

Feasibility Study of Augmenting Regional Water Supply System for Tarrant Regional Water District and Wichita Falls with Impaired Groundwater Supplies

WaterSMART: Development of Feasibility Studies under the Title XVI Water Reclamation and Reuse Program for Fiscal Year 2014

Funding Opportunity Announcement Number: R14AS00030



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Technical Proposal (20 page maximum)

I. Executive Summary

Date: May 2014

Applicant Name: Tarrant Regional Water District (TRWD)

Location: TRWD's administrative office is in Fort Worth, Tarrant County, Texas. The locations of the two focus areas for this study are Clay County and the Navarro and Freestone County area. All of which are located in West Central and North Texas, respectively.

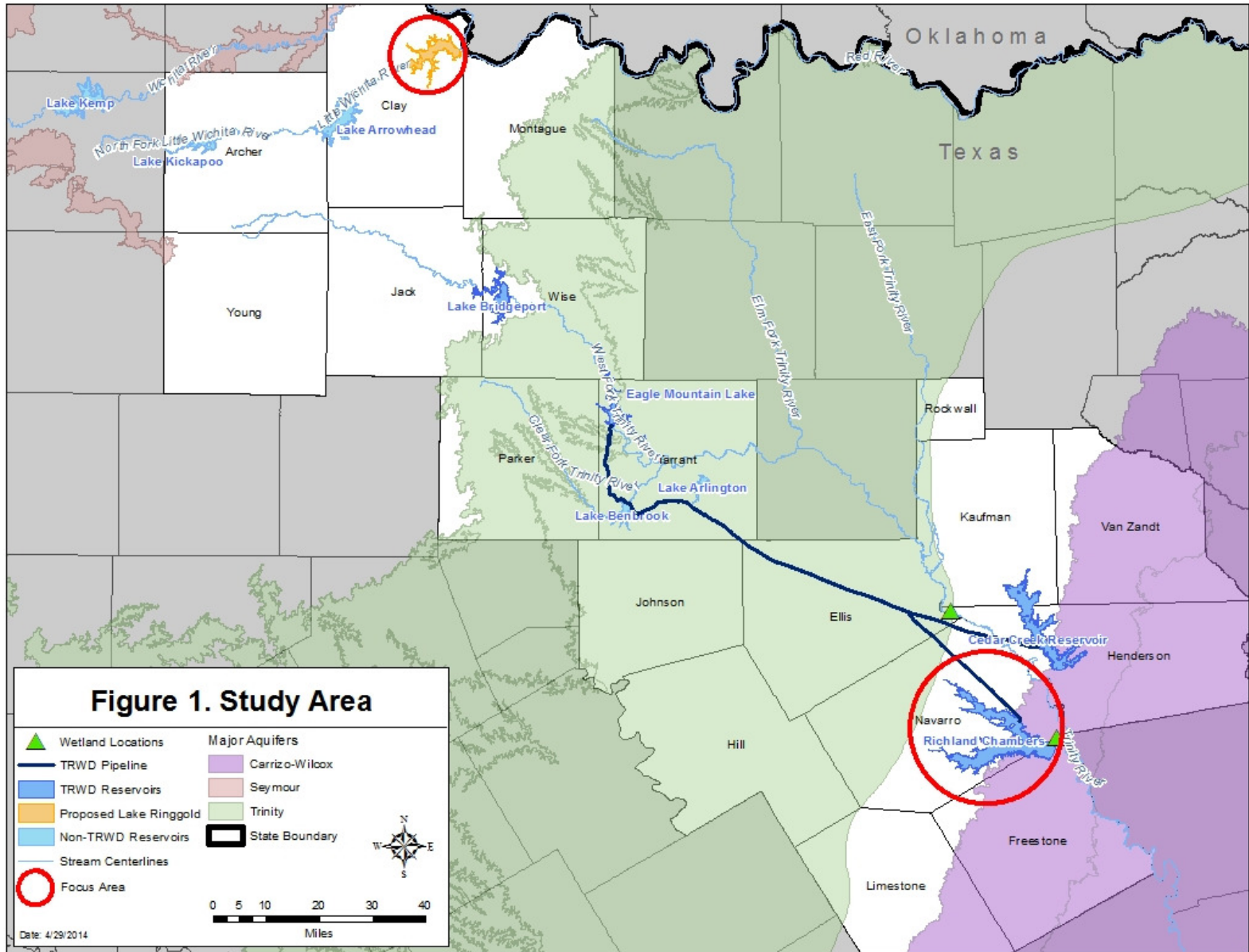
Proposed Schedule: The proposed study is anticipated to take 18 months. Assuming the study begins in October 2014, the study would then be complete by March 2016. If the study begins earlier or later than anticipated, the completion date will be 18 months from the start date.

Summary of Proposal: The surface water supplies in North and West Central Texas are greatly impacted by the ongoing drought. Tarrant Regional Water District and the City of Wichita Falls intend to study the feasibility of adding impaired groundwater supplies to the regional water supply system. The feasibility study will focus on two potential locations for developing groundwater well fields. The study will investigate existing groundwater quality information to determine potential locations of impaired groundwater. The feasibility study will also consider surface water quality in the two focus areas. Feasible options of mixing surface water with impaired groundwater aquifers will provide TRWD and Wichita Falls the information they need to determine the feasibility of using impaired groundwater to supplement surface water supplies. The potential well field locations are in the Seymour aquifer, Paleozoic Formations, and Red River Alluvium in Clay County and in the Carrizo-Wilcox and Trinity aquifers on the south side of Richland-Chambers Reservoir in Freestone and Navarro Counties. Figure 1 shows the study area.

II. Technical Study Description

Tarrant Regional Water District provides raw water supply to an 11 county area in North Texas. TRWD provides raw water to more than 1.8 million people, serving more than 70 cities in North Texas. The current water supply includes four major reservoirs, three storage reservoirs, and a 2,000-acre wetland water reuse project. The City of Wichita Falls provides treated water to approximately 105,000 residents and raw water to more than 14 wholesale water customers in the Wichita, Archer and Clay County area. Wichita Falls and TRWD have been discussing potential partnering opportunities to develop or bring additional reliable water supply to both service areas.

The proposed study will investigate the feasibility of augmenting the existing TRWD surface water supply system and Wichita Falls' proposed Lake Ringgold by adding impaired groundwater. TRWD participation in the development of the proposed Lake Ringgold is dependent on whether or not the new surface water supply could be augmented by impaired



groundwater. Increasing the yield of the proposed surface water supply is critical to TRWD and Wichita Falls partnering in its development.

The study will use existing Groundwater Availability Models (GAMs) to identify available supplies of potential groundwater sources. Water quality analyses will be determined using existing reports, readily available information, and water samples using existing groundwater wells. TRWD is aware of potential groundwater temperature and chemistry issues that may need to be addressed before the groundwater could be added to the existing water supplies.

The scope of work for this feasibility study includes the following tasks:

Task 1. Determine Impaired Groundwater Availability

Task 1 will obtain and use publicly available information from state agencies, academia, and existing Groundwater Availability Models to estimate the potential groundwater availability from impaired groundwater sources near TRWD and Wichita Falls surface water supplies. Groundwater supplies to be considered include the Trinity, Carrizo-Wilcox, and Seymour aquifers. This task will obtain, review and estimate the potential for developing groundwater supplies from the Paleozoic Formations and the Red River Alluvium near the Red River in Clay County.

Task 2. Evaluate Existing Water Quality Data

Task 2 is the development of a GIS database that summarizes existing groundwater and surface water quality data from the Texas Water Development Board (TWDB), Texas Commission on Environmental Quality (TCEQ), TRWD, and Wichita Falls. Groundwater sources to be considered include the Trinity and Carrizo-Wilcox aquifers near Richland-Chambers Reservoir (Freestone and Navarro Counties) and the Seymour aquifer, Paleozoic Formations, and the Red River Alluvium near the surface water supplies of the proposed Lake Ringgold (Clay County).

Task 2 includes the development of appropriate representations of groundwater quality that demonstrate the degree of impairment in an aquifer due to the presence of constituents that exceed EPA primary or secondary drinking water standards. Potential impairments may include iron, manganese, chloride, sulfate, temperature, total dissolved solids, and other constituents identified in this task.

Task 3. Collect and Analyze Groundwater Samples

In the event that adequate groundwater quality data is not readily available, Task 3 provides for the collection and analysis of groundwater samples. This task will include the selection of up to three existing groundwater wells near each reservoir site (approximately 6 wells) at which to collect groundwater samples from aquifers that are anticipated to be impaired based on the results of Task 2. The water samples will be analyzed for a suite of major and minor dissolved inorganic constituents, and the test results will be added to the GIS database.

If possible, this task will include the development of a statistical profile of the surface and groundwater chemistry to estimate the frequency of and variability of potential blending scenarios to account for the changing chemistry in the water sources throughout the year.

Task 4. Modeling Groundwater and Surface Water Mixes

Task 4 involves running a hydrochemical mixing model of groundwater and surface water quality parameters using PHREEQC or similar software for each of the surface-groundwater source pairs. This task will assess mineral precipitation, dissolution, or corrosion potential caused by mixing or changes in temperature. Task 4 will identify hydrochemical processes that may impact the feasibility of a surface-groundwater pairing. Potential blend ratios that achieve a mixed water meeting EPA/Texas drinking water standards will be estimated. This task will identify any antiscalants, pH adjustments or other chemical amendments that may be added to improve the blend ratios.

Task 5. Determine Feasible Solutions to Potential Surface-Groundwater Pair Supplies

Task 5 uses the information found in Tasks 3 and 4 to determine feasible solutions, if any, for each of the surface-groundwater pairings. Feasible solutions may include blending of sources, membrane treatment, chemical treatments, and others. Costs associated with the development of each feasible solution will be determined, including the cost of storage, treatment, blending facilities, transmission facilities, and waste disposal.

Task 5 includes the review of renewable energy options that could be used with the recommended strategies. Potential sources of renewable energy include wind and solar. Webber Energy Group¹ has researched the energy-water nexus. The results of the Webber research will be considered in determining feasible alternative energy sources.

Task 6. Assess Regulatory Framework

Task 6 will assess local, state and federal regulations that may affect the proposed project. Coordination needs with Groundwater Management Areas, Groundwater Conservation Districts, and Regional Water Planning Groups will be determined. Potential state regulations that might affect the feasible projects will be assessed and a regulatory strategy developed that describes the cost, timing, and risk from each regulator. Texas regulations regarding the discharge of impaired groundwater to surface water bodies will be reviewed and proper permitting approaches under the Texas Pollutant Discharge Elimination System (TPDES) program will be identified. Texas regulations regarding injection wells for the disposal of resulting waste will be investigated and the process to obtain such a permit will be identified.

Task 7. Study Results and Deliverables

The feasibility study will be summarized into a report and will provide recommendations and costs for potential surface-groundwater pairings. The advantages, disadvantages, and risks (availability and regulatory) for each pairing will be clearly described. The study will provide recommendations for the next steps to implement the feasible strategies. If results are favorable, the study could provide a recommendation to develop a pilot project to increase TRWD and/or Wichita Falls surface water supplies.

The deliverables associated with this feasibility study include semi-annual status reports, GIS-based database, maps, draft report and final report. Electronic copies of these deliverables will

be provided to the Bureau of Reclamation, TRWD and Wichita Falls. Paper copies of the draft report and final report will be provided as well.

The technical study description required by Section 4.B of the Reclamation Manual Directives and Standards, *Title XVI Water Reclamation and Reuse Program Feasibility Study Review Process (WTR 11-01)* are covered by the Evaluation Criteria in Section III below.

III. Evaluation Criteria

Criterion 1: Statement of Problems and Needs (10 points)

The North and West Central regions in Texas continue to endure an on-going drought. These regions experienced the worst single-year drought in 2011² since the drought of record in the 1950s. According to the U.S. Drought Monitor³, the study area is experiencing Moderate to Exceptional drought conditions as of April 29, 2014. The water level at TRWD's Lake Bridgeport is 21.71 feet below normal. All of TRWD customers are currently implementing Stage 1 water use restrictions.

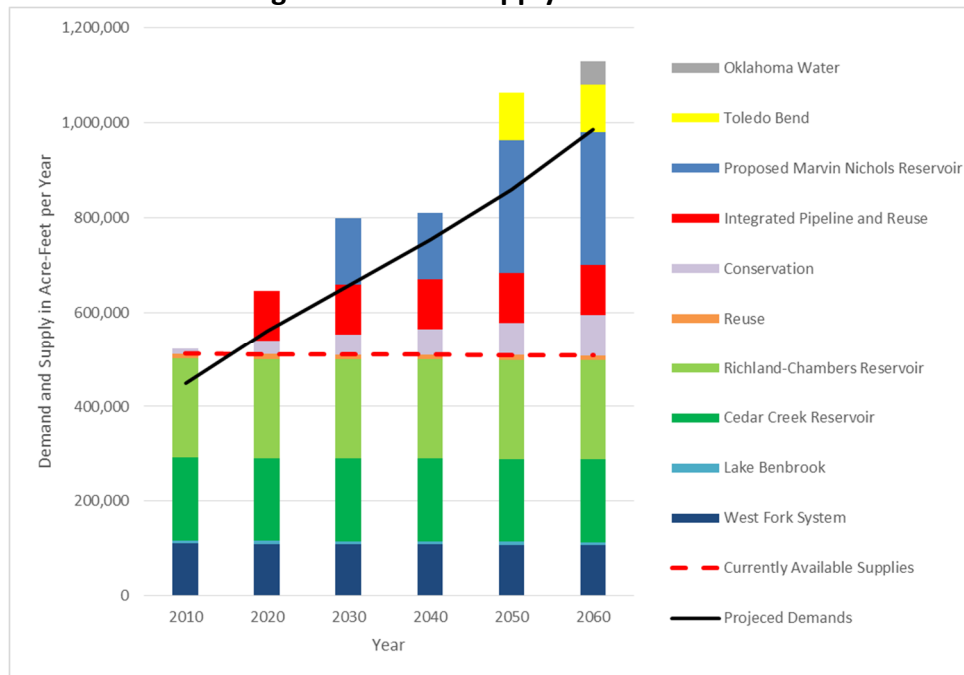
Wichita Falls is a partner in this study and is approaching implementing Stage 5 of its drought contingency plan, which requires extreme water use restrictions. The combined capacity of the three reservoirs in Wichita Falls' water supply system is below 30 percent of the storage capacity. Wichita Falls has been proactive with the implementation of increased water conservation in addition to its drought contingency plan. In hot weather climates like Texas, outdoor water usage represents approximately 60 percent of the total water usage in the summer months.⁴ Outdoor water usage is considered to be negligible in the winter months. Wichita Falls conservation and drought contingency programs have been so effective that the City's summer 2013 water usage was less than that of the previous winter. While record-breaking in terms of decreased seasonal usage, the reduction in water sales has a financial impact on Wichita Falls' water revenue. Therefore, Wichita Falls has less revenue to spend on developing additional water supplies.

Wichita Falls needs to find additional, reliable water supplies soon to avoid worsening drought impacts. This feasibility study will provide the answer as to whether or not using impaired groundwater within the study area will alleviate the situation.

TRWD provides raw water, wholesale supply to over 30 customers who in turn treat and distribute the water to more than 1.8 million people in North Texas. Figure 2 shows the currently available water supplies, projected demands, and recommended strategies that were included in the *2011 Region C Water Plan*⁵. Based on this information, TRWD needs to increase its water supplies before 2030. A recent TRWD study⁶ indicates that the current demands are not as high as previously projected and that additional supplies may be delayed if these lower demands continue to hold true.

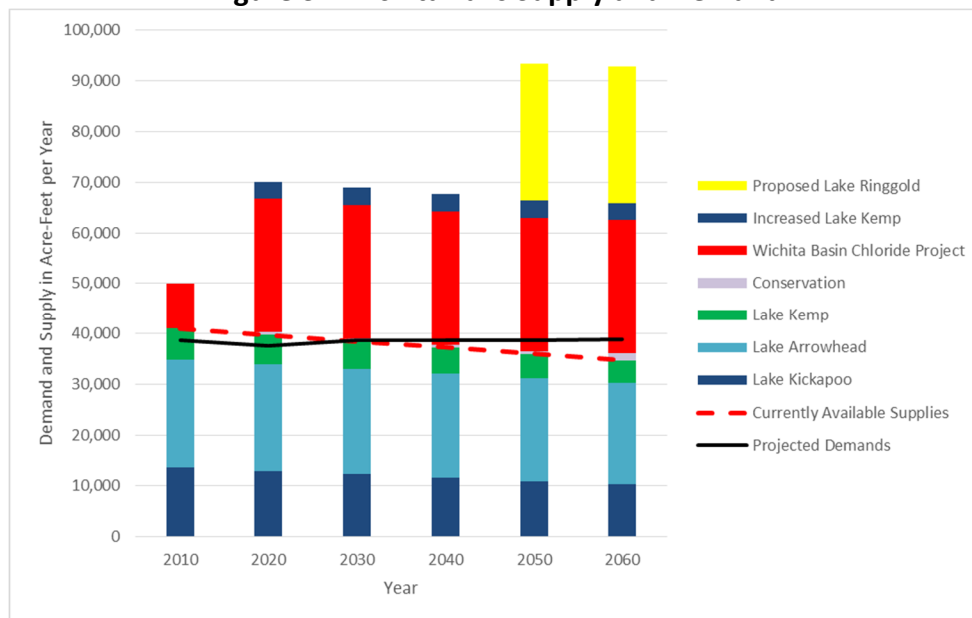
The City of Wichita Falls provides treated water to approximately 105,000 residents and raw water to more than 14 wholesale water customers in the Wichita, Archer and Clay County area. The 2011 Region B Water Plan shows that Wichita Falls will need additional supplies before

Figure 2. TRWD Supply and Demand



2030. However, the extreme drought situation has impacted the water supply storage for Wichita Falls that the City needs to find additional water supply immediately. Figure 3 shows the currently available supplies, projected demands, and recommended strategies in the *Region B Regional Water Plan*⁷.

Figure 3. Wichita Falls Supply and Demand



The current water supplies for TRWD and Wichita Falls are surface water supplies⁸, which are greatly impacted by the ongoing drought. TRWD and Wichita Falls plan to study the feasibility

of using impaired groundwater supplies to potentially supplement the existing surface water supplies within the TRWD and Wichita Falls water supply systems.

TRWD currently owns and operates four water supply reservoirs: Lake Bridgeport, Eagle Mountain Lake, Cedar Creek Reservoir and Richland-Chambers Reservoir. The TRWD water supply system includes three terminal storage reservoirs: Lake Benbrook, Lake Arlington, and Lake Worth. TRWD has a 2,000-acre wetland water reuse project adjacent to Richland-Chambers Reservoir. TRWD also holds water rights for an additional wetland reuse project at Cedar Creek Reservoir.

Wichita Falls currently relies on Lake Kickapoo and Lake Arrowhead for its water supply. Recently, Wichita Falls added Lake Kemp to its water supply system. While the State Water Plan indicates additional water supply is not needed for a number of years, the reality of the ongoing drought is proving that additional water supply is needed now for the City of Wichita Falls and its customers.

In addition to the physical impacts of the diminishing water supply in storage due to the ongoing drought, the lack of water supply represents a financial impact to the area. The *2012 State Water Plan*⁹ includes analyses of the socioeconomic impacts of not meeting the projected water needs. The results concluded that if a severe drought occurred in a single year, the projected 2060 employment would be reduced by 546,676 jobs in Region C and 108 jobs in Region B. Regional income would be reduced by \$49.7 billion in Region C and \$6 million in Region B in the year 2060. State and local business taxes would lose \$3 billion in Region C and \$0.5 million in Region B. When considering these impacts, it is important to keep in mind that Wichita Falls is the only wholesale water provider in the 11 counties that makeup Region B.

The existing TRWD and Wichita Falls water supplies do not have any significant water quality concerns. Therefore, these water supplies potentially could be used to blend impaired groundwater supplies, depending on the quality of the groundwater. This feasibility study will determine what, if any, additional pretreatment would be necessary to incorporate the groundwater supplies into the existing surface water systems.

TRWD and Wichita Falls are interested in identifying impaired groundwater supplies that can be used in a sustainable manner without impacting others who currently rely on these supplies. The goal of the proposed study is to determine feasible options to treat or blend the impaired groundwater with existing surface water supplies to limit the need to dispose of treatment byproducts, which may occur if saline groundwater is simply desalinated.

Criterion 2: Water Reclamation and Reuse Opportunities (15 points)

Potential Uses for Reclaimed Water

The feasibility study will focus on water reclamation associated with the potential use of impaired groundwater for additional water supply. TRWD provides water supply for municipal, manufacturing, mining, irrigation, and power generation. Wichita Falls provides water supply for municipal, manufacturing, and power generation. The water supply reservoirs have a recreational aspect to them, but that use is simply an added benefit to having the reservoirs.

The water quality from the existing supplies is acceptable for these uses. The study will investigate the type of treatment that would be needed to add impaired groundwater to the existing water supply systems without harming the existing systems or users.

Potential Water Market

The potential water markets that may be interested in purchasing impaired groundwater from TRWD and Wichita Falls include existing customers plus mining and/or power generation customers. Figure 4 shows the projected demand by type for Region C¹⁰. The majority of the water use in Region C is categorized as municipal use, followed by manufacturing and steam electric. Meeting municipal needs is critical to the growth of North Texas.

Figure 4. Region C Projected Water Demand by Type

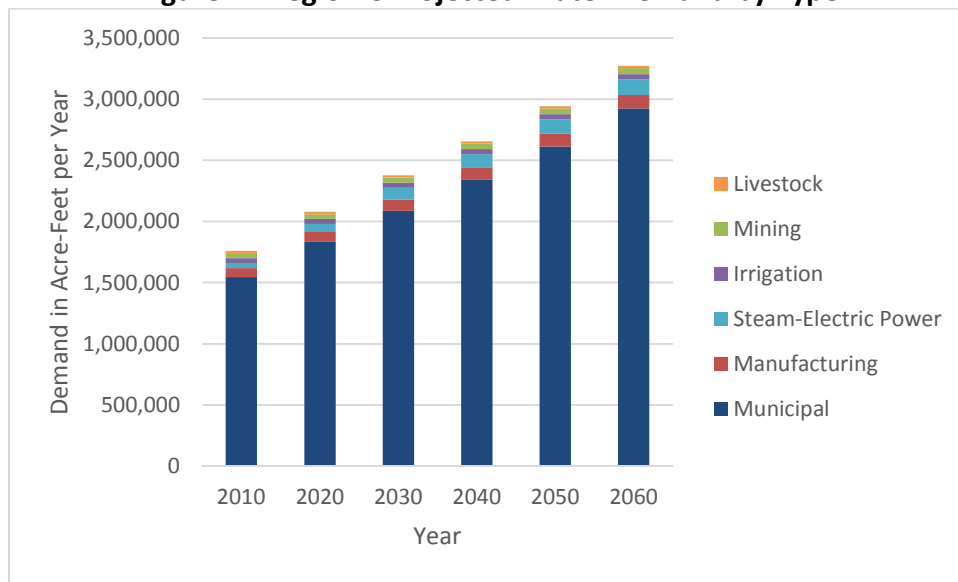
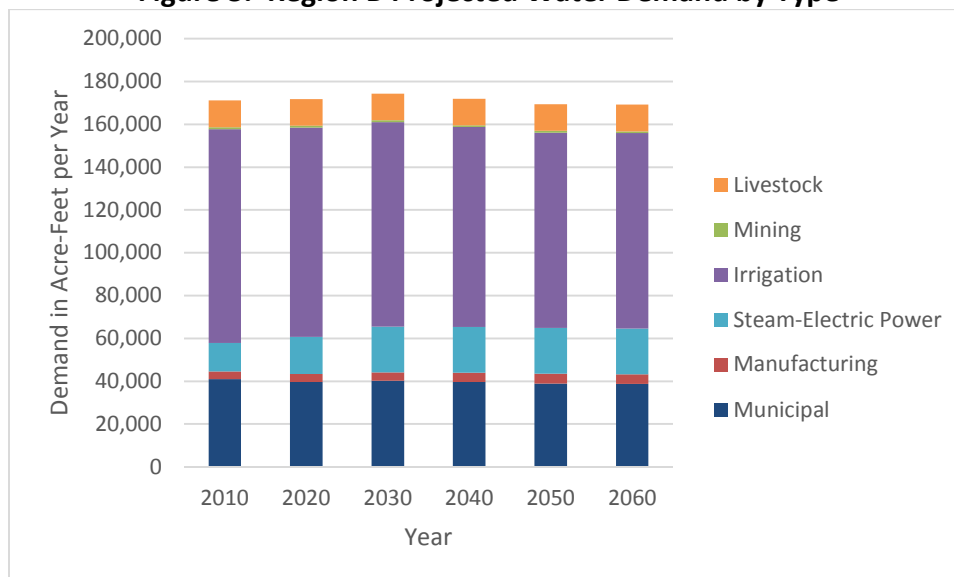


Figure 5 represents the projected water demand by type for Region B¹¹. The greatest water demand in Region B is irrigation. Municipal and steam electric power were the next largest types of water use. Thus, irrigation water demands tend to be the focus of Region B, which also represent the atypical customer of a wholesale water provider in North and West Central Texas. Therefore, meeting the municipal need is critical to sustaining the area.

If determined feasible, the addition of the impaired groundwater supply will be used by the existing customer base. If other potential customers are interested in purchasing this supply, TRWD and Wichita Falls would be open to discussing potential opportunities. However, the goal is to provide for the existing users.

The intent of this study is to provide additional water supply for existing users that is indistinguishable from the current water quality. TRWD and Wichita Falls do not anticipate any public acceptance issues with the proposed feasibility study or potential use of the sources of impaired groundwater. Depending on the study results, TRWD and Wichita Falls may need to develop a public outreach program to educate the public on the impacts associated with

Figure 5. Region B Projected Water Demand by Type



developing and not developing the potential water supply. However, public awareness of the ongoing drought should facilitate acceptance of the project.

The mining category includes oil and natural gas exploration and development. Multiple natural gas plays are being developed in the study area, including the Barnett Shale. The process of hydraulic fracturing, which is required to release oil and gas, requires approximately 4 million gallons of water per well¹². The impaired groundwater may be of high enough quality to be used as is by the mining industry, or it may require minimal treatment to meet the water quality requirements for the hydraulic fracturing process. This idea may be explored further if the groundwater quality is found to require minimal treatment. Again, the results of this study are intended to be used for the existing customer base.

Several power plants within the study area require water for cooling, steam generation and other processes. Water quality of impaired groundwater may be of such quality that it could be easily used for power generation purposes. This idea may be discussed with the power generation companies pending the feasibility study findings. TRWD and Wichita Falls are seeking additional water supplies for their current customers.

Impaired Waters to be Investigated

Impaired groundwater is known to exist in two primary areas within the TRWD and Wichita Falls area (Figure 1). The Trinity and Carrizo-Wilcox aquifers are located in the southeastern portion of the TRWD service area near Richland-Chambers Reservoir. The water quality in the Trinity aquifer is poor in terms of iron¹³ and dissolved solids in Navarro County¹⁴. However, the bigger concern may be the impairment due to elevated temperatures because the depth to water¹⁵ in the Trinity aquifer in Freestone County may be 3,500 to 4,000 feet, which may be too deep to economically develop. The Carrizo-Wilcox aquifer¹⁶ is impaired by elevated concentrations of iron, manganese, low pH, and localized concentrations of methane and

hydrogen sulfide in Freestone County. The proposed study will identify in detail the specific impairments associated with these aquifers using groundwater quality from state agencies and determine potentially feasible solutions to use these untapped water supplies.

The second location of interest is in West Central Texas. The Seymour aquifer in Clay County¹⁷,¹⁸ has elevated salinity and nitrate concentrations, as well as intermittent supply in this area. Other unnamed Paleozoic-age aquifers, including the Wichita-Albany Group¹⁹ have been identified in Clay County and may be of interest in this study. The Red River Alluvium typically has increased concentrations of dissolved solids²⁰.

Wichita Falls and TRWD have studied the possibility of developing the proposed Lake Ringgold²¹ in Clay County. The two water providers will use this study to determine if leveraging impaired groundwater with the surface water of the proposed Lake Ringgold would result in a mutually beneficial water supply project. Wichita Falls has an immediate need for additional water supply, whereas TRWD's water needs are farther out. Therefore, the two providers are in this study to determine how they might leverage their resources together. The two water providers are interested in determining whether or not the impaired groundwater supply could be developed in a cost-effective manner to supplement the existing surface water supply in the Wichita Falls service area.

Criterion 3: Description of Potential Alternatives (15 points)

Objectives of All Alternatives

The alternatives will be designed to meet the following objectives:

- Cost effectiveness
- Reliability of supply (quality, volume)
- Timeliness to implement project

TRWDB and Wichita Falls are interested in studying the feasibility of using impaired groundwater to augment their existing surface water supplies in a cost effective manner. This conjunctive use approach could supplement the existing surface water supplies without the need for developing additional storage for the groundwater.

The potential alternatives must provide reliable supply without impacting existing users that rely on these groundwater sources. The dependable yield of each strategy is of great interest to TRWD and Wichita Falls. Using brackish groundwater may require time for the formation to recover or recharge after certain volumes have been pumped. The recovery time will be considered in determining the reliability of the supply.

Due to the ongoing drought, TRWD and Wichita Falls need to implement additional water supply strategies quickly. Looking at Figures 2 and 3, TRWD's water needs are farther into the future, but Wichita Falls has an immediate need for additional water supplies. The ability of these two water providers to leverage the impaired groundwater with the proposed Lake Ringgold will determine their interest in developing these potential additional resources in partnership. The resulting project must be mutually beneficial to the providers. The time

anticipated to design, permit and construct each alternative is important to the water providers as they look for feasible options to augment the existing supplies that are diminished due to drought.

Other water supplies have already been considered for this area, including water conservation. The *2012 State Water Plan*²² includes the following recommended and alternative water management strategies for TRWD: Toledo Bend Reservoir, Marvin Nichols Reservoir (new reservoir), Oklahoma water, Lake Wright Patman, Lake Tehuacana (new reservoir), and Lake Livingston. The *2012 State Water Plan* recommends additional supply from Lake Kemp by raising the conservation pool and the proposed Lake Ringgold (new reservoir). The cost per acre-foot to develop each of these strategies ranges from \$1,000 to \$2,200. The findings of this feasibility study will be compared to the water management strategies. An economic analysis of the potentially feasible strategies will be performed according to the Economic Analysis requirements presented in the Reclamation Manual Directives and Standards²³. For consistency, the methodology applied in developing the cost estimates for the regional water plans will be applied to the potentially feasible strategies resulting from this study.

General Description

TRWD and Wichita Falls are pursuing this feasibility study together to determine if augmenting their surface water supplies with impaired groundwater supplies would result in a mutually beneficial water supply project. Wichita Falls is in immediate need of additional water supply due to the ongoing drought. The two water providers are cooperating in this study with the goal of finding an opportunity to leverage their partnership and water resources. The two focus areas include impaired groundwater supplies in Freestone and Navarro Counties near Richland-Chambers Reservoir and impaired groundwater in the Clay County area in the area of the proposed Lake Ringgold.

The results of this feasibility study will determine if either or both of these focus areas provide viable additional water supply. Conjunctive use of surface water and impaired groundwater could leverage these supplies and benefit both water providers.

The costs for developing additional water supply can be significant. This study will include a cost comparison of the potentially feasible strategies resulting from this study to those recommended in the *2012 State Water Plan*²⁴. While the costs are considerable, the cost of “doing nothing” could be more expensive and devastate the West Central Texas area. The socio-economic impacts of “doing nothing” were estimated in the 2011 regional water plans and will be compared to the potentially feasible strategies resulting from this study.

Alternative Measures or Technologies to be Investigated

The feasibility study will investigate a variety of potential treatment options (Task 5) that could make the impaired groundwater usable in a cost effective manner. Potential treatment options may include membranes, chemical treatment, and others. The cost of treatment options to improve the quality of the impaired groundwater will impact the feasibility of implementing each strategy.

Membrane treatments²⁵ include microfiltration, ultrafiltration, reverse osmosis, and nanofiltration. Each of these membranes have pores of specific sizes to trap particles from the water. Reverse osmosis is effectively non-porous and removes particles from the flow of water, including salts and organics. The chemical makeup of the impaired groundwater sources will determine which membrane option would be the best candidate to treat the impaired groundwater.

A variety of chemical treatments are available to address impurities in impaired groundwater. Chemical processes present an additional byproduct that will have to be disposed of in addition to the typical waste stream.

In addition to the alternative treatments to be considered, alternative sources of energy will also be considering. Wind and solar energy will be reviewed and recommendations will be made as to how to incorporate alternative energy to more efficiently operate the potentially feasible strategies.

Criterion 4: Stretching Water Supplies (15 points)

Potential to Reduce, Postpone or Eliminate Development of New Water Supplies

The proposed study has the potential to influence the schedule for development of new water supplies. If the study results in a recommendation to develop impaired groundwater in the southeastern portion of the TRWD service area, then TRWD may be able to delay the development of proposed reservoirs. If the study results in a recommendation to develop the impaired groundwater in Clay County, then TRWD and Wichita Falls could delay the development of the proposed Lake Ringgold.

Developing new reservoir projects is a time consuming and expensive venture. If the proposed impaired groundwater projects can be developed quickly and in a cost effective manner, TRWD and Wichita Falls would be interested in pursuing these options to increase the reliable water supply and delay the development of new reservoirs.

Potential to Reduce or Eliminate Use of Existing Sources

The proposed study will augment existing water supply sources. The feasibility study could diversify the water supplies. The current water supply systems for TRWD and Wichita Falls rely on surface water sources. The TRWD supply includes reuse that is diverted from the Trinity River and treated by way of constructed wetlands before introducing the reuse into the reservoir system. Adding a dependable brackish groundwater supply would diversify the overall water supply systems because the groundwater supplies are less likely to be impacted by drought than the surface water supplies. Therefore, the water supply systems would be more tolerant to the impacts of drought.

Potential to Reduce Demand on Federal Water Supply Facilities

Lake Benbrook is a Federal water supply project that is part of the TRWD water supply system. TRWD pumps water from Richland-Chambers Reservoir to Lake Benbrook. The water is stored in Lake Benbrook for use in the Tarrant County area. The water stored in Lake Benbrook is sent

to TRWD wholesale customers for treatment and distribution. Figure 1 shows the TRWD transmission system.

While Lake Benbrook is a Federal water supply project, the proposed study would continue to rely on the facility. The proposed study could potentially increase the use of the reservoir as a terminal storage facility by a nominal amount if the impaired groundwater in the southeastern area is developed and pumped to the Tarrant County area. However, implementing the proposed groundwater supply in Clay County likely would not have any impact on Lake Benbrook.

Criterion 5: Environment and Water Quality (15 points)

Potential to Improve Groundwater Quality

The feasibility study has the potential to improve the water quality of the impaired groundwater sources after the groundwater has been pumped. This study will investigate the current groundwater impairment issues and potential treatment methods. Treatment methods could include blending with existing surface water supplies, treatment plants, cooling facilities, and others.

The Trinity aquifer in the southeastern portion of the study area is known for having impairments associated with water quality and temperature. The Trinity aquifer has areas of brackish to possible saline water. The brackish groundwater could potentially be treated with membranes, or blending with a less saline source.

The Carrizo-Wilcox aquifer in the southeastern portion of the study area has issues with iron and pH. Iron can be treated by precipitating it out using a chemical process. The pH can be addressed using a chemical process or blending.

The Seymour aquifer has a history of water quality concerns, specifically total dissolved solids. These can be addressed by membranes, or blending with a less saline source, depending on the level of salinity. Geophysical logs for wells in the Paleozoic aquifer and the Red River Alluvium are available and indicate that the water quality is brackish in this area along the Red River in Clay County.

Potential to Improve Flow Conditions in Natural Stream

The proposed study could potentially improve flow conditions in natural streams depending on the location of the groundwater in relation to the surface water supply. If the impaired groundwater is located upstream of the reservoir, it may be possible to transmit the groundwater via natural streams using a bed and banks authorization, which would increase the flow in the natural stream up to the point where the water is then diverted into the water supply system.

If the groundwater supply is located downstream of the existing surface water supply, then the developed groundwater would be transported to the surface supply system using a pipeline and pump station. This scenario would not impact the existing natural stream condition in a positive or negative manner.

Depending on the amount of supply generated by the impaired groundwater source(s), the flow in natural streams could benefit from increased wastewater effluent after the water has been blended and used by customers. Tracking this potentially increased flow into the stream may be challenging.

Potential to Provide Habitat for Federally Listed Threatened or Endangered Species

In Clay County²⁶, the following species are listed as federally endangered: Interior Least Tern, Whooping Crane, Gray Wolf, and Red Wolf. In addition, Texas lists Interior Least Tern, Whooping Crane, Gray Wolf, and Red Wolf as endangered. No species are listed as federally threatened. Texas lists the American Peregrine Falcon, Bald Eagle, Peregrine Falcon, Texas Kangaroo Rat, and Texas Horned Lizard as threatened species.

Federally listed endangered species in Freestone County include Houston Toad, Interior Least Tern, Whooping Crane, and Red Wolf. In addition, Texas lists Houston Toad, Interior Least Tern, Whooping Crane, and Red Wolf as endangered species. The only federally listed threatened species is the Piping Plover. Texas shows American Peregrine Falcon, Bachman's Sparrow, Bald Eagle, Peregrine Falcon, Piping Plover, and Wood Stork as threatened species.

In Navarro County, the federally listed endangered species include Interior Least Tern, Whooping Crane, and Red Wolf. In addition, Texas has listed Interior Least Tern, Whooping Crane, and Red Wolf. The Piping Plover is listed as federally threatened. Texas has listed American Peregrine Falcon, Bald Eagle, Peregrine Falcon, Piping Plover, White-Faced Ibis, Wood Stork, Louisiana Pigtoe, Sandbank Pocketbook, Texas Heelsplitter, and Texas Pigtoe as threatened species.

These counties are known to have habitat that these species prefer. None of these species will be negatively impacted by this study. In fact, the study may result in a project that is beneficial to some of these species. In the event that a project uses natural streams to transport the groundwater to the surface water system, the increased flow in the natural stream is anticipated to be beneficial to threatened or endangered species that depend on such an environment. For any projects that are implemented as a result of this study, care would be taken to avoid negatively impacting any of these species if found in the area(s).

The Clean Water Act defines "wetlands" as "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas."²⁷ The U.S. Fish and Wildlife Service established the National Wetlands Inventory (NWI) in 1974 to conduct a nationwide inventory of U.S. wetlands. The NWI data indicates that approximately 910 acres of wetlands (815 acres of forested/shrub and 95 acres of emergent/herbaceous) may be located within the footprint of the proposed Lake Ringgold²⁸. While the proposed reservoir could impact the existing wetlands, the lake may also provide a source of water for the migratory birds that are listed as endangered or threatened.

Criterion 6: Legal and Institutional Requirements (10 points)

This study will consider legal and institutional requirements for implementing the feasible strategies. Texas water law adheres to the rule of capture, which means that no State-issued groundwater rights would have to be obtained in order to use impaired groundwater supplies. If the groundwater is blended with surface water, the groundwater must not come into contact with any surface water except that which is already under the control of TRWD or Wichita Falls. Otherwise, a new surface water right would be required.

The Mid-East Texas Groundwater Conservation District (GCD) oversees groundwater development in Freestone County. The implementation of any groundwater projects in Freestone County will require coordination with the GCD. No such GCD exists in Navarro County or Clay County. The GCD has the authority to establish and implement rules associated with well spacing and production volume within its jurisdiction. Traditionally, GCDs have not received many requests regarding the use of impaired groundwater supplies. Therefore, obtaining a permit from the Mid-East Texas GCD for the development of a recommended strategy in Freestone County is not anticipated to be an issue. Groundwater Management Areas (GMAs) are required to establish the desired future conditions of the aquifer. The proposed study area covers GMA 6 and 12.

TRWD owns property in Freestone County that could be used for the development of an impaired groundwater supply. Therefore, no additional agreements with other landowners would be needed to develop a well field on TRWD-owned property. If the Navarro County area proves to be more cost effective and dependable impaired groundwater supply, then TRWD would need to purchase property or obtain groundwater rights within the county.

The Clay County project location could be located on property already owned by the City of Wichita Falls. If that is the case, then no additional agreements would be needed with other landowners to develop a well field.

The Texas Commission on Environmental Quality (TCEQ) permits and regulates injection wells used for the disposal of municipal waste. Injection wells are used to dispose of waste below groundwater that is used for potable purposes. This study will confirm that a Class I injection well is needed from TCEQ and outline the process for obtaining such a permit.

Criterion 7: Renewable Energy and Energy Efficiency (10 points)

TRWD is aware of ongoing²⁹ and recently completed³⁰ alternative energy research studies by Webber Energy Group at the University of Texas that are of interest to the proposed study. One³¹ of the energy-water nexus studies that is underway is investigating opportunities to apply solar and wind energy to offset the costs associated with treating brackish and saline water. Another study³² identified alternative energy sources in Mexico that could be used to power water treatment processes. The results of the Webber Energy Group research will be considered and applied in this study.

TRWD is proactive in using renewable energy sources to power its water supply system. Since 2008, approximately five percent of the energy required by the District's transmission system is

provided from wind power purchased from West Texas. TRWD is currently in the process of converting its wind power supply to hydroelectric power generation, which will provide two percent of the District's total power needs for the high capacity pump stations. TRWD also uses 236 kWatts of solar power from a solar array that is located on the rooftop of the Annex Building at its Fort Worth office complex. The TRWD solar array is one of the largest in the State of Texas.

The proposed feasibility study will consider renewable or alternative energy options. Such energy options may include using wind turbines or solar panels to provide power to pump or possibly treat groundwater. Energy savings strategies from the Webber research will be applied in this study as appropriate.

Criterion 8: Watershed Perspective (10 points)

The proposed feasibility study is regional in nature. The existing TRWD supply and transmission system is shown in Figure 1. Currently, water from the Richland-Chambers and Cedar Creek Reservoirs is pumped roughly 80 miles to Lake Benbrook and an additional 30 miles to Eagle Mountain Lake for use in Tarrant, Wise, Parker, and Ellis Counties. The impaired groundwater would be added to this system for use throughout the TRWD service area.

The potential to augment the TRWD surface water system with impaired groundwater would impact most of the 1.8 million customers currently served. Wichita Falls provides water to the Wichita, Archer, and Clay County region. If this study recommends developing the impaired groundwater supply in Clay County, the communities served within the three county region would also benefit from the project. TRWD and Wichita Falls have considered joining efforts to provide water supplies to this three county area. If this were to happen, potentially all of the TRWD and Wichita Falls customers could benefit from the development of the impaired groundwater supplies – even if only one supply is implemented.

TRWD and Wichita Falls participate in the Region C and Region B Water Planning Groups in Texas. The regional water plans are developed with input from the local water providers. The plans include population and demand projections, currently available supplies, and recommended strategies to meet anticipated water supply shortfalls. The planning horizon provides a 50-year planning horizon. Afterwards, the Texas Water Development Board spends one year rolling the 16 regional water plans into a single *State Water Plan*³³. This planning effort is required by State law to be updated every five years. The most recent regional water plans are dated 2011 with the *State Water Plan* being 2012.

TRWD is currently finalizing its *Integrated Water Supply Plan*³⁴. The preliminary draft has been referenced multiple times in this application. This plan integrates the discrete planning that TRWD and its customers have performed and identifies new water supplies. The report provides an implementation plan for the next 50 years. This plan will be the guiding basis for TRWD as it moves forward in developing additional reliable water supplies in the future.

Wichita Falls recently completed a feasibility study³⁵ of the proposed Lake Ringgold, which has also been referenced in this application. The feasibility study investigated the viability of

developing the proposed Lake Ringgold. The proposed reservoir is a recommended strategy in the *2011 Region B Regional Water Plan*³⁶. The study concluded that Lake Ringgold is a viable project for additional water supplies and recommended that Wichita Falls proceed with obtaining the necessary water right and Section 404 permits for the project.

Required Permits or Approvals

Groundwater is subject to the “Rule of Capture” doctrine. The Rule of Capture³⁷ is a legal doctrine prescribing that each landowner can pump groundwater from under his or her property, without liability, provided the landowner’s actions are without malice, willful waste, or negligent subsidence, and conform to the rules and regulations of the local Groundwater Conservation District. Therefore, no State-issued groundwater permits will be needed to implement the proposed project if it is found to be a feasible water management strategy in either Clay or Navarro Counties. Permits for production volume and well spacing will need to be obtained from the Mid-East Texas Groundwater Conservation District in Freestone County.

Depending on the selected method to transport the groundwater to the surface water system, a bed and banks permit may be required. This permit would allow the groundwater to use existing natural streams to transport the supply to the water supply system. If a pipeline is needed to transport the groundwater, right-of-way may need to be obtained and environmental studies may be required for the pipeline route.

If a membrane treatment plant is recommended for a groundwater supply downstream of the surface water system, a Texas Pollutant Discharge Elimination System (TPDES) permit may be needed to discharge waste from the plant. TPDES permits require that the discharged effluent be at or above the water quality in the receiving stream prior to being discharged into said stream.

A Class I injection permit may be needed to dispose of the brine concentrate using deep well injection. In addition, TCEQ-approval would be required for the treatment plant and for the well construction.

Funding Plan and Letters of Commitment

TRWD will provide its local match in monetary form. The TRWD local match will include funds from its Fiscal Year Ending (FYE) 2015 and 2016 Revenue Fund Budgets plus contributions from Wichita Falls. Below are the responses to the four topics listed in the grant guidance document:

1. TRWD will provide cash match and will not seek in-kind reimbursements for this proposed study. TRWD is not seeking reimbursement or credit for expenses incurred prior to the anticipated study start date.
2. The full cost of the study is \$300,000. Tarrant Regional Water District has committed to funding the required local match of \$150,000. TRWD will use revenue from its FYE 2015 and 2016 Revenue Fund Budgets to fund the proposed study. The TRWD Board of Directors approved a resolution regarding this grant application and the ability to commit the required local matching funds on April 15, 2014. A copy of this resolution is included in Attachment 1. In addition, Wichita Falls has committed to participate in the



development of the feasibility study and to provide financial support towards the TRWD local match if TRWD is awarded the grant. A copy of the letter of commitment from Wichita Falls is included in Attachment 2.

3. TRWD has not requested or received any additional federal funding for the proposed study.
4. TRWD does not have any pending funding requests that have not yet been approved. TRWD and the City of Wichita Falls are the only two entities providing matching funds for the proposed study.

Table 1 summarizes the sources of funding for the proposed feasibility study. TRWD is committed to providing the full local match of up to \$150,000.00. Wichita Falls has committed to providing funds to offset the costs to be borne by TRWD for the local share by up to \$75,000.00. TRWD is requesting \$150,000.00 from the Bureau of Reclamation to develop the proposed feasibility study. The total cost for the study is \$300,000.00.

Table 1. Summary of Non-Federal and Federal Funding Sources

Funding Sources	Funding Amount
Non-Federal Entities	
1. Tarrant Regional Water District	\$75,000.00
2. City of Wichita Falls	\$75,000.00
<i>Non-Federal Subtotal</i>	<i>\$150,000.00</i>
Other Federal Entities	
1. None	\$0.00
<i>Other Federal Subtotal</i>	<i>\$0.00</i>
<i>Requested Reclamation Funding</i>	<i>\$150,000.00</i>
Total Study Funding	\$300,000.00

Official Resolution

The TRWD Board of Directors approved the resolution regarding this grant application on Tuesday, April 15, 2014. The resolution addresses all four required elements: identifying the designated official, support from the Board of Directors, local match, and deadlines to enter into a cooperative agreement. A copy of the resolution is included in Attachment 1.

Budget Proposal

I. Budget Narrative

TRWD policy requires that the District publish a request for qualifications (RFQs) before awarding studies to consultants or contractors. The May 6 deadline for this grant application does not provide enough time for TRWD to solicit RFQs and select a consultant to perform the study. Therefore, TRWD will solicit RFQs after this application is submitted to the Bureau of Reclamation and if the proposed study is selected to be awarded the grant. The information

regarding consultant/contractor costs to prepare the proposed study is based on input from groundwater specialists.

Salaries and Wages

TRWD will provide staff to direct the proposed study and provide input. However, TRWD is not seeking reimbursement for this activity. TRWD prefers to use the grant funds (if awarded) on developing the study itself. Therefore, the salary and wage rates for TRWD staff are irrelevant to this application. No annual salary wages for TRWD staff need to be accounted for.

In the event that TRWD receives this grant, the District will provide salary and wage information for the selected consultant to the Bureau of Reclamation prior to executing a contract with said consultant.

Fringe Benefits

Since TRWD is not seeking reimbursement for its own staff time spent on the proposed study, the fringe benefit rates are irrelevant to the total cost of the proposed project.

If awarded the grant, TRWD will provide the fringe benefit rates of the selected consultant prior to executing a contract with said consultant.

Travel

This grant does not require any travel to Bureau of Reclamation offices for project updates or project findings. TRWD staff and Wichita Falls staff will travel between Fort Worth and Wichita Falls for meetings associated with this study. They may also travel to the proposed project sites. However, TRWD and Wichita Falls are not requesting reimbursement for travel.

TRWD expects that the selected consultant will have travel expenses. TRWD will provide these anticipated expenses to the Bureau of Reclamation prior to executing a contract with said consultant.

Equipment

The study does not anticipate the need for equipment reimbursement.

Materials and Supplies

The proposed study will require materials and supplies for office and research uses. These costs will be determined by the selected consultant. If awarded this grant, TRWD will provide the Bureau of Reclamation with the anticipated costs of materials and supplies prior to executing a contract with the selected consultant.

Contractual

TRWD intends to publish a request for qualifications (RFQs) from qualified groundwater specialists to develop the proposed study. TRWD shall go through a formal RFQ process prior to selecting a consultant. The grant deadline did not provide ample time to solicit RFQs and select a consultant prior to the application submittal. If awarded this grant, TRWD will go through its

formal consultant selection process and will notify the Bureau of Reclamation as to whom it selects based on qualifications.

TRWD worked with several groundwater specialty firms to develop the scope of work and placeholder fees associated with this proposed study. TRWD understands that the contract executed for consulting services will require Bureau of Reclamation approval. The placeholder costs highlighted in blue in Table 2 are the costs that will be provided by the selected consultant when the contract is executed. The final costs negotiated with the selected consultant will not be greater than the placeholder costs.

Table 2. Budget

Budget Item Description	Computation		Quantity Type	Total Cost	Comments
	\$/Unit	Quantity			
Salaries and Wages				\$0.00	N/A
Fringe Benefits				\$0.00	N/A
Travel				\$0.00	N/A
Equipment				\$0.00	None
Materials and Supplies				\$0.00	N/A
Contractual					
Consultant				\$300,000.00	Placeholder value
Reporting				\$0.00	Consultant fee
Other				\$0.00	N/A
Indirect Costs				\$0.00	N/A
Total Cost				\$300,000.00	

Notes: ■ Blue entries indicate that the value is a placeholder cost until the costs are finalized by the selected consultant.

N/A indicates that the field is not applicable because reimbursement is not requested.

The proposed scope of work is as follows:

Task 1. Determine Impaired Groundwater Availability

Using publicly available information from state agencies, academia, and existing Groundwater Availability Models, estimate the potential groundwater availability from impaired groundwater sources near TRWD and Wichita Falls surface water supplies. Groundwater supplies to be considered include the Trinity, Carrizo-Wilcox, and Seymour aquifers. Obtain, review and estimate the potential for developing groundwater supplies from the Paleozoic Formations and the Red River Alluvium near the Red River in Clay County.

Task 2. Evaluate Existing Water Quality Data

Develop a GIS database summarizing existing groundwater and surface water quality data from the Texas Water Development Board (TWDB), Texas Commission on Environmental Quality (TCEQ), TRWD, and Wichita Falls. Groundwater sources to be considered include the Trinity and Carrizo-Wilcox aquifers near Richland-Chambers Reservoir (Freestone and Navarro

Counties) and the Seymour, Paleozoic Formations, and the Red River Alluvium near the surface water supplies of the proposed Lake Ringgold (Clay County).

Develop appropriate representations of groundwater quality that demonstrate that an aquifer is considered to be impaired due to the presence of constituents that exceed EPA primary or secondary drinking water standards. Potential impairments may include iron, manganese, chloride, sulfate, temperature, total dissolved solids, and other constituents identified in this task.

Task 3. Collect and Analyze Groundwater Samples

In the event that adequate groundwater quality data is not readily available, select up to three existing groundwater wells near each reservoir site (approximately 6 wells) at which to collect groundwater samples from aquifers that are anticipated to be impaired based on the results of Task 2. Analyze the water samples for a suite of major and minor anions and add the test results to the GIS database.

If possible, develop a statistical profile of the surface and groundwater chemistry to estimate the frequency of and variability of potential blending scenarios to account for the changing chemistry in the water sources throughout the year.

Task 4. Modeling Groundwater and Surface Water Mixes

Run a hydrochemical mixing model of groundwater and surface water quality parameters using PHREEQC or similar software for each of the surface-groundwater source pairs. Assess mineral precipitation, dissolution, or corrosion potential caused by mixing or changes in temperature. Identify hydrochemical processes that may impact the feasibility of a surface-groundwater pairing. Estimate potential blend ratios that will achieve a mixed water that meet EPA/Texas drinking water standards. Identify any antiscalants, pH adjustments or other chemical amendments that may be added to improve the blend ratios.

Task 5. Determine Feasible Solutions to Potential Surface-Groundwater Pair Supplies

Using the information found in Tasks 3 and 4, determine feasible solutions, if any, for each of the surface-groundwater pairings. Feasible solutions may include blending of sources, membrane treatment, chemical treatments, and others. Determine costs associated with developing each feasible solution, including the cost of storage, treatment, blending facilities, transmission facilities, and waste disposal.

Review renewable energy options that could be used with the recommended strategies. Potential sources of renewable energy include wind and solar. Webber Energy Group³⁸ researches opportunities to maximize the energy-water nexus. The results of the Webber research will be considered in determining feasible alternative energy sources.

Task 6. Assess Regulatory Framework

Assess local, state and federal regulations that may affect the proposed project. Coordination needs with Groundwater Management Areas, Groundwater Conservation Districts, and Regional Water Planning Groups will be determined. Potential state regulations that might



affect the feasible projects will be assessed and a regulatory strategy developed that describes the cost, timing, and risk from each regulator. Texas regulations regarding the discharge of impaired groundwater to surface water bodies will be reviewed and proper permitting approached under the Texas Pollutant Discharge Elimination System (TPDES) program will be identified. Texas regulations regarding injection wells for the disposal of resulting waste will be investigated and the process to obtain such a permit will be identified.

Task 7. Study Results and Deliverables

The feasibility study will be summarized into a report and will provide recommendations and costs for potential surface-groundwater pairings. The advantages, disadvantages, and risks (availability and regulatory) for each pairing will be clearly described. The study will provide recommendations for the next steps to implement the feasible strategies. If results are favorable, the study could provide a recommendation to develop a pilot project to increase TRWD and/or Wichita Falls surface water supplies.

The deliverables associated with this feasibility study include semi-annual status reports, GIS-based database, maps, draft report and final report. Electronic copies of these deliverables will be provided to the Bureau of Reclamation, TRWD and Wichita Falls. Paper copies of the draft report and final report will be provided as well.

Table 3 presents the scope of work tasks and placeholder costs anticipated for each task and associated expenses. The hours to complete each task may be adjusted based on the selected consultant’s recommendations. Therefore, the final contract may show that one task costs more or less than what is presented in this application, but the total cost for the feasibility study will not exceed the amount requested in this grant application.

Table 3. Placeholder Summary Costs per Task

Task #	Task Description	Estimated Hours	Estimated Cost
1	Determine Impaired Groundwater Availability	350	\$35,000.00
2	Evaluate Existing Water Quality Data	350	\$35,000.00
3	Collect and Analyze Groundwater Samples	550	\$55,000.00
4	Modeling Groundwater and Surface Water Mixes	550	\$55,000.00
5	Determine Feasible Solutions	650	\$65,000.00
6	Assess Regulatory Framework	200	\$20,000.00
7	Study Results and Deliverables	350	\$35,000.00
Total			\$300,000.00

Blue entries indicate that the value is a placeholder cost until the costs are finalized by the selected consultant.

The proposed study is anticipated to begin on October 1, 2014 and take 18 months to complete. If awarded the contract, TRWD anticipates completing its RFQ process within six weeks of receiving notification that this feasibility study will be funded by this grant. TRWD assumes that the Bureau will review and approve the draft consultant contract within two weeks. TRWD anticipates executing a contract with the selected consultant two weeks after



receiving approval from Bureau of Reclamation. The feasibility study will begin upon contract execution. The entire study will be complete by March 31, 2016, assuming that the project begins by October 1, 2014. The proposed schedule is shown in Table 4.

Table 4. Schedule

Task	2014			2015												2016		
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Awards announced	█																	
Consultant selection	█																	
Bureau approval of consultant	█	█																
TRWD executes contract		█																
Task 1. Determine Impaired Groundwater Availability			█	█	█													
Submit semi-annual status report						█												
Task 2. Evaluating Existing Water Quality Data				█	█	█	█											
Task 3. Analyze Water Samples					█	█	█	█										
Task 4. Modeling Groundwater and Surface Water Mixes									█	█	█	█						
Submit semi-annual status report													█					
Task 5 Determine Feasible Solutions												█	█	█	█			
Task 6. Assess Regulatory Framework				█	█								█	█	█			
Task 7. Study Results and Deliverables														█	█	█	█	█
Submit semi-annual status report						█							█					█

Reporting

TRWD understands that the Bureau of Reclamation requires semi-annual status reports to be prepared and submitted to keep the Bureau informed of the status of the proposed study. TRWD will submit semi-annual status reports every six months based on input provided by the selected consultant. The status report will include a description of the tasks completed. In addition, form SF-425 will be prepared and submitted semi-annually that summarizes the costs incurred.

Other

No other costs are submitted for consideration.

Indirect Costs

No indirect costs are submitting for consideration.

Total Cost

The total cost for the proposed study is \$300,000. The details of the cost estimate are shown in Table 2. TRWD is requesting \$150,000 from the Bureau of Reclamation through this grant application. TRWD guarantees to cover the local match of \$150,000. TRWD and Wichita Falls have agreed to share the cost of local match with each entity providing \$75,000. Table 5 summarizes the sources of funding for the proposed study. In the event that the Bureau of Reclamation is able to fund a portion of the requested funding, TRWD is willing to negotiate the scope of work and fee to accommodate whatever level of funding could be made available.

Budget Form

SF-424A has been completed and is attached to SF-424.

Table 5. Funding Sources

Funding Sources	% of Total Study Cost	Total Cost by Source
TRWD Funding (local match)	25%	\$75,000.00
Wichita Falls Funding (local match)	25%	\$75,000.00
Reclamation Funding	50%	\$150,000.00
Total	100%	\$300,000.00

Attachment 1 - TRWD Resolution

**RESOLUTION OF THE BOARD OF DIRECTORS OF THE
TARRANT REGIONAL WATER DISTRICT
AUTHORIZING APPLICATION TO THE BUREAU OF RECLAMATION
FOR WaterSMART GRANT FUNDING UNDER TITLE XVI WATER RECLAMATION
AND REUSE PROGRAM**

WHEREAS, Tarrant Regional Water District, a Water Control and Improvement District ("District") supplies wholesale raw water supply to a service area population of approximately 1.8 million persons residing in more than seventy (70) cities and eleven (11) counties , and ;

WHEREAS, the District has an established record of regional water supply provision, as well as establishing effective planning and resource management relationships throughout North Texas and neighboring regions, and;

WHEREAS, the Department of the Interior through the Bureau of Reclamation WaterSMART grant program under Title XVI Water Reclamation and Reuse Program offers to applicants up to 50 percent of the cost of feasibility studies of water reclamation and reuse projects, and;

NOW, THEREFORE, be it resolved by the Board of Directors of the Tarrant Regional Water District, that staff is authorized to submit application to the Bureau of Reclamation individually or with partner agencies for WaterSMART grant funding under Title XVI Water Reclamation and Reuse Program. Jim Oliver is authorized to enter into cooperative agreements related to both securing grant funding and compliance with grant requirements and deadlines without further action of this Board.

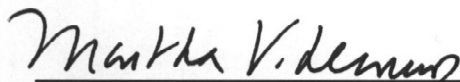
PASSED, APPROVED AND ADOPTED THIS 15TH DAY OF APRIL, 2014

TARRANT REGIONAL WATER DISTRICT

BY: 

Victor W. Henderson
President
Board of Directors

ATTEST:



Martha V. Leonard
Secretary



PUBLIC WORKS DEPARTMENT

April 28, 2014

Tarrant Regional Water District
800 E. North Side Drive
Fort Worth, Texas 76102

Attn: Wayne Owen

Re: Grant Application for Feasibility Study of the Potential Use of Impaired Groundwater Supplies

Mr. Owen,

The City of Wichita Falls would be pleased to partner with the Tarrant Regional Water District (TRWD) in the above referenced study. With the unprecedented drought conditions in the North Texas area, the City is interested in diversifying its water supply portfolio in any way possible. This study could potentially be the first step in that process.

Negotiations for the City's level of participation and financial obligations would be established if the grant application is successful.

Thank you for considering the City as a partner in this study.

Sincerely:

Russell Schreiber P.E.

Director of Public Works.

CITY OF WICHITA FALLS

Attachment 3 – References

References

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- ² Nielsen-Gammon, J.W. (October 2011). *The 2011 Texas Drought: A Briefing Packet for the Texas Legislature*. Austin, Texas. Downloaded April 24, 2014 from URL: http://climatexas.tamu.edu/files/2011_drought.pdf
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- ⁴ Alliance for Water Efficiency. (2010). “Residential End Users of Water Supply”. Downloaded May 2, 2014 from URL: <http://www.allianceforwaterefficiency.org/residential-end-uses-of-water-study-1999.aspx>
- ⁵ Freese and Nichols, Inc., Alan Plummer Associates, Inc., CP&Y, Inc. and Cooksey Communications, Inc. (October 2010). *2011 Region C Water Plan*, prepared for the Region C Water Planning Group. Downloaded on May 2, 2014 from URL: http://www.twdb.state.tx.us/waterplanning/rwp/plans/2011/C/Region_C_2011_RWPV1.pdf
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- ⁸ Texas Water Development Board. (January 2012). *Water for Texas 2012 State Water Plan*. Austin, Texas. Downloaded April 24, 2014 from URL: <http://www.twdb.state.tx.us/waterplanning/swp/2012/index.asp>
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- ¹⁰ Texas Water Development Board. (January 2012). *Water for Texas 2012 State Water Plan*. Austin, Texas. Downloaded April 24, 2014 from URL: <http://www.twdb.state.tx.us/waterplanning/swp/2012/index.asp>
- ¹¹ Texas Water Development Board. (January 2012). *Water for Texas 2012 State Water Plan*. Austin, Texas. Downloaded April 24, 2014 from URL: <http://www.twdb.state.tx.us/waterplanning/swp/2012/index.asp>
- ¹² Nicot, J.P. and Scanlon, B.R. (2012). “Water Use for Shale-Gas Production in Texas, U.S.” published in *Environmental Science and Technology*, on behalf of the Bureau of Economic Geology. Austin, Texas. Downloaded April 24, 2014 from URL: http://www.circleofblue.org/waternews/wp-content/uploads/2013/04/Nicot+Scanlon_EST_12_Water-Use-Fracking.pdf
- ¹³ Nordstrom, P.L. (1982). “Occurrence, availability, and chemical quality of ground water in the Cretaceous aquifers of North-Central Texas”. *TDWR Rept. 269, 2 vols.* Austin, Texas.

Attachment 3 – References

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¹⁴ Nordstrom, P.L. (1982). "Occurrence, availability, and chemical quality of ground water in the Cretaceous aquifers of North-Central Texas". *TDWR Rept. 269, 2 vols.* Austin, Texas.

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¹⁶ Ashworth, J.B. and Hopkins, J. (1995). "Aquifers of Texas". *Texas Water Development Board Report 345.* Austin, Texas. Downloaded April 25, 2014 from URL:

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¹⁸ Nicot, J.P. and Scanlon, B.R. (2012). "Water Use for Shale-Gas Production in Texas, U.S." published in *Environmental Science and Technology*, on behalf of the Bureau of Economic Geology. Austin, Texas. Downloaded April 24, 2014 from URL:

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²² Texas Water Development Board. (January 2012). *Water for Texas 2012 State Water Plan.* Austin, Texas. Downloaded April 24, 2014 from URL:

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