MUNICIPAL AND INDUSTRIAL BENEFITS EVALUATION STUDY

AREA VI RED RIVER CHLORIDE CONTROL PROJECT

Prepared for

United States Army Corps of Engineers
Tulsa District

Contract No. W912BV-10-D-1000, Task Order DY07

January 2012

URS Group, Inc.
Infomart
1950 North Stemmons Freeway, Suite 6000
Dallas, Texas 75207
Tel: (214) 741-7777
Fax:(214) 741-9413

TABLE OF CONTENTS

ITEM **PAGE**

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

AFY	acre-feet per year
BCI	Building Cost Index
EDR	Electrodialysis reversal
ENR	Engineering News-Record
EPA	Environmental Protection Agency
GTUA	Greater Texoma Utility Authority
M&I	Municipal and industrial
MCL	Maximum Contaminant Level
mgd	million gallons per day
mg/l	milligrams per liter
NED	National economic development
NTMWD	North Texas Municipal Water District
O&M	Operation and maintenance
OWRB	Oklahoma Water Resources Board
RED	Regional economic development
RRA	Red River Authority
TAC	Texas Administrative Code
TDS	Total dissolved solids
TWDB	Texas Water Development Board
TXU	Texas Utilities
USACE	United States Army Corps of Engineers
WTP	Water Treatment Plant

1 INTRODUCTION

The United States Army Corps of Engineers (USACE), Tulsa District, is evaluating the effects of implementing Area VI of the Red River Chloride Control Project. The Red River Chloride Control Project is a multicomponent initiative to reduce naturally occurring brine spring emissions from entering the Red River. Chlorides make up about one-third of the total dissolved solids (TDS) in the Red River. Sulfates and other solutes generated by the natural brine springs also impair the water quality. The high levels of chlorides, sulfates, and other TDS in the Red River, its tributaries, and Lake Texoma can render the water less desirable or even unsuitable for use without prior treatment or demineralization.

There is renewed interest in Area VI due to increased demand for water. Area VI is located on the Elm Fork of the Red River in Harmon County, OK. Approximately 3,300 tons of chlorides from natural sources enter the Red River and its tributaries on a daily basis. Of that amount, about 510 tons per day are contributed by Area VI, accounting for just over 11 percent of the total chloride load of the Red River. Chloride reduction measures in Area VI involve the construction of detention and evaporation basins that would prevent the brine spring emissions from entering the Elm Fork of the Red River.

1.1 PROJECT DESCRIPTION AND PURPOSE

The Red River Chloride Control Project aims to reduce chlorides, sulfates, and other TDS from entering the Red River to improve water quality and benefit current and potential users of Red River water. Reducing chlorides, and in turn TDS, in the Red River may reduce the costs of treating the raw water to achieve water quality standards. Furthermore, successful implementation of the Red River Chloride Control Project may decrease damages to water supply infrastructure associated with the use of Red River water.

The purpose of this study is to assess the benefits to municipal and industrial (M&I) users of Red River water if chloride reduction measures in Area VI of the Red River Chloride Control Project are implemented. This study is one component of the overall analysis to estimate the impacts of Area VI.

1.2 STUDY AREA

The Red River flows from its headwaters in New Mexico across Texas and along the border between Texas and Oklahoma into Arkansas and Louisiana before it flows into the Mississippi River. The study area for this M&I study is generally located in the Red River Basin, which stretches from the panhandle of Texas, through southern Oklahoma, down into the southwestern corner of Arkansas, and into northwestern Louisiana (Figure 1-1). Consistent with the *Area VI M&I FSM Package* (USACE 2011a), the study area is divided into five economic reaches.

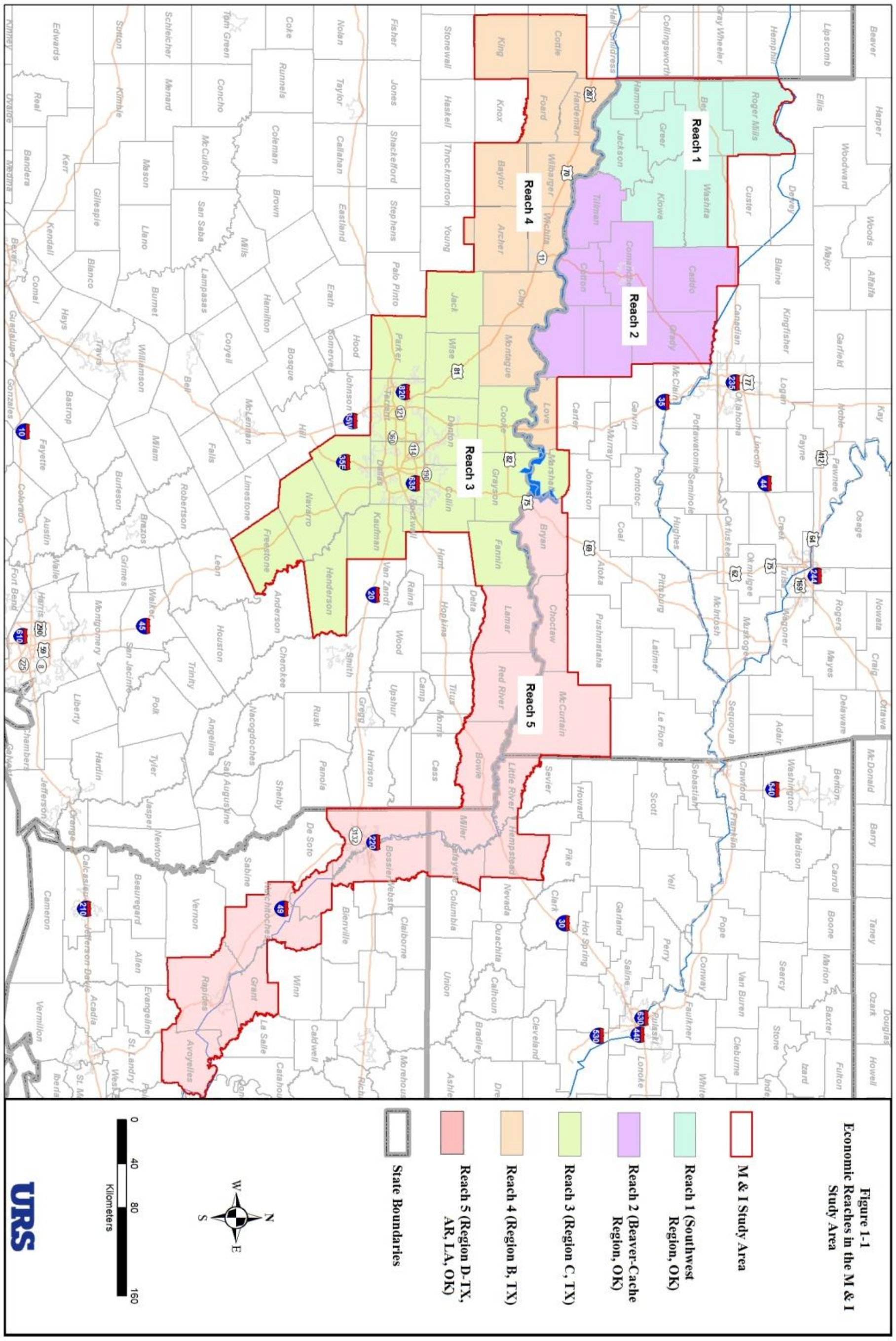


Figure 1-1: Economic Reaches in the M&I Study Area

1.2.1 Reach 1

Reach 1 is located in southwest Oklahoma and contains all of Harmon, Jackson, and Greer Counties, and portions of Tillman, Kiowa, Beckham, Roger Mills, Comanche, and Washita Counties. The largest cities in the reach are Altus, Elk City, and Hobart. The area consists primarily of farm land and the Quartz Mountains in southeastern Kiowa and Greer Counties. Average annual precipitation is between 22 inches in the west to 28 inches in the east. Reach 1 comprises 12 basins and is consistent with the Southwest Watershed Planning Region as defined in *the Draft Oklahoma Comprehensive Water Plan, Southwest Watershed Planning Region Report (*Oklahoma Water Resources Board [OWRB] 2011a).

1.2.2 Reach 2

Reach 2 is also located in southwest Oklahoma and contains all or portions of Tillman, Comanche, Cotton, Grady, Stephens, and Jefferson Counties. The largest cities in the region include Lawton, Duncan, Frederick, and Marlow. The average annual precipitation ranges from 28 inches in the west to 34 inches in the east. Reach 2 comprises eight basins and is consistent with the Beaver-Cache Watershed Planning Region of the *Draft Oklahoma Comprehensive Water Plan, Beaver-Cache Watershed Planning Region Report* (OWRB 2011b).

1.2.3 Reach 3

Reach 3 is located in north-central Texas and contains Cooke, Grayson, Marshall, Fannin, Jack, Wise, Denton, Collin, Parker, Tarrant, Dallas, Rockwall, Kaufman, Ellis, Navarro, and Freestone Counties, and part of Henderson County. The largest population center in Reach 3 is the Dallas-Fort Worth area. The average annual precipitation in Reach 3 increases from west to east and ranges from 30 inches to 44 inches per year. Reach 3 lies in the upper Trinity River Basin and part of the Red River Basin around Lake Texoma. Reach 3 is consistent with Region C of the *Texas Regional Water Plan* (Texas Water Development Board [TWDB] 2010a).

1.2.4 Reach 4

Reach 4 is located in the north-central region of Texas and contains Archer, Baylor, Clay, Cottle, Foard, Hardeman, King, Love, Montague, Wichita, and Wilbarger Counties, and a portion of Young County, including the City of Olney. The largest cities in Reach 4 are Wichita Falls and Vernon. The average annual precipitation in Reach 4 is 27.4 inches, but can greatly vary from year to year. Reach 4 is located in the Red River Basin, Trinity River Basin, and Brazos River Basin, with most of the area lying in the Red River Basin. Reach 4 is consistent with Region B of the *Texas Regional Water Plan* (TWDB 2010b).

1.2.5 Reach 5

Reach 5 is located in southeast Oklahoma, northeast Texas, far southwest Arkansas, and Louisiana, and comprises the counties located along the Red River below Lake Texoma. Reach 5 includes Bryan, Choctaw, and McCurtain Counties in Oklahoma; Lamar, Red River, and Bowie Counties in Texas; Little River, Hempstead, Miller, and Lafayette Counties in Arkansas; and Caddo, Bossier, Red River, Natchitoches, Grant, Rapides, and Avoyelles Parishes in Louisiana. The average annual rainfall ranges from 47.4 inches in the west to 61.8 inches in the east. Reach 5 is consistent with Region D of the *Texas Regional Water Plan* (TWDB 2010c).

1.3 RELEVANT STUDIES

This section presents a summary of the studies that are most relevant to this M&I Benefits Evaluation Study. Much of the base data for this study were drawn from the following sources.

1.3.1 Wichita River Basin Project Reevaluation, Red River Chloride Control Project

The *Wichita River Basin Project Reevaluation, Red River Chloride Control Project* (USACE 2003) was used to support the implementation of Areas V and VIII. The study developed costs for using Red River and Wichita River (and/or affected tributaries) water. The cost categories included in the study were:

- Treatment of Red/Wichita River water to acceptable water quality standards as a source of water supply
- Damages to M&I users associated with TDS
- Blending Red River water with existing sources of water supply for M&I use

The study used available research reports and journal articles to develop TDS damage coefficients for M&I facilities. Damage coefficients for M&I facilities were developed as discussed below.

1.3.1.1 Municipal Damage Coefficient

According to the USACE *Wichita River Basin Project Reevaluation* report, a report titled *Report on Determination of Economic Values for Improved Water Quality in the Red River Basin* prepared by Black & Veatch in 1975 was used to develop the damage coefficient for municipal facilities. Damages to municipal facilities associated with TDS were estimated for a range of residential components and the public distribution system. The initial study (Black & Veatch 1975) calculated the annual capital cost differential between the listed items at 250 milligrams per liter (mg/l) and 1,750 mg/l of TDS. The annual cost differential was distributed over the annual residential water usage of 100,000 gallons. This value was further distributed over the difference in TDS to develop a “damage coefficient” in terms of dollars per 1,000 gallons per 100 mg/l of TDS.

The economic analysis conducted for the *Wichita River Basin Project Reevaluation* report indexed and adjusted the original damage coefficient from the Black & Veatch report using the Building Cost Index (BCI) from Engineering News-Record (ENR). The damage coefficient was estimated as $ 0.1636 per 1000 gallons per 100 mg/l TDS in 2001 dollars (Table 1-1). The damage coefficient was updated to 2011 dollars using the ENR index.

Table 1-1: Combined Municipal Damage Coefficient

Component	Average Annual Cost (2001)	Average Annual Cost (2011)
Residential:		
Water piping	$22.55	$31.81
Wastewater piping	$12.54	$17.69
Water heaters	$39.86	$56.22

Component	Average Annual Cost (2001)	Average Annual Cost (2011)
Faucets	$48.35	$68.20
Toilet flushing mechanisms	$11.64	$16.42
Garbage disposals	$10.96	$15.46
Washing equipment (dishes and clothes)	$36.05	$50.85
Cooking utensils	$6.10	$8.60
Washable fabrics (4 people @ $800/each)	$27.64	$38.99
Soap and detergent use	$18.55	$26.16
Subtotal Residential Damages	**$234.25**	**$330.39**
Public:		
Supply and production equipment	$3.49	$4.92
Distribution piping	$0.45	$0.63
Storage facilities	$0.38	$0.54
Utility service lines	$0.28	$0.39
Water meters	$0.25	$0.35
Sewage facilities	$6.32	$8.91
Subtotal Public Damages	**$11.17**	**$15.75**
Total Annual Damage Cost Differential	**$245.42**	**$346.14**
Damage cost per 1,000 gallons (with assumed 100,000 gallon annual usage)	$2.45	$3.46
Damages per 1,000 gallons per 100 mg/l TDS	**$0.16**	**$0.23**

TDS = Total Dissolved Solids; mg/l = milligrams per liter

Source: Wichita River Basin Project Reevaluation, Red River Chloride Control Project (USACE 2003)

1.3.1.2 Industrial Damage Coefficient

According to the USACE *Wichita River Basin Project Reevaluation* report, the 1975 Black & Veatch report also developed the original industrial damage coefficient. The coefficient was a composite value of $0.014 per 1,000 gallons per 100 mg/l of TDS (in 1967 dollars). The composite value was compiled by averaging the coefficients from four previous studies prepared between 1959 and 1972.

The economic analysis conducted for the *Wichita River Basin Project Reevaluation* report indexed and adjusted the original damage coefficient from the Black & Veatch report using the ENR BCI. The damage coefficient was estimated as $ 0.0489 per 1000 gallons per 100 mg/l TDS in 2001 dollars (Table 1-2). The damage coefficient was updated to 2011 dollars using the ENR index.

Table 1-2: Industrial Damage Coefficient

Year	ENR BCI	Indexed Coefficient	Adjusted Coefficient
1967 (Avg.)	676	$0.01	-
1980 (Jan.)	1895	$0.04	-
1999 (Jan.)	3425	$0.07	$0.04
2000 (Jan.)	3503	$0.07	$0.04
2001 (Jan.)	3545	$0.08	$0.05
2011	5041		$0.07

ENR = Engineering News-Record, BCI = Building Cost Index

1.3.2 Area VI Reevaluation Concentrations Duration/Low Flow Study

The *Area VI Reevaluation Concentrations Duration/Low Flow Study* (USACE 2011b) reevaluated the changes to flow and solute concentrations on the Elm Fork, North Fork, and entire main stem of the Red River if chloride reduction were implemented in Area VI. The study also summarized the impacts of implementing chloride reduction in the Wichita River (Areas VII, VIII, and X) and Prairie Dog Town Fork (Area V) projects**.**

Five conditions were evaluated in the study (Table 1-3). The conditions include natural conditions, which represent no chloride reduction in the Red River Basin. Each of the conditions includes chloride reduction scenarios in the Red River Basin in the areas shown in Table 1-3. Condition 2, reduction of chloride in Areas V and VIII, has already been implemented. Conditions 3, 4, and 5 represent potential chloride reduction scenarios in the Red River Basin. The USACE study estimated chloride, sulfate, and TDS loads in each of the five economic reaches for each condition. The study also evaluated two future actions by the Federal government that could potentially impact the Red River Basin. The two actions evaluated are the reallocation of conservation storage in Lake Texoma and the construction of Cable Mountain Reservoir. These actions were evaluated separately.

Table 1-3: Conditions Investigated

Condition	Chloride Control Areas
1	Natural Conditions
2	Areas V and VIII
3	Areas V, VII, VIII, and X
4	Areas V, VI, and VIII
5	Areas V, VI, VII, VIII, and X

Source: Area VI Reevaluation Concentrations Duration/Low Flow Study (USACE 2011b)

The resulting estimated loads for each condition were used in this M&I study as base data. Since Condition 2 has already been implemented, results associated with Condition 2 were considered as the Without-Project condition for the M&I study. Condition 4 assumes that Areas V, VI, and VIII, are implemented. Because this condition represents the incremental addition of Area VI, Condition 4 was used when evaluating the impacts for the With-Project condition.

Conditions 2 and 4 are referred to as the Without-Project and the With-Project conditions, respectively, throughout the remainder of this study.

1.4 CHLORIDE AND TOTAL DISSOLVED SOLIDS CONCENTRATION GUIDELINES

Various secondary Maximum Contaminant Levels (MCLs) have been established by the U.S. Environmental Protection Agency (EPA) and State water quality agencies. Typically, these secondary MCLs are not enforceable, but are intended as guidelines to maintain drinking water aesthetic value and drinkability, and to minimize health risks. The MCLs for the State of Texas are enforceable (but exceptions can be granted) and were used for this evaluation.

Title 30 of the Texas Administrative Code (TAC) Chapter 290, PUBLIC DRINKING WATER, provides pertinent regulations for Texas drinking water providers. Table 1-4 presents MCLs for chlorides, sulfates, and TDS as listed in Title 30 TAC §290.118(b) secondary constituent levels for drinking water.

Table 1-4: MCLs for Drinking Water

Constituent	MCLs (mg/l)
Chlorides	300
Sulfates	300
TDS	1,000

MCL = Maximum Contaminant Level; mg/l = milligrams per liter

Source: Texas Commission on Environmental Quality

30 TAC §290.118 mandates that:

> "the requirements for secondary constituents apply to all public water systems. Water that does not meet the secondary constituent levels may not be used for public drinking water without written approval from the executive director. When drinking water that does not meet the secondary constituent levels is accepted for use by the executive director, such acceptance is valid only until such time as water of acceptable chemical quality can be made available at reasonable cost to the area(s) in question."

2 MUNICIPAL AND INDUSTRIAL DEMAND AND SUPPLY

This section presents an overview of the demand and use of Red River water for M&I purposes. The current and projected demand for water for each economic reach provided in the following section was developed from the components of the *Draft Oklahoma Comprehensive Water Plan* (OWRB 2011a, OWRB 2011b, and OWRB 2011c) and the *Texas Regional Water Plans* (TWDB 2010a, TWDB 2010b, and TWDB 2010c). The water quality data provided in each of the following sections were taken from the water plans mentioned above and *Area VI Reevaluation, Concentrations Duration/Low Flow Study* (USACE 2011b).

2.1 REACH 1

Overall, Reach 1 accounts for 9 percent of the State of Oklahoma's total water demand. Surface water is used to meet about 37 percent of the reach's demand. The reach is supplied by three major rivers: the North Fork of the Red River, the Elm Fork of the Red River, and the Salt Fork of the Red River. The Red River is not used as a supply source because of water quality concerns. Reservoirs constructed on several rivers and creeks in the reach provide a portion of the public water supply. Major reservoirs in Reach 1 include: Lugert-Altus Reservoir, Elk City Lake, Tom Steed Reservoir, Altus City Lake, and Rocky Lake.

The total demand for all uses in the reach is projected to increase 36,100 acre-feet per year (AFY), or about 20 percent, to 213,100 AFY from 2010 to 2060. By 2020, surface water supplies are forecasted to be insufficient to meet regional demand.

2.1.1 Municipal and Industrial Use and Demand

M&I demand makes up approximately 7 percent of total water use in Reach 1. The M&I demand is projected to increase approximately 20 percent from 2010 to 2060 (Figure 2-1).

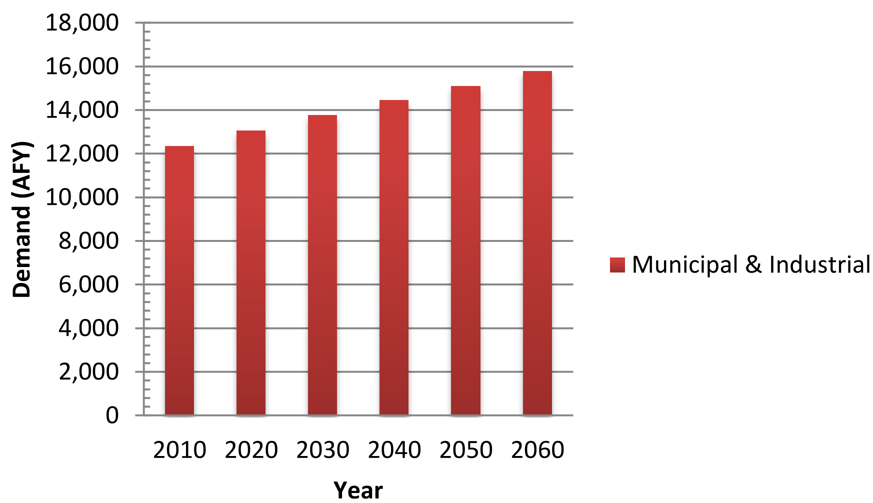


Figure 2-1: Projected M&I Water Demand for Reach 1

Source: Draft Oklahoma Comprehensive Water Plan (OWRB 2011a, OWRB 2011b, and OWRB 2011c)

2.1.2 Water Quality

The surface water quality in Reach 1 is considered fair to poor. Water from the lakes, creeks, and major rivers is impaired for M&I uses because of high levels of TDS and sulfates, and relatively high chloride levels (with seasonal variations). The Red River is not used as a direct supply source because of water quality concerns.

As indicated in *Area VI Reevaluation Concentrations Duration/Low Flow Study* (USACE 2011b), implementation of chloride reduction measures in Areas V, VI, VII, VIII, and X (Conditions 4 and 5) would remove a significant amount of chlorides and TDS in the Red River (Table 2-1). Condition 4 (Areas V, VI, and VIII) is the With-Project condition for this M&I study. Two gage stations—Carl and Headrick—are located in Reach 1. Because no separate assessment was performed for With-Project conditions, With-Project + Condition 5 was used for comparison purposes. The gage station locations are presented on Figure 2-2.

Table 2-1: Reach 1 Water Quality Assessment

Constituent	Condition	Percent of Time Equaled or Exceeded								
		1	5	10	20	50	80	90	95	99
Carl Gage Station										
Chloride	Natural	117300	44124	25998	17217	9900	5351	3778	2502	818
	With Project*	19110	8940	6276	3944	1970	980	610	212	0
TDS	Natural	212600	78971	47816	32106	19483	11616	8571	6263	2900
	With Project	38362	21362	16258	11554	6273	4135	3140	2025	0
Headrick Gage Station										
Chloride	Natural	5709	4298	3718	1940	1807	797	457	263	0
	With Project	1816	1182	962	739	407	166	94	54	0
TDS	Natural	11821	9150	8222	6825	4529	2263	1427	814	0
	With Project	9660	6364	5182	3985	2415	1121	695	400	0

TDS = Total Dissolved Solids

Source: Exhibit C, Area VI Reevaluation Concentrations Duration/Low Flow Study (USACE 2011b)

**Conditions 4 and 5 have the same TDS and chloride levels for Carl Gage Station and Headrick Gage Station in the Area VI Reevaluation Concentrations Duration/Low Flow Study. The TDS and chloride amounts for Condition 4 and 5 are presented as the "With-Project" condition for this analysis.*

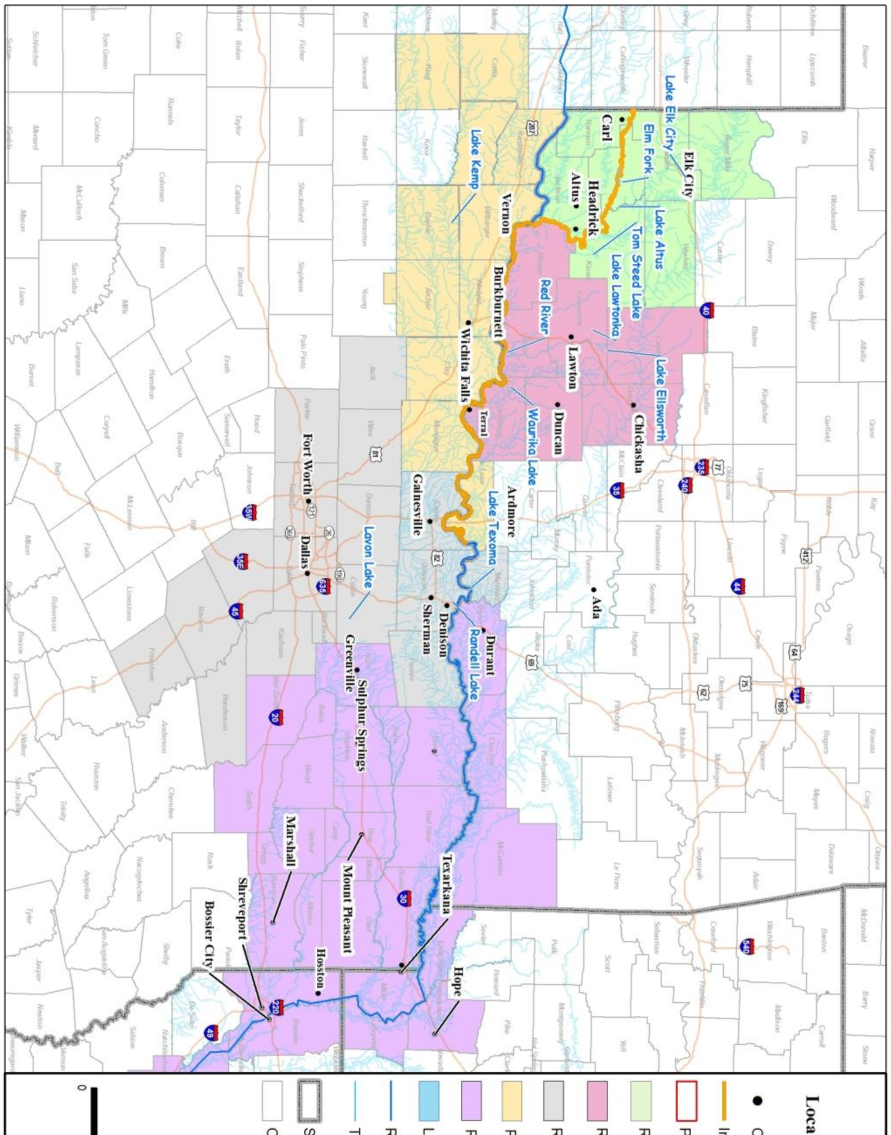


Figure 2-2: Areas Potentially Impacted by Area VI Chloride Control Project

2.2 REACH 2

Reach 2 accounts for 2 percent of Oklahoma's total water demand. The total demand in the reach is projected to increase by 27 percent (12,000 AFY) from 2010 to 2060. Surface water is used to meet almost two-thirds of demand in Reach 2. The reach is supplied by three large creeks that flow into the Red River: Beaver Creek, Cache Creek, and Deep Red Creek. Existing reservoirs in the reach increase the dependability of surface water supply for many public water systems and other users. The largest is Waurika Lake, constructed on Beaver Creek by the USACE in 1977. The City of Lawton impounds two large municipal lakes in the region: Lake Ellsworth, located on East Cache Creek in Comanche and Caddo Counties, and Lake Lawtonka located on Medicine Creek (tributary to East Cache Creek) in Comanche County. Many other small Natural Resources Conservation Service, municipal, and privately owned reservoirs provide water for public water supply, agriculture, flood risk management, and recreation.

2.2.1 Municipal and Industrial Use and Demand

The largest water demand in Reach 2 comes from M&I users (55 percent), followed by crop irrigation (28 percent). Currently, 89 percent of the demand from M&I users is supplied by surface water, 3 percent by alluvial groundwater, and 8 percent by bedrock groundwater. Figure 2-3 shows the projected M&I user demand for 2010 through 2060.

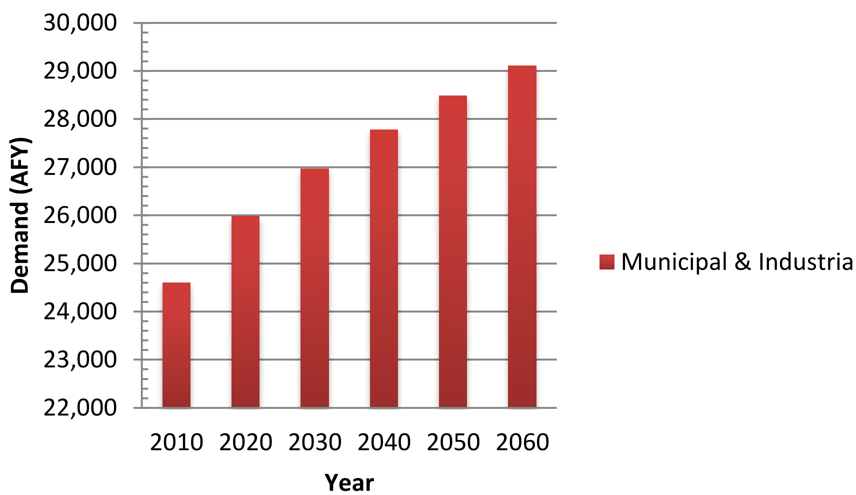


Figure 2-3: Projected M&I User Water Demand for Reach 2

Source: Draft Oklahoma Comprehensive Water Plan (OWRB 2011a, OWRB 2011b, and OWRB 2011c)

2.2.2 Water Quality

Natural elevated levels of chlorides in Reach 2 make several streams unsuitable for use as public water supply, including the Red River. The water quality of public and private water and agriculture supplies in Lake Lawtonka, Waurika Lake, Cow Creek, Deep Red Creek, and Beaver Creek is currently impaired due to elevated levels of TDS and sulfates. Stream flow is not a dependable supply source for most purposes because of generally intermittent flow and poor water quality. Therefore, without extensive water treatment or management techniques, the high chloride content of the Red River renders water generally unsuitable for most consumptive uses.

As presented in the *Area VI Reevaluation Concentrations Duration/Low Flow Study* (USACE 2011b) and shown in Table 2-2, implementing chloride reduction measures in Area VI would reduce some concentration of chlorides and TDS in the Red River compared to the Without-Project condition. One gage station—Terral—is located in Reach 2. The measured Without-Project water quality and the projected With-Project water quality for the gage station are shown in Table 2-2. Its location is presented on Figure 2-2.

Table 2-2: Reach 2 Water Quality Assessment

Constituent	Condition	Percent of Time Equaled or Exceeded								
		1	5	10	20	50	80	90	95	99
Terral Gage Station										
Chloride	Without Project	3584	2926	2532	2093	1255	733	473	335	174
	With Project	3134	2558	2214	1830	1098	641	414	293	152
TDS	Without Project	8642	7266	6615	5462	3301	1994	1343	967	518
	With Project	7941	6676	6079	5021	3034	1833	1234	889	475

TDS = Total Dissolved Solids

Source: Exhibit C, Area VI Reevaluation Concentrations Duration/Low Flow Study (USACE 2011b)

2.3 REACH 3

About 56 percent of the existing water supply available to Reach 3 is from reservoirs. Water imported from outside the reach supplies 26 percent of the water and reuse water accounts for 9 percent, followed by groundwater (6 percent) and local supplies (2 percent). Water use in Reach 3 has increased in recent years, primarily in response to increasing population. Most of the water suppliers in Reach 3 will have to develop additional supplies before 2060.

Located on the Red River, Lake Texoma has the largest storage capacity and is a vital surface water supply source in the reach. Other major reservoirs with storage capacity over 200,000 acre-feet are Richland Creek, Cedar Creek, Lewisville, Ray Hubbard, Lavon, Bridgeport and Eagle Mountain. The major water suppliers have supplies in excess of current needs, but they will require additional supplies to meet projected growth.

2.3.1 Municipal and Industrial Use and Demand

The TWDB categorizes water use as municipal, manufacturing, steam electric power generation, mining, irrigation, and livestock. Municipal use is the largest category accounting for 90 percent of the current water use in Reach 3, with manufacturing use as the second largest category. Figure 2-4 summarizes the M&I user demand projected for 2010 through 2060. The M&I demand is calculated as the sum of municipal, manufacturing, and steam electric power generation demand.

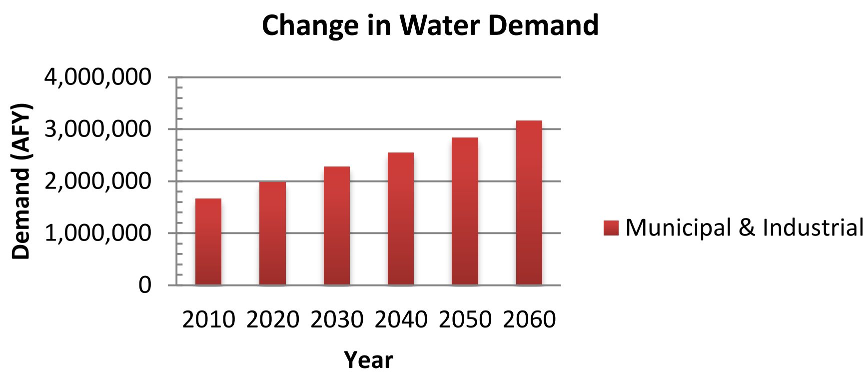


Figure 2-4: Projected M&I User Water Demand for Reach 3

Source: Texas Regional Water Plans (TWDB 2010a, TWDB 2010b, and TWDB 2010c).

As discussed in the *Summary of 2011 Regional Water Plans* report (TWDB 2011), an additional supply of 1,588,236 AFY will be needed by 2060. Water management strategies such as water conservation and reuse each account for 12 percent of the total projected 2060 volume (includes M&I). Therefore, recommended total volume for 2060, based on water management strategies (including water conservation and reuse), is 2,360,302 AFY. The construction of four major reservoirs (Ralph Hall, Lower Bois D'Arc, Marvin Nichols, and Fastrill Replacement Project) is recommended in the TWDB 2011 report.

2.3.2 Water Quality

Dissolved solids in the Red River and Lake Texoma along the northern boundary of the reach are generally high in comparison to other current supplies. The water quality within Lake Texoma is high in TDS and chlorides, which has limited both its and the Red River's use for M&I purposes.

As presented in the *Area VI Reevaluation Concentrations Duration/Low Flow Study* (USACE 2011b) and shown in Table 2-3, implementing chloride reduction measures in Area VI would reduce concentration of chlorides and TDS in the Red River compared to the Without-Project condition. The Denison gage station is located in Reach 3. The measured Without-Project water quality and the projected With-Project water quality at the gage station are shown in Table 2-3. The location of the gage station is presented on Figure 2-2.

Table 2-3: Reach 3 Water Quality Assessment

Constituent	Condition	Percent of Time Equaled or Exceeded								
		1	5	10	20	50	80	90	95	99
Denison Gage Station										
Chloride	Without Project	540	428	410	387	319	254	228	207	162
	With Project	484	384	367	347	285	227	204	186	145
TDS	Without Project	1680	1261	1208	1146	948	737	642	569	474
	With Project	1575	1182	1133	1074	889	691	601	534	440

TDS = Total Dissolved Solids

Source: Exhibit C, Area VI Reevaluation Concentrations Duration/Low Flow Study (USACE 2011b)

2.4 REACH 4

Water users in Reach 4 receive surface water from sources in the Brazos, Trinity, and Red River Basins. Eleven reservoirs within the reach and one outside the reach supply surface water to the users in Reach 4. In addition, groundwater accounts for 34 percent of the water supply and is primarily provided by two aquifers: the Seymour and the Blaine. The total demand in Reach 4 is projected to decrease from 171,164 AFY to 169,153 AFY from 2010 to 2060. The water supplies to the reach are also projected to decrease from 209,683 AFY to 157,761 AFY. However, because of issues with existing reservoirs, by 2020, surface water supplies are projected to be insufficient to meet demand throughout the reach.

The City of Wichita Falls is the only wholesale water provider in Reach 4 and is a regional provider for much of the water in Wichita, Archer, and Clay Counties. Agriculture irrigation is the main component of regional water use, accounting for approximately 60 percent of all water used in Reach 4.

2.4.1 Municipal and Industrial Use and Demand

The total municipal water use for Reach 4 is expected to decline from 40,964 AFY in the year 2010 to 38,696 AFY in 2060. However, steam electric power generation use is expected to increase from 13,360 AFY in 2010 to 21,360 AFY in 2060. Manufacturing use is also expected to increase from 3,547 AFY in 2010 to 4,524 AFY in 2060. The M&I user demand is calculated as the sum of municipal, manufacturing, and steam electric power generation demand. In general, the M&I demand increases from 2010 through 2030 and remains relatively stable afterwards. Figure 2-5 summarizes the M&I user demand for 2010 through 2060.

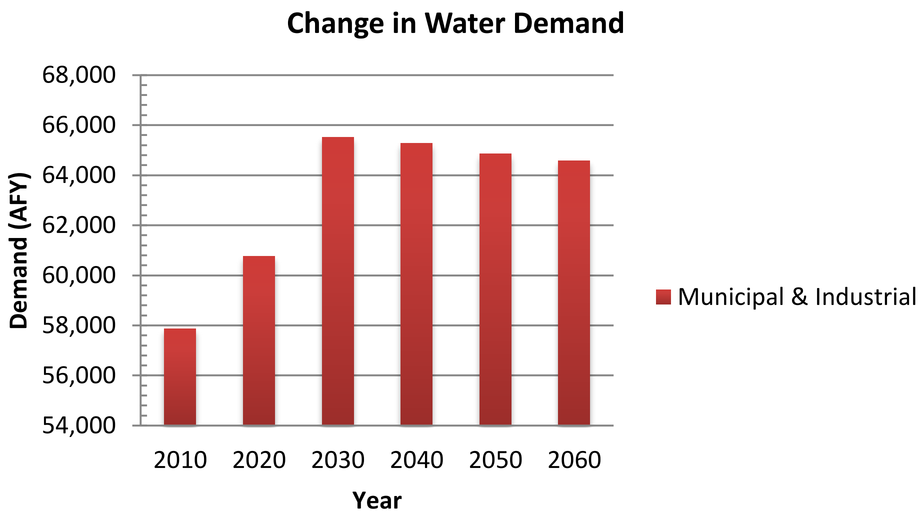


Figure 2-5: Projected M&I User Water Demand for Reach 4

Source: Texas Regional Water Plans (TWDB 2010a, TWDB 2010b, and TWDB 2010c).

2.4.2 Water Quality

Water quality is a significant issue in Reach 4. Because of limited resources, some user groups are using water of impaired quality or having to install additional treatment systems to use existing sources. An implied assumption of the supply analysis is that the quality of existing water supplies is acceptable for its use.

Reach 4 is largely located upstream of the confluence with the Elm Fork and implementing chloride reduction measures in Area VI would not influence the water quality in Reach 4. Therefore, water quality assessment data associated With- and Without-Project conditions are not provided in the *Area VI Reevaluation Concentrations Duration/Low Flow Study* (USACE 2011b).

2.5 REACH 5

Reach 5 comprises southeast Oklahoma, northeast Texas, far southwest Arkansas, and Louisiana. Surface water is the main source of water supply in northeast Texas. The Oklahoma portion of Reach 5 receives more than 90 percent of its water supply from surface water and most of the demand in this reach is for M&I uses. In Louisiana, Bossier City, located on the lower portion of the Red River relies on the Red River for its water supply.

2.5.1 Municipal and Industrial Use and Demand

The Red River is generally not used as a public water supply source in Oklahoma because of water quality concerns. The largest demand sectors in southeast Oklahoma are self-supplied industrial (51 percent of the region’s overall 2010 demand), thermoelectric power (14 percent), and M&I (12 percent). The percent demand for M&I use is projected to remain the same (12 percent) in the southeast Oklahoma region through 2060. M&I user demand in the region is currently supplied by surface water (97 percent), bedrock groundwater (3 percent), and alluvial groundwater (less than 1 percent).

Steam electric power generation and municipal demands in the Texas portion are projected to increase significantly. M&I demand in the Texas portion is expected to increase to approximately 51 percent in 2060. Bossier City, LA, also has some M&I demand, but the demand for M&I in the Arkansas portion of Reach 5 is very small.

2.5.2 Water Quality

The upstream portions of the Red River, especially above Denison (Texoma) Dam, contain high levels of TDS and chlorides. Downstream of its confluence with the Blue River, Boggy Creek, and Kiamichi River, the quality of the Red River becomes better, though is still inferior to that of other streams in the region.

As presented in the *Area VI Reevaluation Concentrations Duration/Low Flow Study* (USACE 2011b) and shown in Table 2-4, implementing chloride reduction measures in Area VI would only minimally improve the water quality in Reach 5. The location of the gage station is presented on Figure 2-2.

Table 2-4: Reach 5 Water Quality Assessment

Constituent	Condition	Percent of Time Equaled or Exceeded								
		1	5	10	20	50	80	90	95	99
Hosston Gage Station										
Chloride	Without Project	397	261	224	177	81	35	21	14	9
	With Project	356	258	221	176	80	34	20	14	9
TDS	Without Project	1396	946	858	682	387	188	138	105	83
	With Project	1308	887	804	639	362	176	130	98	78

TDS = Total Dissolved Solids

Source: Exhibit C, Area VI Reevaluation Concentrations Duration/Low Flow Study (USACE 2011b)

2.6 DEMAND FOR RED RIVER WATER

As discussed in the water quality section for each reach, implementing chloride reduction measures in Area VI would improve water quality in Reaches 1, 2, and 3 based on projections provided in the *Area VI Reevaluation Concentrations Duration/Low Flow Study* (USACE 2011b). Area VI would not improve water quality in Reach 4, and Reach 5 would experience only minimal improvement. As shown in Figure 2-2, Area VI would potentially improve water quality of the Red River from Carl, OK, to the Denison Dam in Texas, including Lake Texoma.

Water is not used directly from the Red River to meet the demands for M&I use in Reaches 1 and 2 and there are no such plans for using it in the future. However, the Lake Texoma portion of the Red River is an important water supply source for M&I users in Reach 3. Because M&I water providers in Reaches 1 and 2 are not anticipated to use water from the Red River, and would, therefore, not benefit from implementation of Area VI, these reaches were not considered further in this study. The remainder of this study focuses on the impact of the project on M&I users in Reach 3.

The use of Red River water for M&I purposes is governed by the Red River Compact, which defines the amount of water that can be withdrawn from Lake Texoma for M&I purposes. The five entities allowed to withdraw water from Lake Texoma for M&I use, listed in Table 2-5, are discussed below.

Table 2-5: Entities Allowed to Withdraw Lake Texoma Water and their Allocations

Entity	Water Rights, AFY
North Texas Municipal Water District	190,300
Greater Texoma Utility Authority	81,500
City of Denison	24,400
Texas Utilities	16,400
Red River Authority	2,250
TOTAL	**314,850**

AFY = acre-feet per year

2.6.1 North Texas Municipal Water District

The North Texas Municipal Water District (NTMWD) serves much of the rapidly growing suburban area north and east of Dallas-Fort Worth, TX. Demands on NTMWD are expected to more than double from 2010 to 2060, and NTMWD will need more than 368,000 AFY in additional supplies by 2060. NTMWD receives its water supply from three primary sources: Lake Lavon, Lake Cooper, and Lake Texoma. Lake Texoma water is pumped and then transported by gravity to Lake Lavon. Water from Lake Texoma is blended with Lake Lavon to meet water quality standards. NTMWD does not have desalination capabilities to treat for chlorides, and none are anticipated to be installed in the future.

The projected rate of water withdrawal from Lake Texoma by NTMWD for M&I use is anticipated to increase by 2060 (Table 2-6).

Table 2-6: NTMWD Projected Rate of M&I Withdrawal from Lake Texoma (AFY)

Entity	2010	2020	2030	2040	2050	2060
NTMWD	77,300	77,300	146,500	145,800	190,300	190,300

NTMWD = North Texas Municipal Water District

2.6.2 Greater Texoma Utility Authority

The Greater Texoma Utility Authority (GTUA) provides water to the cities of Pottsboro and Sherman, manufacturing in Grayson County, customers of the Collin Grayson Municipal Alliance, and NTMWD. The GTUA is planning to participate in the Grayson County Water Supply Project and is expected to provide water to 21 water user groups in Grayson and Collin Counties by 2060.

Lake Texoma is the primary surface water source utilized by the GTUA. Water from Lake Texoma is processed by the Sherman Water Treatment Plant (WTP). For desalination, the Sherman WTP has an electrodialysis reversal (EDR) facility that can treat up to 10 million gallons per day (mgd). The EDR process is used as needed to treat water that has undergone conventional water treatment processes.

The projected rate of water withdrawal from Lake Texoma by GTUA for M&I use is anticipated to remain constant through 2060 for the Sherman WTP and increase for other water recipients in GTUA (Table 2-7).

Table 2-7: GTUA Projected Rate of M&I Withdrawal from Lake Texoma (AFY)

Entity	2010	2020	2030	2040	2050	2060
Sherman WTP	8,000	8,000	8,000	8,000	8,000	8,000
Other Recipients	8,353	29,101	37,820	45,918	57,930	70,338

WTP = Water Treatment Plant

2.6.3 City of Denison

The City of Denison receives its water supply from two surface water sources: Lake Texoma and Lake Randell. The Denison WTP is located on Lake Randell and is used to blend water from Lake Randell and Lake Texoma. Lake Randell regulates the diversions of water from Lake Texoma for conventional treatment and use by the City. No other treatment process is currently installed for demineralization of the conventionally treated water. Groundwater supplies in the area are high in dissolved solids and are generally unsuitable for use.

The projected rate of water withdrawal from Lake Randell by the City of Denison for M&I use is anticipated to remain constant through 2060 (Table 2-8). A WTP expansion is planned in 2040 that will draw additional water from Lake Texoma from 2040 through 2060.

Table 2-8: City of Denison Projected Rate of M&I Withdrawal from Lake Texoma and Lake Randell (AFY)

Entity	Source	2010	2020	2030	2040	2050	2060
City of Denison	**Lake Randell**	1,400	1,400	1,400	1,400	1,400	1,400
	Lake Texoma	5,791	5,791	5,791	6,912	6,912	6,912

2.6.4 Texas Utilities

The projected rate of water withdrawal from Lake Texoma by Texas Utilities (TXU) for M&I use is anticipated to remain constant through 2060 (Table 2-9).

Table 2-9: TXU Projected Rate of M&I Withdrawal from Lake Texoma (AFY)

Entity	2010	2020	2030	2040	2050	2060
TXU	16,400	16,400	16,400	16,400	16,400	16,400

TXU = Texas Utilities

2.6.5 Red River Authority

The projected rate of water withdrawal from Lake Texoma by Red River Authority (RRA) for M&I use is anticipated to remain constant through 2060 (Table 2-10).

Table 2-10: RRA Projected Rate of M&I Withdrawal from Lake Texoma (AFY)

Entity	2010	2020	2030	2040	2050	2060
RRA	2,250	2,250	2,250	2,250	2,250	2,250

RRA = Red River Authority

3 ENGINEERING EVALUATION

The analysis of the benefits and costs of implementing Area VI is based on the information summarized in Section 2.0. The benefits associated with Area VI are estimated in Section 4 of this report. The following section presents the engineering analysis used to determine the costs and/or damages associated with both the Without-Project and With-Project conditions.

3.1 GENERAL APPROACH TO THE STUDY

The benefits associated with implementing the chloride reduction measures in Area VI were estimated based on two components: 1) reduction in treatment costs, and 2) reduced damages associated with higher quality water. The reduction in treatment cost component refers to the cost savings associated with reducing the amount or duration of treatment for chlorides and/or TDS. The reduced damages component refers to the cost savings associated with reducing damage to M&I facilities (e.g., water treatment, supply, distribution) and end users (e.g., residential household appliances), and was evaluated based on TDS reduction.

The costs associated with treating the water to remove a range of chloride, sulfate, and TDS concentrations were determined based on the information obtained from the City of Denison and Sherman WTPs. The City of Denison uses blended Lake Randell and Lake Texoma water, while the Sherman WTP treats Lake Texoma water using EDR technology to meet drinking water standards. Because treatment or blending is required to meet the standards, no additional benefit for reducing M&I damages was assigned; this is because the treatment or blending already maintains a theoretical "cap" on TDS at 1,000 mg/l in water delivered to customers.

The costs associated with damage to M&I facilities and end users was determined using the TDS damage coefficients presented in the *Wichita River Basin Reevaluation, Red River Chloride Control Project* (USACE 2003). The damage coefficients were applied only when treatment or blending is not necessary to meet the standards, based on projected seasonal water quality.

The secondary MCLs for the State of Texas (refer to Section 1.4) were used in this study to indicate contaminant levels at which treatment would be required. It was assumed that water providers would not let the chlorides and/or TDS levels exceed the Texas limits in the distribution system. This assumption limits the theoretical chloride and/or TDS concentrations that could impact end users. It was also assumed that water providers would not treat for these constituents if the source water concentrations are lower than the applicable State of Texas MCLs.

3.2 INTERVIEWS WITH WATER PROVIDERS

Major water providers in the Red River Basin were contacted to review their usage of Red River water and to understand what benefits, if any, could be realized by reducing chloride concentrations in the Red River water. Of the water providers located in the five reaches that use surface water, most draw water from tributaries flowing into the Red River or from lakes or reservoirs not connected to the Red River. A questionnaire was developed (see Appendix A) that was sent to 11 water providers to confirm their sources of water supply and request information about the type of water treatment used and the impact of chlorides on their water treatment system, water supply system, and water users. Initially, 11 municipal providers and two power plants were contacted but only seven municipal providers responded and agreed to participate in an interview. Phone interviews and some in-person interviews (City of Denison and Sherman) were conducted with representatives from:

- City of Altus
- City of Denison
- City of Sherman
- City of Wichita Falls
- GTUA
- NTMWD
- Bossier City

Although the City of Altus and the City of Wichita Falls are not located in Reach 3, they were included in the interview process based on their previous experience with chloride reduction or their proximity to the Red River.

Information obtained during the interviews indicates that the regional water providers are tasked with managing a wide variety of challenges, including drought, zebra mussels, economical operations, water supply planning, and regulatory compliance. At most locations, the impact of chloride concentrations in the water supply is obscured by other water quality issues such as hardness, which has a more immediate and direct impact on M&I users. In general, the water providers report that they are using either treatment or blending strategies to maintain chloride concentrations below the MCL, and have not experienced identifiable damage directly attributable to chloride concentrations. Appendix B includes the notes from the interviews.

3.3 METHODS USED TO MANAGE CHLORIDES

Municipal water providers in the study area employ two basic methods of managing high chloride concentrations in Red River/Lake Texoma water: 1) blend the water with higher quality water sources prior to treatment, or 2) treat water directly from Lake Texoma with desalination technology (after conventional treatment) and blend as necessary with non-desalinated water to maintain chloride and other constituents below secondary MCLs. The City of Denison is an example of the former approach, and the Sherman WTP is an example of the latter.

3.4 ANALYSIS OF WATER PROVIDERS

This section describes the engineering analysis applied to each of the five entities that draw water from Lake Texoma for M&I purposes.

3.4.1 North Texas Municipal Water District

NTMWD supplies wholesale water to member cities and customers in Collin, Denton, Fannin, Dallas, Rockwell, Hunt, and Kaufman Counties in north-central Texas. The cities of Plano, Richardson, Garland, Mesquite, and McKinney are a few of the larger municipalities receiving all or part of their service from NTMWD. Water demand is expected to double from 387,574 AFY in 2010 to 789,466 AFY in 2060. NTMWD receives its water supply from three primary sources, Lake Lavon, Cooper Lake and Lake Texoma. The main treatment plant for the NTWMD is located near Lake Lavon. Lake Texoma water is blended with Lake Lavon water to meet the MCLs before undergoing conventional treatment.

Lake Lavon has conservation storage of 380,000 acre-feet with a dependable yield of about 92.0 mgd. The entire yield is allocated and contracted to NTMWD, which has a water right to 104,000 acre-feet of storage. The lake is the receiving point for inter-basin transfers of water from Lake Texoma and Lake Cooper. Facilities are in place to use the entire available yield of Lake Lavon.

Based on the information available, desalination facilities are not anticipated to be needed to treat water from Lake Texoma. The MCLs will continue to be maintained through blending. Therefore, the benefits of Area VI would be associated with the reduction in damages to end users from lower TDS and chloride levels.

3.4.2 Greater Texoma Utility Authority

Water from Lake Texoma is processed at the Sherman WTP, operating since 1993. The Sherman WTP operates a 10 mgd WTP that includes conventional treatment, and 10 mgd of additional desalination treatment capability using EDR technology. The only surface water source for this treatment plant is Lake Texoma; therefore, the water must be treated seasonally with the desalination technology (after conventional treatment) to maintain chloride concentrations (and other parameters) below secondary MCLs.

A spreadsheet model (refer to Appendix C) was developed to evaluate the chloride mass balance for operations at the Sherman WTP to determine projected operating requirements for the EDR process to maintain treated chloride concentrations below 300 mg/l given a range of chloride concentrations in the Lake Texoma feed water. The range of modeled chloride concentrations covered the full range of potential water quality in Lake Texoma based on historic data and projected water quality benefits. The evaluation was used to determine how much water must be treated through the EDR process per day under various conditions and how the resulting daily operational costs were affected by the chloride concentrations in Lake Texoma source water.

The spreadsheet results illustrate that, simply based on chloride concentrations (as opposed to other water quality parameter such as hardness that can also be controlled), the EDR does not need to be operated until the Lake Texoma chloride concentration reaches the 300 mg/l MCL threshold. As the Lake Texoma chloride concentration rises, a higher proportion of the plant flow must be treated through the EDR process to maintain concentrations below the MCL in the blended treated water. As the proportion of flow that must be treated through the EDR increases, operating costs increase.

Projected future water demands will require either expansion of the Sherman WTP or construction of one or two additional treatment facilities. Because Lake Texoma water will be the only source for this expanded capacity to meet future demand, desalination technology is projected to be installed to treat likely water quality issues regardless of potential long-term reductions in chloride concentrations resulting from implementing Area VI. Therefore, capital costs for this expanded treatment capability were not included in this analysis. However, ongoing seasonal treatment operation and maintenance (O&M) costs were included in the analysis because of potential reductions in future chloride and TDS concentrations. To summarize, the capital cost of new desalination facilities was not included in the evaluation because they will be constructed regardless of Area VI, but future desalination O&M costs could be reduced by the project.

The Sherman WTP costs were based on actual facility operational costs of $0.43 per 1,000 gallons treated by the EDR desalination process, as reported in a *GE Water & Process Technologies* technical paper entitled "Electrodialysis Reversal at the City of Sherman," dated March 2008 (Sherman 2008). In addition, an operational cost of $0.40 per 1,000 gallons of water is spent for all of the water treated through the conventional treatment process at the Sherman WTP before the water is processed through EDR. Therefore, water that is only treated conventionally (no desalination) costs $0.40 per 1,000 gallons, and water treated with the conventional process followed by EDR desalination costs $0.83 per 1,000 gallons. The brine disposal cost was reported to be the equivalent of $1.97 per 1,000 gallons of brine discharged to the local wastewater treatment plant, based on a 15-percent reject rate.

3.4.3 City of Denison

The City of Denison, TX, operates a 13-mgd conventional WTP, with no desalination capability, located on Lake Randell, which is the primary water source. However, Lake Randell has a relatively small watershed (11 square miles) that is susceptible to localized drought conditions and has a limited water yield. Additional water is transferred from Lake Texoma as needed to supplement the Lake Randell water supply. The Lake Texoma water is pumped from an intake near the Denison Dam into Lake Randell and blended with the higher quality water. The City of Denison manages chloride concentrations by proactively pumping Lake Texoma water when it is higher quality, and reducing transfer when Lake Texoma water has higher chloride concentrations. However, a combination of conditions, including periodic drought, high water demand, and poorer Lake Texoma water quality can all combine to cause the drinking water chloride concentrations to exceed the 300 mg/l Texas secondary MCL, as was the case during the 2006 drought.

A chloride mass balance spreadsheet (refer to Appendix C) was developed for various water supply scenarios and a range of Lake Texoma chloride concentrations from 250 mg/l to 450 mg/l to model its effect on blended water chloride concentrations. To determine the impact of other variable parameters, Lake Randell chloride concentrations (before blending with Lake Texoma water) were assumed to be relatively constant at 100 mg/l. This concentration is based on water quality data from an adjacent watershed. The spreadsheet model suggests that the ability of the City of Denison to meet the chloride MCL is highly dependent on water production from Lake Randell.

According to the TWDB planning projections, the City of Denison includes moderate growth in demand that will be met by water conservation measures. However, by the year 2040, an additional 2 mgd of treatment capacity is projected to be needed and that water source will be Lake Texoma. If current conditions remain, this treatment expansion should be planned to include desalination because of the current uncertain capability of providing drinking water that consistently meets the secondary MCLs. For purposes of this study, increased future use of Lake Texoma water (without benefit of upstream chloride reduction beyond projected benefits from

Area VI) was assumed to necessitate construction, operation, and maintenance of 2 mgd of desalination treatment in addition to conventional treatment.

For the City of Denison, the cost evaluation includes the estimated capital cost for a 2 mgd desalination treatment process (projected to be reverse osmosis after conventional treatment) constructed in 2040, and ongoing O&M costs thereafter for approximately 1 mgd average annual water treated. The capital cost (in 2011 dollars) is projected to be approximately $4 million based on cost curves provided in Appendix R, "Draft Saline Water Special Study," of the *Region C Water Plan* (TWDB 2010d), as well as the *Desalting Handbook for Planners* (U.S. Bureau of Reclamation 2003). The future O&M cost for operating the desalination treatment and disposing of the resulting brine is estimated to be $1.00 per 1,000 gallons treated based on these same sources.

3.4.4 Texas Utilities

The MCLs will continue to be maintained through the current process. Therefore, the benefits of Area VI are associated with the reduction in damages to end users from the lower TDS and chloride levels.

3.4.5 Red River Authority

The MCLs will continue to be maintained through the current process. Therefore, the benefits of Area VI are associated with the reduction in damages to end users from the lower TDS and chloride levels.

4 ECONOMIC EVALUATION

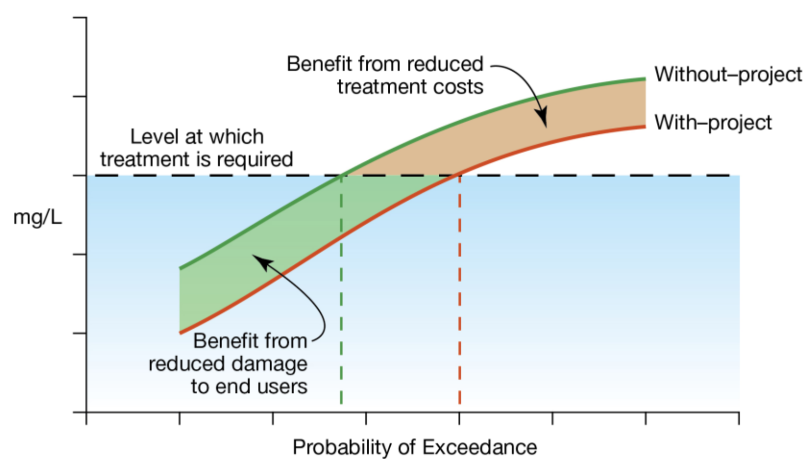
The economic evaluation includes the calculation of national economic development (NED) benefits, regional economic development (RED) benefits, and an analysis of the risk and uncertainty associated with the benefits for NTMWD, GTUA, the City of Denison, TXU, and RRA.

Because the proposed construction of the Cable Mountain Reservoir could potentially impact flows and water quality in the Red River Basin, the economic evaluation was performed for two scenarios. The first scenario estimated NED and RED benefits without the proposed Cable Mountain Reservoir. The results of the first scenario are presented in Section 4. The second scenario estimated NED and RED benefits with the proposed Cable Mountain Reservoir. Results of the second scenario are presented in Section 6.

4.1 NATIONAL ECONOMIC DEVELOPMENT BENEFITS

The following sections evaluate the NED benefits for NTMWD, GTUA, the City of Denison, TXU, and RRA. The first step was to establish the Without- and With-Project water quality conditions for the study area. The water quality assessments for the Denison gage station in Reach 3 (Table 2-3) were used as the basis for this evaluation. Table 2-3 presents the chloride and TDS concentrations as a percent of the time equaled or exceeded for both the Without-Project and With-Project conditions. For example, for the Without-Project condition, 5 percent of the time, the chloride concentration exceeds or is equal to 428 mg/l. For the With-Project condition, 5 percent of the time, the chloride concentration exceeds or is equal to 384 mg/l.

NED benefits are estimated for two categories: 1) benefits resulting from a reduction in treatment costs, and 2) benefits resulting from a reduction in damages to end users. The percentage of time the chloride and TDS levels are exceeded in Table 2-3 can be plotted as curves to demonstrate the calculation of these separate benefits. Figure 4-1 provides an illustration of what these curves would look like. The basic concept is used for both chloride and TDS. The Y-axis represents the level of chloride or TDS as mg/l. The X-axis represents the probability of exceedance.



Note: Image is not to scale, for illustrative purposes only; mg/L = milligrams per liter

Figure 4-1: Example of Probability of Exceedance for Chloride and TDS Levels

As the probability of exceedance decreases, the level of chloride or TDS increases. The curve representing the Without-Project condition has higher levels of chloride or TDS than the With-Project condition. The area between the two curves is the overall benefit of improving the water quality.

This overall benefit is then broken into two areas: the benefit from reduced damage to end users and the benefit from reduced treatment costs. On Figure 4-1, the black dotted line is the level at which treatment would be required, which is based on the secondary MCL guidelines for the State of Texas (see Section 1.4). It is assumed that water with a chloride level greater than 300 mg/l would be treated, and water with a TDS level higher than 1,000 mg/l would be treated. This level is the maximum cap; water will be treated so the level for end users would not exceed 300 mg/l of chloride and/or 1,000 mg/l of TDS. Above the dotted line, the area between the curves represents the benefits from reductions in treatment costs. The With-Project condition results in lower levels of chloride and TDS, and would have lower treatment costs to get the water to the required level.

Water with chloride and TDS levels below the cap does not need to be treated, so there is no benefit from a reduction of treatment costs below this point. However, levels of chloride and TDS between 0 mg/l and the secondary MCLs still cause damages to end users, such as damage to pipes, faucets, and washing equipment. A lower level of TDS or chlorides in the With-Project condition would result in reduced damages to the end users. The area between the curves below the level at which treatment is required represents this benefit.

To refine the estimations of benefits, the point on the With- and Without-Project curves where the chloride level is equal to 300 mg/l and the point where the TDS level is equal to 1,000 mg/l were estimated. These points are estimated by plotting the curves to find the corresponding probability of exceedance. Tables 4-1 and 4-2 show the concentration tables for chloride and TDS, updated with these points.

Table 4-1: Modified Chloride Concentrations

Condition	Percent of Time Equaled or Exceeded										
	1	**5**	**10**	**20**	**43**	**50**	**59**	**80**	**90**	**95**	**99**
Without-Project	540	428	410	387	**335**	319	**300**	254	228	207	162
With-Project	484	384	367	347	**300**	285	**268**	227	204	186	145

Table 4-2: Modified TDS Concentrations

Condition	Percent of Time Equaled or Exceeded										
	1	**5**	**10**	**20**	**32**	**42**	**50**	**80**	**90**	**95**	**99**
Without-Project	1680	1261	1208	1146	**1067**	**1000**	948	737	642	569	474
With-Project	1575	1182	1133	1074	**1000**	**938**	889	691	601	534	440

For the Without-Project condition, 59 percent of the time the chloride concentration exceeds 300 mg/l and 42 percent the TDS concentration exceeds 1,000 mg/l. For the With-

Project condition, 43 percent of the time the chloride concentration exceeds 300 mg/l and 32 percent of the time the TDS concentration exceeds 1,000 mg/l.

Section 4.1.1 provides further details on the estimation of the benefits resulting from a reduction in treatment costs, and Section 4.1.2 provides further details on the estimation of the benefits resulting from a reduction in damages to end users.

4.1.1 Reduction in Treatment

The GTUA and the City of Denison would both benefit from a reduction in treatment costs resulting from implementation of Area VI. Two different methodologies were used to evaluate the NED benefits resulting from a reduction in chlorides for the GTUA and the City of Denison. Benefits for the GTUA are based on a reduction in treatment costs due to lower chloride levels. Benefits for the City of Denison are based on an avoided cost of constructing a desalination treatment and a conventional treatment plant associated with a reduction in chlorides. The methodologies are further explained in the following sections.

4.1.1.1 GTUA

The cost evaluations developed and described in Section 3 are used to estimate the benefits of implementing Area VI to M&I water use. The GTUA cost evaluation is based on a portion of water from Lake Texoma being processed by the Sherman WTP. The Sherman WTP is a conventional WTP with the capability to treat a portion of the water flow through EDR.

The chloride concentration at each percent of time equaled or exceeded for the Without- and With-Project condition is used to calculate the amount of Lake Texoma water that needs to go through the EDR process. For this analysis, the resulting concentration is assumed to always equal the Texas secondary MCL of 300 mg/l chloride. Assuming 10 mgd of water is flowing into the WTP, the volume of water needed to be treated through EDR is determined. The volume that would be required to go through EDR for the Without- and With-Project conditions and percent of time the chloride concentrations equaled or exceeded the MCL is presented in Table 4-3. Using the previous example, 5 percent of the time the chloride concentration is 428 mg/l for the Without-Project condition and 384 mg/l for the With-Project condition. To meet the 300 mg/l level for the Without-Project condition, 3.47 mgd of water would need to go through EDR. At this concentration level for the With-Project condition, only 2.53 mgd of water would need to be processed through EDR to obtain a resulting chloride concentration of 300 mg/l.

Table 4-3: Amount of Water to Undergo EDR for Without- and With-Project (mgd)

Condition	Percent of Time MCL is Equaled or Exceeded										
	1	5	10	20	43	50	59	80	90	95	99
Without-Project	5.17	3.47	3.13	2.6	1.2	0.7	0	0	0	0	0
With-Project	4.41	2.53	2.13	1.57	0	0	0	0	0	0	0

MCL = Maximum Contaminant Level

The amounts to be processed through EDR presented in Table 4-3 were then multiplied by the costs of EDR. The EDR process includes a cost for the EDR and also a cost for brine disposal. The average conventional treatment cost is about $0.40 per 1,000 gallons, while the demineralization treatment cost (which includes conventional treatment and the additional EDR treatment) is approximately $0.83 per 1,000 gallons. These costs are based on O&M costs for the WTP. Therefore, EDR costs an extra $0.43 per 1,000 gallons to operate beyond the conventional process ($0.83 – $0.40 = $0.43 per 1,000 gallons). Table 4-4 shows the daily O&M cost of EDR for the Without- and With-Project conditions.

Table 4-4: EDR Daily O&M Cost

Condition	Percent of Time Equaled or Exceeded										
	1	5	10	20	43	50	59	80	90	95	99
Without-Project	$2,223	$1,492	$1,346	$1,118	$516	$301	$0	$0	$0	$0	$0
With-Project	$1,896	$1,088	$916	$675	$0	$0	$0	$0	$0	$0	$0

The brine unit disposal cost is $1.97 per 1,000 gallons. Brine also has a 15-percent average reject rate. Similar to the EDR costs, this cost is multiplied by the amounts of water to use in EDR (Table 4-3). The costs for brine disposal are shown in Table 4-5.

Table 4-5: Daily Brine Disposal Cost

Condition	Percent of Time Equaled or Exceeded ($)										
	1	5	10	20	43	50	59	80	90	95	99
Without-Project	$1,528	$1,025	$925	$768	$355	$207	$0	$0	$0	$0	$0
With-Project	$1,303	$748	$629	$464	$0	$0	$0	$0	$0	$0	$0

The daily cost for EDR O&M is then added to the daily cost of brine disposal and multiplied by the 365 days to estimate the cost per year of EDR (Table 4-6).

Table 4-6: EDR O&M Cost per Year ($1,000s)

Condition	Percent of Time Equaled or Exceeded ($)										
	1	5	10	20	43	50	59	80	90	95	99
Without-Project	$1,369	$919	$829	$689	$318	$185	$0	$0	$0	$0	$0
With-Project	$1,168	$670	$564	$416	$0	$0	$0	$0	$0	$0	$0

The benefit attributed to the With-Project condition is the reduction in the amount of Lake Texoma water that needs to go through the EDR process and be blended to have a chloride level of 300 mg/l, or the Without-Project costs minus the With-Project costs (Table 4-7).

Table 4-7: Annual Benefits for With-Project Condition ($1,000s)

Condition	Percent of Time Equaled or Exceeded ($)										
	1	5	10	20	43	50	59	80	90	95	99
With-Project	$201	$249	$265	$273	$318	$185	$0	$0	$0	$0	$0

The area between the resultant damage-frequency curves is integrated to produce the annual benefit for the With-Project condition. The annual benefit of a reduction in EDR O&M costs is approximately $134,400. However, these benefits would only be realized once the full benefits of Area VI are realized, which is estimated to be 20 years after implementation.

4.1.1.2 City of Denison

Future growth is projected to create a need for an additional 2 mgd of treatment capacity at the City of Denison WTP. Increased future use of Lake Texoma water (without the benefit of upstream chloride reduction) is assumed to necessitate construction, operation, and maintenance of a 2-mgd desalination facility in addition to conventional treatment. Therefore, the Without-Project condition includes the construction, operation, and maintenance of a desalination treatment. The With-Project condition assumes that if Area VI is implemented, a 2-mgd expansion of the conventional treatment facility will still need to be constructed to meet the increased demand. However, the reduction in chlorides resulting from Area VI would negate the need for a desalination facility in addition to the conventional treatment.

The cost of the Without-Project condition is calculated assuming that construction of the increased treatment facilities would take place in the year 2040. The additional cost of the desalination treatment is $4 million. This cost is discounted back to 2011, and then annualized using the USACE water resources 2011 discount rate of 4 percent and a 50-year period of analysis. The annualized cost of the construction of the desalination treatment is approximately $59,700.

O&M costs will begin after the construction in 2040. O&M costs are estimated to be $1.00 per 1,000 gallons of water. The *2011 Region C Water Plan* (TWDB 2010a) estimates that from 2040 to 2060, 1 mgd of Lake Texoma water would need to be treated in the 2-mgd WTP expansion. Therefore, the daily O&M cost is about $1,000. The reverse osmosis treatment is assumed to only need to be operated approximately 59 percent of the time in the Without-Project condition. The annual O&M cost of the reverse osmosis process is about $215,400. This cost is applied to years 2040 through 2061, discounted back to present value, and then annualized. The annual cost over the period of analysis for O&M is approximately $48,300.

The annual cost of construction is added to the annual cost of O&M to estimate a total annual cost of $108,000 for the Without-Project condition. For the With-Project condition, this cost is an avoided cost resulting from implementation of Area VI. Therefore, the annual benefit attributed to the With-Project condition is $108,000.

4.1.2 Reduction in Damages to End Users

Reduction in damages to end users is estimated for municipal end users and for industrial end users. The process is described in the following sections.

4.1.2.1 Municipal

NTMWD, GTUA, the City of Denison, and RRA are anticipated to benefit from a reduction in damages to municipal end users. Benefits to municipal end users are estimated using the modified TDS concentrations shown in Table 4-2 and a combined municipal damage coefficient. The *Wichita River Basin Project Reevaluation, Red River Chloride Control Project* (USACE 2003) estimates a combined municipal damage coefficient. This coefficient estimates the damages caused by TDS to end users in terms of dollars per 1,000 gallons per 100 mg/l of TDS. At a 2001 cost level, damages to end users were estimated to be $0.1636 per 1,000 gallons per 100 mg/l of TDS (Table 1-1). This value was updated to a 2011 cost level, using the BCI yearly averages from 2001 and 2011, of $0.23 per 1,000 gallons per 100 mg/l of TDS.

The damage coefficient is divided by 100 to estimate per 1 mg/l of TDS, and then multiplied by the TDS concentrations in Table 4-2. The 1-, 5-, 10-, and 20-percent levels have TDS concentrations greater than 1,000 mg/l. Levels greater than 1,000 mg/l will be treated down to 1,000 mg/l of TDS, and, therefore, have constant damages of $2.31 per 1,000 gallons (Table 4-8).

Table 4-8: Municipal Damages per 1,000 Gallons

Condition	Percent of Time Equaled or Exceeded										
	1	**5**	**10**	**20**	**32**	**42**	**50**	**80**	**90**	**95**	**99**
Without-Project	$2.31	$2.31	$2.31	$2.31	$2.31	$2.31	$2.19	$1.70	$1.48	$1.31	$1.09
With-Project	$2.31	$2.31	$2.31	$2.31	$2.31	$2.16	$2.05	$1.59	$1.39	$1.23	$1.02

The damages per 1,000 gallons are multiplied by projected Lake Texoma water withdrawals for NTMWD, GTUA, the City of Denison, and RRA. Projected water use is taken from the Texas *2011 Region C Water Plan* (TWDB 2010a) (Tables 2-6 through 2-10 in Section 2.6). Lake Texoma water use for the RRA is not projected in the *Region C Water Plan*, so RRA's water right to Lake Texoma of 2.0 mgd is used. These volumes are converted to 1,000 gallons per year and multiplied by the damages.

The benefit is the reduction in damages resulting from the With-Project condition. This is found by subtracting the With-Project damages from the Without-Project damages.

The area between the With- and Without-Project curves is integrated to produce the annual benefit for the With-Project condition. The average annual benefit of a reduction in damages to municipal end users is approximately $3,594,400 (Table 4-9). However, these benefits would only be realized once the full benefits of Area VI are realized, which is estimated to be 20 years after implementation.

Table 4-9: Municipal Damages

Entity	Average Annual Benefit
North Texas Municipal Water District	$2,412,000
Greater Texoma Utility Authority	$938,800
City of Denison	$187,100
Red River Authority	$56,600
TOTAL	**$3,594,400**

4.1.2.2 Industrial

Benefits to industrial end users are estimated using the TDS duration table shown in Table 2-4 and the combined industrial damage coefficient estimated in the *Wichita River Basin Project Reevaluation, Red River Chloride Control Project*. This coefficient estimates the damages caused by TDS to end users in terms of dollars per 1,000 gallons per 100 mg/l of TDS.

In 2001 dollars, the estimated damages to the industrial end user were $0.05 per 1,000 gallons per 100 mg/l of TDS (Table 1-2). This value was updated to a 2011 cost level, using the BCI yearly averages from 2001 and 2011, of $0.07 per 1,000 gallons per 100 mg/l of TDS.

The damage coefficient is divided by 100 to estimate per 1 mg/l of TDS, and then multiplied by the TDS concentrations in Table 4-2. The 1-, 5-, 10-, and 20-percent levels have TDS concentrations greater than 1,000 mg/l. Levels greater than 1,000 mg/l would be treated down to 1,000 mg/l of TDS, and, therefore, have constant damages of $0.69 per 1,000 gallons (Table 4-10).

Table 4-10: Industrial Damages per 1,000 gallons

Condition	Percent of Time Equaled or Exceeded										
	1	5	10	20	32	42	50	80	90	95	99
Without-Project	$0.69	$0.69	$0.69	$0.69	$0.69	$0.69	$0.65	$0.51	$0.44	$0.39	$0.33
With-Project	$0.69	$0.69	$0.69	$0.69	$0.69	$0.65	$0.61	$0.48	$0.41	$0.37	$0.30

The damage per 1,000 gallons is multiplied by the projected water use for TXU. The Lake Texoma water allocation is used to project water use. TXU is allocated 16,400 AFY of Lake Texoma water, which converts to 14.6 mgd. This volume is converted to 1,000 gallons per year and multiplied by the damages in Table 4-10. Table 4-11 shows the results.

Table 4-11: Industrial Damages per Year ($1,000s)

Condition	Percent of Time Equaled or Exceeded										
	1	5	10	20	32	42	50	80	90	95	99
Without-Project	$3,684	$3,684	$3,684	$3,684	$3,684	$3,684	$3,493	$2,715	$2,365	$2,096	$1,746
With-Project	$3,684	$3,684	$3,684	$3,684	$3,684	$3,456	$3,276	$2,546	$2,214	$1,968	$1,621

The benefit is the reduction in damages resulting from implementing Area VI. This is found by subtracting the With-Project damages from the Without-Project damages (Table 4-12).

Table 4-12: Benefit of With-Project from Reduced Industrial Damages to End Users ($1,000s)

Condition	Percent of Time Equaled or Exceeded										
	1	5	10	20	28	39	50	80	90	95	99
With-Project	$0	$0	$0	$0	$0	$228	$217	$169	$151	$129	$125

The area between the With- and Without-Project curves is integrated to produce the annual benefit for the With-Project alternative. The average annual benefit of a reduction in damages to industrial end users is approximately $123,200. However, these benefits would only be realized once the full benefits of Area VI are realized, which is estimated to be 20 years after implementation.

4.1.3 Total Annualized National Economic Development Benefits

The annual NED benefits calculated for each of the entities using water from Lake Texoma were added together to estimate the total annual NED benefits. The total annual NED benefits in the study area are $3,960,100 once the full benefits of implementing Area VI are realized.

The study area is not likely to realize the full benefits of Area VI immediately after implementation. The *Region B Water Plan 2010* (TWDB 2010b) states that full benefits may not be realized until 20 years after implementation. The total annualized NED benefits were adjusted to reflect the delay in full benefits. The reduction in chlorides and TDS were straight-lined over 20 years so the benefits are increasing each year at a constant rate until full benefits are realized every year from year 21 forward. The adjusted annual benefits were annualized again for a total equivalent annual NED benefit of $2,608,400 (Table 4-13).

Table 4-13: Equivalent Annual NED Benefits

Entity	Equivalent Annual Benefit
North Texas Municipal Water District	$1,588,700
Greater Texoma Utility Authority	$706,900
City of Denison	$194,400
Texas Utilities	$81,200
Red River Authority	$37,300
TOTAL	**$2,608,400**

4.2 REGIONAL ECONOMIC DEVELOPMENT BENEFITS

The RED benefits were analyzed using the NED benefits found in Section 4.1. The MIG, Inc. software program IMPLAN was used for the economic modeling. IMPLAN is used to analyze the indirect and induced effects of a change on the local economy. The data can be analyzed on a national, State, county, or zip code level. For this analysis, the county level was used. The Sherman WTP (part of GTUA) and the City of Denison are both located in Grayson County, so the RED benefits for these areas are based on Grayson County data. The results were then applied to NTMWD, GTUA, TXU, and RRA on a per mgd basis.

The NED benefit analysis estimates that a reduction in chloride levels and damages to end users in the With-Project condition results in equivalent annual NED benefits in the study area of $2,608,400. Interviews with the WTP personnel in the area indicate a reduction in chloride levels would not increase production or the use of Lake Texoma water; the demand for water is more dependent on the population growth and restrained by water allocation agreements. Because the WTPs are regulated public utilities, benefits were assumed to be passed on to the end consumer as a reduction in the cost of the final water product. This reduction in cost represents an increase in household income. The reduction in damages to end users is a benefit to the households as the households have lower and less frequent damages.

IMPLAN breaks down households by income brackets. The U.S. Census Bureau provides percentage breakdowns of the number of households in each income bracket by county. Table 4-14 shows the income bracket breakdown for Grayson County.

Table 4-14: Income Bracket by Percent of Households for Grayson County

Income	Percent
Less than 10K	7.8
10K–15K	6.2
15K–25K	12.2
25K–35K	11.3
35K–50K	16.8
50K–75K	18.8
75K–100K	13.4
100K–150K	9.1
150K+	4.4

Source: American FactFinder, 2005–2009 American Community Survey Estimates (U.S. Census Bureau 2009)

The increase in household income would benefit all households in the county. The percentage of households in each income bracket was multiplied by the annual NED benefit for Sherman WTP and Denison of $415,400 to estimate the benefit per income bracket (Table 4-15). These benefits per bracket were then used as the input for IMPLAN to calculate the RED effect for reduced treatment costs and municipal damages for Sherman and Denison. As presented in Section 4.1, NTMWD, GTUA, TXU and RRA do not have NED benefits from treatment costs. Therefore, only the RED benefits resulting from a reduction in municipal damages were used in the RED analysis of these entities. Table 4-15 shows the NED benefits by income bracket for reduced treatment costs and municipal damages as well as for municipal damages alone.

Table 4-15: NED Benefits by Income Bracket*

Income	Treatment Costs & Municipal Damages			Municipal Damages		
	Sherman	Denison	Total	Sherman	Denison	Total
Less than 10K	$17,200	$15,200	$32,400	$10,300	$9,600	$19,900
10K–15K	$13,700	$12,100	$25,800	$8,200	$7,600	$15,900
15K–25K	$27,000	$23,700	$50,700	$16,200	$15,000	$31,200
25K–35K	$25,000	$22,000	$46,900	$15,000	$13,900	$28,900
35K–50K	$37,100	$32,700	$69,800	$22,300	$20,700	$43,000
50K–75K	$41,500	$36,500	$78,100	$24,900	$23,200	$48,100
75K–100K	$29,600	$26,000	$55,700	$17,800	$16,500	$34,300
100K–150K	$20,100	$17,700	$37,800	$12,100	$11,200	$23,300
150K+	$9,700	$8,600	$18,300	$5,800	$5,400	$11,300
TOTAL	**$221,000**	**$194,400**	**$415,400**	**$132,500**	**$123,200**	**$255,700**

**Values are rounded*

4.2.1 Indirect Effects

No indirect effects are associated with the NED benefits. IMPLAN defines indirect effects as the impact of local industries buying goods and services from other local industries. The reduction in chloride does not result in the WTPs buying more goods or services. The WTPs have the same demand in the Without- and With-Project conditions, but have a lower cost in the With-Project. Because the cost savings are passed on to the end consumers, all the RED benefits are considered induced effects. Induced effects are the effects on households, and because all the benefits are transferred to the households, all the RED benefits are considered induced effects.

4.2.2 Induced Effects

IMPLAN defines induced effects as the response to a direct effect that occurs when an addition (or subtraction) of income causes re-spending (or reduced spending). Induced effects refer to the effects on households in the study area. Households would experience a decrease in the cost of water from the WTPs, which translates to an increase in household income. Households then take this increase in income and spend it in other industries and businesses in the county. IMPLAN calculates this induced spending through multipliers.

The NED benefits by income bracket (reduced treatment costs and municipal damages) presented in Table 4-15 are the inputs to IMPLAN. IMPLAN uses these inputs to calculate the effects on Grayson County using multipliers. Table 4-16 presents the induced effects for Sherman WTP and Denison.

Table 4-16: Induced Effects for Sherman WTP and Denison

Employment	Labor Income	Value Added	Output
3.2	$120,100	$209,200	$345,600

The effect of the total NED benefits results in an increase in employment of 3.2 jobs. Labor income is a sum of all types of employment income, including proprietor income and employee compensation. Labor income is estimated to increase by $120,100 per year. Value added is the value of total outputs minus the total cost of intermediate inputs. Value added is estimated to increase by $209,200 in the study area. Output is the total value of industry production. Output is estimated to increase by $345,600 per year. A few of the IMPLAN industry categories that have the highest increases in output are imputed rental activity for owner-occupied dwellings, private hospitals, medical offices, food services and drinking places, insurance carriers, monetary authorities and depository credit intermediation activities, real estate establishments, and nursing and residential care facilities.

The induced effects results were then applied to NTMWD, GTUA, TXU, and RRA on a per mgd basis. The NED benefits for a reduction in municipal damages (Table 4-15) were input to IMPLAN. The induced effects resulting from the reduction in municipal damages alone are presented in Table 4-17.

Table 4-17: Induced Effects for Sherman WTP and Denison, Municipal Damages

Employment	Labor Income	Value Added	Output
2.0	$73,900	$128,800	$212,700

The total amount of water analyzed for Sherman WTP and the City of Denison is 13.56 mgd. The total induced effects in Table 4-17 are divided by 13.56 mgd to estimate an RED effect per mgd of water. This result was multiplied by the mgd of water for NTMWD, GTUA, TXU, and RRA. The results per year are presented in Tables 4-18, 4-19, 4-20, and 4-21. Lake Texoma use projections for NTMWD and GTUA include an increase in use through 2060, so induced effects for NTMWD and GTUA are presented by year.

Table 4-18: Induced Effects for NTMWD

Year	Employment	Labor Income	Value Added	Output
2010	10.2	$376,200	$655,300	$1,082,500
2020	10.2	$376,200	$655,300	$1,082,500
2030	19.3	$714,200	$1,244,100	$2,055,100
2040	19.2	$708,700	$1,234,600	$2,039,400
2050	25.1	$926,800	$1,614,400	$2,666,900
2060	25.1	$926,800	$1,614,400	$2,666,900

Table 4-19: Induced Effects for GTUA

Year	Employment	Labor Income	Value Added	Output
2010	1.1	$40,600	$70,800	$116,900
2020	3.8	$141,600	$246,600	$407,400
2030	5.0	$184,000	$320,500	$529,500
2040	6.0	$223,400	$389,200	$642,900
2050	7.6	$281,900	$491,000	$811,100
2060	9.3	$342,200	$596,100	$984,700

Table 4-20: Induced Effects for TXU

Employment	Labor Income	Value Added	Output
2.2	$79,600	$138,700	$229,000

Table 4-21: Induced Effects for RRA

Employment	Labor Income	Value Added	Output
0.3	$10,900	$19,000	$31,400

4.2.3 Total Regional Economic Development Benefits

The labor income, value added, and output were annualized over the 50-year period of analysis at a 4-percent discount rate. Total equivalent annual RED benefits for GTUA, the City of Denison, NTMWD, TXU, and RRA are shown in Table 4-22.

Table 4-22: Total RED Benefits for the Study Area

Labor Income	Value Added	Output
$888,600	$1,547,900	$2,557,000

5 RISK AND UNCERTAINTY

A risk and uncertainty analysis was performed on the economic analysis. The Excel add-on @Risk was used to evaluate the risk and uncertainty. @Risk uses Monte Carlo simulations to perform a risk analysis. The following variables were analyzed for risk and uncertainty:

- Treatment costs of EDR, O&M, brine disposal, and the average brine rejection rate for the Sherman WTP
- Capital cost of the 2-mgd reverse osmosis process add-on, reverse osmosis cost of O&M, and the amount of water to be treated in the reverse osmosis process for the City of Denison
- Water projections for GTUA, the City of Denison, and NTMWD
- M&I damage coefficients
- Percentage of time the chloride concentration exceeds 300 mg/l in the Without- and With-Project condition

The values for the above variables presented in Section 4 are assumed to be the most likely value. A triangular distribution was created around each most likely value to estimate the uncertainty. The most likely values for water use projections were varied by 10 percent to estimate the low and high values of the distribution. The most likely values for the other variables were varied by 20 percent to estimate the low and high values of the distribution.

In addition to these variables, risk and uncertainty were calculated for the 20-year timeframe until the full benefits of Area VI would be realized. An analysis was performed to find the range of total benefits for two alternative timeframes, 15 years and 25 years until the full benefits are realized.

Once the probability distributions were identified in the Excel spreadsheet, a simulation was run with 1,000 iterations. The simulation produced distributions of the possible results for identified outputs. Table 5-1 presents the results of the simulation. The results are shown for a 90-percent confidence interval.

Table 5-1: Risk and Uncertainty of NED Equivalent Annual Benefits

Timeframe for Full Benefits to be Realized	90% Probability Range for Total Benefits		
	Low	Mean	High
15 years	$2,539,000	$2,904,000	$3,269,000
20 years	$2,285,000	$2,608,300	$2,939,000
25 years	$2,051,000	$2,346,700	$2,656,000

If the full benefits are realized in 15 years, there is a 90 percent probability that the total equivalent annual benefits would be between$ 2,539,000 and $3,269,000. If the full benefits are realized in 20 years, there is a 90 percent probability the equivalent annual benefits would be between $2,285,000 and $2,939,000. If full benefits are realized in 25 years, there is a 90 percent probability that the total equivalent annual benefits would be between $2,051,000 and $2,656,000.

Another source of uncertainty pertains to the With-Project conditions and the Cable Mountain Reservoir. Construction of the Cable Mountain Reservoir has been proposed on the Elm Fork of the Red River if Area VI is implemented. The reservoir would capture relatively high quality water prior to it entering the main stem of the Red River and could impact the estimated chloride and TDS concentrations from those presented in the *Area VI Reevaluation Concentrations Duration/Low Flow Study* (USACE 2011b). The Cable Mountain Reservoir scenario is presented in Section 6.

6 CABLE MOUNTAIN RESERVOIR

The construction of Cable Mountain Reservoir is proposed as a new reservoir on the North Fork of the Red River downstream of Lake Altus. The reservoir would be located near Headrick, OK, and its use would be to increase the yield and storage of Lake Altus. Cable Mountain Reservoir has the potential to affect the flows and water quality in the Red River Basin. The analysis of NED benefits, RED benefits, and risk and uncertainty for the scenario including Cable Mountain Reservoir used the same methodology presented in Sections 4 and 5. Although the methodology is the same, the resulting benefits differ because of a change in With-Project water quality conditions with the implementation of Cable Mountain Reservoir.

6.1 NATIONAL ECONOMIC DEVELOPMENT BENEFITS

The following sections evaluate the NED benefits for NTMWD, GTUA, the City of Denison, TXU, and RRA if Cable Mountain Reservoir is constructed. The Without-Project water quality conditions are the same as the previous scenario. The With-Project water quality conditions are also taken from *Area VI Reevaluation Concentrations Duration/Low Flow Study* (USACE 2011b). This study presents water quality assessments for the Denison gage station in Reach 3 for the combined effect of implementing chloride control, irrigation, and Cable Mountain Reservoir. These actions were used as the basis for this evaluation. Table 6-1 presents the chloride and TDS concentrations as a percent of the time equaled or exceeded for both the Without-Project and With-Project conditions.

Table 6-1: Reach 3 Water Quality Assessment with Cable Mountain Reservoir

Constituent	Condition	Percent of Time Equaled or Exceeded								
		1	5	10	20	50	80	90	95	99
Denison Gage Station										
Chloride	Without Project	540	428	410	387	335	254	228	207	162
	With Project	512	406	388	367	302	240	216	196	153
TDS	Without Project	1680	1261	1208	1146	948	737	642	569	474
	With Project	1666	1250	1198	1137	940	731	636	565	470

TDS = Total Dissolved Solids

To refine the estimations of benefits, the point on the With- and Without-Project curves where the chloride level is equal to 300 mg/l and the point where the TDS level is equal to 1,000 mg/l were estimated. These points are estimated by plotting the curves to find the corresponding probability of exceedance. Tables 6-2 and 6-3 show the concentration tables for chloride and TDS, updated with these points.

Table 6-2: Modified Chloride Concentrations

Condition	Percent of Time Equaled or Exceeded										
	1	5	10	20	50	52	59	80	90	95	99
Without-Project	540	428	410	387	335	**319**	**300**	254	228	207	162
With-Project	512	406	388	367	302	**300**	**296**	240	216	196	153

Table 6-3: Modified TDS Concentrations

Condition	Percent of Time Equaled or Exceeded										
	1	5	10	20	41	42	50	80	90	95	99
Without-Project	1000	1000	1000	1000	**1000**	**1000**	948	737	642	569	474
With-Project	1000	1000	1000	1000	**1000**	**993**	940	731	636	565	470

For the Without-Project condition, 59 percent of the time the chloride concentration exceeds 300 mg/l and 42 percent of the time the TDS concentration exceeds 1,000 mg/l. For the With-Project condition, 52 percent of the time the chloride concentration exceeds 300 mg/l and 41 percent of the time the TDS concentration exceeds 1,000 mg/l.

Section 6.1.1 provides further details on the estimation of the benefits resulting from a reduction in treatment costs, and Section 6.1.2 provides further details on the estimation of the benefits resulting from a reduction in damages to end users.

6.1.1 Reduction in Treatment

The GTUA and the City of Denison would both benefit from a reduction in treatment costs due to implementation of Area VI. The same methodologies in Section 4.1.1 and 4.1.2 were used to evaluate the NED benefits resulting from a reduction in chlorides for the GTUA and the City of Denison. Benefits for the GTUA are based on a reduction in treatment costs due to lower chloride levels. Benefits for the City of Denison are based on an avoided cost of constructing a desalination treatment and a conventional treatment plant associated with a reduction in chlorides.

6.1.1.1 GTUA

The GTUA cost evaluation is based on a portion of water from Lake Texoma being processed by the Sherman WTP. The chloride concentration at each percent of time equaled or exceeded for the Without- and With-Project condition is used to calculate the amount of Lake Texoma water that needs to go through the EDR process. The volume that would be required to go through EDR for the Without- and With-Project conditions and percent of time the water quality equaled or exceeded the MCL is presented in Table 6-4.

Table 6-4: MGD to use in EDR for Without- and With-Project

Condition	Percent of Time Equaled or Exceeded (mg/l)										
	1	5	10	20	50	52	59	80	90	95	99
Without-Project	5.17	3.47	3.13	2.6	1.2	0.7	0	0	0	0	0
With-Project	4.81	3.03	2.65	2.12	0.08	0	0	0	0	0	0

The amounts to be processed through EDR presented in the Table 6-4 were then multiplied by the costs of EDR and the cost of brine disposal (Table 6-5).

Table 6-5: EDR O&M Cost per Year ($1,000s)

Condition	Percent of Time Equaled or Exceeded ($)										
	1	5	10	20	50	52	59	80	90	95	99
Without-Project	$1,369	$919	$829	$689	$318	$185	$0	$0	$0	$0	$0
With-Project	$1,274	$802	$702	$561	$21	$0	$0	$0	$0	$0	$0

The benefits attributed to the With-Project condition are the reduction of the amount of Lake Texoma water that needs to go through the EDR process and be blended to have a chloride level of 300 mg/l, or the Without-Project costs minus the With-Project costs (Table 6-6).

Table 6-6: Annual Benefits for With-Project ($1,000s)

Condition	Percent of Time Equaled or Exceeded ($)										
	1	5	10	20	50	52	59	80	90	95	99
With-Project	$95	$117	$127	$127	$297	$185	$0	$0	$0	$0	$0

The area between the resultant damage-frequency curves is integrated to produce the annual benefit for the With-Project condition. The annual benefit of a reduction in EDR O&M costs is approximately $92,300. However, these benefits would only be realized once the full benefits of Area VI are realized, which is estimated to be 20 years after implementation.

6.1.1.2 City of Denison

The analysis of the benefits resulting from a reduction in treatment costs at the City of Denison WTP was based on the construction, operation, and maintenance of a 2-mgd desalination facility in addition to conventional treatment. For the analysis including the proposed construction of Cable Mountain Reservoir, the Without- and With-Project conditions remain the same. Therefore, the annual benefit attributed to the With-Project condition is $108,000.

6.1.2 Reduction in Damages to End Users

Reduction in damages to end users is estimated for municipal end users and for industrial end users for the scenario including Cable Mountain Reservoir. The process described in Sections 4.1.2.1 and 4.1.2.2 was used to estimate benefits for this scenario. The results are presented in the following sections.

6.1.2.1 Municipal

Benefits to municipal end users are estimated using the TDS duration table (Table 6-1) and the combined municipal damage coefficient of $0.23 per 1,000 gallons per 100 mg/l of TDS.

The damage coefficient is divided by 100 to estimate per 1 mg/l of TDS, and then multiplied by the TDS concentrations in Table 4-2. The 1-, 5-, 10-, and 20-percent levels have TDS concentrations greater than 1,000 mg/l. Levels greater than 1,000 mg/l will be treated down to 1,000 mg/l of TDS and, therefore, will have a constant damage of $2.31 per 1,000 gallons (Table 6-7).

Table 6-7: Municipal Damages per 1,000 Gallons

Condition	Percent of Time Equaled or Exceeded										
	1	5	10	20	41	42	50	80	90	95	99
Without-Project	$2.31	$2.31	$2.31	$2.31	$2.31	$2.31	$2.19	$1.70	$1.48	$1.31	$1.09
With-Project	$2.31	$2.31	$2.31	$2.31	$2.31	$2.29	$2.17	$1.69	$1.47	$1.30	$1.08

The damage per 1,000 gallons is multiplied by projected Lake Texoma water withdrawals for NTMWD, GTUA, the City of Denison, and RRA.

The benefit is the reduction in damages resulting from the With-Project condition. The area between the With- and Without-Project curves is integrated to produce the annual benefit for the With-Project condition. The average annual benefit of a reduction in damages to municipal end users is approximately $414,300 (Table 6-8).

Table 6-8: Municipal Damages

Entity	Average Annual Benefit
North Texas Municipal Water District	$278,000
Greater Texoma Utility Authority	$108,200
City of Denison	$21,600
Red River Authority	$6,500
TOTAL	**$414,300**

6.1.2.2 Industrial

Benefits to industrial end users are estimated using the TDS duration table (Table 6-1) and the combined industrial damage coefficient of $0.07 per 1,000 gallons per 100 mg/l of TDS.

The damage coefficient is divided by 100 to estimate per 1 mg/l of TDS, and then multiplied by the TDS concentrations in Table 6-1. The 1-, 5-, 10- and 20-percent levels have TDS concentrations greater than 1,000 mg/l. Levels greater than 1,000 mg/l will be treated down to 1,000 mg/l of TDS and, therefore, will have a constant damage of $0.69 per 1,000 gallons (Table 6-9).

Table 6-9: Industrial Damages per 1,000 Gallons

Condition	Percent of Time Equaled or Exceeded										
	1	5	10	20	41	42	50	80	90	95	99
Without-Project	$0.69	$0.69	$0.69	$0.69	$0.69	$0.69	$0.65	$0.51	$0.44	$0.39	$0.33
With-Project	$0.69	$0.69	$0.69	$0.69	$0.69	$0.68	$0.65	$0.50	$0.44	$0.39	$0.32

The damage per 1,000 gallons is multiplied by projected water use for TXU to produce the industrial damages per year (Table 6-10).

Table 6-10: Industrial Damages per Year ($1,000s)

Condition	Percent of Time Equaled or Exceeded										
	1	5	10	20	41	42	50	80	90	95	99
Without-Project	$3,684	$3,684	$3,684	$3,684	$3,684	$3,684	$3,493	$2,715	$2,365	$2,096	$1,746
With-Project	$3,684	$3,684	$3,684	$3,684	$3,684	$3,659	$3,463	$2,693	$2,343	$2,082	$1,732

The benefit was found by subtracting the With-Project damages from the Without-Project damages (Table 6-11).

Table 6-11: Benefit of With-Project from Reduced Industrial Damages to End Users ($1,000s)

Condition	Percent of Time Equaled or Exceeded										
	1	5	10	20	41	42	50	80	90	95	99
With-Project	$0	$0	$0	$0	$0	$26	$29	$22	$22	$15	$15

The area between the With- and Without-Project curves is integrated to produce the annual benefit for the With-Project alternative. The average annual benefit of a reduction in damages to industrial end users is approximately $14,200.

6.1.3 Total Annualized National Economic Development Benefits

The annual NED benefits calculated for each of the entities using water from Lake Texoma were added together to estimate the total annual NED benefits. The total annual NED benefits in the study area is $628,900 once the full benefits of implementing Area VI are realized.

The study area is not likely to realize the full benefits of Area VI immediately after implementation. The reduction in chlorides and TDS were straight-lined over 20 years so the benefits are increasing each year at a constant rate until full benefits are realized every year from year 21 forward. The adjusted annual benefits were annualized again for a total equivalent annual NED benefit of $414,200 (Table 6-12).

Table 6-12: Equivalent Annual NED Benefits

Entity	Equivalent Annual Benefit
North Texas Municipal Water District	$183,100
Greater Texoma Utility Authority	$132,100
City of Denison	$85,400
Texas Utilities	$9,400
Red River Authority	$4,300
TOTAL	**$414,200**

6.2 REGIONAL ECONOMIC DEVELOPMENT BENEFITS

The RED benefits were analyzed using the NED benefits in Section 6.1. The same methodology was used in IMPLAN to estimate the RED benefits. The percentage of households in each income bracket (Table 4-14) was multiplied by the annual NED benefit for Sherman WTP and Denison for a reduction in treatment costs and municipal damages of $161,500 and for a reduction of municipal damages alone of $29,500 to estimate the benefit per income bracket (Table 6-13). These benefits per bracket were then used as the input for IMPLAN to calculate the RED effect for reduced treatment costs and municipal damages for Sherman and Denison.

Table 6-13: NED Benefits by Income Bracket

Income	Treatment Costs and Municipal Damages			Municipal Damages		
	Sherman	Denison	Total	Sherman	Denison	Total
Less than 10K	5,900	6,700	12,600	1,200	1,100	2,300
10K–15K	4,700	5,300	10,000	900	900	1,800
15K–25K	9,300	10,400	19,700	1,900	1,700	3,600
25K–35K	8,600	9,600	18,200	1,700	1,600	3,300
35K–50K	12,800	14,300	27,100	2,600	2,400	5,000
50K–75K	14,300	16,000	30,400	2,900	2,700	5,500
75K–100K	10,200	11,400	21,600	2,000	1,900	3,900
100K–150K	6,900	7,800	14,700	1,400	1,300	2,700
150K+	3,300	3,800	7,100	700	600	1,300
TOTAL	**76,100**	**85,400**	**161,500**	**15,300**	**14,200**	**29,500**

The NED benefits by income bracket (reduction of treatment costs and municipal damages) presented in Table 6-13 were the inputs in IMPLAN. IMPLAN used these inputs to calculate the effects on Grayson County using multipliers. Table 6-14 presents the induced effects for Sherman WTP and Denison.

Table 6-14: Induced Effects for Sherman WTP and Denison

Employment	Labor Income	Value Added	Output
1.3	$46,700	$81,300	$134,300

The induced effects results were then applied to NTMWD, GTUA, TXU, and RRA on a per mgd basis. The NED benefits for a reduction in municipal damages (Table 6-13) were input to IMPLAN. The induced effects resulting from the reduction in municipal damages alone are presented in Table 6-15.

Table 6-15: Induced Effects for Sherman WTP and Denison, Municipal Damages

Employment	Labor Income	Value Added	Output
0.2	$8,500	$14,800	$24,500

The total amount of water analyzed for the Sherman WTP and the City of Denison is 13.56 mgd. The total effect in Table 6-15 is divided by 13.56 mgd to estimate an RED effect per mgd of water. This RED effect was multiplied by the mgd of water for NTMWD, GTUA, TXU, and RRA. The results per year are presented in Tables 6-16, 6-17, 6-18, and 6-19.

Table 6-16: Induced Effects for NTMWD

Year	Employment	Labor Income	Value Added	Output
2010	1.0	$43,400	$75,500	$124,800
2020	1.0	$43,400	$75,500	$124,800
2030	1.9	$82,300	$143,400	$236,900
2040	1.9	$81,700	$142,300	$235,100
2050	2.5	$106,800	$186,100	$307,400
2060	2.5	$106,800	$186,100	$307,400

Table 6-17: Induced Effects for GTUA

Year	Employment	Labor Income	Value Added	Output
2010	0.1	$4,700	$8,200	$13,500
2020	0.4	$16,300	$28,400	$47,000
2030	0.5	$21,200	$36,900	$61,000
2040	0.6	$25,800	$44,900	$74,100
2050	0.8	$32,500	$56,600	$93,500
2060	0.9	$39,400	$68,700	$113,500

Table 6-18: Induced Effects for TXU

Employment	Labor Income	Value Added	Output
0.2	$9,200	$16,000	$26,400

Table 6-19: Induced Effects for RRA

Employment	Labor Income	Value Added	Output
0.0	$1,300	$2,200	$3,600

The labor income, value added, and output were annualized over the 50-year period of analysis at a 4.0 percent discount rate. Total equivalent annual RED benefits for GTUA, the City of Denison, NTMWD, TXU, and RRA are shown in Table 6-20.

Table 6-20: Total RED Benefits for the Study Area

Labor Income	Value Added	Output
$135,300	$235,600	$389,200

6.3 RISK AND UNCERTAINTY

A risk and uncertainty analysis was performed on the economic analysis for the scenario with Cable Mountain Reservoir. The Excel add-on @Risk was used to evaluate the risk and uncertainty using the same methodology and variables as Section 5. The results are shown in Table 6-21.

Table 6-21: Risk and Uncertainty of NED Equivalent Annual Benefits, With-Project Condition with Cable Mountain Reservoir

Timeframe for Full Benefits to be Realized	90% Probability Range for Total Benefits		
	Low	Most Likely	High
15 Years	$419,200	$461,200	$503,200
20 Years	$376,000	$414,200	$453,300
25 Years	$338,600	$372,600	$407,000

7 SUMMARY

The purpose of this study was to evaluate the benefits to M&I users of Red River water if Area VI of the Red River Chloride Control Project is implemented. Based on information from USACE, and the States of Texas and Oklahoma, implementation of Area VI would improve water quality in Reaches 1, 2, and 3. Area VI would not improve water quality in Reach 4, and Reach 5 would experience minimal improvement. Water is not drawn directly from the Red River to meet the demands for M&I in Reaches 1 and 2 and there are no such plans for using it in the future. However, the Lake Texoma portion of the Red River is an important water supply source for M&I use in Reach 3. Therefore, study efforts were concentrated on determining the benefits to M&I users in Reach 3.

The use of water for M&I purposes in Reach 3 is governed by the Red River Compact water allocation agreement, which defines the amount of water that can be withdrawn from Lake Texoma for M&I purposes. Five entities are listed in the agreement: NTMWD, GTUA, the City of Denison, TXU, and RRA.

The benefits associated with implementing Area VI were estimated based on two components: 1) reduction in treatment costs, and 2) reduction in damages associated with higher quality water. An engineering analysis, which included interviews with multiple water providers, was conducted to estimate the reduction in treatment costs and damages associated with implementation of Area VI. An economic analysis used the results of the engineering analysis and the projected demand for Lake Texoma water to estimate the NED and RED benefits of implementing Area VI.

Because the benefits of Area VI would not be realized immediately, the equivalent annual benefits were estimated using a discount rate of 4.0 percent and a 50-year period of analysis, and assumed full benefits would be realized after 20 years. The estimated equivalent annual benefits are $2,608,400 for NED and $2,557,000 for RED output.

Benefits of Area VI were also estimated for the With-Project condition with implementation of Cable Mountain Reservoir. The estimated equivalent annual benefits are $414,200 for NED and $389,200 for RED output.

8 REFERENCES

Oklahoma Water Resources Board (OWRB), 2011a. *Draft Oklahoma Comprehensive Water Plan*, Southwest Watershed Planning Region Report. June 2011.

OWRB, 2011b. *Draft Oklahoma Comprehensive Water Plan*, Beaver-Cache Watershed Planning Region Report. June 2011.

OWRB, 2011c. *Draft Oklahoma Comprehensive Water Plan*, Southeast Watershed Planning Region Report. May 2011.

Sherman, 2008. *GE Water Process and Technologies: Electrodialysis Reversal at the City of Sherman*. March 2008. Available at http://www.gewater.com/pdf/Technical%20Papers_Cust/Americas/English/TP1034EN.pdf. Accessed September 2011.

Texas Water Development Board (TWDB), 2010a. *2011 Region C Water Plan*. October 2010.

TWDB, 2010b. *Region B Regional Water Plan*. September 2010.

TWDB, 2010c. *Region D Regional Water Plan*. September 2010.

TWDB, 2010d. *Draft Saline Water Special Study*. April 2010.

TWDB, 2011. *Water for Texas: Summary of 2011 Regional Water Plans*. 82nd Legislative Session. January 20, 2011.

U. S. Army Corps of Engineers (USACE), 2003. *Wichita River Basin Project Reevaluation, Red River Chloride Control Project*. April 2003.

USACE, 2011a. *Area VI M&I FSM Package*. June 2011.

USACE, 2011b. *Area VI Reevaluation, Concentrations Duration/Low Flow Study*.

U.S. Bureau of Reclamation, 2003. *Desalting Handbook for Planners*. 3rd Edition. July 2003.

U.S. Census Bureau, 2009. *American FactFinder, 2005–2009 American Community Survey 5-Year Estimates*.

This page intentionally left blank.

APPENDIX A

QUESTIONNAIRE RESPONSES

AND REVELANT NOTES

TABLE OF CONTENTS
Appendix A

Page Numbers

QUESTIONNAIRE - MUNICIPAL WATER PROVIDERS

1. Name of the Entity: North Texas Municipal Water District

Basic Water System Information

2. Source of Water Supply: (a) Lake or (b) River or (c) Groundwater

   (a) Lavon Lake, Texoma Lake, Cooper Lake, Lake Tawakoni, Lake Bonham
   (b) East Fork Trinity River via Wetlands
   (c) No groundwater

3. Do you provide water to: (a) retail customer or (b) wholesale customer or (c) both?

   Both. The District is primarily a regional water wholesaler.
   There are 13 Member Cities and 32 Customers for wholesale water, serving a population of approximately 1,500,000
   There are approximately 60 direct retail customers.

4. If you are wholesaler, Please provide a list of municipal utilities and major industrial facilities, if any for: (a) raw water (b) treated water. For treated water, are there different processes or level of treatments for different customers?

   Attachment 1. Same treatment level for all customers.

Treatment Plant Information

5. Treatment Plant(s):

   Wylie WTP complex.

   a. Number of plants 4
   b. Year Installed mid-1950s - 2008
   c. Installed capacity 770
   d. Annual average production 300 MGD
   e. Is the capacity adequate to meet the projected demand? Yes.

   Tawakoni WTP

   a. Number of plants 1
   b. Year Installed September 2011
   c. Installed capacity 30
   d. Annual average production TBD – estimated 15 MGD
   e. Is the capacity adequate to meet the projected demand? Yes.

Bonham WTP

a. Number of plants 1
b. Year Installed 2008
c. Installed capacity 6 MGD
d. Annual average production 1.5 MGD
e. Is the capacity adequate to meet the projected demand? Yes.

6. Type of Treatment (for each plant):
   a. Disinfection **only**: No
   b. Sedimentation + Disinfection **only**: No
   c. Sedimentation + Filtration + Disinfection: Yes for all plants.
   d. Please specify any other unit processes (i.e. ion exchange, reverse osmosis)

   Ozone disinfection systems for primary disinfection are being constructed for all Wylie plants. Initial service date estimated as January 2012. Complete by March 2014.

   Bonham WTP uses ozone as the primary disinfectant. Tawakoni WTP will use ozone as the primary disinfectant.

7. Are there alternate/future water sources available? If so, please specify.

   The District is pursuing the development of a new lake to be called Lower Bois D' Arc Creek Reservoir, and a new North Water Treatment Plant. Initial service estimated 2021.

8. What chemicals are used for treatment? Please provide chemical consumption records/estimates for each treatment plant separately for the last 5 years.

   Chlorine dioxide, polymer, fluoride, ferric sulfate, chlorine, ammonia, lime, caustic.

   See Attachment 2 for list of quantities.

9. Do you have plans for additional treatment or capacity expansion? If so, please provide which plant, brief description of the improvements and the schedule.

   Wylie WTP IV to be expanded from 140 to 210 MGD by 2016. Later an additional 70 MGD will increase the facility to an ultimate capacity of 280 MGD.

   Tawakoni WTP to be expanded from 30 to 75 MGD by 2019.

   Construct North WTP with initial 70 MGD capacity by 2021.

10. Please provide raw water intake and water production data for the last 5 years.

    Attachment 3.

11. Do you monitor/record the following water quality parameters? If so, please provide the recorded data for the past 5 years.

    a. chloride
    b. sulfates
    c. TDS/TSS
    d. pH

    Attachment 4.

<u>Impact of Chloride on the Water System Facilities</u>

12. Do you have an estimate of costs of chlorides/sulfates/TDS impact (additional treatment costs such as additional treatment equipment or chemical costs? If so, please provide the estimate for the past 5 years?

    No special treatment for those parameters.

13. What equipment has been impacted by chlorides (equipment type, size, age, replacement parts) in water supply production facilities, distribution system (storage, piping, valves, utility service lines etc)

    No facility impacts.

14. Have you had any taste or odor complaints from your customers? If so, do you know the cause?

    Periodic taste and odor episodes related to MIB and geosmin. Ozone disinfection system expected to mitigate taste and odors.

15. Any quantitative/Qualitative analysis conducted by the facility to find out the benefits of TDS/Chloride reduction?

    The District has ongoing consultant studies related to importation of Lake Texoma water to Lake Lavon.

16. What impacts, if any, will a reduction or increase in chloride levels have on your overall conveyance and treatment system? Will it change your overall approach? Will you need to add additional sources, technologies/plants?

Should the chloride levels increase to a problematic level, considerations will be made to modify source water contributions and modify treatment processes as needed.

17. What specific impacts, if any, will a reduction or increase in chloride will have on each plant? Would a decrease in chloride levels decrease the costs of treatment? If so, do you have an estimate available?

    Do not currently treat specifically for chloride.

18. What impacts will a reduction or increase in chloride levels have on your customers?

    Increased chloride levels could impact customer plumbing systems.

ATTACHMENT 1

Question 4 - Wholesale Customers

North Texas Municipal Water District - Member Cities, Wholesale Customers

Water Treatment Plant/System	PWS #
North Texas Municipal Water District	0430044

Member Cities	PWS #
Allen	0430025
Farmersville	0430004
Forney	1290002
Frisco	0430005
Garland	0570010
McKinney	0430039
Mesquite	0570014
Plano	0430007
Princeton	0430008
Richardson	0570015
Rockwall	1990001
Royse City	1990002
Wylie	0430051

ATTACHMENT 1

Customers	PWS #	Customers	PWS #
Caddo Basin SUD	1160029	North Collin WSC	0430055
Cash SUD	1160018	Parker	0430045
College Mound WSC	1290012	Prosper	0430009
Copeville WSC	0430029	Rose Hill SUD	1290023
Crandall	1290007	Rowlett	0570056
East Fork SUD	0430033	Sachse	0570057
Fairview	0430034	Seis Lagos Utility District	0430057
Fate	1990006	Sunnyvale	0570059
Forney Lake WSC	1290014	Terrell	1290006
Gastonia / Scurry	1290015	Wylie Northeast SUD	0430051
Greater Texoma Utility Authority (GTUA)	0910148		
Josephine	0430036		
Kaufman	1290003		
Lavon WSC	0430037		
Little Elm	0610035		
Lucas	0430054		
Melissa	0430040		
Milligan WSC	0430041		
Mt. Zion WSC	1990010		
Murphy	0430042		
Nevada WSC	0430053		

ATTACHMENT 2

Question 8 - Treatment Chemicals

Tons of chemical, NOT solution

	CAUSTIC	FERRIC	CHLORINE	CHLORINE DIOXIDE	AMMONIA	FLUORIDE	LIME	POLYMER
2005	4582	2631	2574	0	394	185	3499	729
2006	5524	5211	2775	0	393	175	7308	1272
2007	6793	5929	2208	101	327	108	4730	687
2008	6490	5527	2486	393	432	119	5566	794
2009	6467	5915	2219	346	366	105	4403	749
2010	6191	6056	2641	337	414	154	4843	705

Million Gallons

	Raw	Treated
2006	97,859	96,138
2007	80,941	79,185
2008	96,074	94,209
2009	88,544	86,784
2010	101,400	99,317

ATTACHMENT 3

Question 10 - Production Data

Million Gallons

	Raw	Treated
2006	97,859	96,138
2007	80,941	79,185
2008	96,074	94,209
2009	88,544	86,784
2010	101,400	99,317

ATTACHMENT 4

Question 11 Lab Data

		TDS	Sulfate	Chloride	pH
2006	min	450	105	110	7.8
	max	684	208	229	8.1
	avg	547	153	158	7.9
2007	min	212	75	53	7.8
	max	596	269	214	8.1
	avg	405	140	105	7.9
2008	min	230	45	21	7.6
	max	326	88	50	8.1
	avg	287	65	35	7.9
2009	min	266	76	35	6.8
	max	378	99	47	7.8
	avg	323	85	42	7.3
2010	min	244	56	24	7.4
	max	328	96	34	8.6
	avg	274	79	28	7.8

B QUESTIONNAIRE - MUNICIPAL WATER PROVIDERS

1. Name of the Entity: **City of Denison**

<u>Basic Water System Information</u>

2. Source of Water Supply**<u>: (a) Lake</u>** or (b) River or (c) Groundwater

   Lake Randell and Lake Texoma

3. Do you provide water to: (a) retail customer or (b) wholesale customer or **<u>(c) both</u>**?

4. If you are wholesaler, Please provide a list of municipal utilities and major industrial facilities, if any for: (a) raw water **<u>(b) treated water</u>.** For treated water, are there different processes or level of treatments for different customers? **NO**

   City of Pottsboro, OakRidge / South Gale, Northern Hills, Thompson Heights, Rocky Point / Monarch Utilities, Diamond Pointe and Monarch Ridge

<u>Treatment Plant Information</u>

5. Treatment Plant(s**): City of Pottsboro, Oakridge/ South Gale, Northern Hills, Thompson Heights, Rocky Point/ Monarch Utility, Diamond Pointe, and Monarch Ridge.**

   a. Number of plants **1**
   b. Year Installed   **1909/1941/1954/1979/1994/2009/2011**
   c. Installed capacity **13**
   d. Annual average production **4.5MGD   1.64BG/YR**
   e. Is the capacity adequate to meet the projected demand? **Yes**

6. Type of Treatment (for each plant):
   a. Disinfection **only**:   Yes   **<u>No</u>**
   b. Sedimentation + Disinfection **only**:   Yes   **<u>No</u>**
   c. Sedimentation + Filtration + Disinfection: **<u>Yes</u>**   No   **Ferric Chloride**
   d. Please specify any other unit processes (i.e. ion exchange, reverse osmosis)
   SCC 100%-Conventional, dual media sand anthracite.
7. Are there alternate/future water sources available? If so, please specify. **No**

8. What chemicals are used for treatment? Please provide chemical consumption records/estimates for each treatment plant separately for the last 5 years.
   Ferric Chloride, Caustic Soda, and Poly A, Cationic

9. Do you have plans for additional treatment or capacity expansion? If so, please provide which plant, brief description of the improvements and the schedule.
   None presently

10. Please provide raw water intake and water production data for the last 5 years.

11. Do you monitor/record the following water quality parameters? If so, please provide the recorded data for the past 5 years. **Yes**
    a. chloride
    b. sulfates
    c. TDS/TSS
    d. pH

Impact of Chloride on the Water System Facilities

12. Do you have an estimate of costs of chlorides/sulfates/TDS impact (additional treatment costs such as additional treatment equipment or chemical costs? If so, please provide the estimate for the past 5 years?

13. What equipment has been impacted by chlorides (equipment type, size, age, replacement parts) in water supply production facilities, distribution system (storage, piping, valves, utility service lines etc)

14. Have you had any taste or odor complaints from your customers? If so, do you know the cause? **None, other than occasional distribution system stagnation.**

15. Any quantitative/Qualitative analysis conducted by the facility to find out the benefits of TDS/Chloride reduction? **No**

16. What impacts, if any, will a reduction or increase in chloride levels have on your overall conveyance and treatment system? Will it change your overall approach? Will you need to add additional sources, technologies/plants?

17. What specific impacts, if any, will a reduction or increase in chloride will have on each plant? Would a decrease in chloride levels decrease the costs of treatment? If so, do you have an estimate available?

18. What impacts will a reduction or increase in chloride levels have on your customers? **Excess chlorides from an increase would impact customers with a low-sodium diet and those with cardiovascular disease.**

STD LTR
US POSTAGE
PAID
PERMIT 1011
DENISON, TEXAS
75021

CITY OF DENISON

500 West Chestnut - P.O. Box 347 – Denison, Texas 75021-0347

CONSUMER CONFIDENCE REPORT

2005 DRINKING WATER QUALITY REPORT FOR THE CITY OF DENISON (903) 464-4480

This report is provided in response to the 1996 Safe Drinking Water Act amendments and specifically, USEPA's Consumer Confidence Rule, which became effective September 19, 1998.

HOW IS WATER TREATED?

The City Of Denison uses the latest techniques and equipment to consistently produce superior quality drinking water. Utilizing conventional treatment processes, we produce an average four to nine million gallons of water per day for our customers. The process is divided into four separate steps to achieve the desired quality product mandated by the TCEQ and USEPA. Coagulation, settling, filtration, and disinfection are considered the treatment of choice for surface water in the United States. Coagulation is chemically and mechanically changing the raw water to remove the majority of larger solids. In settling the water, the finer particles have time to be removed before continuing on to filtration to remove microscopic particles. Disinfection is done with chloramine compounds before leaving the water plant and entering the distribution system. The water is sampled and tested throughout the treatment plant. Sampling is performed to make sure the processes are working and that the water is safe before it leaves the plant. The City of Denison tests twenty-five sites per month in the distribution system and reports results to TCEQ and USEPA. All employees involved in treating, collecting samples, and making repairs to the distribution system are certified by TCEQ through training and testing.

SECONDARY CONSTITUENTS

Many constituents (such as calcium, sodium, or iron) which are often found in drinking water, can cause taste, color and odor problems. The taste and odor constituents are called secondary constituents and are regulated by the State of Texas, not the EPA. These constituents are not causes for health concern. Therefore, secondary standards are not required to be reported in this document but they may greatly affect the appearance and taste of your water.

UNREGULATED CONTAMINATE MONITORING RULE

We participated in gathering data under the UCMR in order to assist EPA in determining the occurrence of possible drinking water contaminants. If any unregulated contaminants were detected they are shown in the tables elsewhere in the report.

DEFINITIONS

NTU – Nephelometric Turbidity Units. This is the unit used to measure water turbidity

MCLG – Maximum Contaminant Level Goal. The level of a contaminant in drinking water below which there is no known or expected health risk. MCLG's allow for a margin of safety.

MCL – Maximum Contaminant Level. The highest permissible level of a contaminant that is allowed in drinking water. MCL's are set as close to the MCLG's as feasible using the best available treatment technology.

AL – Action Level The concentration of a contaminant which, if exceeded, trigger treatment or other requirements that a water system must follow.

TURBIDITY – A measure of the cloudiness of water. We monitor it because it is a good indicator of the effectiveness of our filtration system.

TREATMENT TECHNIQUE – A required process intended to reduce the level of a contaminant in drinking water.

ppm – Parts per million. One part per million equals one packet of artificial sweetener sprinkled into 250 gallons of iced tea.

ppb–Parts per billion.. One part per billion is equal to one packet of artificial sweetener added to an Olympic size swimming pool.

ppt- Parts per trillion, or nanograms per liter.

ppq–parts per quadrillion, picograms per liter

pci/l – Picocuries per liter is a measure of radioactivity in water.

MFL – million fibers per liter (a measure for asbestos)

MRDL – Maximum Residual Disinfectant Level
The highest level of disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.

MRLDG –Maximum Residual Disinfectant Level Goal - The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contamination.

NOTICE TO AT-RISK POPULATIONS

Some people may be more vulnerable to contaminants in drinking water than the general population. Immune-compromised persons such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune system disorders, some elderly, and infants can be particularly at risk from infections. These people should seek advice about drinking water from their health care providers. EPA/ Centers for Disease Control and Prevention (CDC) guidelines on appropriate means to lessen the risk of infection by Cryptosporidium and other microbial contaminants are available from the Safe Drinking Water Hotline (800-426-4971).

PUBLIC PARTICIPATION OPPORTUNITIES

A public meeting with the City of Denison's Water Treatment Personnel will be held to answer any questions and respond to comments our water customers may have.

DATE: July 19, 2006

TIME: 1:30 P.M.

LOCATION 4631 RANDELL LAKE ROAD

PHONE NO: (903) 464-4480

OUR DRINKING WATER MEETS OR EXCEEDS ALL EPA DRINKING WATER REQUIREMENTS

This report is a summary of the quality of the water we provide our customers. The analysis was made by using data from the most recent U.S. Environmental Protection Agency (EPA) required tests and is presented in the attached pages. We hope this information helps you become more knowledgeable about what's in your drinking water.

WATER SOURCES

The sources of drinking water (both tap water and bottled) include rivers, lakes, streams, ponds, reservoirs, springs and wells. As water travels over the land's surface or through the ground, it dissolves naturally occurring minerals and, in some cases, radioactive material, and can pick up substances resulting from the presence of animals or human activity. Contaminants that may be in untreated water include microbes, inorganic contaminants, pesticides, herbicides, organic chemical contaminants and radioactive contaminants.

WHERE DO WE GET OUR WATER?

Most of the water we treat is from city-owned Lake Randell, located to the northwest of Denison between US 75 and Lake Texoma. The supply for Lake Randell is supplemented by water transferred from Lake Texoma. Almost all our customers are served by surface water from these two lakes. Our customers in the area of Grayson County Airport are served by a combination of surface water and ground water from wells the City operates on the Grayson County Airport property. These wells produce water from the Trinity/Paluxy aquifer formation. TCEQ completed an assessment of our source water and results indicate that some of sources are susceptible to certain contaminants. The sampling requirements for our water system are based on this susceptibility and previous sample data. Any detection of those contaminants will be found in this report. For more information on source water assessments and protection efforts at our system, please contact us.

ALL DRINKING WATER MAY CONTAIN CONTAMINANTS.

When drinking water meets federal standards there may not be any health related benefits to purchasing bottled water or point of use devices. All drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of these contaminants does not necessarily indicate that water poses a health risk More information about contaminants and potential health effects may be obtained by calling USEPA's Safe Drinking Water Hotline (1-800-426-4791).

En Espanol

Este reporte incluye informacion importante sobre el agua para tomar. Si tiene preguntas o'discusiones sobre este reporte en espanol, favor de llamar at tel. (903)464-4481 par hablar con una persona bilinque en Espanol.

INORGANIC

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN LEVEL	MAX. LEVEL	MCL	MCLG	UNIT OF MEASURE	SOURCE OF CONTAMINANT
2002	Barium	.069	0.053	.085	2	2	ppm	Discharge of drilling [illegible] Discharge from metal refineries, Erosion of natural deposits
2005	Fluoride	0.4	0.6	0.7	4	4	ppm	Erosion of natural deposits; Water additive which promotes strong teeth; Discharge from fertilizer and aluminum factories
2004	Nitrate	0.185	0.12	0.25	10	10	ppm	Runoff from fertilizer use; Leaching from septic tanks, sewage, Erosion of natural deposits.
2005	Gross beta	4.0	4.0	4.0	50	0	pci/l	Decay of natural and man-made deposits

TOTAL ORGANIC CARBON (SOURCE WATER)

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN. LEVEL	MAX LEVEL	SOURCE OF CONTAMINANT
2005	TOC	4.6	3.5	5.3	Naturally occurring organic (No associated adverse health effects)

DISINFECTION BYPRODUCTS

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN LEVEL	MAX. LEVEL	MCL	UNITS OF MEASURE	SOURCE OF CONTAMINANT
2005	Total Haloacetic Acids	13.51	<6.0	18.8	60	ppb	By-product of drinking water disinfect ion.
2005	Total Trihalomethanes	52.43	12.9	68.3	80	ppb	By-product of drinking water chlorination.

DISINFECTION RESIDUALS

YEAR	CONSTITUENT	ANNUAL AVERAGE	RANGE OF DETECTION	MRDL	MCLG	UNITS	SOURCE
2005	Chloramines	2.3	0.1 5.0	4	0	ppm	Disinfectant used to control microbes

UNREGULATED CONTAMINANTS

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN. LEVEL	MAX. LEVEL	UNITS OF MEASURE	SOURCE OF CONTAMINANT
2005	Chloroform	7.88	<2.0	14.6	ppb	By-product of drinking water disinfect ion.
2005	Bromoform	9.61	2.5	18.8	ppb	By-product of drinking water disinfect ion.
2005	Bromodichloromethane	16.25	3.7	21.9	ppb	By-product of drinking water disinfect ion.
2005	Dibromochloromethane	20.53	4.0	26.4	ppb	By-product of drinking water disinfect ion.

LEAD AND COPPER

YEAR	CONTAMINANT	THE 90th PERCENTILE	SITES EXCEEDING ACTION LEVEL	ACTION LEVEL	UNIT OF MEASURE	SOURCE OF CONTAMINANT
2004	Lead	3.0	0	15	ppb	Corrosion of household plumbing systems; Erosion of natural deposits.
2004	Copper	0.0680	0	1.3	ppm	Corrosion of household plumbing systems; Erosion of natural deposits; Leaching [illegible] preservatives.

TURBIDITY

YEAR	CONTAMINANT	HIGHEST SINGLE MEASUREMENT	LOWEST MONTHLY % OF SAMPLES MEETING LIMITS	TURBIDITY LIMITS	UNITS OF MEASURE	SOURCE OF CONT[illegible]
2005	TURBIDITY	.24	100	0.3	NTU	Soil runoff

TURBIDITY has no health effects. However, turbidity can interfere with disinfection and provide a medium for microbial growth. TURBIDITY may indicate the presence of disease-causing organisms These organisms include bacteria, viruses, and parasites that can cause symptoms such as nausea, cramps, diarrhea and associated headaches.

SECONDARY AND OTHER NOT REGULATED CONSTITUENTS (No associated adverse health effects)

YEAR	CONSTITUENT	AVERAGE	MIN.	MAX.	LIMIT	UNIT OF	SOURCE OF CONSTITUENT
2005	Bicarbonate	145	131	170	NA	ppm	Corrosion of carbonate rocks such [illegible] limestone.
2002	Calcium	62.35	46.1	78.6	NA	ppm	Abundant naturally occurring el[illegible]
2005	Chloride	350	260	373	300	ppm	Abundant naturally occurring element, [illegible] water purification, byproduct of oil field activity.
2005	Iron	024	.014	.038	0.3	ppm	Erosion of natural deposits; iron [illegible] delivery equipment of facilities
2005	Magnesium	96	74	116	NA	ppm	Abundant naturally occurring element
2005	Ph	8.0	7.8	8.4	NA	units	Measure of corrosiveness of water
2002	Sodium	134.0	129	139	NA	ppm	Erosion of natural deposits; byproduct [illegible] field activity.
2005	Sulfate	170	75	225	300	ppm	Naturally occurring; common industrial [illegible] byproduct of oil field activity
2005	Total Alkalinity as CaCO3	119	107	139	NA	ppm	Naturally occurring soluble mineral [illegible]
2005	Total Dissolved Solids	800	595	882	1000	ppm	Total dissolved mineral constituents [illegible]
2005	Total Hardness as CaCO3	272	267	336	NA	ppm	Naturally occurring calcium.

CITY OF DENISON

500 West Chestnut - P.O. Box 347 – Denison, Texas 75021-0347

CONSUMER CONFIDENCE REPORT

2006 DRINKING WATER QUALITY REPORT FOR THE CITY OF DENISON

(903) 464-4480

This report is provided in response to the 1996 Safe Drinking Water Act amendments and specifically, USEPA's Consumer Confidence Rule, which became effective September 19, 1998.

HOW IS WATER TREATED?

The City Of Denison uses the latest techniques and equipment to consistently produce superior quality drinking water. Utilizing conventional treatment processes, we produce an average four to nine million gallons of water per day for our customers. The process is divided into four separate steps to achieve the desired quality product mandated by the TCEQ and USEPA. Coagulation, settling, filtration, and disinfection are considered the treatment of choice for surface water in the United States. Coagulation is chemically and mechanically changing the raw water to remove the majority of larger solids. In settling the water, the finer particles have time to be removed before continuing on to filtration to remove microscopic particles. Disinfection is done with chloramine compounds before leaving the water plant and entering the distribution system. The water is sampled and tested throughout the treatment plant. Sampling is performed to make sure the processes are working and that the water is safe before it leaves the plant. The City of Denison tests twenty-five sites per month in the distribution system and reports results to TCEQ and USEPA. All employees involved in treating, collecting samples, and making repairs to the distribution system are certified by TCEQ through training and testing.

SECONDARY CONSTITUENTS

Many constituents (such as calcium, sodium, or iron) which are often found in drinking water, can cause taste, color and odor problems. The taste and odor constituents are called secondary constituents and are regulated by the State of Texas, not the EPA. These constituents are not causes for health concern. Therefore, secondary standards are not required to be reported in this document but they may greatly affect the appearance and taste of your water.

UNREGULATED CONTAMINATE MONITORING RULE

We participated in gathering data under the UCMR in order to assist EPA in determining the occurrence of possible drinking water contaminants. If any unregulated contaminants were detected they are shown in the tables elsewhere in the report.

DEFINITIONS

NTU – Nephelometric Turbidity Units. This is the unit used to measure water turbidity

MCLG – Maximum Contaminant Level Goal. The level of a contaminant in drinking water below which there is no known or expected health risk. MCLG's allow for a margin of safety.

MCL – Maximum Contaminant Level. The highest permissible level of a contaminant that is allowed in drinking water. MCL's are set as close to the MCLG's as feasible using the best available treatment technology.

AL – Action Level The concentration of a contaminant which, if exceeded, trigger treatment or other requirements that a water system must follow.

TURBIDITY – A measure of the cloudiness of water. We monitor it because it is a good indicator of the effectiveness of our filtration system.

TREATMENT TECHNIQUE – A required process intended to reduce the level of a contaminant in drinking water.

ppm – Parts per million. One part per million equals one packet of artificial sweetener sprinkled into 250 gallons of iced tea.

ppb–Parts per billion.. One part per billion is equal to one packet of artificial sweetener added to an Olympic size swimming pool.

ppt- Parts per trillion, or nanograms per liter.

ppq–parts per quadrillion, picograms per liter

pci/l – Picocuries per liter is a measure of radioactivity in water.

MFL – million fibers per liter (a measure for asbestos)

MRDL – Maximum Residual Disinfectant Level
The highest level of disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.

MRLDG –Maximum Residual Disinfectant Level Goal - The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contamination.

NOTICE TO AT-RISK POPULATIONS

Some people may be more vulnerable to contaminants in drinking water than the general population. Immune-compromised persons such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune system disorders, some elderly, and infants can be particularly at risk from infections. These people should seek advice about drinking water from their health care providers. EPA/ Centers for Disease Control and Prevention (CDC) guidelines on appropriate means to lessen the risk of infection by Cryptosporidium and other microbial contaminants are available from the Safe Drinking Water Hotline (800-426-4971).

PUBLIC PARTICIPATION OPPORTUNITIES

A public meeting with the City of Denison's Water Treatment Personnel will be held to answer any questions and respond to comments our water customers may have.

DATE: JULY 17, 2007

TIME: 1:00 PM

LOCATION 4631 RANDELL LAKE ROAD

PHONE NO: (903) 464-4480

OUR DRINKING WATER MEETS OR EXCEEDS ALL EPA DRINKING WATER REQUIREMENTS

This report is a summary of the quality of the water we provide our customers. The analysis was made by using data from the most recent U.S. Environmental Protection Agency (EPA) required tests and is presented in the attached pages. We hope this information helps you become more knowledgeable about what's in your drinking water.

WATER SOURCES

The sources of drinking water (both tap water and bottled) include rivers, lakes, streams, ponds, reservoirs, springs and wells. As water travels over the land's surface or through the ground, it dissolves naturally occurring minerals and, in some cases, radioactive material, and can pick up substances resulting from the presence of animals or human activity. Contaminants that may be in untreated water include microbes, inorganic contaminants, pesticides, herbicides, organic chemical contaminants and radioactive contaminants.

WHERE DO WE GET OUR WATER?

Most of the water we treat is from city-owned Lake Randell, located to the northwest of Denison between US 75 and Lake Texoma. The supply for Lake Randell is supplemented by water transferred from Lake Texoma. Almost all our customers are served by surface water from these two lakes. Our customers in the area of Grayson County Airport are served by a combination of surface water and ground water from wells the City operates on the Grayson County Airport property. These wells produce water from the Trinity/Paluxy aquifer formation. TCEQ completed an assessment of our source water and results indicate that some of sources are susceptible to certain contaminants. The sampling requirements for our water system are based on this susceptibility and previous sample data. Any detection of those contaminants will be found in this report. For more information on source water assessments and protection efforts at our system, please contact us.

ALL DRINKING WATER MAY CONTAIN CONTAMINANTS.

When drinking water meets federal standards there may not be any health related benefits to purchasing bottled water or point of use devices. All drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of these contaminants does not necessarily indicate that water poses a health risk More information about contaminants and potential health effects may be obtained by calling USEPA's Safe Drinking Water Hotline (1-800-426-4791).

En Espanol

Este reporte incluye informacion importante sobre el agua para tomar. Si tiene preguntas o'discusiones sobre este reporte en espanol, favor de llamar at tel. (903)464-4481 par hablar con una persona bilinque en Espanol.

INORGANIC

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN. LEVEL	MAX. LEVEL	MCL	MCLG	UNIT OF MEASURE	SOURCE OF CONTAMINANT
2006	Barium	.132	.132	.132	2	2	ppm	Discharge of drilling wastes; Discharge from metal refineries; Erosion of natural deposits
2006	Fluoride	.74	.74	.74	4	4	ppm	Erosion of natural deposits; Water additive which promotes strong teeth; Discharge from fertilizer and aluminum factories
2006	Nitrate	0.03	0.03	0.03	10	10	ppm	Runoff from fertilizer use; Leaching from septic tanks, sewage; Erosion of natural deposits.
2005	Gross beta	<4.0	<4.0	<4.0	50	0	pci/l	Decay of natural and man-made deposits

TOTAL ORGANIC CARBON (SOURCE WATER)

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN. LEVEL	MAX.LEVEL	SOURCE OF CONTAMINANT
2006	TOC	5.28	4.44	6.6	Naturally occurring organic (No associated adverse health effects)

DISINFECTION BYPRODUCTS

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN. LEVEL	MAX. LEVEL	MCL	UNITS OF MEASURE	SOURCE OF CONTAMINANT
2006	Total Haloacetic Acids	13.29	2.8	25.1	60	ppb	By-product of drinking water disinfect ion.
2006	Total Trihalomethanes	65.74	22.4	94.2	80	ppb	By-product of drinking water chlorination.

DISINFECTION RESIDUALS

YEAR	CONSTITUENT	ANNUAL AVERAGE	RANGE OF DETECTION	MRDL	MCLG	UNITS	SOURCE
2006	Chloramines	2.19	0.05 – 4.0	4	0	ppm	Disinfectant used to control microbes

UNREGULATED CONTAMINANTS

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN. LEVEL	MAX. LEVEL	UNITS OF MEASURE	SOURCE OF CONTAMINANT
2006	Chloroform	4.97	<2.0	11.5	ppb	By-product of drinking water disinfect ion.
2006	Bromoform	20.36	7.3	31.1	ppb	By-product of drinking water disinfect ion.
2006	Bromodichloromethane	13.67	5.7	25.1	ppb	By-product of drinking water disinfect ion.
2006	Dibromochloromethane	26.74	7.3	38.9	ppb	By-product of drinking water disinfect ion.

LEAD AND COPPER

YEAR	CONTAMINANT	THE 90th PERCENTILE	SITES EXCEEDING ACTION LEVEL	ACTION LEVEL	UNIT OF MEASURE	SOURCE OF CONTAMINANT
2004	Lead	3.0	0	15	ppb	Corrosion of household plumbing systems; Erosion of natural deposits.
2004	Copper	0.0680	0	1.3	ppm	Corrosion of household plumbing systems; Erosion of natural deposits; Leaching from wood preservatives.

TURBIDITY

YEAR	CONTAMINANT	HIGHEST SINGLE MEASUREMENT	LOWEST MONTHLY % OF SAMPLES MEETING LIMITS	TURBIDITY LIMITS	UNITS OF MEASURE	SOURCE OF CONTAMINANT
2006	TURBIDITY	.26	100	0.3	NTU	Soil runoff

TURBIDITY has no health effects. However, turbidity can interfere with disinfection and provide a medium for microbial growth. TURBIDITY may indicate the presence of disease-causing organisms. These organisms include bacteria, viruses, and parasites that can cause symptoms such as nausea, cramps, diarrhea and associated headaches

SECONDARY AND OTHER NOT REGULATED CONSTITUENTS (No associated adverse health effects)

YEAR	CONSTITUENT	AVERAGE	MIN.	MAX.	LIMIT	UNIT OF	SOURCE OF CONSTITUENT
2006	Bicarbonate	139	139	139	NA	ppm	Corrosion of carbonate rocks such as limestone.
2002	Calcium	62.35	46.1	78.6	NA	ppm	Abundant naturally occurring element.
2006	Chloride	410	410	410	300	ppm	Abundant naturally occurring element; used in water purification; byproduct of oil field activity.
2005	Iron	.024	.014	.038	0.3	ppm	Erosion of natural deposits; iron or steel water delivery equipment of facilities
2005	Magnesium	96	74	116	NA	ppm	Abundant naturally occurring element
2006	Ph	8.2	7.8	8.4	NA	units	Measure of corrosiveness of water.
2002	Sodium	134.0	129	139	NA	ppm	Erosion of natural deposits; byproduct of oil field activity.
2006	Sulfate	259	259	259	300	ppm	Naturally occurring; common industrial byproduct; byproduct of oil field activity
2005	Total Alkalinity as CaCO3	119	107	139	NA	ppm	Naturally occurring soluble mineral salts.
2006	Total Dissolved Solids	1140	1140	1140	1000	ppm	Total dissolved mineral constituents in water
2005	Total Hardness as CaCO3	272	267	336	NA	ppm	Naturally occurring calcium.

CITY OF DENISON

500 West Chestnut • P.O. Box 347 • Denison, Texas 75021-0347
(903)465-2720 • FAX (903) 464-4499

YEAR 2007 WATER QUALITY DATA

CONTAMINANT	MCL mg/l	DENISON mg/l
ORGANIC CONTAMINANTS		
ATRAZINE	0.003	ND
INORGANIC CONTAMINANTS		
FLUORIDE	4.0	0.79
BARIUM	2.0	0.132
COPPER	1.3	<.006
IRON	0.3	0.033
LEAD	.015	<.0011
NITRATE	10.0	.06
SELENIUM	.05	.0031
OTHER WATER QUALITY DATA		
	AVERAGE LEVEL Mg/L	
TOTAL DISSOLVED SOLIDS	940	
TOTAL HARDNESS	330	
SODIUM	127	
CALCIUM	80.1	
TOTAL TRIHALOMETHANE (CHLORINE DISINFECTION BY PRODUCT)		
MCL FOR TTHM AVERAGE (YEARLY)	80 ppb	
AVERAGE	56.57	
NEPHELOMETRIC TURBIDITY UNITS (NTU) FINISH WATER		
State regulation: Turbidity must stay below 0.3 NTU 95% of the time.		
DENISON HIGHEST DAILY VALUE	.28 NTU	
DENISON AVERAGE DAILY VALUE	.18 NTU	

CITY OF DENISON
WATER LAB
4631 RANDELL LK RD
DENISON, TX 75020

WATER ANALYSIS

SAMPLE SOURCE: Randell Raw

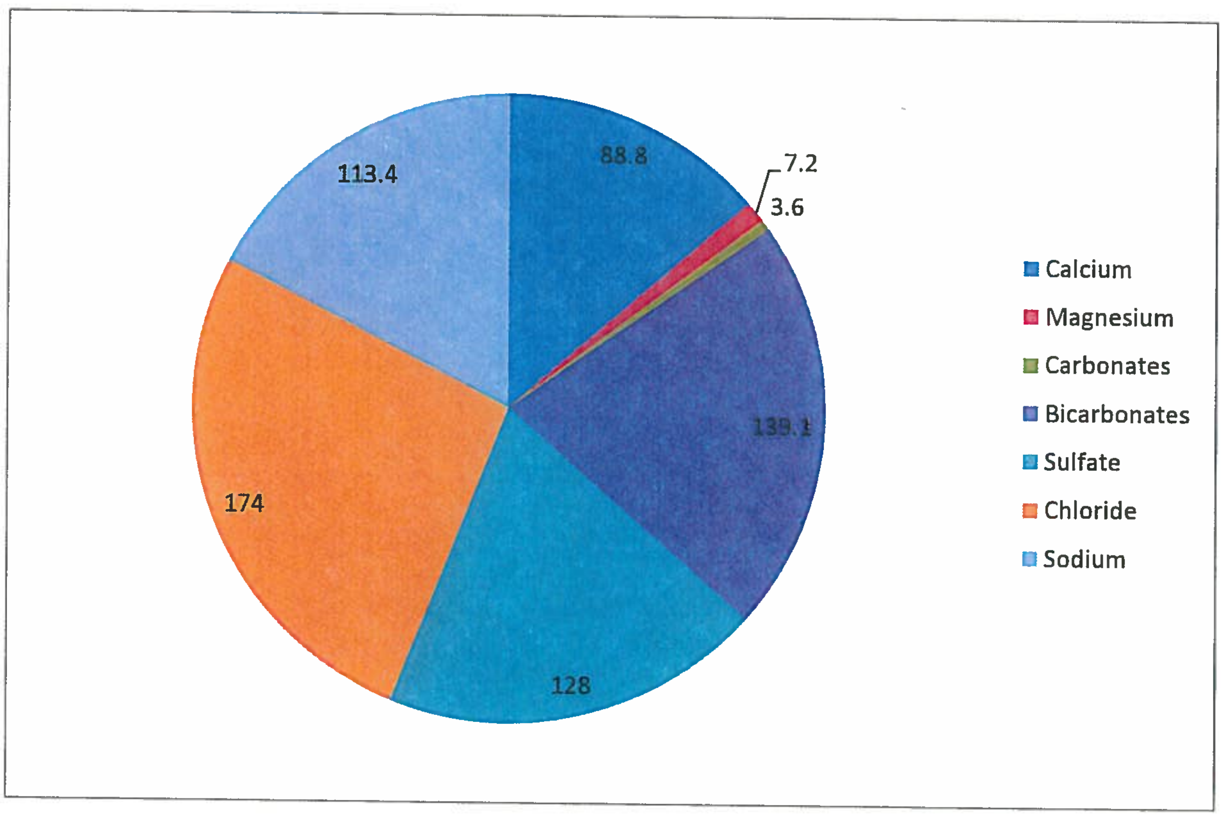
TOTAL HARDNESS:		252
TOTAL ALKALINITY:		114
MAGNESIUM HARDNESS:		30
PHENOL ALKALINITY:		6
SULFATES:		128
CHLORIDES:		174
Ph:	8.5	Units
IRON:		0.234
FLUORIDE:		0.23
		0
TOTAL DISSOLVED SOLIDS		654.0257
CHLORINE RESIDUAL:		na

	CATIONS	ANIONS
Ca	4.44	-----
Mg	0.6	-----
CO3	------	0.12
HCO3	------	2.28
SO4	------	2.66667
Cl	------	4.90141
Na	4.92808	------

ANALYST: KJ
SAMPLE COLLECTED: 7/13/2011
SAMPLE TESTED: 7/14/2011

All results reported in Mg/l.

IONIC CONSTITUENTS	
CALCIUM	88.8
MAGNESIUM	7.2
CARBONATES	3.6
BICARBONATES	139.08
SULFATE	128
CHLORIDE	174
SODIUM	113.346



CITY OF DENISON
WATER LAB
4631 RANDELL LK RD
DENISON, TX 75020

WATER ANALYSIS

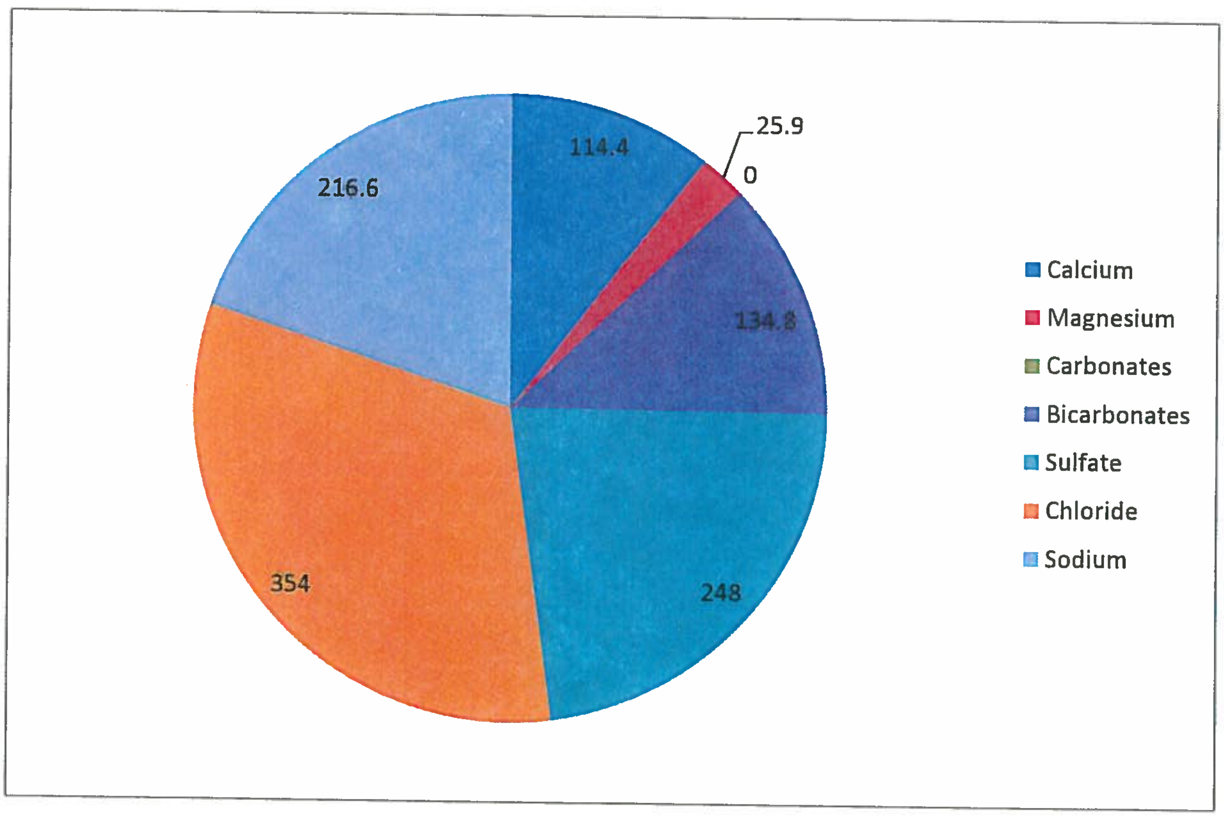
SAMPLE SOURCE: Texoma Raw

TOTAL HARDNESS:		394
TOTAL ALKALINITY:		108
MAGNESIUM HARDNESS:		108
PHENOL ALKALINITY:		0
SULFATES:		248
CHLORIDES:		354
Ph:	8.18	Units
IRON:		0.072
FLUORIDE:		0.37
		0
TOTAL DISSOLVED SOLIDS	1090.705	
CHLORINE RESIDUAL:	na	
ANALYST:	KJ	
SAMPLE COLLECTED:	7/13/2011	
SAMPLE TESTED:	7/14/2011	

All results reported in Mg/l.

	CATIONS	ANIONS
Ca	5.72	-----
Mg	2.16	-----
CO3	------	0
HCO3	------	2.16
SO4	------	5.16667
Cl	------	9.97183
Na	9.4185	------

IONIC CONSTITUENTS	
CALCIUM	114.4
MAGNESIUM	25.92
CARBONATES	0
BICARBONATES	131.76
SULFATE	248
CHLORIDE	354
SODIUM	216.625



CITY OF DENISON
WATER LAB
4631 RANDELL LK RD
DENISON, TX 75020

WATER ANALYSIS

SAMPLE SOURCE: Finished Water

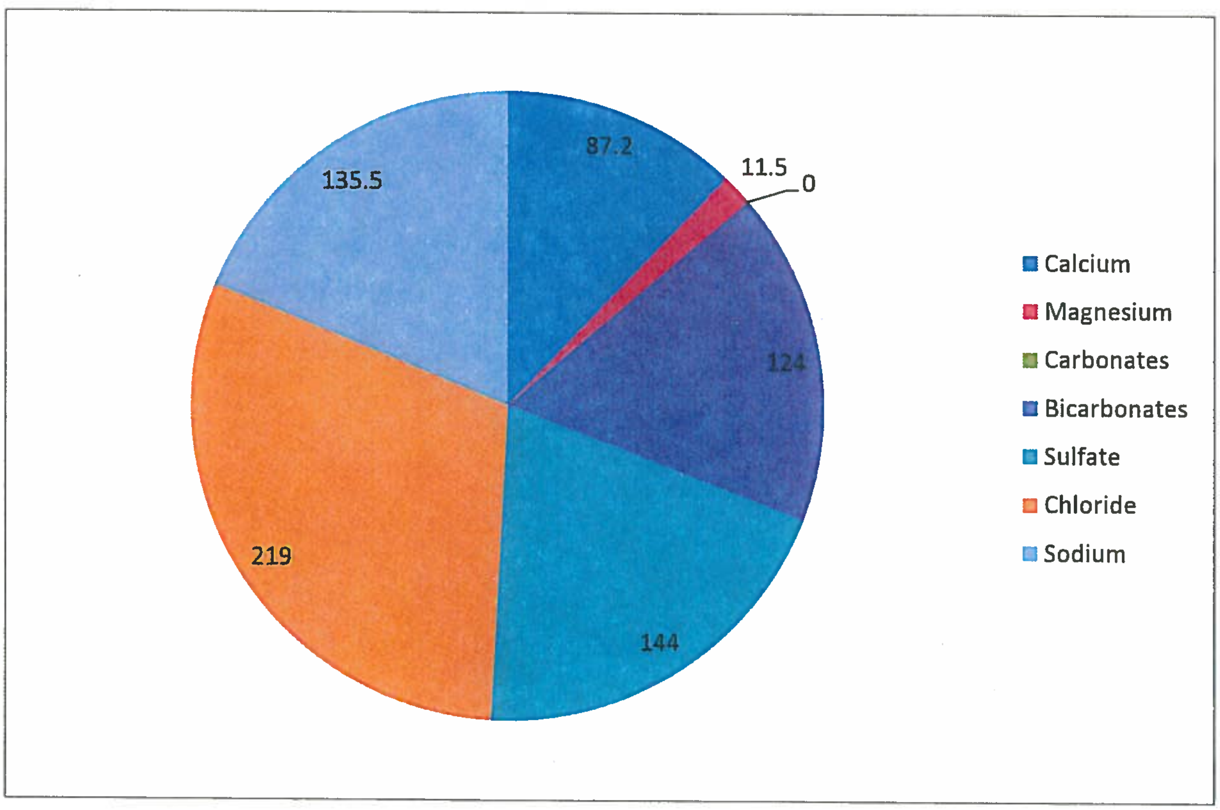
TOTAL HARDNESS:		266
TOTAL ALKALINITY:		102
MAGNESIUM HARDNESS:		48
PHENOL ALKALINITY:		0
SULFATES:		144
CHLORIDES:		219
Ph:	7.67	Units
IRON:		0.101
FLUORIDE:		0.23
		0
TOTAL DISSOLVED SOLIDS		721.6073
CHLORINE RESIDUAL:		3.6

	CATIONS	ANIONS
Ca	4.36	-----
Mg	0.96	-----
CO3	------	0
HCO3	------	2.04
SO4	------	3
Cl	------	6.16901
Na	5.88901	------

ANALYST: KJ
SAMPLE COLLECTED: 7/13/2011
SAMPLE TESTED: 7/14/2011

All results reported in Mg/l.

IONIC CONSTITUENTS	
CALCIUM	87.2
MAGNESIUM	11.52
CARBONATES	0
BICARBONATES	124.44
SULFATE	144
CHLORIDE	219
SODIUM	135.447



HOW IS WATER TREATED?

The City Of Denison uses the latest techniques and equipment to consistently produce superior quality drinking water. Utilizing conventional treatment processes, we produce an average four to nine million gallons of water per day for our customers. The process is divided into four separate steps to achieve the desired quality product mandated by the TCEQ and USEPA. Coagulation, settling, filtration, and disinfection are considered the treatment of choice for surface water in the United States. Coagulation is chemically and mechanically changing the raw water to remove the majority of larger solids. In settling the water, the finer particles have time to be removed before continuing on to filtration to remove microscopic particles. Disinfection is done with chloramine compounds before leaving the water plant and entering the distribution system. The water is sampled and tested throughout the treatment plant. Sampling is performed to make sure the processes are working and that the water is safe before it leaves the plant. The City of Denison tests thirty sites per month in the distribution system and reports results to TCEQ and USEPA. All employees involved in treating, collecting samples, and making repairs to the distribution system are certified by TCEQ through training and testing.

SECONDARY CONSTITUENTS

Many constituents (such as calcium, sodium, or iron) which are often found in drinking water, can cause taste, color and odor problems. The taste and odor constituents are called secondary constituents
and regulated by the State of Texas, not EPA. These constituents are not causes for health concern. Therefore, secondary standards are not required to be reported in this document but they may greatly affect the appearance and taste of your water.

UNREGULATED CONTAMINATE MONITORING RULE

We participated in gathering data under the UCMR in order to assist EPA in determining the occurrence of possible drinking water contaminants. If any unregulated contaminants were detected they are shown in the tables elsewhere in the report.

DEFINITIONS

A-24

NTU – Nephelometric Turbidity Units. This is the unit used to measure water turbidity.
MCLG – Maximum Contaminant Level Goal. The level of a contaminant in drinking water below which there is no known or expected health risk. MCLG's allow for a margin of safety.
MCL – Maximum Contaminant Level. The highest permissible level of a contaminant that is allowed in drinking water. MCL's are set as close to the MCLG's as feasible using the best available treatment technology.
AL – Action Level The concentration of a contaminant which, if exceeded, trigger treatment or other requirements that a water system must follow.
TURBIDITY – A measure of the cloudiness of water. We monitor it because it is a good indicator of the effectiveness of our filtration system.
TREATMENT TECHNIQUE – A required process intended to reduce the level of a contaminant in drinking water.
ppm – Parts per million. One part per million equals one packet of artificial sweetener sprinkled into 250 gallons of iced tea.
ppb–Parts per billion.. One part per billion is equal to one packet of artificial sweetener added to an Olympic size swimming pool.
ppt- Parts per trillion, or nanograms per liter.
ppq–parts per quadrillion, picograms per liter
pci/l – Picocuries per liter is a measure of radioactivity in water.
MFL – million fibers per liter (a measure for asbestos)

NOTICE TO AT-RISK POPULATIONS

Some people may be more vulnerable to contaminants in drinking water than the general population. Immune-compromised persons such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune system disorders, some elderly, and infants can be particularly at risk from infections. These people should seek advice about drinking water from their health care providers. EPA/ Centers for Disease Control and Prevention (CDC) guidelines on appropriate means to lessen the risk of infection by Cryptosporidium and other microbial contaminants are available from the Safe Drinking Water Hotline (800-426-4971).

PUBLIC PARTICIPATION OPPORTUNITIES

A public meeting with the City of Denison's Water Treatment Personnel will be held to answer any questions and respond to comments water customers may have.

DATE: JULY 19, 2011

TIME: 10:00 AM

LOCATION 4631 RANDELL LAKE ROAD

PHONE #: (903) 464-4480

OUR DRINKING WATER MEETS OR EXCEEDS ALL EPA DRINKING WATER REQUIREMENTS

This report is a summary of the quality of the water we provide our customers. The analysis was made by using data from the most recent EPA required tests and is presented in the attached pages. We hope this information helps you become more knowledgeable about what is in your drinking water.

WATER SOURCES

The sources of drinking water (both tap water and bottled) include river, lakes, streams, ponds, reservoirs, springs and wells. As water travels over the land's surface or through the ground, it dissolves naturally occurring minerals and, in some cases, radioactive material, and can pick up substances resulting from the presence of animal or human activity. Contaminants that may be in untreated water include microbes, inorganic contaminants, pesticides, herbicides, organic chemical contaminants and radioactive contaminants.

WHERE DO WE GET OUR WATER?

Most of the water we treat is from city-owned Lake Randell, located to the northwest of Denison between US 75 and Lake Texoma. The supply for Lake Randell is supplemented by water transferred from Lake Texoma. . Almost all our customers are served by surface water from these two lakes. Our customers in the area of North Texas Regional Airport are served by a combination of surface water and ground water from wells the City operates on the NTRA property. These wells produce water from the Trinity/Paluxy aquifer formation. TCEQ completed an assessment of our source water and results indicate that some of the sources are susceptible to certain contaminants. The sampling requirements for our water system are based on this susceptibility and previous sample data. Any detection of those contaminants will be found in this report. For more information on source water assessments and protection efforts at our system, please contact us.

ALL DRINKING WATER MAY CONTAIN CONTAMINANTS

When drinking water meets federal standards there may not be any health related benefits to purchasing bottled water or point of use devices. All drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of these contaminants does not necessarily indicate that water poses a health risk. More information about contaminants and potential health effects may be obtained by calling USEPA's Safe Drinking Water Hotline (1-800-426-4791).

En Espanol

Este reporte incluye informacion importante sobre el agua para tomar. Si tiene preguntas o'discusiones sobre este reporte en espanol, favor de llamar at tel. (903)464-4481par hablar con una persona bilinque en Espanol.

INORGANIC

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN. LEVEL	MAX. LEVEL	MCL	MCLG	UNIT OF MEASURE	SOURCE OF CONTAMINANT
2006	Barium	.132	.132	.132	2	2	ppm	Discharge of drilling wastes; Discharge from metal refineries; Erosion of natural deposits
2010	Fluoride	.12	.12	.12	4	4	ppm	Erosion of natural deposits; Water additive which promotes strong teeth; Discharge from fertilizer and aluminum factories
2010	Nitrate	0.08	.08	.08	10	10	ppm	Runoff from fertilizer use; Leaching from septic tanks, sewage; Erosion of natural deposits.
2008	Gross beta	4.1	4.1	4.1	50	0	pci/l	Decay of natural and man-made deposits

TOTAL ORGANIC CARBON (SOURCE WATER)

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN. LEVEL	MAX.LEVEL	SOURCE OF CONTAMINANT
2010	TOC	4.20	3.26	5.45	Naturally occurring organic (No associated adverse health effects)

DISINFECTION BYPRODUCTS

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN. LEVEL	MAX. LEVEL	MCL	UNITS OF MEASURE	SOURCE OF CONTAMINANT
2010	Total Haloacetic Acids	23.67	12.7	31.6	60	ppb	By-product of drinking water disinfect ion.
2010	Total Trihalomethanes	47.78	22.3	84.0	80	ppb	By-product of drinking water chlorination.

DISINFECTION RESIDUALS

YEAR	CONSTITUENT	ANNUAL AVERAGE	RANGE OF DETECTION	MRDL	MCLG	UNITS	SOURCE
2010	Chloramines	2.2	0.05 – 4.0	4	0	ppm	Disinfectant used to control microbes

LEAD AND COPPER

YEAR	CONTAMINANT	THE 90th PERCENTILE	SITES EXCEEDING ACTION LEVEL	ACTION LEVEL	UNIT OF MEASURE	SOURCE OF CONTAMINANT
2009	Lead	.0016	0	.015	ppm	Corrosion of household plumbing systems; Erosion of natural deposits.
2009	Copper	.0158	0	1.3	ppm	Corrosion of household plumbing systems; Erosion of natural deposits; Leaching from wood preservatives.

TURBIDITY

YEAR	CONTAMINANT	HIGHEST SINGLE MEASUREMENT	LOWEST MONTHLY % OF SAMPLES MEETING LIMITS	TURBIDITY LIMITS	UNITS OF MEASURE	SOURCE OF CONTAMINANT
2010	TURBIDITY	.26	100%	0.3	NTU	Soil runoff

TURBIDITY has no health effects. However, turbidity can interfere with disinfection and provide a medium for microbial growth. TURBIDITY may indicate the presence of disease-causing organisms. These organisms include bacteria, viruses, and parasites that can cause symptoms such as nausea, cramps, diarrhea and associated headaches.

SECONDARY AND OTHER NOT REGULATED CONSTITUENTS (No associated adverse health effects)

YEAR	CONSTITUENT	AVERAGE LEVEL	MIN. LEVEL	MAX. LEVEL	LIMIT	UNIT OF MEASURE	SOURCE OF CONSTITUENT
2010	Bicarbonate	109	109	109	NA	ppm	Corrosion of carbonate rocks such as limestone.
2010	Calcium	54.3	54.3	54.3	NA	ppm	Abundant naturally occurring element.
2010	Chloride	67.6	59	80	300	ppm	Abundant naturally occurring element; used in water purification; byproduct of oil field activity.
2010	Iron	.17	.17	.17	0.3	ppm	Erosion of natural deposits; iron or steel water delivery equipment of facilities
2010	Magnesium	8.39	8.39	8.39	NA	ppm	Abundant naturally occurring element
2010	Ph	7.9	7.2	8.2	NA	units	Measure of corrosiveness of water.
2010	Sodium	44.9	44.9	44.9	NA	ppm	Erosion of natural deposits; byproduct of oil field activity.
2010	Sulfate	38.9	38.9	38.9	300	ppm	Naturally occurring; common industrial byproduct; byproduct of oil field activity
2010	Total Alkalinity as CaCO3	109	109	109	NA	ppm	Naturally occurring soluble mineral salts.
2010	Total Dissolved Solids	298	298	298	1000	ppm	Total dissolved mineral constituents in water
2010	Total Hardness as CaCO3	130	130	130	NA	ppm	Naturally occurring calcium.

2008

INORGANIC

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN. LEVEL	MAX. LEVEL	MCL	MCLG	UNIT OF MEASURE	SOURCE OF CONTAMINANT
2006	Barium	.132	.132	.132	2	2	ppm	Discharge of drilling wastes; Discharge from metal refineries; Erosion of natural deposits
2008	Fluoride	.62	.62	.62	4	4	ppm	Erosion of natural deposits, Water additive which promotes strong teeth, Discharge from fertilizer and aluminum factories
2008	Nitrate	0.16	0.16	0.16	10	10	ppm	Runoff from fertilizer use; Leaching from septic tanks, sewage; Erosion of natural deposits.
2008	Gross beta	4.1	4.1	4.1	50	0	pci/l	Decay of natural and man-made deposits

TOTAL ORGANIC CARBON (SOURCE WATER)

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN. LEVEL	MAX.LEVEL	SOURCE OF CONTAMINANT
2008	TOC	5.78	5.16	6.45	Naturally occurring organic (No associated adverse health effects)

DISINFECTION BYPRODUCTS

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN. LEVEL	MAX. LEVEL	MCL	UNITS OF MEASURE	SOURCE OF CONTAMINANT
2008	Total Haloacetic Acids	11.3	0	38.6	60	ppb	By-product of drinking water disinfect ion.
2008	Total Trihalomethanes	56.57	18	101.2	80	ppb	By-product of drinking water chlorination.

DISINFECTION RESIDUALS

YEAR	CONSTITUENT	ANNUAL AVERAGE	RANGE OF DETECTION	MRDL	MCLG	UNITS	SOURCE
2008	Chloramines	2.0	0.05 – 4.0	4	0	ppm	Disinfectant used to control microbes

UNREGULATED CONTAMINANTS

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN. LEVEL	MAX. LEVEL	UNITS OF MEASURE	SOURCE OF CONTAMINANT
2008	Chloroform	18.44	3.2	27.7	ppb	By-product of drinking water disinfect ion.
2008	Bromoform	19.27	4.1	22.9	ppb	By-product of drinking water disinfect ion.
2008	Bromodichloromethane	14.07	0	28.4	ppb	By-product of drinking water disinfect ion.
2008	Dibromochloromethane	2.6	0	8.1	ppb	By-product of drinking water disinfect ion.

LEAD AND COPPER

YEAR	CONTAMINANT	THE 90th PERCENTILE	SITES EXCEEDING ACTION LEVEL	ACTION LEVEL	UNIT OF MEASURE	SOURCE OF CONTAMINANT
2007	Lead	2.4	0	15	ppb	Corrosion of household plumbing systems; Erosion of natural deposits.
2007	Copper	0.263	0	1.3	ppm	Corrosion of household plumbing systems; Erosion of natural deposits; Leaching from wood preservatives.

TURBIDITY

YEAR	CONTAMINANT	HIGHEST SINGLE MEASUREMENT	LOWEST MONTHLY % OF SAMPLES MEETING LIMITS	TURBIDITY LIMITS	UNITS OF MEASURE	SOURCE OF CONTAMINANT
2008	TURBIDITY	.59	98%	0.3	NTU	Soil runoff

TURBIDITY has no health effects. However, turbidity can interfere with disinfection and provide a medium for microbial growth. TURBIDITY may indicate the presence of disease-causing organisms. These organisms include bacteria, viruses, and parasites that can cause symptoms such as nausea, cramps, diarrhea and associated headaches.

SECONDARY AND OTHER NOT REGULATED CONSTITUENTS (No associated adverse health effects)

YEAR	CONSTITUENT	AVERAGE	MIN.	MAX.	LIMIT	UNIT OF	SOURCE OF CONSTITUENT
2008	Bicarbonate	103	103	103	NA	ppm	Corrosion of carbonate rocks such as limestone.
2002	Calcium	62.35	46.1	78.6	NA	ppm	Abundant naturally occurring element.
2008	Chloride	154	154	154	300	ppm	Abundant naturally occurring element; used in water purification; byproduct of oil field activity.
2005	Iron	.024	.014	.038	0.3	ppm	Erosion of natural deposits; iron or steel water delivery equipment of facilities
2005	Magnesium	96	74	116	NA	ppm	Abundant naturally occurring element
2008	Ph	8.1	8.1	8.1	NA	units	Measure of corrosiveness of water.
2002	Sodium	134	129	139	NA	ppm	Erosion of natural deposits; byproduct of oil field activity.
2008	Sulfate	97.6	97.6	97.6	300	ppm	Naturally occurring; common industrial byproduct; byproduct of oil field activity
2008	Total Alkalinity as CaCO3	103	103	103	NA	ppm	Naturally occurring soluble mineral salts.
2008	Total Dissolved Solids	530	530	530	1000	ppm	Total dissolved mineral constituents in water
2008	Total Hardness as CaCO3	241	241	241	NA	ppm	Naturally occurring calcium.

2009

INORGANIC

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN. LEVEL	MAX. LEVEL	MCL	MCLG	UNIT OF MEASURE	SOURCE OF CONTAMINANT
2006	Barium	.132	.132	.132	2	2	ppm	Discharge of drilling wastes; Discharge from metal refineries; Erosion of natural deposits
2008	Fluoride	.62	.62	.62	4	4	ppm	Erosion of natural deposits; Water additive which promotes strong teeth; Discharge from fertilizer and aluminum factories
2008	Nitrate	0.06	.06	.06	10	10	ppm	Runoff from fertilizer use; Leaching from septic tanks, sewage; Erosion of natural deposits.
2008	Gross beta	4.1	4.1	4.1	50	0	pci/l	Decay of natural and man-made deposits

TOTAL ORGANIC CARBON (SOURCE WATER)

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN. LEVEL	MAX.LEVEL	SOURCE OF CONTAMINANT
2009	TOC	5.78	5.16	6.45	Naturally occurring organic (No associated adverse health effects)

DISINFECTION BYPRODUCTS

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN. LEVEL	MAX. LEVEL	MCL	UNITS OF MEASURE	SOURCE OF CONTAMINANT
2009	Total Haloacetic Acids	30.3	4.9	54.9	60	ppb	By-product of drinking water disinfect ion.
2008	Total Trihalomethanes	56.57	18	101.2	80	ppb	By-product of drinking water chlorination.

DISINFECTION RESIDUALS

YEAR	CONSTITUENT	ANNUAL AVERAGE	RANGE OF DETECTION	MRDL	MCLG	UNITS	SOURCE
2009	Chloramines	2.0	0.05 – 4.0	4	0	ppm	Disinfectant used to control microbes

LEAD AND COPPER

YEAR	CONTAMINANT	THE 90th PERCENTILE	SITES EXCEEDING ACTION LEVEL	ACTION LEVEL	UNIT OF MEASURE	SOURCE OF CONTAMINANT
2009	Lead	.0016	0	.015	ppm	Corrosion of household plumbing systems; Erosion of natural deposits.
2009	Copper	.0158	0	1.3	ppm	Corrosion of household plumbing systems, Erosion of natural deposits, Leaching from wood preservatives.

TURBIDITY

YEAR	CONTAMINANT	HIGHEST SINGLE MEASUREMENT	LOWEST MONTHLY % OF SAMPLES MEETING LIMITS	TURBIDITY LIMITS	UNITS OF MEASURE	SOURCE OF CONTAMINANT
2008	TURBIDITY	..3	100%	0.3	NTU	Soil runoff

TURBIDITY has no health effects. However, turbidity can interfere with disinfection and provide a medium for microbial growth. TURBIDITY may indicate the presence of disease-causing organisms. These organisms include bacteria, viruses, and parasites that can cause symptoms such as nausea, cramps, diarrhea and associated headaches.

SECONDARY AND OTHER NOT REGULATED CONSTITUENTS (No associated adverse health effects)

YEAR	CONSTITUENT	AVERAGE	MIN.	MAX.	LIMIT	UNIT OF	SOURCE OF CONSTITUENT
2009	Bicarbonate	110	110	110	NA	ppm	Corrosion of carbonate rocks such as limestone
2002	Calcium	62.35	46.1	78.6	NA	ppm	Abundant naturally occurring element.
2009	Chloride	142	142	142	300	ppm	Abundant naturally occurring element; used in water purification, byproduct of oil field activity.
2009	Iron	.17	.	.17	0.3	ppm	Erosion of natural deposits; iron or steel water delivery equipment of facilities
2005	Magnesium	96	74	116	NA	ppm	Abundant naturally occurring element
2009	Ph	8.0	8.0	8.0	NA	units	Measure of corrosiveness of water.
2009	Sodium	95.4	95.4	95.4	NA	ppm	Erosion of natural deposits; byproduct of oil field activity.
2009	Sulfate	139	139	139	300	ppm	Naturally occurring, common industrial byproduct, byproduct of oil field activity
2009	Total Alkalinity as CaCO3	110	110	110	NA	ppm	Naturally occurring soluble mineral salts.
2009	Total Dissolved Solids	574	574	574	1000	ppm	Total dissolved mineral constituents in water
2009	Total Hardness as CaCO3	170	170	170	NA	ppm	Naturally occurring calcium.

2010

INORGANIC

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN LEVEL	MAX. LEVEL	MCL	MCLG	UNIT OF MEASURE	SOURCE OF CONTAMINANT
2006	Barium	.132	.132	.132	2	2	ppm	Discharge of drilling wastes; Discharge from metal refineries; Erosion of natural deposits
2010	Fluoride	.12	.12	.12	4	4	ppm	Erosion of natural deposits; Water additive which promotes strong teeth, Discharge from fertilizer and aluminum factories
2010	Nitrate	0.08	.08	.08	10	10	ppm	Runoff from fertilizer use; Leaching from septic tanks, sewage; Erosion of natural deposits.
2008	Gross beta	4.1	4.1	4.1	50	0	pci/l	Decay of natural and man-made deposits

TOTAL ORGANIC CARBON (SOURCE WATER)

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN. LEVEL	MAX.LEVEL	SOURCE OF CONTAMINANT
2010	TOC	4.20	3.26	5.45	Naturally occurring organic (No associated adverse health effects)

DISINFECTION BYPRODUCTS

YEAR	CONTAMINANT	AVERAGE LEVEL	MIN LEVEL	MAX. LEVEL	MCL	UNITS OF MEASURE	SOURCE OF CONTAMINANT
2010	Total Haloacetic Acids	23.67	12.7	31.6	60	ppb	By-product of drinking water disinfect ion.
2010	Total Trihalomethanes	47.78	22.3	84.0	80	ppb	By-product of drinking water chlorination.

DISINFECTION RESIDUALS

YEAR	CONSTITUENT	ANNUAL AVERAGE	RANGE OF DETECTION	MRDL	MCLG	UNITS	SOURCE
2010	Chloramines	2.2	0.05 – 4.0	4	0	ppm	Disinfectant used to control microbes

LEAD AND COPPER

YEAR	CONTAMINANT	THE 90th PERCENTILE	SITES EXCEEDING ACTION LEVEL	ACTION LEVEL	UNIT OF MEASURE	SOURCE OF CONTAMINANT
2009	Lead	.0016	0	.015	ppm	Corrosion of household plumbing systems; Erosion of natural deposits.
2009	Copper	.0158	0	1.3	ppm	Corrosion of household plumbing systems, Erosion of natural deposits, Leaching from wood preservatives.

TURBIDITY

YEAR	CONTAMINANT	HIGHEST SINGLE MEASUREMENT	LOWEST MONTHLY % OF SAMPLES MEETING LIMITS	TURBIDITY LIMITS	UNITS OF MEASURE	SOURCE OF CONTAMINANT
2010	TURBIDITY	.26	100%	0.3	NTU	Soil runoff

TURBIDITY has no health effects. However, turbidity can interfere with disinfection and provide a medium for microbial growth. TURBIDITY may indicate the presence of disease-causing organisms. These organisms include bacteria, viruses, and parasites that can cause symptoms such as nausea, cramps, diarrhea and associated headaches.

SECONDARY AND OTHER NOT REGULATED CONSTITUENTS (No associated adverse health effects)

YEAR	CONSTITUENT	AVERAGE	MIN.	MAX.	LIMIT	UNIT OF	SOURCE OF CONSTITUENT
2010	Bicarbonate	109	109	109	NA	ppm	Corrosion of carbonate rocks such as limestone
2010	Calcium	54.3	54.3	54.3	NA	ppm	Abundant naturally occurring element.
2010	Chloride	67.6	59	80	300	ppm	Abundant naturally occurring element; used in water purification, byproduct of oil field activity.
2010	Iron	.17	.17	.17	0.3	ppm	Erosion of natural deposits; iron or steel water delivery equipment of facilities
2010	Magnesium	8.39	8.39	8.39	NA	ppm	Abundant naturally occurring element
2010	Ph	7.9	7.2	8.2	NA	units	Measure of corrosiveness of water.
2010	Sodium	44.9	44.9	44.9	NA	ppm	Erosion of natural deposits; byproduct of oil field activity.
2010	Sulfate	38.9	38.9	38.9	300	ppm	Naturally occurring, common industrial byproduct, byproduct of oil field activity
2010	Total Alkalinity as CaCO3	109	109	109	NA	ppm	Naturally occurring soluble mineral salts.
2010	Total Dissolved Solids	298	298	298	1000	ppm	Total dissolved mineral constituents in water
2010	Total Hardness as CaCO3	130	130	130	NA	ppm	Naturally occurring calcium.

APPENDIX B

MEETING MINUTES FROM INTERVIEWS

TABLE OF CONTENTS
Appendix B

MEETING MINUTES

► **MEETING:** *USACE M&I Benefit Evaluation Municipality Interview with Altus*

► **DATE:** *July 27, 2011* ► **LEAD:** *Kadambari Reddy*

► **PLACE:** *Phone interview* ► **TIME:** *3:00 PM – 4:00 PM*

► **Distribution / Attendees (‣)**

‣ Kadambari Reddy	URS	‣ Fazle Rabbi	URS	‣ Kenyon Hunt	URS
‣ Sharon Hageman	URS	‣ Priya Hora	URS	‣ Chris Baker	USACE
‣ Ed Rossman	USACE	‣ Glenn Fulton	USACE	‣ Tyler Henry	USACE
‣ Bob Stephenson	City of Altus				

MINUTES

Introduction

Cady Reddy introduced the URS project team and the U.S. Army Corps of Engineers and opened the meeting. URS members conducted an interview with Bob Stephenson of the City of Altus.

Interview Details

Prior to the interview the Corps mentioned that the City of Altus is identified as a potential M&I user. Altus is using water from Tom Steed Reservoir; it is getting water from a watershed that is a tributary to the Red River. Fazle said that the city is near the tributary on which the Area VI project would be implemented, and it would be interesting to get the city's perspective on why they do not use Red River water.

A question was asked about the potential Cable Mountain Dam and reservoir. The Corps also asked if we knew of any sedimentation problems in Tom Steed Reservoir that would affect yield. Fazle replied that he had found a 2009 report that indicated storage has been similar and that sedimentation does not seem to be an issue. The Corps asked if Altus is also using groundwater, and Fazle said no, probably not.

The Corps took an opportunity to describe the Cable Mountain Dam. It is a potential Bureau of Reclamation site that will only be built if there is chloride control. An irrigation district would use the water source generated by the newly created reservoir. It would be located southwest of Tom Steed on the North Fork of the Red River.

The interview began and Bob Stephenson explained that Altus currently regards the Red River as strictly an emergency source. Altus has native water rights of 4800 acre feet in Lake Lugert-Altus filled by a tributary to the Red River, which is used in emergencies. Lake Altus used to be the city's primary water source. In 1976 Tom Steed was built and became the primary source of M&I. Altus has an agreement with Mountain Park Master Conservancy District, a Bureau of Reclamation master conservancy district. Altus has an approximate 76% allocation of the project yield with the remainder allocated to the City of Frederick, the City of Snyder and the "Hackberry Flat" wildlife conservation project area. There is an 18.5 mile aqueduct that carries water from Tom Steed to Altus. Altus is a municipal facility that also provides treated water to 6 other cities or rural water districts, including El Dorado, Olustee, and Blair. Literally most of Jackson Co.

The water quality in Tom Steed is much better than Red River water quality. Chlorides are lower, hardness is about 200 ppm as opposed to 950 to 1000 ppm, and dissolved solids (DS) are probably lower. That is why Altus does not use Red River tributary water even though they are close to it. Mr. Stephenson said that chloride control would be a positive for the area and a tremendous improvement for the Altus treatment facility. It would give Altus more options by making Red River water more usable for emergency or contingency needs.

About 70% of treatment occurs at a multimedia conventional treatment plant however no softening is provided by this plant. . There is a membrane treatment plant that operates parallel to the traditional treatment plant. With membrane treatment, the higher the solids content, etc., the more reject and the more concentrated that reject is. Higher quality feed water is preferred. Softening is only done through the reverse osmosis (RO) portion of the plant. The conventional plant has a capacity/production of approximately 13 MGD. The membrane plant consists of a solids contact clarifier (with ferric addition); then, the water goes to a "UF" treatment process and finally is sent to RO. RO. The membrane process provides softening, treats for viruses and bacteria (disinfection), and removes trihalomethane (THM) precursors. The capacity for the membrane plant is currently at limited due to the age and -membranes have deteriorated, but it is a 4 MGD plant. Mr. Stephenson suspected the reasons for deterioration were that the membranes was were -initially used improperly and that there was no pretreatment in place at the time of plant commissioning, all of which led to fouling and over cleaning. However, they were on year 6 of a 5-7 year life so aging was also a factor.

Mr. Stephenson is aware of Area VI through his work with the Lugert-Altus Irrigation District. He sees many benefits of chloride control ranging from recreation, irrigation, and M&I use out of Lugert-Altus. Altus has a 4800 acre-feet allocation in Lugert-Altus Lake. He asserted that with increased water quality and reduced chlorides, the city can make better use of that water. Treatment would also be easier, in his opinion, since the city could change the chemical regimen. Now, if Altus uses Lugert-Altus water, they rely on membrane treatment to perform softening, and they only temporarily use that water because it causes problems with equipment corrosion, pipelines, citizens' plumbing, and scaling. Despite getting Tom Steed water, Altus has not given up on Luger-Altus water as an alternative water source. They already have a contract with the Bureau of Reclamation – whenever they want water, the irrigation district gets it to the city reservoir (an approximately 680 acre-feet storage facility) through a canal. Altus' interest in using that water would be heightened if chlorides were lowered.

Kenyon explained that we are trying to build up cost information and determine cost benefits. Stephenson said that some benefits will be aesthetic. Odor and taste problems would be alleviated by lower chlorides. Furthermore, the city could reduce the level of softening that they would want the setup to perform. He added that with projected growth and industry development, Altus could need that water in the future. The city used Lugert-Altus until '76 and also had a 100 MGD groundwater well field to supplement and improve water quality by blending the groundwater and surface water. Before switching to Tom Steed, quantity was questionable (the 4800 acre-feet Altus still has in Lugert-Altus was marginal compared to the demand) and water quality was terrible. Residential water heaters and faucets had life spans of 2-3 years due to scaling and corrosion. Tom Steed has lower hardness and chlorides, no fluctuation in lake levels, and no taste or odor issues when it turns over. Overall, Mr. Stephenson is in favor of the project.

Towards the end of the call, there was some discussion amongst the URS team and the Corps about the benefits to water quality in Lugert-Altus Lake due to Area VI. It appears that the confluence of the North Fork and Elm Fork of the Red River occurs beneath Lugert-Altus. If the salts are picked up from the Elm Fork primarily, it is possible that Area VI would only improve water quality downstream of the reservoir and not upstream.

Moving Forward

Mr. Stephenson will get requested water quality and treatment information from the city's treatment supervisor, who is halfway through completing the questionnaire. Mr. Stephenson will e-mail this information to Cady by the first week of August.

These notes are an interpretation of discussions held. Please provide any additions or corrections to the originator within five days of the date signed, otherwise they will be assumed correct as written.

► ***Prepared By:*** Priya Hora ► ***Date:*** July 27, 2011

MEETING MINUTES

► **MEETING:** *USACE M&I Benefit Evaluation Municipality Interview with Bossier City*

► **DATE:** *July 22, 2011* ► **LEAD:** *Kadambari Reddy*

► **PLACE:** *Phone interview* ► **TIME:** *10:30 AM – 11:10 AM*

► **Distribution / Attendees (‣)**

‣ Kadambari Reddy	URS	‣ Fazle Rabbi	URS	‣ Kenyon Hunt	URS
‣ Sharon Hageman	URS	‣ Priya Hora	URS	‣ Jim Barnett	Bossier City

MINUTES

Introduction

Cady Reddy introduced the URS project team and opened the meeting. URS members conducted an interview with Jim Barnett, Superintendent at the Bossier City Water Treatment Division in Louisiana.

Interview Details

At the outset, Fazle Rabbi mentioned that we had obtained additional water plan information as well as water quality data. A 2008 report for expansion of the treatment plant was located. Despite having basic treatment information, we wanted Jim Barnett to verify the information and answer specific questions.

Jim confirmed that the source of Bossier City's water supply is the Red River. There are no alternative or future water sources being considered by the city. Bossier City also acts as a wholesale provider, selling treated water to the cities of Benton and Cypress and is under contract to sell water as a back-up source to another city. According to Jim, Bossier City does not sell water to any industrial facilities nor does the city use different treatment levels or processes for its customers. Currently, Bossier City has one treatment plant originally installed in 1958. Jim confirmed that Bossier City is in the process of constructing and bringing a new water treatment plant online. In his estimation, the plant is approximately 75% complete and will be operational by spring 2012. This expansion will increase overall plant capacity from 25 MGD to 45 MGD. The annual average treatment plant production is currently about 13 MGD, but it can reach peaks from 23 to 24 MGD. At 25 MGD, hydraulic issues occur with flocculation in the clarifiers.

Kenyon Hunt posed a question about the preliminary stages of the treatment process. Jim explained that Bossier City has a 100 acre reservoir. Typically, Red River water is pumped to the reservoir for storage, allowing for settling to happen. On occasion, Bossier City will pump water directly from the Red River. Though they have this capability, they do not like to do that. Both Fazle and Kenyon pointed out that in the 2008 report, water in the reservoir had lower concentrations of chlorides and TDS than raw Red River water. The maximum concentration values noticeably differed while the average concentration values were similar. Jim was unsure of those facts.

Jim was asked if they experienced any challenges using water directly from the Red River. He said that there were sometimes problems with high turbidity (greater than 25 NTU). At such high levels, the plant cannot properly treat for it. When asked about chlorides, he stated that elevated chloride levels go along with hardness issues. There is increased chemical consumption when chlorides are high, and thus hardness is high, because they have to treat more for hardness. The plant has no capability to address chloride levels.

Jim mentioned that customers and residents regularly complain about problems associated with water quality, in particular hardness. The hardness levels sometimes impact plumbing and appliances, such as dishwashers, in residences. Jim said that people are accustomed to the taste of the water.

Kenyon asked about the type of flocculant. Jim said a cationic polymer is used in the contact clarifiers. Previously, they would do lime softening and use liquid ferric to coagulate. With the new plant, lime will be added with the cationic polymer to soften the water when hardness is high. Kenyon wanted Jim to try to quantify the hardness levels and the associated treatment costs. Jim said that the conditions vary seasonally. High hardness is more prevalent during late summer. When TDS and hardness are high (with hardness reaching 200 mg/l, though the concentration can go up to 350 in the raw water), they start getting complaints and must soften the water. They soften around 2 months per year. Typically the dosage of lime is 5 to 7 grains per gallon, though this too varies with season and conditions.

When Cady asked about damages, Jim replied that they deal with corrosion/scaling as would be expected at a facility doing lime softening. Launders and weirs in the upflow clarifiers have been impacted. There are plans to upgrade to stainless steel. About every 10 years, they have to replace the steel on the upflow clarifiers, which costs about $1 million. Jim asserted that if the plant did not have to soften the water, they would save money.

Jim remarked that there was an evaluation of chloride reduction prior to constructing the new plant. The city had considered reverse osmosis (RO) and blending with old plant water, but it was deemed cost prohibitive.

Jim said future plans are to blend water from the new process utilizing membrane filtration with water from the old process. The two processes will be blended prior to entering the clear well. There would be no lime softening on the new membrane side. Softening must be addressed in the old plant. Jim had some questions and concerns about blending waters with different pH's and how that would ultimately impact hardness. The system would use CO_2 to adjust the pH.

Kenyon asked about disinfection; Jim responded that they are still doing chloramination and would be expanding that.

Moving Forward

Jim Barnett stated that he will send us water intake and production data for the last 5 years and chemical consumption records for the last 5 years. He will attempt to find and send the evaluation of chloride reduction as well.

These notes are an interpretation of discussions held. Please provide any additions or corrections to the originator within five days of the date signed, otherwise they will be assumed correct as written.

► *Prepared By:* Priya Hora ► *Date:* July 22, 2011

MEETING MINUTES

► **MEETING:** *USACE M&I Benefit Evaluation Municipality Interview with GTUA*

► **DATE:** *July 25, 2011* ► **LEAD:** *Kadambari Reddy*

► **PLACE:** *Phone interview* ► **TIME:** *10:30 AM – 11:30 AM*

► **Distribution / Attendees (▸)**

▸	Kadambari Reddy	URS	▸	RT Murthy	URS	▸	Jason Weiss	URS
▸	Sharon Hageman	URS	▸	Fazle Rabbi	URS	▸	Kenyon Hunt	URS
▸	Priya Hora	URS	▸	Chris Baker	USACE	▸	Glenn Fulton	USACE
▸	Ed Rossman	USACE	▸	Jerry Chapman	GTUA			

MINUTES

Introduction

Cady Reddy opened the meeting; the URS team and the Corp were introduced. URS members conducted an interview with Jerry Chapman, General Manager at the Greater Texoma Utility Authority (GTUA).

Interview Details

Jerry Chapman started by explaining a little bit about GTUA. GTUA provides raw water and purchases treated water from North Texas Municipal Water District (NTMWD) to supply to its customers and member cities. The sources of its water supply are: Lake Texoma, groundwater (GTUA manages the Red River Groundwater Conservation District), and treated water from the Lavon system bought from NTMWD.

The URS team explained that we are interested in GTUA's experience with Lake Texoma water and would like to know more about water quality and the impacts of pumping raw Lake Texoma water. Jason asked if full implementation of Red River chloride control would affect groundwater quality. Mr. Chapman replied that the groundwater quality is independent of the river water quality and not significantly impacted by intrusion from the Red River. GTUA's groundwater comes from two aquifers: Trinity, which is a major aquifer, and Woodbine, which is a minor aquifer. In the Northwest Grayson County Water Control area, there was some salt/chloride intrusion because it's near the Red River. However, overall, groundwater is independent from intrusion of the Red River.

Mr. Chapman was asked for information about the raw water system. He said that raw water goes through a conduit in Grayson county. This is shared with NTMWD. GTUA buys treated water down at McKinney. In regard to groundwater, he said that the wells are independently owned by municipalities and public systems. The City of Sherman has 25 wells, which produce half of their total supply, and the rest comes from surface water. Sherman has separate systems; surface water and groundwater are not blended. The northern and western portions of the city get surface water and the southern and eastern portions on the lower pressure plane use groundwater. There is an emergency connect for groundwater and raw water. GTUA is a wholesale supplier of raw water from Lake Texoma to Sherman. Treated water purchased from NTMWD goes to the Western Collin-Grayson municipal project.

The Sherman Water Treatment Plant (WTP), which was financed and built by GTUA, was constructed in1993. The plant is designed to serve all of SW Grayson County. It has a capacity of 10 million gallons per day (MGD). It can go up to 25 MGD by adding flocculation and sedimentation basins. There are no immediate plans to expand the plant. The average yearly production is 1.8 billion gallons.

GTUA was created to get surface water to Sherman in the long range. 75 MG was supplied to Sherman, but industry left and industrial demand declined. 4.5 to 5 MGD is provided by the surface water plant. In 2010, GTUA supplied 3,400 acre-feet to Sherman. The plant is operating at a capacity of 5 MGD and there are no plans to increase the capacity or expand the plant.

The Sherman facility was built to treat water from Lake Texoma and was thus designed with the capability to reduce chloride to an acceptable level of 300 ppm. An electrodialysis reversal (EDR) unit was put in the plant, which was an investment of $4 to 5 million in '93. There are extra energy costs to operate EDR. The only major equipment expenditure was 1 membrane replacement at a cost of $1.2 million. The membrane had a 12-13 year life expectancy before it had to be replaced.

Mr. Chapman was asked about the high salinity waste stream being discharged from the EDR unit and how it is handled. The percent of treated water to raw water is 85-90. So, the reject water/brine stream is 10-15% of the influent that came into the plant. The reject water is pumped into 2 lagoons and periodically pumped to the Sherman wastewater collection and treatment system. The reject water is blended with other wastewater and discharged to Choctaw Creek and back to the Red River. The total discharge from the wastewater treatment plant is 7-8 MGD. Mr. Chapman reaffirmed that the water discharged in line is no more than 10-15% of daily production.

Alum is used as a coagulant in the Sherman water treatment plant. The basic treatment process is: out of the water line the raw water goes to a pre-oxidation basin, followed by chemical mixing, then to a sedimentation basin (where alum is used), through filtration (dual media sand and charcoal filters are used), and then a portion of the flow is treated through EDR. Some softening occurs, but it is not a requirement – the city council likes them to do it to accommodate customers. Mr. Chapman speculated that softening happens based on season; he would have to talk to Dewayne Sutherland, the City of Sherman Water Systems Superintendent.

Mr. Chapman also said that Dewayne will check on chemical consumption and spending (however much used per year and dosage amount), and that Dewayne will have raw water quality data. The water quality depends on how much rain water is in the Red River system.

Mr. Chapman said that GTUA is not considering any alternative or future water supply sources. They have purchased about 75000 acre-feet total in Lake Texoma. About 35000 of that goes to Sherman, 10-11000 goes to Denison, 10-11000 goes to Gainesville, and the rest of the water goes to the other member cities. GTUA sells 25000 AFY to NTMWD through a raw water contract; this raw water is sent to Lavon. More recently, GTUA had acquired greater capacity in Lake Texoma, purchasing additional water rights, moving it from hydropower to municipal. 50,000 acre-feet more water became available to them while NTMWD received 100,000 acre-feet more. With the additional Lake Texoma water that they obtained last summer, GTUA does not use its full allotment at present. The acquisition of 50 MGD was part of developing a long term surface supply in the North Texas area since there is little space to build reservoirs. Mr. Chapman did mention some potential reservoir options for the area such as the Lower Bois d'Arc, which is currently underway, and Ralph Hall. Mr. Chapman reiterated that GTUA has a current allocation of 75 to 76000 acre-feet in storage that is made available to member cities; he does not foresee 75 MGD storage failing to meet demand in the near future.

Mr. Chapman explained that about 20% of Lake Texoma is inactive (the lake bottom) due to hydropower; an additional 20-25% is used for hydropower as well. 50% of the lake is used for flood control, leaving about 9% of the lake for municipal water supply. Mr. Chapman does not expect any further reallocation from hydropower to municipal because hydropower will not accept additional storage reallocation for the time being.

Kenyon asked if Mr. Chapman was aware of any damages or corrosion in the plant due to the chlorides. Mr. Chapman said the plant is free of those things, that he is not aware of major problems. When the lake turns over, they occasionally receive complaints about taste and odor. A study evaluating chloride reduction through mixing, etc. was conducted in the 1980s. The study concluded not to pursue mixing of groundwater and surface water in the distribution system so the two streams were split to maintain consistency in water quality.

Mr. Chapman was asked how a reduction in chlorides would impact the facility. He replied that he did not think it would. He also did not know of any studies regarding chloride control since the Sherman plant has been operational. In his opinion, chloride control would take decades to implement and even longer for them to benefit from it.

Fazle asked if the plant had issues with hardness. Mr. Chapman said the surface water is hard while the groundwater is soft. Sherman depended on groundwater prior to the plant. With the transition, there were some issues with taste.

Jason asked if there would be a potential cost reduction resulting from chloride control. Mr. Chapman said that it would take a long time and that they would not immediately turn off EDR because of the water quality issues. He doesn't know if there will be benefits or if money would be saved. He does not anticipate there being a significant reduction in cost. Costs are high because they used to ship to a major industrial load and now they have to spread out the fixed costs to residential customers. Sherman increased its rates 5% last year and will increase them by 4% this year because of that lower industrial demand.

Concluding the questioning, Jason asked if the amount of reject water from the EDR unit depended on chlorides in the water. Mr. Chapman asserted that 10-15% of what the plant produces in a day is brine stream and pumped into the system. 10% reject is as good as they can achieve. With long term reduction of chlorides, it might decrease, but it is hard to say how it would be impacted if chlorides were reduced. He said again that it was assumed the Corps project would take such a long time for benefits to appear, and they always thought chlorides would be in the water. Kenyon suggested that the net effect would be lower concentrated brine going through the sewer; the volume would remain relatively the same.

Moving Forward

Mr. Chapman will try to send maps/schematics of the raw water and treated systems. He will check with Dewayne on the raw water quality and treatment data. A site visit and tour to visually inspect the plant is being scheduled.

These notes are an interpretation of discussions held. Please provide any additions or corrections to the originator within five days of the date signed, otherwise they will be assumed correct as written.

► ***Prepared By:*** Priya Hora ► ***Date:*** July 27, 2011

MEETING MINUTES

► MEETING:	*USACE M&I Benefit Evaluation Municipality Interview with NTMWD*		
► DATE:	*August 31, 2011*	► LEAD:	*Kadambari Reddy*
► PLACE:	*Phone interview*	► TIME:	*9:00 AM – 10:00 AM*

► Distribution / Attendees (►)

►	Kadambari Reddy	URS	►	Jason Weiss	URS	►	Fazle Rabbi	URS
►	Kenyon Hunt	URS	►	Priya Hora	URS	►	Sharon Hageman	URS
►	Joe Berlin	URS	►	Chris Baker	USACE	►	Ed Rossman	USACE
			►	Ted Kilpatrick	NTMWD			

MINUTES

Introduction

Cady Reddy introduced the URS project team and opened the meeting. URS members conducted an interview with Ted Kilpatrick,

Interview Details

Fazle Rabbi started, remarking that NTMWD is one of major users of Lake Texoma water. He wanted to know how NTMWD is currently using Texoma water and how it will use it in the future.

Mr. Kilpatrick explained that currently NTMWD has 190,300 AFY total water rights. The plan in near future is to carry Texoma water through the pipeline. Mr. Kilpatrick proceeded to provide water quality information for us.

The 2006-2007 water quality report showed that chloride and sulfate levels were significantly high. The intake concentration was higher probably because of drought, Mr. Kilpatrick speculated. NTMWD is not currently using Texoma water because of zebra mussels. They haven't used Texoma water since July 2009. This is significant because Texoma accounts for about 20% NTMWD's raw water. Mr. Kilpatrick provided the amounts of lake Texoma water NTMWD used per year. In 2006: 100,293 AF; in 2007: 39,657 AF; in 2008: 73,523 AF; in 2009: 31,852 AF through July; and in 2010-2011: no Texoma water was used.

The present considerations are to restore the use of Texoma water. Mr. Kilpatrick said that the District voluntarily stopped pumping Lake Texoma water because of the mussels. Zebra mussels are not in Lake Lavon and NTMWD did not want to spread them. Historically, NTMWD pumped from Texoma to a high point between the lake and Lake Lavon, discharging the Texoma water to Sister Grove Creek and allowing it to flow to Lavon. The hope is to restore pumping below 54 degrees Fahrenheit. There was a plan to increase pumping capacity from Lavon to move water rights more quickly. Mr. Kilpatrick said it would take about a year for NTMWD to pump their entire water rights. They would pump for 3-4 months per year if they can pump at the 54 degree Fahrenheit threshold. Due to the pressing situation, Mr. Kilpatrick explained that NTMWD is looking for other water sources in addition to Lake Texoma.

Fazle asked more specifically about future plans, in particular with regard to treatment of Lake Texoma water. Mr. Kilpatrick responded that all of NTMWD's plans involve blending to use Lake Texoma water. Additionally, in the next 5 years or so, NTMWD intends to build Lower Bois D'Arc Creek Reservoir and a new water treatment plant. Some Texoma water will be sent there and blended.

MEETING MINUTES

NTMWD will also extend the pipeline from the Texoma pump station to its system at Lavon (the Wylie Water Treatment Plant) and then blend Texoma water with treatment water at the plants. Texoma water is not and will not be blended directly with other lake water. Consultants are studying options of importation. NTMWD might accelerate construction of the North Water Treatment Plant by Lower Bois D'Arc. The plant would have conventional filters where Texoma water could be filtered and discharged into Lake Lavon.

Use allocation if can import it, water rights

For planning purposes, use in next 5 years (filtration process or extended pipeline to bring to plant). Texoma crucial source. About 190,000 AF currently available and available in future. Discussion with GTUA to use some.

Use of Texoma with regard to chloride concentration and blending. Consultant doing TDS study. Cognizant of blending so within regulatory limits. Import water from Jim Chapman and Texoma discharged in Lavon.

Pursuing other water sources. Need additional supplies and realize that Texoma chloride lower. Resolve through blending. Filtration system put in advance of North WTP. Extreme, go into desalination to reduce impact (some degree not complete) – option.

Go to chloride concentration less than 250 mg/l

Costs associated with Texoma having high chloride concentration. Costs for desalination of water source and compared to costs of alternative water sources. Cost impact of Texoma. If increase the quality/threshold value, don't have to spend money on new reservoir. District looking at increasing 368,000 AF additional needed through years. Cannot say for sure if desalination plant required in the future. No, not been determined. District seeking permits from state for Lower Bois D'Arc, more Texoma water, Marvin Nicholls reservoir considered, Toledo Bend, water from southeastern Oklahoma, re-use of water from East Fork of the Trinity River (discussion with Dallas and TRWD about building pump station – mainly effluent from WWTP when no rainfall brought through wetlands and into Lavon). Consideration of alternative supplies.

Add to sources for total demand.

Timing influenced if quality of Texoma degrading Lavon water/adverse effects. Not just for blending. If Texoma water improved, still have to build at certain points to meet total demand. Would be a more readily available source though to meet demand if quality enhanced (have infrastructure [already]). Not enough information to make projection of how far construction timeline pushed.

Not seeing chloride damages associated with high chloride/Texoma water. Life-cycle of pumps? Damages associated with it? Not aware of any. End-users: not aware of reports to that effect.

Texoma accounts for about 25% available water sources. Aspects governing use of water complex – provisions of water rights – use Lavon and charge against Texoma without using Texoma (why usage of Texoma lower because have other water there – Lavon (releasing))… Consider water rights and how stay within limit throughout year. When Lavon spilling, do not import from Texoma. Volume and other considerations limit importation (currently).

Concerned about high TDS throughout the years and continued usage. Can check the status for us on TDS report. Haven't seen measurable direct impact.

Not sure existing pumps could transfer entire volume of water rights. Parallel pipeline could be constructed.
Moving Forward Mr. Kilpatrick is interested in a copy of the report.

These notes are an interpretation of discussions held. Please provide any additions or corrections to the originator within five days of the date signed, otherwise they will be assumed correct as written.

► ***Prepared By:*** Priya Hora ► ***Date:*** August 31, 2011

MEETING MINUTES

► **MEETING:** *USACE M&I Benefit Evaluation Municipality Interview with Wichita Falls*

► **DATE:** *August 26, 2011* ► **LEAD:** *Jason Weiss*

► **PLACE:** *Phone interview* ► **TIME:** *11:00 AM – 12:00 PM*

► **Distribution / Attendees (‣)**

‣	Jason Weiss	URS	‣	Fazle Rabbi	URS	‣	Kenyon Hunt	URS
‣	Sharon Hageman	URS	‣	Joseph Berlin	URS	‣	Priya Hora	URS
‣	Mark Southard	Wichita Falls						

MINUTES

Introduction

Jason Weiss introduced the URS project team and opened the meeting. URS members conducted an interview with Mark Southard, Water Purification Superintendent for the City of Wichita Falls, Texas.

Interview Details

Jason gave a summary of the project and explained our aims for talking to Mr. Southard. The project team was curious to see the impacts of an existing chloride control project.

Mr. Southard was asked about his experience with the USACE's Area VIII chloride control project. Southard said that he started working for the city at the tail end of the project and thus is not familiar with the process. He said that he could talk about the reverse osmosis (RO) process and treatment of high chloride water.

Water drawn from Lake Kemp is treated in the city's RO plant. Lake Kemp is downstream of Area VIII, which was implemented on the Wichita River. In Southard's opinion, Wichita Falls has not seen a big difference in chloride levels after complete implementation of Area VIII. They had hoped for a reduction in levels so that they could ideally treat Lake Kemp water conventionally since RO is expensive. However, there have been no significant drops in chloride levels or noticeable benefits to water quality. Chlorides, sulfates, and total dissolved solids (TDS) are the main parameters Southard is using to judge water quality with chlorides and sulfates being the two major constituents that cause issues, especially for aesthetics.

There is monitoring data prior to and post construction of Area VIII at one location. There is also monitoring data at the RO plant that treats Lake Kemp water. Southard was asked if the data reflected changes, and he said the changes, if any, are small.

The average chloride concentration in Lake Kemp throughout the year is about 1200 – 1300 mg/l. As for the minimum level, Southard cannot recall seeing chloride levels below 1000 and suspects that they probably go no lower than 1000 mg/l. The average sulfate concentration is about 800 – 900 and the minimum is around 700.

Lake Kickapoo has average concentrations of about 120 ppm chloride and about 30 ppm sulfate. Arrowhead's average concentrations are a tad higher: about 150 mg/l chloride and typically 50 – 60 ppm sulfates. Water from lakes Arrowhead and Kickapoo is treated conventionally. Southard estimates that the chloride average in combined Kickapoo and Arrowhead water is about 135 ppm.

Wichita Falls started using Lake Kemp water in 2008, treating it through the RO plant. The use of this source was driven by demand around 2001 – 2002 when other source water supplies dropped to the high 30% range. Lake Kemp was developed for future demand as well as to help with current demand. Kemp water offsets what Wichita Falls has to pull from lakes Arrowhead and Kickapoo (their smallest water source). It also enhances the reliability of the city's water supply during drought conditions when lake levels decline. There was talk of blending Kemp water with conventionally treated water (blending would take place at the head of the treatment plant), but problems were forecasted to occur at a certain threshold. Wichita Falls was told that, without RO, they could use up to 20% Kemp water to blend until it affected the aesthetics of the water. RO was chosen instead of using blending.

A pump station to the plant brings Kemp water. Chlorine dioxide is added at the pump station to have a certain disinfection contact time until the raw water reaches the plant. Baric sulfate is added, then the water goes through microfiltration and clarification before being sent to RO. After RO treatment, chloride levels in the treated Kemp water are about 400 ppm. Then the RO-treated water is blended for 1) re-stabilization and 2) to add disinfectant. Blending occurs in the conventional treatment plant (Cypress water treatment plant) clear-well after filtration and prior to ground storage and sending water to the distribution system. The end user receives water that, after the blending, has a chloride concentration of 150 ppm. This level is similar to what Wichita Falls had in the system before Lake Kemp was used. After RO treatment, the chloride levels will change depending on the RO cleaning schedule (just after cleaning they see the best water quality that can be achieved coming through).

Typically, there are no complaints about water quality from citizens or end-users. Most complaints coincide with algae blooms on the lakes. RO does not improve the taste as dramatically as people might have expected.

Southard was asked about physical damages resulting from high chlorides. He said there was a discussion of a potential problem involving the stainless steel in the microfiltration plant. He was told that at certain chloride levels, the constituents could attack and break down the steel. The plant reaches the edge or limit before attack. In talk with Siemens, the limit is around 200 ppm. They especially approach the limit when the microfiltration cells are cleaned with sodium hypochlorite. The plant has not seen much damage, though there is the potential they might if the chloride concentration gets a little higher. Southard has not heard complaints of damages to water heaters, etc. associated with chlorides from end-users. There are occasional problems with re-stabilization and chlorides out in the system, but Southard cannot think of getting any calls.

The reject water from RO is sent to a pump station on the Wichita River. Wichita Falls is required by the state to monitor 4 parameters, two of which are the chloride and sulfate levels sent to the river. The city does not pretreat typical reject water, but they do treat water used for cleaning (it is sent to a neutralization tank).

Fazle remarked that Wichita Falls has a higher budget for the RO plant this year. Southard replied that demand has been so high this year due to the drought. The budget varies on a year by year basis.

Jason asked how a cost reduction would be realized if chloride control worked out, if there would be savings associated with RO and changes in the volume of water that would need to be treated. Southard said there would be a budgetary reduction due to the electrical costs of using RO and due to the chemicals used in the RO process from adjusting pH, neutralizing, and cleaning. Wichita Falls would pump the same amount of water, but use less chemicals and electricity to remove chlorides if there was lower chloride concentration. Operational costs decline and they would use RO less.

Southard has to look up data on chloride levels in Lake Kemp before Area VIII. He was not sure why the project was not as effective as first thought. He postulated it could have something to do with the fact that the water goes from Kemp to a diversion structure and then to the pump station.

Jason explained that we are helping the Corps to establish the benefits of chloride reduction, yet we are not seeing a large change to the end-user associated with a small reduction in chlorides. With small variations, we are not seeing changes to damages. Southard said it was a fair assumption, that the current chloride levels do not cause significant damages and small fluctuations do not impact it much.

Southard will provide water quality data that the plant monitors to help assess the situation Wichita Falls is experiencing. They do a monthly data survey for the county that also looks at Lake Kemp and the diversion structure. There is also testing at the plant.

Jason said that a trend we are seeing in other situations as well is chloride concentration not beyond 500. He asked at what level would people notice and complain. Southard said it was hard to say and mentioned what he said earlier about how the city looked at blending (bypassing RO), but using about 20% Kemp was the maximum they would be able to treat conventionally after blending.

Moving Forward

Mr. Southard will send water quality data for our consideration.

These notes are an interpretation of discussions held. Please provide any additions or corrections to the originator within five days of the date signed, otherwise they will be assumed correct as written.

► ***Prepared By:*** Priya Hora ► ***Date:*** August 26, 2011

MEETING MINUTES

► **MEETING:** *USACE M&I Benefit Evaluation Municipality Interview with City of Denison*

► **DATE:** *August 3, 2011* ► **LEAD:** *Kenyon Hunt*

► **PLACE:** *In-Person interview* ► **TIME:** *10:30 AM – 12:00 PM*

► **Distribution / Attendees (‣)**

‣	Kenyon Hunt	URS	‣	David Howerton	City of Denison	‣
‣	Priya Hora	URS	‣	Dean Rylant	City of Denison	‣
‣	Doug Guinn	URS	‣			‣

MINUTES

Introduction

URS members conducted an interview with David Howerton and Dean Rylant of the City of Dennison, and then Mr. Rylant led the URS team on a plant tour.

Interview Details

The water supply for the City of Denison is Lake Randell, which includes an 11 square mile watershed. The WTP is located on and draws water from Lake Randell, but water is transferred from Lake Texoma as necessary to meet demand. Water supply and chloride concentrations are quite variable based on precipitation – in 1980s chloride concentrations in Lake Texoma were in the 400s (mg/L), while 1990s flooding washed chlorides through.

Lake Randell water quality data (with Lake Texoma blended) based on memory:

2010 – TDS = 298 mg/L

2009 – TDS = 574 mg/L, Chloride = 142 mg/L

2005 drought – TDS = 800s mg/L, Chloride = 260-373 mg/L

2006 drought – TDS = 1140 mg/L, Chloride = 410 mg/L

Lake Randell water rights are 5400 acre feet/yr, Lake Texoma rights are 31,300 acre-feet/yr.

There have been no chloride damage complaints, but a few hardness-related complaints.

The treatment plant is a conventional plant with no desalination capability. Ferric chloride is used as the coagulant in a solids contact clarifier because of its oxidant benefit in TOC removal.

Industries in the area include food (Reeses), lockset manufacturer, ceramics, AC units, and the Texoma Medical Center which includes dialysis pretreatment of water.

A new intake structure and raw water pump station is under construction to replace the 1909 structure.

Lake Randell was at near-record low levels at the time of the visit.

Water quality data records and the completed survey were collected.

These notes are an interpretation of discussions held. Please provide any additions or corrections to the originator within five days of the date signed, otherwise they will be assumed correct as written.

► ***Prepared By:*** Kenyon Hunt ► ***Date:*** October 2, 2011

APPENDIX C

ENGINEERING ANALYSIS

(Engineering analysis model included in CD)

This page intentionally left blank.

APPENDIX D

ECONOMIC ANALYSIS

(Economic analysis model included in CD)

This page intentionally left blank.