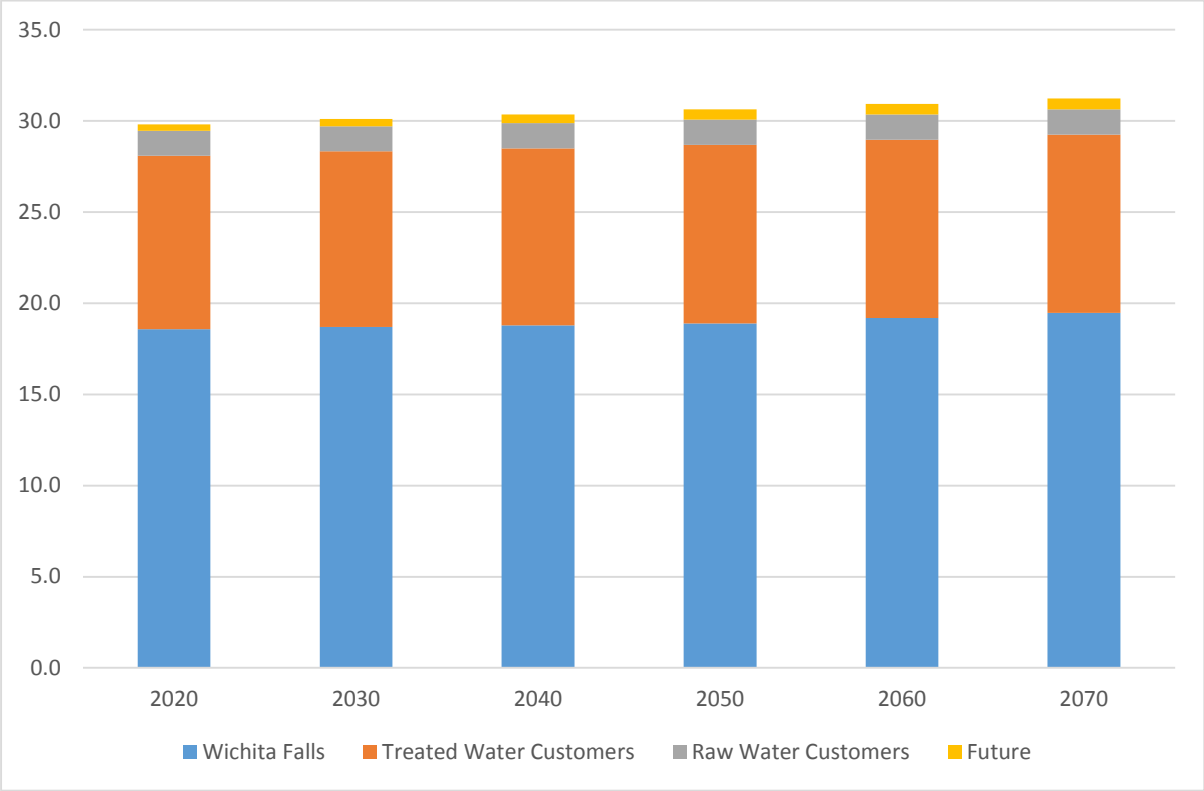


Table 3-2: Wichita Falls Demand (MGD)

Customer	Recipient	Contract Type	Contract	Average Annual Contractual Demands (MGD)						
			MGD	2020	2030	2040	2050	2060	2070	Comments
Wichita Falls	Wichita Falls		N/A	18.6	18.7	18.8	18.9	19.2	19.5	Increased by a safety factor of 1.2
Archer City	Archer City	Max Day	0.6	0.3	0.3	0.3	0.3	0.3	0.3	
Archer Co. MUD #1	Archer County - Other	Max Day	0.15	0.1	0.1	0.1	0.1	0.1	0.1	
Holliday	Holliday		No contract limit	0.3	0.3	0.3	0.3	0.3	0.3	Increased by a safety factor of 1.2
Lakeside City	Lakeside City	Average Annual	0.16	0.2	0.2	0.2	0.2	0.2	0.2	
Scotland	Scotland	Average Annual	0.18	0.2	0.2	0.2	0.2	0.2	0.2	
Windthorst WSC	Windthorst WSC	Max Day	0.75	0.4	0.4	0.4	0.4	0.4	0.4	
Dean Dale WSC	Clay County	Max Day	0.825	0.3	0.3	0.3	0.3	0.3	0.3	
Red River Auth.	Clay County Other	Average Annual	0.37	0.4	0.4	0.4	0.4	0.4	0.4	
Burkburnett	Burkburnett	Average Annual	1.67	1.7	1.7	1.7	1.7	1.7	1.7	
Dean Dale WSC	Wichita County			0.1	0.1	0.1	0.1	0.1	0.1	
Friberg-Cooper WSC.	Wichita County - Other	Average Annual	0.15	0.2	0.2	0.2	0.2	0.2	0.2	
Iowa Park	Iowa Park	Max Day	2.5	1.2	1.2	1.2	1.2	1.2	1.2	
Electra	Electra	Max Day	1.5	0.8	0.8	0.8	0.8	0.8	0.8	
Wichita Valley WSC	Wichita Valley WSC.	Max Day	1.205	0.6	0.6	0.6	0.6	0.6	0.6	
Pleasant Valley	Pleasant Valley	Average Annual	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
Sheppard A.F.B.	Wichita Falls			Part of Wichita Falls demands						
Wichita Valley WSC	Wichita Valley WSC	Average Annual	1.01	1.0	1.0	1.0	1.0	1.0	1.0	
Olney	Olney	Max Day	1	0.5	0.5	0.5	0.5	0.5	0.5	
Manufacturing	Wichita County		No contract limit	1.8	1.8	1.9	2.0	2.0	2.0	Increased by a safety factor of 1.2
Steam Electric Power	Wichita County			0.3	0.3	0.3	0.3	0.3	0.3	
Releases for Henrietta	Henrietta			0.6	0.6	0.6	0.6	0.6	0.6	
TOTAL				**29.5**	**29.7**	**29.9**	**30.1**	**30.4**	**30.6**	

3.3 FUTURE CUSTOMERS

Future customer demand could include new customers or increased demands from existing customers. Only the City of Scotland was found to have an insufficient contract amount to meet its projected demands. Other users in and around the City of Wichita Falls that may request additional water supplies include manufacturing water use and the City of Vernon. Vernon has not requested additional water supplies from Wichita Falls but if Wichita Falls develops a new water source to the west, the City of Vernon may wish to participate or receive water from this source. Table 3-3 shows the future customers and their projected demand on Wichita Falls.

Table 3-3: Projected Future Demand on Wichita Falls (MGD)

Customer	Recipient	Average Annual Future Demands (MGD)					
		2020	2030	2040	2050	2060	2070
Additional supply for Manufacturing	Wichita County	0.3	0.3	0.3	0.3	0.3	0.3
Vernon Needs	Vernon	0.0	0.0	0.0	0.1	0.2	0.2
Additional Supply for Scotland	Scotland	0.1	0.1	0.1	0.1	0.1	0.1
Total		**0.4**	**0.4**	**0.5**	**0.6**	**0.6**	**0.6**

4.0 COMPARISON OF SUPPLY AND DEMAND

Water needs are identified by finding the difference between currently available supplies for Wichita Falls as shown in Chapter 2 and the projected demands as shown in Chapter 3. As previously discussed, the reliable supply for Wichita Falls is based on the reservoir yields with hydrology through June 2015 with a 20 percent reserve supply. The projected demands are based on the Region B water demands for Wichita Falls with a 1.2 safety factor and contractual demands for the City's customers.

4.1 PROJECTED NEED FOR ADDITIONAL SUPPLIES

Table 4-1 and Figure 4-1 show the supply and demand comparison for Wichita Falls. Considering both current and future customers, the City has an immediate need for an additional 11.3 MGD of supply. This need assumes that all of Wichita Falls' customers will be taking the full amount of their contracts and the City will have reserve supplies for its water needs. When considering the historical water demands on the City, the development of additional 11.3 MGD would provide Wichita Falls with a safety factor of about 20 percent for growth and future use. To maintain that level of reserve supply, the City would need to develop 19.3 MGD of additional water by 2070.

Figure 4.1: Supply versus Demand

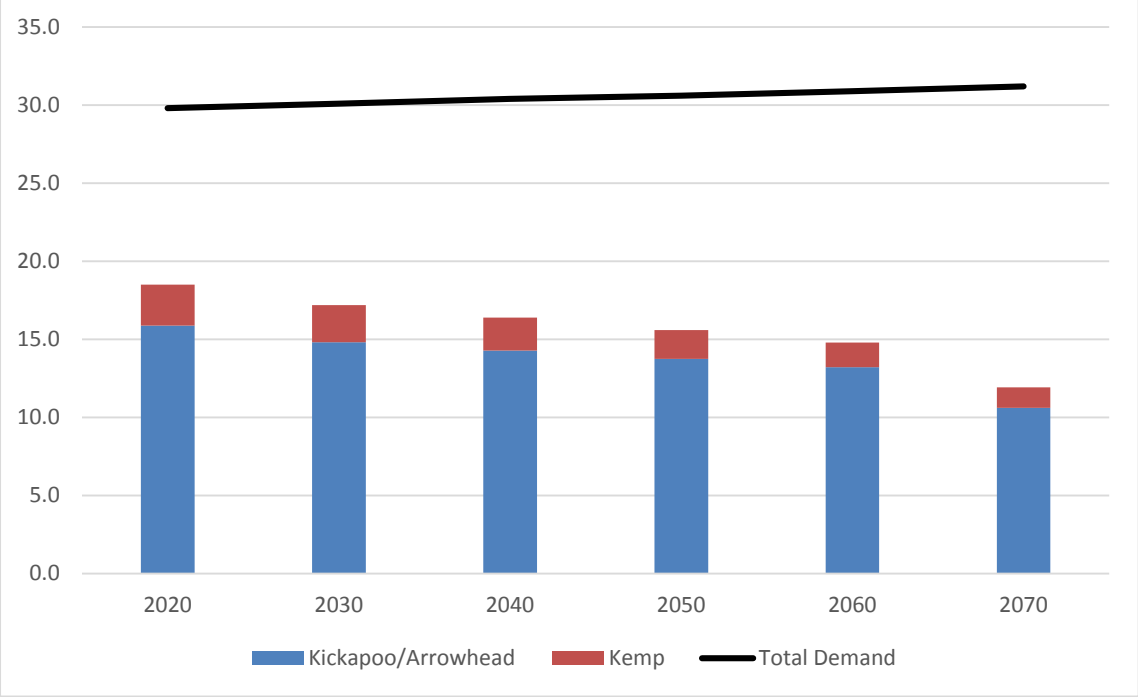


Table 4-1: Wichita Falls Need Analysis
(Values in Average Annual MGD)

Supply Scenario	Safe Yield – June 2015 Hydrology					
	2020	2030	2040	2050	2060	2070
Kickapoo/Arrowhead	15.9	14.8	14.3	13.8	13.2	10.6
Kemp (treated water)	2.6	2.4	2.1	1.8	1.6	1.3
Total Supply	**18.5**	**17.2**	**16.4**	**15.6**	**14.8**	**11.9**
Demand Scenario	**Full Contract**					
	2020	2030	2040	2050	2060	2070
Wichita Falls Demand	18.6	18.7	18.8	18.9	19.2	19.5
Current Wholesale Customer Demand	10.9	11.0	11.1	11.2	11.2	11.2
Future Wholesale Customer Demand	0.4	0.4	0.5	0.6	0.6	0.6
Total Demand	**29.8**	**30.1**	**30.4**	**30.6**	**30.9**	**31.2**
	2020	**2030**	**2040**	**2050**	**2060**	**2070**
Need	**11.3**	**12.9**	**14.0**	**15.0**	**16.1**	**19.3**

4.2 UNCERTAINTIES

As mentioned previously, this recent drought was unprecedented in both the severity of evaporation and the reduction in inflows to Wichita Falls' supplies. The drought came on suddenly and intensely. Unfortunately, there is no way to reliably predict the length and severity of future droughts. This uncertainty is the reason why the supplies used in this analysis include a 20 percent reserve of supply at the end of the recent drought.

Uncertainties also exist regarding the projected demands for Wichita Falls. One of the primary uncertainties identified during the Long Range Water Supply Plan is whether demands will return to pre-drought levels. During this drought the citizens of Wichita Falls have responded to the restrictions in dramatic fashion reducing the demand by approximately half from pre-drought level. It is unclear if the changes in behavior experienced during this drought will remain even after the restrictions are lifted. It is also uncertain whether there may be an unexpected growth in demand due to a new industry or large population growth, as experienced in the past.

5.0 POTENTIAL SOURCES OF ADDITIONAL SUPPLY

With input from City staff, a list of potential sources of additional water supply for Wichita Falls was developed and evaluated for further consideration. Each of these potential sources were discussed with the City staff and ranked based on criteria agreed upon by the City. The strategies with the greatest potential for development were retained and evaluated in more detail. The screening of the potential strategies is discussed in Section 5.1 below. Descriptions of the strategies that are retained are presented in Sections 5.2 and 5.3. A summary of the strategy evaluation is included in Section 5.4.

5.1 SCREENING OF POTENTIAL STRATEGIES

An initial screening of water supply alternatives was conducted as part of the Long Range Water Supply Plan. The list of alternatives were identified with input of Wichita Falls staff and included twenty-two alternatives that were evaluated for potential benefits and drawbacks. The identified alternatives considered are shown in Table 5-1.

Table 5-1: List of Alternatives Being Considered

Brackish Groundwater	Indirect Reuse
Chloride Control Project	Direct Potable Reuse
Dredging of Lake Kemp, all reservoirs	Lake Bridgeport Water
Evaporation Suppression	Lake Kemp Water Right Amendment
Groundwater (Comanche County, Oklahoma)	Lake Ringgold Water
Groundwater From Donley & Gray County	Lake Texoma Water
Groundwater From Floyd County	Groundwater from Denton County
Groundwater from Holliday Creek	Stormwater Collection System
Groundwater From Roberts County	Water Conservation
Groundwater From Wilbarger County	Wichita River Supply
Groundwater HFSJ	Groundwater (Tillman County, Oklahoma)

The purpose of the screening process was to identify the supply alternatives with the greatest potential to meet the City's future water needs using a pre-defined set of criteria. The alternatives selected in this analysis were further evaluated for feasibility.

5.1.1 Evaluation Criteria

Each of the identified potential strategies were evaluated for water quantity, water quality, reliability, regulatory requirements, environmental impacts, potential cost, time to implement, development obstacles, supply independence and competition for water supply. A five point scale was used to score each of the alternatives from least favorable to most favorable. The definition of each criterion is included below.

- **Water Quantity** – The anticipated amount of supply available from this alternative. Supply alternatives that fully meet the needs received the highest score while alternatives that required other supply sources to meet the need scored lower.
- **Water Quality** – The water quality of the supply alternative. Supply alternatives with no water quality concerns scored the highest while alternatives that required advanced treatment scored the lowest. Those alternatives that required some level of blending received an intermediate score.
- **Reliability** – The reliability of the supply source as subjected to climatic conditions or long-term availability. Those sources that are not dependent on climate conditions or have sufficient availability received the highest score. Sources that have been shown to be severely impacted by climatic conditions or have unknown long-term availability were scored the lowest.
- **Regulatory Requirements** – The degree of regulatory requirements needed in order to use a supply alternative including water rights, 404 permits or Groundwater Conservation Districts. Alternatives with minimal regulatory requirements scored the highest while alternatives that have multiple regulatory requirements scored lower.
- **Environmental Impacts** – The level of potential environmental impacts from the supply alternative. If the project will have minimal environmental impact it will score the highest while projects with potentially significant environmental impacts will the score the lowest.
- **Potential Cost** – Detailed cost estimates were not developed for each alternative prior to this analysis, but preliminary cost data were available and the relative cost in terms of low to high cost was evaluated.
- **Time to Implement** – The amount of time required for completion of the alternative. Alternatives that could be implemented quickly (less than two years) scored the highest while projects that required longer periods (greater than ten years) scored the lowest.
- **Development Obstacles** – The level of obstacles that need to be overcome prior to the development of an alternative. The obstacles could be political, feasibility or additional unknown factors that could prevent an alternative supply from being implemented. The

alternatives with minimal development obstacles scored the highest while those with significant obstacles scored the lowest.

- **Supply Independence** – Supplies that are dependent on the same climate conditions or supply source area can be impacted at the same time. This criterion identified if a supply is independent of other sources. Independent sources received a higher score than sources that are impacted or may be interdependent with existing sources.
- **Competition for Water Supply** – The amount of competition for the supply alternative is an important criteria in determining if the availability will be diminished over time. Alternatives with minimal competition from other users received the highest score while those alternatives with substantial competition from other users scored the lowest.

5.1.2 Screening Methodology

An initial screening of the twenty two alternatives was performed using the ten criteria outlined in Section 5.1.1. Appendix B presents the findings of this screening along with a short description of the project, the potential quantity (MGD), potential capital cost and unit cost per MGD if available. Documentation of the justification for each score is noted in the comments column for each project.

A workshop was held with City staff and City officials to review and finalize the screening evaluation. Based on this review, three alternatives were dismissed from the evaluation.

- Chloride Control – The City did not consider this a water supply strategy that the City could pursue and it would not provide additional water.
- Direct Reuse - This was a temporary strategy and Wichita Falls is moving forward with its indirect reuse project.
- Brackish Groundwater – Brackish groundwater is still a potentially viable strategy, but a separate joint study between Wichita Falls and TRWD is being conducted on this alternative. The findings of this study will not be available until late 2015 or early 2016. It was decided to that the results from the study will be incorporated into the long range water supply plan, as appropriate.

With City input, weighting criteria were determined and applied to the strategy screening matrix. Of the ten criteria, three criteria were selected to have a greater weight in the analysis. These were water quantity, reliability and potential cost. Table 5-2 shows the final weighting for each of the ten criteria.

Table 5-2: Weighting Factors for Initial Strategy Evaluation

Criteria	Weighting Factor
Water Quantity	2
Water Quality	1
Reliability	2
Regulatory Requirements	1
Environmental Impacts	1
Potential Cost	5
Time to Implement	1
Development Obstacles	1
Supply Independence	1
Competition for Water Supply	1

5.1.3 Selected Strategies for Further Evaluation

From the initially identified strategies, twelve were selected for further evaluation. This evaluation included more in-depth analyses of ten evaluation criteria, including detailed cost estimates and feasibility analyses. The twelve strategies are listed in Table 5-3. Detailed cost estimates and associated assumptions are included in Appendix C.

Table 5-3: Selected Strategies for Further Evaluation

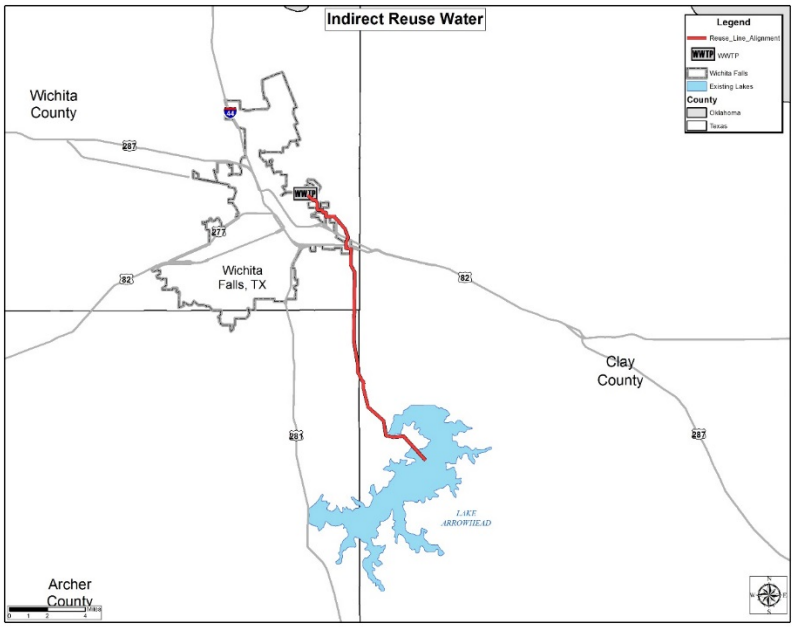
Alternative	Composite Score (max 80)	Rank
Indirect Reuse	72	1
Water Conservation	67	2
Lake Ringgold Water	58	3
Groundwater HFSJ	50	4
Groundwater from Wilbarger County	49	5
Groundwater from Roberts County	47	6
Groundwater from Donley & Gray Counties	45	7
Wichita River Supply	45	7
Lake Kemp Water Right Amendment	43	9
Groundwater from Denton County	41	10
Lake Texoma Water	41	10
Lake Bridgeport Water	40	12

5.2 SHORT-TERM STRATEGIES

Of the 12 strategies retained for further evaluation, four strategies could be implemented within the next two to four years. In addition, a conjunctive use strategy that utilizes groundwater from Wichita County with surface water from the Wichita River was developed and evaluated. This strategy is estimated to take five years to fully implement. None of the short term strategies can provide the quantity of water needed to fully meet the City's shortage. It is assumed that drought measures would need to continue until such time that one of the long-term strategies could be implemented or drought conditions no longer persist. A brief description of each retained short-term strategy and the associated evaluation is presented below.

5.2.1 Indirect Reuse

Wichita Falls currently generates approximately 8 MGD of treated wastewater from the River Road WWTP. As an emergency measure, the City laid 12.5 miles of 32-inch pipeline from the WWTP to the Cypress WTP for advanced treatment and direct reuse with the City's water supplies. The pipeline was not buried, with the intent to reuse this pipeline for the indirect reuse project.



The indirect reuse project would discharge treated wastewater to Lake Arrowhead for diversion by the City for water supply. This would allow the City to fully reuse all of its wastewater effluent. For this strategy, the City would construct a pipeline from the River Road WWTP to Lake Arrowhead to convey approximately 10 MGD of treated wastewater (this amount is the expected amount of wastewater generated by 2040). It is assumed that the existing 32-inch pipeline currently being used for the direct potable reuse project would be removed and reinstalled for this strategy. Approximately 5 miles of new 36-inch pipeline would be needed to reach Lake Arrowhead. The water would be discharged directly to the lake.

Water Quantity, Quality, and Reliability

The River Road WWTP is currently permitted to discharge up to 19.91 MGD. Historical daily discharges vary from 7 MGD to 12 MGD. At this time the strategy is being planned to provide approximately 10 MGD, but during the near-term the supply is expected to be 8 MGD. One advantage of this project over the direct potable reuse project is that it reduces the treatment losses associated with the direct potable reuse, although it does potentially subject any supplies stored in Lake Arrowhead to evaporation. The analysis of Lake Arrowhead with additional inflow shows a comparable increase of the reliable supply.

The project includes advanced treatment at the WWTP to mitigate potential water quality impacts at Lake Arrowhead. Water quality modeling with the advanced treatment shows minimal impacts to the quality in Lake Arrowhead (CDM Smith, 2014).

This supply is drought resistant and should be available in most situations. If water use is restricted, under extreme drought conditions the amount of available reuse supply may be reduced. The other potential impact on reliability is if there is not sufficient supply in Lake Arrowhead with which to blend.

Regulatory Requirements

The City already has obtained their 210 permit to discharge wastewater to Lake Arrowhead. The City is in the process of obtaining a bed and banks water right permit for use of Lake Arrowhead. A Section 404 permit may also be needed for the pipeline and discharge structure.

Impacts

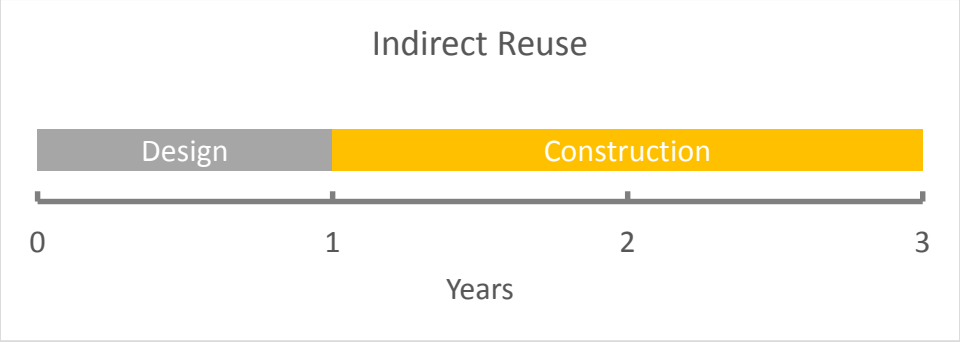
Environmental impacts associated with the pipeline can likely be avoided during design. The increased inflow to the lake should be a benefit to the environment and aquatic species in the lake. There will be reduced stream flow in the Wichita River, but these impacts are expected to be minimal. There should be minimal impacts to other users since the current wastewater discharges comprise a very small amount of overall flow to the Red River and Lake Texoma.

Potential Cost

The City has obtained financial assistance from the Texas Water Development Board for approximately $33.8 million. As shown in the detailed cost estimate the total capital cost is estimated at $36,560,00 with an annual cost of $1.90 per thousand gallons with debt service and an average annual cost of $1.17 per thousand gallons after debt service. Other than water conservation this strategy is the least expensive of the strategies evaluated.

Time to Implement

It is estimated that design and construction could take approximately three years for this alternative. Since Wichita Falls has already initiated the preliminary stages of this project it is possible that it could be implemented in less time.



Supply Independence and Competition for Water

While this supply provides some level of independence from current sources, it relies on current sources for its generation. Development of new sources of water will improve the reliability and independence of this water supply. Reductions in indoor City water use due to drought, conservation, and the implementation of water efficient plumbing fixtures and appliances could impact the quantity of water available for reuse. There is currently no competition for this water supply.

5.2.2 Water Conservation

Water Conservation/Efficiency has been a critical drought response strategy for the City of Wichita Falls. The City has been able to reduce its demand by 50 percent during the recent drought. While these measures were critical for demand management during the drought, once the drought has

ended some water efficiency measures should be continued, some measures may be discontinued, and additional measures could be implemented. The measures considered in this strategy include:

- Leak detection, repair and pipeline replacement,
- Public education program,
- Water waste ordinance (permanent time of day and day of week restrictions for outdoor watering),
- Landscape ordinance requiring low water use landscapes for new residential construction.

Water Quantity, Quality, and Reliability

For the purposes of this plan it was assumed that Wichita Falls could reduce demand by 10 percent from the 2070 estimated demand by actively implementing the identified best management practices. The City has an active leak detection, repair and pipeline replacement program and it is expected that the City will continue with this program. The amount of additional water savings can vary depending on how proactive the program is at identifying leaks and replacing pipe. Permanent day of the week irrigation restrictions such as no more than twice per week watering schedules have been shown to have savings of approximately 5 to 8 percent in communities in North Texas. Cities such as Austin, El Paso and San Antonio have implemented water conserving landscape ordinances that have accounted for substantial savings. On a long-term sustainable basis, the water conservations savings are expected to be 2 MGD by 2070.

Potential water quality impacts associated with water conservation should be neutral to positive. Reductions in water use should increase the amount remaining in the lakes and streams potentially improving the water quality.

The reliability is moderate because this strategy relies on actions of others (customers) and the willingness to change daily behaviors. The suite of recommended strategies focuses on the actions of Wichita Falls, which have shown to be successful in reducing water consumption for other entities.

Regulatory Requirements

There are little to no regulatory requirements associated with water conservation. The City is required to report to TCEQ and TWDB on an annual basis on their water conservation programs and estimated savings. They are also required to submit a Water Loss Audit to TWDB on an annual basis.

Lastly, every five years the City is required to submit a Water Conservation and Drought Contingency plan to TCEQ. The demonstration of an active water conservation program is also required for permitting new surface water projects and obtaining funding from the State for future projects.

Impacts

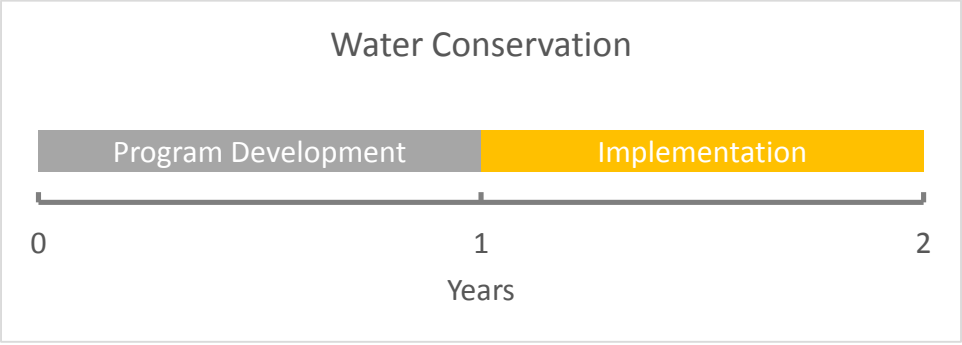
Potential impacts associated with water conservation should be neutral to positive. Reductions in water use will preserve water for other uses, including potential environmental purposes. Conserved water by cities could provide additional supplies to other users, including agricultural and rural areas.

Potential Cost

In the cost estimate some level of pipeline replacement was assumed as part of the leak detection, repair and replacement program. Annual costs were also estimated for leak detection and repair personnel, education program, and enforcement of ordinances. One item that was included in the annual cost is the deferred pumping and treatment costs associated with not having to pump or treat this water. After debt service, the annual cost are offset by the deferred treatment and pumping costs. As shown in the detailed cost estimate the total capital cost is $5,000,000 with an annual cost of $0.08 per thousand gallons with debt service and $-0.44 per thousand gallons cost saving after debt service.

Time to Implement

It is estimated that the water conservation program could take one year to develop and an additional year to implement. Water savings would be realized over time.



Development Obstacles

One potential obstacle is political opposition to permanent water conservation efforts now that the drought has ended. There may be a tendency by customers to revert back to water use patterns prior to the drought. It is the goal of this alternative to create a new normal with the same quality of life (reasonable restrictions) while reducing consumption. Water conservation can potentially reduce revenues for the City, which would need to be recovered either through increased rates or other means.

Supply Independence and Competition for Water

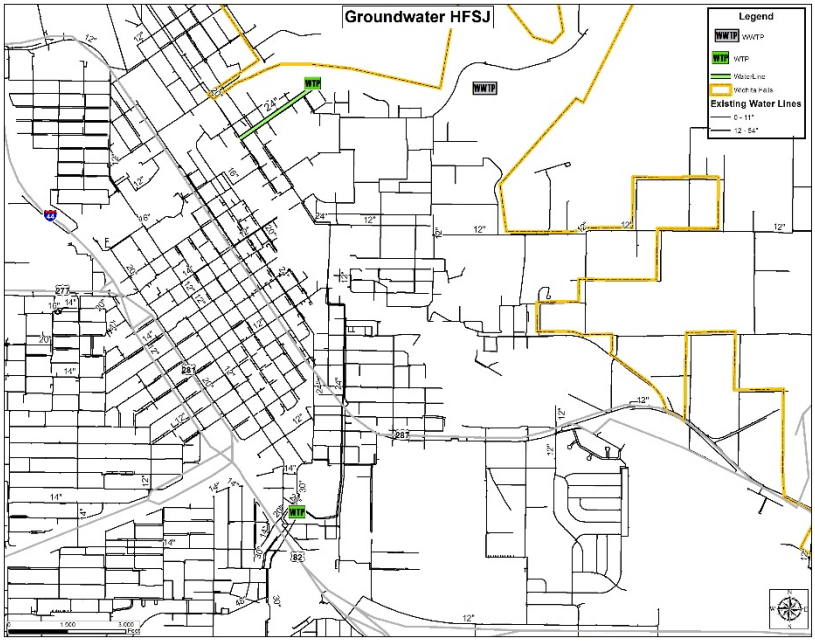
Water conservation is independent of other supplies since it is using less of the water supplies already available. However, certain indoor conservation measures could impact the amount of return flows and ultimately the amount available for indirect reuse project. Thus it is recommended that the City select programs that recover water loss in the distribution system and reduce outdoor usage both of which are not returned to the system.

5.2.3 Groundwater HFSJ

This strategy includes the construction and development of 50 groundwater supply wells in the Seymour Aquifer along the Wichita River, on lands owned by HFSJ Property Holdings, city-owned properties and others. Based on a study performed by INTERA Geoscience & Engineering, it is anticipated that fifty (50) wells pumping at approximately 35 GPM (0.05 MGD) could potentially provide Wichita Falls with a supplemental potable finished water supply of 2 MGD (Letter Report to HFSJ Water Services, LLC, October 31, 2014). The wells would be spaced approximately 1,000 feet apart with collection lines from the well system being pumped into a ground storage tank. However, the current site cannot accommodate 50 wells at 1,000-foot spacing. This strategy assumes that additional property would need to be acquired to provide the 2 MGD supply. The water would be treated on site by Reverse Osmosis (RO) water treatment, and then pumped directly into the water distribution system. The brine waste stream from the RO plant would be discharged to the Wichita River.

Water Quantity, Quality, and Reliability

A preliminary study of the existing wells in this area showed that 20 wells spaced 1,000 feet apart could adequately provide for approximately 1 MGD of well water for a period of six (6) months or more, provided sufficient land is available. It is anticipated that additional areas of the Seymour Aquifer along the Wichita River could potentially be utilized to develop additional well fields with similar productivity.



Based on water quality analysis from existing wells on this property, the water will meet all drinking water standards with the exception of Total Dissolved Solids (TDS), Chlorides, Sulfates, and Iron. However, it is anticipated that by constructing a small onsite RO treatment plant this water could be pumped directly into the City's distribution system for an additional supply of 2 MGD.

The long term reliability of this water is unknown, if selected, this project should be phased in with continuous onsite evaluations being conducted as additional wells are developed. The Seymour Aquifer is an unconfined aquifer, which means that the water supply is contingent upon direct recharge. During drought conditions, water levels and supplies will likely decline.

Regulatory Requirements

With these wells being developed in close proximity to the Wichita River, there is a possibility that this water could be considered underflow as defined by the Texas Water Code and would therefore require a permit for the well system. In addition, there will need to be a discharge permit acquired from TCEQ to discharge the RO reject water back to the Wichita River. The City may be able to amend its wastewater discharge from the Cypress WTP to add a new discharge point near the well field. The

well design, RO treatment facilities, and the distribution system plans must be submitted and approved prior to construction.

Impacts

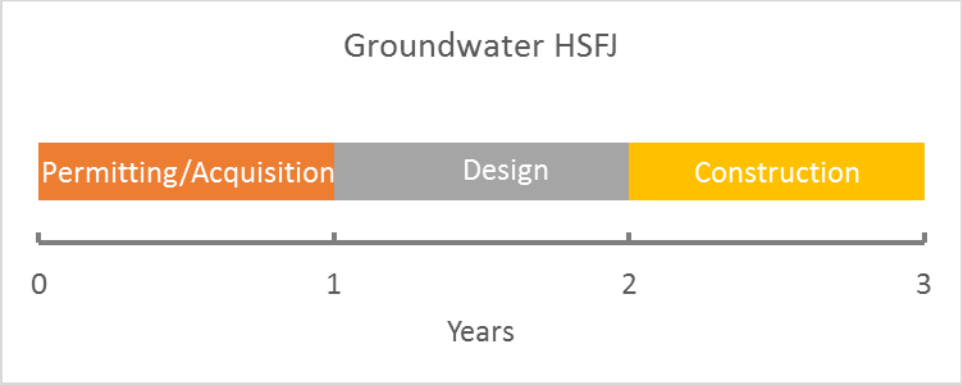
There should be minimal environmental impacts with the construction of the wells, small amount of line work and construction of the treatment plant and pump station. There will also be potential water quality impacts to the Wichita River with the discharge of the reject water from the RO treatment plant. However, if the total discharges to the Wichita River do not exceed the permitted discharges from the Cypress WTP, the impacts should be neutral. This strategy may reduce water supplies that are currently being sold for other uses, such as mining and landscape irrigation.

Potential Cost

To provide for an additional 2 MGD of finished water it is estimated the total capital cost would be $20,824,000 with an annual cost of $4.64 per thousand gallons with debt service and an average annual cost of $2.55 after debt service.

Time to Implement

This strategy could actually be considered short term with the estimated time to complete permitting, design and construction work being approximately three (3) years. This is assuming that some construction may overlap with design.



Development Obstacles

The City would need to negotiate an agreement with the HFSJ Property Holdings Group for the water rights and then would need to pursue a RO discharge permit with TCEQ (either as a new permit or amendment to the Cypress WTP permit). Also, with additional wells currently being drilled at this site, the City should acquire the pumping and well performance data for further monitoring and site evaluation.

Supply Independence and Competition for Water

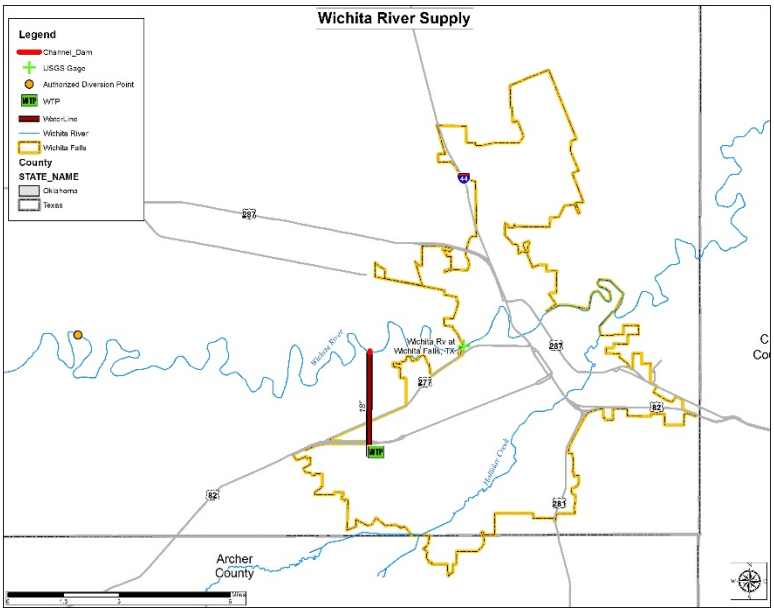
Being a groundwater supply source, this strategy is independent of the City's current surface water supplies. And though not subject to evaporation losses, it is anticipated that as the aquifer is continuously pumped, the water levels will decline during drought conditions.

There is competition for this water. Currently this groundwater source is being utilized for residential uses and to maintain operations of the City public water park. In addition, this water is used by landscape companies and landscape nurseries.

Strategy Variation

As a variation of this strategy, groundwater from this area could be pumped to the River Road WWTP discharge pipeline and transported with the wastewater effluent either directly to the Cypress WTP for the DPR project or to Lake Arrowhead as part of the indirect reuse project. This would eliminate the need for on-site treatment and provide additional water to blend with the wastewater effluent.

5.2.4 Wichita River Supply

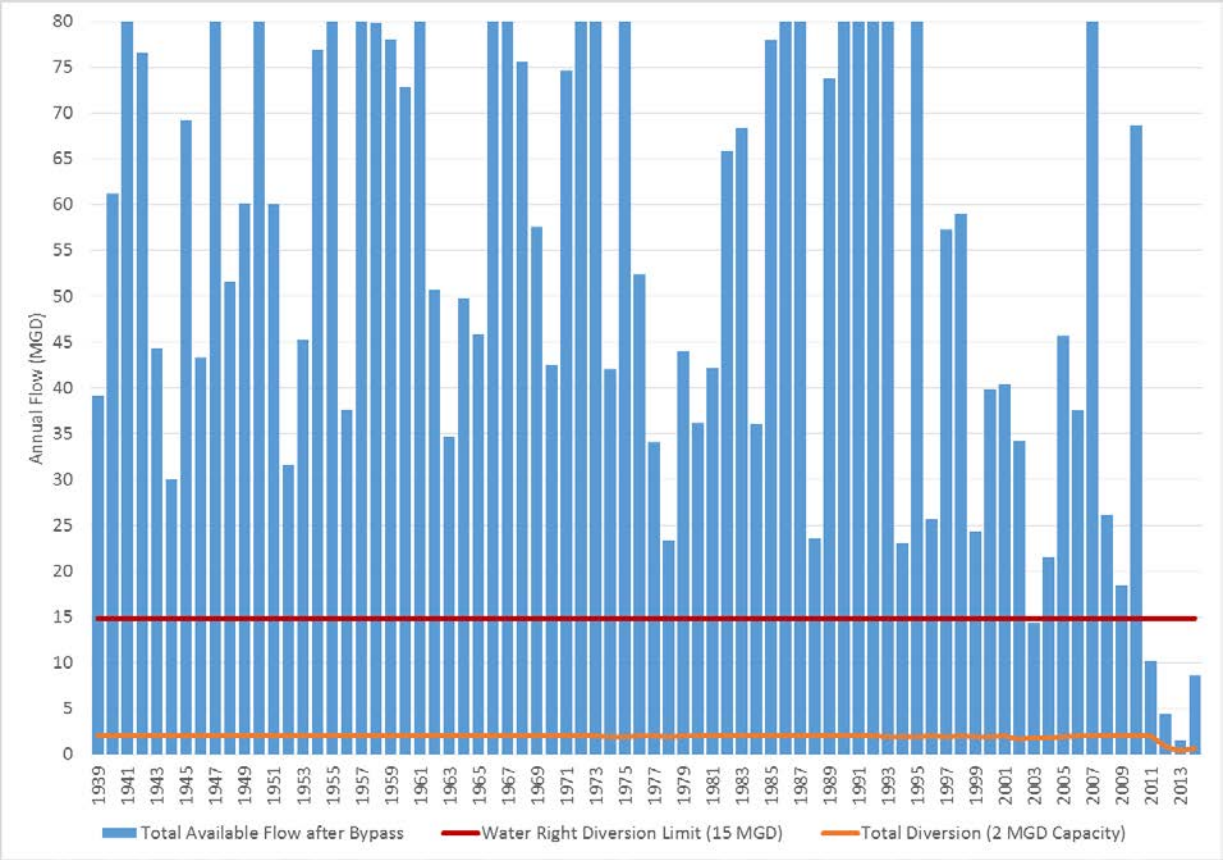


The Wichita River Supply is a direct diversion from the Wichita River at the City of Wichita Falls. The water right for Lake Kemp authorizes diversion and use of up to 16,600 acre-feet per year (14.8 MGD) for irrigation purposes from the Wichita River. For this strategy, it is assumed that the Lake Kemp water right would be amended to allow for municipal use from the diversion point further downstream from the point currently authorized. The strategy assumes that a small diversion structure is constructed just upstream of the Cypress WTP discharge location. Water would be pumped directly from the river and treated at the Cypress WTP, or blended with existing supplies for conventional treatment.

Water Quantity, Quality, and Reliability

The estimated reliable supply from the Wichita River is 2 MGD, but the water right includes the ability to divert up to almost 15 MGD. In order to evaluate the reliability of this diversion, the downstream diversion point of the 15 MGD authorized under the Kemp water right was assumed to be diverted upstream of the USGS Wichita River at Wichita Falls gage. According USGS Gage an annual diversion of 2 MGD would be available in most years except for the most recent drought years. Prior to 2012, nearly the full authorized diversion of 15 MGD was available. Figure 5-1 below shows the total available annual diversion (after bypass requirements) and the strategy amount. The analysis included the bypass of 13 cfs in the water right, a maximum daily diversion rate of 9 cfs from the water right, and an annual limit of 6 MGD, which is the capacity of the pipeline.

Figure 5.1: Available Flows USGS Wichita River at Wichita Falls Gage



This water has high total dissolved solids and would need to be treated at the Cypress Water Treatment Plant or at another reverse osmosis facility or blended with existing supplies. As mentioned above the 2 MGD supply is not fully reliable and another source would be needed in those years. Surface water supplies, especially run-of-river supplies, are very susceptible to drought conditions.

Based on an analysis of the historical flows at the Wichita Falls gage, it appears that the base flow in the river may be dependent on overflows and return flows from the upstream irrigation district. Curtailment of irrigation use or implementation of irrigation conservation and efficiency strategies may reduce the reliable flows in the river. Also, flows at the Wichita Falls gage after 2009 include discharge flows from the Cypress WTP. This may slightly overestimate the available flow at the proposed diversion point in recent years. However, further review of the flows upstream of the Wichita Falls gage indicate there have been considerable river flows over the past five years that are not dependent upon the WTP discharges or irrigation practices. It is recommended that the City

monitor flows in the river before implementing this strategy. Building storage, combining this supply with existing supplies or conjunctive use of groundwater may increase the reliable supply. One option may be to store river water in Lake Wichita during times of higher flows. If this was done, the diversion pump station may need to be upgraded to divert up to 6 MGD, which is the capacity of the transmission line.

Regulatory Requirements

Wichita Falls would need to amend the existing Certificate of Adjudication 02-5123 to move the diversion location further downstream along the Wichita River and to amend the use type to include municipal use. There is currently an instream flow requirement that the flows may be diverted only when the remaining flow of the river equals or exceeds 10 cfs and 13 cfs at the diversion points. Construction of a channel dam would require a Section 404 permit.

Impacts

To access this supply the City would need to build a channel dam to create a pool for diversion. At the channel dam they would need to construct an intake structure. Both of these items along with reduced stream flows due to diversions could impact waters of the U.S. and may require mitigation.

The run-of-river diversion is currently authorized for irrigation use but is not currently being used. Changing the location and amending the use type could impact the potential use of this supply for irrigation. However, since this water supply has not been used and is not expected to be used, there should be no impacts on agriculture or rural interests.

Potential Cost

The cost estimate below assumes that the City will construct a channel dam just upstream of the current Cypress WTP outfall. An intake pump station will be constructed along with an 18” water line to an existing treatment facility for blending. The total capital cost is estimated at $10,410,000. The unit cost with debt service is $2.33 per thousand gallons and $1.27 per thousand gallons after debt service. This cost assumes a 2 MGD pump station at the river. The City could reliably divert more than 2 MGD during normal rainfall periods, but a larger intake pump station would be needed.

Time to Implement

It is estimate that amending the water right could take two years with design and construction taking another two years.

Development Obstacles

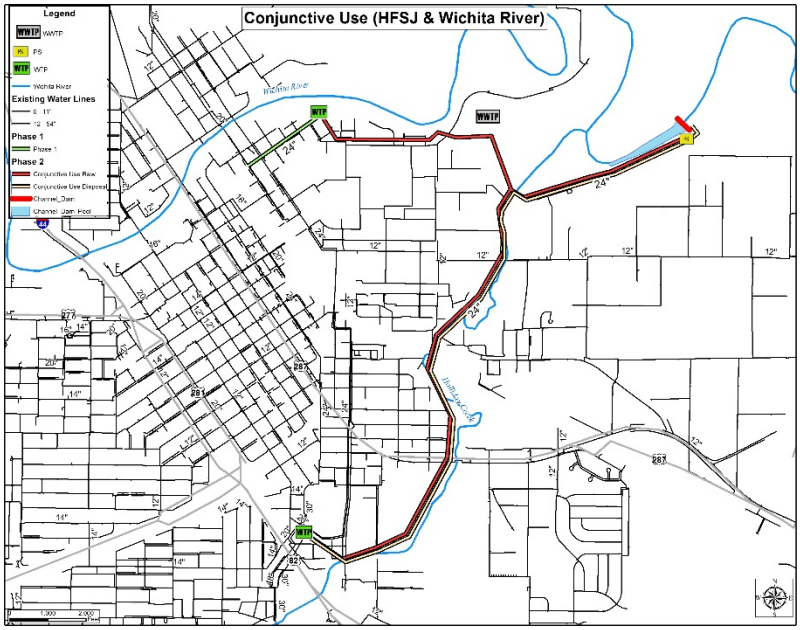
The primary obstacles are the potential water quality and treatment options and the potential impact of irrigation operations on reliable supply. Also since this supply is not one hundred percent reliable it would need to be combined with other sources.

Supply Independence and Competition for Water

This supply is located in the same basin as existing supplies and would be impacted by the same climatic conditions. It appears that the reliability of the supply is affected by current irrigation practices and could be impacted by strategies that reduce irrigation supplies or increase irrigation efficiency. This diversion has not been historically used by any water right user thus there is currently no competition for this supply.

5.2.5 Conjunctive Use – Supplies in Wichita County

This strategy combines the groundwater development associated with the HFSJ strategy and surface water development from the Wichita River to provide a total of 4 MGD of water supply. The conjunctive nature of this strategy allows the City to use surface water when available and reserve groundwater for times when there is little surface water. This requires each component to be able to obtain up to 4 MGD of supply over limited time periods. Due to the different length of time it may take to develop both components of this strategy, it is assumed that the strategy is developed in stages.



The groundwater component would be developed first and provide treated groundwater directly to the Wichita Falls system as discussed under the HFSJ strategy. Phase 1 would also include advanced treatment of the groundwater at the well field with a new brine discharge permit to the Wichita River. During this initial phase, the City would apply for a permit amendment to the Lake Kemp permit to allow surface water diversions from a location immediately downstream of the confluence of the Wichita River and Holiday Creek. The City would also continue to monitor surface water flows in the Wichita River to confirm whether there is reliable surface water during drought and/or non-irrigating periods.

Phase 2 would develop the surface water component and expand the groundwater system to 4 MGD capacity. The surface water component would include a channel dam, pump station and approximately 5 miles of 24-inch pipeline to move the diverted water to the Jasper WTP. The groundwater would be pumped to the new raw water line and blended with the surface water. The reverse osmosis treatment system that is located at the well field would be relocated to the Jasper

WTP and a new discharge pipeline would be constructed to discharge downstream of the surface water diversion. The combined flow of groundwater and surface would be treated at the Jasper WTP.

Water Quantity, Quality, and Reliability

The current estimate is for a reliable supply of 2 MGD from each component (HFSJ groundwater and Wichita River) for a total of 4 MGD. Preliminary studies indicate that there is sufficient supply to provide the 2 MGD each, but there is some uncertainty regarding the ability to provide 4 MGD, especially long-term from the well field. The supply from the Wichita River is likely not available during drought but is more reliable if there is some storage associated with this diversion. In some years, diversions from the Wichita River can easily provide 4 MGD.

The water of both sources is brackish with TDS levels near 2,000 mg/l. This supply will require advanced treatment. It is assumed that at least 2 MGD of the supply would be ultimately treated using reverse osmosis at the Jasper WTP. Treatability studies would be needed to determine the blend ratio and compatibility of the blended sources.

Preliminary studies indicate that the groundwater source is reliable for 2 MGD and possibly could produce up to 4 MGD for limited periods. The surface water supply is not fully reliable as an independent supply, but the conjunctive use of the groundwater supply with the surface water greatly increases the reliability. The uncertainty with this strategy is the length of time that groundwater would need to produce up to 4 MGD to make the strategy fully reliable and whether this quantity is sustainable over the time period. During drought, both the well field and surface water supplies likely will be impacted. The City may need to expand the well field to maintain 4 MGD production.

Regulatory Requirements

Wichita Falls would need to amend the existing Certificate of Adjudication 02-5123 to move the diversion location further downstream along the Wichita River and to amend the use type to include municipal. There is currently an instream flow requirement that the flows may be diverted only when the remaining flow of the river equals or exceeds 10 cfs and 13 cfs at the diversion points. Construction of a channel dam would require a Section 404 permit.

The City would need to obtain a permit to discharge treated wastewater to the Wichita River. As previously discussed, the City may be able to amend its existing permit for the Cypress WTP to include discharges from the new treatment facilities. Water quality studies may be required for the discharge.

Impacts

In order to access this supply the City would need to build a channel dam to create a pool for diversion. At the channel dam they would need to construct an intake structure. Both of these items along with reduced stream flows due to diversions could have an environmental impact. It is assumed that the brine discharge would be evaluated and designed to minimize environmental impacts.

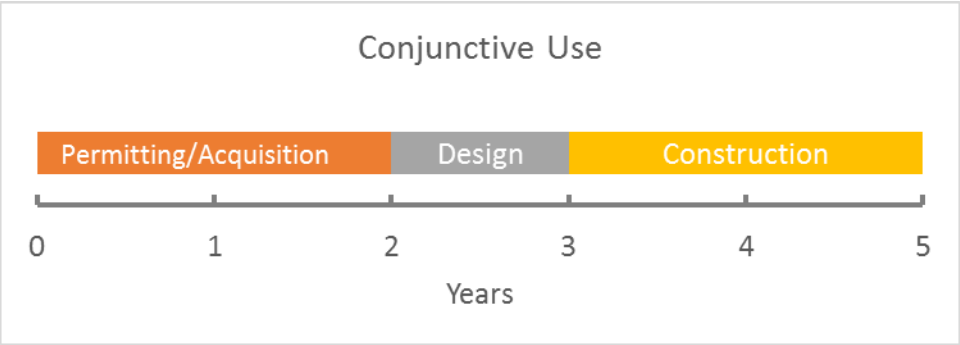
Neither the groundwater nor surface water supply is currently being used for agricultural purposes. There may be small impacts to rural users associated with the purchase of lands for the infrastructure, but most of the pipeline will follow Holiday Creek. Overall, impacts to agricultural and rural users is expected to be minimal.

Potential Cost

The costs for this strategy assume the full project development. Developing the project in phases may increase the total cost due to the construction of the treated water line during Phase 1, but would allow the City to begin using water sooner. The full project capital cost, excluding the treated water line, would be $38,390,000. Annual costs during debt repayment are estimated at $4.39 per thousand gallons. This assumes that the groundwater could be purchased at a rate of $0.50 per 1,000 gallons. Actual water sale costs will be negotiated between the seller and the City. Annual costs after debt service are $2.46 per thousand gallons.

Time to Implement

The groundwater component of this strategy could be implemented fairly quickly to provide a small amount of treated water to the City, assuming that TCEQ would grant a wastewater discharge permit. Potentially, the TCEQ may allow the brine to be discharged under its existing permit (permanently or temporarily) and only require a new discharge location. Overall, it is expected to take approximately 5 years to permit, design and fully construct this option. There is some uncertainty with permitting the channel dam, which could extend the timeline.



Development Obstacles and Competition for Water

The primary obstacles are the timing for the permitting of the surface water and discharge to the Wichita River, potential water quality compatibility issues with the two different water sources and the potential impact of irrigation operations on reliable surface water supply. There is little competition for these water supplies, partly due to the impaired water quality.

This strategy is a variation of the Wichita River Strategy and the HFSJ Groundwater Strategy. Changes in irrigation practices or diversion amounts from Lake Kemp could impact this strategy. Other strategies are not affected.

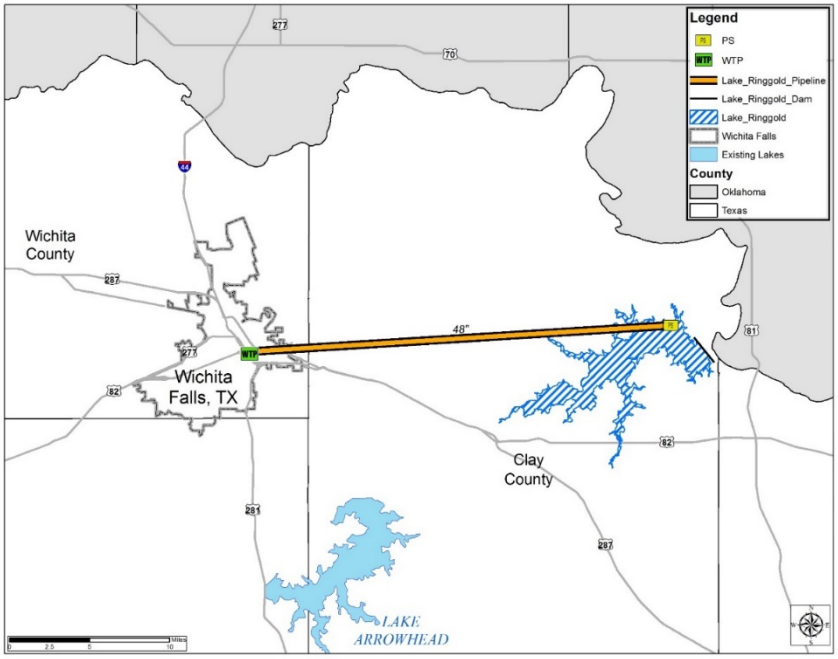
5.3 LONG-TERM STRATEGIES

Long-term strategies are those that likely cannot be implemented in the next few years to meet the immediate water needs. They typically represent a substantial capital investment and many have the potential to meet most or all of the City's projected water shortage. There were seven long term strategies identified for further review. Below is a brief description of each alternative.

5.3.1 Lake Ringgold

Lake Ringgold is a proposed 16,000-acre reservoir site located in Clay County, Texas. The proposed dam would be located on the Little Wichita River, approximately 0.5 miles upstream of its confluence with the Red River, and would impound 275,000 acre-feet of water at the normal pool elevation of 844 feet-msl.

This strategy includes construction of the Lake Ringgold dam, intake pump station and a 30-mile pipeline to transport water to the City.



This reservoir site has been considered as a potential water supply source for Wichita Falls since 1958. There have been many studies on the feasibility of this project, with the most recent study completed in 2012. Information from the 2012 study, along with recent hydrologic analyses, was used as the basis for this evaluation.

Water Quantity, Quality, and Reliability

The City of Wichita Falls has identified a potential reservoir site approximately 30 miles northeast of Wichita Falls, near the town of Ringgold. Hydrologic modeling through June 2015, resulted in a safe yield of approximately 16.9 MGD. The safe yield provides a reserve storage of 19,000 acre-feet, which is reasonable in light of the reserve storage of the City's other water sources.

This reservoir would be in the same drainage basin as Lake Arrowhead and Lake Kickapoo so it is anticipated that the water quality would be very similar to the existing reservoirs. There are currently three permitted wastewater discharges within or upstream of the proposed reservoir. These dischargers may be impacted by higher stream standards, requiring a higher level of treatment and nutrient removal. This is impact will need to be considered in the planning and permitting effort for the reservoir. The reservoir may take up to 20 years for permitting, design and construction. Therefore, there is sufficient time to address modification of existing wastewater plants to achieve the future stream standards and protect Lake Ringgold as a water supply reservoir.

The reliability of this water supply would be good, but with the Ringgold site being downstream and in the same drainage basin as the two existing lakes, Lake Ringgold could be adversely affected during periods of extended drought that affect the existing sources.

Regulatory Requirements

The construction of Lake Ringgold would require the City to obtain a water right permit from the State to impound and divert water from the Little Wichita River. It also would require a Section 404 permit from the Corps of Engineers to construct the dam. It is estimated that permitting for this project could take 10-12 years.

Impacts

Lake Ringgold will impact approximately 120 acres of existing ponds and stock tanks and approximately 165 miles of streams. At the conservation elevation of 844 feet, approximately 910 acres of wetlands will be impacted. An assessment of threatened and endangered species in the feasibility study found low to no potential to negatively impact any federally listed threatened or endangered species. Only two of the nine state listed species (Texas horned lizard and Texas kangaroo rat) were identified as having a moderate potential to be impacted by Lake Ringgold. The greatest uncertainty associated with Lake Ringgold is cultural resources with the project site located in an area with known American Indian activities. Approximately two-thirds of the reservoir's site was identified as high potential for cultural resources. In addition pump stations, and the pipeline into the City would be located in area of low to moderate impact to avoid or minimize environmental and cultural impacts.

The Lake Ringgold alternative would have a moderate to high impact on both agriculture and rural lands in that approximately 9,700 acres of cultivated crops and grassland could be required for the site. Additional lands would likely need to be acquired for mitigation of the project. Potential mitigation sites have not been identified. For planning purpose, it is assumed that an additional 24,000 acres may be needed. The actual amount may be less.

Existing residences and businesses within the footprint of the reservoir would need to be acquired. Also, the City of Henrietta's intake structure and small lake would be impacted by Lake Ringgold. Existing landowners and Henrietta would be compensated as part of the project.

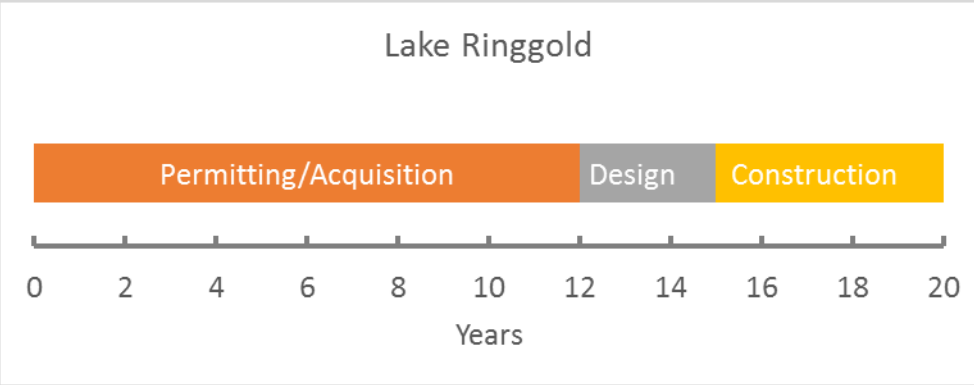
Potential Cost

Of the 24,000 acres of land needed for the reservoir site, the City currently owns approximately 6,662 acres. The infrastructure is sized for the safe yield volume of 16.9 MGD. Along with purchasing the

remaining lands for the site, additional facilities including a 29 MGD lake intake structure and pump station facilities, and 30 miles of 42" transmission line would be required to convey 16.9 MGD of raw water to existing treatment facilities in Wichita Falls. As shown in the detailed cost estimate provided for the construction of the Lake Ringgold Reservoir, the total capital cost is $297,920,000 with an annual cost of $4.45 per thousand gallons during debt service and $1.65 per thousand gallons after debt service.

Time to Implement

It is estimated that it will take approximately 20 years from the start of permitting until Lake Ringgold is complete. The majority of this time, 10-12 years, is estimated for the water right and Section 404 permitting process.



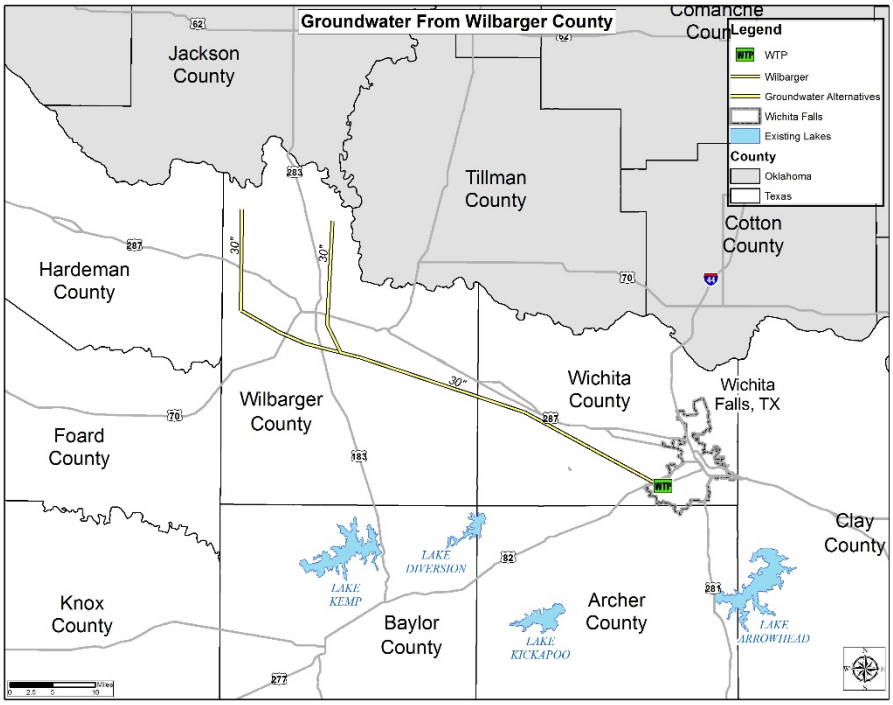
Development Obstacles

In addition to the regulatory requirements there is still some property remaining that would need to be acquired. There is also some opposition from local landowners. The potential impact on cultural resources is uncertain. An additional challenge may be finding suitable mitigation along the Little Wichita River or near the project site.

Supply Independence and Competition for Water

One limitation of Lake Ringgold is that it is in the same watershed as existing supplies and is likely to be impacted by the same climatic conditions as Lakes Arrowhead and Kickapoo. Thus a severe extended drought will impact all of Wichita Falls supplies. A portion of the supply would need to be provided to Henrietta, but the yield in this analysis assumes that supplies to existing water right holders are met.

5.3.2 Groundwater From Wilbarger County



This strategy includes the construction and development of 25 groundwater supply wells in the Seymour Aquifer along the Red River in the northwestern portion of Wilbarger County. The wells would be spaced approximately 1,000 feet apart with collection lines from each well being pumped into storage facilities and conveyed by gravity flow through a 75-mile 30" diameter pipeline to the existing Cypress WTP for enhanced treatment. Pressure reducing stations would be installed on the pipeline route to reduce the conveyance pressure on the pipeline.

Water Quantity, Quality, and Reliability

It is anticipated that 25 wells with a pumping capacity of approximately 200 GPM (0.25 MGD) and spaced approximately 1,000 feet apart could potentially be developed to provide the City with an additional water supply of 5 MGD.

Based on historical information, it is anticipated the water in Wilbarger County will meet all drinking water standards with the exception of Total Dissolved Solids (TDS), Chlorides, Sulfates, and Iron. There may also be elevated nitrates. However, this water can be adequately treated at the Cypress WTP.

Based on past historical information and data, this supply appears to be moderately reliable over the long term; however, as these wells are continually pumped during an extended drought, the water

table will need to be monitored and re-evaluated on an annual basis. However, it may be difficult to identify sufficient groundwater resources to produce 5 MGD.

Regulatory Requirements

There are no special regulatory requirements for this strategy other than approval from TCEQ for the design of the wells, transmission pipeline facilities, and approval for the treatment of the finished water prior to distribution. There is no Groundwater Conservation District in Wilbarger County.

Impacts

Development of additional groundwater water supplies in this area may have a minimal impact on the environment as the various well locations are developed and storage facilities are constructed along with the well collection lines and transmission line from the well site to the Cypress WTP.

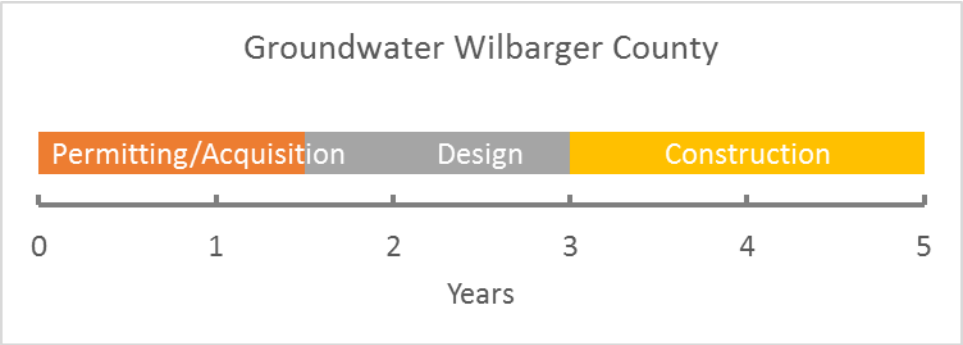
As the water supply wells are developed and required easements are obtained, there will be a minimal impact on the agricultural and rural lands due to construction. Furthermore, as additional water is continually taken from the aquifer, the agricultural lands could experience a reduction in the water levels in the Wilbarger County area.

Potential Cost

To provide for an additional 5.0 MGD of finished water it is estimated the total capital cost would be $107,540,000 with an annual cost during debt service of $6.53 per thousand gallons and $3.12 per thousand gallons after debt service

Time to Implement

This strategy could actually be considered short term with the estimated time to complete the required permitting, design and construction work being approximately five (5) years.



Development Obstacles

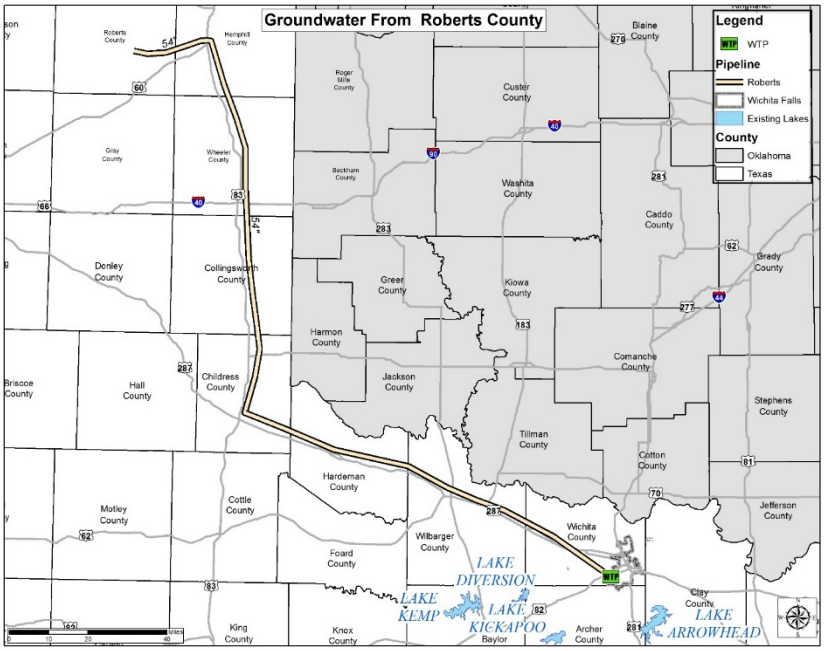
The City would need to negotiate agreements with willing sellers for the water rights and then would need to pursue a routing study to determine the best route for the transmission line along with acquiring all the necessary easements for the conveyance facilities. In addition, the City may want to provide for an additional study to determine the potential for this area being a long term supply for the City.

Supply Independence and Competition for Water

Being a groundwater supply source, this strategy is independent of the City's current surface water supplies. And though not subject to evaporation losses, it is anticipated that as the aquifer is continuously pumped, the water levels will slowly decline during extreme drought conditions.

Currently this groundwater source is being heavily utilized for agricultural irrigation purposes throughout the Wilbarger County area. So the City of Wichita Falls would be competing for the groundwater with the agricultural community.

5.3.3 Groundwater from Roberts County



This strategy includes the construction and development of 40 groundwater supply wells in the Ogallala Aquifer in the eastern portions of Roberts County and southern portion of Lipscomb County.

This strategy assumes that the City could acquire sufficient groundwater rights to provide 24 MGD for at least 100 years. The wells would be spaced approximately 1,000 feet apart with collection lines from the well system being pumped into storage facilities then gravity flow directly into existing storage and pumping facilities in Wichita Falls. A 275-mile 54" pipeline would be constructed from the well field to Wichita Falls. No transmission pump stations are needed. To maintain acceptable pressures in the pipeline, 10 pressure reducing values are included.

Water Quantity, Quality and Reliability

It is anticipated that 40 wells with a pumping capacity of approximately 400 GPM (0.58 MGD) and spaced approximately 1,000 feet apart could potentially be developed to provide the City with an additional water supply of 24 MGD.

Based on historical information on the Ogallala in these two counties, the water quality will meet all state and regulatory standards and will only require disinfection prior to entering the distribution system.

The Ogallala aquifer has large amounts of water in storage in these two counties. The modeled available groundwater for Roberts and Lipscomb Counties total over 670,000 acre-feet per year of available supply (598 MGD). The Canadian River Municipal Water Authority (CRMWA) owns a

considerable amount of water rights in Roberts County and has developed a portion of those rights. The City of Amarillo also owns water rights in Roberts County, but these rights have not been developed. Other users include some irrigation and local use. Water levels have declined in the heavily used areas, but other areas show minimal decline. Due to the large quantity of water that is available in this portion of Ogallala, it is anticipated that the City can develop a reliable long term supplemental water source for over 100 years.

Regulatory Requirements

Roberts County is located within the Panhandle Groundwater Conservation District (PGCD) and Lipscomb County is located within the North Plains Groundwater Conservation District. Each of these Districts has management and regulatory authority over the groundwater in their counties, and therefore, development of wells in either Roberts County or Lipscomb County will require approval from each of the respective Districts.

Impacts

Development of a groundwater supply for the City of Wichita Falls will have a moderate impact on the environment as the various well location are developed, storage facilities are constructed and the conveyance system from Roberts and Lipscomb Counties into Wichita Falls is constructed. Potential environmental impacts associated with the pipeline can be minimized during design.

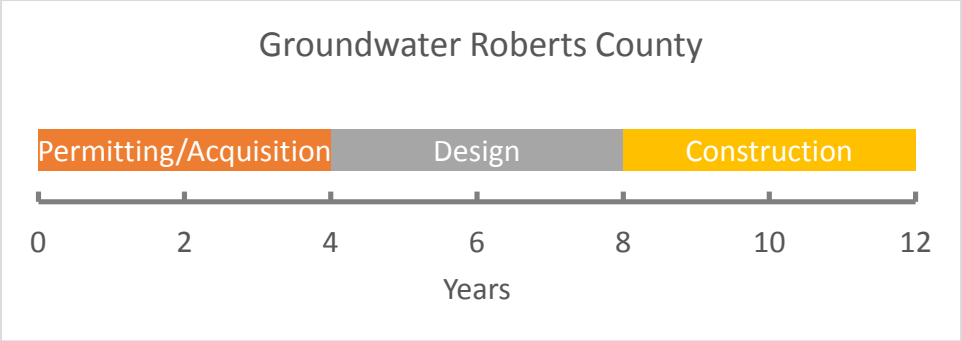
The agricultural and rural impacts of this project will be moderately high, in that large tracts of land would be utilized for the well field and storage facilities in addition to land acquisition for pipeline easements. Development of groundwater supplies in the Roberts and Lipscomb County area could have a moderate impact on entities within that general area. It would, however, provide the City of Wichita Falls with an additional source of supply without impacting the City's surface water sources.

Potential Cost

The total capital cost to provide for a 24 MGD supplemental water supply from the Ogallala in Roberts and Lipscomb Counties is $934,890,000. The annual cost during debt service is $9.63 per thousand gallons and the average annual cost after debt service of $3.75 per thousand gallons.

Time to Implement

It is estimated that this project will take approximately 12 years for permitting, land/easement acquisition, design, and construction.



Development Obstacles

In addition to regulatory requirements, it will be necessary to contract with willing sellers of the land to be developed or contract to purchase the water from the landowners. Furthermore, routing of the conveyance facilities and purchase of right of way and easements will be a challenge. Depending on the location of the well field areas, additional studies may be required to validate the long term supply availability of the groundwater.

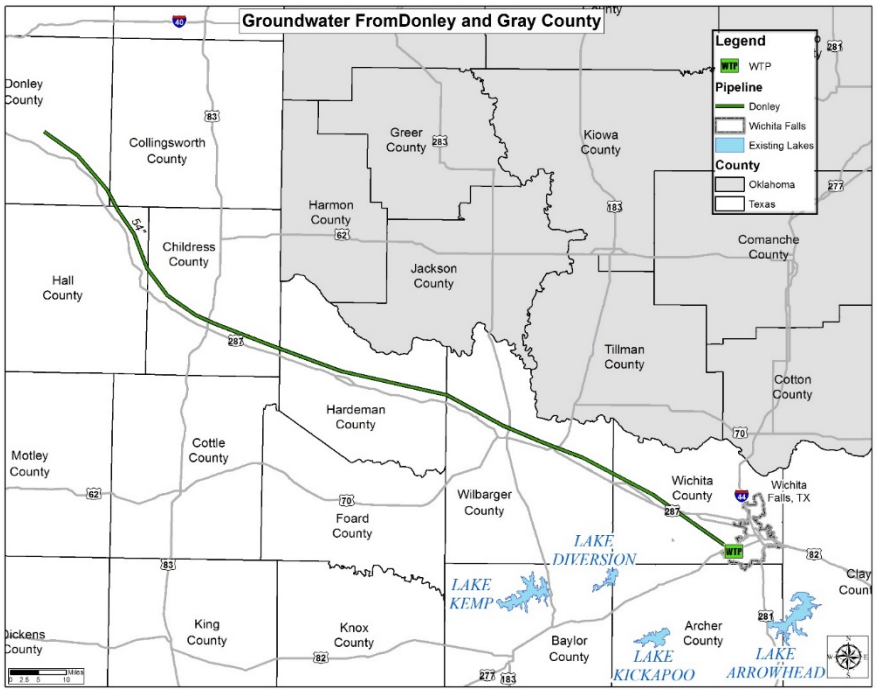
Supply Independence and Competition for Water

This would be the first groundwater supply source that has ever been developed by the City. With the City being totally dependent on surface water, a groundwater source not subject to evaporation losses would be a good additional source of supply for the City of Wichita Falls.

Existing competition for the water includes CRMWA and the City of Amarillo. As the drought continues in Texas, more entities may give serious consideration to the development of groundwater supplies from the Ogallala in the area of Roberts and Lipscomb County. It can be expected that the competition for this water will increase over the years and that the Conservation District's management rules and regulations could begin to limit the development of addition groundwater supplies that can be taken outside of each District.

5.3.4 Groundwater From Donley and/or Gray County

This strategy includes the construction and development of forty (40) groundwater supply wells in the Ogallala Aquifer in the eastern portions of Donley and Gray County. It is anticipated that forty (40) wells each pumping at approximately 260 GPM (0.40 MGD) could potentially be developed to provide the City with an additional water supply of 15 MGD.



This strategy assumes that the City could acquire sufficient groundwater rights to provide the 15 MGD for at least 100 years. The wells would be spaced approximately 1,000 feet apart with collection lines from the well system pumped into storage facilities then gravity flow directly into existing storage and pumping facilities in Wichita Falls. A 185-mile 54" pipeline would be constructed from the well field to Wichita Falls. No transmission pump stations are needed. To maintain acceptable pressures in the pipeline, eight pressure reducing values are included.

Water Quantity, Quality and Reliability

It is anticipated that 40 wells with a pumping capacity of approximately 260 GPM (0.40 MGD) and spaced approximately 1,000 feet apart could potentially be developed so as to provide the City with an additional water supply of 15 MGD. Based on historical information on the Ogallala in these two counties, the water quality will meet all state and regulatory standards and will only require disinfection prior to entering the distribution system.

The Ogallala in Donley County begins to thin out towards the southeast. The saturated thickness is greater to the north and in Gray County. Historically the groundwater supply in this area has been developed for irrigation and as a public water supply for many smaller entities. Though the water

levels have declined over the last ten years, it is anticipated that wells in this area of the Ogallala can be developed for a long term supplemental water source for the City of Wichita Falls.

Regulatory Requirements

Both Donley County and Gray County are located within the Panhandle Groundwater Conservation District (PGCD). The District has management and regulatory authority over the groundwater in both counties, and development of wells in either Donley County or Gray County will require approval from the District. The PGCD manages its groundwater sources based on 50 percent of storage remaining in 50 years. This would need to be considered in evaluating the long-term reliability of the well field.

Impacts

Development of a groundwater supply for the City of Wichita Falls could have a moderate impact on the environment as the various well locations are developed, storage facilities are constructed and the conveyance system from Donley and Gray Counties into Wichita Falls is constructed. Environmental impacts can be minimized during design. The agricultural and rural impacts of this project will be moderately high, in that large tracts of land would be utilized for the well field and storage facilities in addition to land acquisition for pipeline easements.

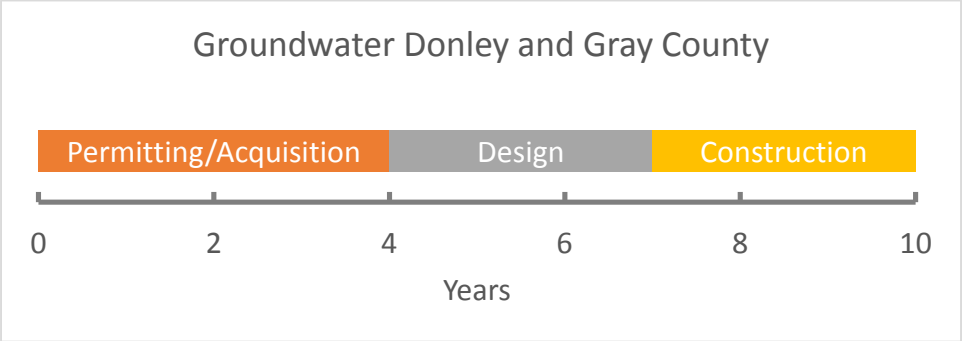
Development of groundwater supplies in the Donley and Gray County area could have a moderate impact on entities within that general area. It would, however, provide the City with an additional source of supply without impacting the City's surface water sources.

Potential Cost

The total capital cost to provide for a 15 MGD supplemental water supply from the Ogallala in Donley and Gray Counties is $628,360,000. The annual cost during debt service is $10.83 per thousand gallons and the average annual cost after debt service is $4.20 per thousand gallons.

Time to Implement

It is estimated that this project will take approximately 10 years for permitting, land/easement acquisition, design, and construction.



Development Obstacles

In addition to regulatory requirements, it will be necessary to contract with willing sellers of the land to be developed or contract to purchase the water from the landowners. Furthermore, routing of the conveyance facilities and purchase of right of way and easements will be a challenge. Depending on the location of the well field areas, additional studies may be required to validate the long term supply availability of the groundwater.

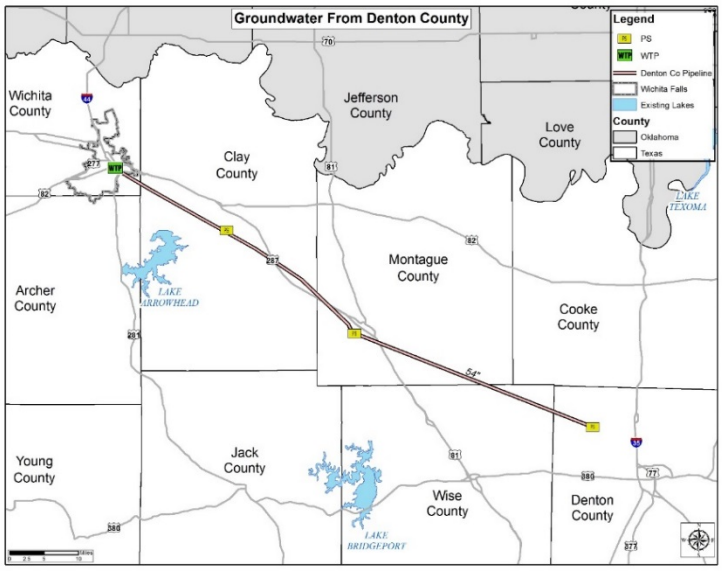
Supply Independence and Competition for water

This would be the first groundwater supply source that has ever been developed by the City. With the City being totally dependent on surface water, a groundwater source not subject to evaporation losses would be a good additional source of supply for the City of Wichita Falls.

As the drought continues in Texas, more entities may give serious consideration to the development of groundwater supplies from the Ogallala in the area of Donley and Gray County. It can be expected that the competition for this water will increase over the years and that the PGCD management rules and regulations could begin to limit the development of addition groundwater supplies that can be taken outside of the District.

5.3.5 Groundwater from Denton County

The Trinity Aquifer is located in the northwest portion of Denton County and in the area there is a substantial amount of available groundwater at depths ranging from 1,000 to 1,500 feet. Groundwater supply wells could be developed in this area to provide the City of Wichita Falls with a groundwater source to supplement their current surface water supply.



Water Quantity, Quality, and Reliability

This strategy assumes that the City would develop up to 15 MGD of groundwater supplies. This area is a proven groundwater supply with wells producing in the range of 0.75 MGD to 1.0 MGD with wells spaced a minimum of 2,500 feet apart. At this time, it appears that obtaining a permit from the local groundwater conservation district for 15 MGD may be difficult. Based on current Desired Future Conditions (DFCs) and proposed DFCs being considered for adoption in 2016, the amount of water available for permitting is likely much less than 15 MGD. Further discussions with the GCD would be needed to confirm the available supply.

The water quality in this area is excellent meeting all the TCEQ Primary and Secondary drinking water standards with only disinfection facilities required prior to utilizing it as a public drinking water source.

Historically the groundwater supply in this area has been developed as both a public water supply for many smaller entities and for irrigation purposes. Though the water levels have declined over the last ten years, it is anticipated that wells in this area can be developed for a long term supplemental water source for the City. However, pending management by the GCD the amount of water allowed to be pumped may decrease over time.

Regulatory Requirements

Denton County is located within the North Texas Groundwater Conservation District (NTGCD) which was created in the latter part of 2009. In addition to TCEQ, the NTGCD has management and regulatory authority over the groundwater in Denton County. Therefore, development of wells in Denton County will require a permit from NTGCD.

Impacts

Development of a groundwater supply for the City will have a moderate impact on the environment as the various well location are developed, pump stations are constructed and the conveyance system from Denton County into Wichita Falls in constructed. The agricultural and rural impacts of this project will be moderately high, in that large tracts of land would be utilized for the well field and pump stations in addition to land acquisition for pipeline easements.

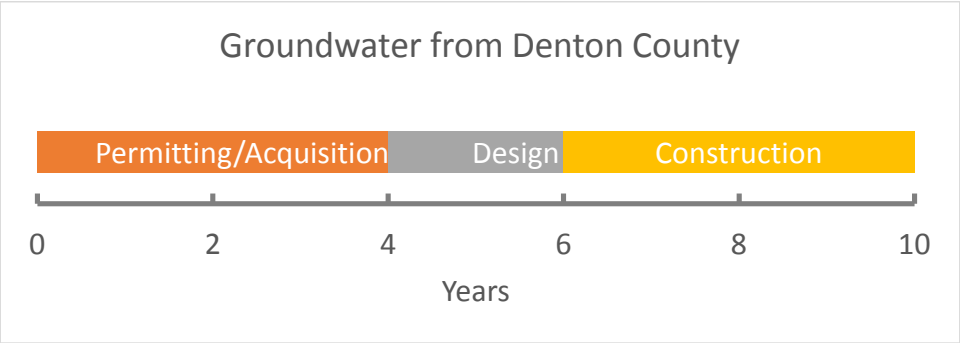
Development of groundwater supplies in the Denton area would have a high impact on entities in the Denton area. It would, however, provide the City with an alternate source of supply without impacting their surface water sources.

Potential Cost

To provide for an additional supply of 15 MGD, a minimum of 20 wells will need to be drilled and completed to a depth of approximately 1300 feet. The total capital cost to provide 15 MGD from Denton County is $372,160,000. The annual cost with debt service is $6.87 per thousand gallons and the average annual cost after debt service is $2.94 per thousand gallons.

Time to Implement

It is estimated that this project will take approximately 10 years for permitting, land/easement acquisition, design, and construction completion.



Development Obstacles

In addition to regulatory requirements, it will be necessary to contract with willing sellers of the land to be developed or contract to purchase the water from the landowner. Furthermore, routing of the conveyance facilities and purchase of right of way and easements will be a challenge. Depending on the location of the well field areas, additional studies may be required to validate the long term supply availability of the groundwater.

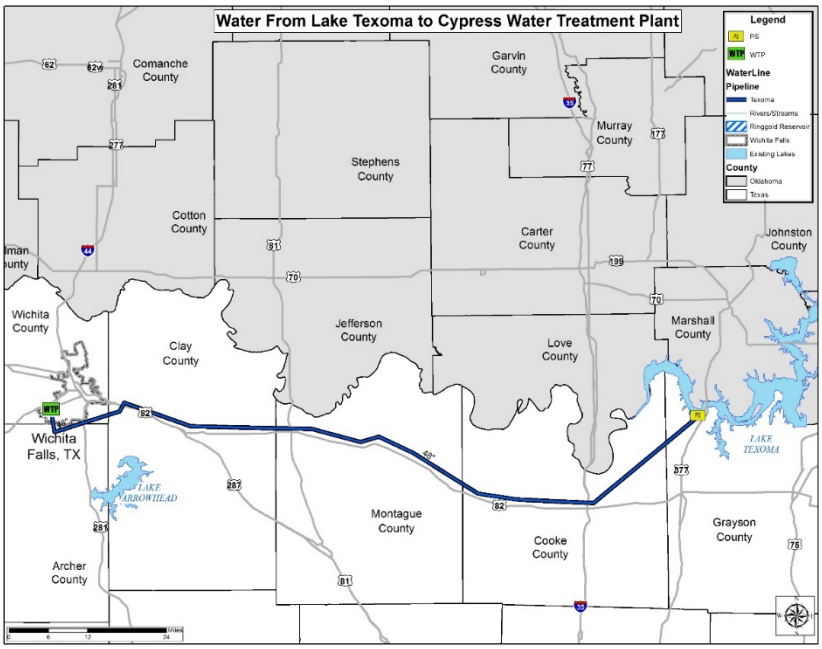
Supply Independence and Competition for Water

This would be the first groundwater supply source that has ever been developed by the City. With the City being totally dependent on surface water, a groundwater source not subject to evaporation losses would be a good alternate source of supply for the City.

As the drought continues in the North Texas area, more entities are giving serious consideration to the development of groundwater in the Denton County area. It can be expected that the competition for this water will increase and NTGCD management rules and regulations could begin to limit the development of addition groundwater supplies that can be taken outside Denton County or outside Region C and transferred to adjacent planning areas.

5.3.6 Lake Texoma Water

This strategy assumes that the City of Wichita Falls enters into an agreement with an existing water right holder to purchase water from Lake Texoma and transport the water to the City. Raw water is transported to the City and treated at the Cypress treatment plant (WTP). This strategy includes an intake structure at Lake Texoma, 120-mile pipeline, three booster pump stations. The raw water would be treated at the Cypress WTP using the existing conventional treatment facilities and expanding the existing RO treatment from 10 MGD to 15 MGD. The brine would be discharged to the Wichita River under the City's existing permit. This strategy includes upsizing the pipeline near the Ringgold Reservoir site to allow transport of Ringgold lake water to Wichita Falls, if this project is developed.



Storage in Lake Texoma is allocated to both Texas and Oklahoma. Texas has nearly permitted all of its share of the lake's storage. Existing water right holders that may be willing to sell water to Wichita Falls include the City of Denison and GTUA. The North Texas Municipal Water District and Red River Authority also own water rights in Lake Texoma, but the quantity is less than the amount needed by the City.

Water Quantity, Quality, and Reliability

Previous discussions with existing water rights holders indicate that there is available water for the City of Wichita Falls. For purposes of this evaluation, it is assumed that 15 MGD of water could be secured from Texas water rights holders for at least 50 years. This water supply is expected to be reliable.

Located on the Red River, the water in Lake Texoma has elevated total dissolved solids and sulfates. Lake Texoma water would need to be treated to reduce the salts or blended with higher water quality

supplies. Since the brackish water is lake water, pretreatment would likely be required before advanced treatment could be used. If advanced treatment is used, the salt levels would likely require approximately 40 to 50 percent of the total supply to be treated using RO and then blended with the remaining supplies or other Wichita Falls' supplies. It is unlikely that this quantity of brackish water (15 MGD) could be blended only with the City's other supplies to meet the drinking water standards.

Zebra mussels are also present in Lake Texoma. While this does not pose a water quality issue, it does create potential maintenance concerns for the intake and transmission system, especially if the water is treated in Wichita Falls.

The reliability is expected to be high. There is some uncertainty regarding reaching agreements with existing water right holders, the contract amounts and terms of the contract. Also, currently Oklahoma is using only a small portion of its allotment. If Oklahoma began using more water from Lake Texoma, then there will be additional competition for this water during drought.

Regulatory Requirements

There is no interbasin transfer required since the use will occur in the Red River Basin. There will be regulatory requirements associated with the treatment and disposal of the reject water although the City may be able to use the Cypress WTP existing discharge permit of 6 MGD. Presently, it may be difficult to obtain a new wastewater discharge permit for brine disposal to the Red River. The City would need to obtain a Section 404 permit for the intake structure and possibly the pipeline.

Impacts

There should be minimal environmental impact from the construction of the pipeline. As mentioned above there could be potential impacts from Zebra mussels and it is likely that any raw water transported from Lake Texoma would have a requirement to stay in a closed system (i.e., could not be blended in another lake).

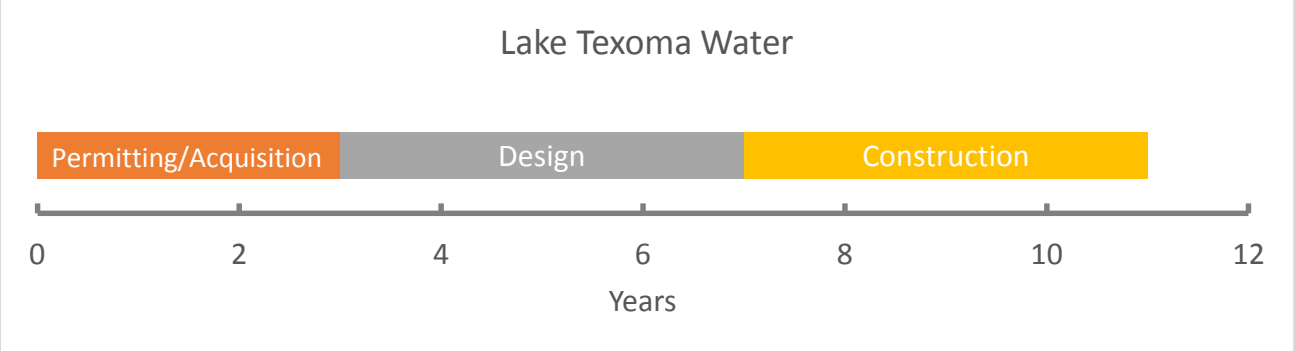
The 180-mile pipeline will cross agricultural and rural lands and require a large number of easements to be obtained. The pipeline route is now shown to follow roads and minimize the potential impacts to agricultural and rural users.

Potential Cost

The cost includes 90 miles of 48" pipeline and 33 miles of 54" pipeline. It was assumed that only a 10 MGD expansion of the Cypress reverse osmosis treatment facilities would be needed. The capital cost is $401,230,000. The annual cost with debt service is $7.66 per thousand gallons and the average annual cost after debt service is $3.42 per thousand gallons.

Time to Implement

It is assumed that a brine discharge permit does not need to be obtained and the water treatment plant improvements consist of only an expansion of the existing RO facilities at Cypress WTP. The permitting, design and construction is estimated to take approximately 11 years.



Development Obstacles

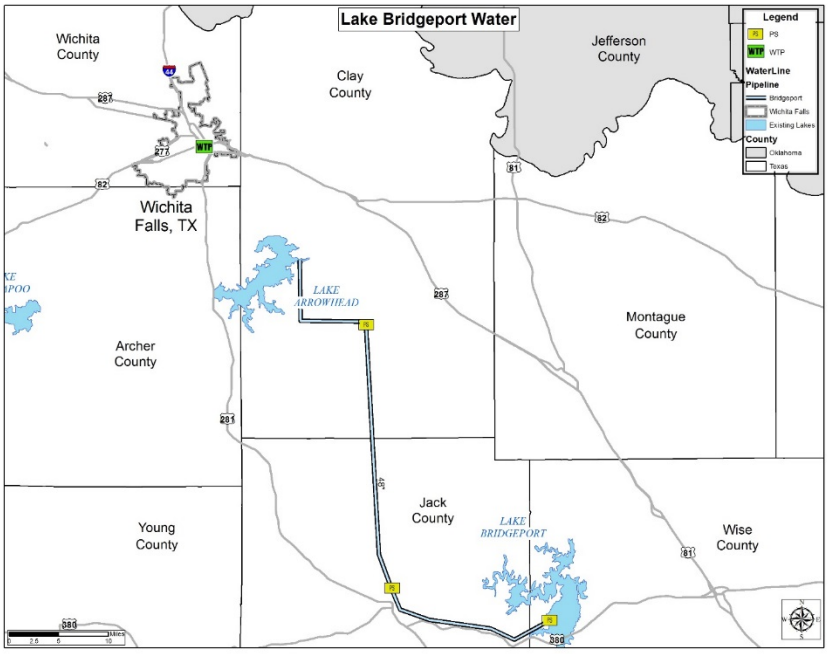
Wichita Falls would need to purchase the supply from another provider. As noted earlier the presence of Zebra mussels in Lake Texoma could pose maintenance issues for transmission and treatment facilities.

Supply Independence and Competition for Water

Lake Texoma has a large contributing drainage area of approximately 33,800 square miles. Lake Texoma is not likely to be impacted in the same manner as Wichita Falls' current supplies during a drought, which provides some level of independence from current supplies.

All or nearly all of the current water conservation pool allotted to Texas is under contract with the USACE and permitted by Texas. Texas water right holders have not fully utilized their contractual amounts to date, but expect to use more Texoma water over the next 50 years. Much of the unused water in Lake Texoma is held by Oklahoma. It is unknown when Oklahoma will permit this water.

5.3.7 Lake Bridgeport Water



This strategy assumes that the City of Wichita Falls enters into an agreement with Tarrant Regional Water District (TRWD) to purchase water from Lake Bridgeport and transport the water to Lake Arrowhead. The would require the construction of one 15 MGD intake pump station and two (2) 15 MGD booster pump stations with storage facilities and approximately 75 miles of 48" diameter pipe to convey the raw water from Lake Bridgeport into Lake Arrowhead. The existing Lake Arrowhead pump station would then be utilized to pump the water into the City's existing secondary reservoir and conveyed to the Cypress WTP and Jasper WTP.

Water Quantity, Quality, and Reliability

Previous discussions with TRWD indicate that there would be available water for the City of Wichita Falls as a supplemental source of up to approximately 15 MGD during most years of normal rainfall.

It is anticipated that the water quality from Lake Bridgeport would be comparable in water quality and compatible with the Lake Arrowhead water so that it can be treated conventionally through the existing City facilities at Cypress WTP and Jasper WTP.

Reliability is expected to be high with the exception of during drought years, such as we are experiencing at the present time. TRWD will set a minimum lake level for Bridgeport, whereby at or below that level, the City of Wichita Falls would not be able to take water from the lake. So, it is anticipated that this strategy would not benefit Wichita Falls during drought conditions. Unless Wichita Falls is able to reach an agreement with TRWD this source is considered unreliable.

Regulatory Requirements

With Lake Bridgeport being in the Trinity River Basin, this would require an interbasin transfer of water into the Red River Basin. The City might need to obtain a 404 permit for the intake structure and the pipeline.

Impacts

The environmental impacts for this strategy should be minimal and those impacts will be related to the construction of the pipeline and the various pump stations in addition to miscellaneous creek crossings.

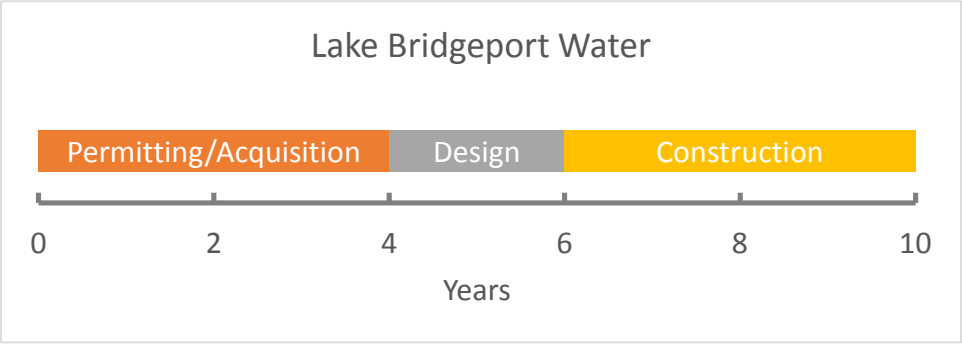
The 75-mile pipeline will cross agricultural and rural lands and require a large number of easements to be obtained. The pipeline route is now shown to follow roads and minimize the potential impacts to agricultural and rural users.

Potential Cost

The total capital cost to provide for a limited supplemental supply from Lake Bridgeport is $235,200,000. The annual cost with debt service is $5.06 per thousand gallons and the average annual cost after debt service is $2.58 per thousand gallons.

Time to Implement

It is estimated that it could take up to ten (10) years to negotiate a water contract, acquire easements, design the facilities, and build the pump stations and transmission line.



Development Obstacles

Wichita Falls would need to negotiate a water supply purchase contract from TRWD. In addition a detailed route study would need to be completed and all easements and pump station sites would need to be acquired.

Supply Independence and Competition for Water

With Lake Bridgeport being in a different drainage basin, it provides for some supply independence, but like the Wichita Falls lakes Lake Bridgeport has also experienced some low lake levels and is impacted by drought conditions.

Lake Bridgeport is owned and heavily utilized by TRWD as a water supply for numerous entities in and around the Wise, Jack, and Parker County area. Therefore, Wichita Falls would have very limited access to the water during drought conditions.

5.3.8 Lake Kemp Water Right Amendment

The water right for Kemp, Certification of Adjudication 02-5123, authorizes diversion and use of up to 193,000 acre-feet per year (172.2 MGD) for multiple purposes, as shown in Table 1. 25,150 acre-feet per year (22.4 MGD) is for municipal and 40,000 acre-feet per year (35.7 MGD) for industrial purposes, about 34 percent of the total authorizations. The water right also includes the option to divert up to 16,660 acre-feet per year (14.8 MGD) of the 120,000 acre-feet per year authorized for irrigation directly from the Wichita River downstream of the reservoir. These authorizations greatly exceed the estimated supply from the reservoir of 44,607 acre-feet per year (29.3 MGD) assuming that the current drought extends for another three years. The City's share of this supply is 3.0 MGD. This strategy considers several elements designed to protect the City's ability to divert an annual average of 10 MGD from the reservoir as long as possible. These elements include:

- Changing the operation of Lake Kemp to prevent excessive use during drought.
- Obtaining additional supplies from the reservoir from other users as existing contracts expire or through direct purchase.
- Implementation of irrigation conservation measures (this portion of the strategy may impact Wichita River supplies if that strategy is also implemented).

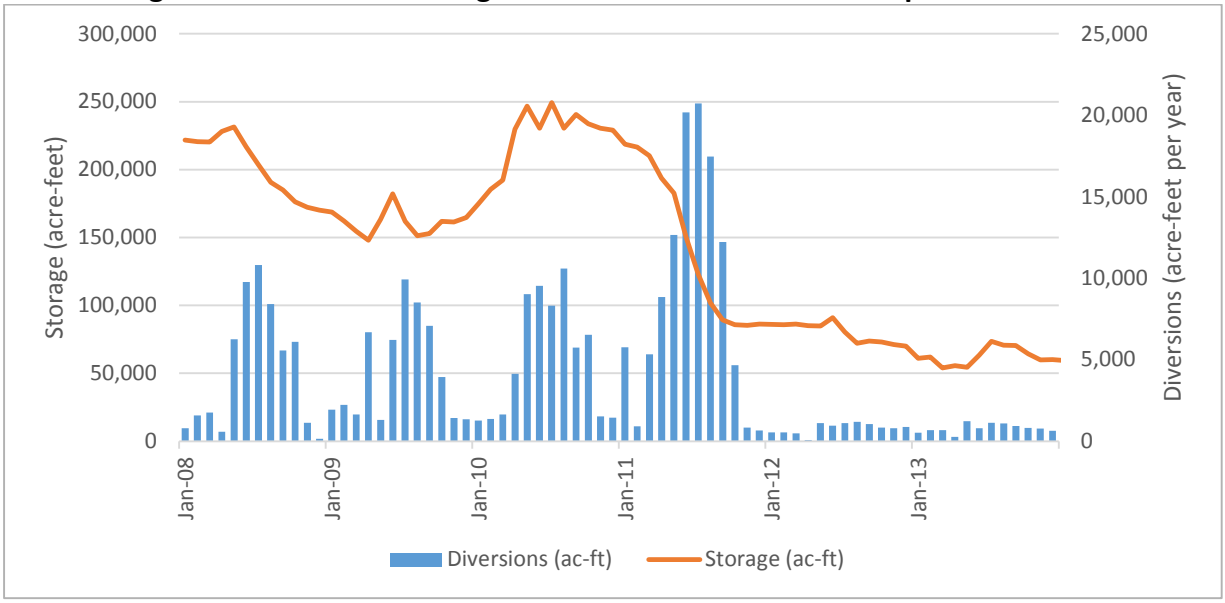
The strategy could include a water right amendment for use type and/or diversion location but this may not be necessary since Wichita Falls has more authorized diversion than the ultimate capacity of the Cypress WTP.

Table 5-4: Lake Kemp Water Rights

Type of Use	Authorized Diversion (acre-feet per year)	Annual Average (MGD)	% of Total
Municipal	25,150	22.4	13.0%
Industrial	40,000	35.7	20.7%
Mining	2,000	1.8	1.0%
Recreation	5,850	5.2	3.0%
Irrigation	120,000	107.0	62.2%
Total	*193,000*	*172.2*	*100.0%*

Figure 5-2 shows the historical storage and diversion from Lake Kemp from 2008 to 2013. Note that in 2011 peak season diversions from Lake Kemp were almost twice as high as the diversions from 2008 to 2010. Most of these diversions were for irrigation use. The 2011 diversions coincided with the lowest inflows into the reservoir in the historical record, accompanied by very high temperatures and evaporation rates. If less water had been used from the reservoir during this extreme drought period there would have been more water left in the reservoir for 2012 and later years. A key part of this strategy would be determining operating procedures that would help protect supplies from the reservoirs for all users by reducing demand from the reservoir during periods of drought.

Figure 5.2: Historical Storage and Diversion from Lake Kemp 2008 to 2013



Water Quantity, Quality, and Reliability

The quantity varies considerably depending on the amount the City is able to negotiate and purchase from other users and the type of operation agreed on by the reservoir users. The amount is also dependent on the capacity to treat this water using reverse osmosis. The current treatment plant has a 10 MGD capacity with the space at the existing facility to expand to 20 MGD total capacity. In order to cost this alternative it was assumed Wichita Falls would expand the current treatment plant to 20 MGD.

Water from Lake Kemp has high TDS and is currently treated with reverse osmosis at the Cypress WTP. The quality of the Lake Kemp water varies, with increased TDS as the reservoir storage decreases.

The recent drought significantly impacted the supply of all users of water from Lake Kemp. A significant part of this strategy is negotiating operating criteria for the reservoir that protects supplies as long as possible during extreme drought.

Regulatory Requirements

This strategy may include amending the Lake Kemp water right from specific uses to multipurpose. This would allow the City to purchase the water rights from other users if desired. There may be other regulatory requirements included with the expansion of the water treatment plant and for discharge/disposal of the reject water.

Impacts

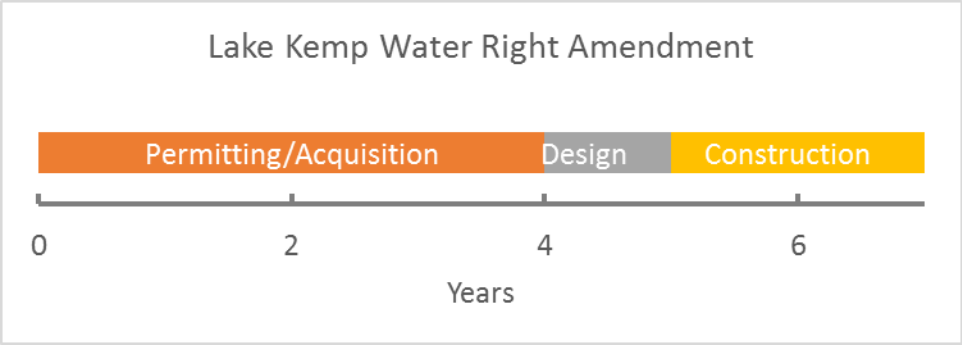
The water is already being used for other purposes and thus would have minimal environmental impacts on Lake Kemp or on stream flows. The discharge/disposal of the reject water could have an impact on the receiving stream by doubling the discharge amount. Depending on which users Wichita Falls is able to negotiate with there could be impacts to agricultural users. Implementation of this strategy may impact other strategies that rely on downstream diversions from the Wichita River.

Potential Cost

The potential cost includes a 10 MGD expansion of the water treatment plant along with purchasing the water rights from other users. As shown in the detailed cost estimate the total capital cost is $42,150,000 with an average annual cost of $2.51 per thousand gallons prior to debt service and $1.84 per thousand gallons after debt service.

Time to Implement

It is estimated that negotiating with other water users, developing an operation plan and possibly amending the current Lake Kemp water right could take up to four years. As previously discussed, to secure 10 MGD on a reliable basis, amending the water right may not be necessary. It is estimated that design and construction to expand the water treatment plant could require three years of additional time.



Development Obstacles

The primary development obstacle is negotiating with existing users to purchase their water rights or change the operation of Lake Kemp. Another possibility is to reach agreements with property owners to pay for more efficient irrigation equipment in exchange for a transfer of the remaining supply to Wichita Falls. This model has worked well for the Lower Colorado River Authority and the San Antonio Water System.

Supply Independence and Competition for Water

Lake Kemp does not provide significant supply independence since it is in the adjacent watershed as Wichita Falls other supplies and is currently a water supply. Actions under this strategy may impact other strategies that rely on downstream diversions from the Wichita River.

Unless Wichita Falls is able to purchase all the supply there will still be some competition from other users. The management practices of these users could have a significant impact on the available water in Lake Kemp and potentially the water quality. As opportunities arise, Wichita Falls should look for opportunities to coordinate operations of Lake Kemp with other users.

5.4 SUMMARY OF STRATEGIES

The twelve strategies identified in this section were presented at a workshop with the City of Wichita Falls. This section provides a comparison of the strategies included in Table 5-5.

Table 5-5: Summary Strategy Costs

Strategy	Strategy Amount (MGD)	Annual Cost before amortization	Annual Cost after amortization	Cost per 1,000 Gallons before amortization	Cost per 1,000 Gallons after amortization
Indirect Reuse	10.0	$6,950,000	$4,260,000	$1.90	$1.17
Water Conservation	2.0	$60,000	-$310,000	$0.08	-$0.44
GW HFSJ	2.0	$3,390,000	$1,860,000	$4.64	$2.55
Wichita River	2.0	$1,700,000	$930,000	$2.33	$1.27
Conjunctive Use	4.0	$6,410,000	$3,590,000	$4.39	$2.46
Ringgold	16.9	$27,420,000	$10,190,000	$4.45	$1.65
GW Wilbarger Co	5.0	$11,910,000	$5,690,000	$6.53	$3.12
GW Roberts & Lipscomb Co	24.0	$86,950,000	$32,890,000	$9.93	$3.75
GW Donley & Gray Co	15.0	$59,310,000	$22,970,000	$10.83	$4.20
GW Denton Co	15.0	$37,640,000	$16,120,000	$6.87	$2.94
Texoma	15.0	$41,920,000	$18,720,000	$7.66	$3.42
Bridgeport	15.0	$27,730,000	$14,130,000	$5.06	$2.58
Kemp	10.0	$9,160,000	$6,720,000	$2.51	$1.84

For comparison purposes the strategies were sorted by unit cost before amortization (with debt service) and after amortization (after debt service). Figure 5-3 and Figure 5-4 shows the cost per thousand gallons sorted from lowest to highest. The comparison show that the short term strategies tend to have lower unit costs due to the close proximity to Wichita Falls. The comparison also shows that both indirect reuse and water conservation have limited liabilities with the lowest cost after debt service and should be implemented by Wichita Falls.

Figure 5.3: Unit Costs for Strategies with Debt Service

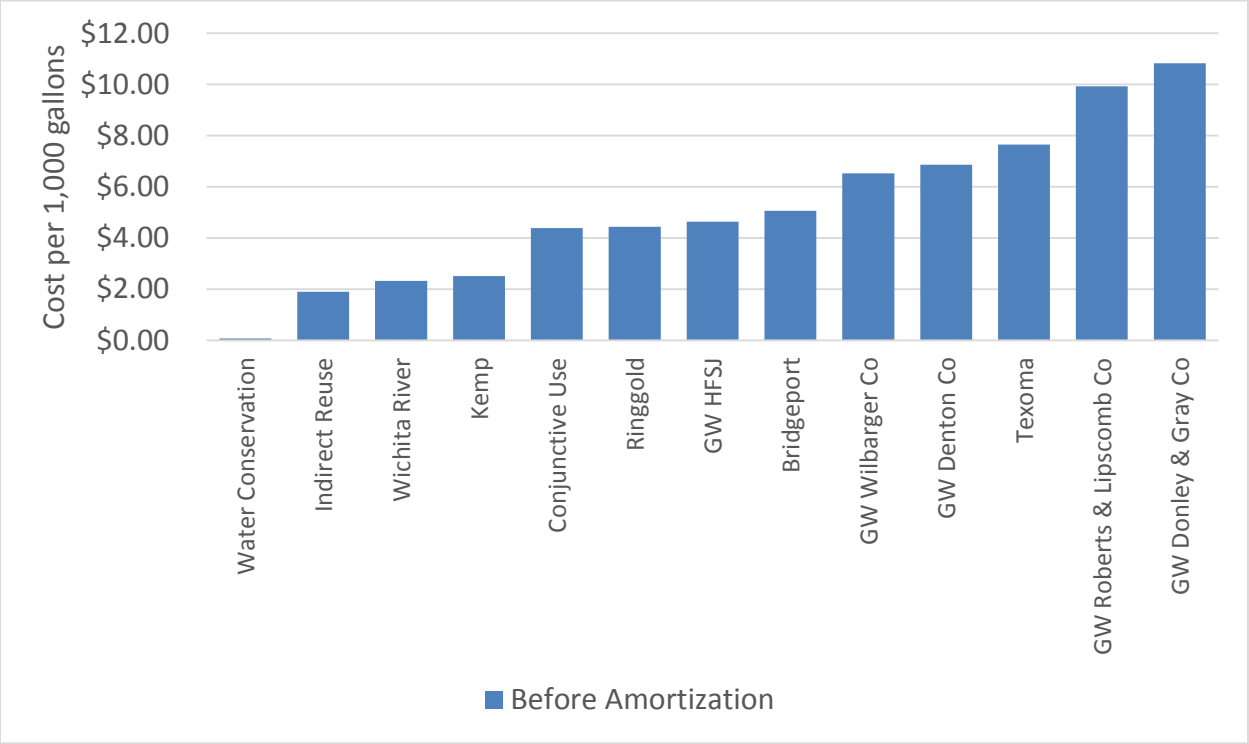
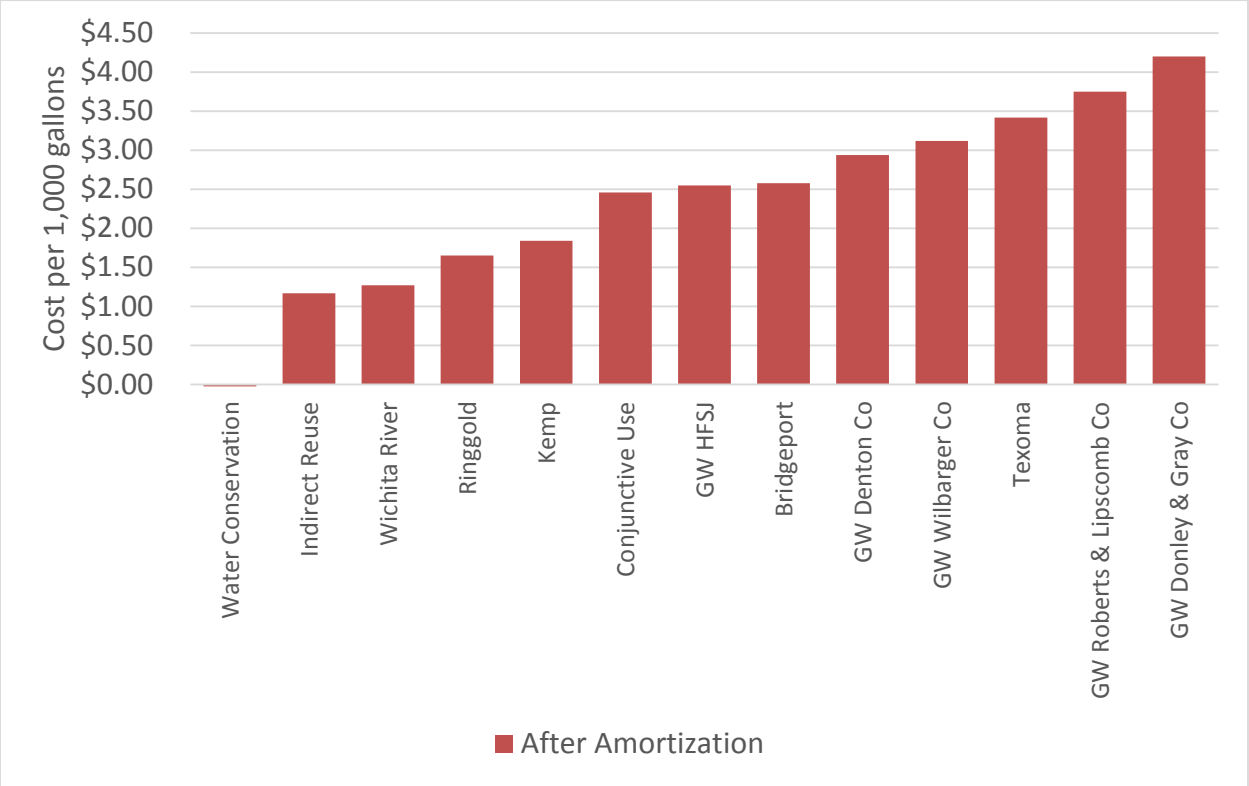


Figure 5.4: Unit Costs for Strategies after Debt Service



6.0 WATER SUPPLY SCENARIOS

Based on the strategy evaluations and consultation with City staff, the strategies that provide the greatest potential for reliable water supply to Wichita Falls include water conservation, indirect reuse, Lake Ringgold, Lake Texoma and one of the Panhandle groundwater strategies. Short term strategies that could provide supplies in the near-term until a long-term strategy could be implemented include Groundwater from Wichita County (HFSJ), Wichita River diversions and/or Conjunctive Use of these two strategies. The City also requested further consideration of Groundwater from Wilbarger County as a potential short-term supply and a potential interconnection with Tarrant Regional Water District through Lake Bridgeport.

To better assess the potential direction for water supply development, four scenarios were developed to meet Wichita Falls' water needs. Since the City is moving forward with its water conservation program and indirect reuse project, and both ranked very highly, all scenarios include both conservation and indirect reuse. Each scenario considered the quantity of water that could be developed, the timing of when the supply would be online and cost to the City and rate payers.

6.1 DESCRIPTION OF SCENARIOS

Scenario 1 – HFSJ groundwater, Wichita River and Lake Ringgold. Scenario 1 assumes the City will develop local water supplies to help meet short term demands, and then develop Lake Ringgold for long-term supplies. The HFSJ groundwater project can be implemented fairly quickly while the necessary permits are being obtained for the Wichita River supplies and Lake Ringgold. Once the permits are obtained for the Wichita River supplies, construction of this strategy could be completed within a year. Now that the drought has abated, the City may delay constructing the short-term supplies until they are needed.

Scenario 2 –HFSJ groundwater, Lake Bridgeport, Lake Ringgold. Scenario 2 provides a water supply plan that connects the Tarrant Regional Water District (TRWD) system with Wichita Falls to help mitigate impacts associated with drought and provide needed supplies to the TRWD's northwest system. The local groundwater supplies would be used to meet short-term needs while the permitting and construction of the Lake Bridgeport project were being implemented. Lake Ringgold provides a long-term reliable supply to both Wichita Falls and TRWD.

Scenario 3 – Wilbarger groundwater, Lake Texoma. Scenario 3 combines two strategies with minimal regulatory requirements so there is less uncertainty with the time to implement. There is no groundwater conservation district in Wilbarger County, therefore, groundwater from this county does not require a groundwater permit and there are no restrictions associated with Desired Future Conditions. Surface water from Lake Texoma is in the Red River basin, and no interbasin transfer is needed. The water would be purchased from willing sellers that have surplus supplies. For this scenario, it is assumed that the water from Texoma is delivered to the Cypress WTP for treatment and blending with the City's other sources.

Scenario 4 – Conjunctive Use, Donley County groundwater. Scenario 4 provides future supplies that are independent of the City's current sources and are less subject to drought conditions. This scenario utilizes the conjunctive use strategy for short-term water needs and develops groundwater from the Ogallala Aquifer in Donley and Gray Counties for long-term supplies. Donley and Gray Counties groundwater was chosen due to the shorter distance for infrastructure and the lower capital costs which would allow Wichita Falls to develop this strategy alone. If potential partners could be identified the Roberts and Lipscomb Counties groundwater could become a lower cost option.

6.1.1 Supply Amount

The supplies for each scenario by source is shown on Table 6-1. Each scenario is developed to meet the City's long-term water supply need of 19.3 MGD with sufficient supplies for future customers. Due to the timing of the short term strategies, Scenario 3 has limited new supplies until Year 2020. This is because it is estimated that the Wilbarger groundwater supplies will take approximately 5 years to develop.

The supply amounts shown in Table 6-1 are based on the strategy volumes developed in Chapter 5. The indirect reuse supply is shown as 8 MGD in its first decade of operation because recent discharges to the River Road WWTP after drought restrictions has averaged this amount. It is assumed that increased water demands will increase the supply amount to 9 MGD by 2030, up to 10 MGD in 2040. The HFSJ groundwater strategy is assumed to be implemented in phases with Phase 1 consisting of 25 wells for a total average production of 1 MGD. Phase 2 would develop another 25 wells for an additional 1 MGD. If during Phase 1 the water supply is shown not to be reliable, then Phase 2 may not be implemented.

Generally, the short-term strategies are assumed to be used only until the long-term strategies can be implemented. These strategies, specifically the local strategies, could continue to be used during periods of drought or to meet peaking demands. Figure 6-1 shows the supplies over time for each strategy and the City's projected shortages.

Figure 6.1: Need versus Strategy Supply

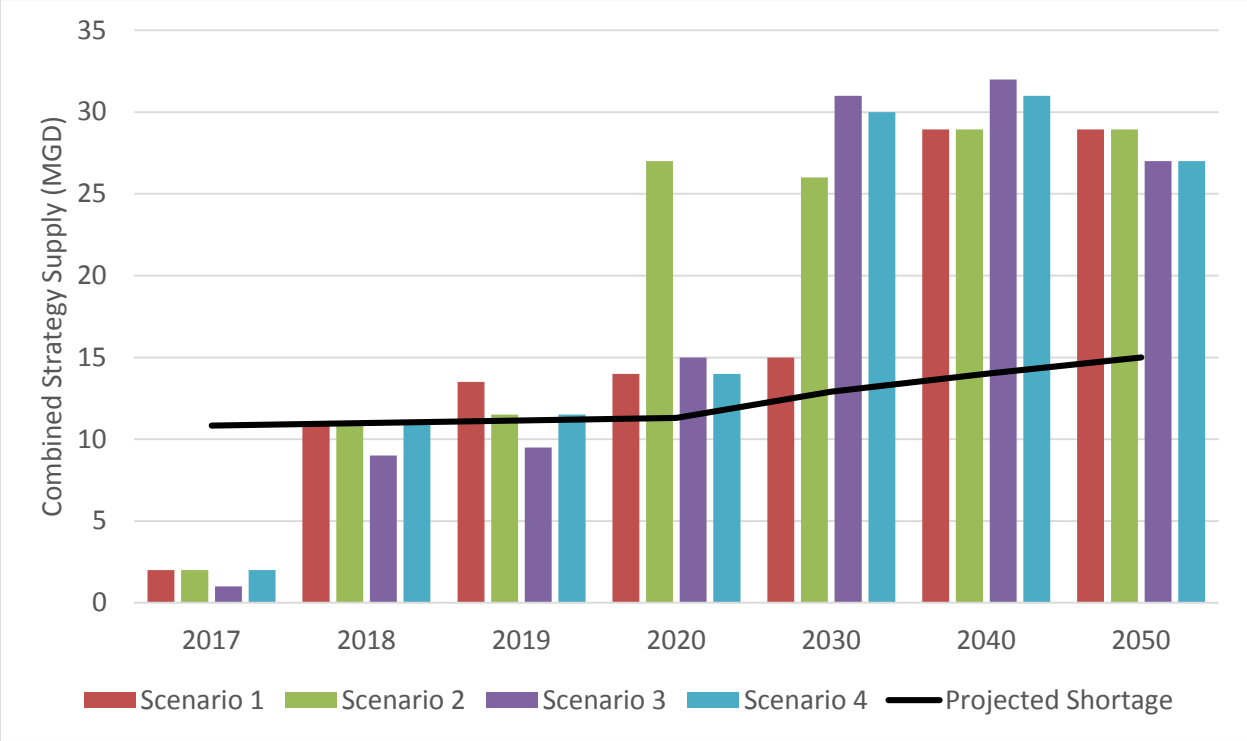


Table 6-1: Summary of Supplies by Strategy for Each Water Supply Scenario

Year	Supply from Potential Scenarios (MGD)										
	Conservation	Indirect Reuse	HFSJ GW	Wichita River	Conjunctive use	Wilbarger GW	Texoma	Bridgeport	Ringgold	Donley GW	TOTAL
Scenario 1											
2017	1		1								2
2018	1	8	2								11
2019	1.5	8	2	2							13.5
2020	2	8	2	2							14
2030	2	9	2	2							15
2040	2	10							16.9		28.9
2050	2	10							16.9		28.9
Scenario 2											
2017	1		1								2
2018	1	8	2								11
2019	1.5	8	2								11.5
2020	2	8	2					15			27
2030	2	9						15			26
2040	2	10							16.9		28.9
2050	2	10							16.9		28.9
Scenario 3											
2017	1										1
2018	1	8									9
2019	1.5	8									9.5
2020	2	8				5					15
2030	2	9				5	15				31
2040	2	10				5	15				32
2050	2	10					15				27

Year	Supply from Potential Scenarios (MGD)										
	Conservation	Indirect Reuse	HFSJ GW	Wichita River	Conjunctive use	Wilbarger GW	Texoma	Bridgeport	Ringgold	Donley GW	TOTAL
Scenario 4											
2017	1				1						2
2018	1	8			2						11
2019	1.5	8			2						11.5
2020	2	8			4						14
2030	2	9			4					15	30
2040	2	10			4					15	31
2050	2	10								15	27

6.1.2 Costs

The costs for the scenarios are based on the costs developed for each strategy. Unit costs were estimated, using the quantity of water provided by the scenario in a given year, and the sum of the annual cost for each strategy for the scenario in the given year. For all of the short term strategies the debt service was assumed to be paid over twenty years, while the long term strategies were assumed to be paid over thirty years. Table 6-2 shows the total capital cost for each scenario and the minimum, average and maximum unit cost. Figure 6-2 shows the annual cost for each scenario by decade and Figure 6-3 shows the unit cost for each scenario by decade.

Table 6-2: Scenario Summary Table

Scenario	Components	Total Capital Costs	Unit Cost in $ per 1,000 gallons		
			Minimum	Average	Maximum
1	HFSJ, Wichita River, Lake Ringgold	$364,194,000	$1.76	$3.14	$5.64
2	HFSJ, Lake Bridgeport, Lake Ringgold	$588,984,000	$2.66	$4.27	$6.24
3	Wilbarger, Lake Texoma	$543,810,000	$2.17	$3.90	$5.71
4	Conjunctive Use, Donley County	$701,790,000	$2.66	$4.60	$7.36

Figure 6.2: Annual Costs for Scenarios by Decade

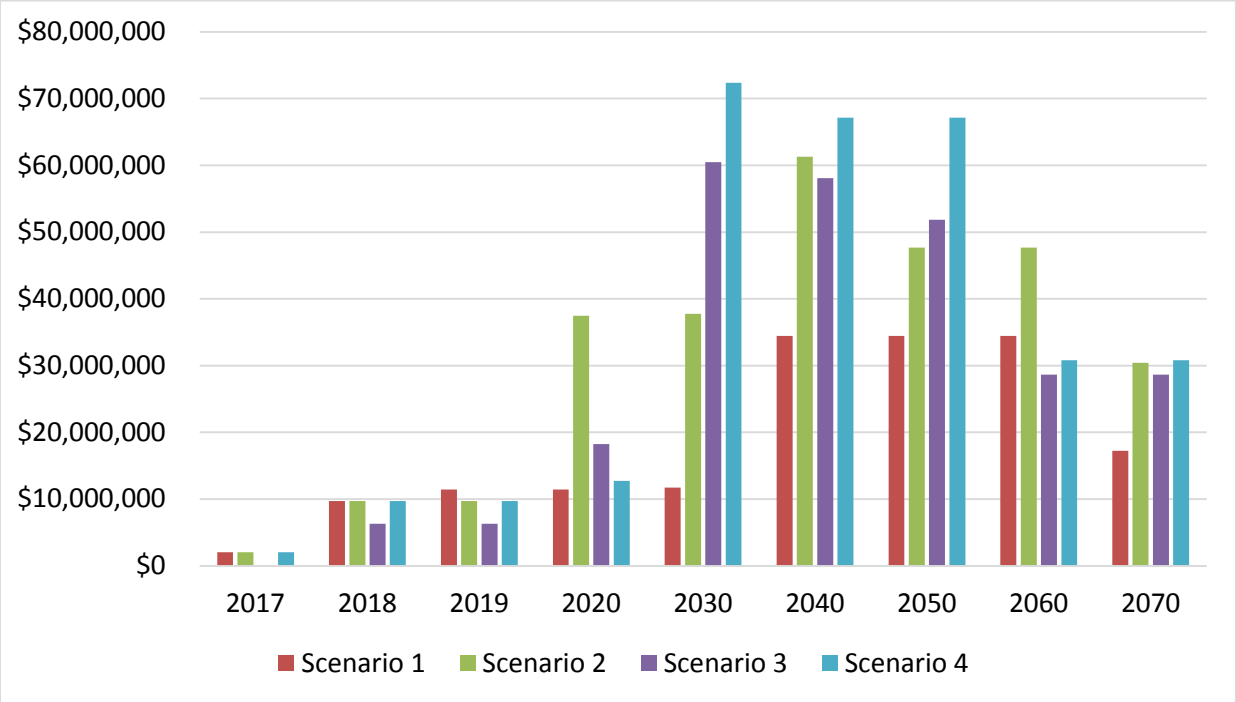
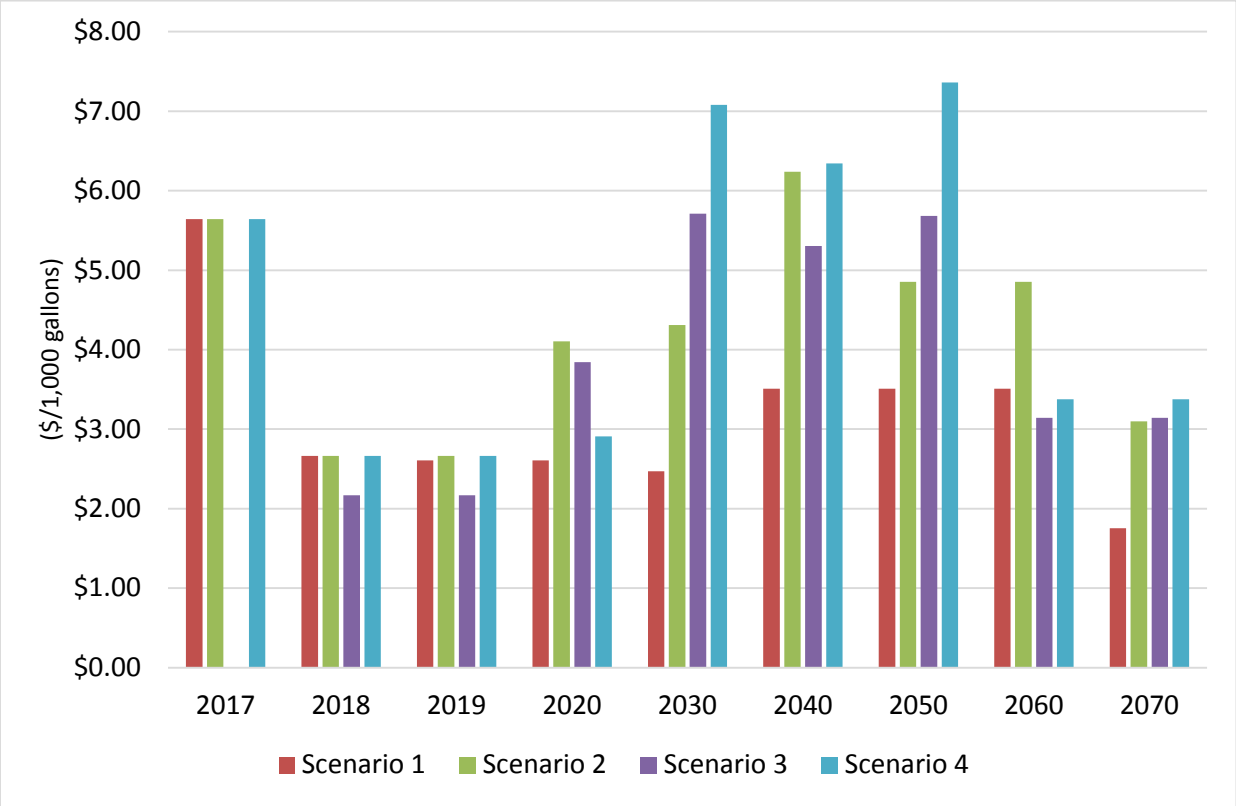


Figure 6.3: Unit Costs for Scenarios by Decade



6.2 COMPARISON OF SCENARIOS

6.2.1 Reliability Comparison

By 2020, all four scenarios can provide sufficient supplies to Wichita Falls to meet its projected water needs, and by 2040 all four scenarios can provide supplies above the City's needs. Due to the timing and quantities of the short-term strategies, the City shows a need through at least 2017. Only Scenario 1 can meet the City's need by 2017. This is because it is assumed that the Wichita River strategy can be implemented sooner as a stand along strategy than the conjunctive use strategy, which is included in Scenario 4. That is because the conjunctive use strategy requires additional infrastructure and new treatment capacity at the Jasper WTP. The short-term strategies for the other scenarios require longer implementation times. For all of the short-term strategies there are some uncertainties with the reliability of the supplies during drought. The indirect reuse project provides the highest certainty of reliable supply. However, if the water levels in Lake Arrowhead fall to below 5 percent capacity, the ability to use this supply may be compromised.

Scenario 2 shows the greatest amount of available supply in 2020, which may be important if the drought were to continue much beyond 2016. This supply is associated with the connection to Lake Bridgeport. Currently, contracts for water supply from TRWD limit deliveries if the combined capacity in the West Fork system (Bridgeport and Eagle Mountain) fall below 50 percent. This constraint may significantly impact the ability to use this supply, especially if both Wichita Falls' lakes and Lake Bridgeport are in drought conditions at the same time. For this strategy to be viable, TRWD must be willing to provide water to Wichita Falls during drought. It is unlikely that this will happen unless additional supplies are made available in Lake Bridgeport. This could possibly be accomplished through an interconnection between TRWD's other lakes and Bridgeport, but it is uncertain whether TRWD is considering such a connection and whether it would need to be implemented prior to this strategy.

Both Scenarios 1 and 2 rely on Lake Ringgold for long-term supplies. This lake is located in the same watershed as Lakes Kickapoo and Arrowhead, which witnessed new drought of record conditions. This plan addresses the uncertainty of the water supplies from Lake Ringgold by assuming a safe yield analysis reserving a year's supply at the end of the recent drought.

Scenarios 3 and 4 likely have the most reliable long-term supplies of the four scenarios. There is some uncertainty with the conjunctive use supply in Scenario 4 and groundwater in Wilbarger County (Scenario 3), but all short-term supplies have similar uncertainties. The Lake Texoma water supplies in Scenario 3 can easily provide the 15 MGD identified for this project. There is some competition for this water from Texas water right holders but Oklahoma is using very little of the water today. The lake is also used for hydropower, which may compete with other users. Due to the size of the lake and total yield of Lake Texoma, this strategy would be very reliable. The uncertainties are associated with the ability to secure a long-term contract for the water.

Scenario 4 utilizes groundwater from Donley and/or Gray Counties. The Ogallala aquifer has substantial supplies that are less subject to drought conditions than surface water supplies. However, the Ogallala has little to no recharge, which means that once the water is extracted from the ground it is not replenished. The key to reliable supplies from this strategy is to obtain water rights with sufficient saturated thickness in an area that is not heavily irrigated. During droughts local users will place additional demands on the aquifer which can impact nearby water supplies. The Ogallala

formation begins to thin out in Donley County. Therefore, this strategy may need to extend into Gray County where the saturated thickness tends to be greater. If the City obtains sufficient water rights, this strategy has good long-term reliability.

6.2.2 Costs Comparison

The costs for the different scenarios are shown in Section 6.1.2. The lowest long-term costs are associated with Scenario 1, where with the construction of Lake Ringgold, annual costs total approximately $35 million. This corresponds to a unit cost of $3.51 per 1,000 gallons of treated water supply. The scenario with the highest cost is Scenario 4. By 2030, the annual cost totals $72 million. This decreases slightly over the next decades as debt service for the conjunctive use strategy is paid. The annual costs for Scenarios 2 and 3 are also significantly higher than Scenario 1, at costs of about $60 million each. The costs for Scenario 2 assumes that Wichita Falls would be developing the infrastructure for the Lake Bridgeport connection and Lake Ringgold. This scenario could be developed as a joint project with TRWD, where TRWD would be able to use water from Lake Ringgold during times when Wichita Falls does not need the water. Also, the pipeline between Lakes Bridgeport and Arrowhead could be used to move water in either direction. If a joint project is pursued, then it is likely that TRWD would participate in the construction of these facilities and the total cost to Wichita Falls would be less.

6.2.3 Regulatory and Development Obstacles

Scenario 3 (Wilbarger groundwater and Lake Texoma) has the fewest current regulatory requirements as previously described in the strategy descriptions and few development obstacles. There are some potential future considerations. If Wilbarger County authorizes the creation of a groundwater conservation district, the supplies from this scenario may be impacted. This is because the competition for groundwater is high in Wilbarger County and the existing use is in excess of the modeled available groundwater values. A new GCD could limit the amount of supply pumped and exported from the county. The purchase of water from Lake Texoma would not require new water rights. It would require a contract with a willing seller. Also due to the presence of zebra mussels in the lake, the City may need to take extra precautions along the transmission pipeline to not release zebra mussels to other water sources. The zebra mussels may also create maintenance issues along the transmission system and at the water treatment plant.

Scenario 2 has the greatest number of regulatory requirements and development obstacles. Both the Lake Bridgeport connection and Lake Ringgold would require new state water rights. Lake Bridgeport connection would require an interbasin transfer and a bed and banks permit to transport the water through Lake Arrowhead. Lake Ringgold would require a water right for the storage and diversion of State water. This strategy would also require a Section 404 permit to construct the dam, which would likely include the development of an Environmental Impact Statement. These permitting processes take time and can be challenged, which could further delay the issuance of the permits. Also, as previously discussed, one of the biggest developmental challenges with Scenario 2 is the ability to use water from Lake Bridgeport during drought. If this obstacle is not adequately addressed, then this scenario is not feasible.

As with Scenario 2, the development of Lake Ringgold for Scenario 1 will have significant permitting requirements. The timing of this strategy is shown to provide a reasonable estimate for this process but it could take longer. One component that would need to be addressed is adequate mitigation for the impacts associated with the reservoir. If mitigation is identified early in the process, the permitting could possibly move more quickly. There are similar permitting issues for the Wichita River supply for Scenario 2. This short-term strategy will require a permit amendment, Section 404 permit and possibly mitigation for impacts, if any are identified. The time for permitting would be considerably less for the Wichita River supply than Lake Ringgold, but there is some uncertainty with the ability to move the process very quickly.

Scenario 4 has similar regulatory issues for the conjunctive use project as the Wichita River supply in Scenario 1, but the conjunctive use project also will require a new wastewater discharge permit for the new reverse osmosis treatment facility at the Jasper WTP. The Wichita River supply in Scenario 1 assumes this water is treated at the Cypress WTP and the waste is discharged under the plant's existing wastewater permit. The groundwater development component of Scenario 4 will require identification of potential water rights for purchase and a permit from the Panhandle GCD. It may take some time to acquire the water rights and conduct appropriate studies, but this could likely take less time than the development of a new reservoir that is included in Scenarios 1 and 2.

6.2.4 Summary

All four strategies can meet the City's long-term water needs. Scenario 2 has a fatal flaw with the Lake Bridgeport supply unless Wichita Falls and TRWD can reach an agreement to allow the City to use water from Bridgeport during drought conditions. Scenario 1 has the lowest cost over time and focuses on water supply development from sources nearest to Wichita Falls. Scenarios 1, 2 and 4 have reliability concerns if a drought worse than the recent drought were to occur. Each of these scenarios rely on the local groundwater and/or Wichita River to provide water until the long-term strategy can be implemented. There is considerable uncertainty of the available supplies from these sources during drought. Conservation and indirect reuse will provide sufficient water to meet the City's short-term needs, but it may fall short of providing a safety factor. Scenarios 3 and 4 have fewer development concerns but are more costly than the other scenarios due to the distance from the City. This also creates maintenance concerns for the distant infrastructure and long transmission systems.

7.0 SUMMARY OF FINDINGS

This Long Range Water Supply Plan includes a compilation of many studies, analyses, conversations and evaluations that have been performed for the City of Wichita Falls during the ongoing drought. The report provides a consolidated document that systematically evaluates the water needs for Wichita Falls and provides data necessary for the City to make decisions regarding securing water supplies for the future. This section provides a brief overview of the findings of these analyses.

A critical aspect of this study is the amount of existing supply that Wichita Falls can rely on for future water needs. Wichita Falls' existing water supplies were greatly impacted during the recent drought. To address this, the supplies were evaluated using a range of modeling techniques including traditional yield modeling, conditional reliability modeling, and modeling leaving a 20 percent reserve. Each of these evaluations provided information to the City to better understand the impacts to its water supplies. With City staff input, it was decided to use the calculated safe supplies assuming a 20 percent reserve. (Note: This assumes there is at least 20 percent of the reservoir capacity remaining in the lake at the end of the critical drought.) The recent drought significantly reduced previous estimates of water supplies from the City's lakes, but it is greater than the amount the City was using under drought restrictions. Now that the drought is over, the expected reliable supply from Wichita Falls' current sources is 18.5 MGD in 2020 decreasing to approximately 11.9 MGD in 2070 due to sedimentation.

The demands for Wichita Falls and its customers were based on the regional water planning estimates, review of contractual obligations, and potential future customers. To account for potential uncertainties in these projections, a safety factor of 1.2 was applied to the City of Wichita Falls' demands and direct customers that do not have contract limits (such as the City of Holliday). These demands are shown to remain fairly steady over the planning horizon at about 30 MGD.

The comparison of the supply and the demand shows an immediate need of 11.3 MGD in 2020 increasing to approximately 19.3 MGD in 2070. It is difficult to fully meet this immediate need in the short term. Strategies that could be implemented within the next four years had limited supply quantities and several had concerns about the reliability of the sources during drought. As due diligence, the City initially considered 22 sources of additional supply. From this list, twelve strategies were selected for further evaluation.

The twelve selected strategies that were broken into two categories, short-term strategies and long-term strategies. The short-term strategies were strategies which could be implemented within two to four years including indirect reuse, water conservation, local groundwater (HFSJ), Wichita River supplies, and a conjunctive use project of local groundwater and Wichita River supplies. The remaining eight strategies were evaluated as long-term strategies. The detailed analysis was presented at a workshop with City staff for input.

The two short-term strategies that were found to be most favorable are the indirect reuse project and conservation. Both of these strategies are cost effective and are generally reliable. Indirect reuse can provide the greatest amount of supply within the shortest timeframe. The other short-term strategies can only provide between 1 to 5 MGD. The challenge with these strategies is that the indirect reuse project relies on water from the City's existing lakes to be able to be reused. If the severity of the drought were to continue, the amount of supply from indirect reuse could be less. However, to provide new water in the near-term, the quantity and quality is limited. The most promising near-term strategies, other than indirect reuse and conservation, include groundwater from Wichita County (HFSJ), Wichita River diversions and/or Conjunctive Use of these two strategies. Each of these strategies could provide supplies until a long-term strategy could be implemented. However, there are concerns about the reliability of these sources during drought. Also, it still could take several years to implement these strategies.

The long-term strategies that were determined to have the greatest potential for implementation include Lake Ringgold, Lake Texoma and one of the Panhandle groundwater strategies. The City also requested further consideration of groundwater from Wilbarger County as a potential mid-term supply and a potential interconnection with Tarrant Regional Water District through Lake Bridgeport. Lake Ringgold is the most cost effective of these strategies, but could be susceptible to future droughts worse than the recent drought. Both the Lake Texoma strategy and Panhandle groundwater strategy require very long transmission systems which result in high capital costs.

To better assess the potential direction for water supply development, four scenarios were developed to meet Wichita Falls' water needs. Since the City is moving forward with its water conservation program and indirect reuse project, which both were ranked very highly, all scenarios include both conservation and indirect reuse. Each scenario considered the quantity of water that

could be developed, the timing of when the supply would be online and cost to the City and rate payers. Each scenario has beneficial aspects and potential drawbacks which are discussed briefly.

- Scenario 1 – HFSJ groundwater, Wichita River and Lake Ringgold. Scenario 1 is the lowest cost scenario with both short and long-term supplies in close proximity to Wichita Falls. The potential drawbacks are the uncertainty, small quantities and unproven reliability of short-term supplies, and limiting supply independence to the Little Wichita and Wichita River watersheds. This scenario has the longest time before a long-term strategy can be developed.

- Scenario 2 – HFSJ groundwater, Lake Bridgeport, Lake Ringgold. Scenario 2 provides a potential interconnection with TRWD which could in the long-term provide increased reliability and cost sharing for Lake Ringgold. However, at this time without an acceptable agreement with TRWD this scenario is not feasible.

- Scenario 3 – Wilbarger groundwater, Lake Texoma. Scenario 3 is the scenario that could be developed with the least amount of permitting and within the shortest time frame for a long term supply. The potential drawbacks include the high capital costs, treatment of Lake Texoma water, Zebra mussels and competition for groundwater in Wilbarger County.

- Scenario 4 – Conjunctive Use, Donley County groundwater. Scenario 4 provides the greatest independence from current supplies by providing a groundwater supply which is not as susceptible to drought conditions. The drawbacks of this scenario include the high cost, uncertainty in obtaining water rights, and potential maintenance of a well field and transmission system far from Wichita Falls.

Each of the scenarios can meet Wichita Falls projected shortage by 2020 while providing options for the City to pursue. All of the short-term strategies have uncertainties regarding the reliability of the supplies during drought. Assuming the City has sufficient lake water to utilize the reuse supplies, each of these scenarios will be able to meet the City's projected demands, but may not provide the 20 percent safety factor included in the needs analysis if worse drought occurs.

8.0 RECOMMENDATIONS

The following are recommendations for Wichita Falls to move forward with securing additional water supplies. These recommendations include new supply development, additional recommendations related to system operations, and other miscellaneous items.

- It is recommended that the City pursue Scenario 1 (Indirect Reuse, Conservation, Local Groundwater, Wichita River and Lake Ringgold). This scenario will have the least impact to rate payers while providing supplies to meet the projected needs.

- Prior to constructing the Local Groundwater and Wichita River short-term strategies associated with Scenario 1, the City should weigh the risk factors of its existing sources against the options and costs for these new supplies. If the City choses to pursue local groundwater, the City should conduct independent water quantity and quality testing of potential well field sites. Development of the Indirect Reuse project and advanced Conservation should be pursued for short-term needs.

- Wichita Falls should continue to monitor flows in the Wichita River to assess whether reduced flows in 2012-2014 were due to reductions in irrigation water use or possibly other reasons. This monitoring should occur during the permitting and/or acquisition phase of the project, and the City should reassess the supplies associated with this strategy prior to major financial commitments.

- It is recommended that Wichita Falls initiate relevant water right amendments and applications for Scenario 1 in early 2015 since one of the limiting factors in the schedule is the time for permitting. This includes preparing a water right application for Lake Ringgold and preparing a water right amendment to CA5123 to allow diversions from the Wichita River for municipal use.

- It is recommended that the City initiate field studies for the water right application for submittal with the application. It is recommended that the Section 404 application be prepared and submitted to the USACE following the water right permitting process.

- Wichita Falls should review their current contracts with customers including the rate structure to ensure adequate funding for future infrastructure. Also, some of their current contracts allow customers to reserve large supply amounts while only charging for their actual use. This commits the City to develop supplies to meet these contracts, yet the funding by customers may be considerably less. Other suppliers address this issue through take or pay contracts or contracts with a reservation fee. Wichita Falls should work with a financial rate firm to develop an appropriate rate structure for wholesale customers.

- During the Long Range Water Supply Plan an analysis was conducted looking at lake operations during the recent drought. Based on this analysis some of the operations for Lake Kemp during 2011 may have exacerbated the drought. Wichita Falls should seek to cooperate with the irrigation district to develop an operating plan for Lake Kemp.

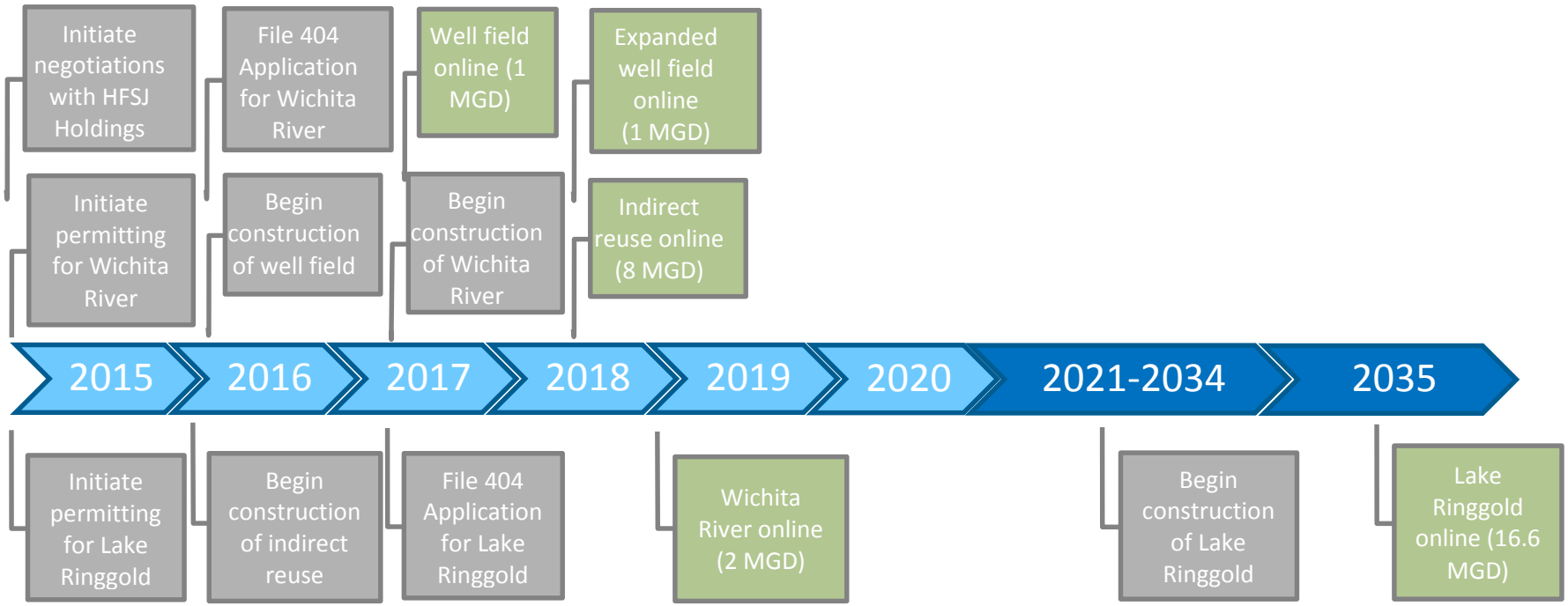
- As opportunities arise Wichita Falls may seek to purchase additional supplies from Lake Kemp. This would provide the City with a greater percentage of supplies in the Lake Kemp/Diversion system.

- Wichita Falls should continue discussions with TRWD to determine whether there is any possibility of reaching an agreement that beneficially interconnects the two entities.

- A separate study is currently underway to evaluate potential brackish water supplies for Wichita Falls and TRWD. This study is expected to be completed by the end of 2015. When the Brackish Water Report is completed Wichita Falls should determine if any of those options are feasible.

A timeline for Scenario 1 is provided on the following page. If the City cannot obtain the necessary permits or agreements, or drought conditions are worse than expected, Wichita Falls should consider an alternative scenario or alternative strategies identified in this Long Range Water Supply Plan.

Timeline for Recommended Scenario 1



APPENDIX A
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Appendix B
Strategy Screening

Indirect Reuse

Project Description

Wichita Falls is currently meeting approximately a third of their demand through Direct Potable Reuse (DPR) which is treating reuse and blending with water at the Water Treatment Plant. This project would be to reuse the existing DPR pipeline and discharge wastewater into Lake Arrowhead and then be pumped and treated at the Water Treatment Plant.

Potential Quantity (MGD)	8-10
Potential Capital Cost	$33,400,000
Capital Cost/MGD	$3,340,000

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	4	2	8	10 MGD capacity can meet a majority of the need. The indirect reuse project eliminates treatment losses associated with the DPR project.
Water Quality	4	1	4	Potential water quality impacts to Arrowhead.
Reliability	5	2	10	Supply should be available in most situations. May diminish over time as low flow plumbing fixtures reduce the amount to be treated.
Regulatory Requirements	4	1	4	A new water right to use the bed and banks would be needed. This will also require a TPDES permit for the outfall.
Environmental Impacts	4	1	4	Potential water quality impacts to receiving stream.
Potential Cost	5	5	25	Moderate cost include the additional transmission cost and the pipeline.
Time to Implement	4	1	4	The project would require some time to build the pipeline to Arrowhead and obtain the necessary permits.
Development Obstacles	4	1	4	Potential loss to evaporation, no treatment losses.
Supply Independence	4	1	4	Relies on other supplies for blending.
Competition for Water Supply	5	1	5	No competition from other users.
Composite Score			**72**	

Water Conservation

Project Description

Water Conservation/Efficiency has been a critical drought response strategy for the City of Wichita Falls. The City has been able to reduce its demand by 50% during the recent drought. While these measures were critical for demand management during the drought once the drought has ended certain water efficiency measures should be continued and additional measures could be implemented.

Potential Quantity (MGD)	0.1-1.2
Potential Capital Cost	$1,100-$109,00
Capital Cost/MGD	$12,000-$91,000

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	1	2	2	The recent drought measures have shown there is potential water efficiency to be gained in Wichita Falls, but the overall amount remains low.
Water Quality	5	1	5	No water quality impacts.
Reliability	4	2	8	The measures have proven to provide savings, but the adoption rate may decrease once the drought has subsided.
Regulatory Requirements	5	1	5	None
Environmental Impacts	5	1	5	None
Potential Cost	5	5	25	Low cost initially, but increased cost as programs become more involved.
Time to Implement	4	1	4	Most programs could be implemented within a year.
Development Obstacles	4	1	4	There may be some drought fatigue.
Supply Independence	4	1	4	Reduction in current supplies, it does not add any new supplies.
Competition for Water Supply	5	1	5	No competition from other users
Composite Score			**67**	

Direct Reuse

Project Description

Wichita Falls is currently meeting approximately a third of their demand through Direct Potable Reuse (DPR) which is treating reuse and blending with water at the Water Treatment Plant. This project could become permanent if the TCEQ would approve the process on a permanent basis. This would require the expansion of the RO treatment plant to recover the capacity lost from the DPR.

Potential Quantity (MGD)	5-8
Potential Capital Cost	$21,400,000
Capital Cost/MGD	$2,700,000

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	3	2	6	Current supply amount relative to demand 5-8 MGD capacity can meet a portion of the need.
Water Quality	4	1	4	Already have the treatment processes in place to control water quality.
Reliability	5	2	10	Supply should be available in most situations.
Regulatory Requirements	4	1	4	TCEQ would need to approve the DPR on a permanent basis.
Environmental Impacts	4	1	4	Minimal impact since the supply is already in use.
Potential Cost	3	5	15	The primary cost is the plant expansion to replace the lost capacity. A portion of the cost has already been spent in developing the temporary DPR project.
Time to Implement	4	1	4	The DPR is already in operation, the plant expansion would require additional time.
Development Obstacles	3	1	3	In order to keep the DPR on a permanent basis the plant capacity would need to be expanded to replace the lost capacity.
Supply Independence	5	1	5	This supply is independent of other supplies.
Competition for Water Supply	5	1	5	No competition from other users.
Composite Score			**60**	

Lake Ringgold Water

Project Description

Lake Ringgold is a proposed 16,000-acre reservoir site located in Clay County, Texas. The proposed dam would be located on the Little Wichita River, approximately 0.5 miles upstream of its confluence with the Red River, and would impound 275,000 acre-feet of water at the normal pool elevation of 844 feet-msl.

Potential Quantity (MGD)	25
Potential Capital Cost	$382,900,000
Capital Cost/MGD	$15,400,000

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	5	2	10	Recent modeling through June 2015 calculated a safe yield of 19,000 acre-feet.
Water Quality	5	1	5	Consistent with other sources in the basin.
Reliability	3	2	6	Recent drought conditions in the Little Wichita River Basin have potentially diminished the reliability and have reduced the yield.
Regulatory Requirements	2	1	2	Requires both a water right and 404 permit.
Environmental Impacts	3	1	3	Low wetland areas, Low impact to threatened and endangered species, low density of cultural resources.
Potential Cost	4	5	20	Relatively expensive capital cost, but low operating (transmission) cost.
Time to Implement	1	1	1	Approximately 10+ year with permitting and construction.
Development Obstacles	3	1	3	Some of the property has already been acquired and there is some opposition from local landowners.
Supply Independence	3	1	3	In the same watershed as other supplies.
Competition for Water Supply	5	1	5	Would need to provide a portion of the supply to Henrietta, but the yield assumes existing water right holders already have their supplies.
Composite Score			**58**	

Groundwater from HFSJ

Project Description
Potential groundwater supply available from a ranch northeast of Wichita Falls.

Potential Quantity (MGD)	5
Potential Capital Cost	$31,900,000
Capital Cost/MGD	$6,400,000

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	3	2	6	Seymour supplies are impacted by drought.
Water Quality	2	1	2	Potentially high nitrates.
Reliability	2	2	4	Highly uncertain.
Regulatory Requirements	4	1	4	None
Environmental Impacts	4	1	4	Low
Potential Cost	3	5	15	Moderate cost.
Time to Implement	4	1	4	Could be implemented quickly, requires further testing and study.
Development Obstacles	4	1	4	Agreements with land owner needed, appears to be a willing seller.
Supply Independence	4	1	4	Independent of current supplies but may be subject to similar climate conditions as current supplies.
Competition for Water Supply	3	1	3	Unknown
Composite Score			**50**	

Groundwater from Wilbarger County

Project Description

Purchase water rights from the Seymour Aquifer in Wilbarger County, drill wells and construct a pipeline to deliver groundwater to Wichita Falls. This project may be in conjunction with other suppliers to reduce the unit cost.

Potential Quantity (MGD)	15
Potential Capital Cost	$268,100,000
Capital Cost/MGD	$17,900,000

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	4	2	8	Seymour aquifer is impacted by drought. 15 MGD is about half of the total amount of reliable supply in the county.
Water Quality	2	1	2	Potential for high nitrates. May require advanced treatment or blend with existing supplies
Reliability	3	2	6	Uncertain. Some areas of the Seymour are more reliable than others. Recent drought resulted in reductions in capacity for many systems in Wilbarger County.
Regulatory Requirements	4	1	4	No GCD.
Environmental Impacts	4	1	4	Low impacts expected for pipeline project
Potential Cost	3	5	15	Moderate to high costs
Time to Implement	3	1	3	Moderate. Take time to locate and negotiate water rights purchase
Development Obstacles	3	1	3	Purchasing sufficient quantities of water rights. May have opposition from local water users.
Supply Independence	3	1	3	Independent but subject to same climate conditions as City's other supplies. If blending water, requires a certain quantity of other supplies.
Competition for Water Supply	1	1	1	High competition with other users, including irrigators and Vernon.
Composite Score			**49**	

Groundwater from Roberts County

Project Description

Purchase water rights for the Ogallala Aquifer in Roberts County, drill wells and construct a pipeline to deliver groundwater to Wichita Falls. This project may be in conjunction with other suppliers to reduce the unit cost.

Potential Quantity (MGD)	24
Potential Capital Cost	$973,000,000
Capital Cost/MGD	$40,500,000

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	5	2	10	There is plenty of water in Roberts County but it is nonrenewable. May be a limited supply.
Water Quality	5	1	5	Good water quality. Need to evaluate the compatibility with other existing supplies.
Reliability	4	2	8	Reliability is expected to be high but depends upon the competition for water supplies.
Regulatory Requirements	4	1	4	Requires a groundwater permit
Environmental Impacts	3	1	3	Moderate impacts associated with pipeline of this length.
Potential Cost	1	5	5	Very expensive
Time to Implement	1	1	1	Requires water rights purchase with landowners and construction of well field and long pipeline
Development Obstacles	3	1	3	Development of this supply may require continued expansion of well field to meet regulatory drawdown limits. May have local opposition to transfer of water out of county.
Supply Independence	5	1	5	Independent
Competition for Water Supply	3	1	3	CRMWA holds a vast amount of water rights in Roberts County and will be competing for water supplies.
Composite Score			**47**	

Groundwater from Donley and Gray County

Project Description

Purchase water rights from the Ogallala Aquifer in Donley or Gray County, drill wells and construct a pipeline to deliver groundwater to Wichita Falls. This project may be in conjunction with other suppliers to reduce the unit cost.

Potential Quantity (MGD)	15
Potential Capital Cost	$694,000,000
Capital Cost/MGD	$46,300,000

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	4	2	8	Depending on location of well field, supply is expected to sufficient, but it is nonrenewable. May be a limited supply.
Water Quality	5	1	5	Good water quality. Need to evaluate the compatibility with other existing supplies.
Reliability	4	2	8	Reliability is expected to be high but depends upon the competition for water supplies.
Regulatory Requirements	4	1	4	Requires a groundwater permit
Environmental Impacts	3	1	3	Moderate impacts associated with pipeline of this length.
Potential Cost	1	5	5	Very expensive
Time to Implement	1	1	1	Requires water rights purchase with landowners and construction of well field and long pipeline
Development Obstacles	3	1	3	Development of this supply may require continued expansion of well field to meet regulatory drawdown limits. May have local opposition to transfer of water out of county.
Supply Independence	5	1	5	Independent
Competition for Water Supply	3	1	3	Other users will be competing for water supplies.
Composite Score			**45**	

Wichita River Supply

Project Description

The water right for Kemp authorizes diversion and use of up to 16,600 acre-feet per year for irrigation purposes from the Wichita River. The water right would need to be amended to allow for a diversion point further downstream from the point currently authorized. Assume water is treated at Cypress Water Treatment Plant and waste discharged under existing permit.

Potential Quantity (MGD) 2
Potential Capital Cost $5,800,000
Capital Cost/MGD $2,900,000

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	1	2	2	Current estimate is for 2 MGD but the water right includes up to 14 MGD.
Water Quality	1	1	1	Brackish, requires treatment.
Reliability	2	2	4	Long term viability of supply uncertain. Could be backed up with releases from Diversion.
Regulatory Requirements	3	1	3	This project would require a water right amendment.
Environmental Impacts	3	1	3	Potential instream flow restrictions to protect aquatic habitat.
Potential Cost	4	5	20	Low to moderate cost.
Time to Implement	4	1	4	The infrastructure could be built quickly and the water right amendment should only require a short period of time.
Development Obstacles	3	1	3	may require infrastructure to move and/or store water.
Supply Independence	1	1	1	Relies on the same supply sources.
Competition for Water Supply	4	1	4	Minimal competition from current users.
Composite Score			**45**	

Kemp Water Right Amendment

Project Description
The water right for Kemp authorizes diversion and use of up to 193,000 acre-feet per year for multiple purposes of which 25,150 acre-feet per year is for municipal and 40,000 acre-feet per year for industrial purposes. The water right also includes a run-of-river diversion from the Wichita River for irrigation purposes. This strategy considers reallocation/purchase of Kemp water from other existing users (AEP and Irrigation District) to Wichita Falls. It may include a water right amendment for use type and/or diversion location.

Potential Quantity (MGD) Low-Moderate
Potential Capital Cost Low-Moderate
Capital Cost/MGD Low-Moderate

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	3	2	6	Varies depending on the amount available.
Water Quality	3	1	3	Brackish, requires treatment.
Reliability	1	2	2	The recent drought has impacted the yield of Kemp. Reservoir operations could impact reliability.
Regulatory Requirements	3	1	3	May require a water right amendment depending on quantity and ultimate use.
Environmental Impacts	5	1	5	The water is already being used for another use and thus would have minimal environmental impacts.
Potential Cost	3	5	15	The cost to amend the water right should be low, it is uncertain how much it will be to purchase the supply from other users.
Time to Implement	4	1	4	It depends on the willingness of the sellers.
Development Obstacles	2	1	2	Requires willing sellers.
Supply Independence	1	1	1	The same supply source.
Competition for Water Supply	2	1	2	Unless Wichita Falls is able to purchase all the supply there will still be some competition.
Composite Score			**43**	

Groundwater from Denton County

Project Description
Purchase water rights in Denton County, drill wells and construct a pipeline to deliver groundwater to Wichita Falls. This project may be in conjunction with other suppliers to reduce the unit cost.

Potential Quantity (MGD)	15
Potential Capital Cost	$627,500,000
Capital Cost/MGD	$41,800,000

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	4	2	8	Significant supply available.
Water Quality	4	1	4	Water quality is generally good.
Reliability	3	2	6	Unknown
Regulatory Requirements	3	1	3	North Texas GCD.
Environmental Impacts	4	1	4	The project should have minimal environmental impact.
Potential Cost	1	5	5	High cost associated with transmission and infrastructure.
Time to Implement	1	1	1	Will require the purchase of water rights and construction of a pipeline and pump station.
Development Obstacles	3	1	3	Willingness of sellers.
Supply Independence	5	1	5	Independent of current supplies.
Competition for Water Supply	2	1	2	Significant growth expected in Denton County over time.
Composite Score			**41**	

Lake Texoma Water

Project Description
Purchase Lake Texoma water, construct a pipeline and deliver Lake Texoma water for blending with other sources. Wichita Falls would need to purchase from an existing water right holder.

Potential Quantity (MGD)	15
Potential Capital Cost	$560,400,000
Capital Cost/MGD	$37,400,000

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	5	2	10	Enough supply to meet needs.
Water Quality	2	1	2	Lake Texoma water would need to be pre-treated before transport or blended with existing supplies.
Reliability	3	2	6	Lake Texoma has substantial supplies, although it is uncertain if there is a willing seller.
Regulatory Requirements	4	1	4	No interbasin transfer required.
Environmental Impacts	3	1	3	Low to moderate environmental impacts associated with the pipeline.
Potential Cost	1	5	5	The high cost for treatment and pumping.
Time to Implement	3	1	3	
Development Obstacles	1	1	1	Need to purchase the supply from another provider. Zebra mussels can pose maintenance issues for transmission and treatment facilities.
Supply Independence	4	1	4	Independent of current supplies.
Competition for Water Supply	3	1	3	Most of the current water conservation pool is under contract with the Corps. Much of the unused water is held by Oklahoma.
Composite Score			**41**	

Brackish Groundwater

Project Description

Wichita Falls is examining the possibility of pumping brackish groundwater and using advanced treatment to treat it to standards appropriate for potable use or for blending with existing sources. This study will focus on Clay, Wichita and Wilbarger Counties.

Potential Quantity (MGD) Unknown
Potential Capital Cost Moderate-High
Capital Cost/MGD Moderate-High

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	1	2	2	Supply may be available in sufficient quantities but that has not been determined yet. Based on other studies, amount of supply is likely less than 5 MGD long term.
Water Quality	1	1	1	Advanced treatment (desalt) will be needed to treat to a potable standard or the water will need to be blended with existing sources
Reliability	3	2	6	Supply may be available in sufficient quantities but that has not been determined yet.
Regulatory Requirements	3	1	3	Possibly need permits for disposal of treated water (brine), also the regulations governing brackish groundwater have not been fully determined. No GCD.
Environmental Impacts	4	1	4	Where will the waste stream be disposed. There are some potential environmental impacts from where this is disposed.
Potential Cost	2	5	10	The cost for advanced treatment and disposal is potentially high.
Time to Implement	3	1	3	Requires identification of locations with brackish groundwater and negotiating with land owners.
Development Obstacles	3	1	3	The need to first identify if the quantities are available and if they can be treated or blended appropriately.
Supply Independence	4	1	4	Provides an alternative source of supply independent of the current supply.
Competition for Water Supply	4	1	4	Low
Composite Score			**40**	

Lake Bridgeport Water

Project Description

Lake Bridgeport water could be purchased from TRWD and a pipeline built from Lake Bridgeport to bring raw water to Wichita Falls. The project would require an amendment to the current water right to allow for an interbasin transfer to the Red River Basin.

Potential Quantity (MGD)	15
Potential Capital Cost	$401,700,000
Capital Cost/MGD	$26,800,000

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	4	2	8	Quantity is good, but supplies may not be available during drought.
Water Quality	4	1	4	Water quality is good.
Reliability	2	2	4	The recent drought has impacted Lake Bridgeport in a similar way to the Wichita River Basin.
Regulatory Requirements	3	1	3	Interbasin transfer would require a water right amendment. May trigger environmental flow requirements.
Environmental Impacts	3	1	3	Potentially lower supply in Bridgeport could impact aquatic life.
Potential Cost	2	5	10	Transmission cost will be a factor.
Time to Implement	1	1	1	Agreements would need to be reached. Uncertain on time for permit amendment.
Development Obstacles	2	1	2	Requires an agreement to purchase from TRWD. TRWD may place restrictions on use of water when the lake is in drought.
Supply Independence	4	1	4	Independent from current supplies, but not other suppliers.
Competition for Water Supply	1	1	1	TRWD is already using this supply for fast growing Wise County.
Composite Score			**40**	

Groundwater from Arbuckle formation (Comanche County, Oklahoma)

Project Description
Purchase water rights from the Arbuckle formation in Comanche County, Oklahoma, drill wells and construct a pipeline to deliver groundwater to Wichita Falls. This project may be in conjunction with other suppliers to reduce the unit cost.

Potential Quantity (MGD)	15
Potential Capital Cost	$247,800,000
Capital Cost/MGD	$16,500,000

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	3	2	6	To be Determined
Water Quality	2	1	2	Likely High Fluoride
Reliability	2	2	4	Unknown
Regulatory Requirements	1	1	1	Allotted Indian Lands
Environmental Impacts	2	1	2	Unknown
Potential Cost	3	5	15	Moderately High
Time to Implement	2	1	2	Long Term
Development Obstacles	1	1	1	Multiple Individual Land Owners
Supply Independence	2	1	2	Questionable
Competition for Water Supply	3	1	3	Currently Limited Competition
Composite Score			**38**	

Groundwater (Tillman County, Oklahoma)

Project Description
Purchase water rights in Tillman County, Oklahoma, drill wells and construct a pipeline to deliver groundwater to Wichita Falls. This project may be in conjunction with other suppliers to reduce the unit cost.

Potential Quantity (MGD)	10
Potential Capital Cost	$265,400,000
Capital Cost/MGD	$26,500,000

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	2	2	4	To be determined
Water Quality	2	1	2	Likely High Nitrates
Reliability	3	2	6	Unknown
Regulatory Requirements	4	1	4	Minimal
Environmental Impacts	4	1	4	Minimal
Potential Cost	2	5	10	Moderately High
Time to Implement	2	1	2	Long Term
Development Obstacles	2	1	2	Routing and Long Term Contract
Supply Independence	3	1	3	Questionable
Competition for Water Supply	1	1	1	Large Amount of Irrigation
Composite Score			**38**	

Groundwater from Holliday Creek

Project Description
Drilling wells and pumping groundwater from the alluvium near Holliday Creek.

Potential Quantity (MGD)	2
Potential Capital Cost	$20,000,000
Capital Cost/MGD	$10,000,000

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	1	2	2	Alluvium is a limited source and is subject to drought. Expect quantities to be low.
Water Quality	1	1	1	Unknown quality. May have nitrates.
Reliability	2	2	4	Long term viability of supply uncertain.
Regulatory Requirements	3	1	3	No GCD or water right needed, unless it is determined that the well is under the influence of surface water.
Environmental Impacts	4	1	4	Pipeline
Potential Cost	2	5	10	Lower cost than other groundwater projects due to close proximity.
Time to Implement	3	1	3	This project could be implemented in two years.
Development Obstacles	4	1	4	Ability to find a location with sufficient supply. Power required to each well location.
Supply Independence	2	1	2	Alluvial groundwater tends to be very sensitive to drought conditions.
Competition for Water Supply	4	1	4	Minimal current competition.
Composite Score			**37**	

Groundwater from Floyd County

Project Description

Purchase water rights in Floyd County, drill wells and construct a pipeline to deliver groundwater to Wichita Falls. This project may be in conjunction with other suppliers to reduce the unit cost. May require treatment at well field if other entities received water along the pipeline route.

Potential Quantity (MGD)	10
Potential Capital Cost	$648,000,000
Capital Cost/MGD	$64,800,000

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	3	2	6	This supply could meet a portion of the need.
Water Quality	1	1	1	The water is brackish and would require advanced treatment.
Reliability	3	2	6	Determination of long term supply availability needed.
Regulatory Requirements	3	1	3	Would require contracts with willing sellers and there is a GCD in Floyd County. Requires a groundwater permit and may require a waste discharge permit.
Environmental Impacts	3	1	3	Low impacts associated with the pipeline. Uncertain impacts associated with the well field and disposal of treatment waste.
Potential Cost	1	5	5	The distance makes this supply relatively expensive.
Time to Implement	1	1	1	This could take several years to design and construct.
Development Obstacles	3	1	3	May be local oppositions to transfer of groundwater out of Floyd County.
Supply Independence	4	1	4	Independent of current supplies.
Competition for Water Supply	4	1	4	The supply should have minimal competition due to quality concerns.
Composite Score			**36**	

Evaporation Suppression

Project Description
Wichita Falls has a pilot program testing the effectiveness of an evaporation suppressant on Lake Arrowhead. If proven effective this product could decrease the amount of evaporation increasing the available supply from Wichita Falls reservoirs.

Potential Quantity (MGD)	Unknown
Potential Capital Cost	$400,000/75 days
Capital Cost/MGD	Unknown

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	1	2	2	Uncertain
Water Quality	5	1	5	No water quality impacts.
Reliability	1	2	2	Uncertain
Regulatory Requirements	5	1	5	None at this time
Environmental Impacts	3	1	3	Claims to be safe for aquatic species.
Potential Cost	2	5	10	If an annual cost it could be substantial.
Time to Implement	5	1	5	This program could be implemented immediately.
Development Obstacles	1	1	1	Uncertain effectiveness.
Supply Independence	1	1	1	Same water supplies.
Competition for Water Supply	2	1	2	Current users
Composite Score			**36**	

Stormwater Collection System

Project Description

This strategy would require a city-wide collection system that would collect runoff from every stormwater outfall prior to discharging into a creek, river, or lake to maintain control of the water. If the water is discharged to a creek, the City would need to apply for a water right. In order to collect this water, significant construction would be required to tie the storm sewer system to a single point for storage. An appropriate storage site would need to be located near the city.

Potential Quantity (MGD) Low
Potential Capital Cost High
Capital Cost/MGD High

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	1	2	2	While the impervious surfaces within the city generate more runoff than open land outside of the city, the amount of supply is only available during rain events and is a relatively small quantity. From 2011-2013 Wichita Falls has received an average of 18 inches per year.
Water Quality	3	1	3	May have high dissolved solids and other pollutants.
Reliability	1	2	2	The small amount of supply is only available during rain events.
Regulatory Requirements	4	1	4	As long as the stormwater is collected from the storm sewer system prior to entering a creek, river, or lake, a water right should not be required.
Environmental Impacts	4	1	4	Potential reduced flow to the creeks.
Potential Cost	1	5	5	High cost to connect all of the storm sewer systems to storage location(s).
Time to Implement	3	1	3	Time to complete construction is approximately 5 years.
Development Obstacles	2	1	2	Significant construction would be required to tie the storm sewer system to a single point. Also a storage site near the city would be required.
Supply Independence	2	1	2	Downstream of other sources, but still in the same watershed and prone to similar climate conditions.
Competition for Water Supply	4	1	4	
Composite Score			**31**	

Dredging of Lake Kemp, all reservoirs

Project Description
All reservoirs experience loss of storage due to sedimentation, and Kemp specifically has experienced significant sedimentation. This strategy would call for the dredging of Lake Kemp, Kickapoo and Arrowhead.

Potential Quantity (MGD)	1
Potential Capital Cost	$24,200,000
Capital Cost/MGD	$27,100,000

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	1	2	2	Would restore a portion of the yield lost due to decreased storage.
Water Quality	4	1	4	May have some impacts to suspended sediments during dredging though the long term impacts would be minimal.
Reliability	2	2	4	Over time the sediment would once again accumulate.
Regulatory Requirements	2	1	2	Would require a 404 permit.
Environmental Impacts	3	1	3	May have some impacts during dredging and could impact habitat for certain aquatic species.
Potential Cost	1	5	5	High cost includes disposal of dredged material.
Time to Implement	3	1	3	Depending on approval of the 404 permit.
Development Obstacles	1	1	1	Disposal site for dredged materials
Supply Independence	1	1	1	Same water supplies.
Competition for Water Supply	3	1	3	
Composite Score			**28**	

Chloride Control Project

Project Description
The Corps of Engineers has a Red River Chloride Control Project to control natural chloride brine emissions at ten major source areas to improve water quality. The Wichita Basin portion was completed May 2004. It is a federally funded and directed project.

Potential Quantity (MGD) Low
Potential Capital Cost $59,000,000
Capital Cost/MGD High

Criteria	Scoring (1-5)	Weighting Factor	Weighted Score	Comments
Water Quantity	1	2	2	No gain in water quantity. Could eliminate the need for RO treatment which would provide additional supply.
Water Quality	5	1	5	Improves water quality in Lake Kemp.
Reliability	1	2	2	Uncertain.
Regulatory Requirements	2	1	2	404 permit for diversion of salty water.
Environmental Impacts	3	1	3	See CCP study.
Potential Cost	1	5	5	Without cost sharing from the Federal government this is a very expensive project.
Time to Implement	1	1	1	No federal funding and the likelihood of receiving funding is low.
Development Obstacles	1	1	1	Without cost sharing from the Federal government this is a very expensive project.
Supply Independence	1	1	1	It is in the same basin as other supplies.
Competition for Water Supply	3	1	3	
Composite Score			**25**	

Appendix C
Cost Tables

Wichita Falls Long Range Water Supply Plan Cost Estimate
Indirect Reuse to Lake Arrowhead
September 2014 Dollars

Supply (Ac-ft)	11,210			
Supply (MGD)	10			
Construction Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
32" Water Line*	66,000	LF	$150	$9,900,000
36" Water Line*	13,200	LF	$172	$2,270,000
RRWWTP-Pump Station Improvements*	1	EA	$17,000,000	$17,000,000
Road Crossings	3,000	LF	$290	$870,000
* Cost provided by City, includes contingencies				
Total Construction Costs:				**$30,040,000**
Other Project Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Additional Construction Contingencies*				$1,000,000
Engineering, Legal & Financial @ 10%			10%	$3,000,000
Land, Easements and Conflicts	76	AC	$1,500	$110,000
Environmental Studies, Mitigation & Permitting	13	MI	$25,000	$310,000
Interest During Construction (2 Years)				$2,100,000
Total Other Project Costs:				**$6,520,000**
Total Capital Cost:				**$36,560,000**
Annual Costs:	**Quantity**	**Unit**	**Unit Price**	**Total**
Debt Service (20 yrs. @ 4%)				$2,690,000
Operation and Maintenance @ 3%				$910,000
Power Costs	2,777,800	kwh	0.09	$250,000
Water Treatment Costs	3,650,000	1,000 gallons	$0.85	$3,100,000
Total Annual Costs:				**$6,950,000**
During Amortization				
Cost of Water ($Per MGD)				**$1,904**
Cost of Water ($Per 1,000 Gallons)				**$1.90**
After Amortization				
Cost of Water ($Per MGD)				**$1,167**
Cost of Water ($Per 1,000 Gallons)				**$1.17**

Wichita Falls Long Range Water Supply Plan Cost Estimate
Water Conservation
September 2014 Dollars

Supply (Ac-ft)	2,186			
Supply (MGD)	1.95			
Construction Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
6" Pipeline Replacement	10,000	LF	$25	$250,000
12" Pipeline Replacement	10,000	LF	$49	$490,000
18" Pipeline Replacement	10,000	LF	$98	$980,000
24" Pipeline Replacement	2,000	LF	$146	$290,000
30" Pipeline Replacement	2,000	LF	$194	$390,000
36" Pipeline Replacement	2,000	LF	$242	$480,000
42" Pipeline Replacement	1,000	LF	$290	$290,000
48" Pipeline Replacement	1,000	LF	$339	$340,000
Total Construction Costs:				**$3,500,000**
Other Project Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Construction Contingencies @ 20%			20%	$700,000
Engineering, Legal & Financial @ 20%			20%	$700,000
Landscape Ordinance				$50,000
Water Waste Ordinance				$50,000
Total Other Project Costs:				**$1,500,000**
Total Capital Cost:				**$5,000,000**
Annual Costs:	**Quantity**	**Unit**	**Unit Price**	**Total**
Debt Service (20 yrs. @ 4%)				$370,000
Operation and Maintenance @ 3%				$130,000
Leak Detection and Repair Personnel				$100,000
Education Program				$100,000
Enforcement				$50,000
Power Cost Deferred	1,000,000	kwh	$0.09	($90,000)
Water Treatment Cost Deferred	711,750	1,000 gallons	$0.85	($600,000)
Total Annual Costs:				**$60,000**
During Amortization				
Cost of Water ($Per MGD)				**84**
Cost of Water ($Per 1,000 Gallons)				**0.08**
After Amortization				
Cost of Water ($Per MGD)				**-436**
Cost of Water ($Per 1,000 Gallons)				**-0.44**

Wichita Falls Long Range Water Supply Plan Cost Estimate
Groundwater from HFSJ (Wichita Falls)
September 2014 Dollars

Supply (Ac-ft)	2,242			
Supply (MGD)	2			
Construction Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Water Supply Wells	50	EA	$85,000	$4,250,000
Well Field Collection System	50	EA	$20,000	$1,000,000
24" Treated Water Line	2,323	LF	$104	$240,000
Pump Station	1	EA	$1,721,000	$1,720,000
Storage Tank with Roof	1	EA	$255,858	$260,000
2 MGD RO Treatment Plant	1	EA	$6,590,000	$6,590,000
Road Crossings	500	LF	$200	$100,000
Total Construction Costs:				**$14,160,000**
Other Project Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Construction Contingencies @ 20%			20%	$2,830,000
Engineering, Legal & Financial @ 20%			20%	$2,830,000
Land, Easements and Conflicts	3	AC	$1,500	$4,000
Environmental Studies, Mitigation & Permitting	0.4	MI	$25,000	$10,000
Interest During Construction (2 Years)				$990,000
Total Other Project Costs:				**$6,664,000**
Total Capital Cost:				**$20,824,000**
Annual Costs:	**Quantity**	**Unit**	**Unit Price**	**Total**
Debt Service (20 yrs. @ 4%)				$1,530,000
Operation and Maintenance @ 3%				$310,000
Power Costs	2,777,800	kwh	$0.09	$250,000
Purchase Water Costs ($0.50/Kgal)	730,000	Kgal	$0.50	$370,000
Water Treatment Costs	730,000	Kgal	$1.28	$930,000
Total Annual Costs:				**$3,390,000**
During Amortization				
Cost of Water ($Per MGD)				**$4,644**
Cost of Water ($Per 1,000 Gallons)				**$4.64**
After Amortization				
Cost of Water ($Per MGD)				**$2,548**
Cost of Water ($Per 1,000 Gallons)				**$2.55**

Wichita Falls Long Range Water Supply Plan Cost Estimate
Wichita River (Surface Water Development)
September 2014 Dollars

Supply (Ac-ft)	2,242			
Supply (MGD)	2			
Construction Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
18" Water line	16,000	LF	$98	$1,570,000
Intake Pump Station	1	EA	$1,597,000	$1,600,000
Channel Dam	1	EA	$3,840,000	$3,840,000
Total Construction Costs:				**$7,010,000**
Other Project Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Construction Contingencies @ 20%			20%	$1,400,000
Engineering, Legal & Financial @ 20%			20%	$1,400,000
Land, Easements and Conflicts	18	AC	$1,500	$30,000
Environmental Studies, Mitigation & Permitting	3	MI	$25,000	$80,000
Interest During Construction (2 Years)				$490,000
Total Other Project Costs:				**$3,400,000**
Total Capital Cost:				**$10,410,000**
Annual Costs:	**Quantity**	**Unit**	**Unit Price**	**Total**
Debt Service (20 yrs. @ 4%)				$770,000
Operation and Maintenance @ 3%				$250,000
Power Costs	666,700	kwh	$0.09	$60,000
Water Treatment Costs	730,000	Kgal	$0.85	$620,000
Total Annual Costs:				**$1,700,000**
During Amortization				
Cost of Water ($Per MGD)				**$2,329**
Cost of Water ($Per Kgal)				**$2.33**
After Amortization				
Cost of Water ($Per MGD)				**$1,274**
Cost of Water ($Per Kgal)				**$1.27**

Wichita Falls Long Range Water Supply Plan Cost Estimate
Conjunctive Use (HFSJ and Wichita River)
September 2014 Dollars

Supply (Ac-ft)	4,484
HFSJ Supply (MGD)	2
Wichita River Supply (MGD)	2
Total Conjunctive Supply (MGD)	4

Construction Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Phase 1				
Water Supply Wells	75	EA	$50,000	$3,750,000
Well Field Collection System	75	EA	$18,000	$1,350,000
24" GW Raw Water Line	5,800	LF	$104	$600,000
Pump Station	1	EA	$1,721,000	$1,720,000
Storage Tank with Roof	1	EA	$369,278	$370,000
2 MGD RO Treatment Plant	1	EA	$6,590,000	$6,590,000
Road Crossings	500	LF	$200	$100,000
River Crossing	1	EA	$625,000	$630,000
Phase 2				
24" SW Water line	23,800	LF	$146	$3,470,000
Pump Station	1	EA	$1,597,000	$1,600,000
Road Crossings	1	EA	$1,000,000	$1,000,000
Channel Dam	1	EA	$3,840,000	$3,840,000
8" Brine discharge pipeline	24,000	LF	$40	$960,000
Total Construction Costs:				**$25,980,000**

Other Project Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Construction Contingencies @ 20%			20%	$5,200,000
Engineering, Legal & Financial @ 20%			20%	$5,200,000
Land, Easements and Conflicts	34	AC	$1,500	$50,000
Environmental Studies, Mitigation & Permitting	6	MI	$25,000	$140,000
Interest During Construction (2 Years)				$1,820,000
Total Other Project Costs:				**$12,410,000**

Total Capital Cost:	**$38,390,000**

Annual Costs:	**Quantity**	**Unit**	**Unit Price**	**Total**
Debt Service (20 yrs. @ 4%)				$2,820,000
Operation and Maintenance @ 3%				$740,000
Power Costs	3,444,500	kwh	$0.09	$310,000
Purchase Water Costs ($0.50/1,000 Gallons)	730,000	Kgal	$0.50	$370,000
RO Water Treatment Costs	730,000	Kgal	$1.28	$930,000
Water Treatment Costs	1,460,000	Kgal	$0.85	$1,240,000
Total Annual Costs:				**$6,410,000**
During Amortization				
Cost of Water ($Per MGD)				**$4,390**
Cost of Water ($Per 1,000 Gallons)				**$4.39**
After Amortization				
Cost of Water ($Per MGD)				**$2,459**
Cost of Water ($Per 1,000 Gallons)				**$2.46**

Wichita Falls Long Range Water Supply Plan Cost Estimate
Lake Ringgold Development
September 2014 Dollars

Supply (Ac-ft)	18,900			
Supply (MGD)	16.9			
Construction Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Ringgold Reservoir & Dam	1	LS	$64,270,000	$64,270,000
42" Raw Water Line	156,800	LF	$207	$32,460,000
Road Crossings	20,000	LF	$510	$10,200,000
29 MGD Pump Station with Intake Structure	1	EA	$10,743,000	$10,740,000
Total Construction Costs:				**$117,670,000**
Other Project Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Construction Contingencies @ 20%			20%	$23,530,000
Engineering, Legal & Financial @ 20%			20%	$23,530,000
Land, Easements & Conflicts	17,460	Acre	$2,100	$36,670,000
Environmental Studies, Mitigation & Permitting	1	LS	$75,930,000	$75,930,000
Interest During Construction (5 Years)				$20,590,000
Total Other Project Costs:				**$180,250,000**
Total Capital Cost:				**$297,920,000**
Annual Costs:	**Quantity**	**Unit**	**Unit Price**	**Total**
Debt Service (30 yrs. @ 4%)				$17,230,000
Operation and Maintenance @ 3%				$4,240,000
Power Costs	7,891,878	kwh	$0.09	$710,000
Water Treatment Costs	6,056,200	1,000 gallons	$0.85	$5,230,000
Total Annual Costs:				**$27,410,000**
During Amortization				
Cost of Water ($Per MGD)				**$4,454**
Cost of Water ($Per 1,000 Gallons)				**$4.45**
After Amortization				
Cost of Water ($Per MGD)				**$1,654**
Cost of Water ($Per 1,000 Gallons)				**$1.65**

Wichita Falls Long Range Water Supply Plan Cost Estimate
Groundwater From Wilbarger County
September 2014 Dollars

Supply (Ac-ft)	5,605			
Supply (MGD)	5			
Construction Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Water Supply Wells	25	EA	$75,000	$1,880,000
Well Field Collection System	25	EA	$20,000	$500,000
30" Raw Water Line	400,000	LF	$139	$55,600,000
Storage Tank with Roof	1	EA	$430,000	$430,000
Press. Red. Valves	3	EA	$1,000,000	$3,000,000
Road Crossings	40,000	LF	$250	$10,000,000
Total Construction Costs:				**$71,410,000**
Other Project Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Construction Contingencies @ 20%			20%	$14,280,000
Engineering, Legal & Financial @ 20%			20%	$14,280,000
Land, Easements and Conflicts	459	AC	$1,500	$690,000
Environmental Studies, Mitigation & Permitting	75	MI	$25,000	$1,880,000
Interest During Construction (2 Years)				$5,000,000
Total Other Project Costs:				**$36,130,000**
Total Capital Cost:				**$107,540,000**
Annual Costs:	**Quantity**	**Unit**	**Unit Price**	**Total**
Debt Service (30 yrs. @ 4%)				$6,220,000
Operation and Maintenance @ 3%				$2,570,000
Power Costs	13,333,300	kwh	$0.09	$1,200,000
Purchase Water Costs($0.75/1,000 Gallons)	1,825,000	1,000 gallons	$0.75	$1,370,000
Water Treatment Costs	1,825,000	1,000 gallons	$0.30	$550,000
Total Annual Costs:				**$11,910,000**
During Amortization				
Cost of Water ($Per MGD)				**$6,526**
Cost of Water ($Per 1,000 Gallons)				**$6.53**
During Amortization				
Cost of Water ($Per MGD)				**$3,118**
Cost of Water ($Per 1,000 Gallons)				**$3.12**

Wichita Falls Long Range Water Supply Plan Cost Estimate
Groundwater From Roberts & Lipscomb County
September 2014 Dollars

Supply (Ac-ft)	26,904			
Supply (MGD)	24			
Construction Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Water Supply Wells	40	EA	$400,000	$16,000,000
Well Field Collection System	40	EA	$20,000	$800,000
54" Raw Water Line	1,452,000	LF	$276	$400,750,000
Storage Tank with Roof	1	EA	$1,360,000	$1,360,000
Press. Red. Valves	10	EA	$1,000,000	$10,000,000
Road Crossings	145,200	LF	$1,020	$148,100,000
Total Construction Costs:				**$574,850,000**
Other Project Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Construction Contingencies @ 20%			20%	$114,970,000
Engineering, Legal & Financial @ 20%			20%	$114,970,000
Land, Easements & Conflicts	1,667	AC	$1,500	$2,500,000
Environmental Studies, Mitigation & Permitting	275	MI	$25,000	$6,880,000
Interest During Construction (6 Years)				$120,720,000
Total Other Project Costs:				**$360,040,000**
Total Capital Cost:				**$934,890,000**
Annual Costs:	**Quantity**	**Unit**	**Unit Price**	**Total**
Debt Service (30 yrs. @ 4%)				$54,060,000
Operation and Maintenance @ 3%				$20,690,000
Power Costs	33,333,333	kwh	$0.09	$3,000,000
Purchase Water Costs ($0.75/1,000 Gallons)	8,760,000	Kgal	$0.75	$6,570,000
Water Treatment Costs	8,760,000	Kgal	$0.30	$2,630,000
Total Annual Costs:				**$84,320,000**
During Amortization				
Cost of Water ($Per MGD)				**$9,626**
Cost of Water ($Per 1,000 Gallons)				**$9.63**
After Amortization				
Cost of Water ($Per MGD)				**$3,755**
Cost of Water ($Per 1,000 Gallons)				**$3.75**

Wichita Falls Long Range Water Supply Plan Cost Estimate
Groundwater From Donley & Gray Co.
September 2014 Dollars

Supply (Ac-ft)	16815			
Supply (MGD)	15			
Construction Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Water Supply Wells	40	EA	$400,000	$16,000,000
Well Field Collection System	40	EA	$20,000	$800,000
54" Raw Water Line	976,800	LF	$276	$269,600,000
Storage Tank with Roof	1	EA	$1,000,000	$1,000,000
Press. Red. Valves	8	EA	$1,000,000	$8,000,000
Road Crossings	97,600	LF	$1,020	$99,550,000
Total Construction Costs:				**$394,950,000**
Other Project Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Construction Contingencies @ 20%			20%	$78,990,000
Engineering, Legal & Financial @ 20%			20%	$78,990,000
Land, Easements and Conflicts	1,121	AC	$1,500	$1,680,000
Environmental Studies, Mitigation & Permitting	185	MI	$25,000	$4,630,000
Interest During Construction (5 Years)				$69,120,000
Total Other Project Costs:				**$233,410,000**
Total Capital Cost:				**$628,360,000**
Annual Costs:	**Quantity**	**Unit**	**Unit Price**	**Total**
Debt Service (30 yrs. @ 4%)				$36,340,000
Operation and Maintenance @ 3%				$14,220,000
Power Costs	33,333,300	kwh	$0.09	$3,000,000
Purchase Water Costs($0.75/1,000 Gallons)	5,475,000	1,000 gallons	$0.75	$4,110,000
Water Treatment Costs	5,475,000	1,000 gallons	$0.30	$1,640,000
Total Annual Costs:				**$59,310,000**
During Amortization				
Cost of Water ($Per MGD)				**$10,833**
Cost of Water ($Per 1,000 Gallons)				**$10.83**
After Amortization				
Cost of Water ($Per MGD)				**$4,195**
Cost of Water ($Per 1,000 Gallons)				**$4.20**

Wichita Falls Long Range Water Supply Plan Cost Estimate
Groundwater From Denton County.
September 2014 Dollars

Supply (Ac-ft)	16,815			
Supply (MGD)	15			
Construction Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Water Supply Wells	20	EA	$1,500,000	$30,000,000
Well Field Collection System	20	EA	$20,000	$400,000
54" Raw Water Line	500,000	LF	$276	$138,000,000
Storage Tank with Roof	1	EA	$1,000,000	$1,000,000
15 MGD Pump Station	3	EA	$6,390,000	$19,170,000
Road Crossings	50,000	LF	$1,020	$51,000,000
Total Construction Costs:				**$239,570,000**
Other Project Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Construction Contingencies @ 20%			20%	$47,910,000
Engineering, Legal & Financial @ 20%			20%	$47,910,000
Land, Easements and Conflicts	574	AC	$1,500	$860,000
Environmental Studies, Mitigation & Permitting	95	MI	$25,000	$2,370,000
Interest During Construction (4 Years @4%)				$33,540,000
Total Other Project Costs:				**$132,590,000**
Total Capital Cost:				**$372,160,000**
Annual Costs:	**Quantity**	**Unit**	**Unit Price**	**Total**
Debt Service (30 yrs. @ 4%)				$21,520,000
Operation and Maintenance @ 3%				$8,620,000
Power Costs	19,444,400	kwh	$0.09	$1,750,000
Purchase Water Costs ($0.75/1,000 Gallons)	5,475,000	Kgal	$0.75	$4,110,000
Water Treatment Costs	5,475,000	Kgal	$0.30	$1,640,000
Total Annual Costs:				**$37,640,000**
During Amortization				
Cost of Water ($Per MGD)				**$6,875**
Cost of Water ($Per 1,000 Gallons)				**$6.87**
After Amortization				
Cost of Water ($Per MGD)				**$2,944**
Cost of Water ($Per 1,000 Gallons)				**$2.94**

Wichita Falls Long Range Water Supply Plan Cost Estimate

Lake Texoma Water

September 2014 Dollars

Supply (Ac-ft)	16,815
Supply (MGD)	15

Construction Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
48" Raw Water Trans. Line	475,000	LF	$242	$114,950,000
54" Raw Water Line	175,000	LF	$276	$48,300,000
Road Crossings	60,000	LF	$710	$42,600,000
15 MGD Booster Pump Station	3	EA	$5,059,000	$15,180,000
15 MGD Intake Pump Station	1	EA	$9,638,000	$9,640,000
10 MGD RO Treatment Plant Expansion	1	EA	$27,150,000	$27,150,000
Total Construction Costs:				**$257,820,000**

Other Project Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Construction Contingencies @ 20%			20%	$51,560,000
Engineering, Legal & Financial @ 20%			20%	$51,560,000
Land, Easements and Conflicts	746	AC	$1,500	$1,120,000
Environmental, Mitigation & Permitting	123	MI	$25,000	$3,080,000
Interest During Construction (4 Years)				$36,090,000
Total Other Project Costs:				**$143,410,000**
Total Capital Cost:				**$401,230,000**

Annual Costs:	**Quantity**	**Unit**	**Unit Price**	**Total**
Debt Service (30 yrs. @ 4%)				$23,200,000
Operation and Maintenance @ 3%				$8,470,000
Power Costs	17,777,777	kwh	$0.09	$1,600,000
Purchase Water Costs ($0.50/1,000 Gals)	5,475,000	Kgal	$0.50	$2,740,000
Conventional Treatment Costs	2,555,000	Kgal	$0.85	$2,170,000
RO Treatment Costs	2,920,000	Kgal	$1.28	$3,740,000
Total Annual Costs:				**$41,920,000**

During Amortization	
Cost of Water ($Per MGD)	**$7,657**
Cost of Water ($Per 1,000 Gallons)	**$7.66**
After Amortization	
Cost of Water ($Per MGD)	**$3,419**
Cost of Water ($Per 1,000 Gallons)	**$3.42**

Wichita Falls Long Range Water Supply Plan Cost Estimate
Lake Bridgeport Water to Lake Arrowhead
September 2014 Dollars

Supply (Ac-ft)	16,815			
Supply (MGD)	15			
Construction Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
48" Raw Water Trans. Line	396,000	LF	$242	$95,830,000
Road Crossings	40,000	LF	$710	$28,400,000
15 MGD Pump Station	3	EA	$8,946,000	$26,840,000
Total Construction Costs:				**$151,070,000**
Other Project Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Construction Contingencies @ 20%			20%	$30,210,000
Engineering, Legal & Financial @ 20%			20%	$30,210,000
Land, Easements and Conflicts	455	AC	$1,500	$680,000
Environmental Studies, Mitigation & Permitting	75	MI	$25,000	$1,880,000
Interest During Construction (4 Years @ 4%)				$21,150,000
Total Other Project Costs:				**$84,130,000**
Total Capital Cost:				**$235,200,000**
Annual Costs:	**Quantity**	**Unit**	**Unit Price**	**Total**
Debt Service (30 yrs. @ 4%)				$13,600,000
Operation and Maintenance @ 3%				$5,440,000
Power Costs	14,444,400	kwh	$0.09	$1,300,000
Purchase Water Costs ($0.50/1,000 Gallons)	5,475,000	Kgal	$0.50	$2,740,000
Water Treatment Costs	5,475,000	Kgal	$0.85	$4,650,000
Total Annual Costs:				**$27,730,000**
During Amortization				
Cost of Water ($Per MGD)				**$5,065**
Cost of Water ($Per 1,000 Gallons)				**$5.06**
After Amortization				
Cost of Water ($Per MGD)				**$2,581**
Cost of Water ($Per 1,000 Gallons)				**$2.58**

Wichita Falls Long Range Water Supply Plan Cost Estimate
Lake Kemp Water Right Amendment
September 2014 Dollars

Supply (Ac-ft)	11,210			
Supply (MGD)	10			
Construction Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Expansion of RO Treatment Facility	1	EA	$27,150,000	$27,150,000
				$0
				$0
Total Construction Costs:				**$27,150,000**
Other Project Cost:	**Quantity**	**Unit**	**Unit Price**	**Total**
Construction Contingencies @ 20%			20%	$5,430,000
Engineering, Legal & Financial @ 20%			20%	$5,430,000
Land, Easements and Conflicts				$0
Environmental Studies, Mitigation & Permitting				$0
Purchase of Water Rights	11,210	$/AF	$200	$2,240,000
Interest During Construction (2 Years)				$1,900,000
Total Other Project Costs:				**$15,000,000**
Total Capital Cost:				**$42,150,000**
Annual Costs:	**Quantity**	**Unit**	**Unit Price**	**Total**
Debt Service (30 yrs. @ 4%)				$2,440,000
Operation and Maintenance @ 3%				$980,000
Power Costs	11,891,394	kwh	$0.09	$1,070,000
Water Treatment Costs	3,650,000	1,000 gallons	$1.28	$4,670,000
Total Annual Costs:				**$9,160,000**
During Amortization				
Cost of Water ($Per MGD)				**$2,510**
Cost of Water ($Per 1,000 Gallons)				**$2.51**
After Amortization				
Cost of Water ($Per MGD)				**$1,841**
Cost of Water ($Per 1,000 Gallons)				**$1.84**