



**US Army Corps  
of Engineers®**

Tulsa District

*FINAL*

**SUNFLOWER H2O  
STATE OF KANSAS  
SECTION 22  
PLANNING ASSISTANCE TO STATES**

# **WATER SUPPLY AND DEMAND REPORT**

**TULSA DISTRICT  
U.S. ARMY CORPS OF ENGINEERS**

**FEBRUARY 2013**

**SUNFLOWER H2O  
STATE OF KANSAS  
SECTION 22  
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## EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers, Tulsa District facilitated this study at the request of the Kansas Water Office and the Sunflower H2O Coalition, a consortium of stakeholders interested in water issues in south central Kansas and north central Oklahoma. The purpose of the study was to determine the water supply and water demand of a portion of the Sunflower H2O Initiative area in four Kansas counties (Barber, Harper, Kingman Pratt) and one Oklahoma county (Woods) , as well as to identify associated water based recreation opportunities. The Corps' involvement in the study was executed under Section 22 of the Water Resources Development Act of 1974, as part of the Corps Planning Assistance to States Program. The study examined three areas: 1. demand and net need for water in the Sunflower H2O Initiative defined study area; 2. supply for water with a focus on the water quantity and costs of future ground and surface sources; and, 3. recreational opportunities and possible usage of a potential new surface water reservoir. This report provides a summary of the analysis conducted to address these areas. This report references appendices, which present the details on the methods, assumptions and findings of the study. The existing water supply and demand analysis was led by the Kansas Water Office. The analysis of water quantity and costs was conducted by C.H. Guernsey, a private contractor, and the recreation analysis was performed by Corps of Engineers staff.

The study found that the existing demands for water supply in the study area counties of south central Kansas and north central Oklahoma are currently being met - entirely by groundwater sources. The population in this area has been in a slight decline in recent decades. Though water demand from population growth may not be a major consideration in the future, historic trends of decline may not continue in the long term. Emerging economic activities such as that associated with the energy exploration/production sector, may reverse - to a degree - those historic trends of decline. In the future, the issue of groundwater quality may be an increasing challenge due to the prevalence of nitrate contamination in the region.

The study identified several potential ground and surface sources for the region's water supply. The optimal groundwater source would be the Kiowa County Aquifer, costing approximately \$2.2 million to develop with an estimated yield of 1.2 million gallons per day. The optimal surface water source would be a proposed Elm Creek Reservoir, costing approximately \$95.5 million to develop with an estimated yield of 12.4 million gallons per day. The costs do not reflect environmental mitigation costs or, real estate and mineral acquisition, which could be substantial. In examining recreational opportunities for the Elm Creek Reservoir site, the study found that such a lake could generate approximately 282,000 visitors annually.

The study recommends that the Kiowa County Aquifer be used, if the stakeholders decide there is a need for additional water supply in the future and the stakeholders choose to use groundwater for this source. The Elm Creek Reservoir should be developed if stakeholders decide that investment in a surface water source is necessary to meet potential future demand. There is sufficient interest in development of a recreational lake in the study area. Consequently, the issues of costs, environmental consequences, and social acceptability along with the associated benefits should be part of the decision making process during future considerations.

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**1.0 INTRODUCTION.**

**1.1 Background.**

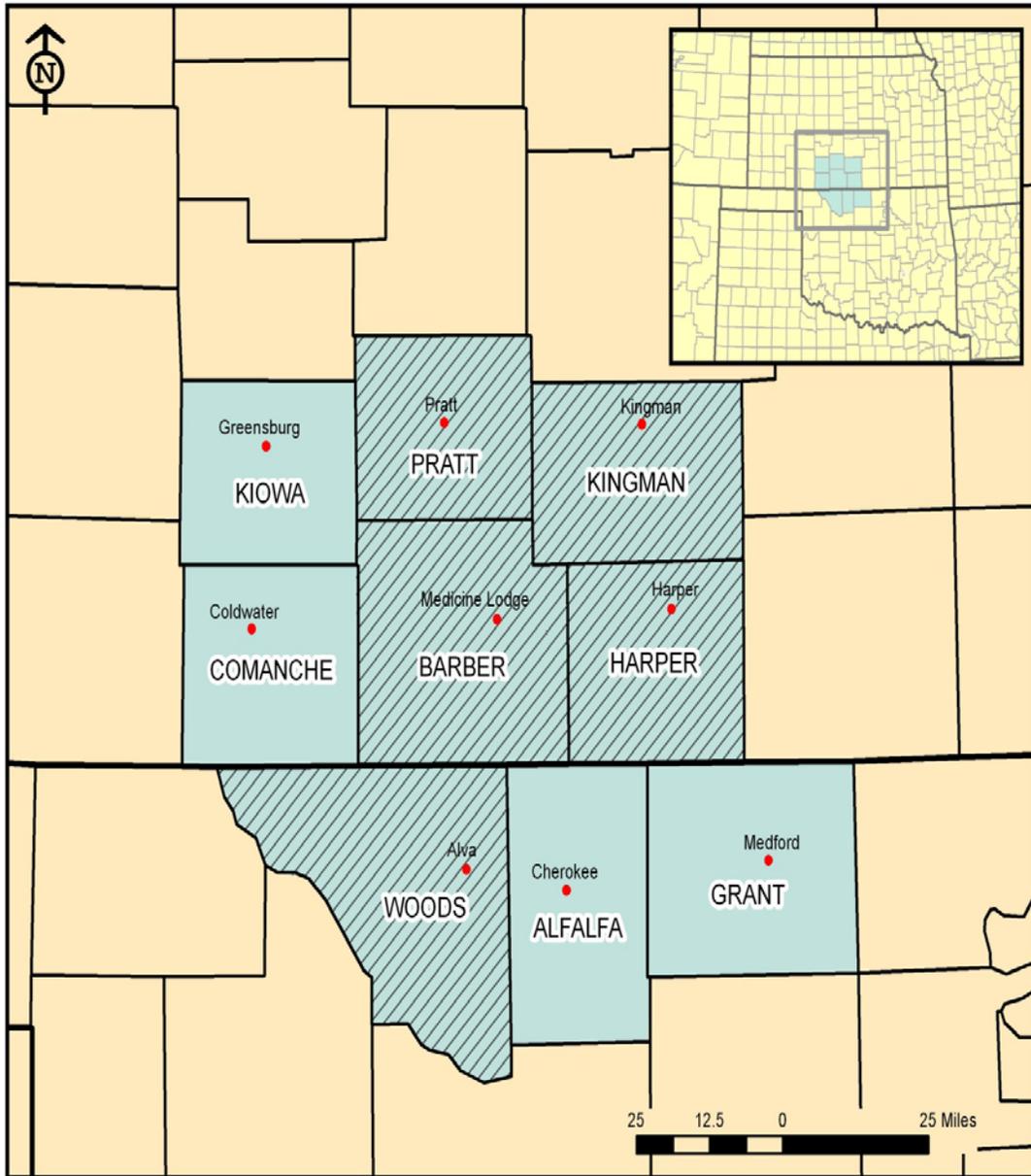
This water supply and demand study was undertaken at the request of the Kansas Water Office and the Sunflower H2O Initiative to determine the water supply and water demand of the Sunflower Initiative H2O area. The Sunflower H2O Initiative is a consortium of rural communities and water districts in south central Kansas and north central Oklahoma. This study builds upon information presented in the document “Preliminary Engineering Report Phase 1: Sunflower H2O Initiative” dated January 2008. The Phase 1 report included all of the Sunflower H2O Initiative area (six counties in south central Kansas and four counties in north central Oklahoma) as indicated on Figure 1.

**1.2 Purpose and Need.**

The exact nature of future water demand and supply sources in south-central Kansas and north-central Oklahoma is uncertain. A stakeholder group - the Sunflower H2O Initiative - in conjunction with the Kansas Water Office and the Oklahoma Water Resources Board have taken an interest in developing a better understanding of what the demand is in this portion of Kansas and Oklahoma. They have also examined practical ways of meeting that demand in the future. The purpose of this study is to define the existing and future water supply demand and the current and potential supply sources to meet the demand. This study also addresses potential water supply sources to meet future demand by users in the Sunflower H2O Initiative area. To maximize the beneficial uses of the water resources, this study will also examine how these water supply sources could meet the demand for water based recreation in the region.

**1.3 Study Scope.**

The scope of this water supply and demand study is the partial Sunflower H2O Initiative membership area, which covers rural communities and water districts in four counties in south-central Kansas and one county in north-central Oklahoma. The four counties in Kansas are Barber, Harper, Kingman and Pratt; and Woods County in Oklahoma. There are approximately 36 public water supplies within the study area. The study area is shown on Figure 1 by the crosshatched area.



LEGEND

- Sunflower H<sub>2</sub>O Initiative Area
- Water Supply and Demand Study Area

Figure 1 – Study Vicinity Map

#### 1.4 Study Authority.

This Planning Assistance to States study is conducted under authority of Section 22 of the Water Resources Development Act of 1974 as amended which states:

*"(a) The Secretary of the Army, acting through the Chief of Engineers, is authorized to cooperate with any State in the preparation of comprehensive plans for the development, utilization, and conservation of the water and related resources of drainage basins located within the boundaries of such State and to submit to Congress reports and recommendations with respect to appropriate Federal participation in carrying out such plans.*

*(b) There is authorized to be appropriated not to exceed \$2,000,000 annually to carry out the provisions of this section except that not more than \$200,000 shall be expended in any one year in any one State."*

The total cost for this water supply and demand study was \$200,000 which was cost shared 50/50 between the Kansas Water Office and the Federal government. Federal funds in the amount of \$100,000 were appropriated in Fiscal Year 2010 for the Federal government's share and the Kansas Water Office contributed \$45,000 in cash and \$55,000 in work-in-kind for their share of this study. The Sunflower H2O Initiative contributed 50 percent of the Kansas Water Office's share of this study with \$40,000 in cash and \$10,000 as work-in-kind.

#### 1.5 Study Area Description.

The study area consists of four counties in Kansas (Barber, Harper, Kingman, and Pratt) and one county in Oklahoma (Woods). There are over 30 public water supply systems in the study area and groundwater is the sole source for these water supplies.

#### 1.6 Prior Studies.

The Bartlett & West and C.H. Guernsey report titled "Preliminary Engineering Report Phase 1: Sunflower H2O Initiative" dated January 2008, previously examined the water supply and the water demand needs of the Sunflower H2O Initiative area and concluded that additional studies were needed to accurately determine the water need (demand) and the current and future water supply sources available to the study area.

#### 1.7 Study Approach.

This study consisted of five parts -water needs assessment, identification of potential surface water sources, identification of potential groundwater sources, a preliminary recreation analysis and an integrated report to combine parts 1 through 4 into a complete water supply and demand report.

The first part - Water Needs Assessment - of this study for the Sunflower H2O Initiative area was supplied by the Kansas Water Office, as work in kind for this study. The Water Needs Assessment will be discussed in Section 2.0 of this water supply and demand report.

After the Water Needs Assessment was submitted to the Corps, C. H, Guernsey – through contract (and using Bartlett and West as a sub-contractor) - developed both (parts 2 and 3), the potential surface water and potential groundwater sources for the Sunflower H2O Initiative area. The potential water supply sources will be discussed in Section 3.0 of this water supply and demand report.

After the potential water supply sources were developed enough to determine which potential surface water supply source would be selected, the Corps began to work on the preliminary recreation analysis (part 4) for this study. The Recreation Analysis will be discussed in Section 4.0 of this water supply and demand study.

Lastly, the first four parts of this study will be consolidated into a complete water supply and demand report for the Sunflower H2O Initiative with a conclusion and recommendation, which will be discussed in Section 5.0.

## **2.0 WATER NEEDS ASSESSMENT.**

The water needs assessment supplied by the Kansas Water Office was prepared by the Kansas Rural Water Association under the direction of the Water Office. The assessment is titled “Needs Assessment, A component of the Sunflower H2O Water Supply and Demand Study”, dated November 2012, and is located in Appendix A of this report. This section of the report will be a synopsis of the water needs assessment.

This assessment covered four (Barber, Harper, Kingman and Pratt) of the six Kansas counties and one (Woods) of the three Oklahoma counties in the Sunflower H2O Initiative. The assessment had an objective to determine if the public water supplies in these five counties could meet their future water demands. This assessment looked at populations, water diverted, water rights, water quality, water supply operations and a summary of the eight largest public water supplies in the five counties.

The four county Kansas area has a total of 30 public water supplies and serves 20,921 people. The total 2010 census population for the four county area was 27,067; therefore 77 percent of these four counties were served by these public water supplies. For Woods County in Oklahoma, there are 6 public water supplies and they serve approximately 7,200 people or about 98 percent of the county population.

The historical and projected populations for these five counties are shown in tables included in Appendix A and show that for these counties, and as a whole, the populations are decreasing and expected to continue to decrease in the future. The populations of these four counties have been declining since 2000 with a range in 2000-2010 of 4.3 – 13.8%. The overall average for the four counties is a decrease of 9.8%. The projected future populations for these four counties and overall average continues to decline. In 2010-2020, the population is forecast to decrease from 2.66 – 11.99% while the overall average population projection is an 8.14% decrease. By 2030 the population is forecasted to decrease by a range of 4.1 – 21.6% in the four county area with an

average of 14.5% decrease for all four counties. On the other hand, Woods County in Oklahoma is expected to have a population increase of about 2% between 2007 and 2030.

The yearly amount of water diverted by the four Kansas counties has declined over the last 10 years (2000 – 2009). Overall, the public water supplies in the four Kansas county area is going from 1.6 billion gallons to 1.2 billion gallons, this is a decrease of about 25% (Table 3, Appendix A). The six largest public water supplies in the four Kansas county area contain 77% of all the Kansas users and uses between 81 – 86% of the total water for the Kansas area. The ten largest public water supplies in the four Kansas county area have 87% of the Kansas users and use about 92 – 93% of the total water for the Kansas area. The six largest public water supplies and ten largest water supplies in the four county Kansas area have each also had declining water usage of 20% and 24%, respectively. Water diverted for Woods County Oklahoma and Alva, Oklahoma were not included in the tables in the water assessment report. The text of the water assessment report did state that Alva's long term water needs would be looking for a new water supply source (drilling a new well or wells).

All of the public water supplies in the four Kansas county area should have sufficient water rights at the present time and in the future. The four Kansas county area have over twice as much water rights, as they are currently diverting from their public water supplies. The public water supplies in Alva, Oklahoma are currently using less than half of their allotted water rights of 1.3 billion gallons per year. Through 2060, Alva will still have over half of their water rights available.

All of the public water supplies in the five county area (Kansas and Oklahoma) have groundwater as their source. All of the public water supplies at the present time have adequate water quality, but some of the wells are now near or exceeding the Maximum Contaminate Level for nitrates. Several of the public water supplies (Anthony, Harper, Pratt, Norwich, Argonia, Conway Springs, Sumner County Rural Water District #5 and Harper County Rural Water District #4 all in Kansas), have nitrate issues and are in the process of either constructing a nitrate removal plant or considering building one.

All of the public water supplies' operational facilities in the five county area (Kansas and Oklahoma) were considered as adequate at the present time. Other than the nitrate issue found at some of the Kansas public water supply facilities, most of the violations were either distribution, administration or record keeping issues. Other than the nitrates, these issues are common to public water supply facilities throughout Kansas and Oklahoma.

The eight largest public water suppliers (city of Pratt, Pratt City Airport, city of Kingman, city of Anthony, city of Harper, city of Kiowa, and city of Medicine Lodge, Kansas; and city of Alva, Oklahoma) in the five county area were highlighted in the needs assessment report. The Kansas county area water suppliers make up 77% of the total population served in Kansas and 83% of the total water used in the Kansas part of the study area.

The city of Pratt's water consumption decreased between the years of 2003 and 2009. The city has plenty of water rights and water available for future water use. The drawback for the city of

Pratt's water supply is that nitrate levels in their wells ranged from 3.3 to 9.2 milligrams/liter (mg/l) (10 mg/l is the limit). These nitrate levels have been increasing for the last decade.

The Pratt City Airport has plenty of water, but one of their wells is closed due to carbon tetrachloride contamination. Their only other water well has a nitrate problem. The airport supplies bottled water to all of its customers for potable purposes.

The city of Kingman supplies their residents and sells water to Kingman County Rural Water District #1. The city has some of its water wells that are influenced by springs and surface water and because of this, the Kansas Department of Health and Environment restricts their use. The installation of three new wells has allowed the city to abandon the wells influenced by the springs and surface water if needed. The water usage for the city has decreased from 2000 to 2009 by about 30%. The city has a good quality water supply and has sufficient water to meet its future needs.

The city of Anthony provides water locally and to the Harper County Rural water District #2. The amount of water used by the city has decreased from 2001 to 2009 by about 40%. The water wells for the public water supply have high nitrate concentrations, but the city has obtained funding to construct a nitrate removal plant to remedy this problem. Upon completion of the plant, the city will have ample water for the future.

The city of Harper provides water locally and also for the Harper County Rural Water Districts #1 and #5. The city has three water wells, but is only using two due to nitrate levels that have exceeded the allowable limits in the third well. The amount of water usage by the city has been decreasing from 2000 to 2009 by 20%. The remaining two water wells are now experiencing high levels of nitrates. The city of Harper, like the city of Anthony, is anticipating construction of a nitrate removal plant. When this plant is completed, the city will have substantial water for the future.

The city of Kiowa provides water locally and to the city of Hazelton, and some water to Barber County Rural Water District #2 through an emergency interconnection. The water usage by the city has remained fairly constant over the last 10 years and should be sufficient for future water needs.

The city of Medicine Lodge provides water locally and to Barber County Rural Water District #1. The amount of water usage has declined from 2004 to 2009 by about 45%. The city should have sufficient water for its future needs.

The city of Alva has the second largest population in the study area with only Pratt, Kansas being larger. The city of Alva receives 100% of their public water supply from groundwater sources and sells some of their public water supply to 3 rural water districts and one public water authority. The city of Alva expects its population to grow by approximately 5% over the next 50 years and during this same time their water supply demand will increase by 5%

Water usage in the eight largest public water supplies and the other public water supplies throughout the five county area appear to have sufficient water rights and water supplies for the

future. At this time, this four Kansas county area has approximately 2.69 billion gallons per year in water rights and is currently using only 1.2 billion gallons per year of water, which is about 45% of what is permitted. Water usage in the four Kansas county area has decreased as a whole during the last 10 years as populations have also decreased. The water usage in Alva, Woods County, Oklahoma is currently less than 50% of their permitted water rights and the future water usage for Alva is projected to continue to be less than 50% of the allotted water rights.

Water supply stakeholders have two other considerations in meeting future demands. First, consideration is that historic trends may not be a good representation of future conditions. Emerging economic activities such as that associated with the energy exploration/production sector, may reverse - to a degree - those historic trends of decline.

The second consideration focuses on the fact that much of the study area is used for agriculture. Years of agricultural practices have resulted in some public water supplies experiencing high levels of nitrates in their groundwater. Four of the largest public water suppliers in the four county Kansas area have wells currently experiencing high levels of nitrates as well as some other contaminants like gypsum, magnesium and calcium sulfate. One water supplier, Pratt City Airport has experienced carbon tetrachloride in one of its wells. Some of the current water supply wells do not produce water even acceptable for livestock consumption. Water supply providers are addressing the issue with nitrate removal or taking wells out of production. However, the removal plants come with a cost and could make other water sources a cost competitive choice. In the future, the issue of groundwater quality may be an increasing challenge due to the prevalence of nitrate contamination in the region.

These two considerations lead to the question of what other sources of water supply can be developed to meet future challenges and perhaps offer opportunities in the form of water based recreation.

### **3.0 IDENTIFICATION OF POTENTIAL SURFACE WATER AND GROUNDWATER SOURCES.**

The second and third parts of this study took the results from the needs assessment (Section 2.0) and determined the baseline demand for water in the study area. The potential surface water sources and groundwater sources were then analyzed for the Sunflower H2O Initiative five county study area to determine if they could be used if more public water supplies were needed in the future.

For the Sunflower H2O Initiative five county study area, the Water Needs Assessment showed that the area utilized about 50% of their allotted water rights.

The determination of potential surface water and groundwater sources were combined into one task and contracted to C.H. Guernsey. Three potential surface water source sites and three potential groundwater source sites were chosen by the Kansas Water Office, the Sunflower H2O Initiative and the Corps for the contractor to study and make a determination regarding the availability of use for each site with regard to their potential as a future water supply.

All of the potential water sources are located in Kansas except for the Woods/Woodward Oklahoma Aquifer. The three potential surface water source sites are Elm Creek, East Branch Little Sandy Creek and Turkey Creek located on Figure 1 in Appendix B. The three potential groundwater source sites are Kingman County Aquifer, Kiowa County Aquifer and Woods/Woodward Counties Oklahoma Aquifer also shown on Figure 1 in Appendix B. The complete report developed by the contractor, C.H. Guernsey, entitled “Final Report Sunflower H2O Initiative Water Supply and Demand Study, Identification of Potential Surface Water and Groundwater Sources”, dated June 2012, is included in Appendix B. The following is a brief overview of the conclusions and recommendations in the Guernsey report.

The potential surface water source sites were investigated using existing information, professional judgment and the following assumptions: 1) No geotechnical issues exist; 2) Water quality is sufficient for drinking water; and 3) that the determination of flow sufficiency will be made with nearby gauges when/where gauge data is insufficient.

The potential groundwater source sites were studied using available information from local, state and Federal agencies to identify the availability of groundwater at the potential sites. The groundwater sites’ characteristics are described and any physical, economic, legal, and/or social constraints are identified. The groundwater sites dependable yields and probable permit limits were used to help determine which groundwater site, if any, would be the best potential source.

Using the information from the previous two paragraphs, the contractor had eight major tasks to perform for each potential source in completing this report. These eight tasks were 1) Review all background information; 2) Develop conceptual reservoir layouts/groundwater aquifer definitions; 3) Analyze fatal flaws; 4) Identify water rights; 5) Analyze hydrology; 6) Perform preliminary geotechnical analysis; 7) Select best surface water and groundwater sites for further

analysis; and 8) Prepare preliminary cost estimates for the best surface water and groundwater sites.

The contractor, performing the eight tasks just listed, developed a preliminary evaluation of each potential surface water and groundwater source sites. This evaluation process for each source considered dependable yield, water rights, hydrology and hydrogeology, land use, geology/faults and soils, environmental conditions/contamination, biological resources, cultural resources, oil & gas issues, utilities, highways/railroads/cemeteries/residences, permits required, and any other issues. These evaluations are shown in Table 13 (page 53) of Appendix B.

The analysis indicated the following six sources and their potential water supply yields in million gallons per day (MGD).

Elm Creek	12.4 MGD
East Branch Little Sandy Creek	2.9 MGD
Turkey Creek	6.2 MGD
Kingman County Aquifer	2.47 MGD
Kiowa County Aquifer	1.16 MGD
Woods/Woodward County Aquifer	0.71 MGD

All of these six potential water sources have a positive dependable yield for use as water supplies. For the reservoir sites, the Elm Creek site has the largest drainage area and therefore has the largest dam height and length, the largest maximum surface area, greatest flood storage, conservation storage and total storage. As we look at the water rights, the reservoir sites have water rights available but may be restricted. All of the groundwater sites have water rights available without any restrictions.

The surface water site with the greatest yield and fewest constraints was Elm Creek Reservoir, with an estimated construction cost of \$95.5 million. The groundwater site with the greatest yield while being drought tolerant and fewest constraints was Kiowa County Aquifer with an estimated cost of \$2.2 million. These costs do not include environmental mitigation costs, which could be substantial, when considering, surface water development.

If water demand becomes such that another water source is needed for the Sunflower H2O Initiative users, then the Elm Creek Reservoir site would be recommended for additional study.

#### **4.0 RECREATION ANALYSIS.**

The supply portion of this study identified three locations in the Kansas portion of the Sunflower H2O Initiative area as possible surface water supply sources; Turkey Creek, East Branch Little Sandy Creek and Elm Creek. The Elm Creek Reservoir, which was further identified as the optimal surface water source, was selected for this recreation analysis for its size and accessibility. The complete recreation analysis report, titled “Sunflower H2O Recreation Demand”, dated 7/29/2012, is located in Appendix C. The proposed dam site is on Elm Creek located in Barber County, Kansas, approximately seven miles upstream from the mouth of the stream’s confluence with Medicine Lodge Creek. The Elm Creek Reservoir site would be seventy-two miles west by southwest of Wichita, Kansas, six miles north of Medicine Lodge, Kansas, eighty miles northwest of Enid, Oklahoma and twenty miles south of Pratt, Kansas . The proposed site would inundate Highway 281; the new location of Highway 281 would provide ideal access for induced recreation infrastructure.

Kansas Department of Wildlife, Parks and Tourism (KDWPT) updated the State of Kansas Comprehensive Outdoor Recreation Plan (SCORP) in 2009. The Kansas SCORP provides an inventory of outdoor recreation supply. The Elm Creek Reservoir site could potentially fit in the SCORP and Strategic Plan to expand efforts to develop and expand water based and outdoor recreation opportunities in the south-central Kansas region.

To compare and to further assess demand, the recreation analysis examined existing water based/lake based recreation in the region. The analysis included reservoirs within 80 miles of a potential visitor’s origin as substitutes. Of the 20 reservoirs, the number of annual visitors at the lakes ranged from an estimated 23,000 to 1,000,000 visitors per year. This existing visitation provides a notion of what sort of demand for recreation one might expect with a new lake in the region.

Demographic characteristics of the area such as population, income, age, ethnic background, education and other factors were used to estimate visitation at a new lake. Travel time to a recreation site is also a factor in determining visitation to a lake. These variables were used to estimate visitation at the Elm Creek Reservoir. For this study, the visitation estimate was calculated using a Regional Recreation Demand Model (RRDM). The RRDM is a regional regression demand model based on spatially referenced demographic variables and their effects on recreation demand. That model is based on recreation behavior at existing reservoirs in regions similar to the study area. The study estimates that the new reservoir could generate approximately 282,400 visitors per year. The visitation could increase over time. There are a number of considerations that have to be made in such estimates. The type of recreation facilities, economic conditions, weather, water quality, development of other water based

recreation in the region and a variety of other factors would determine recreation behavior and water based recreation use at a new lake.

The preliminary recreation analysis estimates approximately 282,391 visitors annually to the potential reservoir. Over a fourth of the visitation being camping users and the other three quarters being day users. The largest contributing factor to recreation is the proximity to large populations. As of the 2010 Census, Wichita, Kansas has a population of 382,368. Wichita has also experienced substantial growth in the past ten years. The “Teens Outside” national initiative supported by Kansas in their 2009 SCORP (State Comprehensive Outdoor Recreation Plan) identifies a need for opportunities for inner city youth to get outdoors. The Elm Creek Reservoir site could potentially meet the need of providing outdoor recreation and educating the City of Wichita’s urban youth with the wonders of the great outdoors. Possible amenities such as: shared hard surface trails, playground equipment, open space, free ride area, shared use soft surface trails, hiking trails, waterfront and equestrian trails could be provided at the Elm Creek Reservoir site which would fulfill many of the stated preferences documented in the SCORP and the recreation demand for these amenities and contributing to recreation activity in South Central Kansas and North Central Oklahoma. While a reservoir with these amenities will be fulfilling some stated recreation demand for the City of Wichita, excess demand will remain. Other activity preferences would likely be unattained. Amenities such as: community parks, special use area sports parks, skate parks, neighborhood park acreage, climbing trails and shooting sports park have a stated preference but are unlikely to be fulfilled by this project.

## **5.0 CONCLUSION AND RECOMMENDATION.**

### **5.1 Conclusion.**

The existing demands for water supply in the study area counties in south-central Kansas and north-central Oklahoma are currently being met; entirely by groundwater sources. The population in this area has, in recent decades, been in slight decline. Though demand from population growth may not be a major consideration in the future, historic trends of decline may continue in the long term. Emerging economic activities, such as that associated with the energy exploration/production sector, may reverse - to a degree - that historic trend. However, under the case of a stable population growth in the future, the public water supply systems have sufficient water rights and sources to meet present and future needs. Dependency upon groundwater sources presents challenges in areas heavily dependent upon agriculture. Some communities are faced with costly treatment of nitrates linked to past agricultural practices.

The study examined six sources for potential development - three surface water sites and three groundwater sources. The sources produced a range of 2.9 to 12.4 million gallons per day for the surface water sources and .7 to 2.5 million gallons per day for groundwater sources. A preliminary cost estimate for the selected reservoir, Elm Creek, and the selected aquifer, Kiowa County, were developed. The cost estimates and yield for the selected surface water and groundwater alternatives are as follows:

- Elm Creek Reservoir: \$95,544,000 with 12.4 million gallons per day
- Kiowa County Aquifer: \$2,163,000 with 1.2 million gallons per day

The Elm Creek Reservoir site cost is for construction only and does not include costs for mitigation. Historically, the costs for mitigation on reservoir projects are twice the cost of construction.

In analyzing the recreational opportunities for the Elm Creek Reservoir, the preliminary recreation analysis estimates approximately 282,400 visitors annually to the potential reservoir, with over a fourth of the visitation being camping users and the other three quarters being day users. The largest contributing factor to recreation is the proximity to large populations. The Elm Creek Reservoir site could potentially meet the need of providing outdoor recreation and environmental education. In addition to water based activities, the reservoir could provide possible amenities such as trails, playgrounds, open space, free ride area, waterfront and would fulfill recreation demand in the region. With expenditures of recreation users, such a reservoir could become an important component of the local and regional economy.

## 5.2 Recommendation.

Though current and near term water needs in the region are being met, future conditions may merit re-examination of development of new sources of water. Groundwater sources would be the least costly new supply, but would only yield about 1.2 million gallons per day. If local stakeholders decide to develop groundwater supply, the Kiowa County aquifer should be the first choice for further evaluation. The possible reservoir on Elm Creek could provide substantially more supply than groundwater. If stakeholders decide to develop a surface water source to meet any anticipated needs, the Elm Creek site offers the greatest volume. Surface water supply would also provide for new recreation opportunities. However, that cost would require a substantial investment during a time of limited public funding for public works projects. It is likely that a substantial portion of the cost would be borne by local stakeholders. Construction of reservoirs also involves significant environmental considerations, along with requirements for acquisition of sizable amount of private lands. Such considerations would be tied to the likelihood that such surface water development is politically and socially acceptable.