Strategic Water Supply Plan

February 2013

city of lubbock TEXAS

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Prepared by:

city of lubbock TEXAS

City Council

Glen C. Robertson, Mayor
Karen Gibson, District 5 (Mayor Pro Tem)
Victor Hernandez, District 1
Floyd Price, District 2
Todd Klein, District 3
Jim Gerlt, District 4
Latrelle Joy, District 6

Water Advisory Commission

James Collins, Chairperson
Suzanne Baker
Zachary Brady
James Conkwright
Bruce Maunder
Ken Rainwater
George Sell
Maggie Trejo

Strategic Water Supply Plan

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STATE OF TEXAS
AUBREY A. SPEAR, III
79097
REGISTERED
PROFESSIONAL ENGINEER

2/18/2013

Aubrey A. Spear, P.E.

STATE OF TEXAS
DAVID D. DUNN
82630
REGISTERED
PROFESSIONAL ENGINEER

2/18/2013

David D. Dunn, P.E.

city of lubbock TEXAS

HDR | ONE COMPANY *Many Solutions*®

Texas Registered Engineering Firm No. 754

HDR was responsible for conceptual design and costing of water supply projects, review of water and wastewater demand projections, and present value analyses of water supply packages.

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List of Acronyms & Abbreviations

AAD	Average Annual Day
ac-ft/yr	acre-feet per year
ASR	Aquifer Storage and Recovery
AWD	Average Water Demand
AWWA	American Water Works Association
BCWF	Bailey County (Sandhills) Well Field
BNR	Biological Nutrient Removal
BRA	Brazos River Authority
CCEFN	Consensus Criteria for Environmental Flow Needs
CCL	Candidate Contaminate List
CIP	Capital Improvement Plan
CM	Capacity Maintenance
CR	County Road
CRMWA	Canadian River Municipal Water Authority
DBS&A	Daniel B. Stephens & Associates
DFCs	Desired Future Conditions
ECC	Emerging Constituents of Concern
EID	Environmental Information Document
EPS	Effluent Pump Station
FM	Farm-to-Market Road
GCD	Groundwater Conservation District
gpcd	gallons per capita per day

List of Acronyms & Abbreviations

gpf	gallons per flush
GMA	Groundwater Management Area
gpm	gallons per minute
HET	high efficiency toilet
HLAS	Hancock Land Application Site
hp	Horse Power
ICM	Initial Capacity Maintenance
IFAS	Integrated Fixed Film Activated Sludge
JBLS	Jim Bertram Lake System
kwh	kilowatt hour
LAH	Lake Alan Henry
LAHPS	Lake Alan Henry Pump Station
LLAS	Lubbock Land Application Site
mg	million gallons
mgd	million gallons a day
mg/L	milligrams per liter
MS4	Municipal Separate Storm Sewer System
msl	mean sea level
mw	megawatt
North Fork	North Fork Double Mountain Fork Brazos River
NFD-LAHPS	North Fork Diversion to Lake Alan Henry Pump Station
NFSO	North Fork Scalping Operation

List of Acronyms & Abbreviations

NTU	Nephelometric Turbidity Units
NWTP	North Water Treatment Plant
PDD	Peak Day Demand
PF	Peaking Factor
PPCPs	Pharmaceuticals and Personal Care Products
PS	Pump Station
psi	pressure per square inch
PPS	Post Pump Station
PV	Present Value
RCWF	Roberts County (John C. Williams) Well Field
RO	Reverse Osmosis
RWD	Reclaimed Water Demand
SCADA	Supervisory Control and Data Acquisition
SLPS	Southland Pump Station
SEWRP	Southeast Water Reclamation Plant
South Fork	South Fork Double Mountain Fork Brazos River
SWSP	Strategic Water Supply Plan
SWTP	South Water Treatment Plant
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TDS	Total Dissolved Solids
TPDES	Texas Pollutant Discharge Elimination System

List of Acronyms & Abbreviations

TWDB	Texas Water Development Board
UV	Ultraviolet
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
WAM	Water Availability Model
WCET	Water Conservation Education Team
WRMWD	White River Municipal Water District
µS/cm	microSiemens per cm (units for conductivity)

Executive Summary

The City of Lubbock's goal is to provide a "road map," plan, and guidance document for the development and implementation of its water supplies over the next 100 years. This document is intended to be updated frequently as conditions change.

Historic Water Supplies

Historically, Lubbock's water supplies have varied between groundwater and surface water. Some water supplies have been discontinued due to diminished water quality, reduction in the water availability, and/or more stringent drinking water regulations. Lubbock's historic water supply usage is depicted in Figure ES.1.

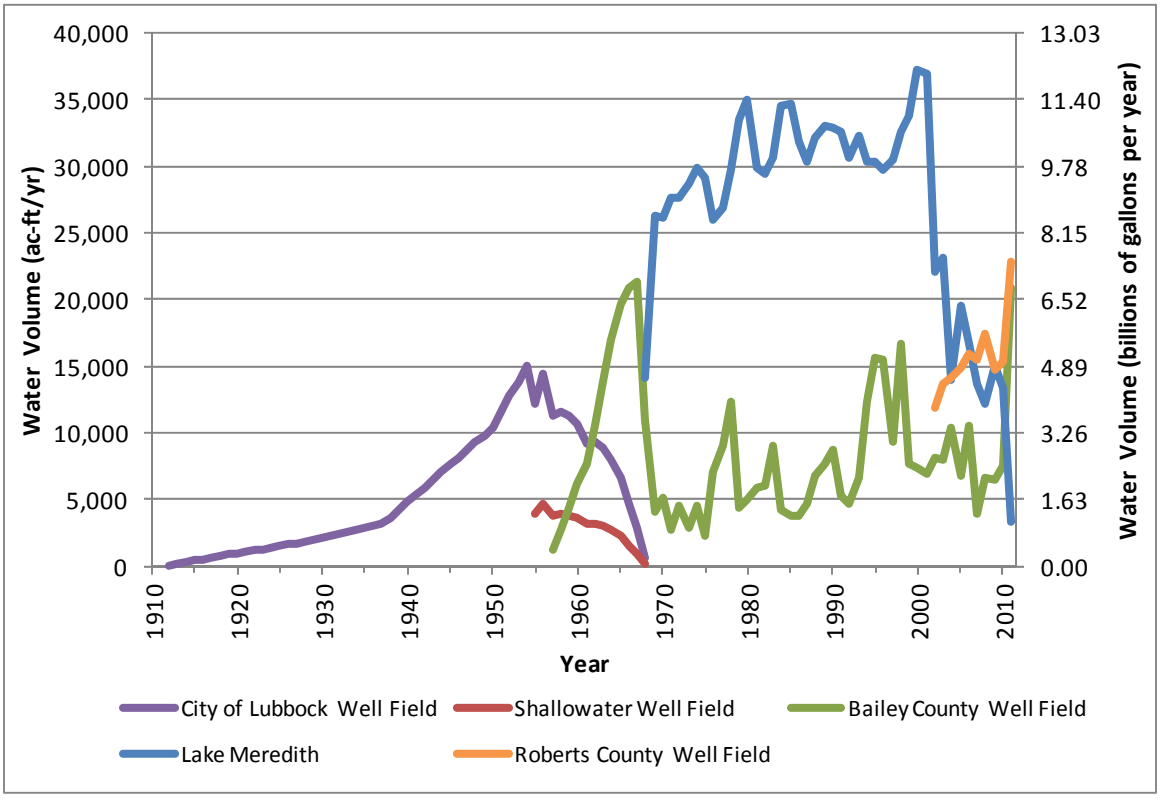

Figure ES.1 – Lubbock's Historic Water Supply Usage

The sources of Lubbock's water supplies have changed over time. Even within the last 20 years, the profile of Lubbock's water supply has changed dramatically as depicted in Figure ES.2. Because of the dynamic water supply situation, continuous planning is essential.

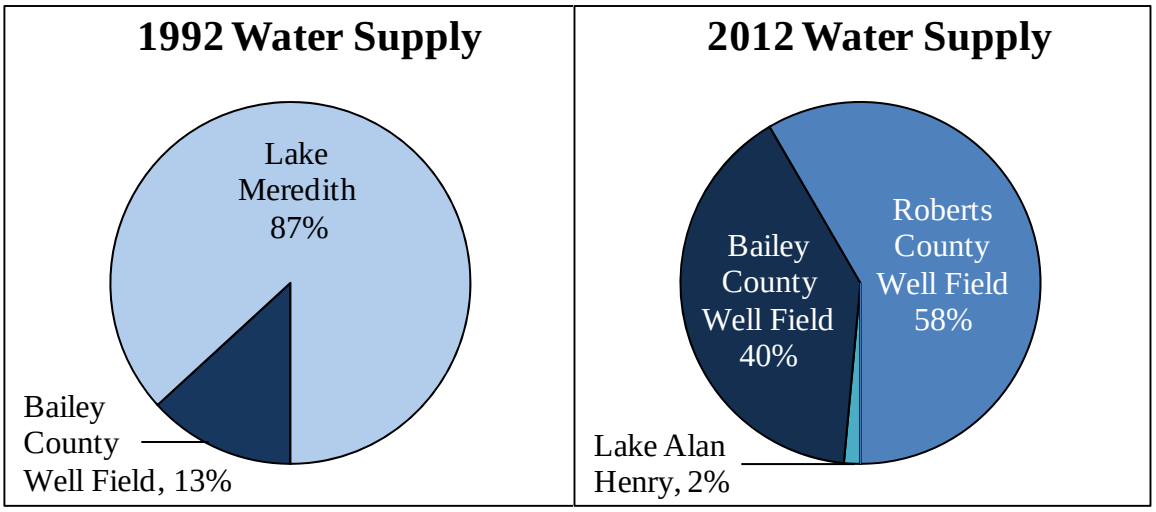

Figure ES.2 – Water Supply Contribution Comparison for 1992 and 2012

Water Demand Projections

The planning process included in this document begins with projecting the City's water demand over a 100-year timeframe. Water demand projections are the driving force behind water supply decisions, and are dependent upon population and per capita consumption estimates. In Section 2.0, three important annual water demand scenarios are developed as follows:

Probable Annual Demand = Probable Growth x Probable Consumption
Accelerated Annual Demand = Accelerated Growth x Probable Consumption
Conservation Annual Demand = Probable Growth x Conservation Consumption

Peak demand is also important to consider when planning for new water supplies. Satisfying peak demand can in some cases accelerate the need for a new water supply. Peak water demand scenarios are developed as follows:

Probable Peak Day Demand = Probable Average Day Demand x Probable Peak Factor
Accelerated Peak Demand = Accelerated Average Day Demand x Probable Peak Factor
Conservation Peak Demand = Probable Average Day Demand x Conservation Peak Factor

Projections for these three scenarios for both Average Annual Demand and Peak Day Demand are depicted in Figure ES.3.

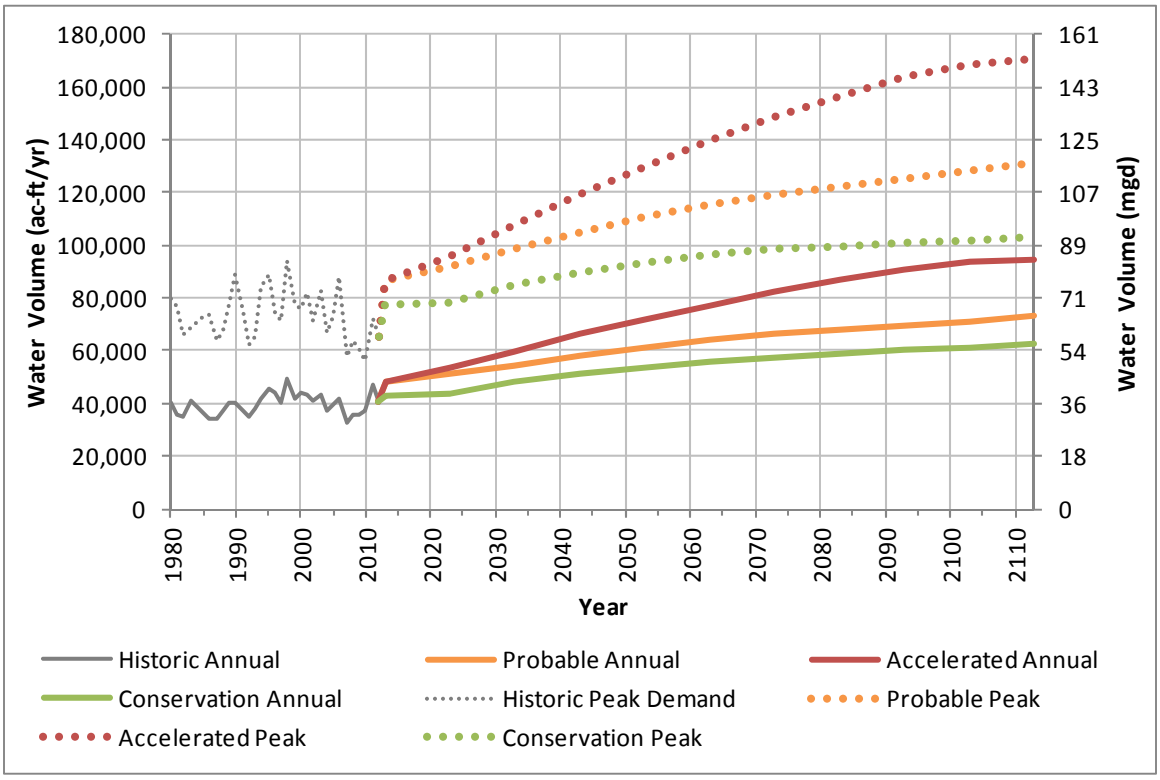

Figure ES.3 – Average Annual Demand and Peak Day Demand Projections

Current Water Supply Situation

Lubbock's current water supply sources consist of Lake Alan Henry (LAH), Roberts County Well Field (RCWF), and the Bailey County Well Field (BCWF) as discussed in Section 4.0. A comparison of probable water demand (orange line) and the total annual current water supply is depicted in Figure ES-4. This figure indicates that by 2014, additional water supplies and/or aggressive water conservation (green line) is needed in order to preserve the BCWF for a peaking supply during the summer months. Without additional water supplies by 2025, Lubbock will not be capable of supplying the projected water demand even with aggressive conservation.

RCWF and BCWF are groundwater supplies. In the Ogallala Aquifer, groundwater production continues to decline over time if additional wells are not added periodically. LAH should be a renewable supply of water throughout the planning period as long as its yield does not change due to dramatic changes in the lake's environment.

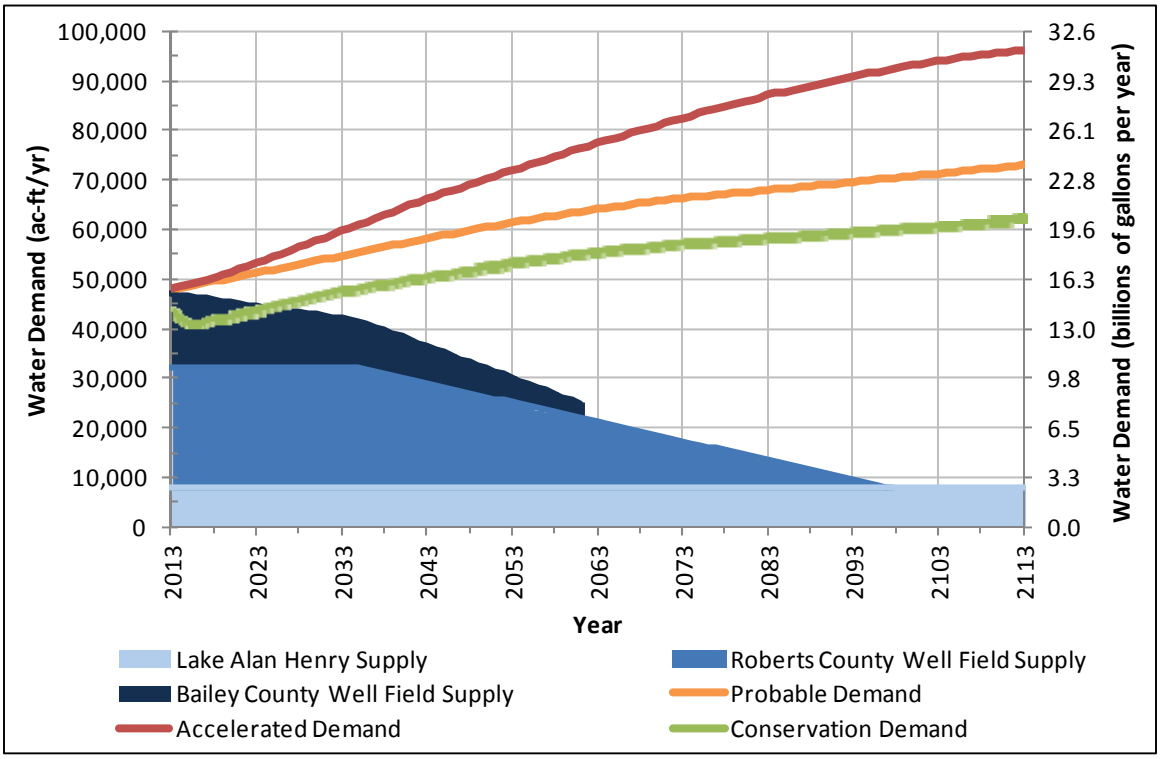

Figure ES.4 – 100-Year Annual Water Demand vs. Current Water Supply

In order to meet the projected deficit created by an increasing demand and a decreasing supply of water, multiple supply strategies are developed and evaluated in this plan.

Water Conservation Strategies

Water conservation is considered the least expensive supply of water that we possess. It appears that the City could potentially delay future water supply projects by as much as 23 years by implementing a consistent and aggressive water conservation program. In Section 5.0, the conservation strategies discussed include public education and awareness, stringent seasonal watering restrictions, increased water volume rates, indoor water fixture replacement programs, landscape rebate program, and reducing unaccounted for water losses. It appears that some of the most effective water conservation programs include increasing water volume rates and stringent seasonal watering restrictions.

Potential Water Supply Strategies

Table ES.1 provides a short explanation of each of the 16 water supply strategies evaluated as part of this plan. These strategies, as described in Sections 6.0, 7.0 and 8.0, are categorized as reclaimed water, groundwater, or surface water, respectively.

Table ES.1 – Strategy Explanation

Reclaimed Water	North Fork Diversion at County Road 7300	Reclaimed water discharged at Outfall 001 on the North Fork will be re-captured 2.7 miles downstream and pumped to the South Water Treatment Plant (SWTP) for treatment.
	Direct Potable Reuse to the SWTP	Reclaimed water will be treated and blended with other raw water supplies and pumped to the SWTP for further treatment.
	Direct Potable Reuse to the NWTP	Reclaimed water will be treated and blended with other raw water supplies and pumped to the North Water Treatment Plant (NWTP) for further treatment.
	North Fork Diversion to LAH Pump Station	Reclaimed water discharged at Outfall 001 will travel 67 miles downstream on the North Fork to the diversion site where it will be pumped directly to the Lake Alan Henry (LAH) Pump Station.
	Reclaimed Water to ASR	Reclaimed water will be treated and injected into the Ogallala Aquifer, recovered down gradient, and transported to the NWTP for treatment.
	South Fork Discharge	The existing effluent pipeline to the Hancock Land Application Site will be extended to a tributary on the South Fork so that reclaimed water can be discharged and flow into LAH.
Groundwater	RCWF – Capacity Maintenance	New wells will be installed to maintain the capacity of the existing RCWF.
	BCWF – Capacity Maintenance	New wells will be installed to maintain the capacity of the existing BCWF.
	RCWF New Transmission Line	Construction of a second transmission line from the RCWF to the Canadian River Municipal Water Authority (CRMWA) Aqueduct will almost double Lubbock's CRMWA allocation and fill the aqueduct to capacity.
	CRMWA to ASR	Water received from CRMWA during winter months will be injected into the Ogallala Aquifer and recovered from the aquifer during summer months.
	South Lubbock Well Field	Construction of numerous wells in south Lubbock - collect groundwater and treat it near Pump Station 10 before transmission into the system.
	SWTP Brackish Well Field	Brackish groundwater will be pumped from the Dockum Aquifer and treated at a desalination plant prior to blending with other water supplies at the SWTP.
Surface Water	LAH Phase 2	Expansion of existing infrastructure will double the quantity of water that Lubbock can transport and treat from LAH.
	Jim Bertram Lake 7	A reservoir will be constructed on the North Fork upstream of Buffalo Springs Lake. Lake 7 water will be pumped to the SWTP for treatment.
	Post Reservoir	A reservoir will be constructed on the North Fork located east of Post in Garza County. Post Reservoir water will be pumped to the Post Pump Station.
	North Fork Scalping Operation	Stormwater on the North Fork will be captured and transported to LAH, increasing the lake's firm yield.

In order to evaluate the strategies relative to one another, each strategy has been ranked on a scale from 1 (low) to 5 (high) in 10 different categories. Each category is weighted either 1.0 or 0.5, depending on the category's importance. The range of possible total scores is 0 to 40. Section 10.0 describes the ranking process in detail. Figure ES.5 summarizes the results of the evaluation process.

Supply Packages that Satisfy Future Needs

Combinations of supply strategies in conjunction with the various demand projections were used to develop five different supply packages that can potentially provide the City with water for the 100-year planning period. In all supply packages, the BCWF and LAH play an important role in providing Lubbock with its peaking capacity over the planning period. In order to preserve the BCWF, efforts should be made to reduce the annual usage from this source. ***Many strategies used in these supply packages are interchangeable with other strategies. Just because a strategy is not used in one of these examples, does not mean the strategy may not prove to be a more appropriate strategy in the future.*** Section 11 describes these supply packages in greater detail. The five different supply packages developed are described below.

Supply Package 1 – Baseline

This supply package is considered a baseline package that consists of the following supply strategies that will be necessary to meet the Probable Demand over the next 100 years: BCWF Initial Capacity Maintenance, BCWF Capacity Maintenance, LAH Phase 2, RCWF New Transmission Line, RCWF Capacity Maintenance, and Direct Potable Reuse at the North Water Treatment Plant.

Supply Package 2 – LAH Delayed

This supply package is similar to Package 1 except it delays the implementation of LAH Phase 2 from 2017 until 2031. In addition, this strategy uses an indirect reuse strategy instead of direct reuse of reclaimed water. This package consists of the following supply strategies that will be necessary to meet the Probable Demand over the next 100 years: BCWF Initial Capacity Maintenance, BCWF Capacity Maintenance, LAH Phase 2, RCWF New Transmission Line, RCWF Capacity Maintenance, and North Fork Diversion at CR 7300.

Package 3 – RCWF Line Delayed

This supply package is similar to Package 1 except it delays the implementation of the RCWF New Transmission Line from 2025 until 2035. In addition, this package accelerates the implementation of direct reuse of reclaimed water from 2054 to 2020. This package consists of the following supply strategies that will be necessary to meet the Probable Demand over the next 100 years: BCWF Initial Capacity Maintenance, BCWF Capacity Maintenance, LAH Phase 2, RCWF New Transmission Line, RCWF Capacity Maintenance, and Direct Potable Reuse at the North Water Treatment Plant.

Supply Package 4 – Conservation

This supply package is different from Packages 1, 2, and 3 because its objective is to meet the Conservation Demand projections described in Section 2. Since the Conservation Demand projections are less than the Probable Demand projections used in the first three packages, the implementation of the RCWF New Transmission Line is delayed indefinitely. Strategies used in Supply Package 4 include: BCWF Initial Capacity Maintenance, BCWF Capacity Maintenance, LAH Phase 2, RCWF Capacity Maintenance, and Direct Potable Reuse at the North Water Treatment Plant.

Package 5 – Growth

This supply package is different from Packages 1, 2, and 3 because its objective is to meet the Accelerated Growth Demand projections described in Section 2. Since the Accelerated Growth Demand projections are higher than the Probable Demand projections used in the first three packages, more strategies are needed in Supply Package 5. Strategies used in this package include: BCWF Initial Capacity Maintenance, BCWF Capacity Maintenance, LAH Phase 2, RCWF New Transmission Line, RCWF Capacity Maintenance, Direct Potable Reuse at the North Water Treatment Plant, Jim Bertram Lake 7, North Fork Scalping Operation, and Brackish Well Field at the South Water Treatment Plant.

Table ES.2 compares strategy timelines and implementation dates for each of the five supply packages discussed.

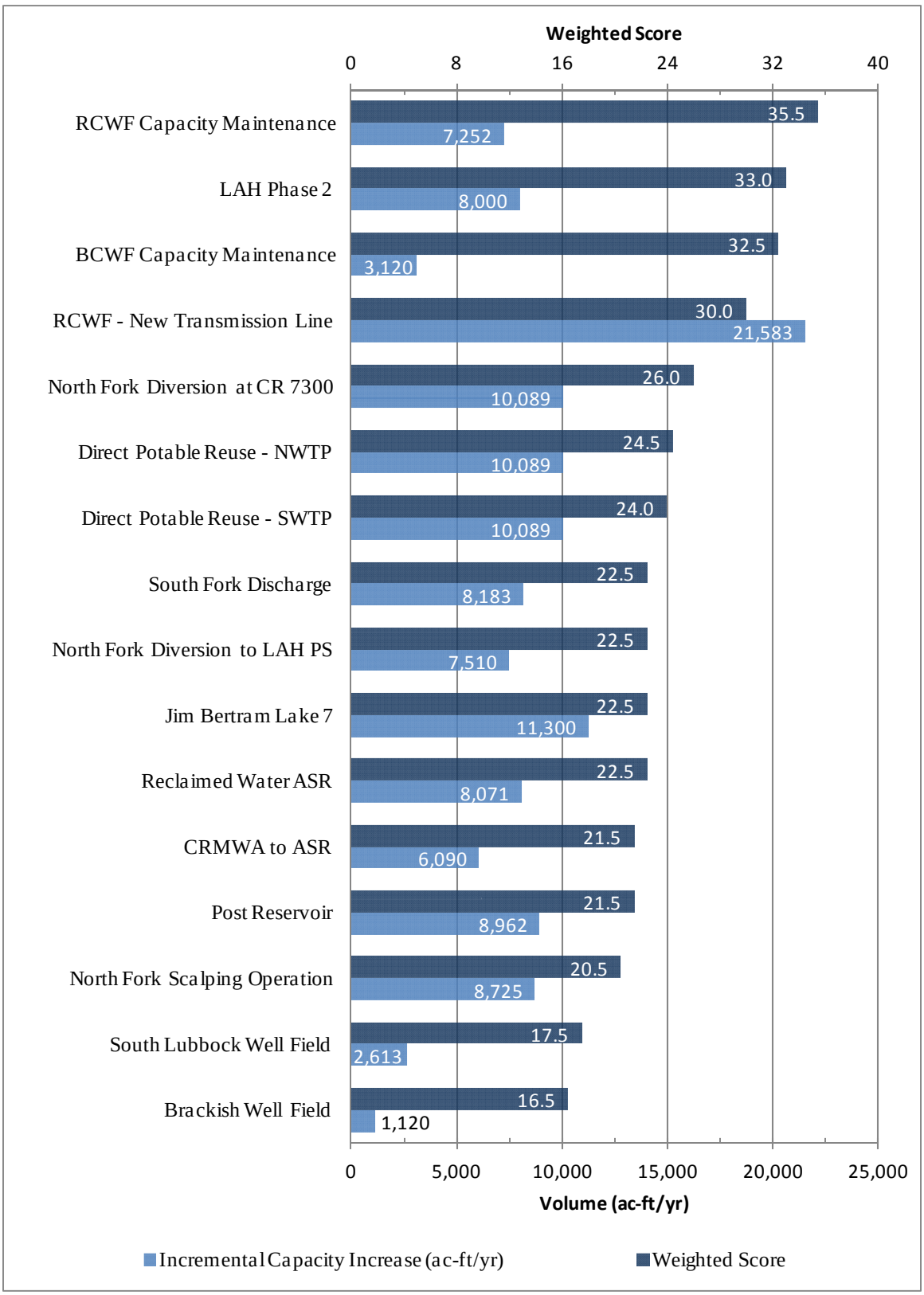

Figure ES.5 – Supply Strategies Sorted by Rank (Highest to Lowest)

Table ES.2 – Comparison of Supply Packages

Supply Package 1 Baseline	Supply Package 2 LAH Delayed	Supply Package 3 RCWF Delayed	Supply Package Conservation	Supply Package 5 Accel. Growth
2013				
2013: BCWF - ICM 2017: LAH Phase 2	2013: BCWF - ICM 2017: BCWF CM-1	2013: BCWF - ICM 2017: LAH Phase 2 2020: Direct Reuse	2013: BCWF - ICM 2017: LAH Phase 2 2020: Direct Reuse	2013: BCWF - ICM 2017: LAH Phase 2 2020: Direct Reuse
2023				
2023: BCWF CM-1 2025: RCWF New Transmission Line	2023: BCWF CM-2 2025: RCWF New Transmission Line 2031: LAH Phase 2	2023: BCWF CM-1 2025: RCWF CM-1	2023: BCWF CM-1 2025: RCWF CM-1	2023: BCWF CM-1 2025: RCWF New Transmission Line
2033				
		2033: BCWF CM-2 2035: RCWF New Transmission Line		
2043				
2053				
2054: Direct Reuse 2055: RCWF CM-1	2054: North Fork Diversion at CR 7300 2055: RCWF CM-1		2055: RCWF CM-2	2055: North Fork Scalping Operation 2055: RCWF CM-2
2063				
		2065: RCWF CM-2	2063: BCWF CM-2	
2073				
				2079: Jim Bertram Lake 7
2083				
2085: RCWF CM-2	2085: RCWF CM-2		2085: RCWF CM-3	2085: RCWF CM-3
2093				
		2095: RCWF CM-3		2098: Brackish Well Field
2103				
			2103: BCWF CM-3	
2113				

Note: ICM = Initial Capacity Maintenance, CM-1 = Capacity Maintenance-1, CM-2 = Capacity Maintenance-2, etc.

Financial Impact to Water Rates

The financial impact of each of the five strategy packages has been evaluated for the short-term planning period of 12-years. The results of this evaluation are detailed in Section 12.0 and summarized below. Figure ES.6 shows the net present value for each of the five supply packages. As expected, Supply Package 4 is the least expensive alternative since it requires the fewest water supply strategies to meet the aggressive Conservation Demand projections. Conversely, Supply Package 5 is the most expensive alternative since it requires the implementation of the most water supply strategies in order to meet the Accelerated Demand projections.

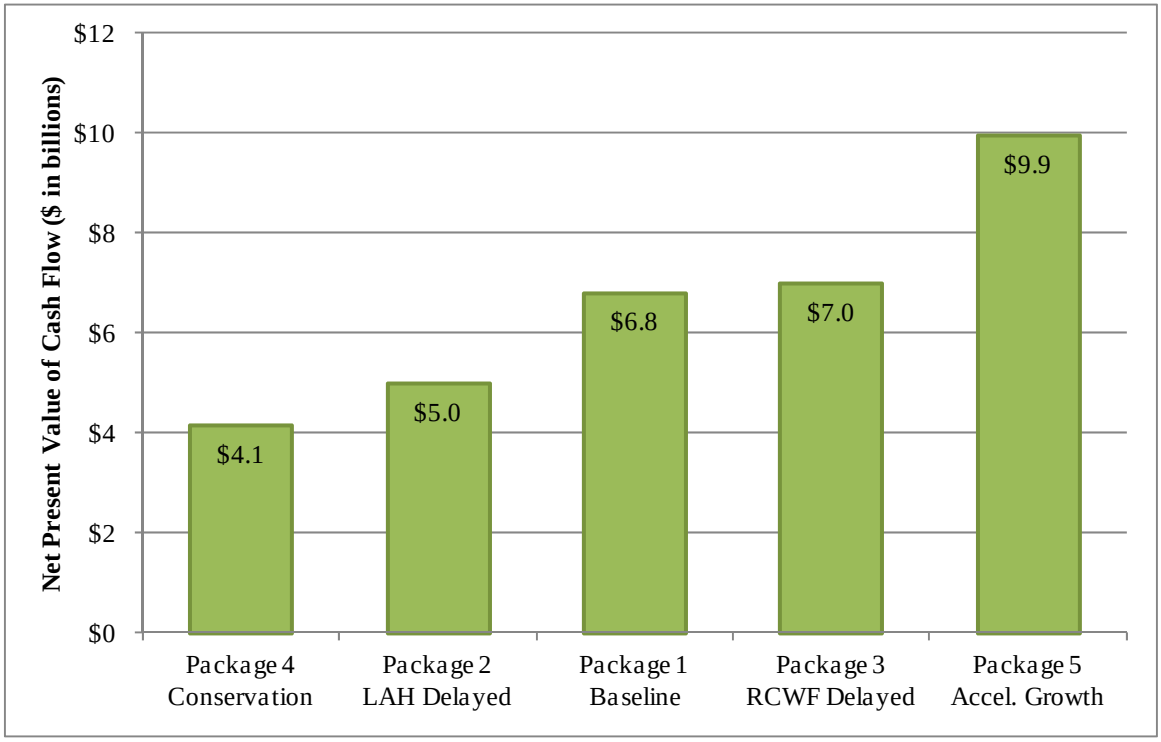

Figure ES.6 – Net Present Value Comparison of Supply Packages

Supply Packages 1, 2, and 3 are all based on satisfying the Probable Demand projections. Supply Package 2 is less expensive than Supply Packages 1 and 3 for several reasons. This package draws more heavily upon the existing BCWF supply for a longer period of time. Heavy usage of the BCWF may not be sustainable. Package 1 implements LAH Phase 2 sooner in order to relieve BCWF. Package 3 implements direct reuse of reclaimed water sooner in order to relieve BCWF.

In order to provide information for water rate planning, the City's Finance Department created a financial spreadsheet model for the Water Fund that extends over the 12 year short-term planning period. Models were developed for all five supply packages discussed in Section 11.0. In each model, volume rates increase more dramatically during the first part of the modeling period, since the base rates are reduced in FY 2013, FY 2014, and FY 2015. This transition was initiated by the City Council to promote additional water conservation.

Financial models for each supply package are included in Appendix E. Key drivers of these financial models include debt service, appropriable net asset levels, a RCWF reserve fund, and increases to the volume and/or base rates. The financial models are used to estimate how much water rates will increase over the next 12 years in order to fund each of the supply packages. Figure ES.7 compares a 3/4-inch meter residential monthly water bill at 2013 water rates (7,000 gallons usage) with projected water bills for each supply package in 2025. An average water bill is estimated to increase from $49.00 per month to at least $63.73 per month.

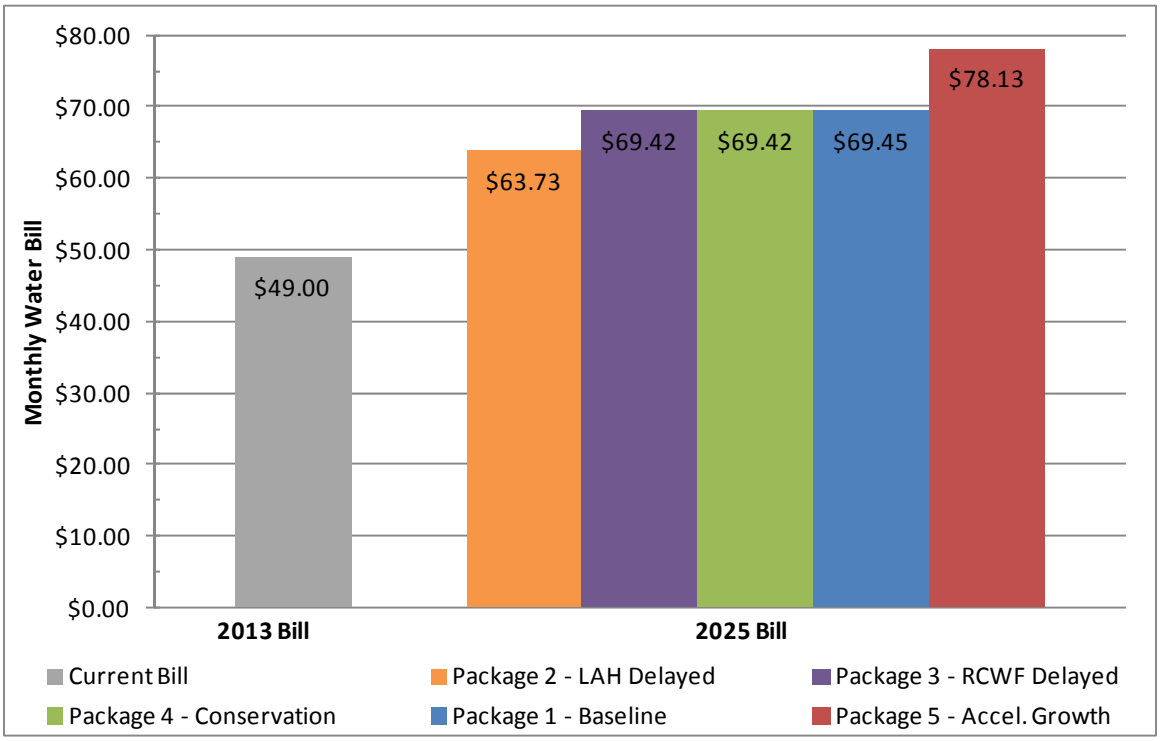

Figure ES.7 – Comparison of Average Monthly Water Bill for Supply Packages

1.0 Introduction

1.1 History

The City of Lubbock's City Council approved an initial Strategic Water Supply Plan (SWSP) in July 2007. The goal of the Water Resources Department is to update the Plan every five years in order to keep planning information as current as possible. Prior to the 2007 Plan, other water planning documents were prepared as needed by the City or by consultants hired by the City. Excerpts from these documents are referenced in the 2007 Plan[1] and include:

- 2004 City of Lubbock Strategic Water Plan, Water Texas
- 2001 City of Lubbock Water Supply Evaluation, Black & Veatch
- 1999 City of Lubbock 50-Year Water Plan, Water Staff
- 1992 Comprehensive Groundwater Management Study for the City of Lubbock, Geraghty & Miller, Inc.
- 1975 Plan for Additional Water Supply- Lubbock, Texas, Freese & Nichols
- 1971 Report on Water Supply – Lubbock, Texas, Freese, Nichols & Endress
- 1968 Interim Report on Water Supply – Lubbock, Texas, Freese, Nichols & Endress

In addition to Lubbock's planning efforts, the State of Texas passed legislation in 1999 which required the creation of 16 Regional Water Planning Areas across the State. Regional Water Planning Groups were appointed for each area and are tasked with developing water supply plans for their respective areas. Lubbock is located within the Llano Estacado (Region O) Water Planning Area as depicted in Figure 1.1, and is currently represented by two City staff on the Region O Water Planning Group. The first regional plans were completed in 2001 with subsequent updates to the plans in 2006 and 2011. All of the regional plans are incorporated into the State Water Plan which is released one year later (i.e. 2002, 2007, 2012). The Region O Plan includes water management strategies for Lubbock and surrounding communities as well as for agriculture, mining, and industry.

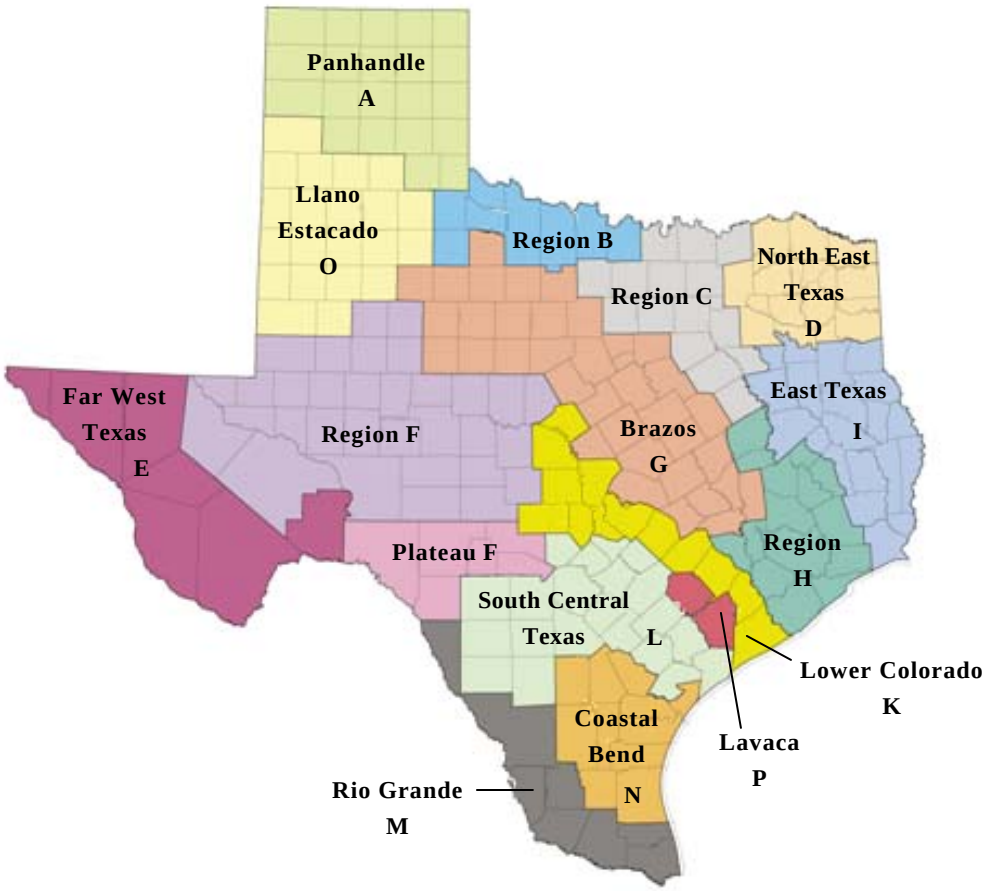

Figure 1.1 – Regional Planning Areas
(Map courtesy of Texas Water Development Board[2])

1.2 Purpose

The City of Lubbock's goal is to continuously refine and implement its 100-year strategic water supply plan. This goal is essential in order to ensure that a sufficient water supply is available at the time that it is needed. The purpose of this Plan is to provide the framework for the City to develop sustainable water supply sources that can be implemented within appropriate time frames and in the most cost efficient manner. This Plan will also be utilized to support the City's position in the on-going regional water planning process.

1.3 Description

The following steps are involved in the water supply planning process:

Step 1 – Estimate Water Demand
Step 2 – Calculate Long-Term Yield of Current Water Supplies
Step 3 – Determine when Water Deficits Begin to Occur
Step 4 – Evaluate the Role of Water Conservation
Step 5 – Identify New Water Supply Strategies
Step 6 – Evaluate and Rank New Water Supply Strategies
Step 7 – Create Supply Packages to Satisfy Future Needs
Step 8 – Calculate Financial Impact to Water Rates
Step 9 – Plan Implementation
Step 10 – Continuously Analyze and Refine Plan

This Plan follows Steps 1 through 8. Steps 9 and 10 are dynamic steps that will evolve year by year. The planning horizon in this document includes the next 100 years. Projections have been made with the following three planning periods in mind:

Short Range Planning	12 years	2013 – 2025
Medium Range Planning	50 years	2026 – 2063
Long Range Planning	100 years	2064 – 2113

In order to meet the projected deficit created by an increasing demand and a decreasing supply of water, multiple supply strategies are developed and evaluated in this plan. Potential water conservation strategies with associated costs are evaluated. In addition, potential water supply strategies are grouped into three categories: reclaimed water, groundwater, and surface water. These strategies include estimated volumes of available water and costs to implement each strategy. Sixteen water supply strategies are evaluated, ranked, and subsequently packaged to meet future needs.

Various strategies are placed into five supply packages to demonstrate ways to meet Conservation, Probable, and Accelerated Demand scenarios. Three of the supply packages provide examples of how to meet the Probable Demand projections. The other two packages provide examples of how to meet the Conservation Demand and Accelerated Demand. Supply packages are presented for planning purposes only. ***Many supply strategies are interchangeable. The attractiveness of each strategy may change over***

time. Implementation schedules may change based on a variety of unpredictable variables including climate conditions, population, per capita consumption, industry need, changes in regulatory environments, etc. Each package of strategies includes a net present value financial analysis. In addition, a financial model has been created for each package that estimates the potential impact to water rates over the next 12 years.

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[1] 2007 Strategic Water Supply Plan for the City of Lubbock, Section 4.0.

[2] Texas Water Development Board. 2002 State Water Plan. Volume 3: Fig. 4-1.

2.0 Water Demand Projections

Water demand projections are the driving force behind water supply decisions, and are dependent upon population and per capita consumption estimates. In this section, the 2013 Plan projections are compared with former projections from the City's 2007 Strategic Water Supply Plan[1] and the 2011 Llano Estacado (Region O) Regional Water Plan.[2] It is important to note that the 2011 Region O Water Plan only extends to the year 2060, and the City's 2007 Plan extends to 2105 while the 2013 Plan extends to 2113. Where applicable, at least 30 years of historic data are also provided to place future projections into the appropriate context.

2.1 Population

The population projections in this 2013 Plan are based on the 2010 Federal Census data[3] and the City Planning Department's historical population information.[4] This Plan projects population for the following four communities that receive water from the City of Lubbock Water System (2010 Census populations included):

- City of Lubbock (229,573 people)
- City of Shallowater (2,484 people)
- Town of Ransom Canyon (1,096 people)
- Buffalo Springs Lake (453 people)

The smaller communities make up less than 2% of Lubbock's total population, which is well within the margin of error for population projections.

Two population scenarios are presented in this Plan. These scenarios are described below:

> *Probable Growth* – This scenario depicts the most likely scenario for population growth in the City and closely corresponds to the City Planning Department's projections for the first 20 years. The Probable Growth projection consists of a 1.20% per year growth rate through 2033. After this period, the growth rate drops to 0.80% per year and declines 0.10% every decade until 2074, at which point it remains constant at 0.40% per year growth.

Accelerated Growth – This scenario depicts what would occur if the City experiences accelerated growth over the next 20 years. The Accelerated Growth projection starts at 1.20% per year and increases by 0.10% per year until it reaches a 1.7% per year growth rate that remains constant through 2033. After 2033, the growth rate declines to 1.20% per year for a decade, 1.00% per year for the following decade, and then declines 0.10% per decade from 2054 through 2093. For the last two decades, the growth rate declines by 0.15% per decade.

Previous population projections from the 2007 Strategic Water Supply Plan and the 2011 Region O Water Plan were based on 2000 Federal Census data and Texas Water Development Board (TWDB) projections. Therefore, both of these documents contain projections that are not as consistent with the City's 2013 Plan as they would have been if the 2010 Census data had been used. Figure 2.1 compares the population projections from these three planning documents. Historic and projected population tables are included in Appendix A-1 and A-2, respectively.

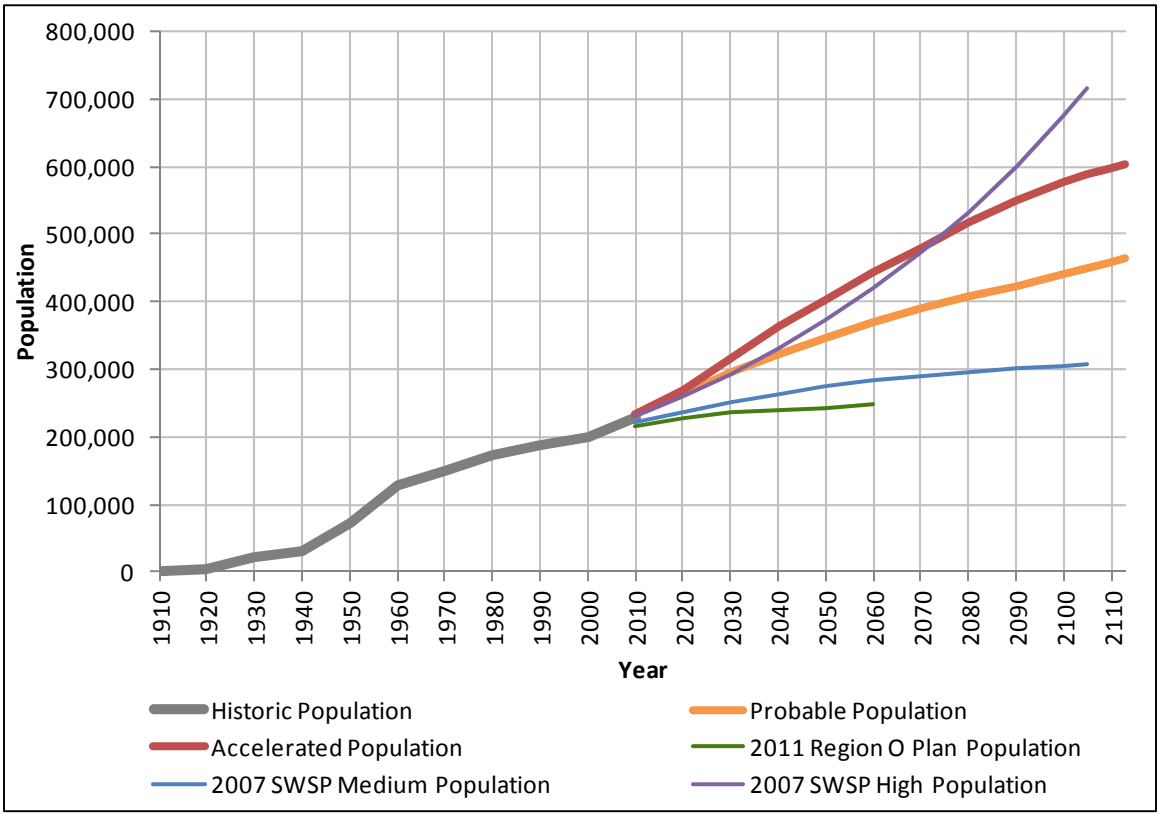

Figure 2.1 - Population Projections

The Probable Growth scenario for this 2013 Plan projects the following populations for the City of Lubbock and three customer cities in the future:

- 277,586 in the year 2025
- 376,463 in the year 2063
- 464,228 in the year 2113

2.2 Per Capita Consumption

The Region O Water Planning Group and the State of Texas Water Conservation Task Force have established realistic municipal per capita consumption goals, urging cities to implement measures that lower their per capita consumption each year. The Region O recommended target for municipal consumption is 172 gallons per capita per day (gpcd).[5] The Water Conservation Task Force has recommended a per capita consumption goal of 140 gpcd.[6]

In this 2013 Plan, two per capita consumption scenarios were developed. Each meet the more stringent goal of 140 gpcd set by the Water Conservation Task Force, but the scenarios differ in terms of the time in which this is accomplished. The two consumption scenarios are described below.

Probable Consumption – This scenario starts at 178 gpcd (the per capita consumption from 2011, the driest year on record) and declines 0.54% per year until 2033, reaching a gpcd of 160. Over the next 80 years, the per capita consumption declines at a slower rate, ending at 140 gpcd in 2113.

Conservation Consumption – This scenario demonstrates the effect on water demand if the City creates and maintains a more aggressive water conservation program. The Conservation Consumption scenario starts at 160 gpcd (Lubbock's ten year average per capita consumption). This scenario declines to 150 gpcd in 2015 and 146 gpcd in 2020, meeting the goals set forth in the City of Lubbock's 2010 Water Conservation Plan.[7] By 2033, the gpcd reaches 140. After this period, the per capita consumption declines at a slower rate, ending at 120 gpcd in 2113.

A comparison of these two scenarios with the 2011 Region O Plan and the City's 2007 Plan is depicted in Figure 2.2. Historic and projected per capita consumption tables are included in Appendix A-1 and A-3 respectively.

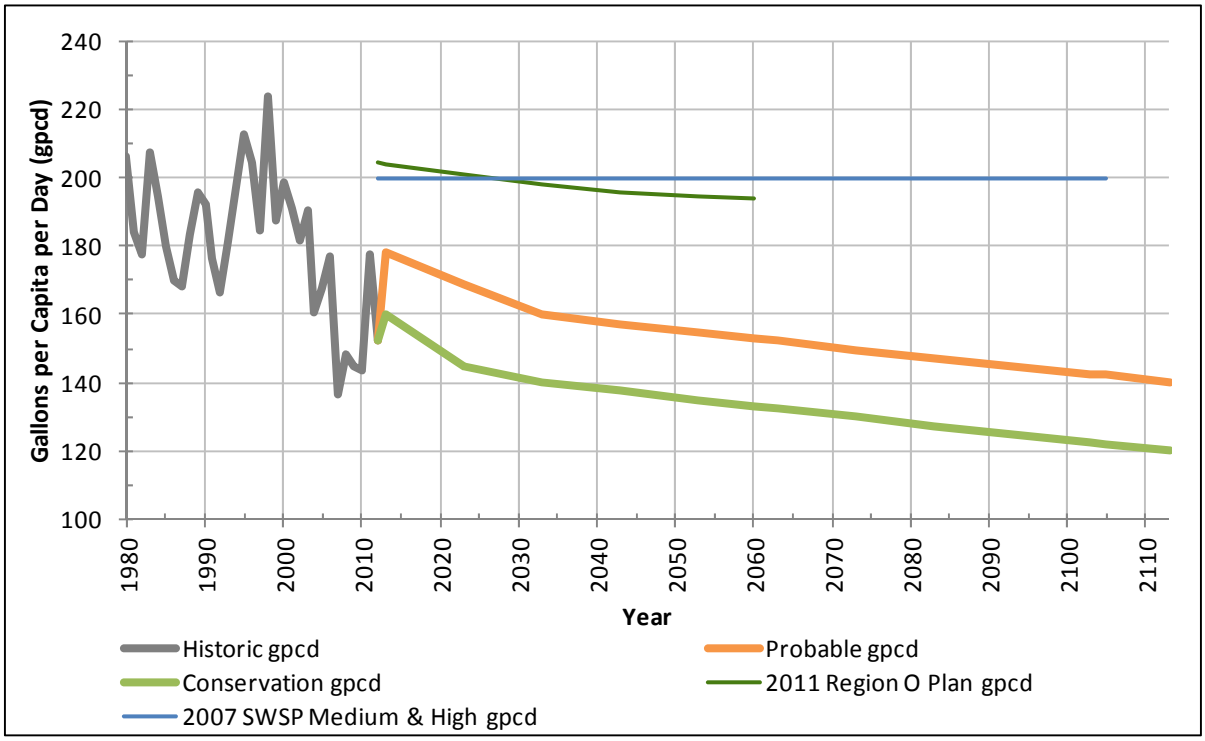

Figure 2.2 - Per Capita Water Consumption

2.3 Annual Water Demand

Lubbock's Annual Water Demand (AWD) projections consist of three scenarios which were developed by using different combinations of the two population scenarios described in Section 2.1 and the two per capita consumption scenarios described in Section 2.2. The AWD scenarios are as follows.

Probable Demand – (Probable Growth x Probable Consumption) –
This scenario is the most likely projection since it includes probable population and probable consumption projections.

Accelerated Demand – (Accelerated Growth x Probable Consumption) – This scenario provides for a water demand projection that reflects an accelerated population growth combined with probable consumption.

Conservation Demand – (Probable Growth x Conservation Consumption) – This scenario is included to provide an understanding of the impact that aggressive water conservation efforts may have on the water demand.

A comparison of this Plan's AWD to the 2011 Region O Plan and the City's 2007 Plan is depicted in Figure 2.3. Historic and projected AWD tables are included in Appendix A-1 and A-3 respectively.

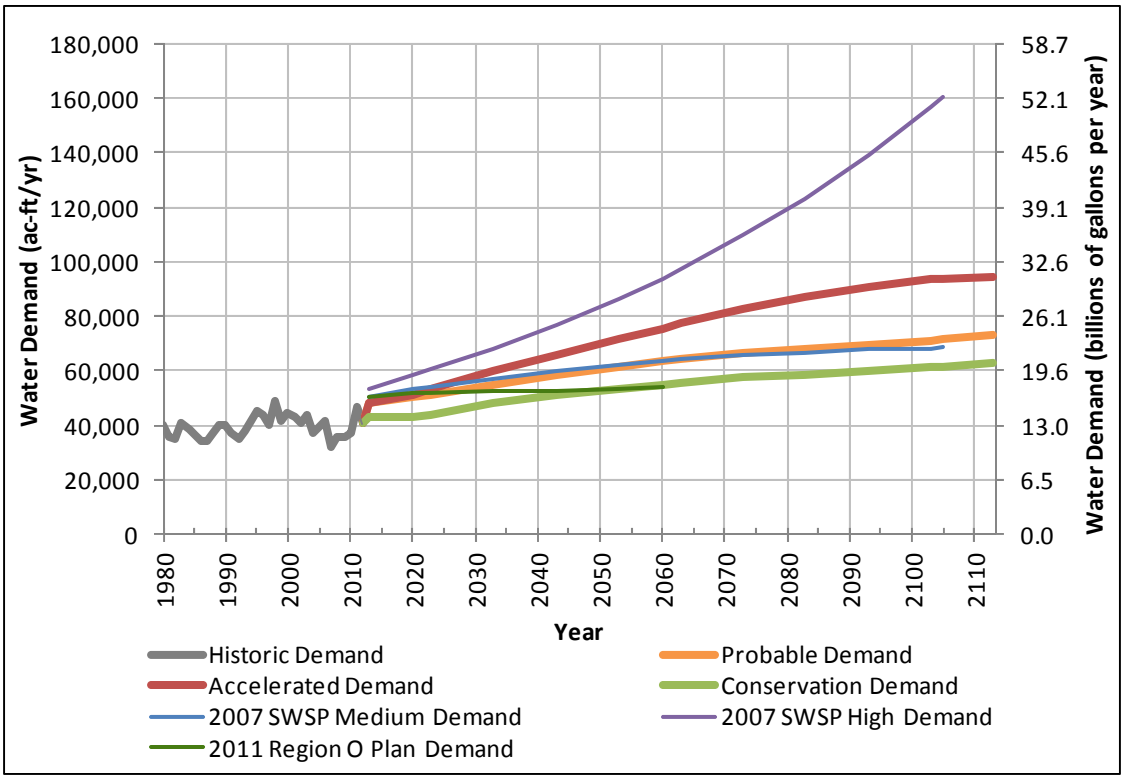

Figure 2.3 - Annual Water Demand Projections

The 2013 Plan's Probable Demand curve is similar to the 2007 Plan's Medium Demand curve. However, the 2013 Accelerated Demand curve increases more gradually than the 2007 High Demand curve. The 2011 Region O demand curve increases more gradually than both the 2013 Plan's Probable and Accelerated Demand curves.

2.4 Peak Day Water Demand

Peak Day Demand (PDD) must be considered when designing water system infrastructure. The purpose of evaluating the PDD in this Plan is to determine whether existing and future water supplies can be delivered at PDD rates. The PDD is based on the AWD discussed in Section 2.3. Projections for PDD are calculated as follows:

Average Annual Day (AAD) in million gallons (mg) = AWD / 365 days

PDD in mg = AAD x Peaking Factor (PF)

The PF is a constant determined using historical trend data. Table 2.1 shows highlighted years for Lubbock's historic PDD, ADD, and PF. Appendix A-1 includes a more comprehensive table of historical peaking factors.

Table 2.1 - Historic Peak Day Data

Year	Historic PDD (mg)	Historic AAD (mg)	Historic PF
Historic Reference			
1980	70.85	35.89	1.97
1985	65.18	32.41	2.01
1990	79.00	35.79	2.21
1995	79.54	41.32	1.92
2000	67.82	39.51	1.72
Last 10 Years			
2003	73.61	38.95	1.89
2004	59.94	33.05	1.81
2005	62.54	35.09	1.78
2006	68.77	37.38	1.84
2007	47.30	28.97	1.79
2008	57.18	31.76	1.80
2009	54.23	31.63	1.71
2010	50.40	32.38	1.56
2011	64.12	41.25	1.55
2012	58.07	36.23	1.60

Note that PDD, AAD, and PF vary from year to year due to variation in annual precipitation patterns and temperature fluctuations.

For planning purposes, the following two peaking factors have been developed.

Probable PF – A common rule of thumb employed in the water planning industry is to assume a PF of 2.0. However, over the last 10 years, the City of Lubbock's PF has been much lower than 2.0. Therefore, a PF of 1.8 is used in this Plan. This number is derived from the City's 10-year average

PF. This means that the City is projecting that the amount of water used on a peak day will be 1.8 times higher than on an "average" day.

Conservation PF – The Conservation PF shows the reduction in PDD that may be achieved if the City adopts more aggressive water conservation policies. The conservation PF begins at 1.8 (the average PF from the previous 10 years) and then decreases from 1.8 to 1.6 over the 100-year planning period.

These two peaking factors were used to create three PDD scenarios. The Probable PF was combined with the Probable AWD to produce the Probable PDD and with the Accelerated AWD to produce the Accelerated PDD. The Conservation PF was multiplied by the Conservation AWD to produce the Conservation PDD.

A comparison of this Plan's PDD to the City's 2007 Plan is provided in Figure 2.4 (see Appendix A-1 and A-4). The 2011 Region O Plan does not include PDD information.

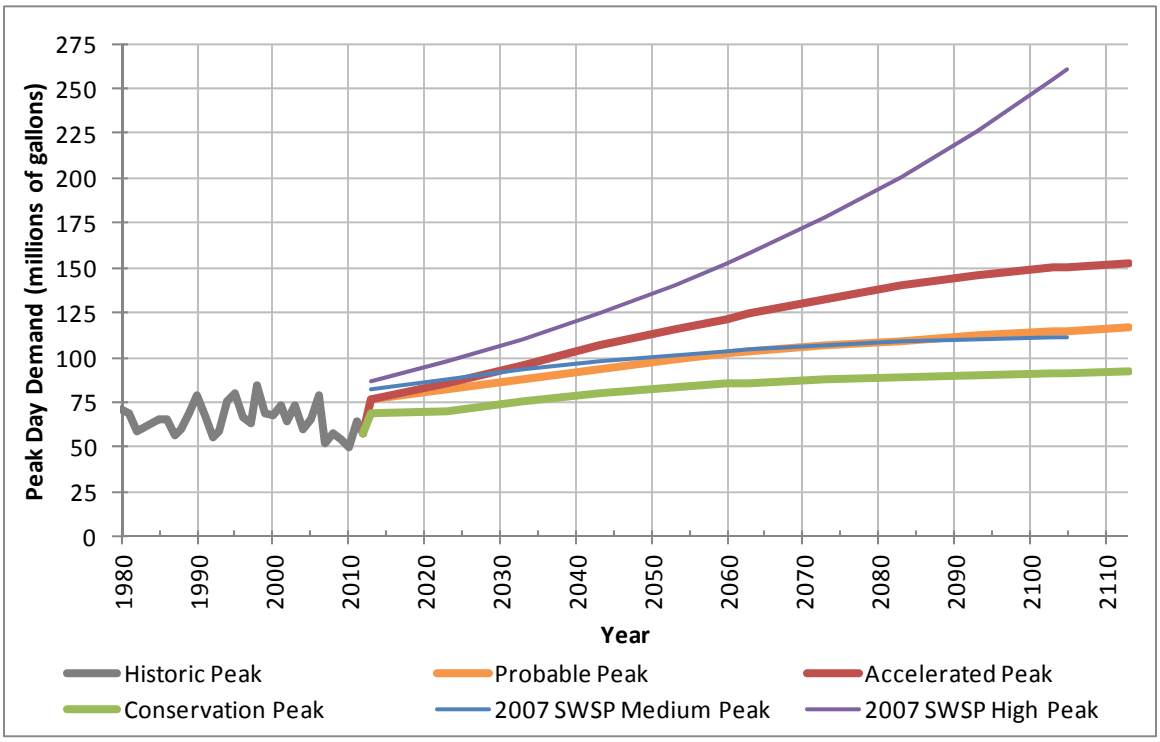

Figure 2.4 - Peak Day Demands

The 2013 Plan's Probable PDD curve is similar to the 2007 Plan's Medium PDD curve. The 2013 Plan's Accelerated PDD curve increases more gradually than the 2007 Plan's High PDD.

[1] Strategic Water Supply Plan. City of Lubbock. July 2007: section 3a.

[2] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: 2-8, 2-44.

[3] State & County QuickFacts. U.S. Census Bureau. Address: http://quickfacts.census.gov/qfd/states/48/4845000.html.

[4] The City of Lubbock Planning Department projects a 1.12% annual growth rate from 2010-2040. The Planning Department has not generated population projections beyond 2040.

[5] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: 4-110.

[6] Texas Water Development Board Special Report: Report to the 79th Legislature. Water Conservation Implementation Task Force. Austin, TX. November 2004: 31-33.

[7] 2010 Water Use Management Plan – Water Conservation Plan and Drought and Emergency Contingency Plan. City of Lubbock. 2010: Ordinance No. 2010-00055, section 2.4.

3.0 Decommissioned Water Supplies

Water supplies are dynamic natural resources. Over a period of decades, a once productive and cost effective water supply can become less desirable for a variety of reasons. Undesirable changes that can occur in a water supply include decreases in water quality, a decline in the sustainable yield, a depletion of the source of water, or a shift in the regulations governing water. Figure 3.1 depicts the City's historic water supply usage since the establishment of the City in 1911.

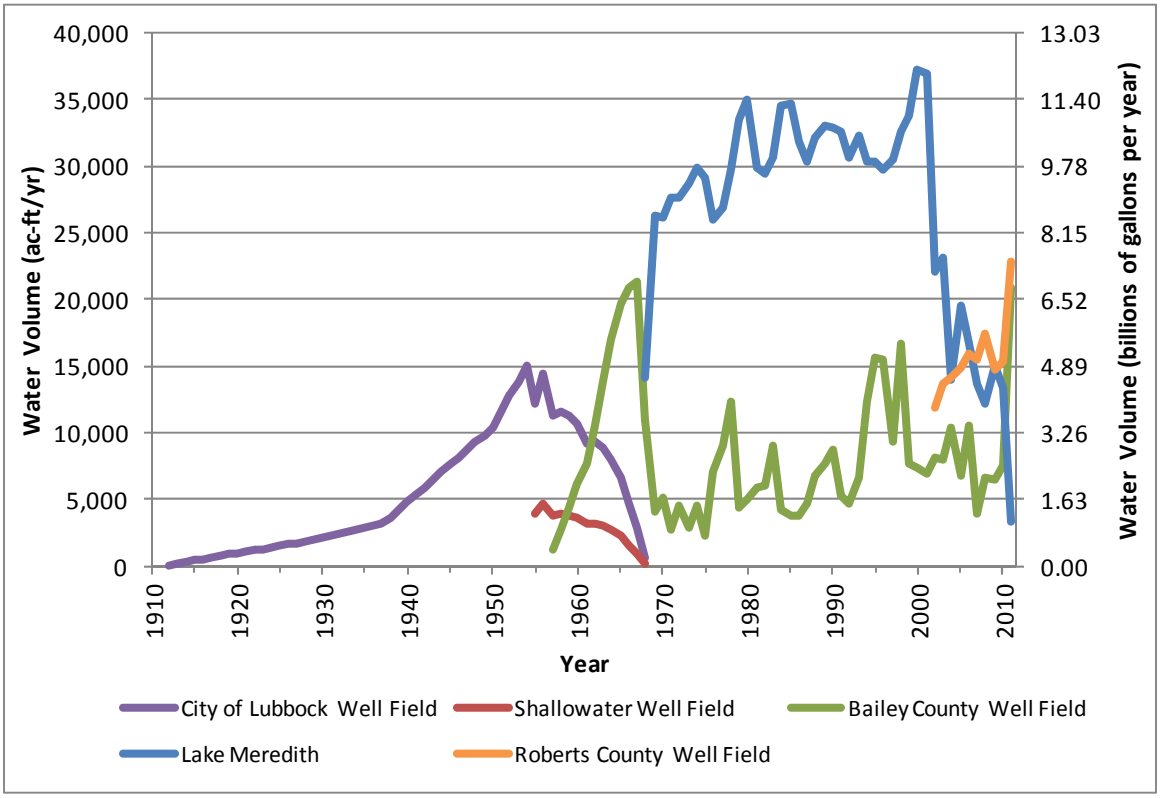

Figure 3.1 – Lubbock's Historic Water Supply Usage

As shown on the graph, two of the City's past water supplies (City and Shallowater Well Fields) were used for a period of time and later decommissioned. A brief history of each of these decommissioned supplies is presented in this section.

3.1 City of Lubbock Well Field

When the first municipal water system was constructed for the City in 1911, it consisted of one well installed at a depth of 206 feet near the current intersection of 5th Street and Avenue J. From 1911 to 1954, the City owned 5.0 acres of water rights in and adjacent to the city limits. The City gradually expanded the number of wells it used. Groundwater pumped from well fields near the City was the only water supply for the City until the late 1950s when the Shallowater and Bailey County (Sandhills) Well Fields began to be used. Local well fields owned and operated by the City included the Northeast Well Field, the Airport Well Field, Pump Station #3 Well Field, Pump Station #6 Well Field, and Pump Station #7 Well Field. Figure 3.2 shows the location of the wells in the City Well Field.

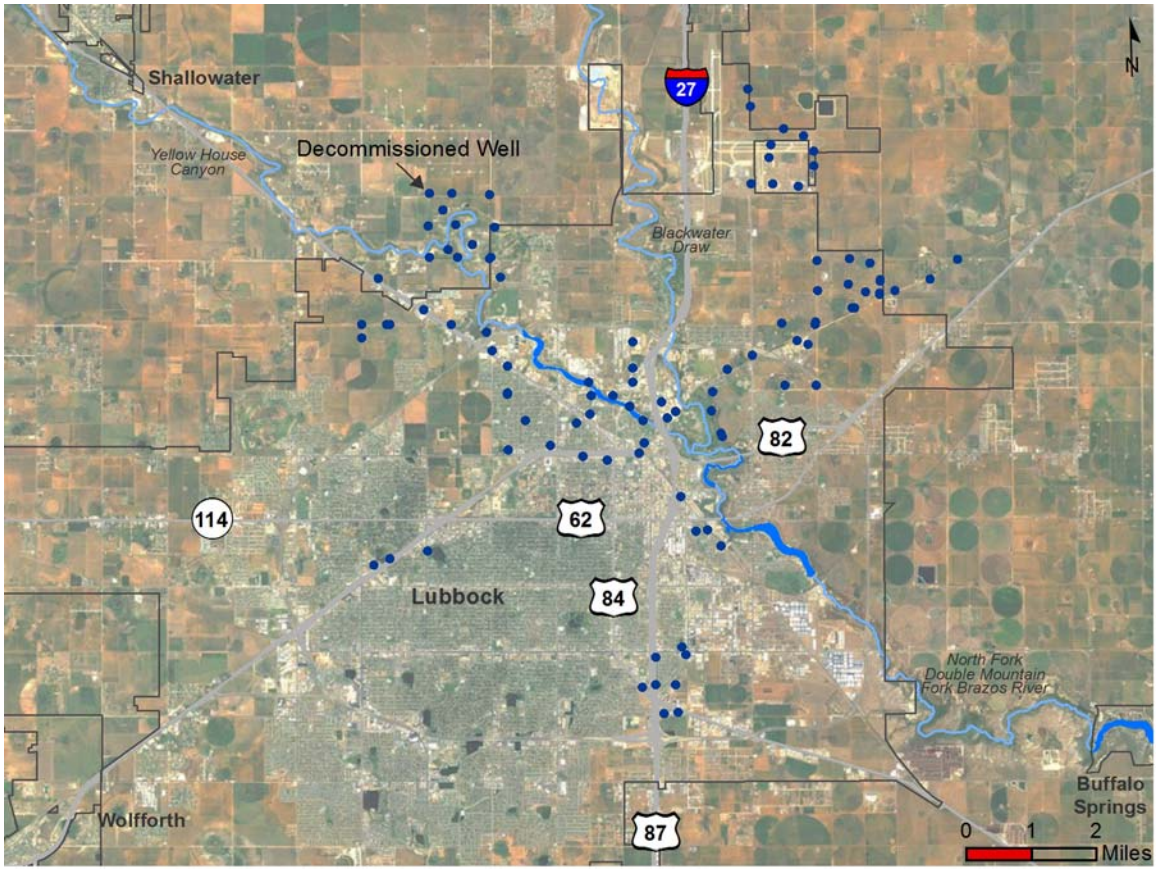

Figure 3.2 – City Well Field Locations

At its peak, the City Well Field included 61 wells. In the mid-1950s, the City began reducing the City Well Field production as the Shallowater Well Field and subsequently the Bailey County Well Field became operational. The City discontinued the use of the City Well Field when Lake Meredith water became available in 1968. The only local wells that were in operating condition and could potentially produce water for the City in the

1990s were the eight wells associated with Pump Station #6. At that time, it was estimated the combined production of these wells was 8 million gallons per day (mgd).[1]

The City eventually decided to decommission the City Well Field due to changes in the water quality of the groundwater under the City as Lubbock became more populated and urban sources of contamination impacted the groundwater supply. In addition, some of the naturally occurring minerals (such as fluoride) could not meet the increasingly stringent water quality standards set by regulatory agencies. These local wells that were once used for potable purposes are no longer part of the City's water supply. By 2012, all of the inactive City potable water supply wells had been plugged and abandoned.

3.2 Shallowater Well Field

In 1953, the City purchased 2,060 acres of water rights in Hockley and Lubbock counties, about 12 miles northwest of the City of Lubbock, and subsequently constructed the Shallowater Well Field.[2] The well field was used by the City from 1955 until 1968 when Lake Meredith became the main source of drinking water for the City. It appears that the City stopped using the Shallowater Well Field in the 1960s due to water quality issues. Furthermore, the production capacity of the Ogallala Aquifer near the well field had declined rapidly due to heavy agricultural irrigation practices surrounding the well field over the past century.

The Shallowater Well Field consists of 17 wells which cover the entire water rights acreage. The well field location and infrastructure are depicted in Figure 3.3.

In 2011, City staff evaluated whether the well field should be rehabilitated or decommissioned. Staff recommended that the well field be decommissioned.[3] This recommendation was made for the following reasons:

- Production capacity of the Shallowater Well Field is poor (average well capacity is 20 gpm);
- Ogallala Aquifer groundwater underlying the well field is of poor quality; and
- Existing water system infrastructure in the well field is in very poor condition.

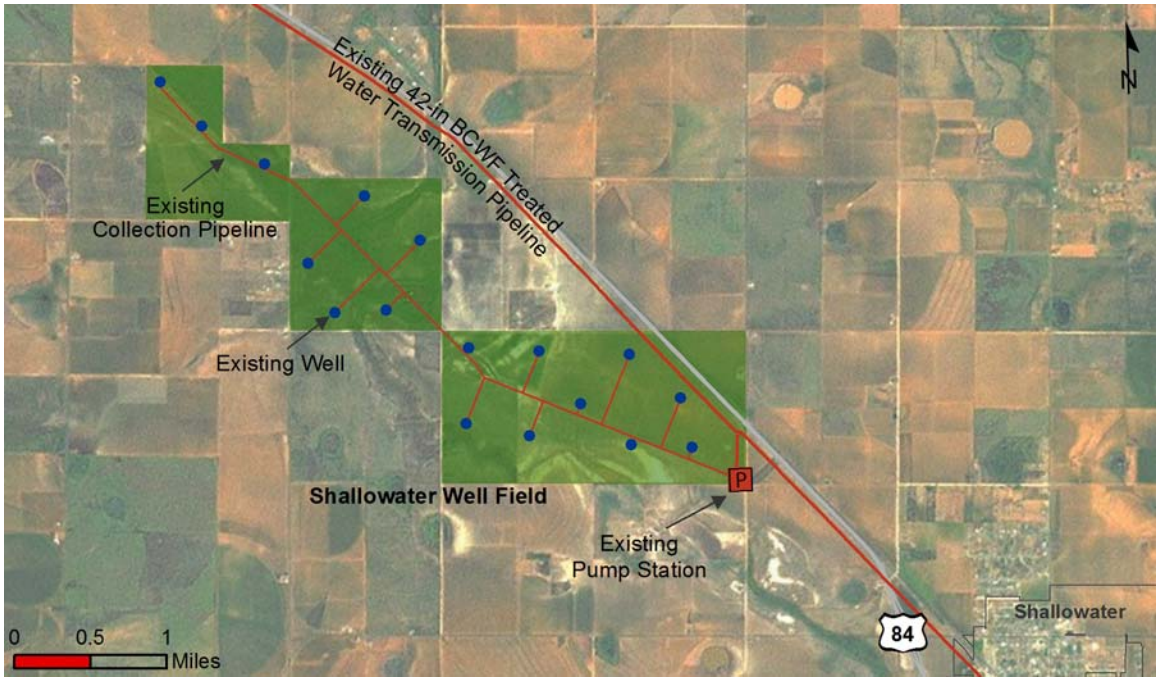

Figure 3.3 – Shallowater Well Field

It was estimated that it could cost more than $8,000,000 to replace all of the wells and upgrade the related infrastructure to meet current regulatory standards. These estimates did not include the cost of advanced water treatment facilities to correct water quality problems. Overall, the cost per recoverable acre-foot of groundwater for the Shallowater Well Field was determined to be at least seven times more expensive than expansions associated with the Roberts County (John C. Williams) and Bailey County (Sandhills) Well Fields.

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[1] Comprehensive Groundwater Management Study for the City of Lubbock. Geraghty & Miller, Inc. April 1992: Vol. 1, 57.

[2] City of Lubbock Water Advisory Commission; Orientation Manual. September 18, 2003.

[3] Shallowater Well Field Decommissioning Evaluation Memorandum. April 8, 2011.

4.0 Current Water Supplies

The City of Lubbock has relied upon both surface and groundwater for over 45 years. During this time, the City's main water supplies have consisted of the following sources:

- Canadian River Municipal Water Authority (CRMWA)
  - Lake Meredith
  - Roberts County Well Field (RCWF)
- Bailey County Well Field (BCWF)
- Lake Alan Henry (LAH)

Prior to 1968, groundwater withdrawals from the BCWF and local well fields were sufficient to meet the City's total water demand. In 1968, with the availability of surface water from Lake Meredith, groundwater withdrawals were reduced substantially. By the 1980s, Lake Meredith provided up to 90% of the City's water demand. However, Lake Meredith's yield began declining. By the end of 2001, groundwater was being used to replace a portion of Lake Meredith's supply. By September 2011, Lake Meredith's water levels had fallen too low for CRMWA's member cities to continue using water from the reservoir. From the fall of 2011 until the fall of 2012, the City met its water demand with 100% groundwater from the RCWF and the BCWF. Water from LAH became available in the fall of 2012. Phase 1 of LAH's water supply infrastructure is expected to provide approximately 17% of the City's annual supply starting in 2013.

Lubbock's water supplies are constantly changing over time. Within the last 20 years, the profile of Lubbock's water supply has changed dramatically, as depicted in Figure 4.1. In 1992, Lubbock received 87% of its water supply from Lake Meredith, and the RCWF did not exist. By 2012, Lake Meredith was no longer a supply, and RCWF provided 58% of Lubbock's water supply. As a result of the dynamic water supply situation, continuous planning is essential. Figure 4.2 includes a map depicting the locations of the City's current water supplies.

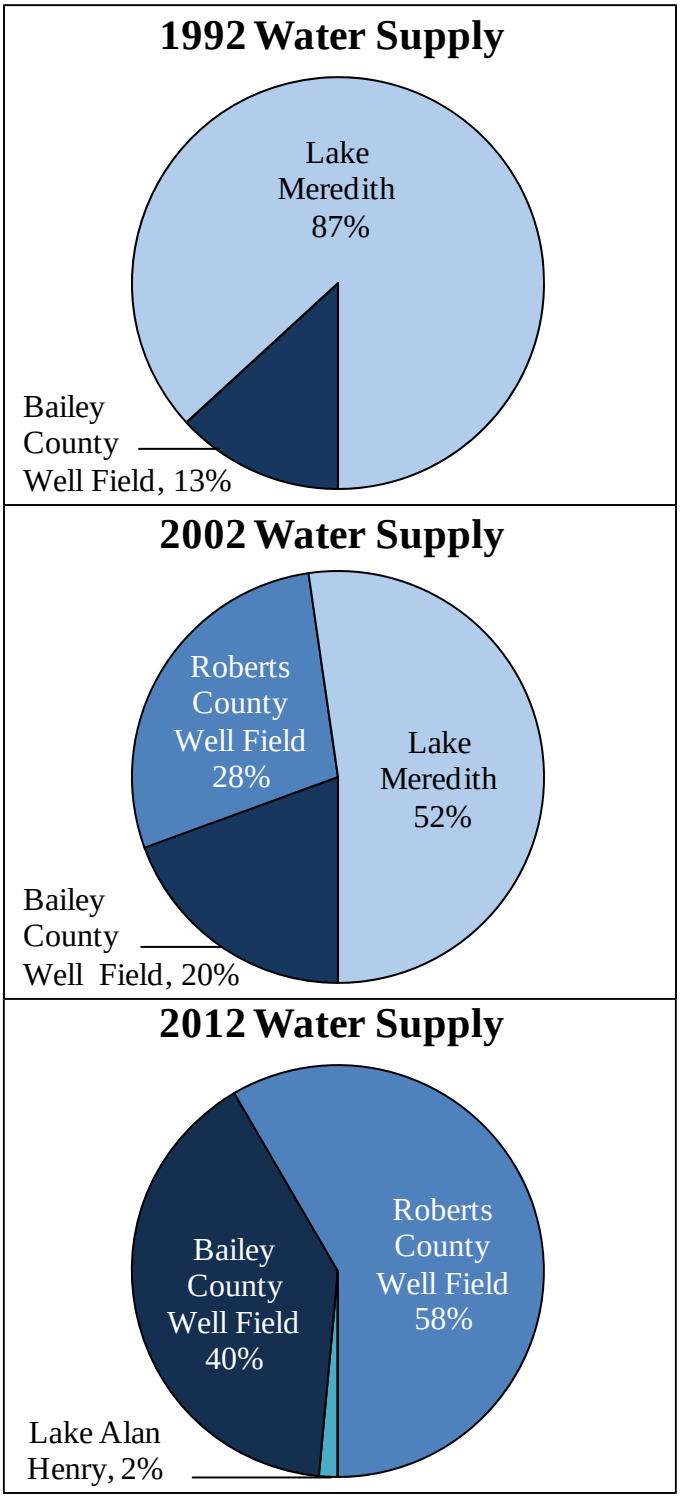

Figure 4.1 – Water Supply Contribution Comparison for 1992, 2002, and 2012

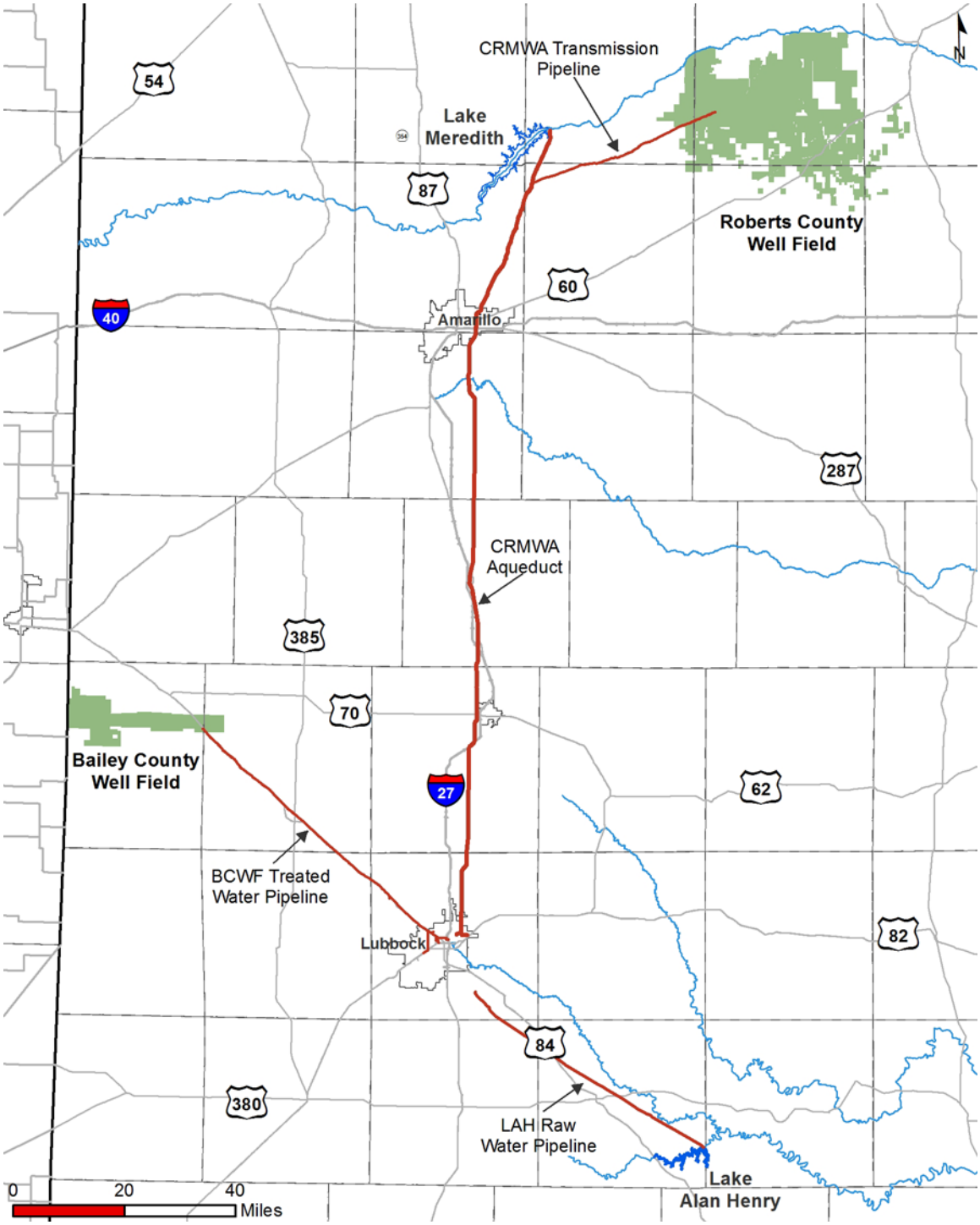

Figure 4.2 - Current Water Supply Location Map

As depicted in Figure 4.2, Lubbock's closest existing water supply source is Lake Alan Henry which is over 60 miles southeast of Lubbock. The RCWF is Lubbock's most distant water supply source, located over 150 miles northeast of Lubbock.

Table 4.1 compares the water quality for each of Lubbock's current water supplies. In general, the groundwater quality in Roberts County is comparable to the City's groundwater resources in Bailey County and the City's surface water resource at LAH. Lake Meredith water quality has degraded significantly as the lake's volume of water has been depleted over the past decade.

Table 4.1 Water Quality Comparison

Selected Water Quality Parameters	Lake Alan Henry[A]	Lake Meredith[B]	BCWF[C]	RCWF[D]
pH	7.8	8.5	7.0	7.8
Total Alkalinity (mg/L)[E]	167	196	232	192
Turbidity (NTU) [F]	3.60	7.15	0.80	1.22
Conductivity (uS/cm)[G]	1,160	4,588	600	1,214
Total Dissolved Solids (mg/L)	633	2,935	319	715
Fluoride (mg/L)	1.10	0.80	1.50	0.75
Chloride (mg/L)	234	1,114	20	219
Nitrate (mg/L)	0.06	0.34	1.33	1.64
Sulfate (mg/L)	84	624	41	84
Potassium (mg/L)	4.6	13.7	5.7	6.2
Sodium (mg/L)	210	934	33	171
Calcium (mg/L)	27.2	100.0	56.8	71.6
Magnesium (mg/L)	8.3	94.7	18.1	33.6

A- Analytical results extracted from the City of Lubbock's 2010 Water Quality Report.
B- Analytical results provided by Rod Goodwin, CRMWA. Sample collected from intake tower 7-7-2011.
C- Analytical results extracted from the City of Lubbock's 2010 Water Quality Report.
D- Analytical results provided by Rod Goodwin, CRMWA. Composite sample for all Phases collected 7-5-2011.
E- mg/L = milligrams per liter
F- NTU = Nephelometric Turbidity Units
G- µS/cm = microSiemens per cm

The water in the Ogallala Aquifer underlying CRMWA's existing well field in Roberts County becomes saltier with depth. Therefore, total dissolved solids (TDS), chloride, and sodium are higher than the BCWF. Overall, Lubbock's sources of water are generally compatible with one another.

4.1 Canadian River Municipal Water Authority

CRMWA supplies raw water to eleven member cities which have a combined population of over 500,000 people in the Texas Panhandle and South Plains. The water supply is conveyed via a 358-mile aqueduct system. CRMWA was created by the Texas Legislature in 1953 to provide a source of municipal and industrial water for its member cities. Figure 4.3 depicts the current groundwater allocation of CRMWA water between the member cities.

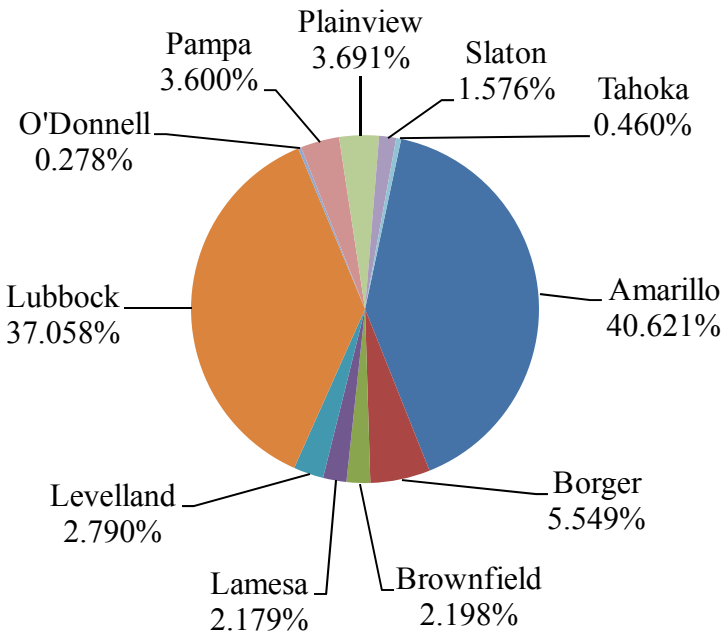

Figure 4.3 - Current CRMWA Member City Allocations

The CRMWA headquarters is located at Sanford Dam about 37 miles northeast of Amarillo, Texas. Originally, CRMWA was organized to operate Lake Meredith, which was built and financed by the U.S. Bureau of Reclamation as part of the Canadian River Project. Later, the RCWF was constructed to supplement the lake supply.

Lake Meredith

When construction began on Lake Meredith in 1962, initial estimates placed the firm yield of the Lake at 103,000 acre-feet per year (ac-ft/yr). After the Sanford Dam was completed in 1965, water began being stored in Lake Meredith. In 1968, CRMWA began delivering water to member cities. Lubbock's initial allocation was 38,169 ac-ft (37.058%). Later studies indicated that the firm yield of the lake was only 76,000 ac-ft/yr. Lubbock's

allocation was adjusted to 28,164 ac-ft/yr. However, the drought conditions over the last decade necessitated a further reduction in the estimated firm yield of the lake to less than 50,000 ac-ft/yr. By the fall of 2011, insufficient inflows rendered the lake unusable as a water supply.

Figure 4.4 – Lake Meredith and Sanford Dam, 1967

Water quality issues became a concern in Lake Meredith shortly after CRMWA began delivering water to its member cities. In 1969, CRMWA began preparing a plan to address the elevated levels of chlorides in the lake. In 1971, the source of the problem was identified when salt springs along the Canadian River were discovered near Logan, New Mexico. This problem was eventually addressed in 2001 when the Lake Meredith Salinity Control Project was placed into operation to mitigate the salt springs. In addition to salinity, CRMWA also made plans to address the general water quality of the lake. In 2002, the RCWF was constructed to improve the lake's water quality by blending the two sources in the aqueduct system. In the early 2000s, Lake Meredith's water level began to decline which led to further water quality issues. Figure 4.5 depicts the increasing chloride concentration in the lake over time.

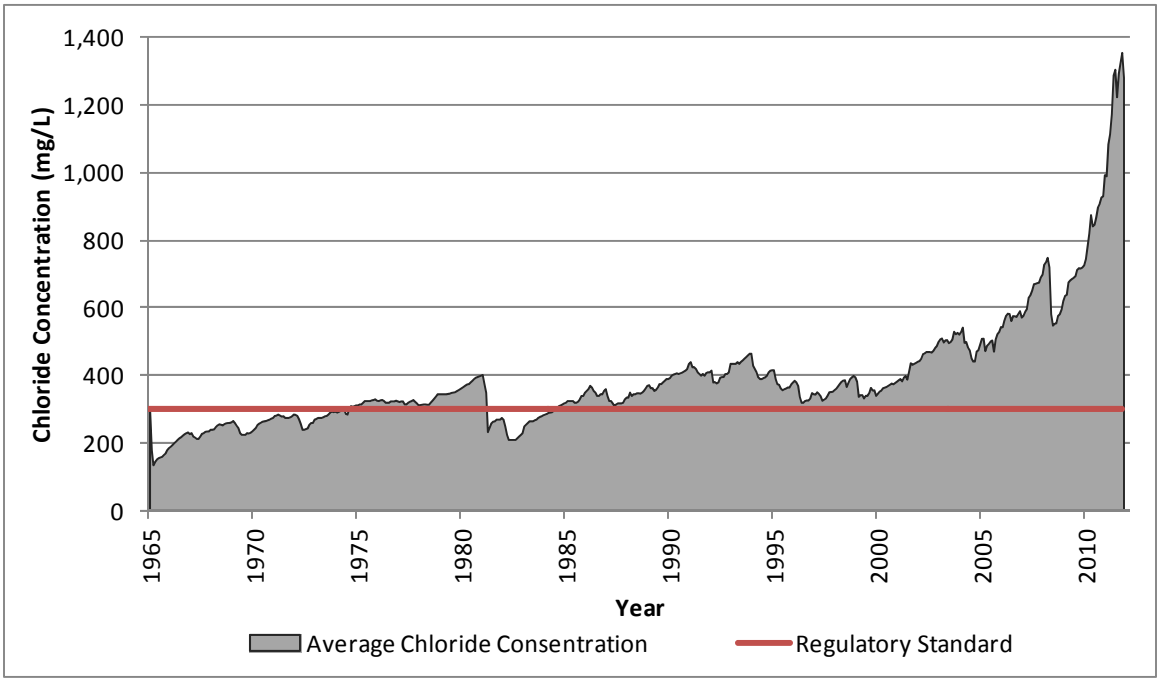

Figure 4.5 - Lake Meredith Chloride Concentration Trend

As a result of the declining water levels in the lake, the allocations to the member cities were reduced. Groundwater from the RCWF was used to make up the difference as much as possible. In 2011, during the worst one-year drought of record, Lake Meredith was used for summer peaking capacity only. After the summer of 2011, water could no longer be pumped from the lake. Historic water levels in Lake Meredith are presented in Figure 4.6.

In January 2009, the results of a Freese & Nichols, Inc. Lake Meredith report titled *Surface Water Study*[1] was presented to the Panhandle (Region A) Regional Water Planning Group. The conclusions of this study indicated that the decreased capacity of Lake Meredith was most likely attributed to changes in the groundwater to surface water interactions and land-use changes in the watershed. Declines in the Ogallala Aquifer and Dockum Formation water levels appeared to impact spring flow into the lake. In addition, the increase in shrub (especially salt cedar) in the watershed appeared to be a factor contributing to reduced reservoir inflows. The report indicated that the decreased capacity of the lake did not appear to be meteorological in origin. Precipitation amounts, precipitation intensity, and evaporation were not considered to be contributing factors. As a result, it is uncertain whether or when Lake Meredith will recover and resume supplying water to member cities.

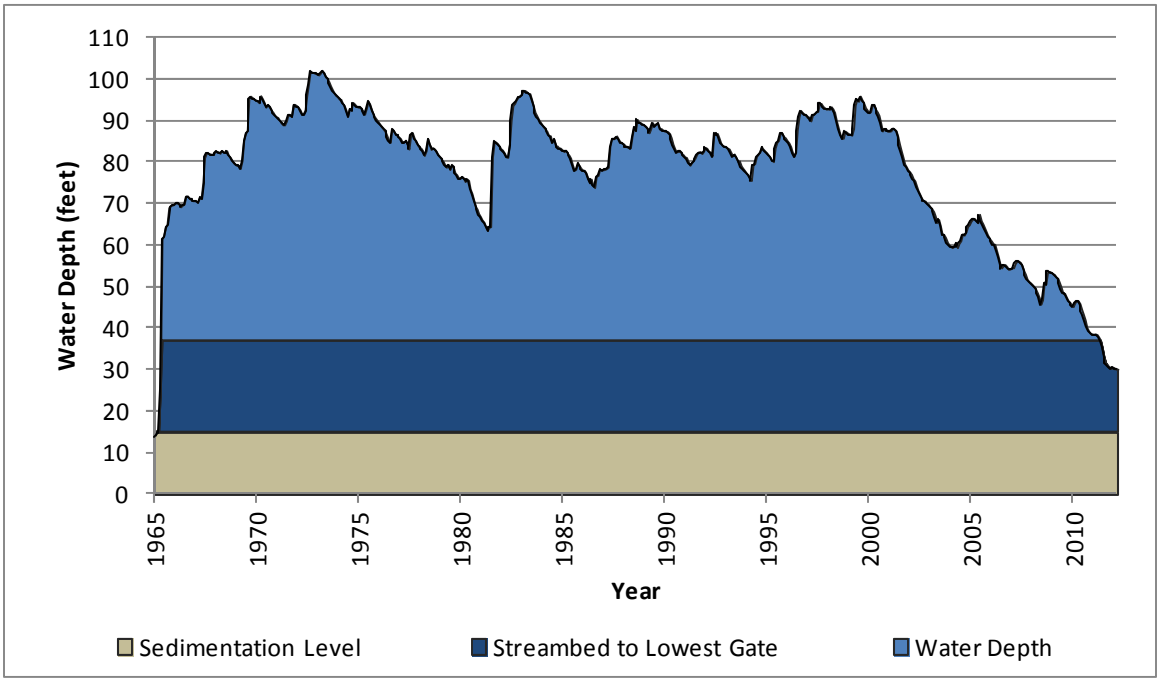

Figure 4.6 - Historic Water Levels in Lake Meredith

Lake Meredith is not considered a viable water supply strategy at this time. If the lake begins to refill, this water supply strategy will be re-evaluated.

Roberts County (John C. Williams) Well Field

CRMWA began efforts to supply supplemental groundwater to Lake Meredith's supply as early as the 1990s. In 1994, CRMWA purchased 42,864 acres of water rights in Roberts and Hutchinson counties and began construction of the RCWF (also called the John C. Williams Well Field). Phase 1 and Phase 2 of the RCWF were completed in 2002 and 2006 respectively, totaling 29 wells. A 35-mile, 54-inch diameter transmission line was also constructed connnecting Phases 1 and 2 of the well field to the main CRMWA Aqueduct that transports water to its member cities. Phase 1 and 2 were initially permitted to supply up to 40,000 ac-ft/yr. CRMWA began blending the well water with Lake Meredith water in 2002. Due to the need to replace lost capacity created by Lake Meredith's decline, Phase 3 of the RCWF was constructed and placed into operation in 2011, expanding the total number of wells to 45.

On June 23, 2011, CRMWA signed a contract with Mesa Water to purchase 144,000 additional acres of water rights that were predominately contiguous to the RCWF. This purchase increased CRMWA's water rights holdings in the well field to over 400,000

acres. According to an internal memorandum[2] prepared by City staff to evaluate the purchase of the Mesa Water rights, the strategic value of this purchase included:

- expansion of the RCWF which is one of Lubbock's key water supplies;
- Mesa's water rights' accessibility to the existing RCWF infrastructure;
- Mesa's water rights' volume of water per surface acre that is at least three times greater than well fields on the South Plains; and
- the high quality of the groundwater in Roberts County.

By the fall of 2011, CRMWA began supplying 100% groundwater when Lake Meredith's water levels declined below the lowest gate of the intake structure (Figure 4.6). The layout of the RCWF is depicted in Figure 4.7.

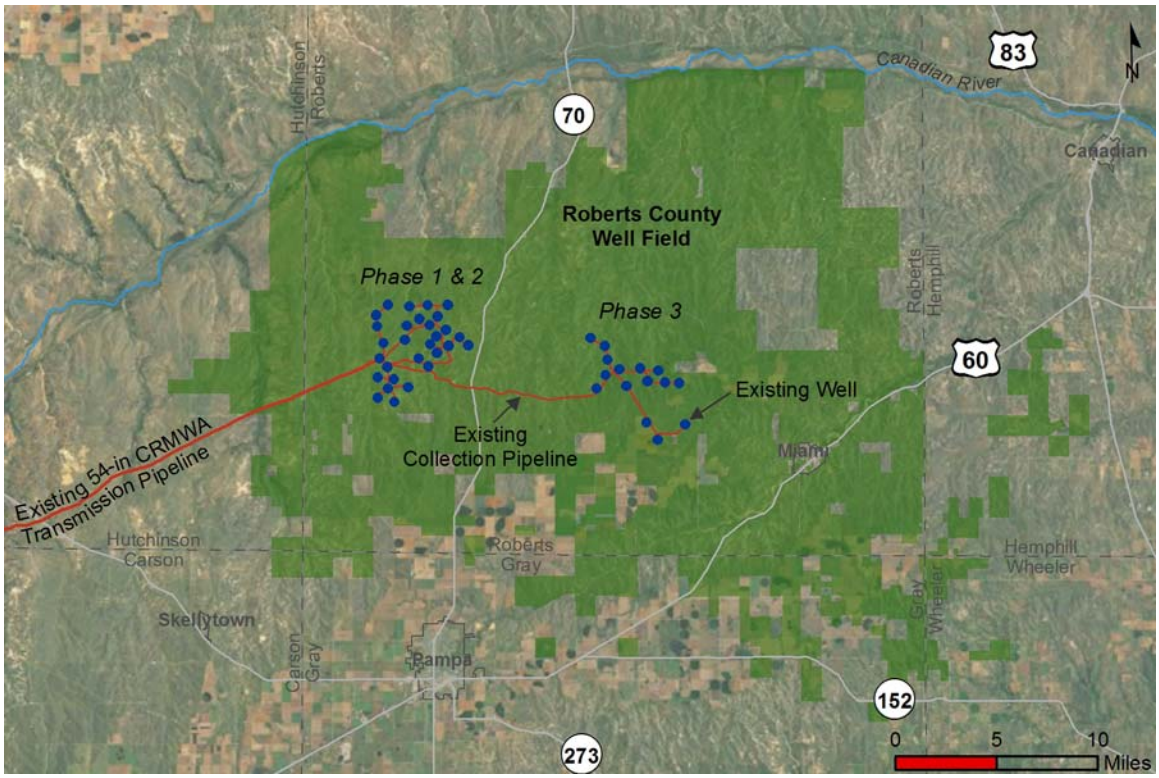

Figure 4.7 - Roberts County Well Field

CRMWA's goal is to maintain the peak capacity of the RCWF at 92 mgd even though the 54-inch diameter transmission line can only supply approximately 65 mgd. At a 92 mgd peaking capacity, the RCWF can maintain a 70% load factor giving CRMWA the operational flexibility to rotate and rest wells. The current capacity of the RCWF is

estimated to be 86 mgd. Without capacity maintenance, the well field capacity will continue to decrease over time.

Lubbock's 2013 CRMWA allocation is 24,088 ac-ft/yr. CRMWA cannot increase Lubbock's allocation until an additional transmission line is constructed from the RCWF to the main aqueduct.

4.2 Bailey County (Sandhills) Well Field

The BCWF (also called the Sandhills Well Field) is located approximately 60 miles northwest of the City of Lubbock in Bailey and Lamb counties. In 1954, the City purchased the initial 53,910 acres of water rights to create the well field. In 1957, the City's water rights were expanded to 75,041 acres.[3] Today, the current water right holdings for the BCWF are approximately 83,305 acres. Water from the BCWF is pumped from the Ogallala Aquifer. Most of the wells were constructed in the 1950s and 1960s.[4] The 175 active wells are distributed over approximately 50% of the water rights owned by the City in this well field. Figure 4.8 shows a layout of the BCWF with the associated well locations and collection system. The number of irrigated fields surrounding the BCWF indicates that groundwater usage adjacent to the well field for agriculture is extensive.

The City used the well field at an average rate of 6,000 ac-ft/yr from 2000 to 2010. However, during 2011, with the loss of Lake Meredith as a water supply, the City was forced to pump over 20,000 ac-ft from the BCWF. Over the past couple of years, the well field's capacity has decreased from 50 mgd to 38 mgd, dropping below the 40 mgd capacity of the transmission line that transports water from the BCWF to the City. The well field capacity will continue to decrease each year unless additional wells are installed. Since the average well production capacity is 200 gallons per minute, 35 wells would be required for every additional 10 mgd capacity needed. The goal for this well field is to extend its useful life by reducing its usage to less than 7,000 ac-ft/yr and using it only during the summer months to provide peaking capacity as recommended in a 2012 report completed by Daniel B. Stephens & Associates, Inc.[5]

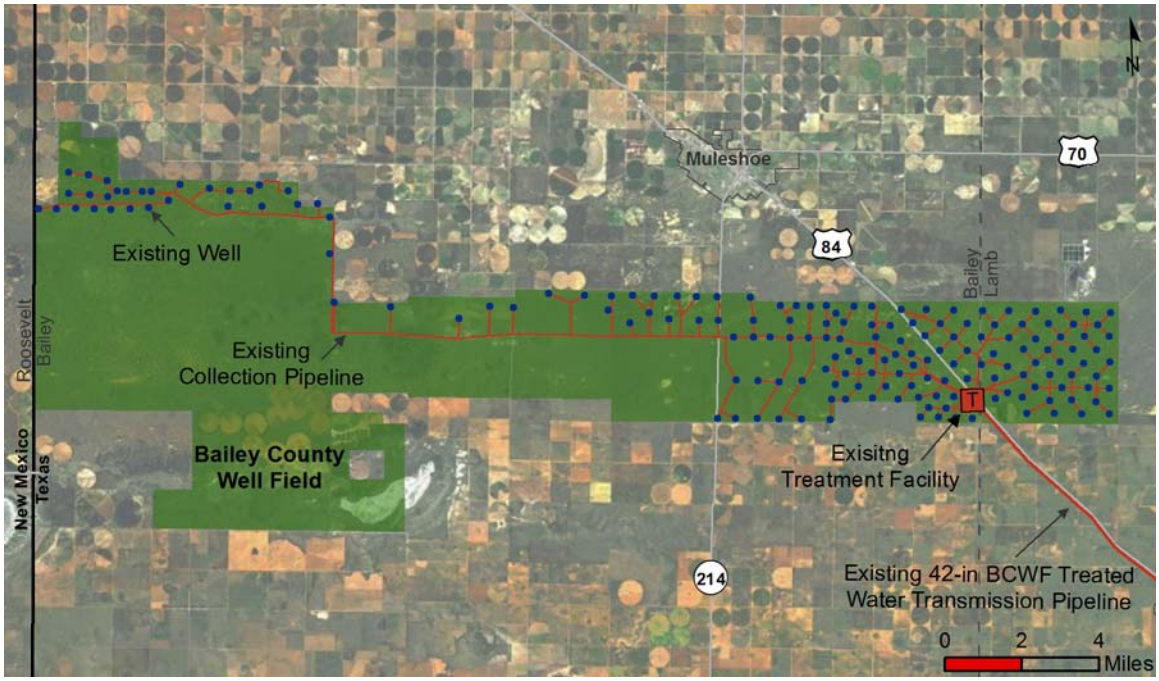

Figure 4.8 – Bailey County Well Field

4.3 Lake Alan Henry

Construction of the John T. Montford Dam was completed in October 1993. The lake can hold 94,808 ac-ft of water. According to a 2008 LAH Yield Model memorandum[6] prepared by HDR Engineering, Inc., the firm yield of the lake is 22,210 ac-ft/yr and the 2-year safe yield of the lake is 16,080 ac-ft/yr.

In 2007, the City began the preliminary engineering for the water supply infrastructure that would deliver treated water to the City's distribution system. Infrastructure for LAH was designed to be completed in two phases. Phase 1 infrastructure includes two pump stations, 50-miles of raw water pipeline, a water treatment plant, and finished/treated water transmission pipelines connecting to the City's distribution system. Phase 1 was completed in September 2012 and can treat and deliver a peak capacity of 15 mgd and an annual capacity of 8,000 ac-ft. Phase 2 of the LAH infrastructure project will expand the system to a peak capacity of 30 mgd and an annual capacity of 16,000 ac-ft. Phase 2 is anticipated to begin in the near future.

Figure 4.9 – Lake Alan Henry and John T. Montford Dam, 2007

During July 2010, significant rainfall and flooding filled the reservoir to its capacity and engaged its spillway for several days. However, during the extreme 2011 drought, the water level in LAH declined over eight feet due to significant evaporation and low inflows. Historic water levels are presented in Figure 4.10.

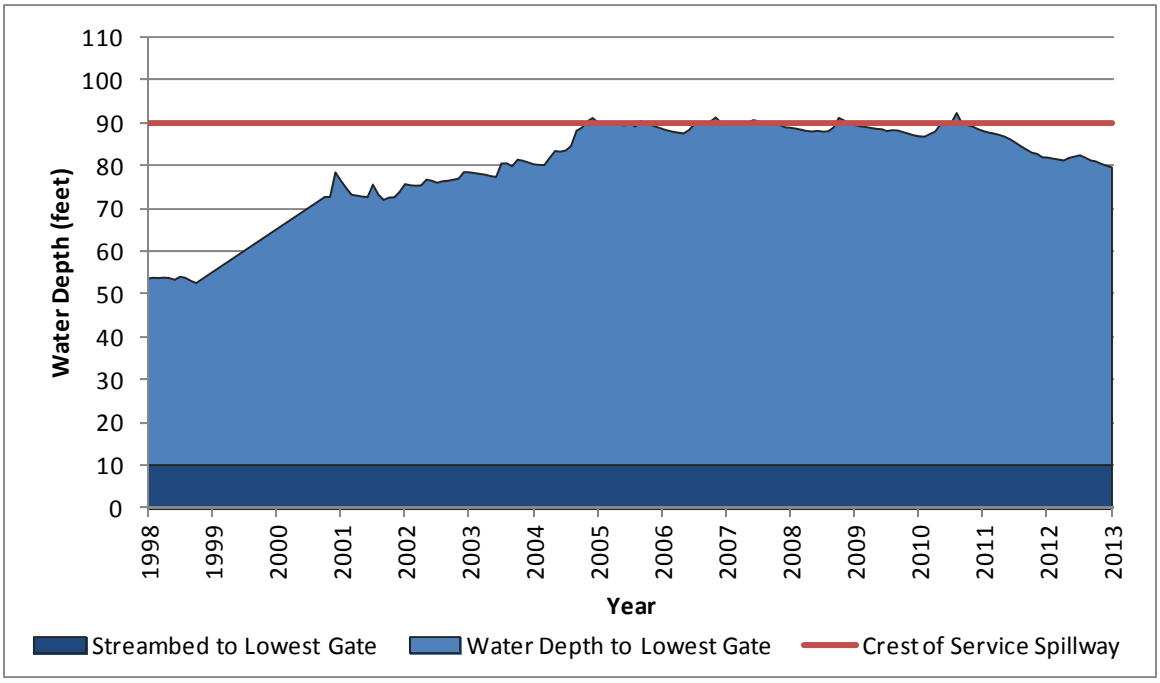

Figure 4.10 – Lake Alan Henry Water Levels

4.4 Current Water System Capacity

In order to evaluate the amount of water that Lubbock can supply to its customers, the capacity of various parts of the existing water system infrastructure must be evaluated. Figure 4.11 depicts Lubbock's current water sources and supply infrastructure with the corresponding capacity of each item. As the City adds new water supply strategies and increases the amount of water being delivered, improvements to the supply and distribution system will be necessary.

Lubbock's raw water supplies are treated at one of three treatment facilities before entering into the City's distribution system. These treatment facilities include the BCWF chlorination facility, the North Water Treatment Plant (NWTP), or the South Water Treatment Plant (SWTP. The NWTP has excess capacity to treat additional water and transport it into the distribution system. However, the SWTP does not have any additional capacity. LAH Phase 1 can deliver up to 15 mgd of treated water to pump stations 8, 10, and 14. These pump stations are operating at maximum capacity. Therefore, additional quantities of water transported to the SWTP for treatment will need to be routed to a different pump station, such as PS 7, as depicted in Figure 4.l2.

Currently, water from the BCWF is transported to Lubbock and enters the distribution system at PS 9 and the Lowhead B Pump Station. Plans are in progress to build a 36-in treated water transmission pipeline that by-passes PS 9 and transports water to PS 7. These plans include the demolition of the Lowhead B Pump Station. This project is currently under design. Several of the water supply strategies in this Plan include the cost of a 4-mile, 42-in transmission line that will connect the existing transmission line at PS 14 to PS 7. This will allow for additional water to be treated and transported from the SWTP into the distribution system.

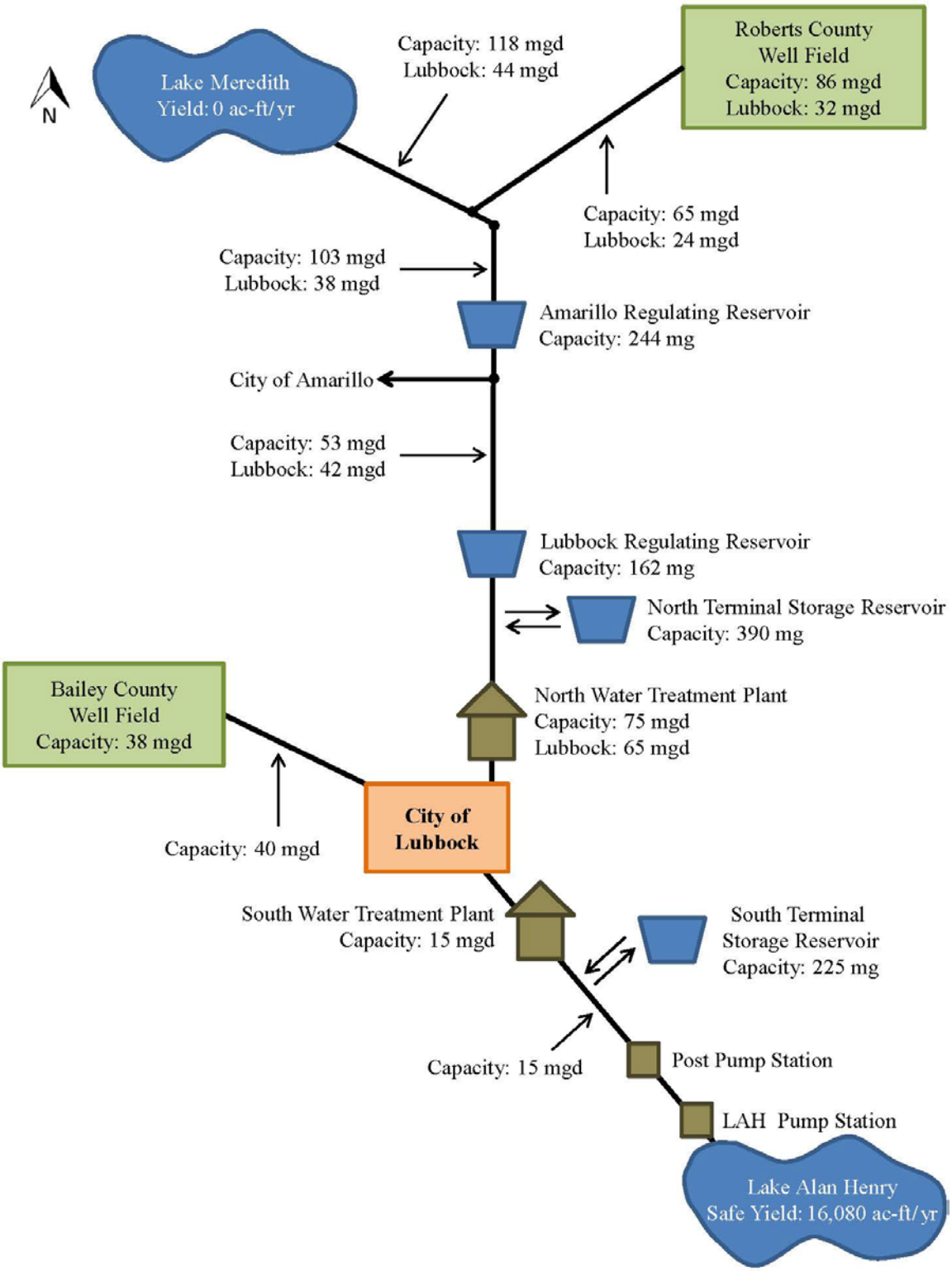

Figure 4.11 - Current Water Supply Capacity Schematic

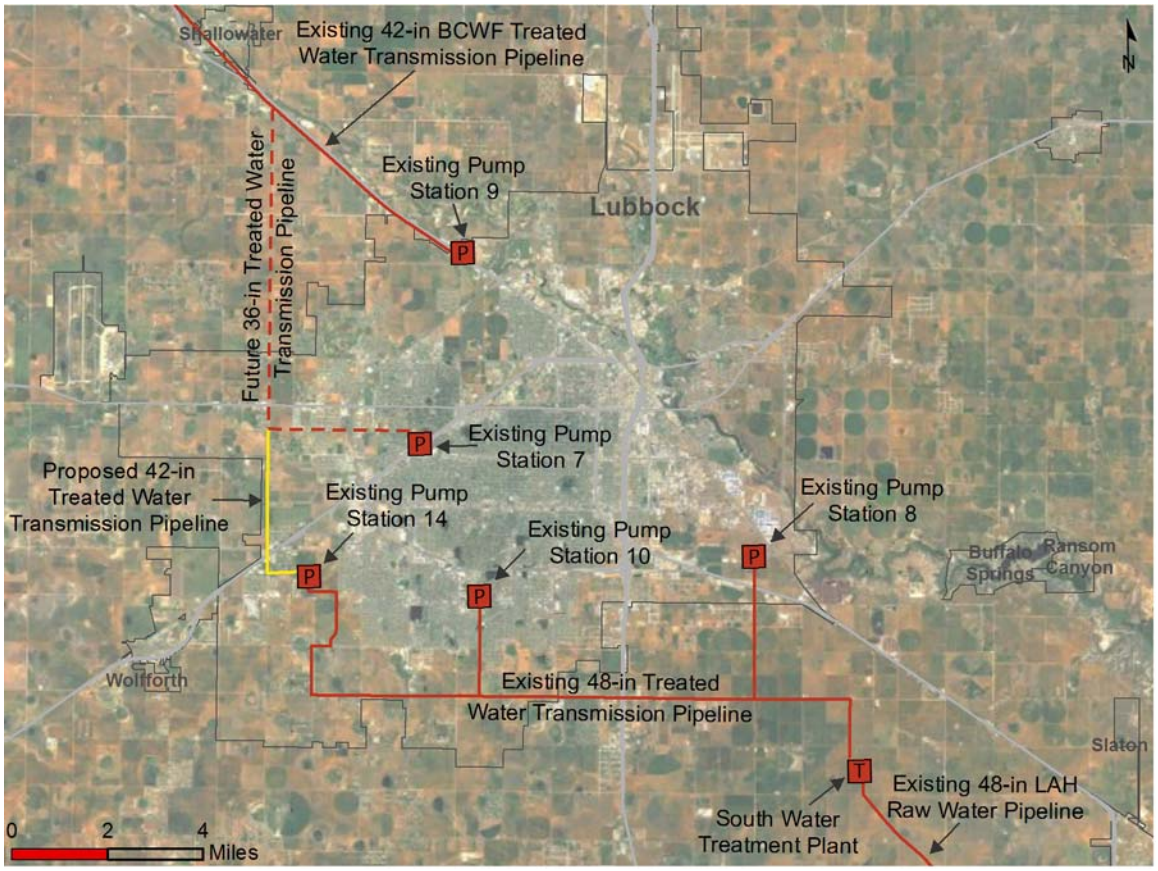

Figure 4.12 – Proposed Transmission Line from PS 14 to PS 7

4.5 Water Demand vs. Current Water Supply

Evaluation of both the AWD and PDD compared to available water supply and capacity is essential in determining when additional water supplies and/or infrastructure may become necessary. In order to make such an evaluation, current water supply projections have been made.

Annual Water Supply

Development of the projected AWD scenarios is discussed in Section 2.0 (Appendix A-3). In order to determine how to meet these projected demand scenarios, the City inventoried its current water supply sources. Current annual water supply projections were developed for each of the City's water supply sources as described below. These annual water supply projections estimate the existing supply capabilities with no expansion or maintenance over the 100-year planning period.

Lake Alan Henry – Since LAH's 2-year safe yield is 16,080 ac-ft/yr, Lubbock's current 8,000 ac-ft/yr withdrawal from the lake should be sustainable throughout the planning period.

Roberts County Well Field – CRMWA's well field is currently at 70% utilization. This is important for well rotation and maintenance. The 54-inch transmission line connecting to the main aqueduct is near capacity. Well field production should keep the transmission line flowing full for the next 22 years supplying 24,088 ac-ft of water to Lubbock. In 2035, the RCWF capacity is estimated to drop below the capacity of the transmission line. The system capacity will continue to decline gradually until 2098 when RCWF will no longer be able to supply the City of Lubbock with water.

Bailey County Well Field – The City's well field will continue to decline in capacity due to heavy utilization. It is anticipated that the decline will continue until the well field is exhausted in 2037.

The current water supply projections for the next 100 years (Appendix B-1) are depicted with respect to the three water demand scenarios (Appendix B-2) in Figure 4.13.

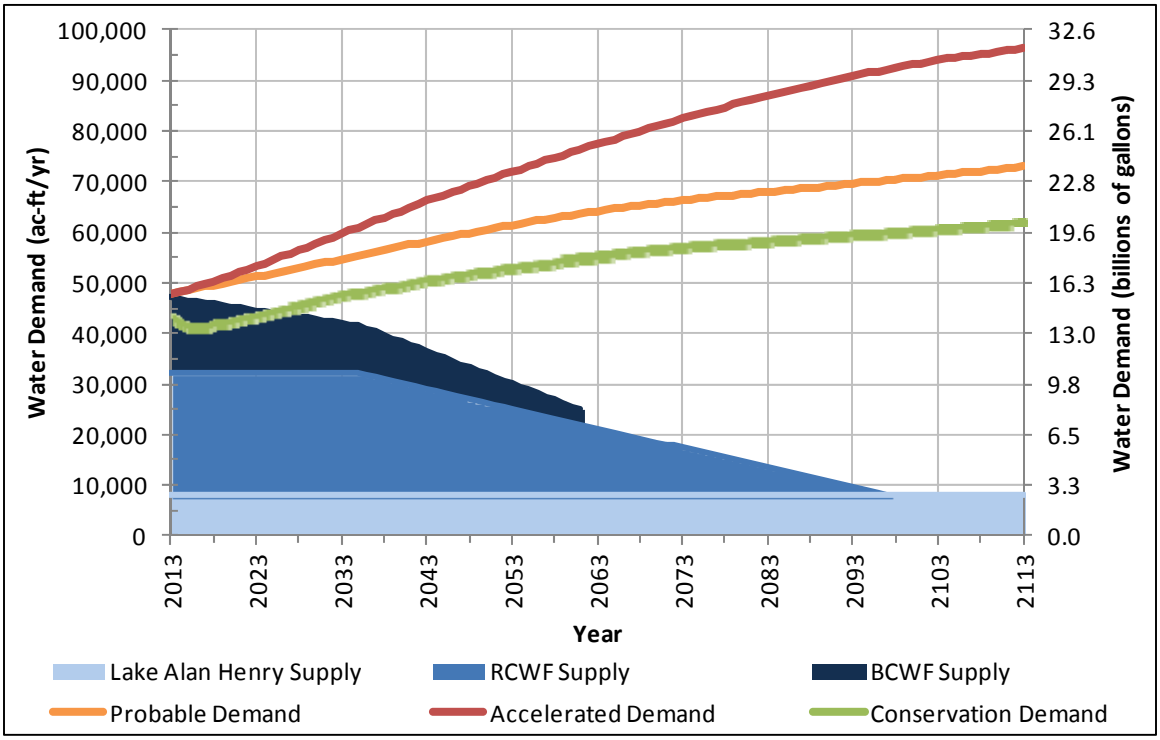

Figure 4.13 – 100 Year Annual Water Demand vs. Current Water Supply

While it appears that the City's current water supplies can be utilized for many more years, additional infrastructure will be necessary in the near future to either increase capacity or maintain the capacity of each water supply. A comparison of the Probable Demand to the total Annual Water Supply in Figure 4.13 indicates that as early as 2013, an additional water supply will be needed unless BCWF is used heavily or aggressive conservation efforts are effectively implemented (Conservation Demand). Implementing conservation efforts could delay additional water supply needs for another decade (2023).

Peak Day Supply

In addition to meeting the AWD, PDD must also be satisfied. Current peak day supply projections were developed for each of the City's water supply sources as described below. These peak day supply projections depict the supply capabilities of the City's already existing water sources with no expansion or maintenance over the 100-year planning period.

> *Lake Alan Henry* – The SWTP capacity of 15 mgd sets the maximum peak day capacity that can be delivered to the City's distribution system from LAH during a given day.

Roberts County Well Field – The 54-inch transmission line transporting water from the well field to the CRMWA Aqueduct will set the maximum peak day capacity for Lubbock at 24 mgd from the RCWF water supply until the well field capacity declines below the transmission line capacity in 2035. After 2035, the well field capacity will continue to drop until 2098 when RCWF is exhausted.

Bailey County Well Field – The 48-inch transmission line from the BCWF to Lubbock has a maximum capacity of 40 mgd. In 2012, the BCWF capacity was 38 mgd. The BCWF will continue to decline in capacity due to heavy utilization until the well field is exhausted in 2061.

At the end of 2012, Lubbock's water supply could deliver a maximum peak day supply of 77 mgd. The current water supply peak day projections for the next 100 years (Appendix B-1) are depicted with respect to the three peak day demand scenarios (Appendix B-3) in Figure 4.14. Development of the projected PDD scenarios is discussed in Section 2.0.

The total terminal storage reservoir capacity is ***not*** included in these projections. Terminal storage reservoir capacity is reserved for emergency situations only. During an emergency situation, Lubbock has 616 million gallons of storage when the terminal storage reservoirs are full (see Figure 4.11). This would be an equivalent of 10 days of water supply at a peak demand of 60 mgd.

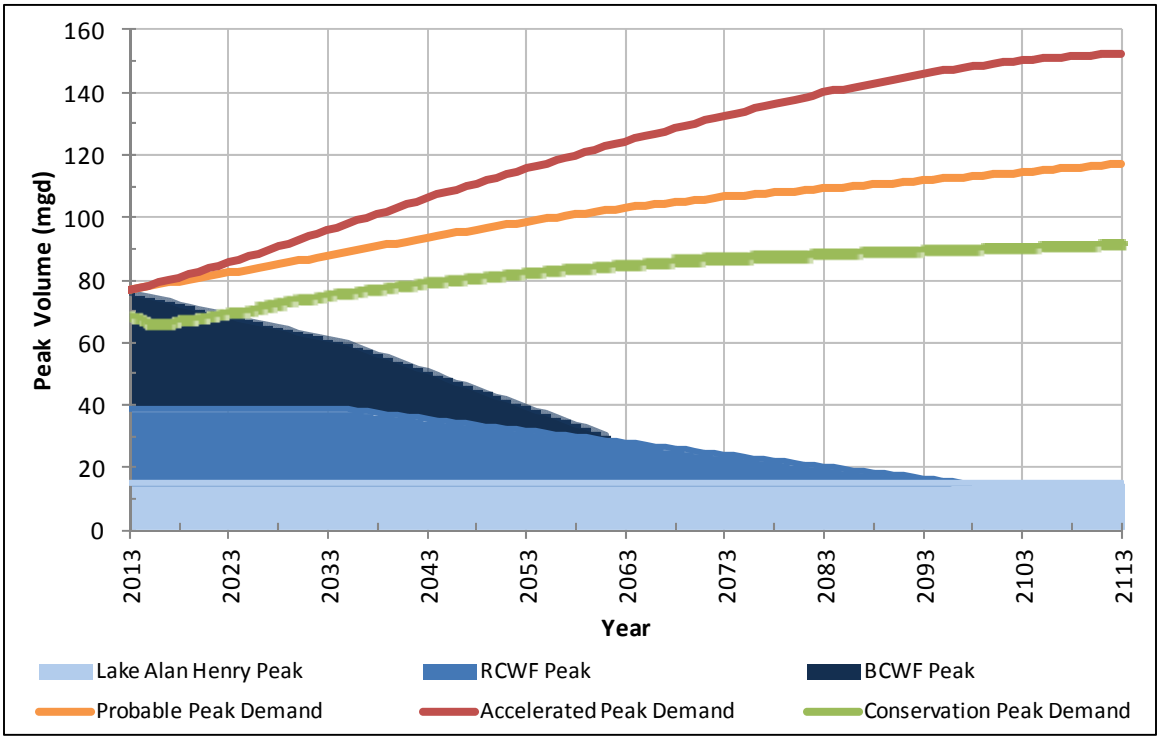

Figure 4.14 - 100 Year Peak Day Demand vs. Supply

Net Water Supply Summary

Based on the projections discussed in Section 4.3, Table 4.2 depicts the deficit amount at the end of 12 years, 50 years, and 100 years (see Appendix B-3). Based on projections, additional water supply strategies must be evaluated, recommended, and implemented to meet the City's future water needs. In addition to the City's current water supplies, several potential water supply strategies are evaluated in the subsequent sections in an effort to meet Lubbock's projected water demand in the future. These strategies are grouped into four main categories: water conservation, reclaimed water, groundwater, and surface water.

Table 4.2 - Demand, Supply, and Net Amounts for Annual vs. Peak

Year	Annual Demand, Supply, and Net (ac-ft/yr)						
	Probable Annual Demand	Accel. Annual Demand	Conserv. Annual Demand	Annual Supply	Probable Annual Net	Accel. Annual Net	Conserv. Annual Net
2013	47,965	47,965	43,654	47,088	-877	-877	3,434
2025	51,865	54,486	44,763	44,088	-7,777	-10,398	-675
2063	64,159	77,418	55,800	21,245	-42,915	-56,174	-34,555
2113	72,956	94,847	62,567	8,000	-64,956	-88,847	-54,567
Year	**Peak Day Demand, Supply, and Net (mgd)**						
	Probable Peak Demand	Accel. Peak Demand	Conserv. Peak Demand	Peak Supply	Probable Peak Net	Accel. Peak Net	Conserv. Peak Net
2013	77.08	77.08	70.15	75.97	-1.11	-1.11	5.82
2025	83.34	87.55	71.18	67.09	-16.25	-20.46	-4.09
2063	103.10	124.41	85.85	28.01	-75.09	-96.40	-57.84
2113	117.24	152.41	92.16	15.00	-102.24	-137.41	-77.16

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[1] Surface Water Study. Freese and Nichols. January 2009.

[2] Evaluation of Mesa Water Rights in Roberts County – Memo, City Staff, August 9, 2011.

[3] City of Lubbock Water Advisory Commission; Orientation Manual. September 18, 2003.

[4] Comprehensive Ground Water Management Study for the City of Lubbock. Geraghty & Miller, Inc. April 1992: (Vol. 1) 36.

[5] Updated Bailey County Well Field Modeling, Daniel B. Stephens & Associates, Inc. October 2012: 6.

[6] Lake Alan Henry Yield Model - Memo. HDR, Inc. January, 24 2008.

5.0 Water Conservation Strategies

Water conservation can be defined as any beneficial reduction in water loss, water use, or waste of water. Conservation also includes the preservation of water quality. A reduction in water use can be accomplished by implementation of water conservation or water efficiency measures.

> A *water conservation measure* is an action, behavioral change, device, technology, or improved design or process implemented to reduce water loss, waste, or use.
>
> *Water efficiency* is a tool of water conservation that results in more efficient water use and thus reduces water demand. The value and cost-effectiveness of a water efficiency measure must be evaluated in relation to its effects on the use and cost of other natural resources (e.g. energy or chemicals).

Water conservation is considered an important water supply strategy because it can effectively delay expensive water supply projects and decrease the costs of meeting peak day demand during the summer months. In this section, the City's current conservation efforts are highlighted and eight potential conservation strategies are discussed for the future. The water conservation strategies presented in this section are not ranked against other water supply strategies in this Plan because it is hard to quantify the impact of conservation efforts. However, conservation is the "least expensive supply of water" that we can develop.

5.1 Overall Water Conservation Trends

Lubbock's overall water conservation (combined indoor and outdoor) can be quantified by calculating the change in per capita potable water consumption (gpcd) from year to year. The City's per capita consumption has declined gradually over the past 30 years. The City's per capita potable water demand decreased approximately 26% from 1980 to 2012 as depicted in Figure 5.1 (see Appendix A-1).

The City incorporated water conservation goals into its Water Use Management Plan[1] that was adopted by City Council on July 22, 2010. These goals were set in accordance with Texas Commission on Environmental Quality (TCEQ) rules[2] that require that water conservation plans contain specific, quantifiable five- and ten-year goals. The City's Water Use Management Plan sets a per capita goal for year 2015 of 150 gpcd and a year 2020 goal of 146 gpcd. The State of Texas Water Conservation Task Force has recommended that cities seek to achieve a per capita consumption of 140 gpcd.[3] The Task Force considers this to be a realistic goal for most cities.

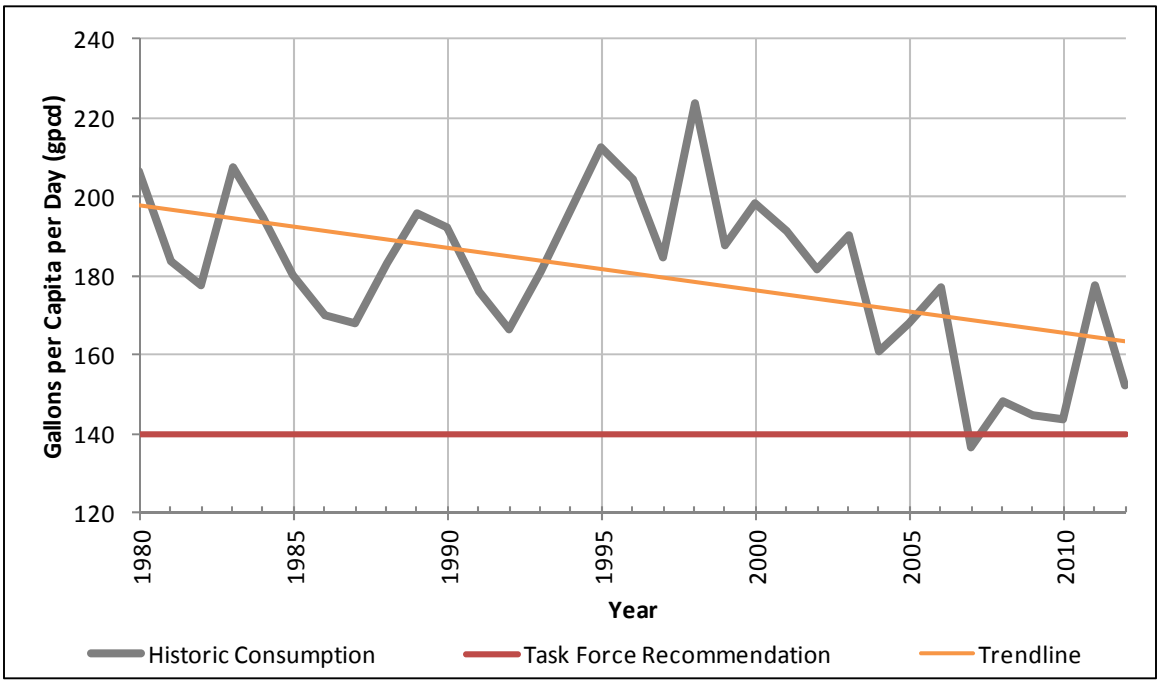


Figure 5.1 – Lubbock's Historic Per Capita Water Consumption

Based on a comparison of the projections developed in Section 2.2 for the Probable Consumption and the Conservation Consumption, continued conservation could reduce the per capita demand for the City by 20 gpcd by 2033 (see Figure 5.2). This translates into a reduction of the Probable Water Demand in 2033 by 6,718 acre-feet, or 12%. This means that additional water supply projects could be delayed as much as 23 years (until 2055).

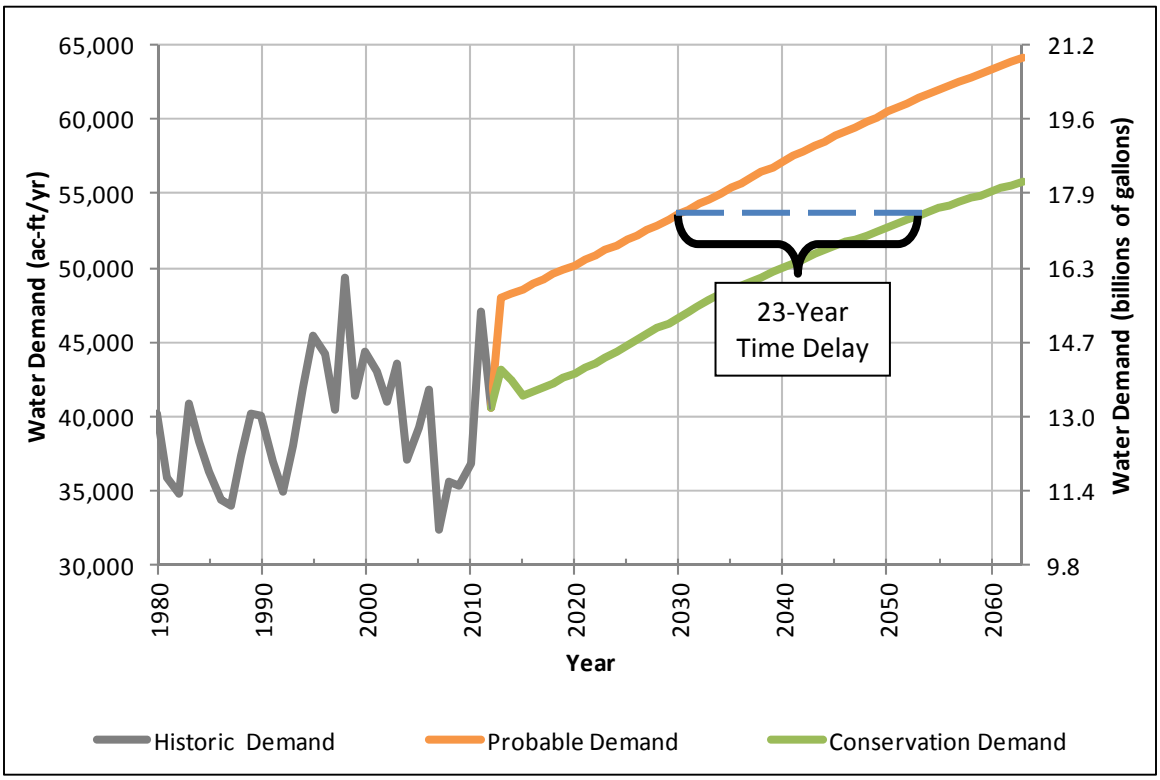


Figure 5.2 – Time Delay in Probable Demand vs. Conservation Demand

To continue to achieve its water conservation goals, the City must continue to facilitate and support cost effective measures that reduce residential and commercial water use year round. Much of the water conservation achieved thus far can be attributed to the implementation of a conservation rate structure, conservation education, and water conservation ordinances.

5.2 Indoor Water Conservation Trends

Treated wastewater usage trends provide insights into the amount of indoor water conservation that is occurring. Figure 5.3 reveals that the City has experienced a long history of indoor water conservation, presumably due to more efficient residential and commercial plumbing fixtures as well as reduced potable water usage in industrial processes and commercial ventures such as restaurants.

Figure 5.3 shows that the wastewater gpcd decreased by 27% from 1995 to 2012 while the population served increased by 22% over the same time period.

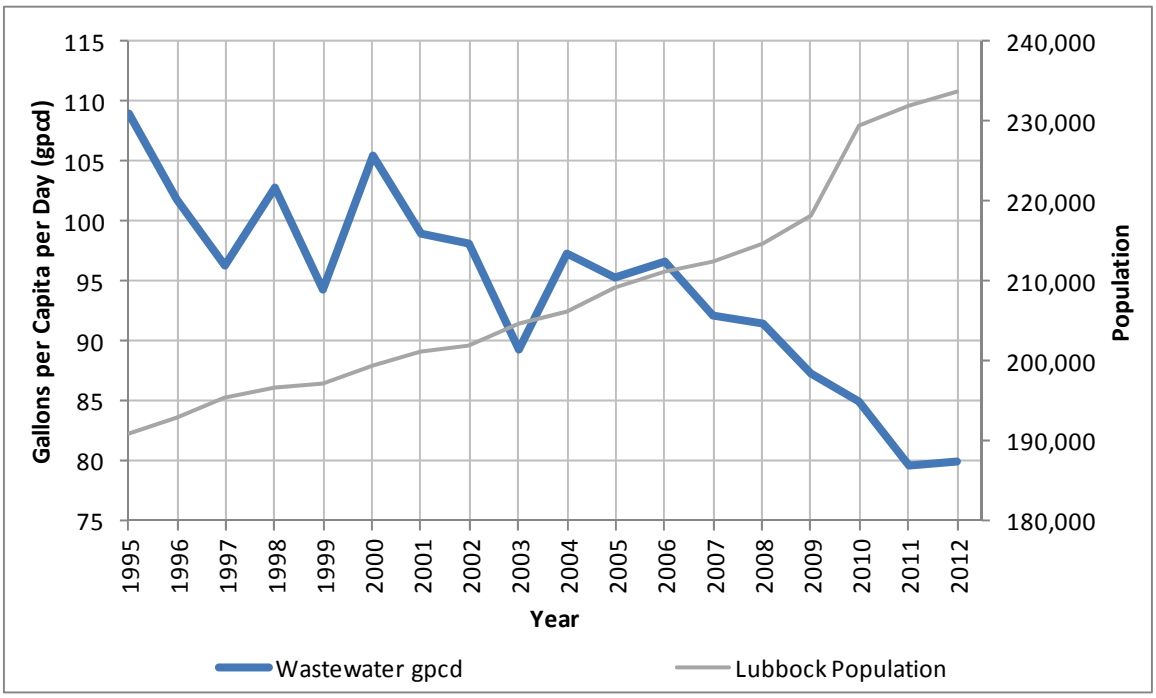


Figure 5.3 – Per Capita Wastewater Usage Trend

Much of the indoor water savings has been driven by State of Texas legislative actions. The State acknowledged the need for indoor water conservation in 1991 when the legislature passed the Water Saving Performance Standards (Senate Bill 587), placing stringent water-use standards on indoor plumbing equipment.[4] Toilets sold in Texas prior to January 1, 1992 used between 3.0 to 8.0 gallons per flush (gpf), whereas toilets installed after January 1, 1992 were required to use 1.6 gpf or less.[5] This legislation also set standards for urinals (1.0 gpf), faucets (2.2 gallons per minute (gpm)), and showerheads (2.5 gpm). The 2011 Region O Plan estimated that up to 18 gpcd could be saved by replacing pre-1992 fixtures with the newer, more water efficient models.[6] More recently, the State has passed House Bill 2667 which takes effect in 2014. This bill raises the standards by requiring that toilets sold in Texas must be high-efficiency toilets (HET) that use 1.28 gpf or less.

The American Water Works Association (AWWA) completed a study in 1999 that examined residential indoor water usage. Figure 5.4 shows the breakdown of an average household's indoor water usage based on their findings. As the figure shows, the main water using fixtures are toilets, washing machines, and showerheads.

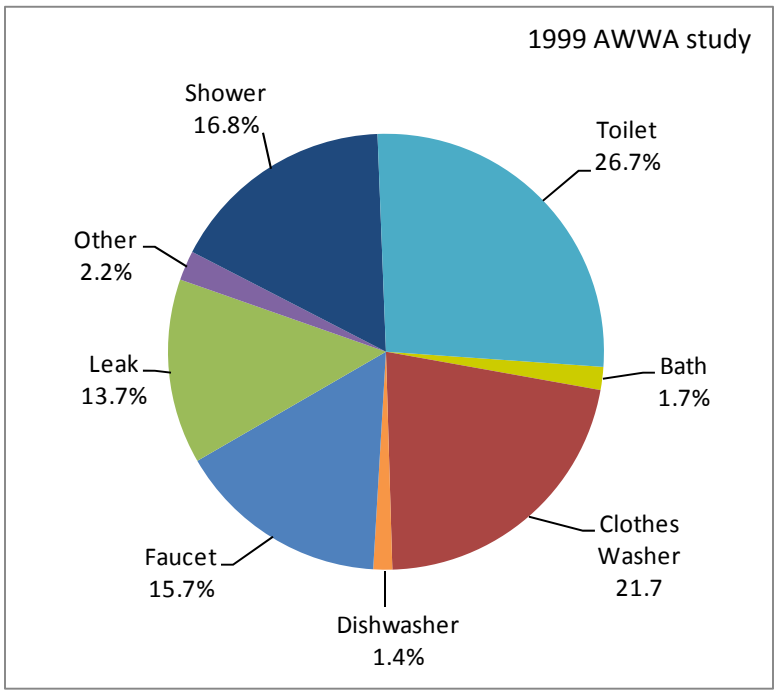


Figure 5.4 – Average Household Indoor Water Usage[7]

5.3 Current Conservation Rate Structure

Prior to 1991, the City used a decreasing water block rate. This meant that the cost of water per 1,000 gallons decreased as a customer used more. In 1991, the City changed the decreasing block rate to a uniform rate where the customer paid the same rate regardless of the volume used. In 2007, the City implemented an increasing block, or conservation, rate structure. The current structure encourages customers to use their water more efficiently by charging higher rates for the higher volumes of water used. See Table 5.1 for Lubbock's volume block rates as of December 2012. Additional details regarding Lubbock's current and historic water rates are located in Appendix C-1.

Table 5.1 – Lubbock's Current Volume Rates

	Block 1	Block 2	Block 3
Monthly Rates per 1,000 Gallons	$4.00	$5.46	$6.55

Figure 5.5 compares the City's water rates to those of 16 other major Texas cities with populations over 150,000 during January 2012 (see Appendix C-2). The monthly water bills used in this comparison include the base charge, volume charges, and water supply fees (if applicable). The following cities were used in the comparison:

Amarillo	Arlington	Austin	Brownsville
Corpus Christi	Dallas	El Paso	Fort Worth
Garland	Grand Prairie	Houston	Irving
Laredo	Pasadena	Plano	San Antonio

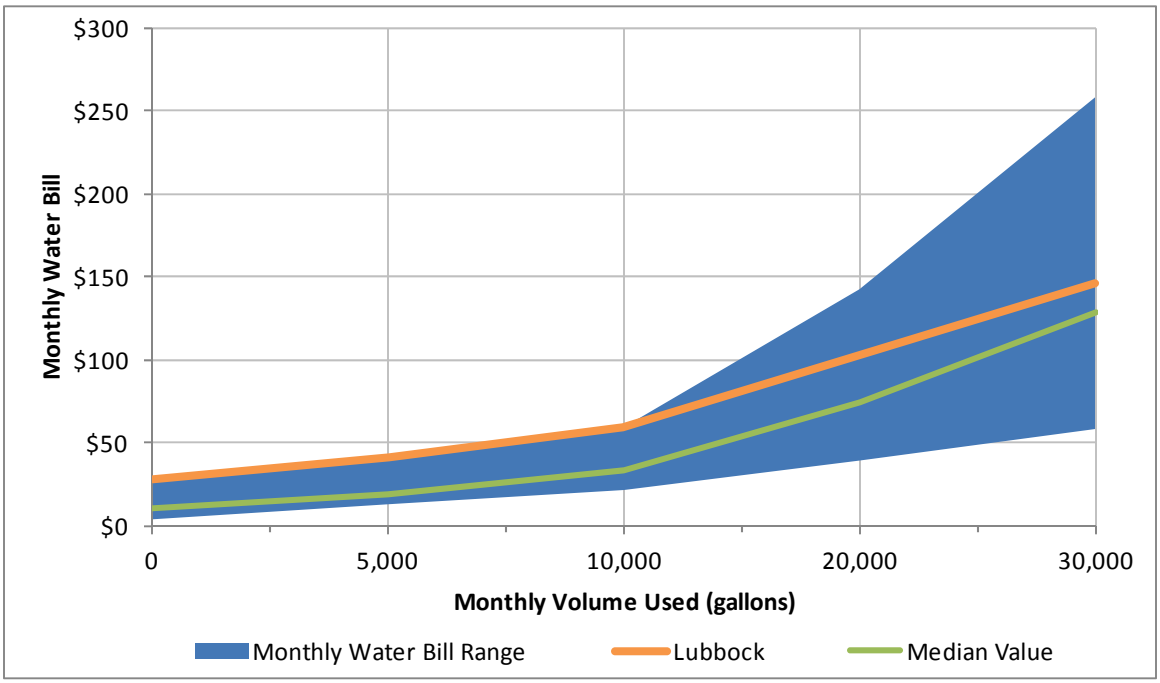


Figure 5.5 – 2012 Residential Water Bill Comparison for Major Texas Cities
(rates shown for 5/8″ and/or 3/4″ meters)

The City of Lubbock's rate structure attempts to optimize three competing goals that all water systems must seek to balance. These goals are revenue stability, water conservation, and affordability.

- **Revenue stability** is strengthened by covering a portion of the City's debt through the base rate.
- **Water conservation** is facilitated through an increasing volume block rate structure.
- **Affordability** is addressed by seeking to set base charges and Block 1 volume rates at reasonable levels.

Overall, Lubbock's water rates have encouraged customers to conserve and use water more efficiently under normal weather conditions. During drought conditions, additional conservation measures may be necessary.

5.4 Unaccounted for Water Loss

One important method of conserving water is to reduce the amount of unaccounted for water lost from the system. The City's water system's historic unaccounted for water as a percent of the total water used in the system is depicted in Figure 5.6. The figure includes AWWA's 2007 Distribution System Water Loss benchmark for water purveyors in the South region of the United States. Over half of the purveyors achieve 8.9% or lower water loss in this region. The top 25% achieves 3.8% or lower. The bottom 25% achieves 14.1% or lower.[8]

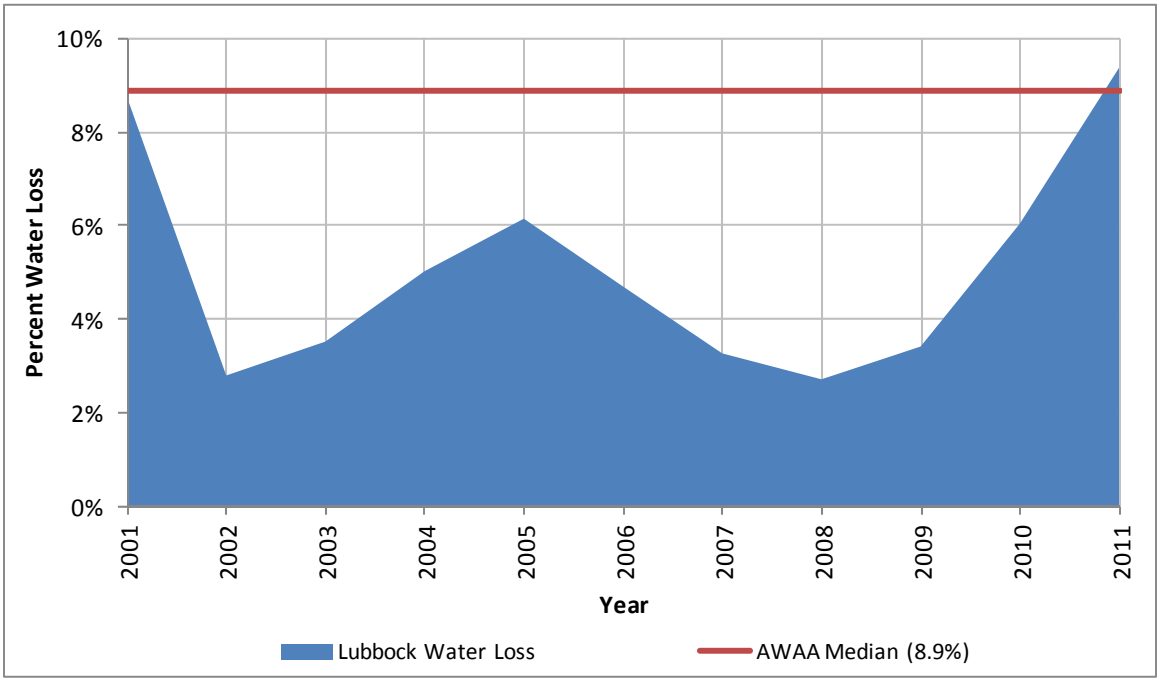


Figure 5.6 – City of Lubbock Water Loss History

The City's goal is to keep water losses below 10% for its delivery system.[9] As depicted in Figure 5.3, the City has been successful in meeting this goal. In 2011, water losses were at 9%. The City seeks to continually improve this measure by implementing effective meter change out, construction meter control, and water main repair and replacement programs.

Water Main Replacement Program

This program attempts to manage the replacement of old water lines that are prone to leaks and breaks. In the past 5 years, the City has spent more than $20 million on the replacement of aging pipelines and valves, including the 34th Street and Downtown Waterline Replacement projects. The City routinely monitors the water system for leaks. The goal is to repair detected and/or reported leaks in a timely manner.

Meter Change-out Program

The City uses a random sampling technique to test meter accuracy and to determine when meters need to be repaired or replaced. The City randomly samples approximately 400 water meters each year. Depending on the results of this sample, additional sampling may be done to target meters of a certain age or meters located within a certain geographical portion of the City. Meters found to have an accuracy of less than +/- 4% are either repaired or replaced as appropriate.

Fire Hydrant - Construction Meter Program

This program attempts to meter water used from fire hydrants by construction contractors and City departments. Contractors lease the fire hydrant meters and are billed at the Block 2 rate for water used. Any City department using water from a fire hydrant must also use a fire hydrant meter.

5.5 Public Education Effort

Public education is a crucial component of the City's water conservation efforts. To make wise water-use decisions, customers must be equipped with accurate information and knowledge about how they can help. The goal of the Water Conservation Education Team (WCET) is to raise awareness and disseminate information about water conservation issues in the City. The WCET focuses on reaching people through public school programs, community outreach events, and irrigation consultations.

Figure 5.7 shows how the City's water conservation effort has shifted over the last eight years from public school lessons to TCEQ mandated irrigation inspections. This shift was necessary due to limited financial resources. Moreover, properly

operating irrigation systems can significantly reduce the amount of water wasted each year.

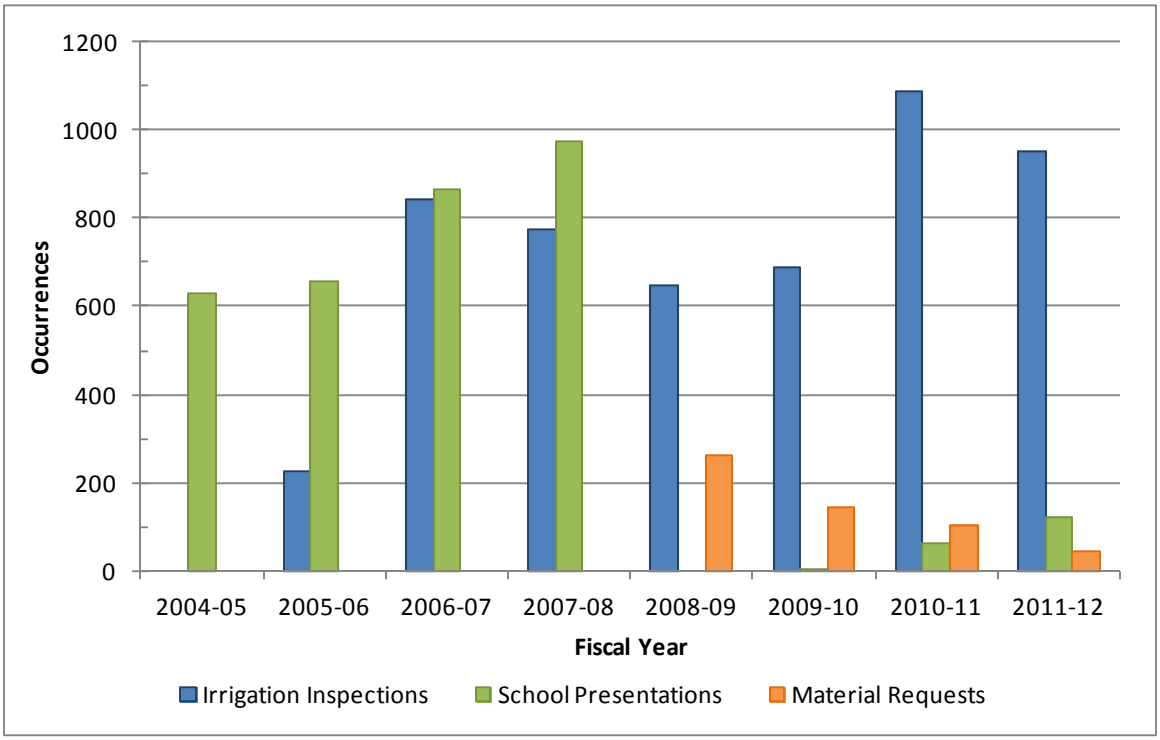


Figure 5.7 – Water Conservation Education Outreach

Public-School Programs

The City started the WCET in 1996 to coordinate and implement educational programs that allow students (kindergarten through 12th grade) to explore the science of water and become familiar with water stewardship concepts. The program is free of charge and consists of nineteen interactive presentations (see Appendix C-3). Teachers can either request that the City's educator give the presentation, or teachers can use the lesson plans that are available on-line (http://water.ci.lubbock.tx.us/education/allEdu.aspx).

The public school program reached its peak during the 2003-2004 school year. At that time, the WCET included three educators who gave 1,313 classrooms presentations reaching approximately 26,260 students. During the 2011-2012 school year, the program was much smaller with one educator on staff who taught or provided material for 165 lessons.

Annual Home & Garden Show

The WCET has participated in the annual West Texas Home Builder's Home and Garden Show since 2001. Each year 6,000-8,000 citizens attend. The WCET is present to provide information, answer questions, make presentations, and support the community-wide water conservation effort through home and landscape design.

SmartScape Promotion Programs

The WCET works with the Lubbock Chamber of Commerce's water conservation council and Lubbock Master Gardeners to promote Texas SmartScape. The SmartScape program encourages the use of native, water-efficient landscaping. The Texas SmartScape website (www.txsmartscape.com) provides detailed information about designing a water-efficient landscape with a list of over 200 water-efficient plants for the West Texas region. It also provides landscape design tools that help citizens create blueprints for new landscape plans.

Demonstration Gardens and Homes

The WCET works with local sponsors and businesses to develop demonstration gardens, model landscaping, and homes featuring Texas SmartScape materials. Many of the homes are included in the annual West Texas Home Builder's Parade of Homes, which are on display for citizens to tour for a two week period. As many as 10,000 citizens attend annually.

Local Water Conservation Conferences

The WCET participates in annual conferences sponsored by organizations that promote water conservation and provide a forum for the public to participate and learn about energy and water efficient home practices and technologies, water-efficient landscapes, and earth-kind practices.

Irrigation Consultations

The City's irrigation inspectors routinely conduct one-on-one consultations with customers on the proper use of their sprinkler systems. These consultations typically become necessary while performing inspections on irrigation systems. The inspectors assist homeowners and businesses in optimizing their sprinkler system by determining proper "cycle and soak" run times. When requested, they reset customer controllers to optimal settings.

5.6 Existing Water Conservation Ordinances

The City Council has adopted ordinances that encourage customers to avoid wasting water. These ordinances include:

A *Water Rate Ordinance* (Sec. 22.03.081 - 22.03.097) that defines the City's conservation block rate structure where higher rates apply to higher volumes of water consumed.

A *Waste of Water Ordinance* (Sec. 22.03.131 – 22.03.134) that outlines water use standards for outdoor landscapes. These standards identify the times of day that sprinklers can be used (between 6:00 p.m. and 10:00 a.m. from April to September), as well as recognizing that the City may, at times, enact watering schedules, limiting the number of times customers can water their landscape during a given day or week.

A *Water Use Management Plan* (Sec. 22.08.001 – 22.08.103) that promotes water conservation by providing an implementation plan for annual water conservation and drought contingency measures.

5.7 Potential Water Conservation Strategies

Numerous conservation strategies across the United States are used by municipalities in an effort to reduce their annual water demand and peak summer usage. Conservation strategies are categorized as mandatory or voluntary measures. Research has found that mandatory conservation measures tend to result in greater water savings.[10] Both mandatory and voluntary measures can cost a municipality a substantial amount of money to track and/or enforce. The following potential conservation strategies provide a variety of ways to reduce water usage.

More Stringent Seasonal Water Restrictions Strategy

A large percentage of Lubbock's water is used for seasonal irrigation. Lubbock is situated in a semi-arid region that requires more water per capita for landscape irrigation than in many other parts of Texas. Evidence of landscape irrigation demand is apparent when comparing Lubbock's average summer (April through September) water usage of 177 gpcd to the average winter (October through April) water usage of 128 gpcd. This means that approximately 48 gpcd is used during the summer (the difference between average summer and average winter usages) on outdoor landscape irrigation, swimming pools, etc. This totals approximately 34 ac-ft/day. Implementing increased seasonal water restrictions would help reduce the City's non-essential seasonal water usage by limiting the amount of water applied to outdoor landscapes and by limiting the number of days each household can water.

Program Details – Implement a year round outdoor water use restriction that limits each facility to watering landscape with irrigation systems to two days per week on specified days. The suggested landscape application should be less than 1.5 inches per week. For detailed calculations on this strategy, see Appendix C-4.

Water Conserved – It is estimated that this program will reduce seasonal water usage by 15%. This equates to a reduction in water usage of 916 ac-ft/yr.

Program Costs – The cost associated with this strategy includes staff time for amending the current water conservation ordinance and enforcement of the ordinance. The City already has code enforcement officers that check for compliance with water use and conservation ordinances.

Revenue Impact - If 916 ac-ft are conserved each year due to this strategy (assuming that 75% of the water conserved is from Block 2 and 25% is from Block 3), the City will experience a reduction in revenue of $1,710,781 each year.

Increase Water Volume Rates Strategy

Under Lubbock's current water rate structure, Block 1 usage represents a household's base or essential water needs, while Block 2 and Block 3 account for a household's seasonal or non-essential water usage. Increasing Block 2 and Block 3 water rates encourages customers to reduce their seasonal or non-essential water usage.

Strategy Details – Increase Block 2 and Block 3 rates by 10% each. Currently, the Block 2 rate is $5.46 per 1,000 gallons and the Block 3 rate is $6.55 per 1,000 gallons. This strategy would result in increases of $0.55 and $0.66 per 1,000 gallons, respectively. For detailed calculations on this strategy, see Appendix C-5.

Water Conserved – A 2008 water rate study by the National Bureau of Economic Research revealed that a 10% increase in water rates can result in a 3% to 6% reduction in water demand.[11] Applying a 3% reduction to Lubbock's 5-year average annual water demand (37,375 ac-ft/yr) results in savings of 329 ac-ft annually.

Program Costs – This strategy would not cost additional funds for the City to implement and administer. Using volume rates to promote water conservation does not require the City to make an investment of time or capital to enforce water usage.

Revenue Impact –The City will lose revenue on the 329 ac-ft/yr of water that will be conserved. This loss will be offset by the additional revenue that the City will earn due to the rate increase from the volume of water that continues to be used from Blocks 2 and 3 (~10,955 ac-ft/yr). Overall, the City could experience a net gain in revenue of $1,309,967 per year. Rate changes must be made incrementally and cautiously to make sure that revenue stability is not disrupted due to dramatic decreases in water use.

Indoor Water Fixtures Replacement Strategy

This strategy consists of improving water use efficiency by providing rebate incentives for residential, commercial, and institutional facilities for the replacement of fixtures such as toilets, washing machines, and showerheads. Potential programs are discussed below.

<u>Toilet Replacement Rebate for Schools and Universities</u>

Program Details – $90 rebate to replace old toilets with new high-efficiency toilets in public schools and university dorms. For detailed calculations on this strategy, see Appendix C-6.

Water Conserved – Many of the local schools and dorms have toilets pre-dating 1992 which use between 3.0 and 5.0 gallons per flush (gpf). New toilets use 1.6 gpf. The estimated annual water conserved with this program is 283 ac-ft/yr.

Program Costs – This strategy would cost the City approximately $402,030 to administer.

Revenue Impact – This strategy would reduce revenue each year by approximately $368,797, assuming the water conserved is from Block 1 usage.

Washing Machine Rebate

Program Details – The City would offer $300 rebates to replace old commercial washing machines with new high-efficiency machines, and $150 rebates to replace old residential washing machines in apartment complexes and university dorms with new high-efficiency residential machines. For detailed calculations on this strategy, see Appendix C-7.

Water Savings – A case study by Western Resource Advocates found that conversion from an older commercial washer to a newer high-efficiency commercial machine saves approximately 37,800 gallons a year.[12] Estimated water savings for Lubbock commercial washers are 76.6 ac-ft/yr. Replacing older residential washers with new high-efficiency residential machines saves approximately 8,500 gallons a year per machine.[13] However, a typical residential machine only serves 2-5 people whereas apartment complex / university dorm washing machines serve 8-10 people. Therefore, estimated water savings are higher for these washing machines because they are being used more frequently. Estimated water savings for these fixture replacements are 81.5 ac-ft/yr. Total water conserved for the washing machine program is 158.1 ac-ft/yr.

Program Costs – The total program cost is estimated to be $463,650.

Revenue Impact – This strategy would reduce revenue each year by approximately $206,052, assuming that the water conserved is from Block 1 usage.

Residential Showerhead Rebate

Program Details –The City would offer $10 rebates for showerheads to each residential Lubbock Water Utility customer. For detailed calculations on this strategy, see Appendix C-8.

Water Savings – The 1992 Water Saving Performance Standards require that all showerheads meet 2.5 gpm flow rates. It is estimated that an average household in Lubbock (3.35 people) can save 5,500 gallons per year by switching to these low-

flow showerheads. With 10% customer participation, Lubbock could save 116 ac-ft/yr with this program.

Program Costs – With 10% customer participation, this strategy would cost the City $68,530.

Revenue Impact – This strategy would reduce revenue each year by approximately $150,880, assuming that the water conserved is from Block 1 usage.

Landscape Rebate Strategy

As discussed above, a large percentage of the City's water during the summer months is used to maintain residential and commercial landscaping. Landscape rebates are a voluntary conservation measure with a goal of reducing seasonal water usage.

Program Details –Offer a $0.25 rebate per every 1 ft^2 of traditional grass lawn that is removed and replaced with trees and SmartScape or Xeriscape. For detailed calculations on this strategy, see Appendix C-9.

Water Savings – Over the last five years, Lubbock's residential water customers have used an average of 3,741 gallons of water per month per connection during the growing season (May through September). It is estimated that if a property installs SmartScape or Xeriscape, the residence's seasonal water usage could be reduced by 50%.[14] Assuming that 10% of residential customers decide to use this rebate program, it is estimated that this program will reduce the City's water usage by 106 ac-ft/yr.

Program Costs – This strategy would cost the City approximately $770,951 in rebates if 10% of residential customers participate in this rebate program.

Revenue Impact – The annual reduction in revenue created by this strategy is estimated at $198,613, assuming that 75% of the water conserved is from Block 2 and 25% is from Block 3.

Public Education and Awareness Strategy

The aim of public education and awareness is to change water-wasting behaviors. This can often be hard to quantify and measure, but educating the public does help create behavioral changes in the way water is used. Consider the following examples:

- A Lubbock homeowner that irrigates a 1/4-acre lawn uses approximately 540 – 810 gallons per cycle or watering interval (12-18 gpm x 15 minutes x 3 zones). If this homeowner irrigates twice a week for 6 months (April-September), he uses 25,920 – 38,880 gallons per year. By manually initiating each cycle when needed by the landscape (rather than turning the system to automatic), a household can save approximately 50% of their outdoor usage.[15] In this example, this homeowner could save 12,960 – 19,440 gallons of water per year.
- On average, the residential faucet runs 8.1 minutes per person per day.[16] In Lubbock, that adds up to 4,090,990 gallons a day. If every person engaged in water-saving behavior that resulted in a one minute decrease in faucet-use per day (i.e. by turning the faucet off while brushing teeth or shaving, etc.), the City could save over 500 ac-ft/yr.
- The average household does approximately 1 load of laundry each day.[17] If every household reduced clothes washing from 7 times a week to just 6 times a week (this can be accomplished by washing larger loads of clothes at one time), the City could save approximately 435 ac-ft/yr.

Increased public awareness can be achieved through education and advertising. As discussed in Section 5.5, Lubbock currently has an education program that reaches all ages of people through public-school programs, community out-reach programs, and irrigation consultations. Additionally, as in 2003–2010 when the Water Department had a successful series of radio and television campaigns, the City may choose to advertise through local media outlets to bring attention to important regional water issues.

Strategies to Reduce Unaccounted-for Water

The City will continue to look for ways to decrease its water losses. Leak detection programs and audits will be helpful. At a minimum, the City will conduct a water audit using the methodology outlined by the TWDB every five years in accordance with current TWDB rules. Water audits may be conducted on a more frequent basis if the City deems that action to be appropriate. The City has allocated approximately $1 million per year

over the next 5 years to the replacement of aging water lines that are prone to breaks and leaks.

Summary of Conservation Strategies

Table 5.2 provides a summary of some of the conservation strategies discussed in this section. The table compares the amount of water that could potentially be saved each year, the estimated cost to implement the programs, and the potential impact to the City's revenues. The More Stringent Seasonal Water Restrictions strategy appears to conserve the most water annually.

Table 5.2 – Summary of Conservation Strategies

Strategy	Water Saved (ac-ft/yr)	Cost to Implement Program	Change in Annual Revenue
More Stringent Seasonal Water Restrictions	916	$0	-$1,710,781
Increase Non-Essential Water Volume Rates	329	$0	$1,309,967
Public School and University Toilet Replacement	283	$402,030	-$308,797
Commercial, Apartment, & Dorm Washing Machine Replacement	158	$463,650	-$206,052
Residential Showerhead Replacement	116	$68,529	-$,150,880
Landscape Rebate	106	$770,951	-$198,613
TOTAL	1,907	$1,705,160	-$1,325,156

[1] City of Lubbock Code of Ordinances; Water Use Management Plan. Article 22.08.034.

[2] Texas Administrative Code. Title 30; Part 1; Chapter 288; Subchapter A; Rule 288.2; section (a); subsection (1) (C).

[3] Texas Water Development Board Special Report: Report to the 79th Legislature. Water Conservation Implementation Task Force. Austin, TX. 2004: 31-33.

[4] State of Texas Health and Safety Code; Water Saving Performance Standards. Section 372.002.

[5] Waskom, R. and M. Neibauer. "Water Conservation In and Around the Home." Colorado State University; Consumer Series, Housing: Fact Sheet No. 9.952. 2010: 1.

[6] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: 4-108.

[7] Mayer, P.W., W.B. DeOreo, E.M. Opitz, J.C. Kiefer, W.Y. Davis, B. Dziegielewski, and J.O. Nelson. Residential End Uses of Water. AWWA Research Foundation and American Water Works Association. 1999: ES 6.

[8] Benchmarking – Performance Indicators for Water and Wastewater Utilities: 2007 Annual Survey Data and Analyses Report. American Water Works Association. 2007: 6.

[9] City of Lubbock Code of Ordinances; Water Use Management Plan. Article 22.08.034.

[10] Renwick, M.E. and R.D. Green. Do Residential Water Demand Side management Policies Measure Up? An Analysis of Eight California Water Agencies. Journal of Environmental Economics and Management. 2000: (40) 51.

[11] Olmstead, S. M. and R.N. Stavins. Comparing Price and Non-Price Approaches to Urban Water Conservation. National Bureau of Economic Research, Working Paper Series. 2008: 8.

[12] Hern, T., T. Hutchins-Cabibi, B. Miller, and N. Theerasatiankul. Smart Savings Water Conservation: Measures that Make ¢ents. Western Resource Advocates. 2008: ES 4.

[13] Hern, T., T. Hutchins-Cabibi, B. Miller, and N. Theerasatiankul. Smart Savings Water Conservation: Measures that Make ¢ents. Western Resource Advocates. 2008: ES 4.

[14] Hurd, Brian H. Water Conservation and Residential Landscapes: Household Preferences, Household Choices. Journal of Agricultural and Resource Economics. 2006: vol 31(2), 175.

[15] Mayer, P.W. , W.B. DeOreo, E.M. Opitz, J.C. Kiefer, W.Y. Davis, B. Dziegielewski, and J.O. Nelson. Residential End Uses of Water. AWWA Research Foundation and American Water Works Association. 1999: ES 16.

[16] Mayer, P.W. , W.B. DeOreo, E.M. Opitz, J.C. Kiefer, W.Y. Davis, B. Dziegielewski, and J.O. Nelson. Residential End Uses of Water. AWWA Research Foundation and American Water Works Association. 1999: ES 8.

[17] Mayer, P.W. , W.B. DeOreo, E.M. Opitz, J.C. Kiefer, W.Y. Davis, B. Dziegielewski, and J.O. Nelson. Residential End Uses of Water. AWWA Research Foundation and American Water Works Association. 1999: ES 7.

6.0 Reclaimed Water Strategies

The use of reclaimed water (treated wastewater or effluent) is considered an important water supply strategy in the 2012 State Water Plan.[1] The State Water Plan predicts that by 2060, reclaimed water will represent over 10% of the water produced by all water strategies in Texas. Since Lubbock must import its potable water from such long distances, reusing water makes economical and practical sense. Using reclaimed water can reduce dependency on new water supplies. Various types of reclaimed water uses are discussed in the following section.

6.1 Types of Reclaimed Water Uses

Reclaimed water can be used for a variety of beneficial uses depending on the level of wastewater treatment. This includes both non-potable and potable uses.

Non-Potable Reuse

Non-potable reuse is the process of conveying treated wastewater effluent to an end-user for beneficial uses such as irrigation, manufacturing, or power generation. The effluent may need to go through additional treatment by the end user depending on the final use of the water. Reclaimed water used in this way can reduce demand on the City's potable water supply, which is more expensive due to the costs to transport, treat, and deliver potable water to customers. 30 Texas Administrative Code (TAC) Chapter 210.32 identifies the following two types of non-potable reclaimed water uses.

> *Type I Reclaimed Water* is defined as using reclaimed water where contact between humans and the water is likely. Examples of this type of use include landscape irrigation, public golf course irrigation, fire protection, and toilet or urinal flushing.
>
> *Type II Reclaimed Water* is defined as using reclaimed water where contact between humans and the water is unlikely. Examples of this type of use include dust control, cooling tower applications, irrigation of food crops where the reclaimed water is not expected to come in direct contact with the edible part of the crop, and maintenance of impoundments or natural water bodies where direct human contact is not likely.

In order for the City to reuse Type I and II reclaimed water, it must maintain an authorization from the TCEQ pursuant to 30 TAC Chapter 210 (commonly referred to as a "210 Authorization"). The City is preparing to file an "Application for Authorization to Use Domestic Reclaimed Water" with the TCEQ expanding the potential non-potable reuses of its treated wastewater.

The City has not deployed a widespread reclaimed water distribution system since most potential users have opted to use more economical local groundwater supplies. Currently the City's non-potable reuse customers include two private cotton farming operations and the Xcel (Southwestern Public Service) Jones Power Plant.

> *Private Cotton Farming Operations* – In May 2012, the City entered into new contracts with two cotton farmers to supply them Type II reclaimed water under the current 210 Authorization from the TCEQ. The City is not obligated to provide a specific amount of water to the farmers. The contracts expire in 2015.
>
> *Xcel Energy – Jones Power Plant* - In May 1968, the City entered into a contract with Southwestern Public Service (now Xcel Energy) to supply up to 7.7 mgd of reclaimed water to the Jones Power Plant located a few miles southeast of the City's water reclamation plant. The contract was amended in 1992 to send a total of 7.0 mgd. Then, in July 2009, the City amended the contract again to supply up to 9.0 mgd to the Jones Power Plant until 2045.[2] Jones Power Plant typically uses less than 5.0 mgd throughout the year.

Indirect Reuse

Indirect reuse is the process of discharging treated effluent into the "bed and banks of a river" allowing it to flow downstream to a point where it is captured and pumped back into the raw water supply for treatment to potable standards. Water that is discharged into a river basin for conveyance downstream requires a permit from the TCEQ before it can be re-diverted. Several of the City's potential water supply strategies utilize this process.

Direct Potable Reuse

Direct potable reuse is the process of transporting treated wastewater through a pipeline back to the raw water supply used for potable purposes. The wastewater will go through additional advanced treatment barriers before being injected back into the raw water supply. The primary concerns associated with the use of reclaimed water to supplement the water supply include regulatory limitations and public perception. Particular challenges to public acceptance of reuse projects include: perceptions of health risks, the source of recycled water, the issue of choice and options, trust and knowledge, and the cost of recycled water. A successful project will need to address these public acceptance issues. Direct potable reuse strategies are evaluated in Sections 6.5 and 6.6.

6.2 Existing Reclaimed Water Infrastructure

Over the past decade, specific improvements have been undertaken by the City to improve the quality of effluent produced at the Southeast Water Reclamation Plant (SEWRP) so it can be discharged into the North Fork of the Double Mountain Fork of the Brazos River (North Fork). The SEWRP currently consists of two operating treatment facilities, Plants 3 and 4. Plant 1 was taken out of service and demolished. Currently, Plant 2 is not being used to treat wastewater. Plants 3 and 4 are connected at the headworks of the SEWRP, but function independently until the plants discharge into two effluent pumping stations (EPS-1 and EPS-2). Recent Plant 4 modifications completed in 2012 include a conversion of the conventional activated sludge process with aeration basins to biological nutrient removal (BNR) utilizing an Integrated Fixed-film Activated Sludge (IFAS) process. Effluent from the two plants are filtered through new cloth media units and disinfected with an ultraviolet (UV) disinfection system prior to discharge or disposal.

Digester and sludge handling improvements are underway. These improvements will also improve the quality of the effluent. In order for all of the City's effluent to meet stream discharge requirements, Plant 3 will need to be upgraded in a similar manner as Plant 4 has been. The design of Plant 3 improvements is scheduled to begin in 2017. Improvements are estimated to be completed by 2021. By increasing the quality of the effluent, the City achieves greater flexibility in how it can beneficially reuse its reclaimed water. The existing SEWRP layout is depicted in Figure 6.1.

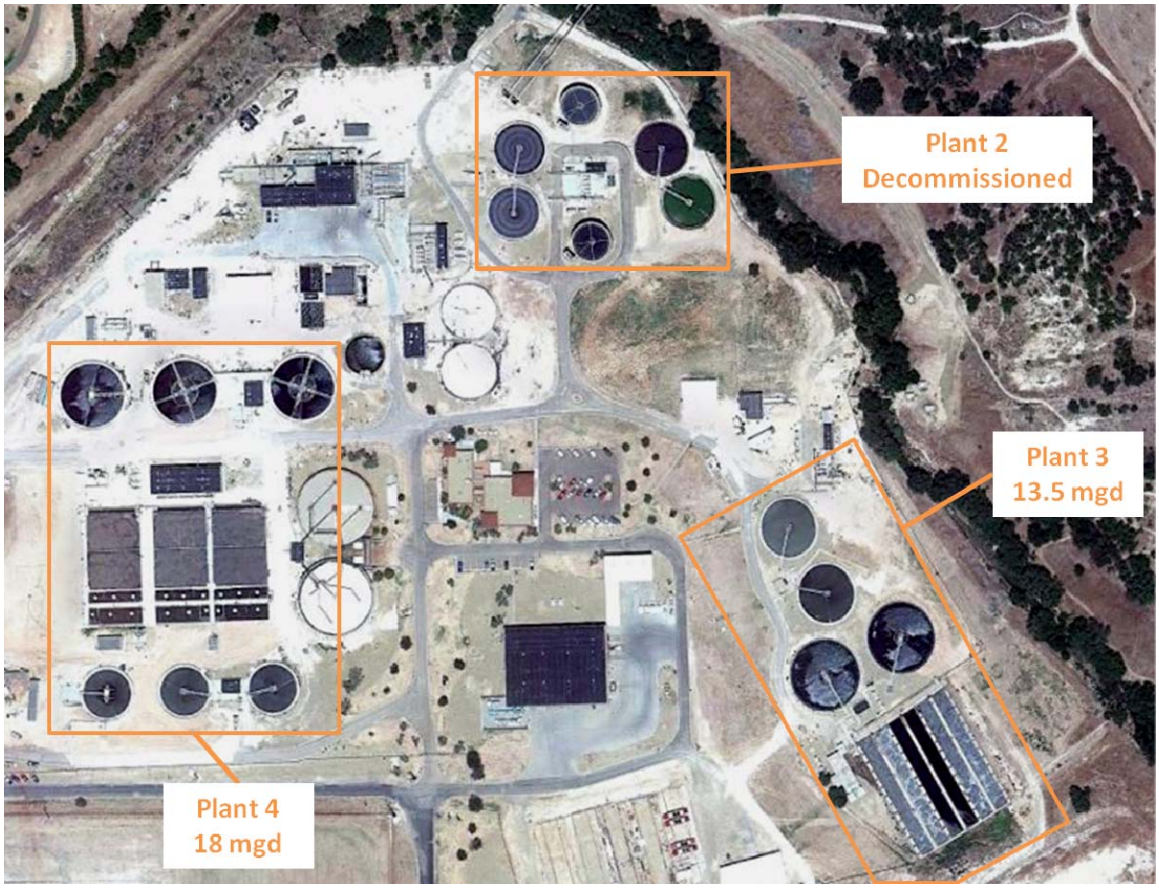


Figure 6.1 – Southeast Water Reclamation Plant (SEWRP) Layout

The current location of the effluent pipeline with its associated capacity is important in the evaluation of potential reuse strategies. Some reuse strategies may require modifications to the treatment and discharge facilities. Figure 6.2 shows a schematic of the existing reclaimed water effluent pipeline configuration.

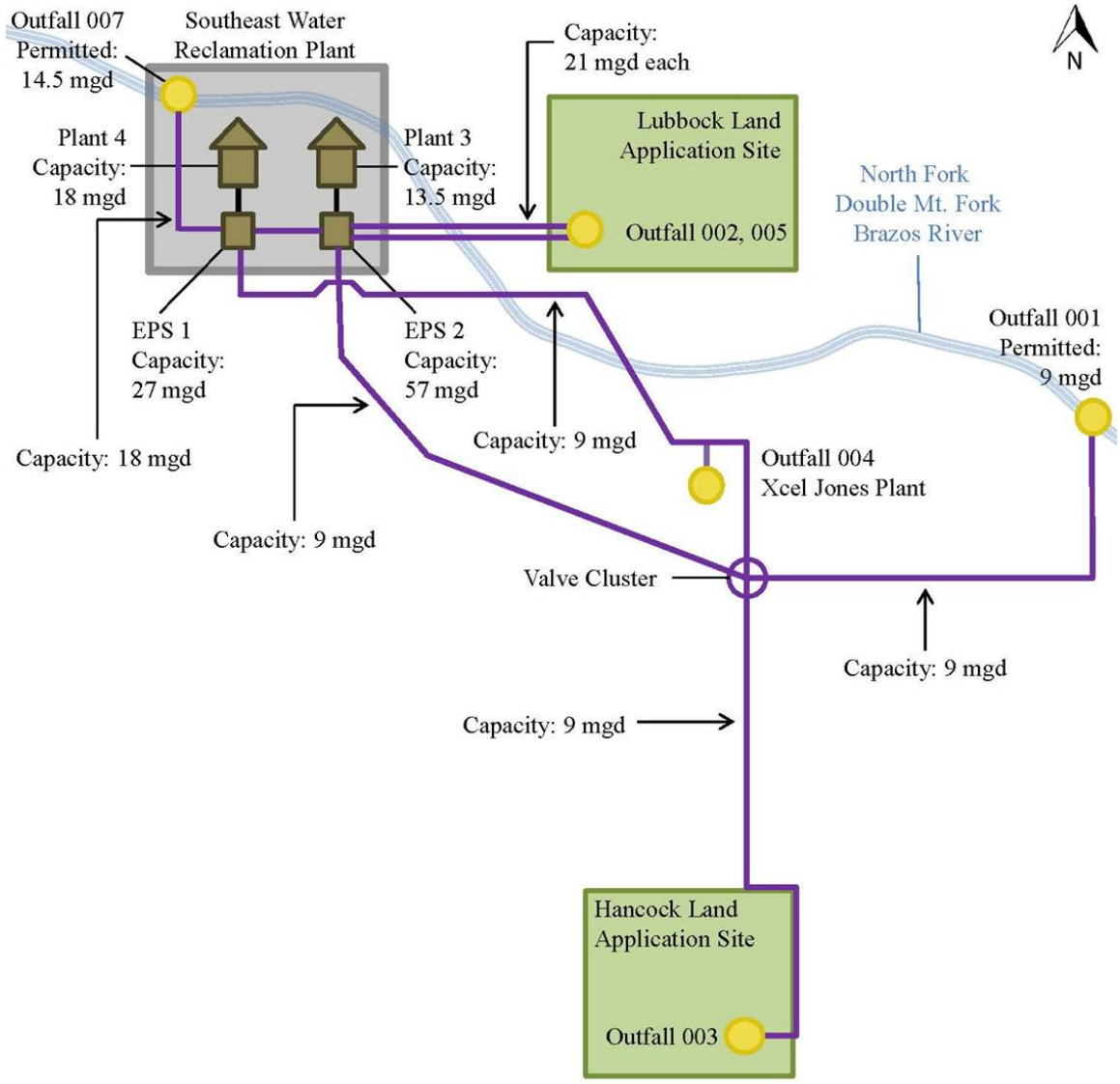


Figure 6.2 – Wastewater Effluent Pipeline System Schematic

The permitted outfalls are labeled on the map. Only two of the currently permitted outfalls allow discharges into the North Fork. Outfall 001 is located at the intersection of FM 400 and the North Fork. Outfall 007 is located next to the SEWRP at the North Fork.

6.3 Available Reclaimed Water

Reclaimed water volume projections are necessary to determine when associated water supply strategies will become viable options. Volume projections are developed by multiplying estimated population by the estimated per capita wastewater effluent usage each year.

Population

Population projections were calculated using the City's population and growth rates discussed in Section 2.1. However, the populations of the four communities that receive potable water from the City were not included in these projections since they operate their own wastewater collection and treatment systems. The Probable Growth scenario is used (as described in Section 2.1) to develop the reclaimed water projections.

Per Capita Wastewater Usage

The City has experienced an average decrease of 1.2% per year in its per capita wastewater usage since 1995. Due to conservation and reuse, most large cities in Texas are continuing to experience decreasing per capita wastewater flows. Therefore, Lubbock's future per capita wastewater usage was determined by using 2012's per capita usage of 80 gpcd as a baseline and reducing the gpcd for 100 years until it reaches 65 gpcd. The City's wastewater flows have dropped as low as 65 gpcd during some months of the year. This usage projection is used in determining the reclaimed water demand projections.

Gross Reclaimed Water Demand

Lubbock's annual Reclaimed Water Demand (RWD) projections consist of a scenario which was developed using the Probable Growth scenario and the per capita wastewater usage described in the preceding paragraphs.

> *Probable RWD* (Probable Growth x Per Capita Wastewater Usage) – This scenario is the most likely projection since it includes probable population growth projections.

A comparison of this Plan's RWD projections to the City's 2009 Wastewater Master Plan[3] and the 2012 Canyon Lakes Water Reuse Preliminary Engineering Report[4] is depicted in Figure 6.3 (see Appendix D-1).

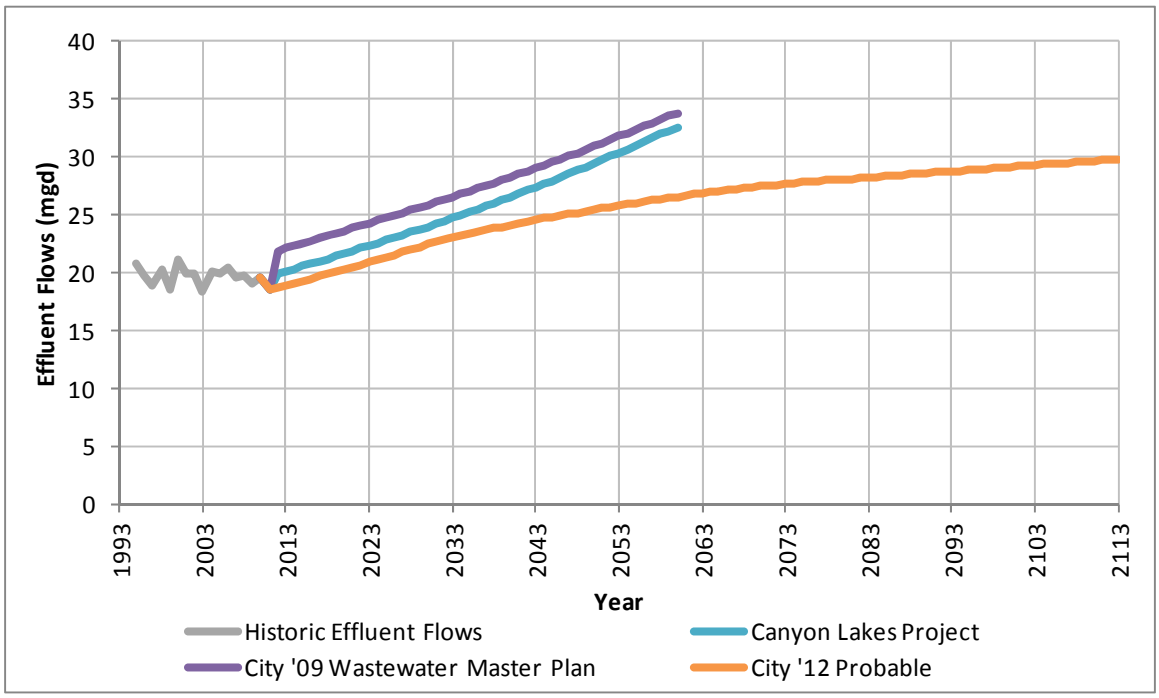


Figure 6.3 – Reclaimed Water Demand Projections

Note that the City's 2009 Wastewater Master Plan and the 2012 Canyon Lakes Water Reuse Report only project wastewater demands to 2060. The Probable Demand scenario projects that the following total volume of reclaimed water will be available for reuse in the designated years:

- 19 mgd (21,151 ac-ft/yr) by the year 2013
- 21 mgd (23,872 ac-ft/yr) by the year 2025
- 27 mgd (30,084 ac-ft/yr) by the year 2063
- 30 mgd (33,379 ac-ft/yr) by the year 2113

Net Reclaimed Water Availability

Electric generation and land application commitments must be subtracted from the total RWD in order to determine how much reclaimed water will be available for potable water supply strategies. Therefore, the following assumptions have been made.

Electric Power Generation – It is anticipated that existing electric power generation demand for reclaimed water will be approximately 9 mgd until 2019. In 2019, additional electric power generation capacity may be added in the Lubbock region. For natural gas power plants, it is estimated that 1 mgd will be required for each 100 megawatts (mw) of power generated.

The following estimated power generation will require reclaimed water by 2019:

Xcel's Jones Power Plant	700 mw	9 mgd
LP&L Cooke Power Plant	200 mw	2 mgd
New Natural Gas Power Plant	500 mw	5 mgd
Total	1,400 mw	16 mgd

It is anticipated that in 2045 (Xcel's Jones Power Plant contract expiration), the Xcel contract will be renegotiated to match more closely the actual reclaimed water that is needed for electric power generation. Therefore, the total electric power commitment drops by 2 mgd in 2045. Within the next 50 years, improvements in technology should reduce the amount of water needed for power generation. Consequently, in 2063 (50 years), the allocation of reused water for power production will reduce by roughly one-third, from 14 mgd to 9 mgd.

Land Application Operations – It is anticipated that it will take a minimum of 4 mgd of effluent to keep Lubbock Land Application Site (LLAS) and 4 mgd of effluent to keep the Hancock Land Application Site (HLAS) operational. Projections assume that by 2019, the LLAS will be reduced in its size and the HLAS site will be decommissioned. Therefore, the combined reclaimed water commitment to the land application sites will drop from 8 mgd in 2013 to 2 mgd in 2019.

Figure 6.4 depicts the projected net reclaimed water that will be available for water supply projects. In addition, it depicts the water reserved for electric power generation and land application operations. Appendix D-2 includes a table of available net reclaimed water projections.

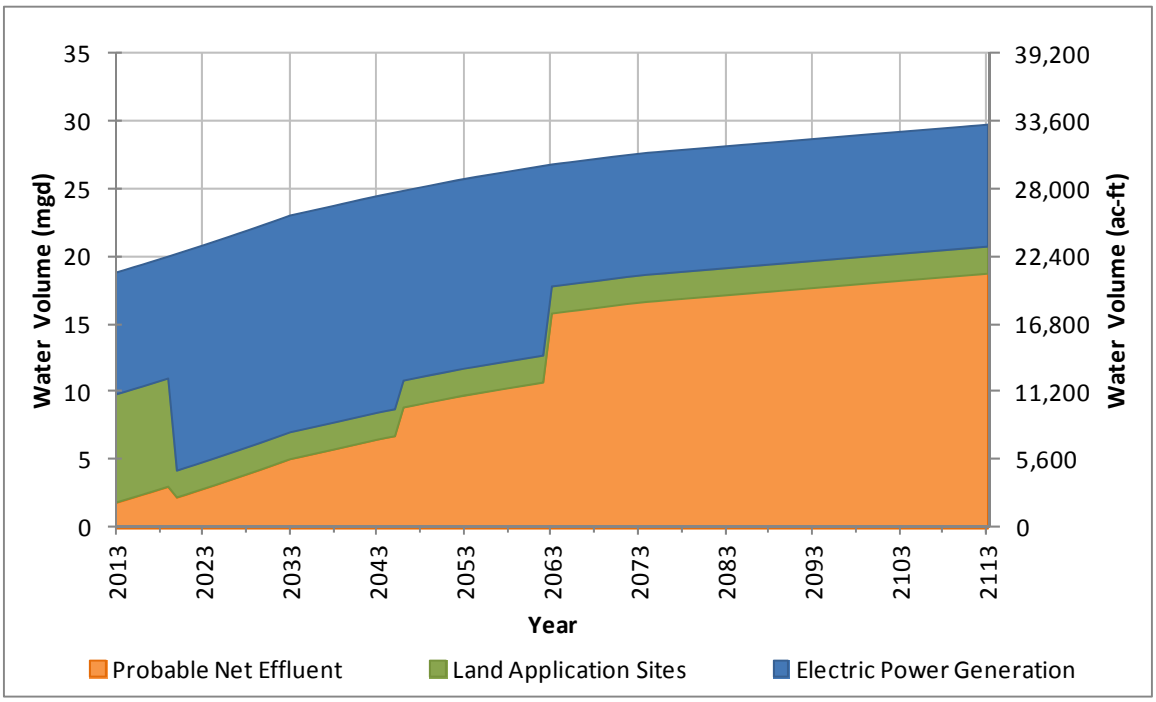


Figure 6.4 – Net Reclaimed Water Availability

In the following sections, six water supply strategies are presented that rely upon the net reclaimed water available during a given year. Both direct and indirect reuse strategies are discussed. Without the availability of reclaimed water, these strategies are not viable options. Each of the strategies utilizes the same reclaimed water source. As a result, if one of the strategies is implemented, it may necessitate the elimination or downsizing of other strategies using the same reclaimed water source.

6.4 North Fork Diversion at County Road 7300 Strategy

The North Fork Diversion at County Road (CR) 7300 Strategy is considered an indirect reuse strategy. The City of Lubbock is permitted to discharge 9 mgd of treated effluent at Outfall 001 located at the intersection of Farm-to-Market Road (FM) 400 and the North Fork (see Figure 6.2). With this strategy, the City will construct a diversion facility 2.7 river miles downstream from Outfall 001 to recapture the discharged effluent. After capture, the water (reclaimed effluent commingled with actual flows) will be pumped through the transmission line to the SWTP. An expansion of the SWTP and a new transmission pipeline between Pump Station (PS) #14 and the Low Head B by-pass line will be necessary to make this strategy viable.

The major design features of this strategy include:

- Design flows associated with the intake, pump station, and transmission pipeline estimated at 5% downtime;
- A new intake structure and a 1,136 horsepower (hp) pump station at the CR 7300 crossing to divert the City's water from the North Fork;
- An 8-mile, 24-in transmission pipeline to deliver the water to the SWTP;
- A 4-mile, 42-in transmission pipeline to connect PS #14 to the Low Head B by-pass line that feeds PS #7 (see Figure 4.12); and
- An expansion of the SWTP capacity and the associated high service pump station by 9 mgd.

Figure 6.5 depicts the relative locations of the CR 7300 infrastructure needed.

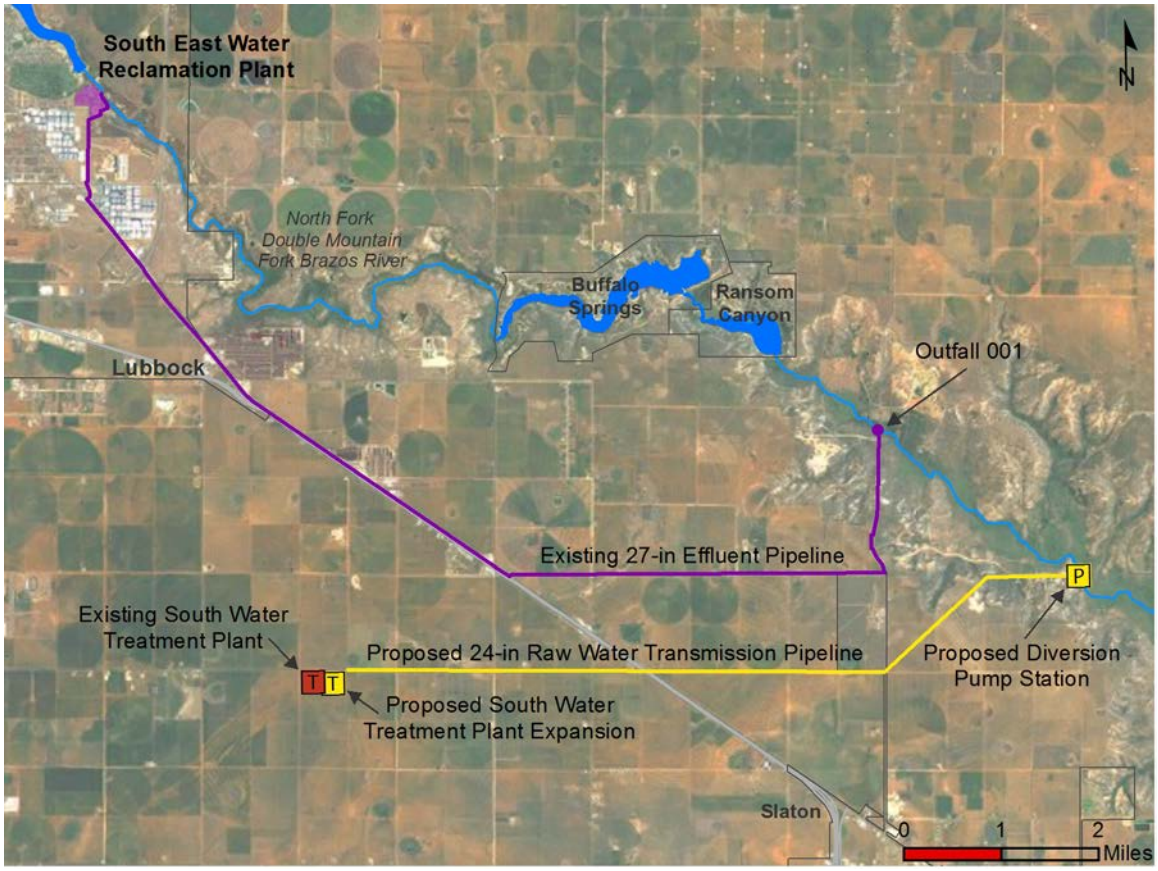


Figure 6.5 – North Fork Diversion at County Road 7300 Map

Quantity of Available Water

This strategy is estimated to provide a peak capacity of 9 mgd and an average capacity of 10,089 ac-ft/yr of reclaimed water for treatment at the SWTP. Carriage losses within the 2.7 miles of stream bed of the North Fork are considered negligible. A similar strategy in the 2011 Region O Plan[5] assumes that the City will discharge as much as 16,444 ac-ft/yr in 2060 from Outfall 001. However, current estimates of the net available reclaimed water for this strategy are less than was estimated in the 2011 Region O Plan.

Strategy Costs

Costs associated with this strategy are presented in Table 6.1. Assumptions and conditions associated with these costs include:

- Existing infrastructure will be used for transmission of treated water from the SWTP into the City's water distribution system;
- Energy costs and upgrades to PS #14 are not included with the transmission pipeline costs;
- Engineering, legal, and contingency costs are 30% of pipeline construction and 35% of other facilities constructed;
- Power is available at $0.09 per kilowatt-hour (kwh);
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period; and
- The project will be financed for 20 years at a 5.5% annual interest rate.

Table 6.1 –North Fork Diversion at County Road 7300 Costs

Cost Estimate Summary / March 2012 Prices	
Item	**Costs**
Capital Costs	
Intake and Pump Station (9.5 mgd)	$9,644,000
Transmission Pipeline	
24-in dia., 8 miles (raw water to line to SWTP)	$4,759,000
42-in dia., 4 miles (PS #14 to Low Head B By-Pass Line)	$6,708,000
SWTP Expansion (9 mgd)	$16,522,000
Total Capital Cost	**$37,633,000**
Engineering, Legal Costs, and Contingencies	$12,598,000
Environmental & Archaeology Studies and Mitigation	$201,000
Land Acquisition and Surveying (37 acres)	$278,000
Interest During Construction (2 years)	$3,550,000
Total Project Cost	**$54,260,000**
Annual Costs	
Debt Service (5.5%, 20 years)	$4,540,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$356,000
SWTP	$1,419,000
Pumping Energy Costs (0.09 $/kwh)	$635,000
Total Annual Cost	**$6,950,000**
Available Project Yield (ac-ft/yr)	10,089
Annual Cost of Water ($ per ac-ft)	$689
Annual Cost of Water ($ per 1,000 gallons)	$2.11

Costs prepared by HDR Engineering, Inc.

As shown, the total project cost is estimated to be $54,260,000. Annual debt service is $4,540,000; and, annual operational cost, including power, is $2,410,000. This results in a total annual cost of $6,950,000. The unit cost for 9 mgd or 10,089 ac-ft/yr supply of water is estimated to be $689 per ac-ft, or $2.11 per 1,000 gallons.

Implementation Issues

Environmental Issues

The primary environmental issue related to this strategy includes the construction of the diversion facilities. Therefore, there will be a potential impact on animal habitats which must be mitigated. Studies will be necessary to determine the actual impact to cultural resources, wetlands, and threatened and endangered species. However, the construction of the diversion facilities should have a low to moderate impact relative to most of these concerns.

Permitting Issues

The City started discharging at Outfall 001 in May 2003 pursuant to Texas Pollutant Discharge Elimination System (TPDES) Permit No. 10353-002. Outfall 001 is permitted to discharge a maximum of 9.0 mgd (10,089 ac-ft/yr). In April 2004, the City filed an amendment to Water Use Permit 3985 with the TCEQ. The amendments approval was delayed due to a contested case hearing regarding ownership of developed water return flows. The TCEQ ruled on the case and issued the City the Water Use Permit in December 2012. This permit authorizes the diversion of up to 10,089 ac-ft annually (minus 0.47% carriage losses) at the CR 7300 facility. Additional permitting will be required to construct the proposed diversion facility.

Other Issues

Property will need to be acquired at the proposed diversion location. In addition, pipeline utility easements will be necessary to construct a raw water transmission line to the SWTP.

6.5 Direct Potable Reuse to NWTP Strategy

This strategy includes advanced treatment with multiple barriers before transporting and discharging up to 9 mgd of reclaimed water into the raw water supply pipeline immediately upstream of the NWTP. The project processes reclaimed water from the SEWRP through advanced treatment (reverse osmosis (RO)) to create a water supply that should be higher quality than the City's other raw water sources. The treated reclaimed water will be pumped to the NWTP where it will be blended with other raw water from CRMWA and undergo conventional treatment for distribution to customers. Human health risks for direct potable reuse are equal or less than those of other water supply sources when full advanced treatment is used (RO, advanced oxidation, and disinfection). These processes are effective at removing identified emerging constituents of concern and other contaminants, including pathogens, from treated wastewater.

The major design features of this strategy include:

- The NWTP has an existing capacity adequate to treat and distribute the additional 9 mgd of reclaimed water. Therefore, an expansion of the NWTP is <u>not</u> necessary;
- A 9 mgd advanced water treatment plant (RO) at the Lubbock SEWRP;
- A Dockum Aquifer well with 200 feet of additional piping to dispose of the RO concentrate at the SEWRP; and
- A new 636 hp pump station at the SEWRP to deliver the treated reclaimed water to the NWTP via a new 24-in, 6-mile transmission pipeline.

Figure 6.6 depicts the relative locations of the infrastructure needed for the Direct Potable Reuse to NWTP strategy.

Figure 6.6 – Direct Potable Reuse to NWTP Map

Quantity of Available Water

This strategy is designed to treat and deliver an average of 9 mgd (10,089 ac-ft/yr) of treated reclaimed water to the NWTP each year.

Strategy Costs

Costs associated with this strategy are presented in Table 6.2. Assumptions and conditions associated with these costs include:

- Concentrate reject from the RO plant will be injected into the Dockum Aquifer;
- Engineering, legal, and contingency costs are 30% of pipeline construction and 35% of other facilities constructed;
- Power is available at $0.09 per kwh;
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period;
- The project will be financed for 20 years at a 5.5% annual interest rate; and
- The project is assumed to have a 2-year construction period.

Table 6.2 – Direct Potable Reuse to NWTP Costs

Cost Estimate Summary / March 2012 Prices	
Item	**Costs**
Capital Costs	
Transmission Pipeline	
24-in dia., 6 miles (SEWRP to NWTP)	$5,163,000
Pump Station at SEWRP	$4,266,000
Advanced Water Treatment at SEWRP (9 mgd, RO)	$36,356,000
Dockum Aquifer Injection Well (RO Waste Disposal)	$750,000
Total Capital Cost	**$46,535,000**
Engineering, Legal Costs, and Contingencies	$16,029,000
Environmental & Archaeology Studies and Mitigation	$0
Land Acquisition and Surveying (28 acres)	$217,000
Interest During Construction (1 year)	$4,395,000
Total Project Cost	**$67,176,000**
Annual Costs	
Debt Service (5.5%, 20 years)	$5,621,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$166,000
Advanced Water Treatment Plant	$2,384,000
Pumping Energy Costs (3,115,767 kwh @ 0.09 $/kwh)	$356,000
Purchase of Water (ac-ft/yr @ $/ac-ft)	$0
Total Annual Cost	**$8,527,000**
Available Project Yield (ac-ft/yr)	10,089
Annual Cost of Water ($ per ac-ft)	$845
Annual Cost of Water ($ per 1,000 gallons)	$2.59

Costs prepared by HDR Engineering, Inc.

As shown, the total cost is estimated to be $67,176,000. Annual debt service is $5,621,000; and annual operational cost, including power, is $2,906,000. This results in a total annual cost of $8,527,000. The unit cost for 10,089 ac-ft/yr of supply at the NWTP is estimated to be $845 per ac-ft, or $2.59 per 1,000 gallons. This cost does not include the distribution of the potable water from the NWTP to potential customers.

Implementation Issues

Environmental Issues

Since the RO treatment facilities are being constructed on property owned by Lubbock that is currently being used for similar purposes, environmental issues should be minimal. The transmission line corridor that will convey the reclaimed water should be selected to avoid potentially sensitive areas.

Permitting Issues

The TCEQ is currently developing potable reuse guidance requirements to be applied to proposed projects and to be used as the basis for reviewing permit applications. Treatment requirements for any reclaimed water as a drinking water source may consider the pretreatment program, influent wastewater quality, vulnerability assessment of the collection system, results of effluent quality sampling/monitoring data, and wastewater treatment process.

Monitoring is likely to include Cryptosporidium (or a surrogate organism), other regulated contaminants, and may include contaminants on the U.S. Environmental Protection Agency (USEPA) Candidate Contaminate List (CCL), including Emerging Constituents of Concern (ECCs) and pharmaceuticals and personal care products (PPCPs).

Other Issues

Advanced treatment design considerations should include:

- multiple process barriers;
- redundancy and backup power sources;
- alternate storage or discharge locations to divert reclaimed water from the potable distribution system during an acute episode; and
- real time monitoring and regular sampling to ensure process performance and avoid any acute episode of pathogens in the reclaimed water.

6.6 Direct Potable Reuse to SWTP Strategy

This strategy includes advanced treatment with multiple barriers before transporting and discharging up to 9 mgd of reclaimed water into the raw water supply pipeline immediately upstream of the SWTP. The project processes reclaimed water from the SEWRP through advanced treatment (RO) to create a water supply that will be higher quality than the City's other raw water sources. The treated reclaimed water will be pumped to the SWTP and be blended with other raw water supplies and treated again prior to being introduced into the distribution system. Human health risks for direct potable reuse are equal or less than those of other water supply sources when full advanced treatment is used (reverse osmosis, advanced oxidation, and disinfection). These processes are effective for removing identified emerging constituents of concern and other contaminants, including pathogens, from treated wastewater.

The major design features of this strategy include:

- Property for the SEWRP expansion and SWTP expansion is owned by the City;
- A 9 mgd RO water treatment plant constructed at the SEWRP;
- A 1,900 ft. Dockum Aquifer injection well will be constructed to dispose of concentrate reject water generated from the RO plant;
- A 0.45 mg ground storage tank and 500 hp pump station will be constructed at the SEWRP;
- A 7.5 mile, 24-inch diameter transmission pipeline to deliver RO water to the SWTP.
- A 9 mgd expansion of the SWTP's treatment facilities; and
- A 4-mile, 42-in transmission pipeline to connect PS #14 to the Low Head B by-pass line that feeds PS #7 (see Figure 4.12)

Figure 6.7 depicts the relative locations of the infrastructure needed for the Direct Potable Reuse to SWTP strategy.

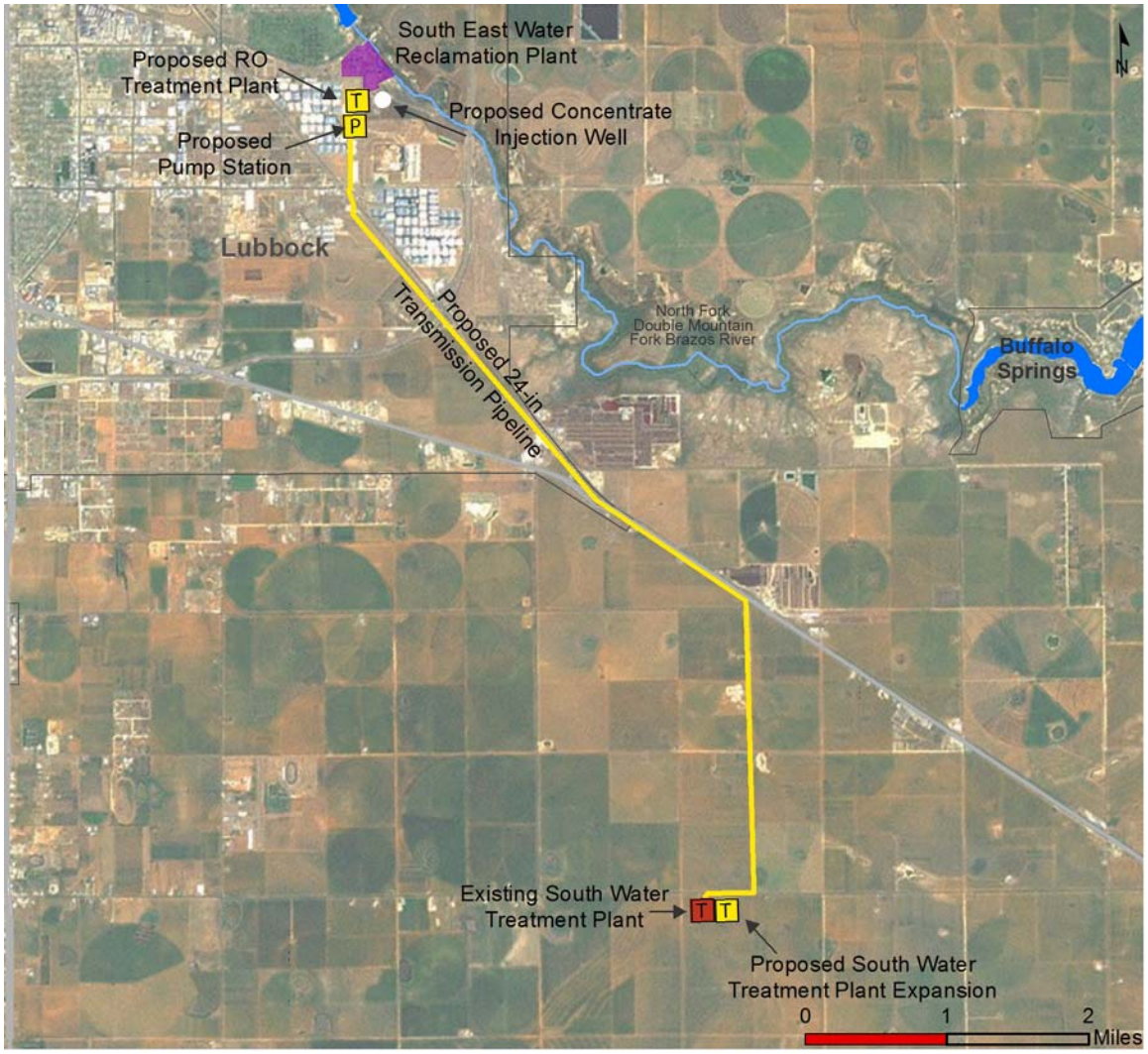


Figure 6.7 – Direct Potable Reuse to SWTP Map

Quantity of Available Water

This strategy is designed to treat and deliver a peak amount of 9 mgd and an average amount of 10,089 ac-ft/yr of treated effluent to the SWTP.

Strategy Costs

Costs associated with this strategy are presented in Table 6.3. Assumptions and conditions associated with these costs include:

- Concentrate reject from the RO plant will be injected into the Dockum Aquifer;
- Right-of-way for pipeline is estimated at $8,712/acre;
- Engineering, legal, and contingency costs are 30% of pipeline construction and 35% of other facilities constructed;
- Power is available at $0.09 per kwh;
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period; and
- The project will be financed for 20 years at a 5.5% annual interest rate.

Table 6.3 – Direct Potable Reuse to SWTP Costs

Cost Estimate Summary / March 2012 Prices	
Item	**Costs**
Capital Costs	
Transmission Pipeline	
24-in dia., 7.5 miles (from SEWRP to SWTP)	$5,924,000
42-in dia., 4 miles (PS #14 to Low Head B By-Pass Line)	$6,708,000
Transmission Pump Station(s)	$2,760,000
Advanced Water Treatment at SEWRP (9 mgd, RO)	$36,356,000
SWTP Expansion (9 mgd)	$16,522,000
Dockum Aquifer Injection Well (RO Waste Disposal)	$750,000
Total Capital Cost	**$68,390,000**
Engineering, Legal Costs, and Contingencies	$23,336,000
Environmental & Archaeology Studies and Mitigation	$285,000
Land Acquisition and Surveying (129 acres)	$443,000
Interest During Construction (2 years)	$3,236,000
Total Project Cost	**$95,690,000**
Annual Costs	
Debt Service (5.5%, 20 years)	$8,007,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$191,000
Water Treatment Plants	$3,803,000
Pumping Energy Costs (3,115,767 kwh @ 0.09 $/kwh)	$280,000
Purchase of Water (ac-ft/yr @ $/ac-ft)	$0
Total Annual Cost	**$12,281,000**
Available Project Yield (ac-ft/yr)	10,089
Annual Cost of Water ($ per ac-ft)	$1,217
Annual Cost of Water ($ per 1,000 gallons)	$3.74

Costs prepared by HDR Engineering, Inc.

As shown, the total cost is estimated to be $95,690,000. Annual debt service is $8,007,000; and, annual operational cost, including power, is $4,274,000. This results in a total annual cost of $12,281,000. The unit cost for a 10,089 ac-ft/yr peaking supply is estimated to be $1,217 per ac-ft, or $3.74 per 1,000 gallons.

Implementation Issues

Environmental Issues

Since the RO treatment facilities are being constructed on property owned by Lubbock that is currently being used for similar purposes, environmental issues should be minimal. The transmission line corridor that will convey the raw water to the SWTP should be designed to avoid any potentially sensitive areas.

Permitting Issues

The TCEQ is currently developing potable reuse guidance requirements to be applied to proposed projects and to be used as the basis for reviewing permit applications. Treatment requirements for any reclaimed water as a drinking water source may consider the pretreatment program, influent wastewater quality, vulnerability assessment of the collection system, results of effluent quality sampling/monitoring data, and wastewater treatment process.

Monitoring is likely to include Cryptosporidium (or a surrogate organism), other regulated contaminants, and may include contaminants on the USEPA Candidate Contaminate List (CCL), including Emerging Constituents of Concern (ECCs) and pharmaceuticals and personal care products (PPCPs).

Other Issues

Advanced treatment design considerations should include:

- multiple process barriers;
- redundancy and backup power sources;
- alternate storage or discharge locations to divert reclaimed water from the potable distribution system during an acute episode; and
- real time monitoring and regular sampling to ensure process performance and avoid any acute episode of pathogens in the reclaimed water.

6.7 South Fork Discharge Strategy

Another potential indirect reuse strategy includes the discharge of treated effluent into the South Fork of the Double Mountain Fork of the Brazos River (South Fork) to increase the firm yield of LAH.[6] The City operates an existing pipeline that transports reclaimed water from the SEWRP to the Hancock Land Application Site (HLAS) located north of the community of Wilson, Texas. This strategy extends the existing reclaimed water pipeline from the HLAS to a tributary on the South Fork enabling the City to discharge up to 9 mgd of reclaimed water into the South Fork. The discharged water will flow downstream and be stored in LAH. The additional water will be pumped to the SWTP via the LAH raw water pipeline.

The major design features of this strategy include:

- A new 9 mgd pump station at the HLAS;
- An 18-mile, 24-in transmission pipeline to discharge reclaimed water into the South Fork tributary;
- A stilling basin located at the discharge point of the 24-in transmission pipeline;
- Expansion of the LAHPS and Post Pump Station (PPS);
- The construction of the Southland Pump Station (SLPS);
- A 7.3 mgd expansion of the SWTP and associated high service pump station; and
- A 4-mile, 42-in transmission pipeline connecting PS #14 to the Low Head B by-pass line (see Figure 4.12).

Figure 6.8 depicts the relative locations of the South Fork Discharge infrastructure needed.

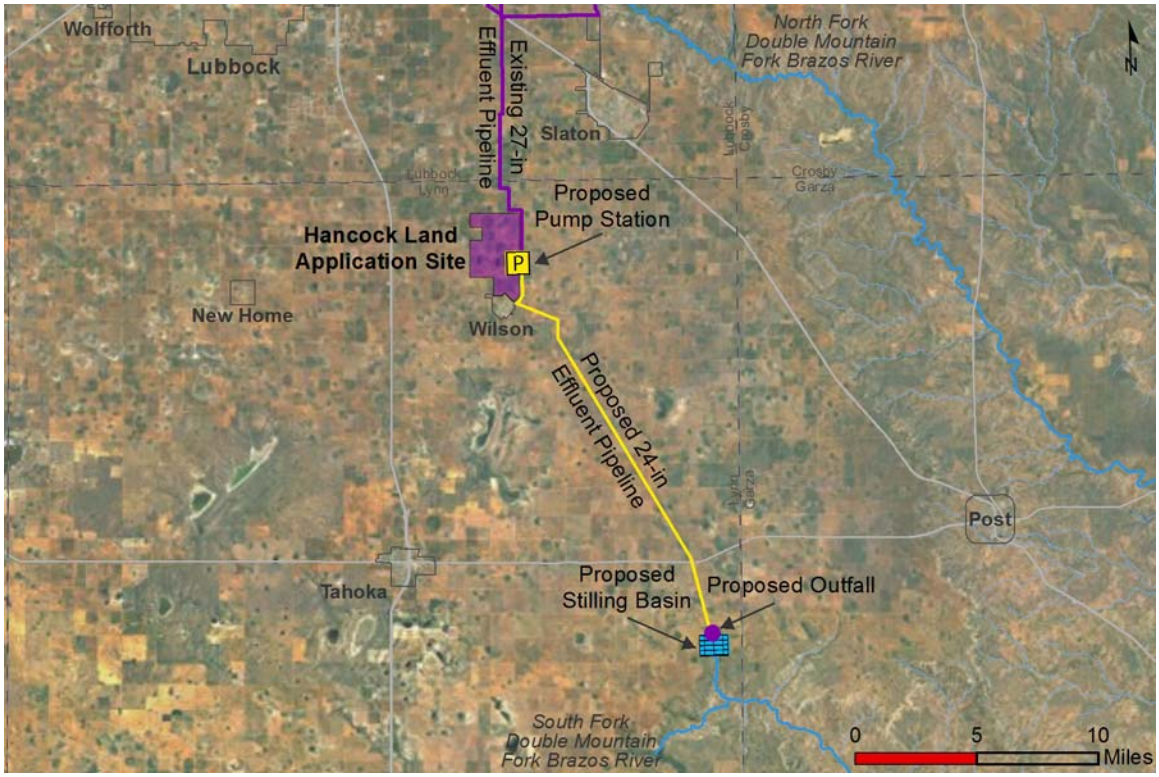


Figure 6.8 – South Fork Discharge Map

Quantity of Available Water

The City will discharge up to 9 mgd of reclaimed water into the South Fork tributary. The water will flow 36 river miles to LAH where the water will be stored until it is pumped back to the SWTP. Carriage losses from the discharge point to LAH are estimated to be 19% or 1.7 mgd. Therefore, this strategy is estimated to provide an additional peak day of 7.3 mgd or an average of 8,183 ac-ft/yr of water supply.

Strategy Costs

Costs associated with this strategy are presented in Table 6.4. Assumptions and conditions associated with these costs include:

- Expansion costs for the LAHPS, PPS, and SLPS are included in costs;
- Energy costs to transmit water through the LAHPS and pipeline are included;
- Existing infrastructure will be used for transmission of treated water from the SWTP into the City's water distribution system;
- Energy costs and upgrades to PS #14 were not included in transmission pipeline costs;
- Engineering, legal, and contingency costs are 30% of pipeline construction and 35% of other facilities constructed;
- Power is available at $0.09 per kwh;
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period; and
- The project will be financed for 20 years at a 5.5% annual interest rate.

Table 6.4 – South Fork Discharge Costs

Cost Estimate Summary / March 2012 Prices	
Item	**Costs**
Capital Costs	
Intake and Pump Station (7.3 mgd)	$2,730,000
Transmission Pipeline	
24-in dia., 18 miles	$12,016,000
42-in dia., 4 miles (PS #14 to Low Head B By-Pass Line)	$6,708,000
Stilling Basin	$34,000
LAH Pipeline Pump Station Expansions	$9,437,000
SWTP Expansion (7.3 mgd)	$13,995,000
Total Capital Cost	**$44,920,000**
Engineering, Legal Costs, and Contingencies	$14,785,000
Environmental & Archaeology Studies and Mitigation	$433,000
Land Acquisition and Surveying (129 acres)	$616,000
Interest During Construction (2 years)	$4,254,000
Total Project Cost	**$65,018,000**
Annual Costs	
Debt Service (5.5%, 20 years)	$5,441,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$256,000
SWTP	$1,201,000
South Fork Pumping Energy Costs (0.09 $/kwh)	$188,000
LAH Pumping Energy Costs (0.09 $/kwh)	$1,747,000
Total Annual Cost	**$8,833,000**
Available Project Yield (ac-ft/yr)	8,183
Annual Cost of Water ($ per ac-ft)	$1,079
Annual Cost of Water ($ per 1,000 gallons)	$3.31

Costs prepared by HDR Engineering, Inc.

As shown, the total project cost is estimated to be $65,018,000. Annual debt service is $5,441,000; and, annual operational cost, including power, is $3,392,000. This results in a total annual cost of $8,833,000. The unit cost for 7.3 mgd or 8,183 ac-ft/yr of supply is estimated to be $1,079 per acre-foot, or $3.31 per 1,000 gallons.

Implementation Issues

Environmental Issues

This strategy should have minimal impact on the environment since the return flows will be discharged into an existing river basin. The discharge parameters dictated by the TCEQ in the TPDES discharge permit that will be required should ensure that the treated effluent does not impair this segment of the South Fork. Mitigation for the impact to wildlife habitats has already been accomplished for LAH.

Permitting Issues

The City's existing discharge permit (TPDES Permit WQ0010353002) will need to be amended to include an additional outfall on the South Fork. If the existing HLAS pipeline is used, the amendment must include a request to discharge up to 10,089 ac-ft annually into the South Fork. The current permit only authorizes the discharge of treated effluent at FM 400 and the North Fork (Outfall 001) and at the SEWRP (Outfall 007). A water rights permit will be required pursuant to the Texas Water Code Section 11.042 to authorize the conveyance and diversion of the associated return flows associated with the City's reclaimed water. In addition, authorization to construct the discharge facility will be required.

Other

Pipeline utility easements will be necessary to extend the existing reclaimed water pipeline to the South Fork. Easements will also be required for the construction of the stilling basin.

6.8 North Fork Diversion to Lake Alan Henry Pump Station Strategy

The North Fork Diversion to Lake Alan Henry Pump Station (NFD-LAHPS) is another potential indirect reuse strategy. Under this strategy, the City would discharge up to 9 mgd as permitted from Outfall 001. The water will travel approximately 67 miles downstream on the North Fork to the diversion site. Due to significant carriage losses, only 6.7 mgd of the discharged reclaimed water is estimated to be available for diversion. The water will then be pumped from the diversion site to the LAHPS. From the LAHPS, the water will be transported to the SWTP near Lubbock via the existing LAH raw water pipeline. The LAH pipeline's capacity was designed to transport up to 36 mgd of raw water (27 mgd of water from LAH and 9 mgd of water from other sources).

The major design features of this strategy include:

- Design flows associated with the intake structure adjusted for carriage losses;
- Design associated with the intake, diversion pump station, and transmission pipeline excludes downtime allocation;
- A new intake structure and a 394 hp pump station constructed at the diversion location.
- The intake structure and diversion pump station include a small coffer dam to allow for the diversion of the reclaimed water at low flows;
- A 5-mile, 27-in transmission pipeline to deliver the diverted water to the LAHPS;
- Expansion of the LAHPS and PPS;
- The construction of the SLPS;
- A 6.7 mgd expansion of the SWTP and associated expansion of the high service pump station at the SWTP; and
- A 4-mile, 42-in transmission pipeline connecting PS #14 to the Low Head B by-pass line (see Figure 4.12).

Figure 6.9 depicts the relative locations of the NFD-LAHPS infrastructure needed.

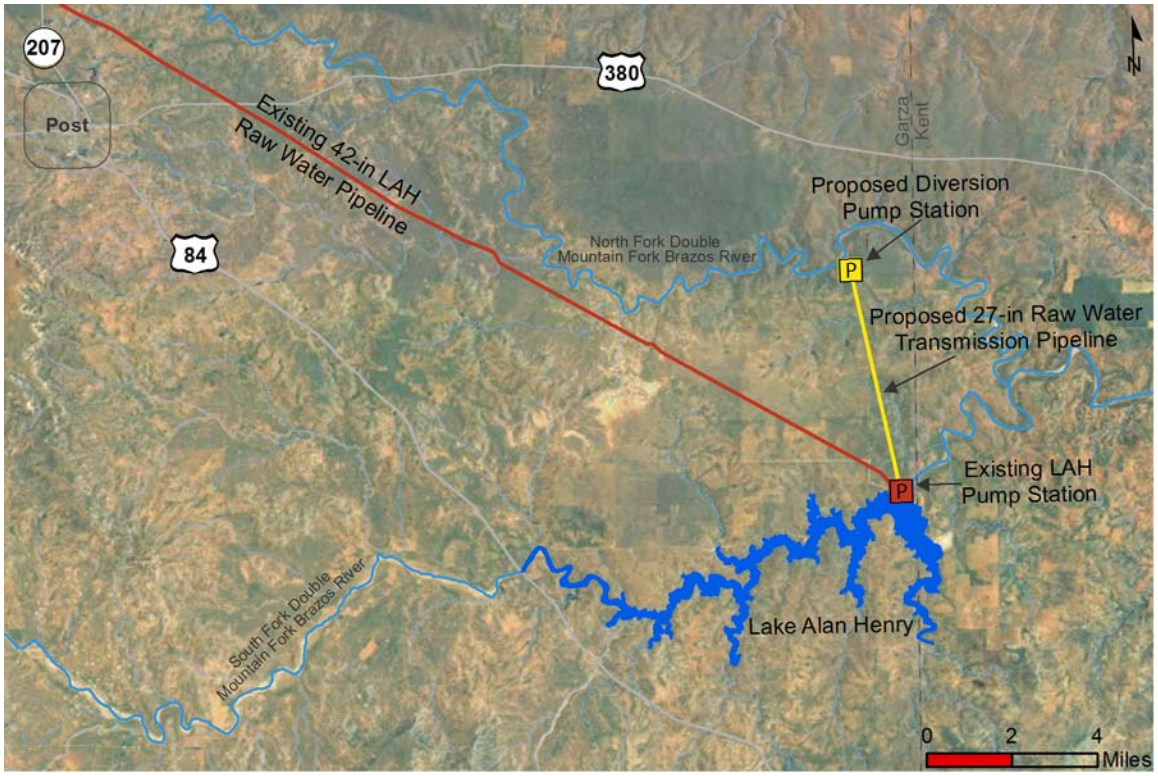


Figure 6.9 – North Fork Diversion to the Lake Alan Henry Pump Station Map

This strategy could be combined with the North Fork Scalping Operation strategy (diverting storm water flows) described in Section 8.5 since both strategies could utilize the same diversion dam and lake.

Quantity of Available Water

The strategy is estimated to provide a constant 6.7 mgd or 7,510 ac-ft/yr of reclaimed water for treatment at the SWTP. This quantity is calculated based on 9 mgd of treated effluent being discharged by the City at Outfall 001 and being reduced by approximately 26% due to carriage losses between the discharge and diversion points on the North Fork. A similar strategy in the 2011 Region O Plan[7] assumes that up to 17,444 ac-ft/yr would be available at the North Fork Diversion location by 2060. However, current estimates of the available reclaimed water for this strategy are less than was estimated in the 2011 Region O Plan.

Strategy Costs

Costs associated with this strategy are presented in Table 6.5. Assumptions and conditions associated with these costs include:

- Expansion costs for the LAHPS, PPS, and SLPS are included in costs;
- Energy costs to transmit water through the LAHPS and pipeline are not included;
- Existing infrastructure will be used for transmission of treated water from the SWTP into the City's water distribution system;
- Energy costs and upgrades to PS #14 were not included in transmission pipeline costs;
- Engineering, legal, and contingency costs are 30% of pipeline construction and 35% of other facilities constructed;
- Power is available at $0.09 per kwh;
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period; and
- The project will be financed for 20 years at a 5.5% annual interest rate.

Table 6.5 –North Fork Diversion to the Lake Alan Henry Pump Station Costs

Cost Estimate Summary / March 2012 Prices	
Item	**Costs**
Capital Costs	
Intake and Pump Station (6.7 mgd)	$4,508,000
Transmission Pipeline	
27-in dia., 5 miles	$3,372,000
42-in dia., 4 miles (PS #14 to Low Head B By-Pass Line)	$6,708,000
LAH Pipeline Pump Station Expansions	$9,077,000
SWTP Expansion (6.7 mgd)	$12,976,000
Total Capital Cost	**$36,641,000**
Engineering, Legal Costs, and Contingencies	$12,320,000
Environmental & Archaeology Studies and Mitigation	$141,000
Land Acquisition and Surveying (37 acres)	$194,000
Interest During Construction (2 years)	$3,451,000
Total Project Cost	**$52,747,000**
Annual Costs	
Debt Service (5.5%, 20 years)	$4,414,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$213,000
SWTP	$1,112,000
North Fork Pumping Energy Costs (0.09 $/kwh)	$220,000
LAH Pumping Energy Costs (0.09 $/kwh)	$1,601,000
Total Annual Cost	**$7,560,000**
Available Project Yield (ac-ft/yr)	7,510
Annual Cost of Water ($ per ac-ft)	$1,007
Annual Cost of Water ($ per 1,000 gallons)	$3.09

Costs prepared by HDR Engineering, Inc.

As shown, the total project cost is estimated to be $52,747,000. Annual debt service is $4,414,000; and, annual operational cost, including power, is $3,146,000. This results in a total annual cost of $7,560,000. The unit cost for 6.71 mgd or 7,510 ac-ft/yr supply is estimated to be $1,007 per ac-ft, or $3.09 per 1,000 gallons.

Implementation Issues

Environmental Issues

The primary environmental issue related to this strategy is the change in land use from ranchland to a low water dam. Therefore, there will be an impact on animal habitats which must be mitigated. Studies will be necessary to determine the actual impact to cultural resources, wetlands, and threatened and endangered species. However, the construction of the diversion lake should have a low to moderate impact associated with most of these concerns.[8] The sharpnose shiner and smalleye shiner exist along this part of the Brazos River Basin and may soon be included on the Federal threatened and endangered species list. Other threatened species that live in the region surrounding the North Fork include the Texas horned lizard and black-footed ferret.

Permitting Issues

The City started discharging at Outfall 001 in May 2003 under its existing discharge permit TPDES Permit 10353-002. Outfall 001 is permitted to discharge a maximum of 9.0 mgd (10,089 ac-ft/yr). In order to implement this strategy, the City would need to submit an application to the TCEQ for a new water use permit which includes a bed and banks authorization allowing for the transportation and diversion of up to 10,089 ac-ft annually (minus carriage losses) of the City's return flows at the diversion location. Additional permitting will be required to construct the proposed diversion facility.

Other Issues

The existing LAH raw water pipeline capacity is 38,112 ac-ft/yr.[9] If the North Fork Diversion to Lake Alan Henry Pump Station strategy is employed alone, and not in conjunction with the NFSO (see section 8.5), the capacity of the pipeline should be sufficient.

Property will need to be acquired at the proposed diversion location to accommodate the pumping facilities. In addition, pipeline utility easements will be necessary to construct a raw water transmission line to the LAHPS.

6.9 Reclaimed Water Aquifer Storage and Recovery Strategy

The Reclaimed Water Aquifer Storage and Recovery (ASR) Strategy will treat and transport reclaimed water from the SEWRP to an ASR facility located northeast of the City. The reclaimed water will then be injected into the Ogallala Aquifer and then recovered approximately 1.25 miles downgradient. The injected water is assumed to flow in a southeasterly direction. The recovered water will be delivered to the NWTP for disinfection and blending with other treated water from CRMWA for distribution to customers.

The major design features of this strategy include:

- Ten Ogallala ASR injection wells with spacing of 1,200 feet or greater with one contingency or standby well;
- Eight 700 gpm ASR recovery wells constructed at about 220 feet deep with horizontal spacing of 1,200 feet or greater with one contingency or standby well;
- A 9 mgd advanced water treatment plant (RO) at the Lubbock SEWRP;
- A Dockum Aquifer well used to dispose of the RO concentrate at the SEWRP;
- A new 552 hp pump station at the SEWRP to deliver the treated reclaimed water to ground storage at the well field via a new 24-in, 7-mile transmission pipeline;
- A booster pump station to deliver the reclaimed water from the ground storage to ASR wells for injection;
- A new 20-in, 2.5 mile pipeline to deliver the recovered water to the NWTP. Due to the relatively small quantity of water being recovered, a booster pump station and ground storage were not deemed necessary for delivery to the NWTP; and
- An expansion of the NWTP is necessary for additional chlorine disinfection.

Figure 6.10 depicts the relative locations of the Reclaimed Water ASR wells and associated infrastructure.

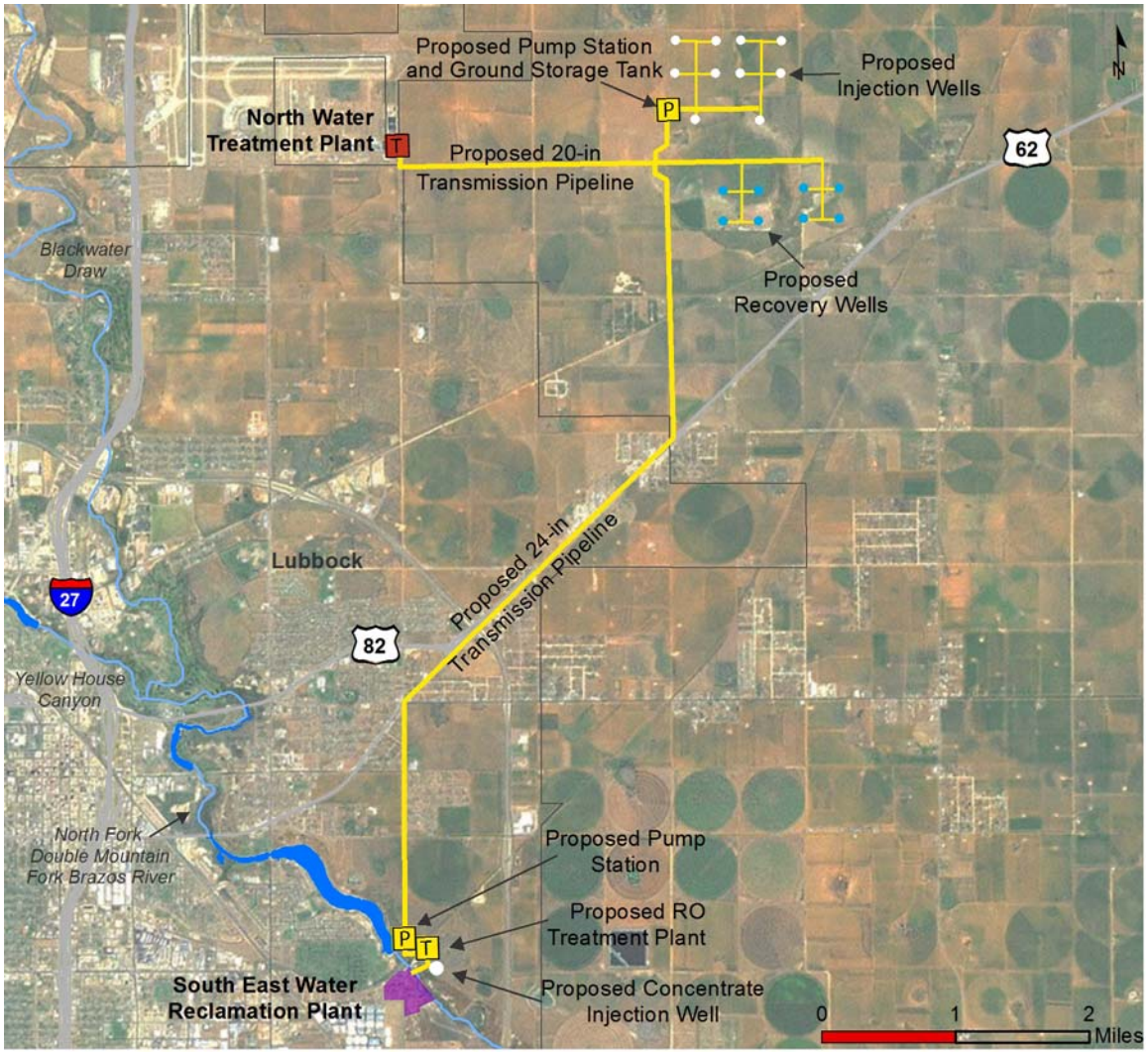


Figure 6.10 – Reclaimed Water Aquifer Storage and Recovery Infrastructure

Quantity of Available Water

This Reclaimed Water ASR strategy assumes that up to 9 mgd of reclaimed water will be sent to the ASR. However, due to nearby Ogallala irrigation wells, an estimated 20 percent of the original 9 mgd will be lost, leaving a final supply of 7.2 mgd (8,071 ac-ft/yr) for disinfection and distribution at the NWTP.

Strategy Costs

Costs associated with this strategy are presented in Table 6.6. Assumptions and conditions associated with these costs include:

- Property for the well field can be purchased for $2,000 per acre, which is twice the average of rural lands in this part of the state;
- Due to Ogallala irrigation wells in the vicinity of the ASR well field, it is assumed that 20% of the injected water will be lost to other wells before it is recovered;
- The depth to the base of the Ogallala Aquifer is about 220 feet;
- Additional costs for well field Supervisory Control and Data Acquisition (SCADA), valves and pump controls were included in the strategy costs;
- Engineering, legal, and contingency costs is 30% of pipelines and 35% for other facilities;
- Power is available at $0.09 per kwh;
- Interest during construction is 4%, and a 1% return on investments;
- The project will be financed for 20-years at a 5.5% interest rate; and
- The project is assumed to have a 2-year construction period.

Table 6.6 – Reclaimed Water Aquifer Storage and Recovery Costs

Cost Estimate Summary / March 2012 Prices	
Item	**Costs**
Capital Costs	
Advance Water Treatment at SEWRP (9 mgd RO)	$36,356,000
Disposal Well (1 Dockum well, 200 ft of pipeline)	$750,000
Pump Station (from SEWRP to ASR Well Field)	$3,834,000
Transmission Pipeline	
24-in dia., 7 miles (SEWRP to ASR Well Field)	$6,161,000
20-in dia., 2.5 miles (ASR to NWTP)	$1,062,000
Injection Booster Station and Ground Storage Tank at ASR	$1,132,000
ASR Injection Well Field	
(10 wells, 2.5 miles of distribution pipeline)	$5,184,000
ASR Recovery Well Field	
(8 wells, 2.7 miles of collector pipeline)	$3,930,000
ASR Well Field SCADA, Valving, Pumps	$250,000
NWTP Modifications (7.8 mgd)	$315,000
Total Capital Cost	**$58,974,000**
Engineering, Legal Costs, and Contingencies	$20,279,000
Environmental & Archaeology Studies and Mitigation	$1,280,000
Land Acquisition and Surveying (1,470 acres)	$1,752,000
Interest During Construction (1 year)	$5,760,000
Total Project Cost	**$88,045,000**
Annual Costs	
Debt Service (5.5%, 20 years)	$7,367,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$292,000
Water Treatment Plant	$2,450,000
Transmission Pumping Energy Costs (0.09 $/kwh)	$331,000
ASR Pumping Energy Costs (0.09 $/kwh)	$344,000
Total Annual Cost	**$10,784,000**
Available Project Yield (ac-ft/yr)	8,071
Annual Cost of Water ($ per ac-ft)	$1,336
Annual Cost of Water ($ per 1,000 gallons)	$4.10

Costs prepared by HDR Engineering, Inc.

As shown, the total cost is estimated to be $88,045,000. Annual debt service is $7,367,000; and, annual operational cost, including power, is $3,417,000. This results in a total annual cost of $10,784,000. The unit cost for 8,071 ac-ft/yr of supply at the NWTP is estimated to be $1,336 per ac-ft, or $4.10 per 1,000 gallons. This cost does not include the distribution of the potable water from the NWTP to potential customers.

Implementation Issues

Environmental Issues

The installation of wells and collection pipelines should be planned and installed so that sensitive habitats, cultural resources, and other environmentally sensitive areas are avoided.

Permitting Issues

The City does not own groundwater rights in the area of interest. Groundwater rights will need to be purchased so wells can be drilled within the proposed ASR area. The City will need to acquire permits from the High Plains Underground Water Conservation District No. 1. The design and construction of public water supply wells and water transmission facilities must be approved by the TCEQ. In addition, the High Plains Underground Water Conservation District No. 1 will need to promulgate rules regarding ASR projects. There may also be permitting obligations pursuant to Texas Water Code Section 11.154 depending upon regulatory characterization of the associated return flows.

[1] Water for Texas : 2012 State Water Plan. Texas Water Development Board. January 2012: 194.

[2] Third Amendment to Contract between the City of Lubbock and Southwestern Public Service for the sale and purchase of treated sewage effluent. July 28, 2009: Resolution 2009-R0271.

[3] Wastewater Master Plan. City of Lubbock, Texas. Jacobs Engineering, Inc. 2009.

[4] Canyon Lakes Water Reuse Project: Preliminary Engineering Report. Alan Plummer Associates, Inc. March 2012.

[5] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: 4-199 – 4-213.

[6] Strategic Water Supply Plan. City of Lubbock. July 2007: section 12.

[7] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: 4-202.

[8] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: 4-206 – 4-211.

[9] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: 4-179.

7.0 Groundwater Strategies

Groundwater has always been a vital source of water for Lubbock. When the first municipal water system was constructed for the City in 1911, it consisted of one well pumping water from the Ogallala Aquifer. The City relied solely upon groundwater until 1968 when surface water from Lake Meredith was made available (see Figure 3.1).

7.1 Groundwater Sources

The TWDB recognizes 30 major and minor aquifers in the State of Texas. Aquifers that supply large quantities of water over large areas of the state are defined as major aquifers. Aquifers that supply relatively small quantities of water over large areas of the state or supply large quantities of water over small areas of the state are defined as minor aquifers. Each aquifer has unique characteristics.[1] The major aquifers in Texas are depicted in Figure 7.1 and the minor aquifers are depicted in Figure 7.2.

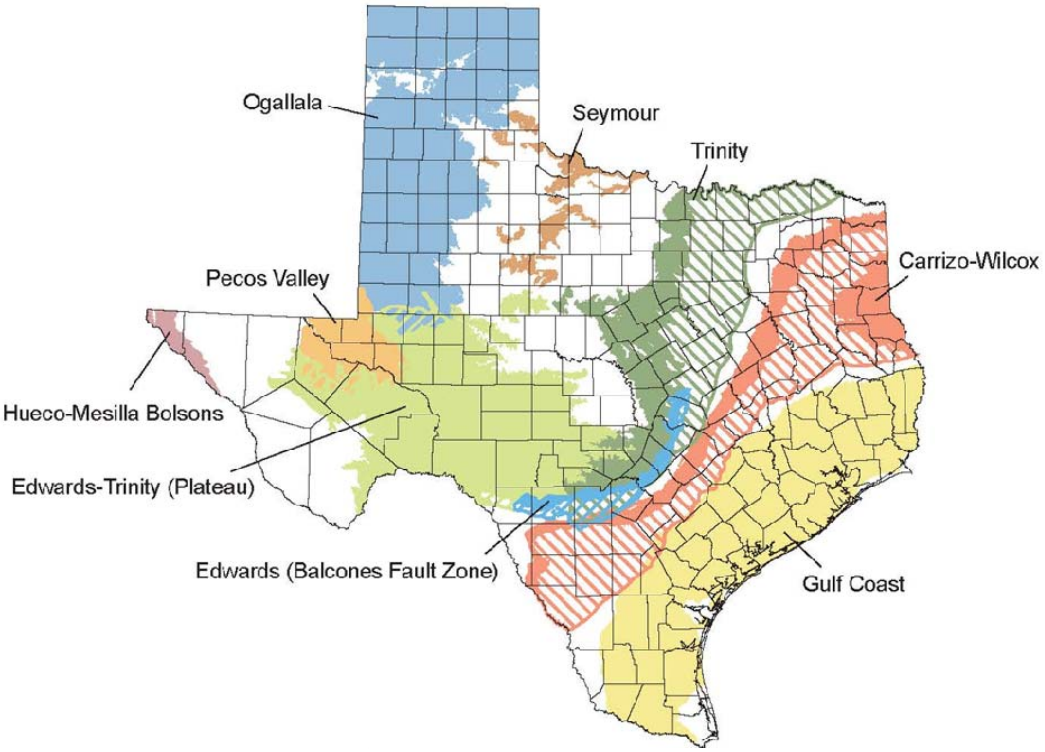


Figure 7.1 – Major Aquifers (Map courtesy of TWDB[2])

The Ogallala and Seymour aquifers are the major aquifers in Lubbock's region. The Edwards-Trinity (High Plains) and the Dockum aquifers are the minor aquifers in the Lubbock region.

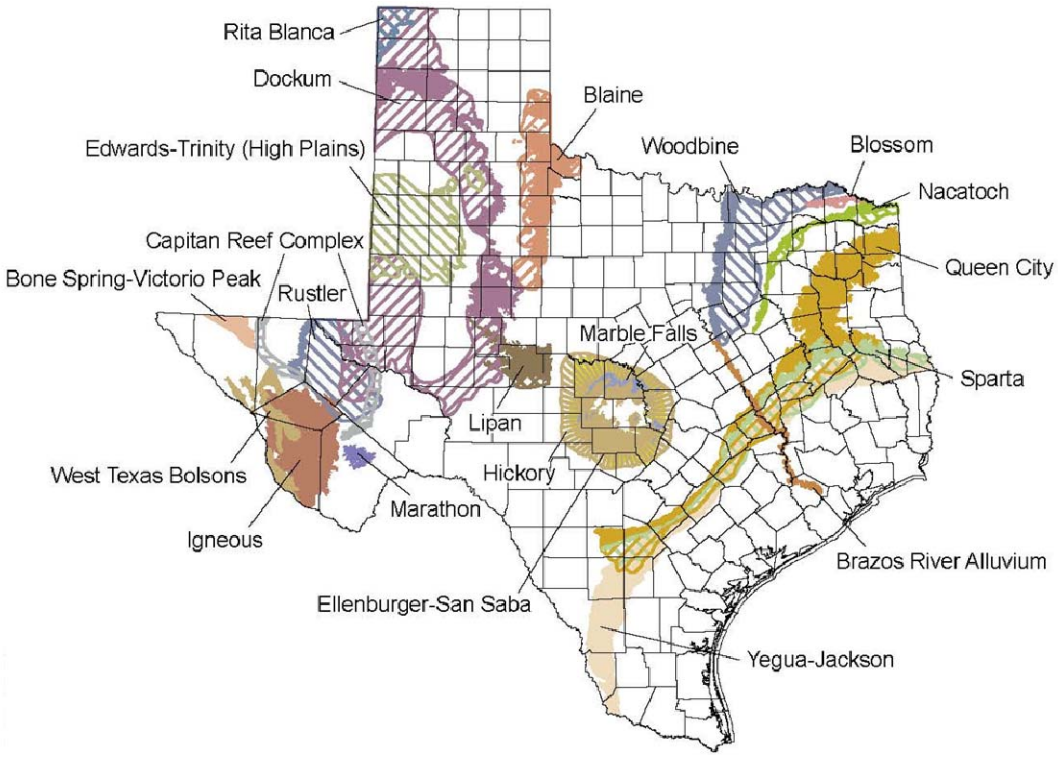


Figure 7.2 – Minor Aquifers (Map courtesy of TWDB[3])

Ogallala Aquifer

The High Plains of Texas lies above the largest groundwater formation in the State of Texas, known as the Ogallala Aquifer. The Ogallala has been the main source of potable and agriculture water in the Lubbock region since the early 1900s. However, only 5% of the Ogallala groundwater on the Southern High Plains is used for domestic purposes.[4] Most of the water is used for irrigating crops. Because of the heavy agricultural activities on the Southern High Plains for over 100 years, the saturated thickness levels have dropped significantly. Figure 7.3 depicts the saturated thickness of the Ogallala Aquifer in 2008. The figure demonstrates that the portion of the Ogallala Aquifer to the north of Lubbock near Amarillo contains the greatest volumes of groundwater in the Texas portion of the aquifer. Historically, groundwater use in this region has been minor, primarily for cattle grazing with windmills used to pump relatively small quantities of groundwater for stock tanks.

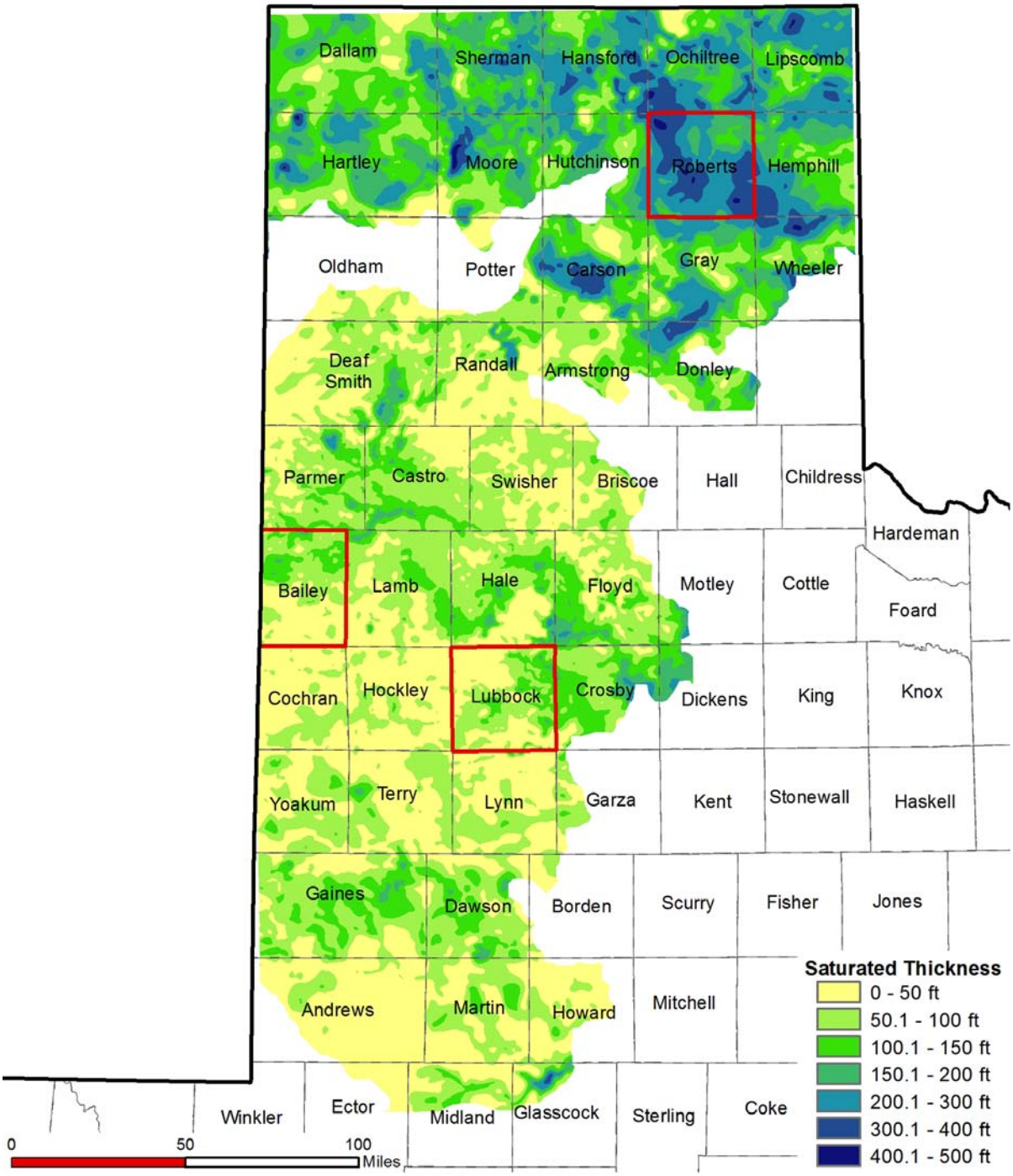


Figure 7.3- Saturated Thicknesses of the Ogallala Aquifer

(Data courtesy of the Center for Geospatial Technology at Texas Tech University, 2008[5])

Figure 7.4 depicts the saturated thicknesses of groundwater in Lubbock County. Several studies have evaluated the potential for using the groundwater underlying the City of Lubbock and Lubbock County. However, the saturated thickness of the groundwater in

Lubbock County has declined greatly from heavy agricultural irrigation over the past 100 years, and wells in many areas of the county produce less than 30 gpm. There exists little potential for long-term development of groundwater within Lubbock County.

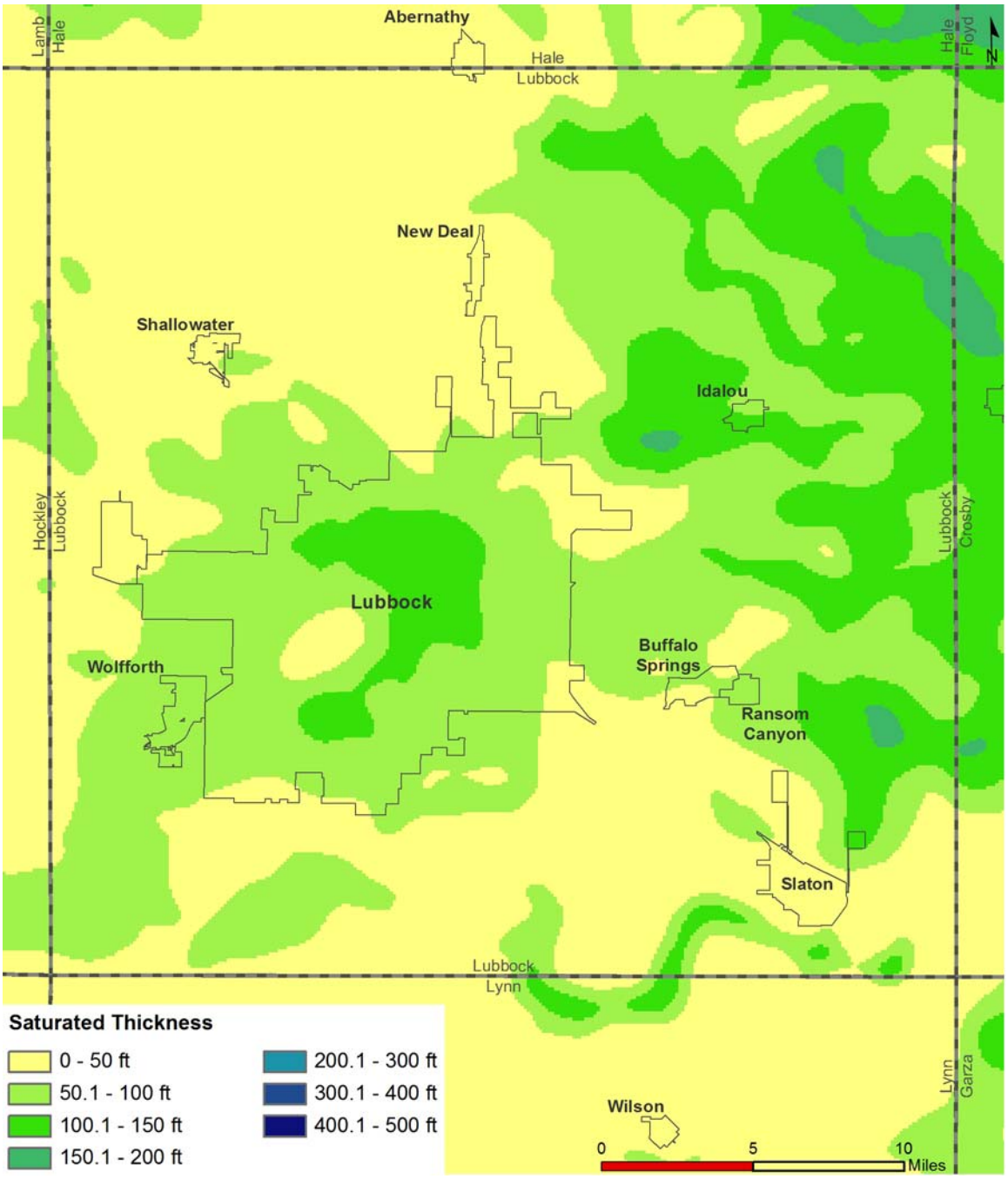
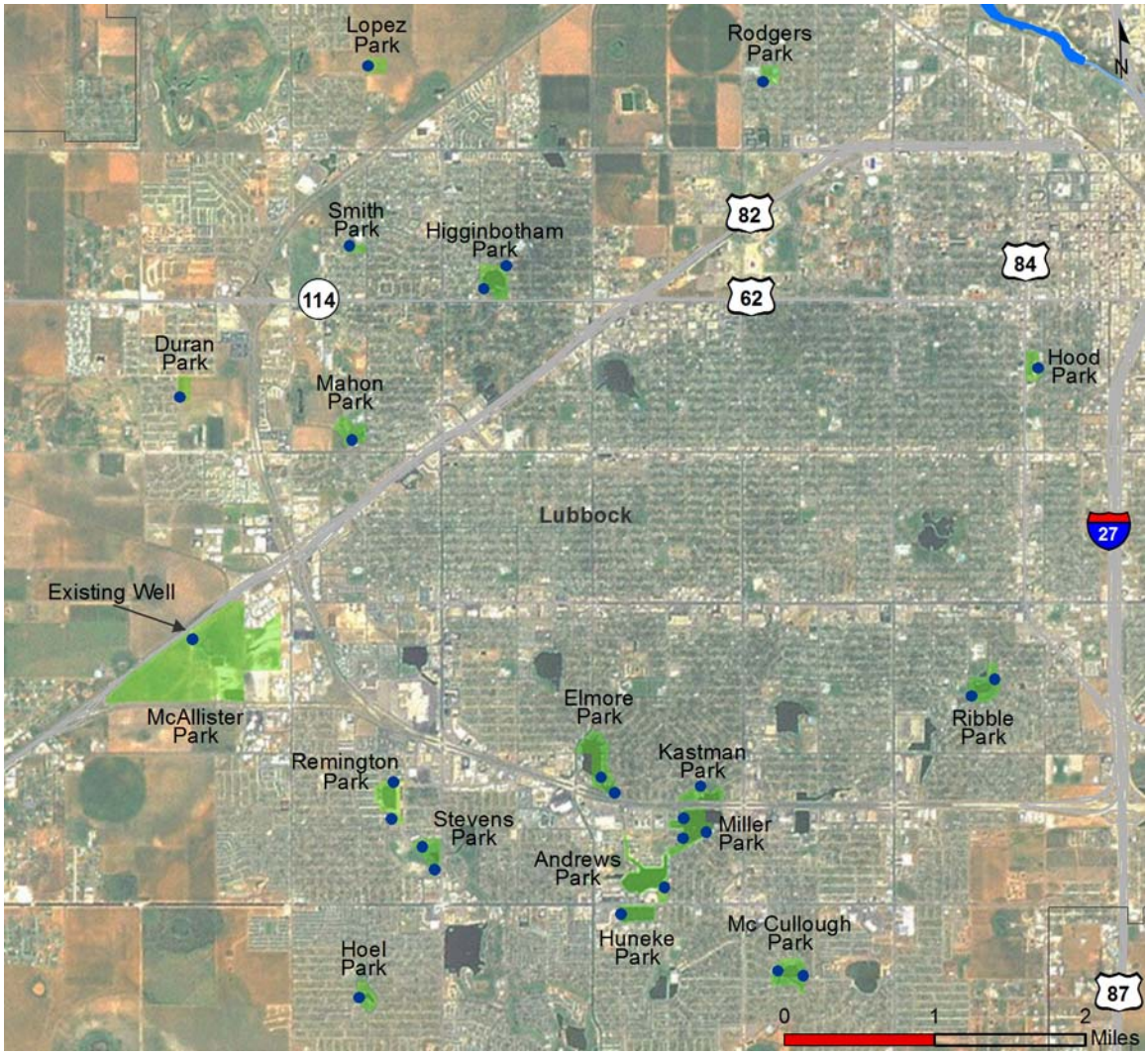


Figure 7.4 – Saturated Thickness of the Ogallala Aquifer in Lubbock County
(Data courtesy of the Center for Geospatial Technology at Texas Tech University, 2008[6])

The Parks and Recreation Department has historically been among the City's top water users. In 2006, the City began evaluating ways to reduce the amount of potable water used to irrigate its parks. In the 2007 Strategic Water Supply Plan, the City indicated that there were 78 parks with a total water demand of 1.356 billion gallons per year or 4,161 ac-ft/yr.[7] Of these 78 parks, it was determined that it was not feasible to irrigate 20 of the parks with groundwater from the Ogallala Aquifer. Nine parks are irrigated with water diverted from the Jim Bertram Lake System as discussed in Section 8.1. From 2007 and 2008, 26 water wells were installed throughout 18 different City-owned parks



(encompassing 319 acres) as depicted in Figure 7.5.

Figure 7.5 – Location of Parks with Groundwater Wells

Due to the production rates of these wells and time-of-day irrigation restrictions at City parks, irrigation of the parks requires supplemental supply from the City's potable water system to operate properly. Over the last five years, this initiative has helped conserve roughly half of the potable water used to irrigate the 18 parks in which wells were installed. The total annual amount of water conserved represents less than 1% of the City's total potable water demand. Table 7.1 shows the volumes of water saved each year.

Table 7.1 – Potable Water Conserved at City Parks

Year	Potable Water Conserved (Well Water Used, ac-ft/yr)	Percent of Total Annual Demand
2008	70.8	0.2%
2009	100.7	0.3%
2010	249.4	0.7%
2011	218.6	0.5%
2012	147.6	0.4%

Edwards-Trinity Aquifer

The Edwards-Trinity Aquifer is a Cretaceous-aged minor aquifer located on the Southern High Plains of Texas and New Mexico (see Figure 7.6). The Edwards-Trinity spans approximately 9,000 square miles[8] and lies just underneath the Ogallala Aquifer and above the Dockum Aquifer. Approximately 95% of the water pumped from this aquifer is used for irrigation.[9]

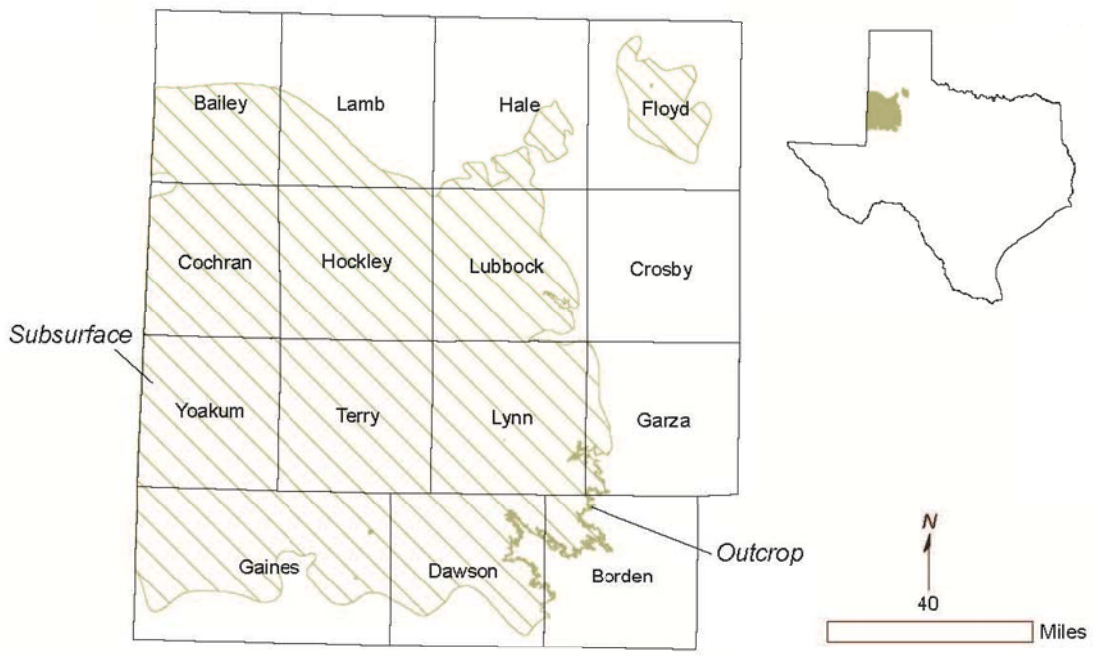


Figure 7.6 –Edwards-Trinity Aquifer (Map courtesy of TWDB[10])

Figure 7.7 shows a cross-section of the Southern High Plains. The Edwards Trinity Aquifer is located within the blue Cretaceous layer (for reference, the Ogallala is yellow and the Dockum is purple). In certain locations where the soils are permeable and the dividing formations are thin, water will move between the Edwards-Trinity and the Ogallala, constituting the main source of recharge for the Edwards-Trinity Aquifer.[11]

There is a limited quantity of water in the Edwards-Trinity. The average yield for an Edwards-Trinity well is between 50-200 gpm, with maximum yields reported at over 1,000 gpm.[12] In 2010, the total estimated yield from the Edwards-Trinity was 4,160 ac-ft/yr. This is expected to diminish to 2,065 ac-ft/yr by 2060.[13]

Water quality in the Edwards-Trinity varies by location, ranging from fresh to slightly brackish. The typical range for TDS is between 1,000 – 2,000 mg/L.[14] However, maximum TDS values can reach 20,000 mg/L in extremely low-quality areas.[15]

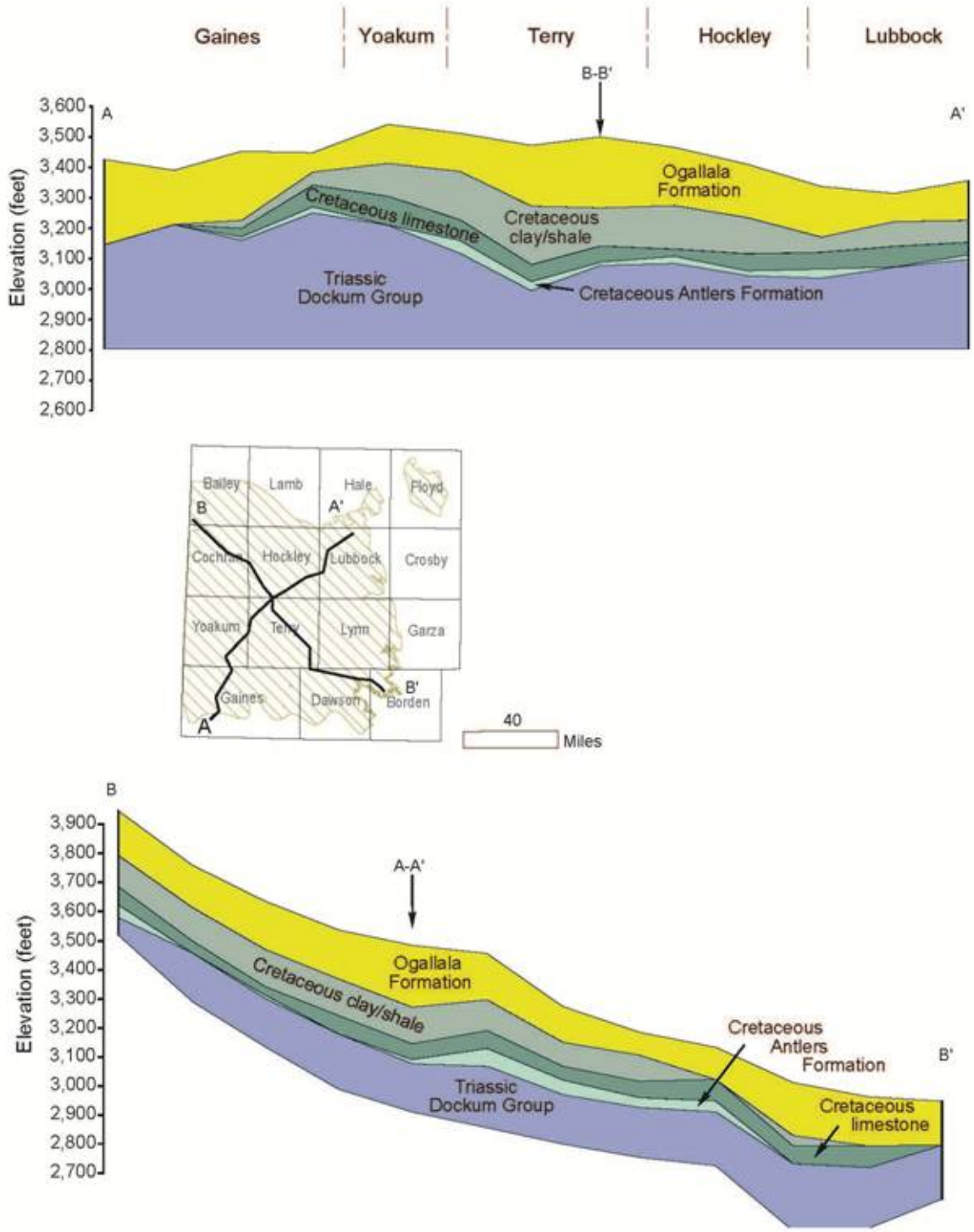


Figure 7.7 – Cross-Sections of the Southern High Plains (Map courtesy of TWDB[16])

Dockum Aquifer

The Dockum Aquifer is a minor aquifer found in the northwest part of Texas, as depicted in Figure 7.8. The formation underlies all counties from Castro to Upton, including Bailey and Lubbock counties. However, the figure does not depict the formation under these two counties because data regarding the characteristics of the Dockum Aquifer is sparce in these areas.

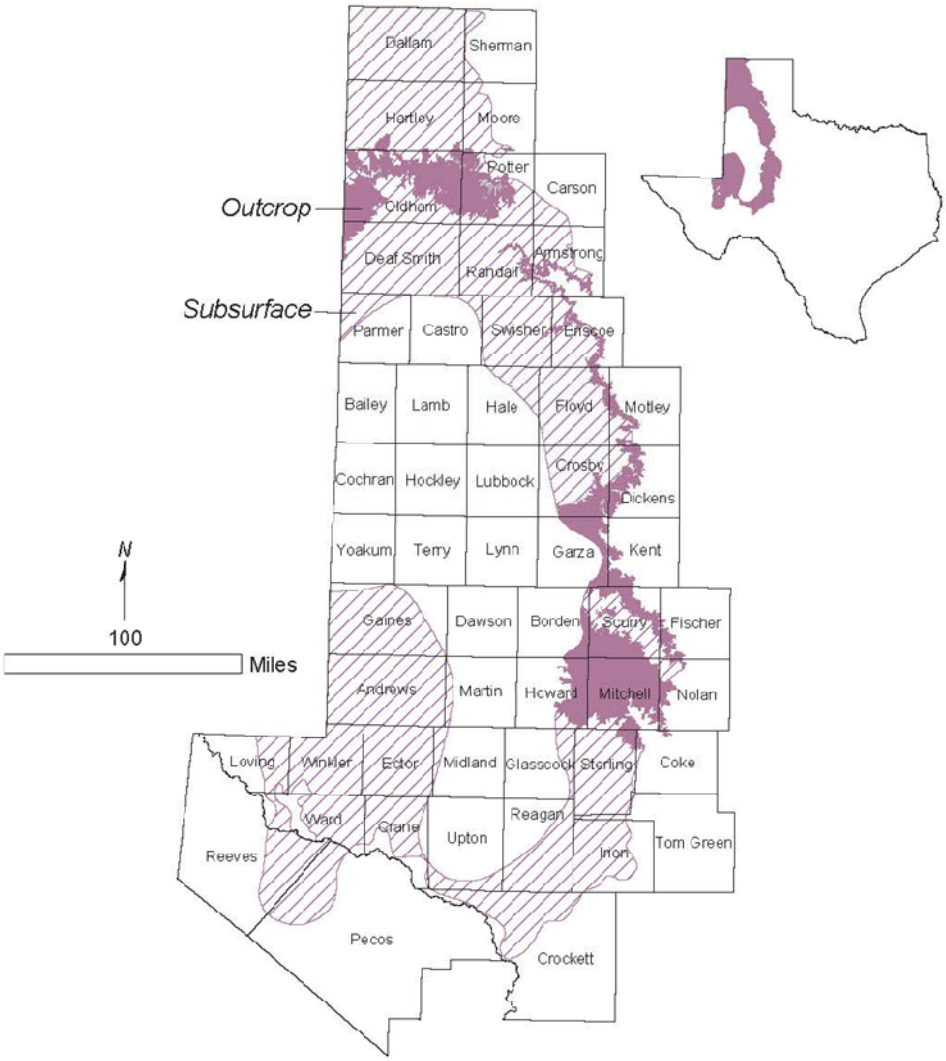


Figure 7.8 – Dockum Aquifer (Map courtesy of TWDB[17])

This aquifer is defined stratigraphically by the Dockum Group and includes four formations (from oldest to youngest): the Santa Rosa, the Tecovas, the Trujillo Sandstone, and the Cooper Canyon. The highest groundwater yields come from the Santa Rosa sandstones at the base of the Dockum. The Dockum is approximately 2,000 feet deep in

the Lubbock area and contains high concentrations of chlorides and TDS. The TWDB's Final Report: Groundwater Availability Model for the Dockum Aquifer indicates that there "has not been widespread use of the Dockum Aquifer because of poor water quality, low yields, declining water levels, and deep pumping depth."[18] Because of low use of this aquifer, very little data exist for the Lubbock region.

Figure 7.9 depicts the base of the Dockum Aquifer, and Figure 7.10 depicts the concentrations of TDS in the formation.

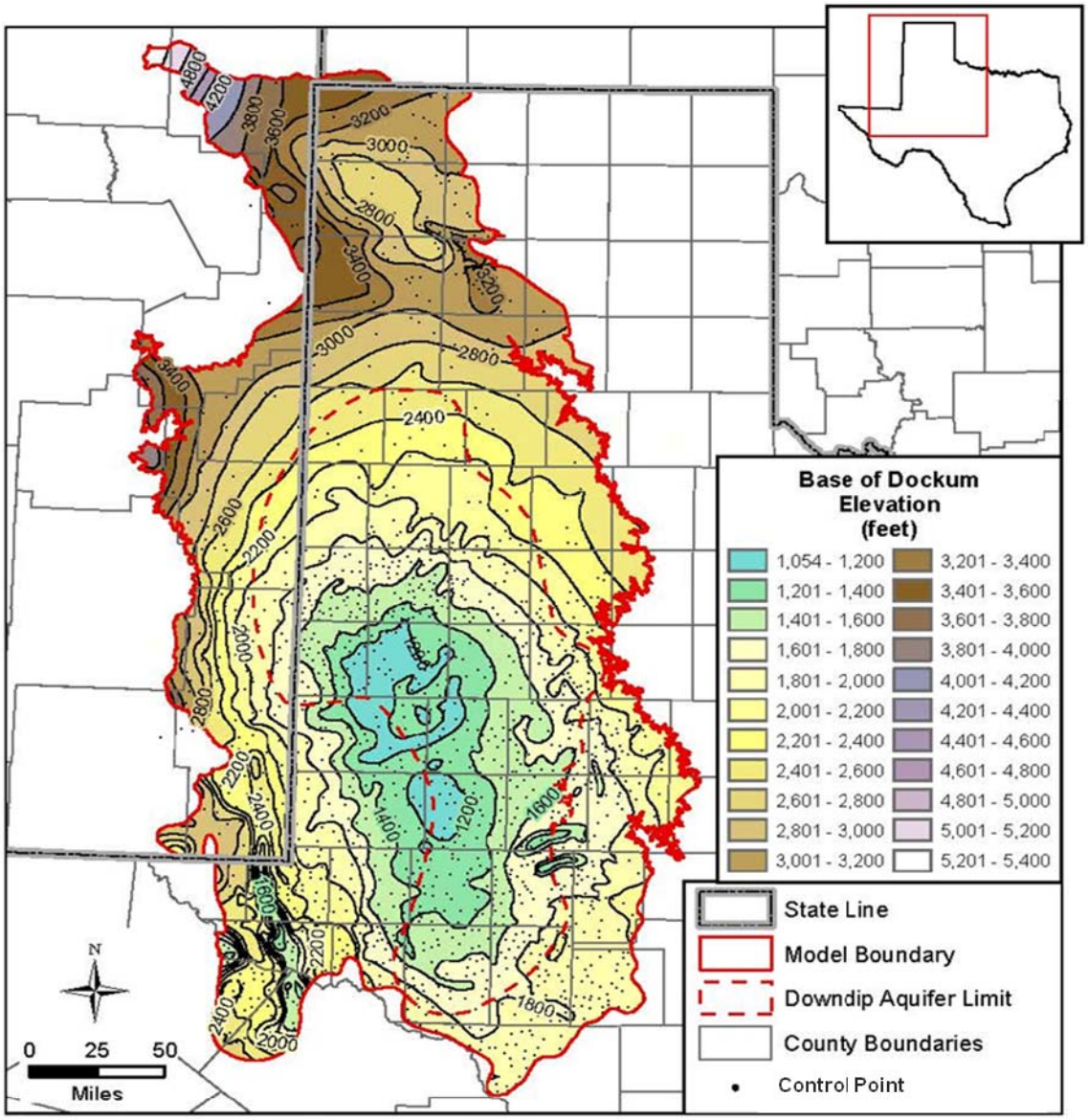


Figure 7.9 – Base of the Dockum Aquifer (Map courtesy of TWDB[19])

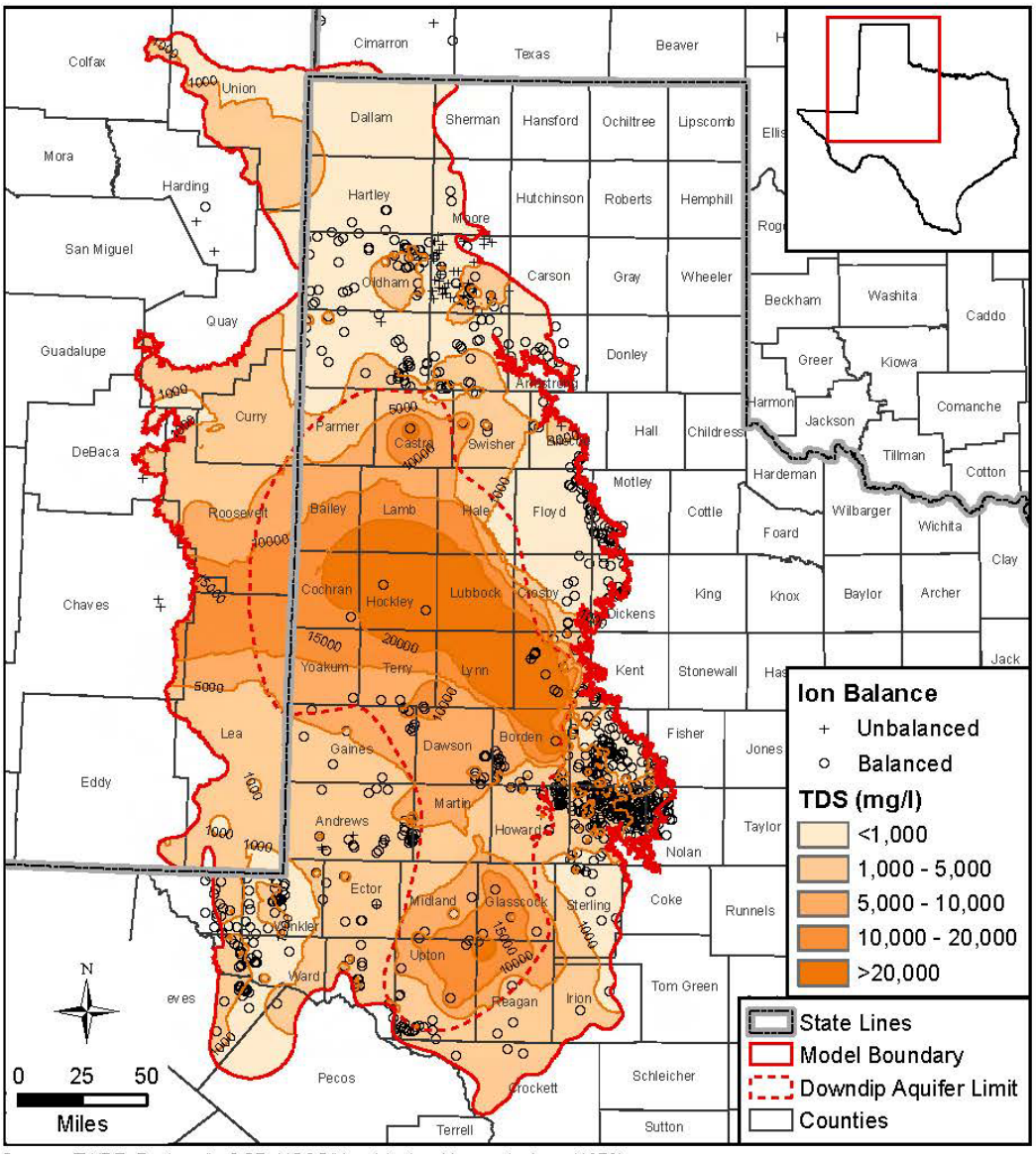


Figure 7.10 – Dockum TDS Concentrations, 1981-1996 (Map courtesy of TWDB[20])

Seymour Aquifer

The Seymour Formation is one of the nine major aquifers in Texas, but would be a poor groundwater supply option for the City of Lubbock. The formation is located a considerable distance to the east of Lubbock, and the water quality and aquifer yield are very inconsistent.

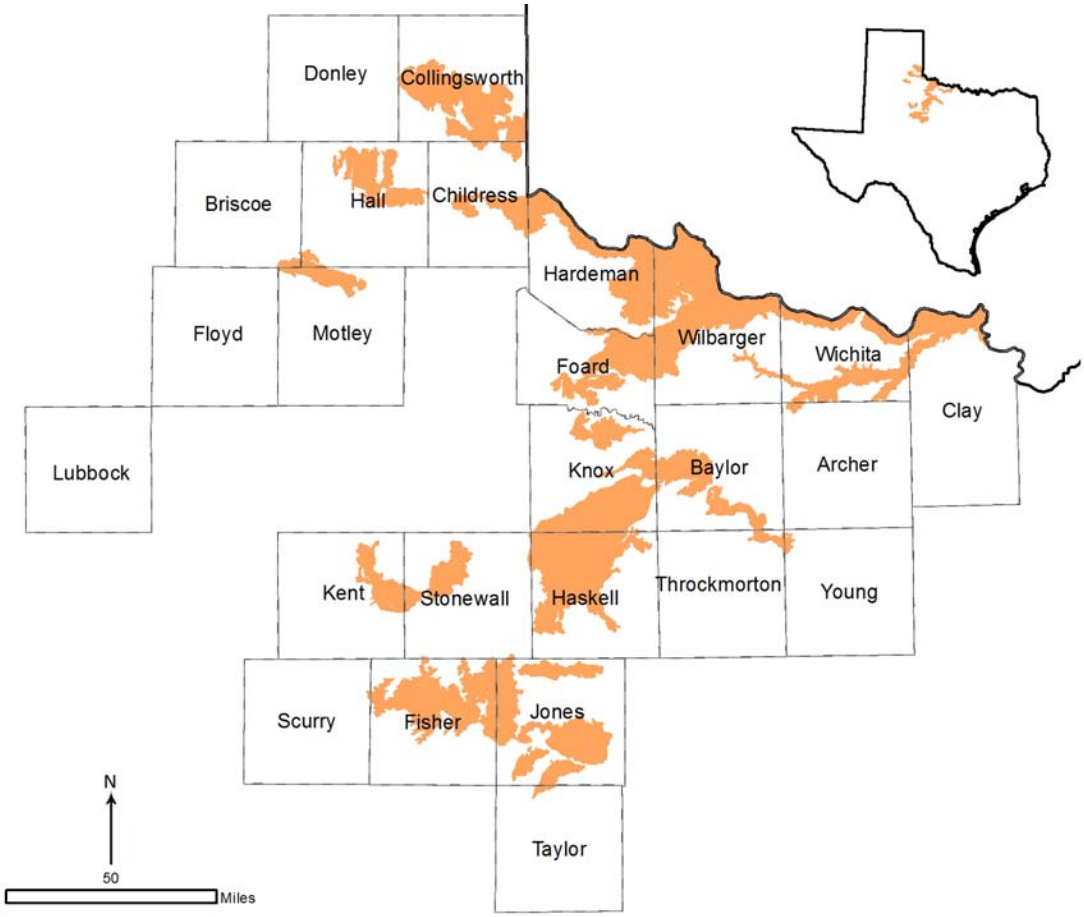


Figure 7.11 – Seymour Aquifer (Map courtesy of TWDB[21])

7.2 Groundwater Usage Regulations

In Texas, groundwater usage is legally recognized as a private property interest subject to the rule of capture and limited by regulation by local Groundwater Conservation Districts (GCDs). There are 119 GCDs across the state. Because of the size of many of the aquifers in Texas, numerous conservation districts manage the resources from a given aquifer. For example, Lubbock and Bailey Counties are part of the High Plains Underground Water Conservation District No. 1, while Roberts County is part of the Panhandle Groundwater Conservation District.

In 1995, Groundwater Management Areas (GMAs) were created "in order to provide for the conservation, preservation, protection, recharging, and prevention of waste of the groundwater, and of groundwater reservoirs or their subdivisions, and to control subsidence caused by withdrawal of water from those groundwater reservoirs or their subdivisions, consistent with the objectives of Section 59, Article XVI, Texas Constitution…" (Texas Water Code §35.001) Added by Acts 1995, 74th Leg., ch. 933, §2, eff. Sept. 1, 1995. The creation of GMAs made it possible to establish common groundwater management goals among multiple GCDs. The TWDB was delegated responsibility to delineate GMAs, and subsequently divided Texas into 16 GMAs in 2002 (Figure 7.12). These areas correspond roughly to aquifer boundaries in the State and help State agencies regulate different aspects of groundwater usage.

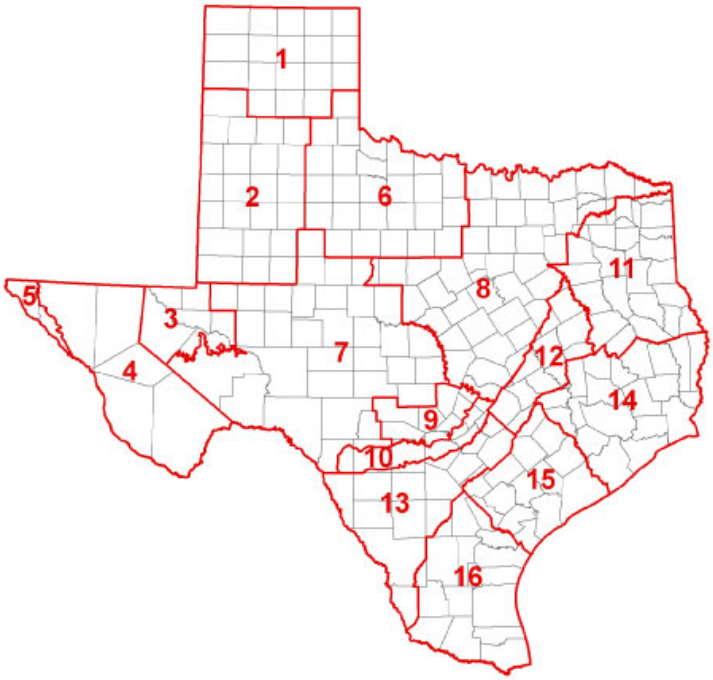


Figure 7.12 – Groundwater Management Areas in Texas (Map courtesy of TWDB[22])

The Texas Legislature mandated that by September 1, 2010, GCDs must establish Desired Future Conditions (DFCs) for aquifers in each GMA. These DFCs may differ across GMAs and impact the amount of groundwater that can be pumped from a given aquifer on an annual basis. Most of Lubbock's current or potential groundwater supplies are located within GMA #1 or #2.

7.3 Roberts County Well Field Capacity Maintenance Strategy

The RCWF produces water from the Ogallala Aquifer. For operational sustainability and flexibility, CRMWA maintains a production capacity in the RCWF that is 30% greater than the capacity of the transmission line from the RCWF to the main CRMWA Aqueduct. The target capacity of the RCWF is 93 mgd. The maximum capacity of the transmission line is 65 mgd. As is common in Ogallala well fields, the RCWF's capacity continues to decline over time with consistent utilization. Eventually, replacement wells become necessary to maintain capacity.

This RCWF Capacity Maintenance (CM) strategy is designed to maintain the RCWF's capacity at 93 mgd. Modeling by Lee Wilson & Associates (CRMWA's hydrogeologists) estimates that 11 replacement wells will be needed approximately every 30 years in order to sustain a production of 65 mgd and maintain the 93 mgd RCWF capacity.

The major design features of this strategy include:

- Eleven new wells constructed 950 feet deep;
- On average, each well will operate at 1,768 gpm with a peak production of 2,250 gpm;
- New wells will be located on property where CRMWA holds the interest in groundwater rights; and
- No additional treatment is included in the costs.

Figure 7.13 depicts the relative locations of the well field and associated infrastructure needed.

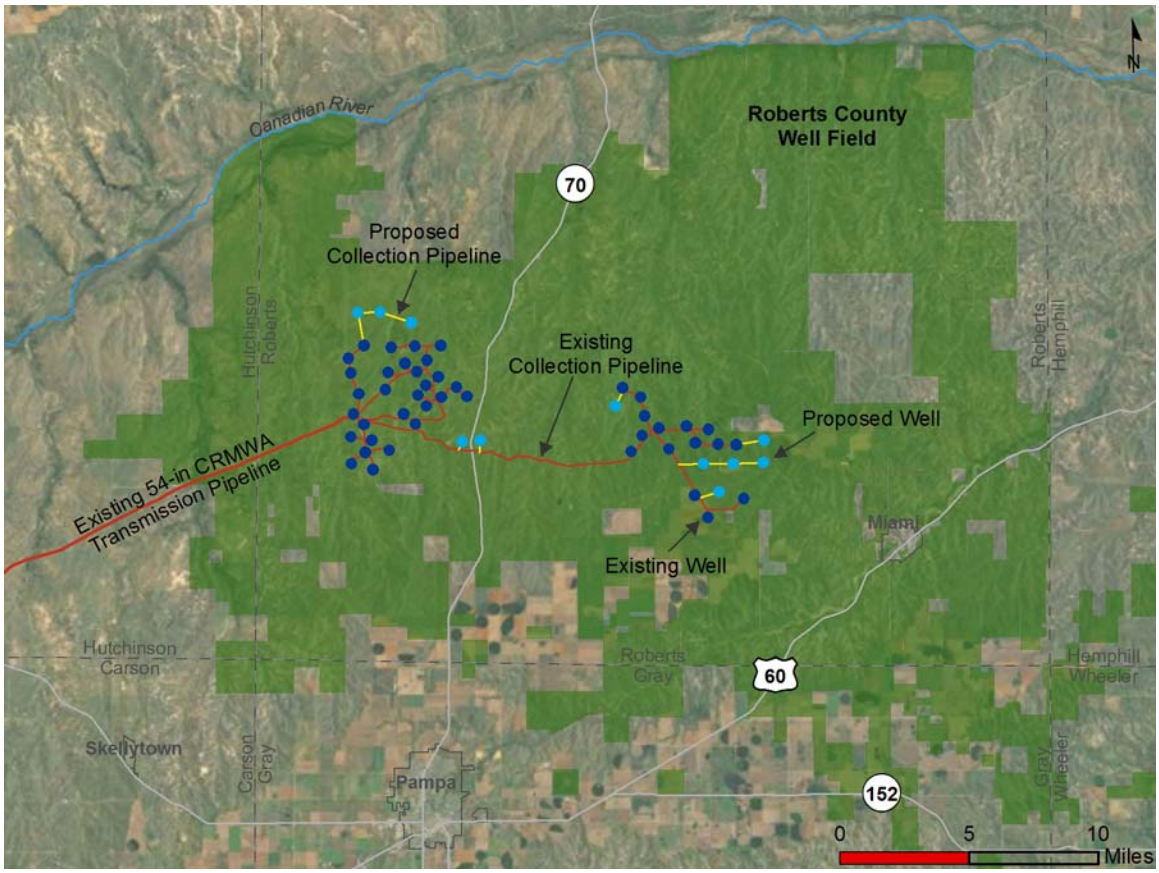


Figure 7.13 – Potential New Well Locations for the RCWF Capacity Maintenance Strategy

Quantity of Available Water

The RCWF Capacity Maintenance strategy is designed to maintain the target RCWF capacity of 93 mgd. Under this strategy, the City's allocation from CRMWA will remain at 24,088 ac-ft/yr and the transmission line from the RCWF to the CRMWA Aqueduct will remain near capacity (65 mgd) at all times. The wells in this strategy increase the RCWF capacity by 28 mgd (11 wells producing approximately 1,768 gpm each). Therefore, the new wells are assumed to provide an annual supply of 7,252 ac-ft/yr, which is equivalent to 28/93rds of the 24,088 ac-ft/yr supply, based upon the new wells' pro-rata contribution to the total capacity of the well field.

Strategy Costs

Costs associated with this strategy are presented in Table 7.2. Assumptions and conditions associated with these costs include:

- City of Lubbock will pay for 37.058% of the costs for this project, which is the City's allocation of water from CRMWA;
- Engineering, legal, and contingency costs are 35% for facilities required by this strategy;
- Power is available at $0.09 per kwh;
- Interest during construction is 4.0%, and a 1.0% return on investments; and
- The project will be financed for 20-years at a 5.5% interest rate.

Table 7.2 – RCWF Capacity Maintenance Costs

Cost Estimate Summary / March 2012 Prices		
Item	**Estimated Costs**	**Lubbock's Portion (37.058%)**
Capital Costs		
Transmission Pipeline (0 miles)	$0	
Transmission Pump Station(s)	$0	
Well Fields		
(11 wells, 2,250 gpm, 950 ft deep; 48,000 ft collection piping)	$18,398,000	
Distribution	$0	
Relocations & Other	$0	
Total Capital Cost	**$18,398,000**	
Engineering, Legal Costs, and Contingencies	$6,439,000	
Environmental & Archaeology Studies and Mitigation	$277,000	
Land Acquisition and Surveying (6 acres)	$0	
Interest During Construction (1 year)	$878,000	
Total Project Cost	**$25,942,000**	**$9,614,000**
Annual Costs		
Debt Service (5.5%, 20 years)	$2,171,000	$805,000
Operation and Maintenance		
Intake, Pipeline, Pump Station	$184,000	$68,000
Pumping Energy Costs (8,740,445 kwh @ 0.09 $/kwh)	$787,000	$292,000
Purchase of Water	$0	
Total Annual Cost	**$3,142,000**	**$1,165,000**
Available Project Yield (ac-ft/yr)	19,516	7,252
Annual Cost of Water ($ per ac-ft)	$161	$161
Annual Cost of Water ($ per 1,000 gallons)	$0.49	$0.49

Costs prepared by HDR Engineering, Inc.

As shown, the total cost is estimated to be $25,942,000. Annual debt service is $2,171,000; and, annual operational cost, including power, is $971,000. This results in a total annual cost of $3,142,000. CRMWA project and operational costs are shared amongst the 11 member cities. Lubbock's share of the project is 37.058% which will result in an annual cost estimated at $1,165,000. Based on the annual allocation of 7,252 ac-ft/yr, the unit cost is estimated to be $161 per acre-foot, or $0.49 per 1,000 gallons.

Implementation Issues

Environmental Issues

The installation of wells and collection pipelines should be planned so that sensitive habitats, cultural resources, and other environmentally sensitive areas are avoided.

Permitting Issues

Currently, CRMWA owns the groundwater interests in over 400,000 acres of property. Wells will be drilled within this area. The City will need to secure well drilling permits from the Panhandle Groundwater Conservation District. The design and construction of public water supply wells and water transmission facilities must be approved by the TCEQ.

Other

Wells will be placed on properties where CRWMA owns the water rights which include the rights to surface improvements to extract and convey their groundwater.

7.4 Bailey County Well Field Capacity Maintenance Strategy

The BCWF produces water from the Ogallala Aquifer. The BCWF's capacity has decreased sharply the last few years because the City has needed to produce more from the BCWF than desired in order to compensate for a reduction in supply coming from Lake Meredith. In 2010, the BCWF's capacity was 50 mgd. In 2012, the well field's capacity had dropped to 38 mgd. The transmission line from the BCWF to Lubbock's distribution system can deliver a peak capacity of 40 mgd.

The City has two goals for the BCWF. The first goal is to maintain a BCWF capacity that is 10 mgd greater than the transmission line capacity. This will continue to allow the City to rotate, rest, and repair wells as needed. The City's second goal is to reserve the BCWF for meeting peak demand during summer months. In order to effectively meet these goals, it is recommended that the City produce less than 7,000 ac-ft/yr from the BCWF.[23] The City is currently using two to three times more than this recommended production rate.

The proposed BCWF CM strategy consists of two phases (Initial CM (ICM) and CM-1) that will assist the City in achieving its goals regarding the BCWF. The ICM includes the installation of 34 wells that will restore the BCWF to a 50 mgd capacity. It is anticipated that the ICM will maintain capacity for 10 years, after which time additional well field maintenance will be needed. According to Daniel B. Stephens & Associates' (DBS&A) October 2012 modeling report,[24] 10 replacement wells will be required every 10 years after the ICM to maintain the capacity in the BCWF using an estimated well field production rate of 10,000 ac-ft/yr. While capacity maintenance will be needed every 10 years, this strategy only considers a 20 year project period in which the ICM and CM-1 are implemented in order to compare this strategy to other strategies in this Plan. The major design features of this strategy include:

- Construction of 34 wells during the ICM;
- Construction of 10 replacement wells 10 years after ICM is implemented (CM-1);
- Wells are assumed to be constructed to 220 feet deep and operate at 250 gpm;
- Wells are located on existing City water rights properties;
- No additional treatment is included in the costs;

- Approximately 15.5 miles of 6-inch to 24-inch diameter collection pipe is required for the ICM;
- Approximately 3.8 miles of 6-inch to 24-inch diameter collection pipe is required for CM-1; and
- Delivery pressure is assumed to be 30 pounds per square inch (psi) at the connection to the original well field.

Figure 7.14 depicts the relative locations of the well field and associated infrastructure needed.

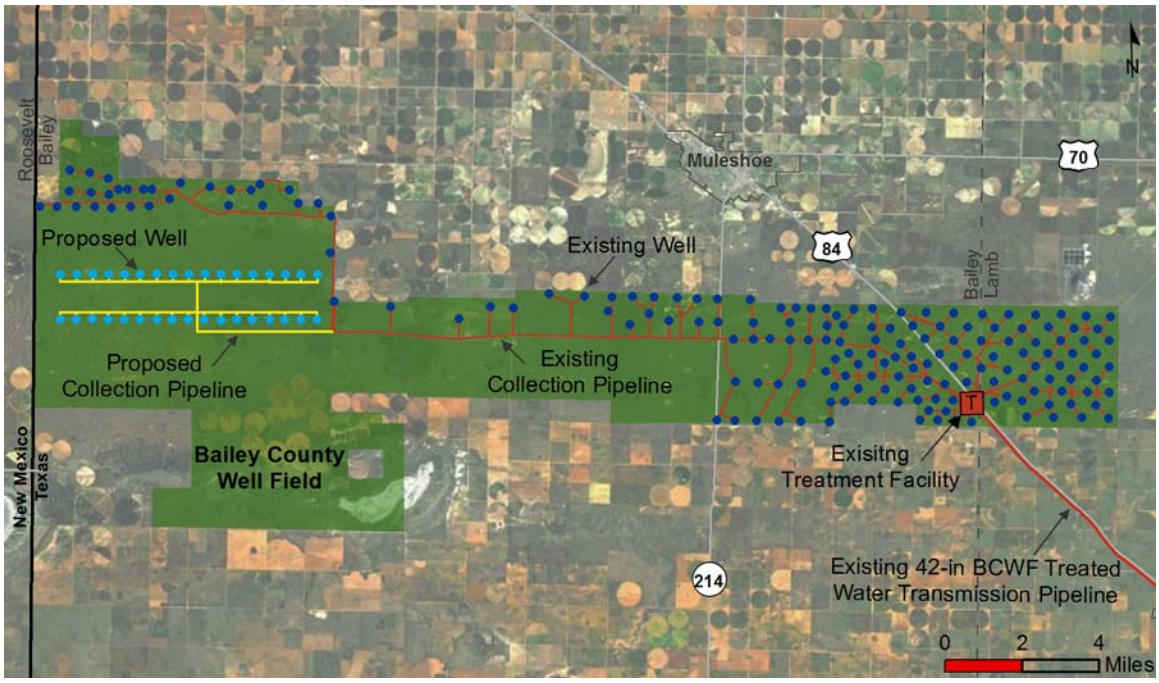


Figure 7.14 – Potential New Well Locations for BCWF Capacity Maintenance Strategy

Quantity of Available Water

The BCWF Capacity Maintenance strategy is designed to restore the total BCWF capacity to 50 mgd (ICM) and then maintain this capacity for at least 20 years (ICM and CM-1). Under this strategy, the City will produce an average of 10,000 ac-ft/yr of water from the BCWF. The wells in the ICM phase of the project increase the BCWF capacity by 12 mgd (34 wells producing approximately 250 gpm each). Therefore, the ICM wells are assumed to provide an annual supply of 2,400 ac-ft/yr, which is equivalent to 12/50ths of the 10,000 ac-ft/yr supply, based upon the new wells' pro-rata contribution to the total capacity of the

well field. These wells are assumed to be utilized during June-September, or about 120 days per year.

Future phases (CM-1, CM-2, etc.) will consist of installing 10 wells every 10 years, providing 3.6 mgd (10 wells at approximately 250 gpm each) of capacity to offset overall capacity declines from the system. Future wells will provide an annual supply of 720 ac-ft/yr, which is 3.6/50ths of the 10,000 ac-ft/yr supply, based on the wells' pro-rate contribution to the total capacity of the well field. The wells are anticipated to be utilized during June-September, or about 120 days per year.

Strategy Costs

Costs associated with this strategy are presented in Table 7.3. Assumptions and conditions associated with these costs include:

- Engineering, legal, and contingency costs are 35% for facilities constructed for this strategy;
- Power is available at $0.09 per kwh;
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period; and
- The project will be financed for 20 years at a 5.5% annual interest rate.

Table 7.3 – BCWF Capacity Maintenance Costs

Cost Estimate Summary / March 2012 Prices			
Item	**Estimated Costs**		
	Initial CM	**Future CM**	***Total***
Capital Costs			
Initial Expansion (ICM)			
ICM Well Field (34 wells, 250 gpm)	$8,951,000		
Well Collection System (15.5 miles – 6, 8, 12, 24-in dia.)	$4,387,000		
Continued Expansion (CM-1, etc.)			
CM Well Field (10 wells, 250 gpm)		$2,633,000	
Well Collection System (3.8 miles – 6, 8, 12, 16-in dia.)		$1,392,000	
Total Capital Cost	**$13,338,000**	**$4,025,000**	**$17,363,000**
Engineering, Legal Costs, and Contingencies	$4,668,000	$1,409,000	$6,077,000
Environmental & Archaeology Studies and Mitigation	$388,000	$95,000	$483,000
Land Acquisition and Surveying (17 acres)	$0	$0	$0
Interest During Construction (1 year)	$644,000	$194,000	838,000
Total Project Cost	**$19,038,000**	**$5,723,000**	**$24,761,000**
Annual Costs			
Debt Service (5.5%, 20 years)	$1,593,000	$479,000	$2,072,000
Operation and Maintenance Intake, Pipeline, Pump Station	$133,000	$40,000	$173,000
Pumping Energy Costs (0.09 $/kwh)	$127,000	$25,000	$152,000
Purchase of Water	$0	$0	$0
Total Annual Cost	**$1,853,000**	**$544,000**	**$2,397,000**
Available Project Yield (ac-ft/yr)	2,400	720	3,120
Annual Cost of Water ($ per ac-ft)	$722	$756	$768
Annual Cost of Water ($ per 1,000 gallons)	$2.37	$2.32	$2.36

Costs prepared by HDR Engineering, Inc.

Costs are separated into ICM (12 mgd project) and Future CM (3.6 mgd increments). As shown, the total cost for the first 34 wells (ICM) to provide 12 mgd of capacity is estimated to be $19,038,000. Annual debt service is $1,593,000; and, annual operational cost, including power, is $260,000 resulting in a total annual cost of $1,853,000 for ICM wells. The unit cost for a 2,400 ac-ft/yr supply is estimated to be $772 per ac-ft, or $2.367 per 1,000 gallons.

The cost of future phases (CM-1, etc.) were estimated using the same assumptions and pricing. Total project costs every 10 years for expansions are $5,723,000. Annual costs will increase by $544,000 with the future phases. Annual unit costs are estimated to be $756/ac-ft for future phases.

For evaluation and ranking of strategies (Section 10), costs for the ICM and one future phase (CM-1) are utilized.

Implementation Issues

Environmental Issues

The installation of wells and collection pipelines should be planned and installed so that sensitive habitats, cultural resources, and other environmentally sensitive areas are avoided.

Permitting Issues

The City already owns groundwater rights on 83,305 acres of contiguous property, and wells will be drilled within this area. The City will need to acquire permits from the High Plains Underground Conservation District No. 1, and the design and construction of public water supply wells and water transmission facilities must be approved by the TCEQ.

Other

Wells will be placed on properties where the City owns the water rights, which include the rights to surface improvements to extract and convey their groundwater. Future CMs (CM-1, CM-2, etc.) must be implemented every 10 years to maintain the BCWF capacity. Additional wells will be necessary beyond the 20 year project life under which this strategy was evaluated.

7.5 Roberts County Well Field - New Transmission Line to Aqueduct Strategy

With the decline in yield from Lake Meredith, CRMWA is planning to expand its groundwater supplies for delivery through the surface water delivery system. This strategy consists of expanding the RCWF and well field transmission pipeline capacity for delivery to the CRMWA Aqueduct. Currently a 54-inch diameter transmission line with a 65 mgd capacity delivers water from the RCWF west toward Borger and then south to Amarillo. A new 54-inch diameter transmission line will be constructed using a new right-of-way to deliver supplies to the CRMWA Aqueduct. Additional wells will also be necessary to increase the RCWF capacity to match the increased pipeline capacity. Eventually, replacement wells will be necessary to maintain the proposed RCWF capacity.

Two 54-inch diameter transmission lines delivering water from the RCWF could deliver a peak supply of 130 mgd to the CRMWA Aqueduct (65 mgd from each pipeline). Lubbock's portion would be 48.2 mgd (37.058% of the total CRMWA water available). However, the current capacity of the CRMWA Aqueduct between Amarillo and Lubbock is 53 mgd, of which Lubbock's allocation is approximately 42 mgd (see Figure 4.9). Therefore, while this strategy could supply up to 48.2 mgd to Lubbock if the transmission lines are operating at a full capacity of 65 mgd each, the aqueduct can only deliver a maximum supply of 42 mgd to Lubbock.

The major design features of this strategy include:

- Twenty new Ogallala wells will be constructed to a depth of 950 feet and operate at 2,050 gpm per well;
- All new wells are located on CRMWA property;
- Approximately 72 miles of 54-inch diameter transmission pipeline is required;
- Three booster pump stations sized for 65 mgd; and
- No additional treatment is included in the costs.

Figure 7.15 depicts the relative locations of the well field, new wells, transmission lines, and associated infrastructure needed.

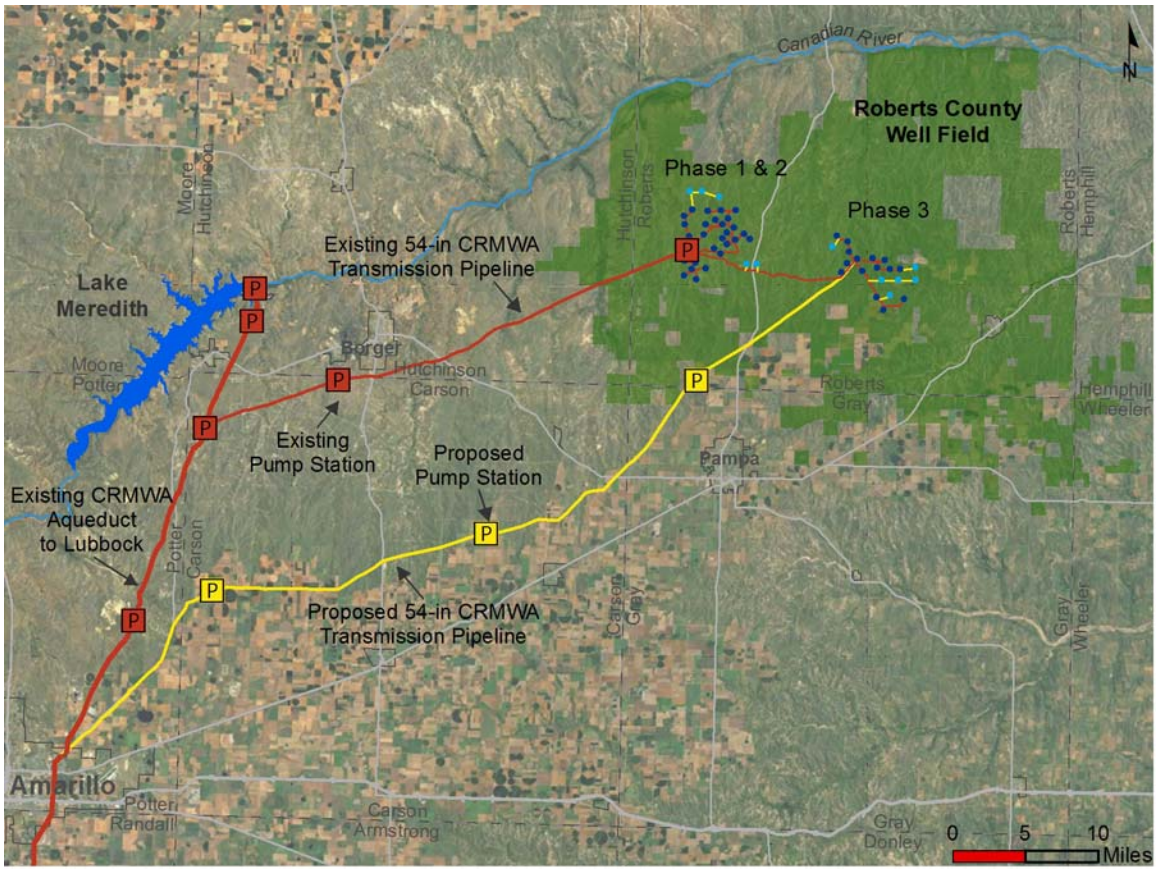


Figure 7.15 – RCWF – New Transmission Line to Aqueduct Strategy

Quantity of Available Water

It is assumed that CRMWA will operate the new transmission line between RCWF and the CRMWA Aqueduct at 80% of its 65 mgd capacity. Thererfore, Lubbock's incremental increase in annual allocation from CRMWA will be 21,583 ac-ft/yr (65 mgd x 1120 ac-ft/yr/mgd x 0.8 x 0.37058). Consequently, the CRMWA Aqueduct between Plainview and Lubbock will be flowing near its peak capacity of 53 mgd with Lubbock's portion of the peak capacity of 42 mgd. Under this strategy, Lubbock's total CRMWA allocation is calculated as follows:

Lubbock's current CRMWA allocation:	24,088 ac-ft/yr
Additional supply with new transmission line:	21,583 ac-ft/yr
Lubbock's total new CRMWA supply:	45,671 ac-ft/yr

Strategy Costs

Costs associated with this strategy are presented in Table 7.4. Assumptions and conditions associated with these costs include:

- The City will pay for 37.058% of the costs for this project;
- Engineering, legal, and contingency costs are 35% for facilities required by this strategy;
- Power is available at $0.09 per kwh;
- Interest during construction is 4.0%, and a 1.0% return on investments; and
- The project will be financed for 20-years at a 5.5% interest rate.

Table 7.4 – RCWF – New Transmission Line to Aqueduct Costs

Cost Estimate Summary / March 2012 Prices		
Item	**Estimated Costs**	**Lubbock's Portion (37.058%)**
Capital Costs		
Transmission Pipeline		
54 in dia., 72 miles	$113,802,000	
Transmission Pump Stations (9,500 hp; 10,400 hp, 9,600 hp)	$46,809,000	
Well Fields (20 wells, 2050 gpm)	$34,409,000	
Water Treatment Plant	$0	
Distribution	$0	
Relocations & Other	$0	
Total Capital Cost	**$195,020,000**	
Engineering, Legal Costs, and Contingencies	$62,567,000	
Environmental & Archaeology Studies and Mitigation	$2,190,000	
Land Acquisition and Surveying (373 acres)	$3,331,000	
Interest During Construction (2 years)	$18,418,000	
Total Project Cost	**$281,526,000**	**$104,328,000**
Annual Costs		
Debt Service (5.5%, 30 years)	$23,558,000	$8,730,000
Operation and Maintenance		
Intake, Pipeline, Pump Station	$2,585,000	$958,000
Pumping Energy Costs (191,602,615 kwh @ 0.09 $/kwh)	$17,244,000	$6,390,000
Purchase of Water	$0	
Total Annual Cost	**$43,387,000**	**$16,078,000**
Available Project Yield (ac-ft/yr)	58,240	21,583
Annual Cost of Water ($ per ac-ft)	$745	$745
Annual Cost of Water ($ per 1,000 gallons)	$2.29	$2.29

Costs prepared by HDR Engineering, Inc.

As shown, the total cost is estimated to be $281,526,000 for facilities to provide peaking capacity of 65 mgd. Annual debt service is $23,558,000; and, annual operational cost, including power, is $19,829,000. This results in a total annual cost of $43,387,000. The unit cost for the average annual supply is $745/ac-ft or $2.29 per 1,000 gallons.

These costs are for delivery of water to Lubbock's terminal storage reservoir and not for any subsequent treatment or transmission from the reservoir. The supply and costs from this strategy will be shared by other CRMWA members. Lubbock's annual cost will be 37.058% of the total annual cost or $16,078,000.

Implementation Issues

Environmental Issues

The installation of wells and collection pipelines should be planned so that sensitive habitats, cultural resources, and other environmentally sensitive areas are avoided. CRMWA should seek to minimize environmental impact when planning the route for the new 54-inch transmission pipeline.

Permitting Issues

Currently, CRMWA owns the groundwater interests in over 400,000 acres of property and wells will be drilled within this area. The City will need to secure permits from the Panhandle Groundwater Conservation District and the design and construction of public water supply wells and water transmission facilities must be approved by the TCEQ.

Other

Wells will be placed on properties where CRWMA owns the water rights which include the rights to surface improvements to extract and convey their groundwater. However, an easement will need to be acquired for the new transmission pipeline.

7.6 CRMWA to Aquifer Storage & Recovery Strategy

This ASR strategy will store water purchased from CRMWA during the fall, winter, and spring in the Ogallala Aquifer and recover the water during June through September. The ASR project aids in balancing the CRMWA deliveries by increasing the deliveries during periods of relatively low winter demands and decreasing demands on the CRMWA system during the summer. Such a project could either delay or eliminate the need for additional wells in Roberts County and/or another transmission line or aqueduct. The raw CRMWA water will be delivered to the NWTP, treated, delivered, and injected into a new ASR well field about two miles east of the NWTP. Later, this water will be recovered and delivered to the NWTP, disinfected, and blended with other treated water from CRMWA for distribution. The framework for this option follows a 2011 CDM Smith report titled *Canadian River Municipal Water Authority Aquifer Storage and Recovery Facility: Project Delivery Plan.*[25]

The major design features of this strategy include:

- Raw water from CRMWA sources will be treated at NWTP;
- A new PS at the NTWP will deliver the treated water to ground storage at the ASR well field;
- A PS to deliver treated water from the ground storage tank to ASR wells for injection;
- Installation of 45 Ogallala ASR wells. Five of the wells are considered to be contingency or standby wells. Their spacing is 1,200 feet or greater;
- Pumps will deliver recovered water to the ground storage at the ASR well field.
- A PS will deliver the recovered water to the NWTP;
- The recovered water will be disinfected and delivered to the NWTP for blending with treated water from the CRMWA supply. Then, the blended water will be pumped into the distribution system; and

Figure 7.16 depicts the relative locations of the ASR wells and associated infrastructure.

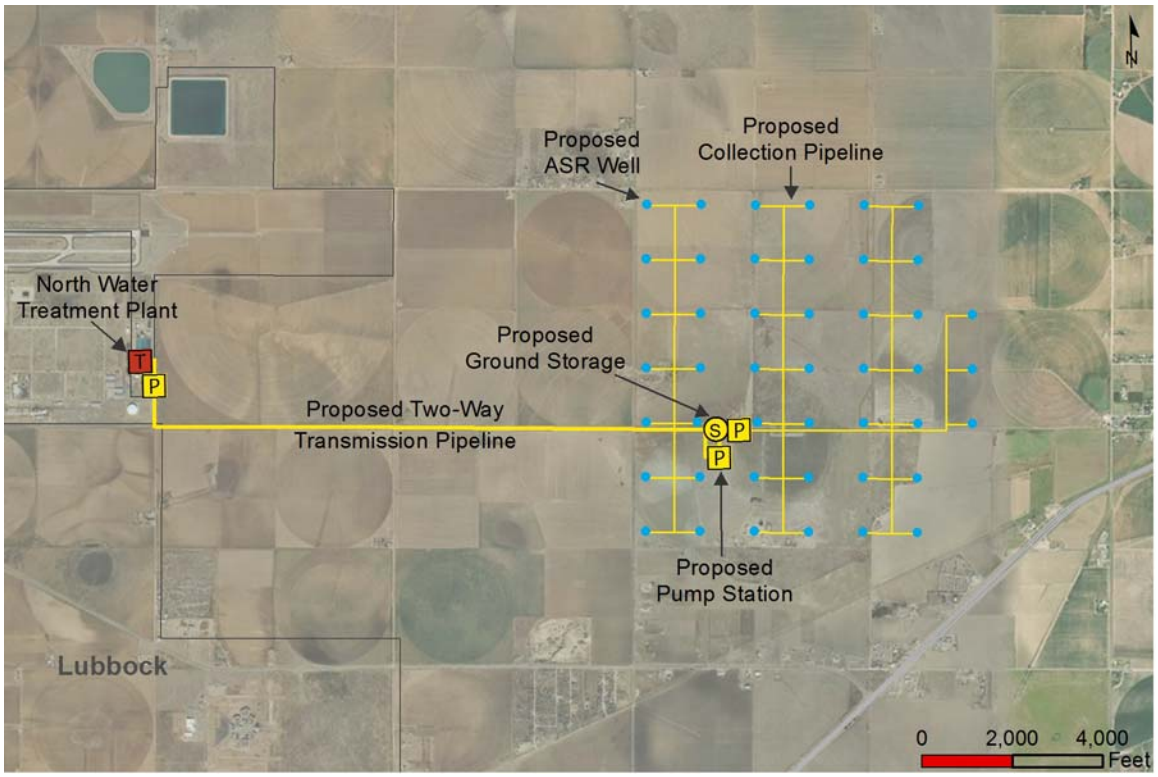


Figure 7.16 – CRMWA to Aquifer Storage and Recovery Infrastructure

Figure 7.17 is a schematic showing how the proposed new ASR infrastructure will interact with the existing NWTP facilities.

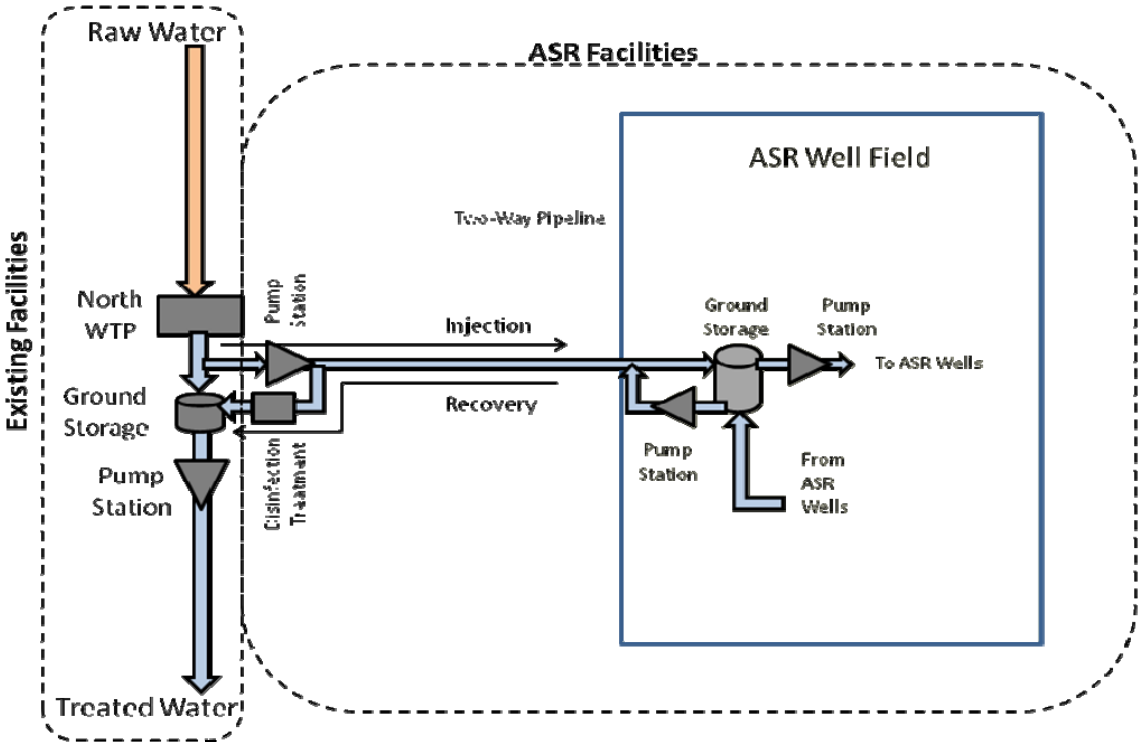


Figure 7.17 – ASR System Schematic

Quantity of Available Water

The strategy assumes that the new transmission line from the RCWF to the CRMWA Aqueduct will be built. As a result, Lubbock's share of the CRMWA water supply will be 45,671 ac-ft/yr. The portion of water available to inject into the aquifer is assumed to be 50% during four winter months each year. This results in an average of 7,612 ac-ft/yr of water available for storage in ASR. The loss of water in ASR storage is assumed to be 20%. As a result, the average annual recovery is 6,090 ac-ft/yr. Recovery would be during four summer months. Peak design capacity is assumed to be 40 mgd, which provides a peaking factor of about 2.4.

Strategy Costs

Costs associated with this strategy are presented in Table 7.5. Assumptions and conditions associated with these costs include:

- A high-capacity Ogallala production well will produce 700 gpm (1.0 mgd);
- The depth to the base of the Ogallala is 220 feet;
- The migration of the injected water will be minimal. However, there are Ogallala irrigation wells in the vicinity of the ASR well field. For purposes of this plan, it's assumed that 20% of the stored water would be lost to other wells;
- Raw water treatment will be provided at no cost to the ASR project. Water will be treated and delivered during November - February when there is unused capacity in the NWTP;
- Property for the ASR well field can be purchased for $2,000 per acre (inclusive of water rights), which is twice the average of rural lands in this part of the state;
- Engineering, legal, and contingency costs is 30% of pipelines and 35% for other facilities;
- Power is available at $0.09 per kwh;
- Interest during construction is 4.0%, and a 1.0% return on investments; and
- The project will be financed for 20-years at a 5.5% interest rate.

Table 7.5 – CRMWA to Aquifer Storage and Recovery Costs

Cost Estimate Summary / March 2012 Prices	
Item	**Costs**
Capital Costs	
Pump Station at Water Treatment Plant	$1,718,000
Pump Station and Ground Storage at ASR Well Field	$4,180,000
Pump Station at ASR Well Field to ASR Wells	$1,449,000
Transmission Pipeline	
48 in dia., 3 miles (SWTP and ASR Well Field)	$4,554,000
ASR Well Field (45 ASR wells, 11 miles of collector pipelines)	$23,876,000
Water Treatment Plant (40 mgd, chlorination only)	$1,710,000
ASR Well Field SCADA, Valving and Pumps	$1,000,000
Total Capital Cost	**$38,487,000**
Engineering, Legal Costs, and Contingencies	$13,243,000
Environmental & Archaeology Studies and Mitigation	$2,880,000
Land Acquisition and Surveying (1,470 acres)	$3,311,000
Interest During Construction (1 year)	$2,028,000
Total Project Cost	**$59,949,000**
Annual Costs	
Debt Service (5.5%, 20 years)	$5,016,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$451,000
Water Treatment Plant	$256,000
Pumping Energy Costs (8,103,764 kwh @ 0.09 $/kwh)	$234,000
Purchase of Water	$0
Total Annual Cost	**$5,957,000**
Available Project Yield (ac-ft/yr)	6,090
Annual Cost of Water ($ per ac-ft)	$978
Annual Cost of Water ($ per 1,000 gallons)	$3.00

Costs prepared by HDR Engineering, Inc.

As shown, the total cost is estimated to be $38,487,000. Annual debt service is $5,016,000; and, annual operational cost, including power, is $941,000. This results in a total annual cost of $5,957,000. The unit cost for a 6,090 ac-ft/yr peaking supply is estimated to be $978 per ac-ft, or $3.00 per 1,000 gallons. This cost does not include the cost of water from CRMWA nor the water treatment prior to storage in the ASR well field.

Implementation Issues

Environmental Issues

The installation of wells and collection pipelines should be planned and installed so that sensitive habitats, cultural resources, and other environmentally sensitive areas are avoided.

Permitting Issues

The City will need to acquire permits from the High Plains Underground Water Conservation District No. 1, and the design and construction of public water supply wells and water transmission facilities must be approved by the TCEQ. In addition, the District will need to promulgate rules regarding ASR projects.

Other

The City does not own groundwater rights in this area. Groundwater rights will need to be purchased so wells can be drilled within the proposed area.

7.7 South Lubbock Well Field Strategy

Although the City used over 60 Ogallala Aquifer wells located within the city limits from 1911 to 1970 for the potable water supply, all of the wells and water collection systems have been decommissioned and abandoned (Section 3.2). However, in 2006, the City initiated a study to evaluate the feasibility of creating a new well field in the southern part of the City where groundwater levels are relatively high and the saturated thickness is relatively large. The results of the evaluation are documented in the City of Lubbock *Groundwater Treatment Plant Engineering Report* delivered by Parkhill, Smith & Cooper and Black & Veatch in May 2006[26] and the *Groundwater Utilization Study* delivered by Daniel B. Stephens & Associates in March 2007.[27] The information in these reports was utilized to evaluate this strategy.

The South Lubbock Well Field Strategy includes the installation of wells in existing City-owned properties. Groundwater is transported to a new water treatment plant at PS #10, near the intersection of Memphis Avenue and 82nd Street. The raw groundwater will need advanced water treatment to overcome relatively high salinity and the possibility of the groundwater being "under the influence" of surface water. The treated water will be discharged into the ground storage tank at PS #10 for blending and distribution. However, there is not sufficient capacity in PS #10 to accommodate this new water supply, and some of the water destined for PS #10 will be diverted to other parts of Lubbock's distribution system.

The major design features of this strategy include:

- Installation of 17 water supply wells (2 are standby wells);
- All wells installed on City property and located to meet TCEQ's sanitary control easement requirements (the well locations are based on previous work by DBS&A);
- Approximately 7 miles of 6 to18-inch diameter raw water collection pipeline;
- Well pumps will be sized to deliver the raw water directly to the new advanced water treatment plant at PS #10;
- A new advanced water treatment plant will be constructed near PS #10. The new treatment plant will provide microfiltration and RO for desalination. The new treatment plant will produce finished water with salinity near the concentration of current potable water supplies;

- Treated water will be delivered to the existing ground storage tank at PS #10 for blending and distribution;
- Since PS #10 is at capacity, an equal portion of water supply to PS #10 would be diverted to another part of the distribution system in order to accommodate the new supply at PS-10;
- A 4-mile, 42-in transmission pipeline will connect PS #14 to the Low Head B by-pass line that feeds PS #7 (see Figure 4.12);
- Desalination concentrate will be disposed of by injecting the concentrate into the Dockum Aquifer;
- The new treatment plant will be designed to produce desalination concentrate with a TDS concentration that is less than or equal to the salinity of water in the Dockum Aquifer; and
- The concentrate disposal well will be located near the new treatment plant.

Figure 7.18 depicts the relative locations of the well field and associated infrastructure needed.

Figure 7.18 – South Lubbock Well Field Infrastructure

Quantity of Available Water

This strategy is estimated to produce 7.0 mgd during the summer months (June - September) each year to assist the City in meeting its peak demand. This pumping schedule would contribute 2,613 ac-ft/yr to Lubbock's overall water supply.[28] However, concerns exist regarding the ability of the Ogallala Aquifer to sustain the level of required pumping from this area of the City for several decades. Additional information is needed to more fully evaluate the quantity of water available from this strategy.

Strategy Costs

Costs associated with this strategy are presented in Table 7.6. Assumptions and conditions associated with these costs include:

- A high-capacity Ogallala Aquifer production well can produce 325 gpm (0.47 mgd);
- The depth to the base of the Ogallala is approximately 135 feet;
- Sparse and relatively old data suggest TDS concentrations range from approximately 570 to over 1,600 mg/L. The composite raw water concentration is expected to be below the secondary drinking water standard of 1,000 mg/L. If not, then the water could be blended with other sources to meet drinking water standards;
- This part of the Ogallala receives rather rapid and direct recharge from rainfall and possibly urban irrigation. Considering the likelihood of the water being slightly brackish and possibly "under the influence" of surface water, advanced water treatment is planned. Advance treatment will include microfiltration and RO;
- Based on a 2003 TWDB report,[29] the depth to the base of the best Dockum sandstone is about 1,900 feet;
- Groundwater in the Dockum at this location has an estimated TDS concentration of about 25,000 milligrams per liter (mg/L);
- Concentrate will be pumped directly into the Dockum disposal well;
- For an operational capacity of 7.0 mgd of potable water, 7.2 mgd of raw water is required. The balance of 0.2 mgd becomes concentrate (50% bypass and 95% efficiency);
- Engineering, legal, and contingency costs is 35% for facilities required by this strategy;
- Power is available at $0.09 per kwh;

- Interest during construction is 4.0%, and a 1.0% return on investments; and
- The project will be financed for 20-years at a 5.5 % interest rate.

Table 7.6 – South Lubbock Well Field Costs

Cost Estimate Summary / March 2012 Prices	
Item	**Costs**
Capital Costs	
Transmission Pipeline	
42-in dia., 4 miles (PS#14 to Low Head B By-Pass Line)	$6,708,000
Well Field (17 Ogallala wells, 7 miles of collector pipeline)	$1,713,000
Disposal Well (1 Dockum well, 200 ft of pipeline)	$750,000
Advanced Water Treatment Plant, with RO for desalination (7 mgd)	$29,920,000
Distribution Improvements	
Interconnect to existing ground storage tank	$50,000
Total Capital Cost	**$39,141,000**
Engineering, Legal Costs, and Contingencies	$15,076,000
Environmental & Archaeology Studies, Permitting and Restoration	$176,000
Land Acquisition and Surveying (14 acres)	$0
Interest During Construction (1 year)	$2,075,000
Total Project Cost	**$56,468,000**
Annual Costs	
Debt Service (5.5%, 20 years)	$5,135,000
Operation and Maintenance	
Wells and Pipelines	$141,000
Water Treatment Plant	$1,920,000
Pumping Energy Costs (1,600,862 kwh @ 0.09 $/kwh)	$144,000
Purchase of Water	$0
Total Annual Cost	**$7,340,000**
Available Project Yield (ac-ft/yr)	2,613
Annual Cost of Water ($ per ac-ft)	$2,809
Annual Cost of Water ($ per 1,000 gallons)	$8.62

Costs prepared by HDR Engineering, Inc.

As shown, the total cost is estimated to be $39,141,000. Costs estimates include adjustment for construction in an urban setting. Annual debt service is $5,135,000; and, annual operational cost, including power, is $2,205,000. This results in a total annual cost of $7,340,000. The unit cost for a 2,613 ac-ft/yr supply is estimated to be $2,809 per ac-ft, or $8.62 per 1,000 gallons.

Implementation Issues

Environmental Issues

Environmental issues should be minimal since the new infrastructure would be installed in an urban area.

Permitting Issues

Water well permits from the High Plains Underground Water Conservation District No. 1 will be necessary. Design and construction of public water supply wells and water treatment facilities must be approved by the TCEQ. Authorization to construct and operate an injection well for concentrate disposal will also be required by the TCEQ.

Other

Wells will be placed on City owned properties. In addition, pipelines will be placed in City utility easements. However, pipeline construction under City streets is costly due to the surface infrastructure restoration necessary.

7.8 Brackish Well Field Strategy

This strategy consists of installing wells in the bottom portion of the Santa Rosa Formation of the Dockum Aquifer. Brackish water would be pumped to the surface and treated before being used for drinking water. The well system would be constructed on the City's existing 320-acre SWTP site. Desalination facilities will be required for proper treatment, and a concentrate disposal well discharing into the Permian formation will be necessary to dispose of the concentrate produced during treatment.

The major design features of this strategy include:

- The installation of 4 Dockum production wells in the corners of the SWTP property. Because of the availability of other water sources, no contingency or standby wells are planned.
- The installation of 2 Permian injection wells. Storage facilities will be located on the east side of the property;
- Approximately 10,400 feet of 8-inch diameter raw water collection pipeline;
- Approximately 8,300 feet of 6-inch diameter concentrate disposal pipeline;.
- Pumps will deliver the raw water directly to the desalination water treatment plant;
- The desalination water treatment plant will use RO technology, which will produce potable water with a TDS concentration of 500 mg/L. The concentrate will have a TDS concentration of about 170,000 mg/L;
- Concentrate will be delivered to a ground storage tank near the desalination water treatment plant, which is sized to hold the amount of concentrate that is produced in a day;
- From the ground storage tank, a high pressure pump will deliver the concentrate to the injection well for disposal;
- For an operational capacity of 1.0 mgd of potable water, 1.17 mgd of raw water is required. The balance of 0.17 mgd becomes concentrate (85% recovery); and
- Treated water will be delivered to the SWTP for blending and distribution.

Figure 7.19 depicts the relative locations of the Brackish Well Field and associated infrastructure needed.

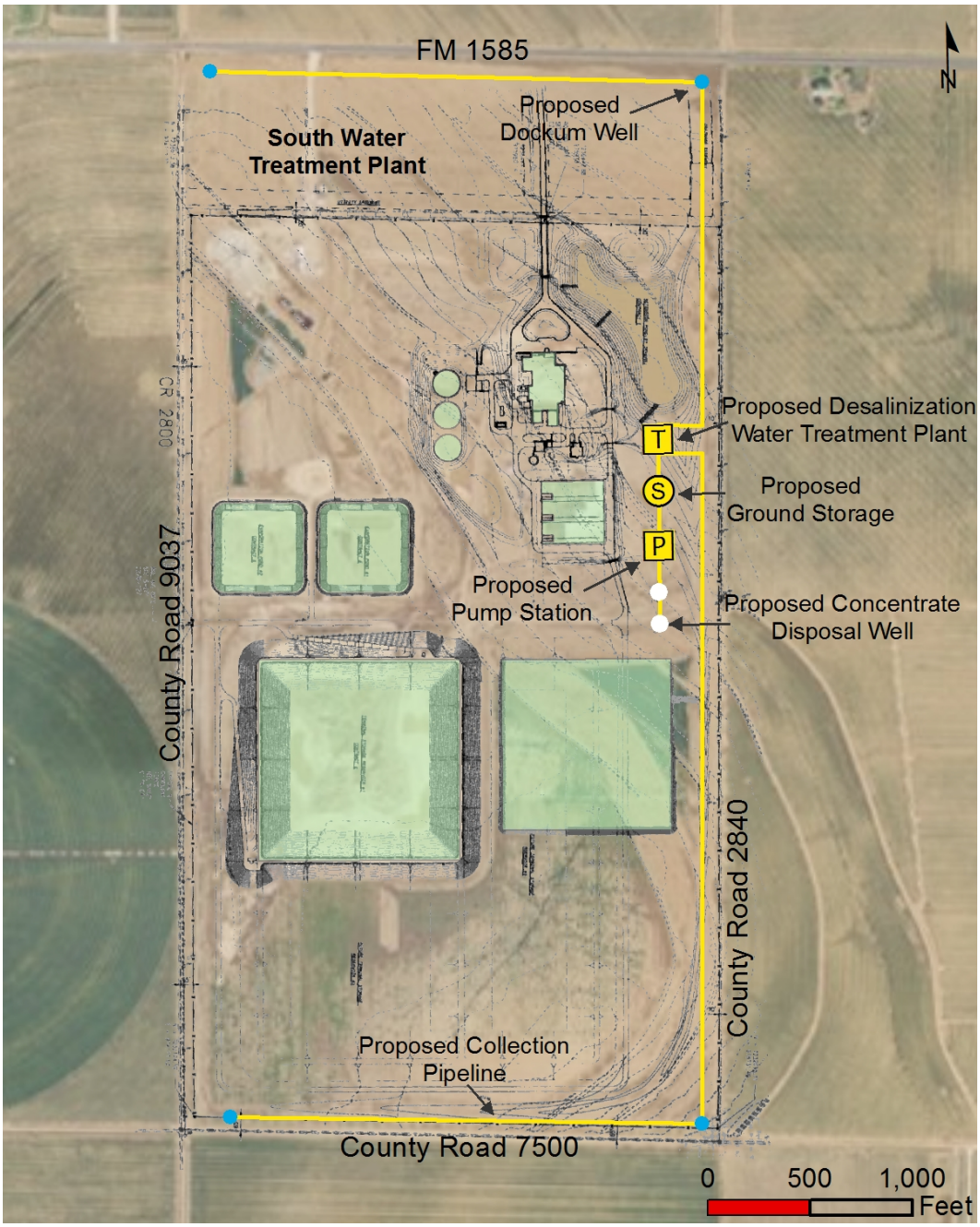


Figure 7.19 – Brackish Well Field Infrastructure

Quantity of Available Water

This strategy is designed for a dependable treated supply of 1,120 ac-ft/yr or 1.0 mgd. The required raw water supply will be about 1,310 ac-ft/yr or 1.17 mgd and will generate approximately 190 ac-ft/yr or 0.17 mgd of concentrate. Because the water supply will come from a deep aquifer, it is considered to be independent of drought conditions.

Strategy Costs

Costs associated with this strategy are presented in Table 7.7. Assumptions and conditions associated with these costs include:

- Based on information in the TWDB Groundwater Availability Model documentation,[30] a high-capacity Dockum production well is expected to produce about 200 gpm (0.29 mgd);
- Based on a 2003 TWDB report,[31] the depth to the base of the best Dockum sandstone is about 1,900 feet;
- The water has an estimated TDS concentration of about 25,000 mg/L. This concentration is estimated from relatively sparse data in the TWDB Groundwater Availability Model report;[32]
- A high-capacity Permian injection well is about 5,000 feet deep for disposal of the brine concentrate;
- Engineering, legal, and contingency costs are 35% for the facilities required by this project;
- Power is available at $0.09 per kwh;
- Interest during construction is 4.0%, and a 1.0% return on investments; and
- The project will be financed for 20-years at a 5.5% interest rate.

Table 7.7 – Brackish Well Field Costs

Cost Estimate Summary / March 2012 Prices	
Item	**Costs**
Capital Costs	
Concentrate Pump Station	$930,000
Well Field (300 gpm, 1,900 ft deep, Dockum)	$3,335,000
Concentrate Well (175 gpm, 5,000 ft deep, Permian)	$3,825,000
Desalination Water Treatment (1.5 mgd)	$15,869,000
Total Capital Cost	**$23,959,000**
Engineering, Legal Costs, and Contingencies	$8,400,000
Environmental & Archaeology Studies and Mitigation	$0
Land Acquisition and Surveying (13 acres)	$0
Interest During Construction (1 year)	$1,135,000
Total Project Cost	**$33,494,000**
Annual Costs	
Debt Service (5.5%, 20 years)	$2,806,000
Operation and Maintenance	
Wells and Pipelines	$92,000
Water Treatment Plant	$917,000
Pumping Energy Costs (600,204 kwh @ 0.09 $/kwh)	$184,000
Purchase of Water	$0
Total Annual Cost	**$3,999,000**
Available Project Yield (ac-ft/yr)	1,120
Annual Cost of Water ($ per ac-ft)	$3,571
Annual Cost of Water ($ per 1,000 gallons)	$10.96

Costs prepared by HDR Engineering, Inc.

As shown, the total cost is estimated to be $33,494,000. Annual debt service is $2,806,000; and, annual operational cost, including power, is $1,193,000. The total annual cost is $3,999,000. The unit cost for a 1,120 ac-ft/yr supply is estimated to be $3,571 per ac-ft, or $10.96 per 1,000 gallons.

Implementation Issues

Environmental Issues

Environmental issues should be minimal since the new infrastructure would be installed on existing City properties. No known wildlife habitat or cultural resources would be affected. An environmental assessment for the SWTP approved by the TWDB was prepared as part of the LAH Phase 1 infrastructure project. In addition, environmental assessments were performed as part of the City's due diligence in purchasing the property for the SWTP.

Permitting Issues

Water well permits from the High Plains Underground Water Conservation District No. 1 will be necessary. Design and construction of public water supply wells and water treatment facilities must be approved by the TCEQ. Authorization to construct and operate an injection well for concentrate disposal will also be required by the TCEQ.

Other

Wells and collection pipelines will be placed on City owned properties.

The target zone for brine disposal from oil and gas production in the area is about 5,000 feet deep in the Permian Formation. No other information is readily available to estimate its suitability for a concentrate disposal well. As a result, there is considerable uncertainty in the capacity of the Permian to accept the required injection rate for an extended period of time.

[1] Water for Texas: 2012 State Water Plan. 163.

[2] George, P.G., R.E. Mace, and R. Petrossian. Aquifers of Texas. Texas Water Development Board: Report 380. 2011: Figure 2-1.

[3] George, P.G., R.E. Mace, and R. Petrossian. Aquifers of Texas. Texas Water Development Board: Report 380. 2011: Figure 2-2.

[4] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: 3-1.

[5] Center for Geospatial Technology, Texas Tech University. 2008.

[6] Center for Geospatial Technology, Texas Tech University. 2008.

[7] 2007 Strategic Water Supply Plan, City of Lubbock, Section 9.

[8] George, P.G., R.E. Mace, and R. Petrossian. Aquifers of Texas. Texas Water Development Board: Report 380. 2011: 101.

[9] George, P.G., R.E. Mace, and R. Petrossian. Aquifers of Texas. Texas Water Development Board: Report 380. 2011: 101.

[10] George, P.G., R.E. Mace, and R. Petrossian. Aquifers of Texas. Texas Water Development Board: Report 380. 2011: 101.

[11] Blanford, T.N., M. Kuchanur, A Standen, K.C. Calhun, P. Kirby, and G. Shah. Edwards-Trinity (High Plains) Groundwater Availability Model. Texas Water Development Board. 2008: 12-13.

[12] Brackish Groundwater Manual for Texas Regional Water Planning Groups. Texas Water Development Board. 2003: 91.

[13] Water for Texas: 2007 State Water Plan. 2007: 169.

[14] Blanford, T.N., M. Kuchanur, A Standen, K.C. Calhoun, P. Kirby, and G. Shah. "Edwards-Trinity (High Plains) Groundwater Availability Model." Texas Water Development Board. 2008: 19.

[15] George, P.G., R.E. Mace, and R. Petrossian. Aquifers of Texas. Texas Water Development Board: Report 380. 2011: 101.

[16] George, P.G., R.E. Mace, and R. Petrossian. Aquifers of Texas. Texas Water Development Board: Report 380. 2011: 102.

[17] George, P.G., R.E. Mace, and R. Petrossian. Aquifers of Texas. Texas Water Development Board: Report 380. 2011: 97.

[18] Final Report: Groundwater Availability Model for the Dockum Aquifer. Texas Water Development Board. October 2008: 1-1.

[19] Ewing, J.E. and others. October 2008. Final Report: Groundwater Availability Model for the Dockum Aquifer. Texas Water Development Board Report. October 2008: Figure 4.2.2.

[20] Ewing, J.E. and others. October 2008. Final Report: Groundwater Availability Model for the Dockum Aquifer. Texas Water Development Board Report. October 2008: Figure 4.8.1.

[21] George, P.G., R.E. Mace, and R. Petrossian. Aquifers of Texas. Texas Water Development Board: Report 380. 2011: 63.

[22] Texas Water Development Board Groundwater Management Areas. Online: http://www.twdb.state.tx.us/groundwater/management_areas/

[23] Updated Bailey County Well Field Modeling Report, Daniel B. Stephens & Associates. September 2012: 6.

[24] Updated Bailey County Well Field Modeling Report, Daniel B. Stephens & Associates. September 2012: 7.

[25] Canadian River Municipal Water Authority Aquifer Storage and Recovery Facility: Project Delivery Plan. CDM Smith. 2011.

[26] Engineering Report: Groundwater Treatment Plant- Lubbock, Texas. Parkhill, Smith & Cooper, Inc. May 2006.

[27] City of Lubbock Groundwater Utilization Study. Daniel B. Stephens & Associates, Inc. March 23, 2007.

[28] City of Lubbock Groundwater Utilization Study. Daniel B. Stephens & Associates, Inc. March 23, 2007: ES-3.

[29] Bradley, R.G., and S. Kalaswad. December 2003. The groundwater resources of the Dockum Aquifer in Texas: TWDB Report 359.

[30] Ewing, J.E. and others. October 2008. Final Report: Groundwater Availability Model for the Dockum Aquifer. Texas Water Development Board Report. October 2008.

[31] Ewing, J.E. and others. October 2008. Final Report: Groundwater Availability Model for the Dockum Aquifer. Texas Water Development Board Report. October 2008.

[32] Ewing, J.E. and others. October 2008. Final Report: Groundwater Availability Model for the Dockum Aquifer. Texas Water Development Board Report. October 2008.

8.0 Surface Water Strategies

The State of Texas contains all or part of 23 river basins, as shown in Figure 8.1.

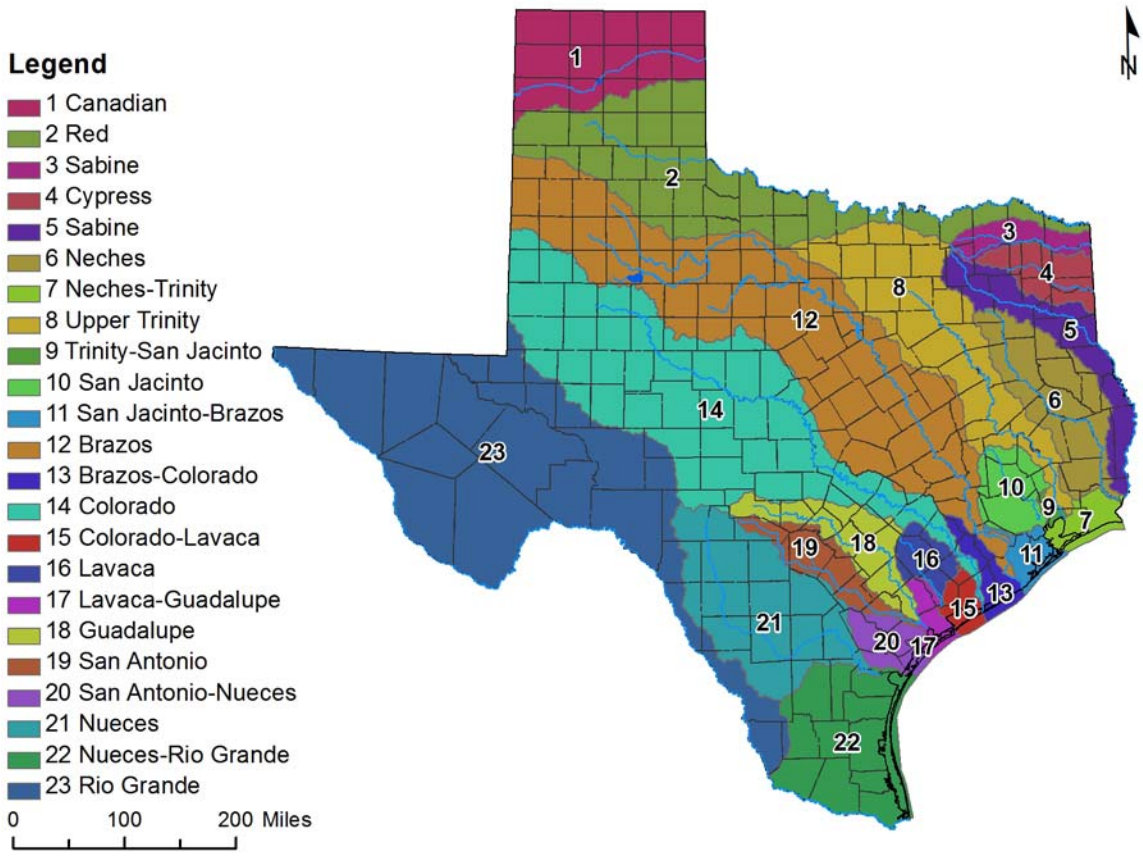


Figure 8.1 - River Basins in Texas

Four of the river basins are within practical reach of Lubbock, including the Canadian River, Red River, Brazos River, and Colorado River basins as depicted in Figure 8.2. However, on the semi-arid High Plains of Texas, surface water is limited. With an average annual rainfall for the Lubbock region of only 19 inches, typical surface water in the region is limited to intermittent stream flows and storm water collected in playa lakes.[1] In the absence of water discharged by the City of Lubbock, the North Fork remains dry most of the year. The South Fork flows into LAH and historically has received greater storm flow events than the North Fork. Lake Meredith is located in the Canadian River Basin. Currently, Lake Meredith does not hold enough water to be a viable water supply for Lubbock.

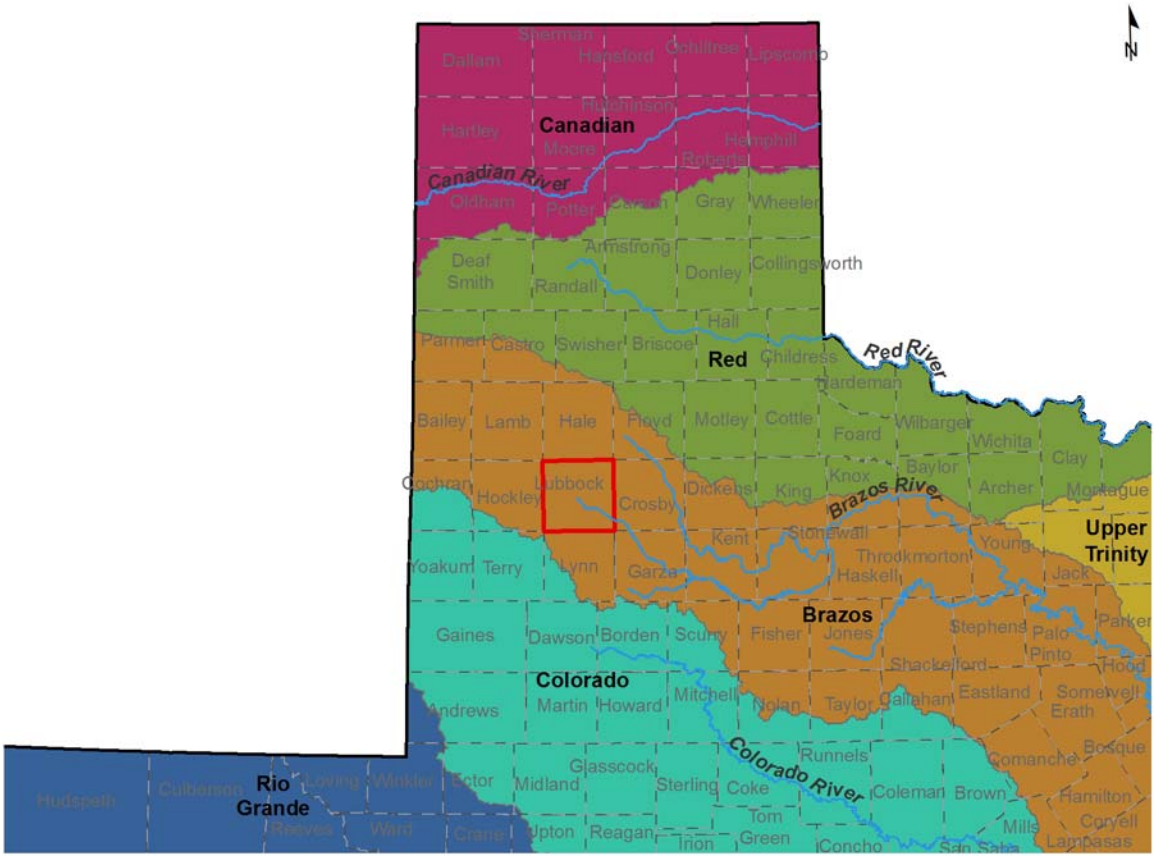


Figure 8.2 – River Basins in the Lubbock Region

8.1 Developed Water – Supplements to Brazos River Basin

Since flows in the upper Brazos River Basin are limited, the addition of developed water is desirable to make new reservoirs viable. Developed water can be defined as water that is non-native to the Brazos River Basin. Developed water includes groundwater, groundwater-based reclaimed water, and playa lake water, the latter of which would be considered privately owned diffuse surface water.

Supplemental Reclaimed Water

Reclaimed water that is treated to stream discharge standards and permitted to be discharged into a surface water body can become a supplemental source of surface water. Reclaimed water supply strategies are described in Section 6.0. Two potential lakes (Jim Bertram Lake 7 and Post Reservoir) that rely upon reclaimed, developed, and storm water

are discussed in Sections 8.3 and 8.4 respectively. These reservoirs only become feasible strategies if a sufficient amount of treated wastewater is discharged into the North Fork and recaptured in one or both of these reservoirs for reuse.

Supplemental Groundwater

The Yellow House Canyon and Blackwater Draw run through Lubbock and discharge into the North Fork. In 1969, the City hired a consultant to perform the initial planning for the Canyon Lakes Project, which consists of a series of eight dams and small reservoirs in the Yellow House Canyon. The City subsequently constructed a series of lakes in the Yellow House Canyon. These lakes were named as follows:

Lake 1 Conquistador Lake
Lake 2 Llano Estacado Lake
Lake 3 Comacheria Lake
Lake 4 Not Constructed
Lake 5 Mackenzie Park Lake
Lake 6 Dunbar Lake

This system of lakes was originally known as the Canyon Lake System but was later renamed the Jim Bertram Lake System (JBLS). The City has developed a park system around these lakes. The JBLS is depicted in Figure 8.3.

These small lakes receive a constant flow of water each year from groundwater that is pumped from under the Lubbock Land Application Site (LLAS) just outside of East Loop 289 adjacent to the City. The pumping began in 1989 as part of an Agreed Order from the TCEQ to reduce a water mound and high levels of nitrate in the groundwater beneath the LLAS. TPDES Discharge Permit No. WQ00004599000 issued on April 28, 2006 (renewed September 18, 2009 with an expiration date on March 1, 2014), allows a maximum daily discharge of groundwater into Lake 1 of 4.3 mgd (4,817 ac-ft/yr).

The City obtained Certificate of Adjudication 12-3705 in February 1985, which authorizes the impoundment of water in the JBLS for recreation purposes, with no diversion right. Certificate 12-3705 was subsequently amended two times at the City's request (12-7305A on February 28, 1997 and 12-7305B on May 11, 2007) to obtain the right to divert from Lakes 1, 2 and 6, and to gain more flexibility in using the water for agriculture, municipal, recreational, and industrial purposes in Lubbock and Lynn Counties. The combined rate of

authorized diversion is 4.3 mgd (4,817 ac-ft/yr). The City can only divert the amount of groundwater that it discharges into the JBLS, less carriage losses. On average, the City currently discharges approximately 2.0 mgd (2,240 ac-ft/yr) into the JBLS. The City diverts water from the JBLS and uses it to irrigate various parks and facilities. The major users of the JBLS water are as follows:

Berl Huffman Soccer Complex	215.7 ac-ft/yr
Meadowbrook Golf Course	484.4 ac-ft/yr
City Cemetery	245.8 ac-ft/yr
Total JBLS Water Used -2011	945.9 ac-ft/yr

By using the JBLS water for irrigation of these large areas, the City is conserving its potable water supply.

Figure 8.3- Jim Bertram Lake System

Supplemental Playa Lake Water

A potential source of surface water that can supplement the natural flows of the Brazos River Basin is the water stored in playa lakes throughout the City. Storm water in the Lubbock area collects in playa lakes and can flood surrounding structures. In an effort to reduce the potential for flooding around the playa lakes, the City completed the construction of the South-Central Drainage System in 2003 and the South Drainage System in 2008. These systems convey excess storm water into the Yellow House Canyon (a tributary to the North Fork) as depicted in Figure 8.4. Discharges into the North Fork are authorized by the TCEQ pursuant to the City's Municipal Separate Storm Sewer System (MS4) TPDES permit no. WQ0004773000.

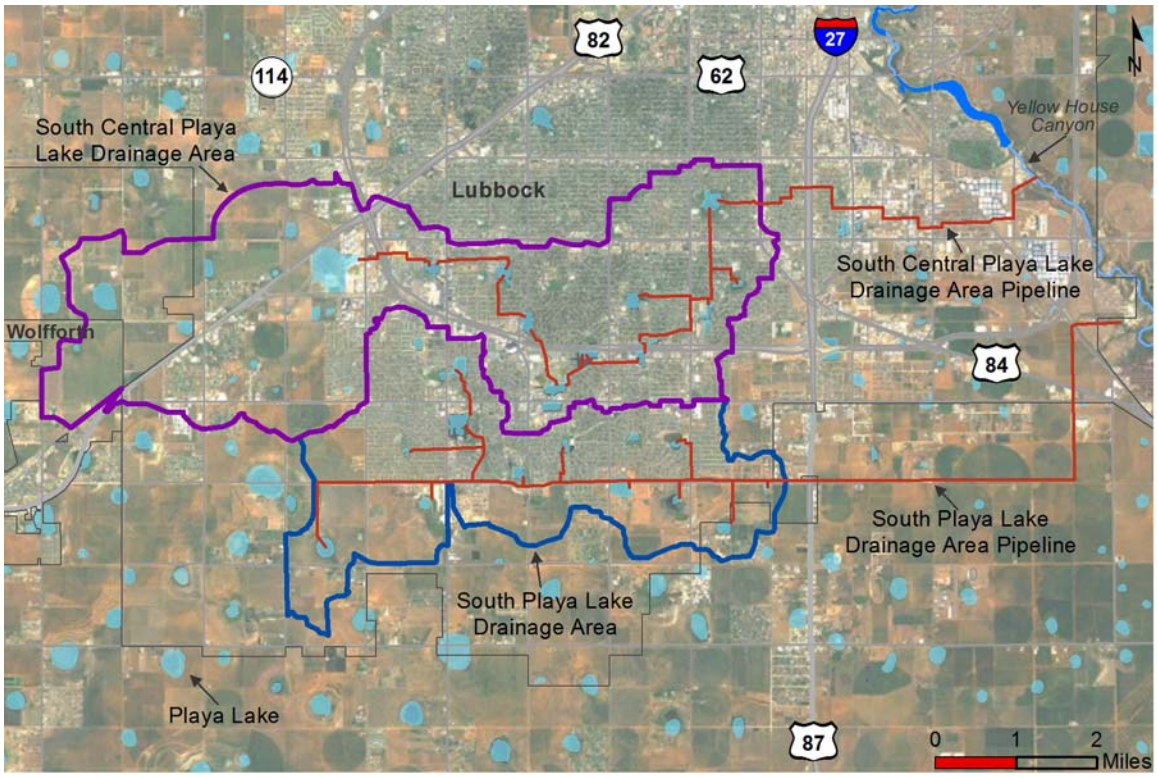


Figure 8.4 – South Central & South Playa Lake Drainage Systems

The quantity of water available from these systems will vary based on seasonal and annual rainfall events. According to a Municipal Precipitation Runoff study performed in October 2008, the following volumes of storm water can be anticipated from these two discharge points designated as No. 30 and No. 31, respectively.[2]

Storm Event	Point 30	Point 31	Total Discharge
2 - Year	1,278	773	2,051 ac-ft
5 - Year	2,182	1,279	3,461 ac-ft
10 - Year	2,941	1,713	4,654 ac-ft

The impoundment and diversion of the storm water after its discharge from the South and South Central Playa Lake Drainage Systems will ultimately require water use permits. In May 2009, the City entered into an Interlocal Agreement with the Brazos River Authority (BRA) where the BRA acknowledged these two drainage systems as the City's developed water.[3] This agreement ensures that the BRA will not contest any of Lubbock's applications or filings that seek to divert and use these storm water flows. The City also has a pending application for Water Use Permit 5921 in which the City is seeking the right to impound in Lake 7 and divert water originating as treated effluent discharges and storm water from the South and South Central Playa Lake Drainage Systems.

8.2 Lake Alan Henry Phase 2 Strategy

Lake Alan Henry impounds water on the South Fork. This water supply strategy includes expanding the existing LAH infrastructure so that its capacity to transport and treat raw water from the lake to the City of Lubbock is increased from 15 mgd to 30 mgd. As discussed in Section 3.0, Lubbock began using LAH as a water supply during the fall of 2012. The existing LAH raw water supply pipeline (Phase 1) consists of:

- Two raw water pump stations—Lake Alan Henry (LAHPS) and Post (PPS) pump stations;
- The SWTP;
- A 42-inch diameter raw water transmission pipeline from the LAHPS to the PPS;
- A 48-inch diameter raw water transmission pipeline from the PPS to the SWTP; and
- Treated water transmission lines that move water into three pump stations (PS #8, PS #10, and PS #14) within Lubbock's water distribution system.

Expansion of the existing infrastructure is necessary to supply water to the City at a greater daily rate. The major design features of the LAH Phase 2 strategy include:

- Construction of a Southland Pump Station (SLPS);
- Capacity expansion of equipment at the LAHPS and the PPS;
- A 15 mgd expansion of the SWTP, which includes expansion of the high service pump station; and
- A 4-mile, 42-in transmission pipeline connecting PS #14 to the Low Head B by-pass line (see Figure 4.12).

Figure 8.5 depicts the additional infrastructure required for this strategy.

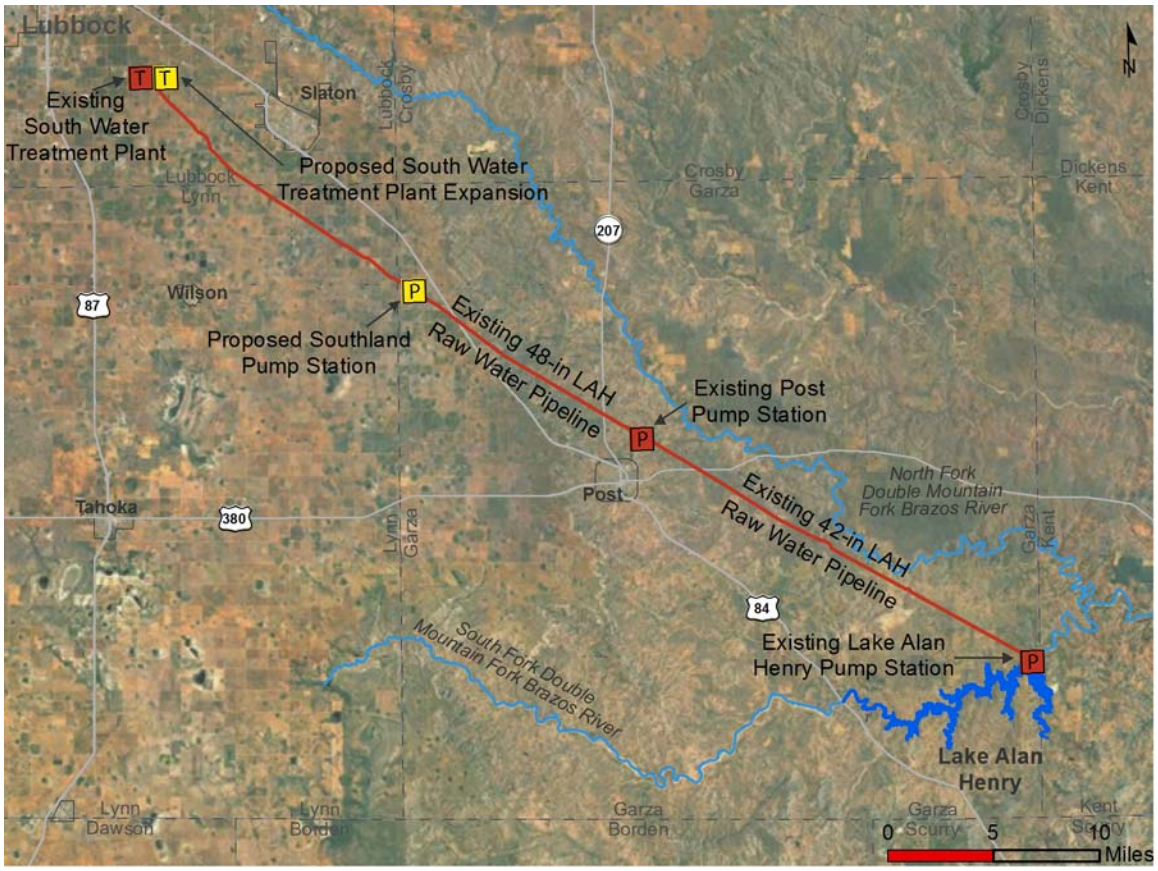


Figure 8.5 – Lake Alan Henry Phase 2

Quantity of Available Water

The City intends to operate LAH near the 2-year safe yield of 16,080 ac-ft/yr.[4] The current water supply infrastructure will only deliver 8,000 ac-ft/yr with a peaking capacity of 15 mgd. Phase 2 will be constructed to increase the total deliverable water to 16,000 ac-ft/yr from LAH, an incremental increase of 8,000 ac-ft/yr. The pump stations and the SWTP will be modified to provide a peak capacity of 30 mgd. Additional raw water transmission lines will not be necessary since the existing pipelines were sized to handle up to 34 mgd[5] with the appropriate pumping capacity.

The additional capacity of the raw water transmission lines may be used if other water supply strategies are implemented, such as the NFD-LAHPS (Section 6.8), the Post Reservoir (Section 8.4), or the North Fork Scalping Operation (Section 8.5).

Strategy Costs

Costs associated with this strategy are presented in Table 8.1. Facility component sizes were obtained from a Freese and Nichols, Inc. Opinion of Probable Construction Cost estimate[6] provided to the City of Lubbock. These costs and facility sizes are used in this cost estimate. Other assumptions and conditions associated with these costs include:

- Energy costs to transmit the additional water from the expansion through the LAHPS and pipeline are included. These costs are based on an average annual delivery of an additional 7.1 mgd (8,000 ac-ft/yr) through the upgraded system;
- Existing infrastructure will be used to transmit treated water from the SWTP into the City's water distribution system;
- Land for the new SLPS has already been purchased;
- Energy costs and upgrades to Pump Station #14 were not included in transmission pipeline costs;
- Engineering, legal, and contingency costs are 30% of pipeline construction and 35% of other facilities constructed;
- Power is available at $0.09 per kwh;
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period; and
- The project will be financed for 20 years at a 5.5% annual interest rate.

Table 8.1 – Lake Alan Henry Phase 2 Costs

Cost Estimate Summary / March 2012 Prices	
Item	**Costs**
Capital Costs	
LAH Pump Station Expansion (additional 15 mgd)	$4,691,000
Post Pump Station Expansion (additional 15 mgd)	$3,330,996
Southland Pump Station Expansion (30 mgd)	$6,910,000
Transmission Pipeline	
42-in dia., 4 miles (PS#14 to Low Head B By-Pass Line)	$6,708,000
Water Treatment Plant Expansion (additional 15 mgd)	$23,875,000
Total Capital Cost	**$45,514,996**
Engineering, Legal Costs, and Contingencies	$15,840,000
Environmental & Archaeology Studies and Mitigation	$5,000
Land Acquisition and Surveying (5 acres)	$6,000
Interest During Construction (2 years)	$4,345,000
Total Project Cost	**$65,710,996**
Annual Costs	
Debt Service (5.5%, 20 years)	$5,557,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$442,000
SWTP Expansion	$112,000
Pumping Energy Costs (0.09 $/kwh)	$1,936,000
Total Annual Cost	**$8,047,000**
Available Project Yield (ac-ft/yr)	8,000
Annual Cost of Water ($ per ac-ft)	$1,006
Annual Cost of Water ($ per 1,000 gallons)	$3.09

Costs prepared by HDR Engineering, Inc.

As shown, the total project cost is estimated to be $65,710,000. Annual debt service is $5,557,000; and, the annual operational cost, including power, is $2,490,000. This results in a total annual cost of $8,047,000. The unit cost for an additional annual supply of 7.1 mgd or 8,000 ac-ft/yr from LAH is estimated to be $1,006 per ac-ft, or $3.09 per 1,000 gallons.

Implementation Issues

Environmental

Environmental issues associated with this option should be minimal. The TWDB approved an environmental assessment[7] for the overall Phase 1 project so the City could qualify for low interest loans administered through the TWDB. In addition, environmental assessments were performed at the locations of the proposed SLPS[8] and the SWTP[9] expansion. Therefore, no additional assessment should be necessary at these locations. The treated water transmission pipeline routes can be selected to avoid sensitive wildlife habitat and cultural resources.

Permitting

Raw water will be obtained from LAH, which is owned by the City of Lubbock. Water Use Permit No. 4146 allows for the diversion of 35,000 ac-ft each year. No additional permitting requirements are anticipated. The TCEQ will need to approve design modifications to the existing system.

Other Issues

The City owns property where the SLPS and the additional SWTP capacity will be constructed. The treated water transmission pipeline will be installed within the city limits and preferably within existing City street easements.

8.3 Jim Bertram Lake 7

The Jim Bertram Lake 7 Strategy was initially conceived as part of the Jim Bertram Lakes Project described in Section 8.1. The Lake 7 reservoir will be located on the North Fork and have a reservoir holding capacity of 20,000 ac-ft at a conservation pool elevation of 3,100 ft-msl.

Most of the yield associated with this strategy is generated by capturing the City's reclaimed water. However, Lake 7 will also capture storm water flows and discharges from the City's South and South Central Playa Lake Drainage Systems discussed in Section 8.1. These three sources of surface water make Lake 7 a viable supply strategy.

The major design features of this strategy include:

- The construction of the dam and 20,000 ac-ft lake inundating 774 acres;
- A new intake structure and 665 hp pump station near the Lake 7 dam;
- A 5-mile, 24-in transmission pipeline that will deliver the raw water to the SWTP;
- A 4-mile, 42-in transmission pipeline connecting PS #14 to the Low Head B by-pass line (see Figure 4.12); and
- A 10.1 mgd expansion of the SWTP which includes an expansion of the high service pump station at the SWTP.

A report entitled *Feasibility of Constructing the Proposed Lake 7* was completed by HDR Engineering, Inc.[10] under the City's direction in September of 2011. This report provided an optimal location for the lake to be built upstream of Buffalo Springs Lake along the North Fork. Figure 8.6 depicts the relative locations of Lake 7 and associated infrastructure that will be needed.

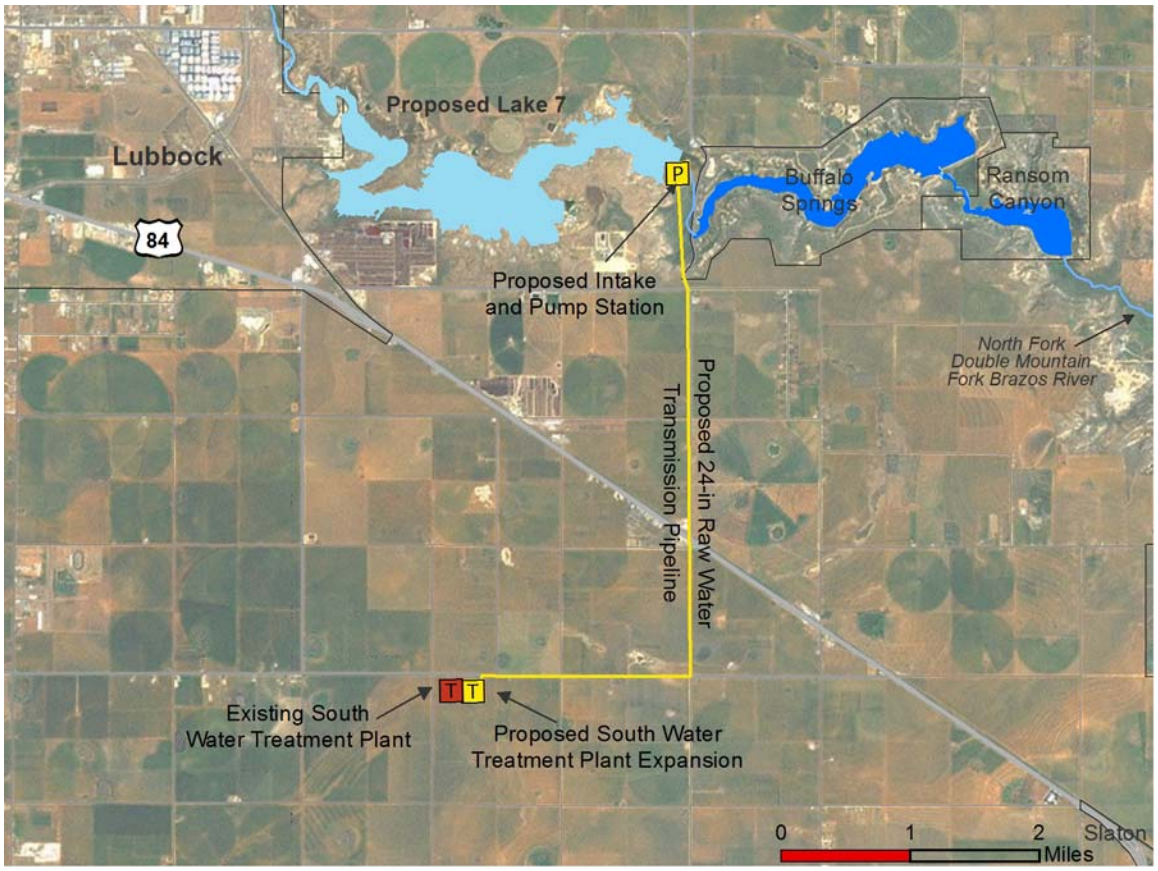


Figure 8.6 – Jim Bertram Lake 7 Infrastructure

Quantity of Available Water

According to the HDR Feasibility Report, Jim Bertram Lake 7 will supply a one-year safe yield of 11,300 ac-ft/yr of raw water. The safe yield is based upon the availability of return flows discharged by the City and the availability of playa lake developed water. Natural inflows captured by Lake 7 were modeled subject to the TCEQ's Consensus Criteria for Environmental Flow Needs (CCEFN) instream flow requirements. The individual contributions of the three sources of inflows to increase the yield of Lake 7 are as follows:

Reclaimed Water (8 mgd):	7,300 ac-ft/yr
Playa Lake Developed Water:	2,200 ac-ft/yr
State Water/Natural Inflow:	1,800 ac-ft/yr
Total	11,300 ac-ft/yr

This yield amount is subject to the City obtaining sole rights to its developed water (playa lake storm water and reclaimed water).[11] Increases and decreases of the reclaimed water available will have an approximate one to one increase or decrease on the reservoir's safe yield. The reclaimed water will come from Outfall 007 located at the SEWRP and/or another future outfall further upstream. The Lake 7 yield does not include any reductions attributed to horizontal leakage through the canyon walls.

Strategy Costs

Costs associated with this strategy are presented in Table 8.2. Assumptions and conditions associated with these costs include:

- Flows used to design the intake, pump station, and transmission pipelines include an estimated 5% downtime;
- The treated water transmission pipeline will be installed within the city limits and preferably within existing city street easements;
- Energy costs and upgrades to PS #14 were not included in transmission pipeline costs;
- Engineering, legal, and contingency costs are 30% of pipeline construction and 35% of other facilities constructed;
- Power is available at $0.09 per kwh;
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period; and
- The project will be financed for 20 years at a 5.5% annual interest rate.

Table 8.2 – Jim Bertram Lake 7 Strategy Costs

Cost Estimate Summary / March 2012 Prices	
Item	**Costs**
Capital Costs	
Dam and Reservoir (20,000 ac-ft, 774 acres, 3,100 ft msl)	$25,322,000
Intake and Pump Station (10.6 mgd)	$6,579,000
Transmission Pipeline	
24 in dia., 5 miles	$3,392,000
42-in dia., 4 miles (PS#14 to Low Head B By-Pass Line)	$6,708,000
SWTP Expansion (10.1 mgd)	$18,097,000
Total Capital Cost	**$60,098,000**
Engineering, Legal Costs, and Contingencies	$20,529,000
Environmental & Archaeology Studies and Mitigation	$914,000
Land Acquisition and Surveying (803 acres)	$1,007,000
Interest During Construction (2 years)	$5,780,000
Total Project Cost	**$88,328,000**
Annual Costs	
Debt Service (5.5%, 20 years)	$4,188,000
Reservoir Debt Service (5.5%, 20 years)	$3,203,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$265,000
Dam and Reservoir	$380,000
SWTP Expansion	$1,557,000
Pumping Energy Costs (0.09 $/kwh)	$372,000
Total Annual Cost	**$9,965,000**
Available Project Yield (ac-ft/yr)	11,300
Annual Cost of Water ($ per ac-ft)	$882
Annual Cost of Water ($ per 1,000 gallons)	$2.71

Costs prepared by HDR Engineering, Inc.

As shown, the total project cost is estimated to be $88,328,000. Annual debt service is $7,391,000; and, the annual operational cost, including power, is $2,574,000. This results in a total annual cost of $9,965,000. The unit cost for 11,300 ac-ft/yr supply is estimated to be $882 per acre-foot, or $2.71 per 1,000 gallons.

Implementation Issues

Environmental Issues

The primary environmental issue related to this strategy is the change in land use of 774 acres from ranchland to a reservoir site. In July 2011, the City provided an Environmental Information Document (EID) to the TCEQ which described the environment that will potentially be affected by the construction of Lake 7.[12] According to the EID, this project will have an impact on the environment, and a mitigation plan will be required to compensate for unavoidable impacts. Some of the issues identified in the EID include:

- No federal or state protected aquatic life has been found (neither the smalleye shiner nor the sharpnose shiner).[13]
- A baseline survey revealed that the Texas horned lizard (Texas listed threatened species) is thriving in the project vicinity. Additional evaluation and a management and mitigation plan will be necessary if the reservoir is built.[14]
- A review of Texas Historical Commission and other records identified 17 archeological sites in or near the project area that will need to be assessed.[15]

Permitting Issues

As discussed in Section 6.0, the existing TPDES Permit No. 10353-002 authorizes the City to discharge up to 14.5 mgd (16,242 ac-ft/yr) of reclaimed water at the SEWRP into the North Fork at Outfall 007. In 2005, the City submitted Water Rights Application No. 5921 which, among other things, seeks the right to impound and divert water from the proposed Lake 7. Although the application was declared administratively complete in April 2006, the TCEQ's technical review is still on-going. The TCEQ has received eight requests for contested case hearings. It will take several more years before the permit may be issued to the City.

In addition, a United States Army Corps of Engineers (USACE) Section 404 permit will be required prior to commencing construction of Lake 7. This lake is large enough to require an individual permit. Mitigation plans for the project's environmental impacts must be developed and agreed upon by the USACE and other state and federal resource agencies.

Other

Property will need to be acquired for the lake, dam, pump station, and mitigation area. In addition, pipeline utility easements will be necessary to construct a raw water transmission line to the SWTP.

The geological formation that the dam foundation will be constructed upon appears to be somewhat pervious. Extensive cut-off wall and grout curtains will need to be installed to avoid water seeping under the dam and around the abutments. In addition, there may be considerable leakage from the reservoir conservation pool to the local groundwater aquifer system. The Comanche Peak formation could also allow vertical leakage from the reservoir through the valley floor.[16] A study was initiated by the City in 2012 to investigate these geologic formation issues.

8.4 Post Reservoir

Post Reservoir is considered an indirect reuse strategy defined in Section 6.0, since much of the lake's capacity will be created by the City's reclaimed water. The proposed reservoir site is located on the North Fork northeast of Post, Texas in Garza County. Certificate of Adjudication No. 12-3711 authorizes the impoundment of 57,420 ac-ft of water and the diversion and use of up to 10,600 ac-ft of water per year. Under this strategy, water will be impounded and diverted from the reservoir and transported to the existing PPS that delivers water from LAH to Lubbock. The 48-inch diameter LAH raw water line is adequate to convey water from both the Post Reservoir and LAH. However, an expansion of the SWTP will be necessary.

The major design features of this strategy include:

- Construction of a 57,420 ac-ft, 2,280 acre reservoir;
- A new intake structure and pump station located at the reservoir site;
- A 6-mile, 24-in transmission pipeline to deliver water from Post Reservoir to the PPS;
- An 8 mgd expansion of the SWTP;
- A 4-mile, 42-in transmission pipeline connecting PS #14 to the Low Head B by-pass line (see Figure 4.12);
- Expansion of the PPS to transport raw water along the LAH pipeline system; and
- The addition of the SLPS located on the LAH raw water pipeline.

Figure 8.7 depicts the additional infrastructure required for this strategy.

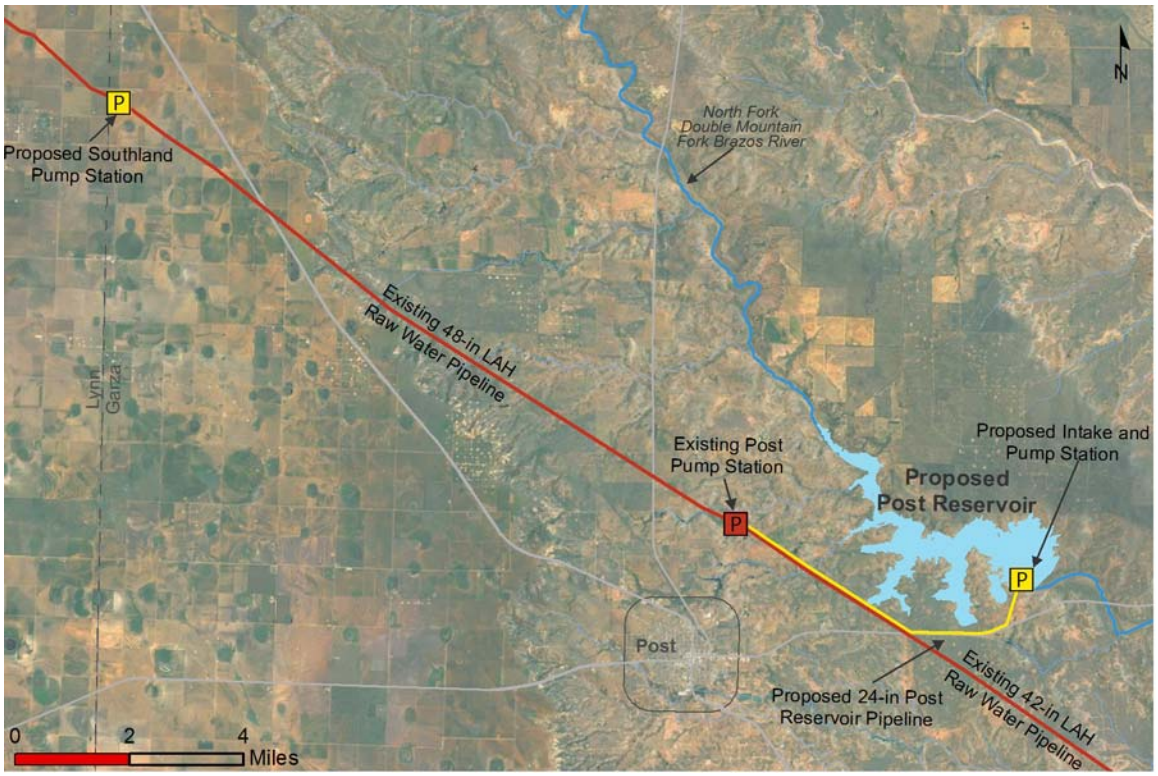


Figure 8.7 – Post Reservoir Infrastructure

Quantity of Available Water

The conservation pool will store approximately 57,420 ac-ft of water (neglecting sedimentation), with a surface area of 2,280 acres. Analyses using the Texas Commission on Environmental Quality (TCEQ) Water Availability Model (WAM) indicate a range of firm and safe yield supplies could be developed for this strategy, depending upon treatment of upstream return flows, sediment storage reserves, instream flow requirements and playa lake stormwater flows. For purposes of this analysis, it is assumed that 8,962 ac-ft/yr (8 mgd) of water is available for diversion from the Post Reservoir, given that Lake 7 would not be constructed upstream.

Strategy Costs

Costs associated with this strategy are presented in Table 8.3. Assumptions and conditions associated with these costs include:

- Flows used to design the intake, pump station, and transmission pipeline designs include an estimated 5% downtime;
- Expansion costs of the PPS is included;
- The construction of the SLPS is included;
- Energy costs to transmit water through the LAHPS and pipeline are included;
- Existing infrastructure will be used for transmission of treated water from the SWTP into the City's water distribution system;
- Energy costs and upgrades to PS #14 were not included in transmission pipeline costs;
- Engineering, legal, and contingency costs are 30% of pipeline construction and 35% of other facilities constructed;
- Power is available at $0.09 per kwh;
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period; and
- The project will be financed for 20 years at a 5.5% annual interest rate.

Table 8.3 – Post Reservoir Strategy Costs

Cost Estimate Summary / March 2012 Prices	
Item	**Costs**
Capital Costs	
Dam and Reservoir	$22,145,000
Intake and Pump Station	$6,295,000
Transmission Pipeline	
24 in dia., 6 miles	$3,512,000
42-in dia., 4 miles (PS#14 to Low Head B By-Pass Line)	$6,708,000
SWTP Expansion (8.0 mgd)	$14,990,000
LAH Pipeline Expansion	$7,798,000
Total Capital Cost	**$61,448,000**
Engineering, Legal Costs, and Contingencies	$20,996,000
Permitting Fees	$5,000,000
Environmental & Archaeology Studies and Mitigation	$2,435,000
Land Acquisition and Surveying (2,307 acres)	$2,609,000
Interest During Construction (2 years)	$6,475,000
Total Project Cost	**$98,963,000**
Annual Costs	
Debt Service (5.5%, 20 years)	$4,824,000
Reservoir Debt Service (5.5%, 20 years)	$3,457,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$260,000
Dam and Reservoir	$322,000
SWTP Expansion	$1,287,000
Post Pipeline Pumping Energy Costs (0.09 $/kwh)	$330,000
LAH Pipeline Pumping Energy Costs (0.09 $/kwh)	$495,000
Total Annual Cost	**$10,975,000**
Available Project Yield (ac-ft/yr)	8,962
Annual Cost of Water ($ per ac-ft)	$1,225
Annual Cost of Water ($ per 1,000 gallons)	$3.76

Costs prepared by HDR Engineering, Inc.

As shown, the total project cost is estimated to be $98,963,000. Annual debt service is $8,281,000; and, annual operational cost, including power, is $2,694,000. This results in a total annual cost of $10,975,000. The unit cost for 8,962 ac-ft/yr supply is estimated to be $1,225 per ac-ft, or $3.76 per 1,000 gallons.

Implementation Issues

Environmental

The primary environmental issue related to this strategy is the change in land use of 2,250 acres from ranchland to a reservoir site. There will be a high impact on animal habitats that must be mitigated. Studies will be necessary to determine the actual impact to cultural resources, wetlands, and threatened and endangered species. However, it is anticipated that the construction of the reservoir will have a low to moderate impact related to these concerns.[17]

Permitting

As discussed in Section 6.0, the existing TPDES Permit No. 10353-002 authorizes the City to discharge up to 14.5 mgd (16,242 ac-ft/yr) of reclaimed water at the SEWRP into the North Fork at Outfall 007, and up to 9.0 mgd (10,089 ac-ft/yr) at FM400 at Outfall 001. The White River Municipal Water District (WRMWD) holds Certificate of Adjudication No. 12-3711, which authorizes the Post Reservoir with a priority date of January 20, 1970. This Certificate authorizes impoundment of 57,420 ac-ft in the reservoir. It also authorizes diversion of 5,600 ac-ft/yr for municipal use, 1,000 ac-ft/yr for industrial use, and 4,000 ac-ft/yr for mining purposes. The City will need to obtain ownership of the water right in order to construct the reservoir. The certificate will need to be amended so the City can obtain authorization to divert and use the full 10,600 ac-ft/yr for municipal purposes and obtain clarification regarding 19,000 ac-ft of sediment reserve identified in the special conditions of the certificate. In addition, a USACE Section 404 permit will be required prior to commencing construction of the Post Reservoir. This lake is large enough to require an individual permit. Mitigation plans for the project's environmental impacts must be developed and agreed upon by the USACE and other interested state and federal resource agencies.

Other Issues

Property will need to be acquired for the lake, dam, pump station, and wildlife mitigation area. In addition, pipeline utility easements will be necessary to construct a raw water transmission line to the PPS.

8.5 North Fork Scalping Operation

The North Fork Scalping Operation (NFSO) strategy is designed to increase the firm yield of LAH by 8,725 ac-ft/yr by collecting and re-directing storm water from the North Fork into the lake. To accomplish this, a diversion reservoir will be built on the North Fork in Garza County. This diversion reservoir will capture storm water flows on the river. A pumping station at the diversion reservoir will move the water from the diversion reservoir through an oversized transmission pipeline that can handle substantial, sudden surges of water into a stilling basin near Gobbler Creek. The stilling basin will decrease the velocity of the scalped water and therefore reduce erosion. The water from the stilling basin will flow into Gobbler Creek which naturally drains into LAH.

The major design features of this strategy include:

- A 1,000 ac-ft, 650 acre diversion reservoir on the North Fork to capture high flows for scalping;
- A new intake structure and a 12,669 hp pump station at the diversion site;
- A 5-mile, 96-in transmission pipeline to deliver the scalped high flows from the North Fork to LAH;
- A stilling basin located at the discharge point located on Gobbler Creek;
- Construction of the SLPS;
- A 7.8 mgd expansion of the SWTP which includes expansion of the high service pump station at the SWTP; and
- A 4-mile, 42-in transmission pipeline connecting PS #14 to the Low Head B by-pass line (see Figure 4.12).

Figure 8.8 depicts the relative locations of the NFSO infrastructure needed.

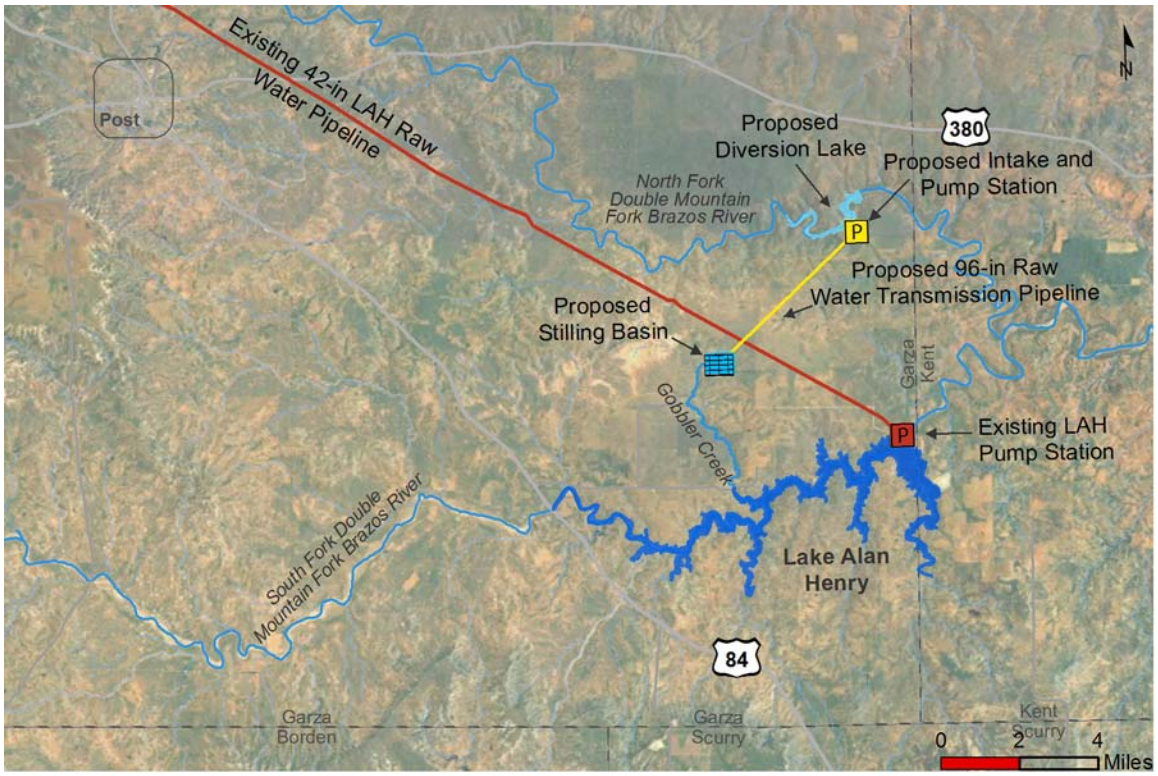


Figure 8.8- North Fork Scalping Operation Infrastructure

The NFSO strategy could be combined with the North Fork Diversion to LAHPS strategy (diverting reclaimed water) described in Section 6.8. since both strategies could utilize the same diversion dam and reservoir.

Quantity of Available Water

The NFSO will be an intermittent and unpredictable source of water because it is dependent upon local precipitation and storm events. However, a model developed by HDR Engineering, Inc., estimates that the NFSO could increase the firm yield of LAH by as much as 7.8 mgd or 8,725 ac-ft/yr.[18]

Strategy Costs

Costs associated with this strategy are presented in Table 8.4. Assumptions and conditions associated with these costs include:

- Expansion costs of the LAHPS and PPS
- Construction of the SLPS;
- Energy costs to transmit water through the LAHPS and pipeline are included;
- Existing infrastructure will be used to transmit treated water from the SWTP into the City's water distribution system;
- Energy costs and upgrades to PS #14 were not included in transmission pipeline costs;
- Engineering, legal, and contingency costs are 30% of pipeline construction and 35% of other facilities constructed;
- Power is available at $0.09 per kwh;
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period.; and
- The project will be financed for 20 years at a 5.5% annual interest rate.

Table 8.4 – North Fork Scalping Operation Costs

Cost Estimate Summary / March 2012 Prices	
Item	**Costs**
Capital Costs	
Dam and Reservoir (Conservation Pool 1,000 ac-ft, 650 acres)	$2,582,000
Intake and Pump Station (162.4 mgd)	$30,334,000
Transmission Pipeline	
96 in dia., 5 miles	$21,388,000
42-in dia., 4 miles (PS#14 to Low Head B By-Pass Line)	$6,708,000
Stilling Basin	$756,000
SWTP Expansion (7.8 mgd)	$14,727,000
LAH Pipeline Expansion (SLPS, PPS, LAHPS)	$10,177,000
Total Capital Cost	**$86,672,000**
Engineering, Legal Costs, and Contingencies	$28,893,000
Environmental & Archaeology Studies and Mitigation	$786,000
Land Acquisition and Surveying (684 acres)	$931,000
Interest During Construction (2 years)	$8,211,000
Total Project Cost	**$125,493,000**
Annual Costs	
Debt Service (5.5%, 20 years)	$10,070,000
Reservoir Debt Service (5.5%, 20 years)	$432,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$1,047,000
Dam and Reservoir	$39,000
SWTP Expansion	$1,264,000
Pumping Energy Costs (0.09 $/kwh)	$504,000
LAH Pumping Energy Costs (0.09 $/kwh)	$1,870,000
Total Annual Cost	**$15,226,000**
Available Project Yield (ac-ft/yr)	8,725
Annual Cost of Water ($ per ac-ft)	$1,745
Annual Cost of Water ($ per 1,000 gallons)	$5.35

Costs prepared by HDR Engineering, Inc.

As shown, the total project cost is estimated to be $125,493,000. Annual debt service is $10,502,000; and, the annual operational cost, including power, is $4,724,000. This results in a total annual cost of $15,226,000. The unit cost for 7.8 mgd or 8,725 ac-ft/yr supply is estimated to be $1,745 per acre-foot, or $5.35 per 1,000 gallons.

Implementation Issues

Environmental Issues

This project should have a low to moderate impact on the environment, including habitats, cultural resources, wetlands, and threatened or endangered species.[19] Some concern exists that discharging storm water from the North Fork into LAH could encourage golden algae growth in LAH. Golden alga is an organism that is toxic to fish under certain conditions, and has been found in lakes along the North Fork.[20] The sharpnose shiner and smalleye shiner may soon be listed as a threatened species on the federal list. These fish have been found along this reach of the North Fork. Increased flows into Gobbler Creek may change the size and configuration of the channel.[21]

Permitting Issues

A new water use permit from the TCEQ will be required for the impoundment and diversion of water from the North Fork and the conveyance of the diverted water into LAH. Diversions will be subject to instream flow requirements. A USACE Section 404 permit will be required prior to commencing construction of the diversion facilities. Mitigation plans for the project's environmental impacts must be developed and agreed upon by the USACE and other interested state and federal resource agencies. The TCEQ must review and approve construction of proposed facilities.

Other Issues

Property will need to be acquired for the diversion reservoir, dam, and pump station. In addition, pipeline utility easements will be necessary to construct a raw water transmission line to Gobbler Creek.

[1] Annual Water Highlights: Technical Summary. Brazos River Authority. 2000: III-6.

[2] Municipal Precipitation Runoff Contributions to the North Fork of the Double Mountain Fork of the Brazos River (City of Lubbock Discharge Points 30 & 31). Parkhill, Smith & Cooper, Inc. August 2008: 20, 47.

[3] Interlocal Agreement Between The Brazos River Authority of Texas and The City of Lubbock, Texas. Resolution No. 2009-R0187. May 14, 2009.

[4] Lake Alan Henry Yield Model - Memo. HDR, Inc. January, 24 2008.

[5] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: 4-179.

[6] Opinion of Probable Construction Cost: LAH System Upgrades for 36 mgd. Freese and Nichols, Inc. September 4, 2012.

[7] Environmental Assessment for the City of Lubbock Lake Alan Henry Water Supply Project. Freese and Nichols, Inc.; June 2009

[8] Phase I Environmental Site Assessment, 4.82 Acre Tract, Southland, Garza County, Texas (Southland Pump Station Site), Prepared by V-Tech Environmental Services, January 8, 2008.

[9] Phase I Environmental Site Assessment, West half of Section 72, Block S, Lubbock County, Texas (South Water Treatment Plant Site), Prepared by the City of Lubbock, August 5, 2008.

[10] Feasibility of Constructing the Proposed Lake 7, HDR, Inc., September 2011.

[11] Feasibility of Constructing the Proposed Lake 7, HDR, Inc., September 2011, p. 7-1.

[12] Environmental Information Document in Support of Water Use permit Application No. 5921; City of Lubbock, July 2011.

[13] Feasibility of Constructing the Proposed Lake 7, HDR, Inc., September 2011, p. 5-4.

[14] Feasibility of Constructing the Proposed Lake 7, HDR, Inc., September 2011, p. 5-5.

[15] Feasibility of Constructing the Proposed Lake 7, HDR, Inc., September 2011, p. 5-7.

[16] Feasibility of Constructing the Proposed Lake 7, HDR, Inc., September 2011, p. 7-2.

[17] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: p. 4-219-221.

[18] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: 4-202.

[19] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: p. 4-213.

[20] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: p. 4-206.

[21] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: p. 4-208, 210.

9.0 Other Strategies Considered

In addition to the 16 water strategies that were fully evaluated and ranked, several strategies were considered that either:

1) did not consist of enough data to be fully evaluated, or
2) were evaluated in the past but found undesirable for various reasons.

These strategies include Jim Bertram Lake 8, a Jim Bertram Lakes well field, a linear well field along the CRMWA Aqueduct, and the addition of a second CRMWA Aqueduct often referred to as CRMWA III. These strategies are discussed in this section.

9.1 Jim Bertram Lake 8

This strategy was included in the 2006 Llano Estacado (Region O) Regional Water Plan. The concept behind this strategy was to construct both Jim Bertram Lake 7 and 8 simultaneously. These lakes were both included to provide a way to use Lubbock's developed water resources. Developed resources include storm water collected into playa lakes, groundwater pumped from under the LLAS, and treated wastewater discharged into the North Fork. Figure 9.4 depicts the proposed location of Lake 8 downstream of Lake Ransom Canyon.

Lake 8 would be built to capture, store, and divert water to the SWTP and subsequently pumped into Lubbock's water distribution system. Design includes: [1]

- A reservoir with 49,900 acre-feet of storage capacity;
- A 26.7 mgd capacity pump station and intake structure;
- A 90-inch diameter raw water transmission pipeline with a 26.7 mgd capacity to transfer water 7 miles to the SWTP; and
- Expansion of the SWTP to include an additional 21 mgd treatment capacity.

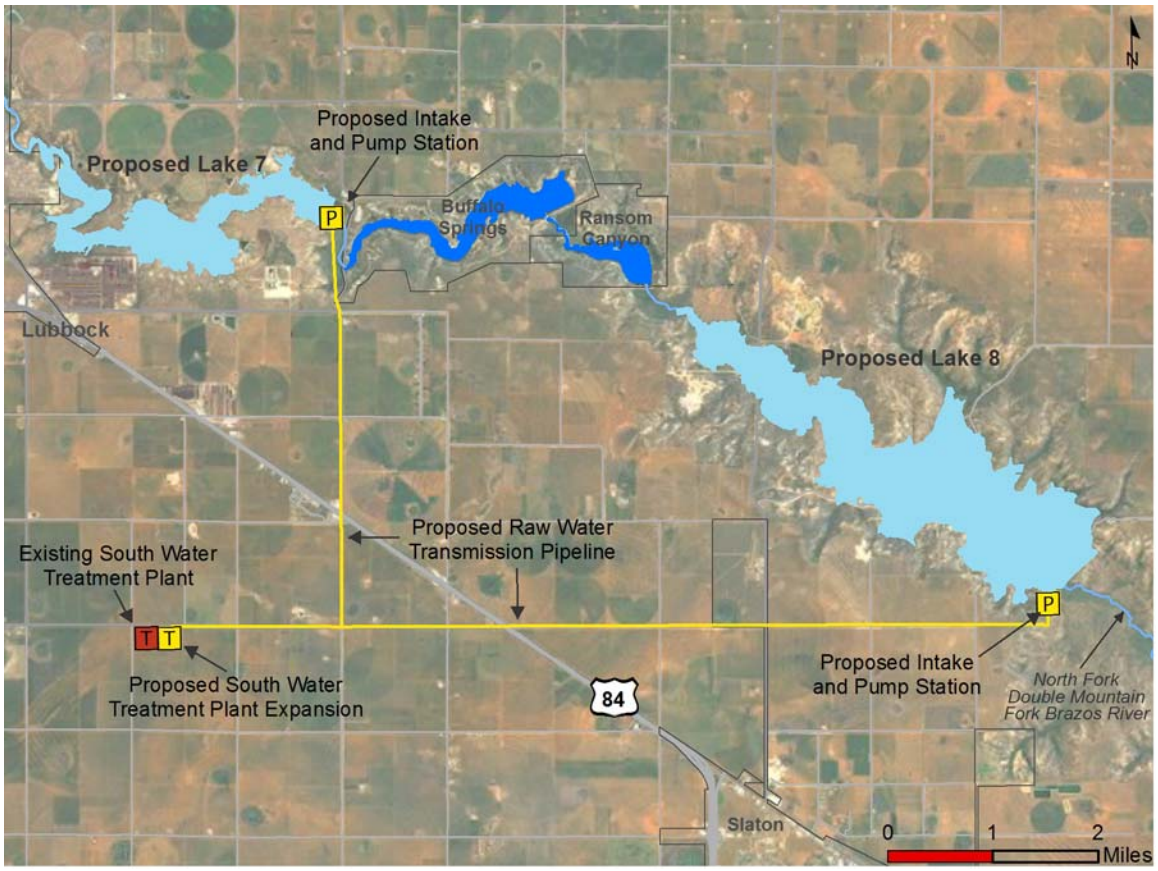


Figure 9.1 – Location of Proposed Jim Bertram Lake 8

Quantity of Available Water

This strategy was estimated to provide an additional 17,720 ac-ft/yr of annual water supply to Lubbock. This firm yield was determined in conjunction with a 3,500 ac-ft/yr yield for Lake 7 for a total system yield of 21,200 ac-ft/yr.[2] Yields for these two lakes were based on 25,648 ac-ft/yr of available reclaimed water. Current projections indicate that by 2113 (in 100 years), less than 22,000 ac-ft/yr of reclaimed water will be available for direct and/or indirect reuse (See Section 6.3).

Implementation Issues

In 2005, the City submitted Water Rights Application No. 5921 which, among other things, originally sought the right to impound and divert water from both Lakes 7 and 8. Although the application was declared administratively complete in April 2006, the TCEQ's technical review is still on-going. On March 4, 2008, a request was made by Lubbock to the TCEQ to remove Lake 8 from the permit application. This was due primarily to the number of existing structures and properties that Lake 8 would inundate if constructed. Lake 8 was subsequently deleted from the 2011 Region O Water Plan.

9.2 Jim Bertram Lakes Well Field

Another potential strategy consists of installing a series of shallow wells in close proximity to the Jim Bertram Lake System. This lake system flows through east Lubbock as depicted in Figure 9.2. Wells would be installed on either side of the Lakes 1, 2 and 3. The water would be pumped to the surface, collected, and transported through a pipeline to the NWTP for treatment and distribution.

Data needed to further evaluate this strategy includes:

- The recommended distance between the "bed and banks" of the river basin to the proposed wells;
- The hydraulic characteristics of the alluvial formation;
- The depth to the groundwater table and the base of the formation;
- The recommended number of wells;
- A determination of the amount of water that these wells can produce over a sustained period;
- A determination of whether the groundwater is under the influence of surface water;
- A determination of whether the groundwater is considered to be part of the "bed and banks" of the river system;
- Water rights or water use permits that will be required;
- The allowable spacing of the proposed wells;
- The size and length of collection and transmission pipelines that will be needed;
- The type of pumping facilities that will be needed; and,
- The level of treatment that will be required.

Figure 9.2 – Jim Bertram Lakes Well Field

This strategy has been considered because installing a well field along the Jim Bertram Lakes System has the potential to be a sustainable supply of water since the water in the lakes is recharging into the surrounding water bearing formations. However, one uncertainty is that most of the water found in the lake system has been supplied by pumping groundwater from the LLAS and discharging it into Lake 1. This groundwater remediation project will not provide a long-term, reliable supply of water (beyond 30 years). When the remediation project is ended, another source of water would need to be discharged into the JBLS to continue recharging the surrounding water bearing formations.

9.3 Linear Well Field - CRMWA Aqueduct

This potential strategy consists of installing a series of wells into the Ogallala Aquifer at optimal locations near the existing CRMWA Aqueduct. The groundwater would be pumped to the surface, collected, and transported to the aqueduct for delivery to Lubbock's NWTP for treatment and distribution. This concept is depicted in Figure 9.3.

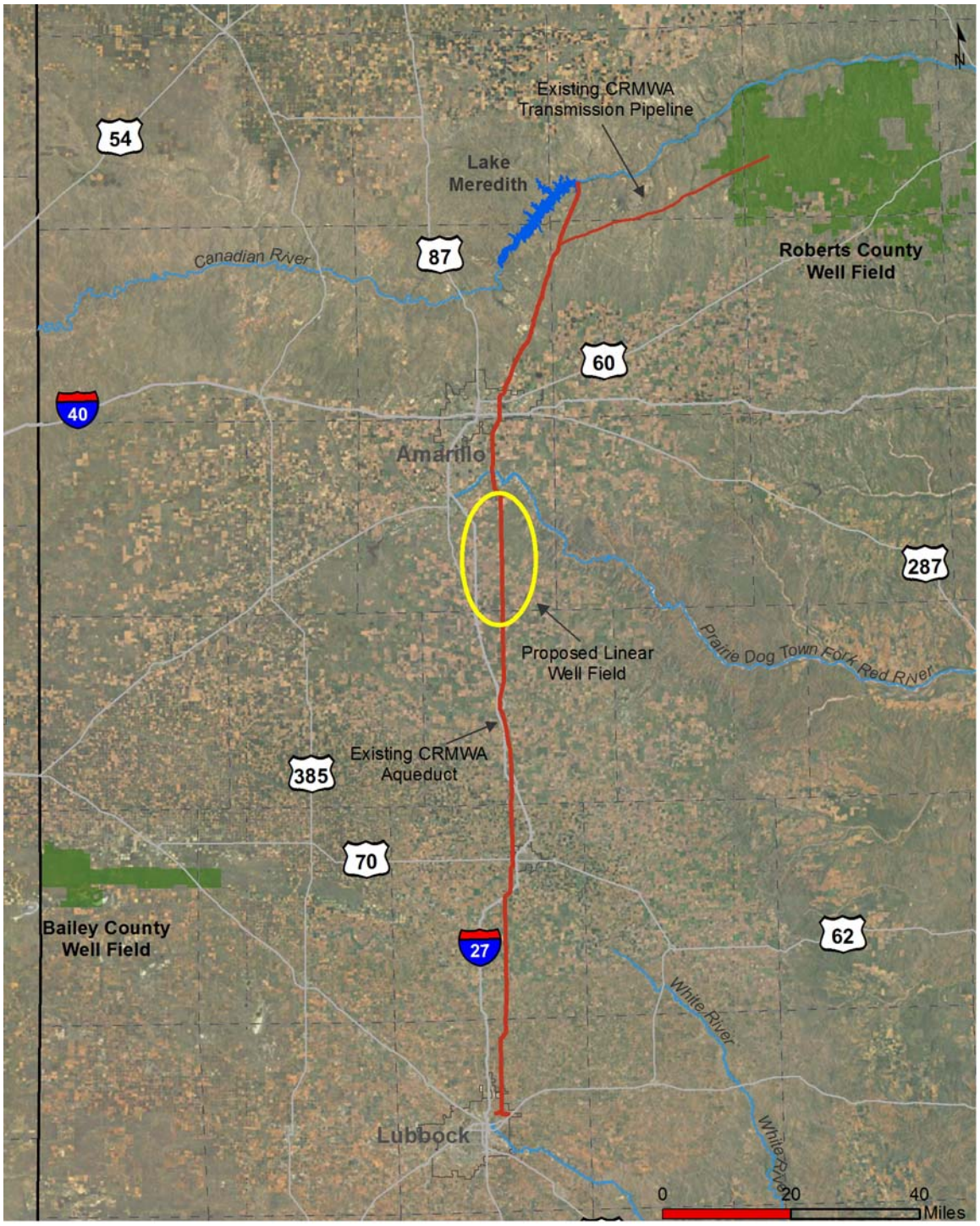


Figure 9.3 – Linear Well Field – CRMWA Aqueduct

The proposed linear well field would be located in an optimal area (encircled in yellow on the figure) between Tulia and Amarillo along the CRMWA Aqueduct.

Data needed to further evaluate this strategy includes:

- Recommended areas along the aqueduct to install proposed wells;
- The hydraulic characteristics of the Ogallala formation in the areas of interest;
- The depth to the groundwater table and the base of the formation;
- The recommended number of wells;
- A determination of the amount of water the wells can produce over a sustained period;
- Water rights and/or water use permits that will be required;
- The allowable spacing of the proposed wells;
- The size and length of collection and transmission pipelines that will be needed;
- The type of pumping facilities that will be needed;
- The level of treatment that will be required.

This strategy has been considered because installing wells along the aqueduct could be a cost effective way to supplement the supply of water in the aqueduct. However, additional information is needed before the evaluation can be completed.

9.4 Additional CRMWA Aqueduct

When the RCWF New Transmission Line (Section 7.5) is built, the current CRMWA Aqueduct will be near capacity delivering up to 43,728 ac-ft/yr to Lubbock. At that point, the only way to increase the allocation of water to CRMWA member cities' will be to expand the capacity of the aqueduct system. This strategy proposes the construction of a new aqueduct that runs parallel to the existing CRMWA Aqueduct from an area north of Amarillo to Lubbock's NWTP. Since Lake Meredith is no longer a source of water for the aqueduct and the two RCWF transmission lines will be at capacity, a third transmission line will also be needed to convey greater quantities of water from the RCWF to the aqueducts.

The existing aqueduct was originally built to transport surface water to member cities. The water must pass through two open top balancing reservoirs between the lake and Lubbock. Therefore, all of the raw water, including groundwater, is treated the same as surface water. If the second aqueduct is constructed, it could be built as a "groundwater only" pipeline and by-pass the balancing reservoirs. This would allow the groundwater to be

chlorinated and by-pass Lubbock's NWTP which is a conventional surface water treatment facility.

Data needed to further evaluate this strategy includes:

- The allowable RCWF field pumping capacity based on Panhandle Groundwater Conservation District rules;
- The optimal rate of RCWF production;
- The recommended size of the second CRMWA aqueduct;
- The recommended size of the third RCWF transmission line to the CRMWA aqueduct system;
- The length of aqueduct and transmission pipelines that will be needed; and,
- The type of pumping facilities that will be needed.

Figure 9.4 shows a schematic of the necessary infrastructure for the CRMWA Aqueduct Expansion.

This strategy has been considered because installing additional aqueduct and transmission lines in the CRMWA system could quadruple the amount of water allocated to Lubbock from the current CRMWA allocation of 24,088 ac-ft/yr to an allocation of approximately 90,000 ac-ft/yr. However, this means that the RCWF would be depleted at least four times faster than current depletion rates. Additional modeling of the RCWF would be necessary to determine its long-term viability at a much higher production rate. In addition, the cost of such a large and long aqueduct may not be as cost effective as other water supply strategies.

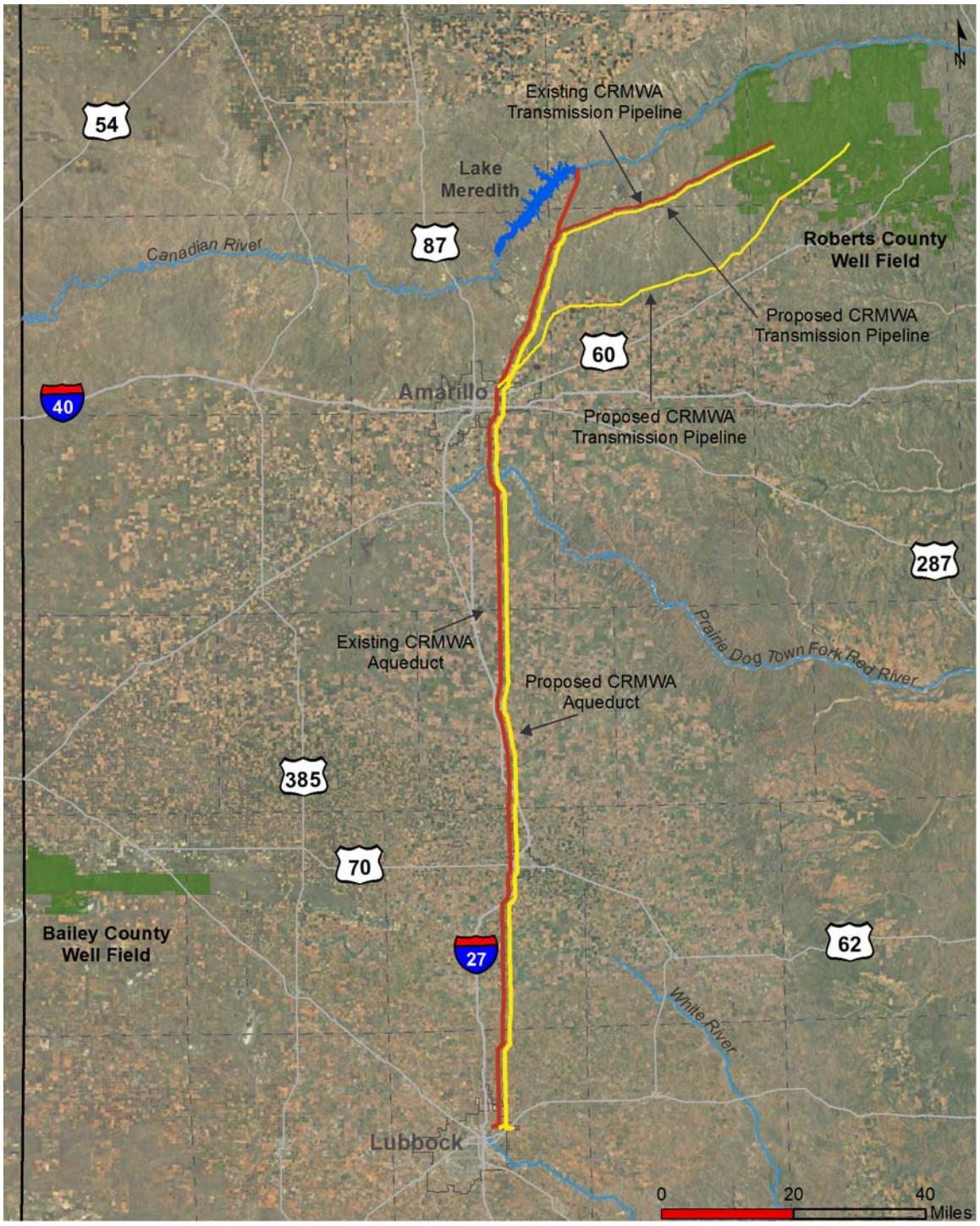


Figure 9.4 – Additional CRMWA Aqueduct

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[1] 2006 Llano Estacado Regional Water Plan, HDR, p. 4-183

[2] 2006 Llano Estacado Regional Water Plan, HDR, p. 4-185

10.0 Supply Strategy Evaluation

The potential water supply strategies developed and discussed in Sections 6, 7, and 8 are evaluated and ranked in this section. The objective of the evaluation is to determine which strategies should become the highest priorities for the City to implement.

10.1 Strategy Scoring Criteria

All strategies were evaluated and scored based on a common set of 10 criteria. The first four criteria – confidence, reliability, sustainability, and permitability consist of some level of subjectivity. The last six criteria – quality, quantity, schedule, unit cost, project cost, and annual cost – are objective. Strategies were assigned a ranking for each criterion on a scale from 1 to 5. The raw scores were then weighted based on the relative importance of each of the criteria. The evaluation criterion helps provide a more objective framework for comparison of these strategies. Descriptions of these criteria and associated weightings are described in Table 10.1.

10.2 Individual Strategy Scoring

Detailed tables providing the rationale for the scoring of each strategy with respect to each criterion are shown in Tables 10.2 through 10.17. Strategy rankings are based on the current known political, regulatory, technological, and other conditions. **Many supply strategies are interchangeable. The attractiveness of each strategy may change over time based on a variety of unpredictable variables.** Rankings will be updated periodically as evaluation factors change in the future.

Table 10.1 – Evaluation Criteria

Category	Weight	1 Low / Poor	2	3 Medium	4	5 High / Excellent
Confidence	1.0	The likely success of the potential project - based upon public perception, political climate, impact to existing infrastructure, involvement of other entities, and staff opinion.				
Reliability	1.0	The likelihood that the water source is available 100% of the time considering seasonality, interuptabilty, etc.				
Sustainability	1.0	The likelihood that the supply will be available for a longer period than other strategies. 1: less than or equal to (≤) 20 yrs; 2: ≤ 40 yrs; 3: ≤ 60 yrs; 4: ≤ 80 years 5: greater than (>) 80 years				
Permitability	1.0	The ease of resolving the legal, regulatory, permitting, and environmental challenges before implementation.				
Quantity	1.0	The relative supply volume (in ac-ft/yr) compared to other strategies. 1: less than or equal to (≤) 3,000; 2: ≤ 6,000; 3: ≤ 9,000; 4: ≤ 12,000 5: greater than (>) 12,000				
Quality	0.5	The relative level of water treatment required for each strategy. 1: Advanced Treatment - RO + Other Techniques; 2: Advanced Treatment - RO; 3: Advanced Treatment - Membrane; 4: Conventional Treatment; 5: Chlorination Only				
Schedule	0.5	The relative length of strategy implementation schedule compared to other strategies. 1: greater than (>) 12 yrs; 2: less than or equal to (≤) 12 yrs; 3: ≤ 9 yrs; 4: ≤ 6 yrs; 5: ≤ 3 yrs				
Unit Cost (cost /1,000 gal)	1.0	The relative unit costs compared to other strategies. 1: greater than (>) $8.00; 2: less than or equal to (≤) $8.00; 3: ≤ $6.00; 4: ≤ $4.00; 5: ≤ $2.00				
Project Cost ($ in millions)	0.5	The relative total project cost compared to other strategies. 1. greater than (>) $100 M; 2: less than or equal to (≤) $100 M; 3: ≤ $75 M; 4: ≤ $50 M; 5: ≤ $25 M				
Annual Cost ($ in millions)	0.5	The annual operational costs compared to other strategies. 1: greater than (>) $8 M; 2: less than or equal to (≤) $8 M; 3: ≤ $6 M; 4: ≤ $4 M; 5: ≤ $2 M				

Table 10.2 – North Fork Diversion at County Road 7300 – Strategy Evaluation

Category	Rank	Reason for Ranking
Confidence	3	This supply strategy is within 15 miles of Lubbock. The City holds permits to discharge, transport, and divert the reclaimed water at CR 7300 on the North Fork. Sufficient reclaimed water will be needed to implement this strategy. Landowner opposition may be an issue at CR 7300.
Reliability	3	This strategy uses 100% reclaimed water. Reclaimed water availability is dependent on commitments to other users and operational decisions. The water supplied is interruptible.
Sustainability	4	Since water used for this strategy is 100% reclaimed water, it should be available for at least 60 years unless the City seeks to use the reclaimed water for another beneficial purpose.
Permitability	3	The City holds a permit to discharge up to 10,089 ac-ft/yr (9 mgd) of treated effluent at Outfall 001 into the North Fork. In addition, the impoundment and diversion permit at CR 7300 was issued in 2012. However, the City must still acquire the land for the diversion facility, easements for the pipelines, and authorization by the TCEQ to construct facilities.
Quantity	4	This strategy has the potential to produce 10,089 ac-ft/yr.
Quality	3	This strategy consists of treated effluent that is discharged into the North Fork and transported downstream 2.7 miles where it will be diverted. Before entering the distribution system, this water will need to undergo advanced treatment that includes membrane barriers.
Schedule	2	This strategy could take between 9 and 12 years to acquire land for the diversion facilities and pipeline easements, receive authorization by the TCEQ, and construct the facilities.
Unit Cost	4	The unit cost of water for this strategy is $2.11/1,000 gal.
Project Cost	3	The project cost for this strategy is $54,260,000.
Annual Cost	2	The annual operational costs associated with this strategy are $6,950,000.

Raw Score	31
Weighted Score	26.0

Table 10.3 - Direct Potable Reuse to NWTP – Strategy Evaluation

Category	Rank	Reason for Ranking
Confidence	2	Public perception of direct potable reuse in Texas has improved some. Improvements in technology and drought conditions have stimulated increased desire in many communities to implement this type of strategy. Standards, rules, and regulations are still being developed.
Reliability	3	This strategy uses 100% reclaimed water. Reclaimed water availability is dependent on commitments to other users and operational decisions. The water supplied is interruptible.
Sustainability	4	The water used by this strategy will be 100% reclaimed water. This supply should be available for at least 60 years unless the City seeks to use the reclaimed water for another beneficial purpose.
Permitability	3	The TCEQ is currently developing potable reuse guidance requirements to be applied to proposed projects and to be used as the basis for reviewing permit applications. Future permits must comply with these "undeveloped" regulations.
Quantity	4	This strategy has the potential to produce 10,089 ac-ft/yr.
Quality	1	The water used by this strategy must be treated using RO plus other barriers during advanced treatment since it includes direct reuse of wastewater effluent.
Schedule	4	It may take from 3 to 6 years to complete the permitting, planning, design, and construction of this project.
Unit Cost	4	The unit cost of water for this strategy is $2.59/1,000 gal.
Project Cost	3	The project cost for this strategy is $67,176,000.
Annual Cost	1	The annual operational costs associated with this strategy are $8,527,000.

Raw Score	29
Weighted Score	24.5

Table 10.4 - Direct Potable Reuse to SWTP – Strategy Evaluation

Category	Rank	Reason for Ranking
Confidence	2	Public perception of direct potable reuse in Texas has improved some. Improvements in technology and drought conditions have stimulated increased desire of many communities to implement this type of strategy. Standards, rules, and regulations are still being developed.
Reliability	3	This strategy uses 100% reclaimed water. Reclaimed water availability is dependent on commitments to other users and operational decisions. The water supplied is interruptible.
Sustainability	4	The water used by this strategy will be 100% reclaimed water. This supply should be available for at least 60 years unless the City seeks to use the reclaimed water for another beneficial purpose.
Permitability	3	The TCEQ is currently developing potable reuse guidance requirements to be applied to proposed projects and to be used as the basis for reviewing permit applications. Future permits must comply with these "undeveloped" regulations.
Quantity	4	This strategy has the potential to produce 10,089 ac-ft/yr.
Quality	1	The water used by this strategy must be treated using RO plus other barriers during advanced treatment since it includes direct reuse of wastewater effluent.
Schedule	4	It may take from 3 to 6 years to complete the permitting, planning, design, and construction of this project.
Unit Cost	4	The unit cost of water for this strategy is $3.74/1,000 gal.
Project Cost	2	The project cost for this strategy is $95,690,000.
Annual Cost	1	The annual operational costs associated with this strategy are $12,281,000.

Raw Score	28
Weighted Score	24.0

Table 10.5 - North Fork Diversion to LAH Pump Station – Strategy Evaluation

Category	Rank	Reason for Ranking
Confidence	2	The diversion point for this strategy is over 50 miles from Lubbock. The City holds a permit to discharge the reclaimed water, but does not hold permits to transport, impound, and divert the reclaimed water at this location. Existing water rights holders and landowners may oppose an application for a permit. Sufficient reclaimed water will be needed to implement this strategy. Carriage losses are high. Water blended with the LAH raw water at the LAHPS could be a problem.
Reliability	3	This strategy uses 100% reclaimed water. Reclaimed water availability is dependent on commitments to other users and operational decisions. The water supplied is interruptible.
Sustainability	4	The water used by this strategy will be 100% reclaimed water. This supply should be available for at least 60 years unless the City seeks to use the reclaimed water for another beneficial purpose.
Permitability	2	The City holds a permit to discharge up to 10,089 ac-ft/yr (9 mgd) of treated effluent at Outfall 001 into the North Fork. However, transport, impoundment, and diversion permits may be difficult to obtain. In addition, the City must acquire the land for the diversion facility, easements for the pipelines, and authorization by the TCEQ to construct facilities.
Quantity	3	This strategy has the potential to produce 7,510 ac-ft/yr. Carriage losses will be 26%.
Quality	3	This water consists of treated effluent that is discharged into the North Fork and transported downstream 67 miles where it will be diverted. Before entering the distribution system, this water will need to undergo advanced treatment that includes membrane barriers.
Schedule	1	This strategy may take more than 12 years to acquire water rights permits, land for the pumping facilities, pipeline easements, and authorization by the TCEQ to begin construction.
Unit Cost	4	The unit cost of water for this strategy is $3.09/1,000 gal.
Project Cost	3	The project cost for this strategy is $52,747,000.
Annual Cost	2	The annual operational costs associated with this strategy are $7,560,000.

Raw Score	27
Weighted Score	22.5

Table 10.6 - Reclaimed Water Aquifer Storage & Recovery – Strategy Evaluation

Category	Rank	Reason for Ranking
Confidence	3	Public perception of direct potable reuse in Texas has improved some. Improvements in technology and drought conditions have stimulated increased desire in many communities to implement this type of strategy. Standards, rules, and regulations are still being developed.
Reliability	3	This strategy uses 100% reclaimed water. Reclaimed water availability is dependent on commitments to other users and operational decisions. The water supplied is interruptible. Also, some water is lost between injection into the aquifer and recovery from the aquifer.
Sustainability	4	The water used by this strategy will be 100% reclaimed water. This supply should be available for at least 60 years unless the City seeks to use the reclaimed water for another beneficial purpose.
Permitability	3	The TCEQ is currently developing potable reuse guidance requirements to be applied to proposed projects and to be used as the basis for reviewing permit applications. Future permits must comply with these "undeveloped" regulations. Permits will also be needed from the Groundwater Conservation District for injection and extraction of groundwater.
Quantity	3	This strategy has the potential to produce 8,071 ac-ft/yr.
Quality	1	The water used by this strategy must be treated using RO plus other barriers during advanced treatment since it includes direct reuse of wastewater effluent
Schedule	3	It may take from 3 to 6 years to complete the permitting, planning, design, and construction of this project.
Unit Cost	3	The unit cost of water for this strategy is $4.10/1,000 gal.
Project Cost	2	The project cost for this strategy is $88,045,000.
Annual Cost	1	The annual operational costs associated with this strategy are $10,784,000.

Raw Score	26
Weighted Score	22.5

Table 10.7 - South Fork Discharge – Strategy Evaluation

Category	Rank	Reason for Ranking
Confidence	2	Public concern exists about discharging reclaimed water into the South Fork that will be mixed with LAH water. Furthermore, high carriage losses make this strategy less attractive.
Reliability	3	This strategy uses 100% reclaimed water. Reclaimed water availability is dependent on commitments to other users and operational decisions. The water supplied is interruptible.
Sustainability	4	The water used by this strategy will be 100% reclaimed water. This supply should be available for at least 60 years unless the City seeks to use the reclaimed water for another beneficial purpose.
Permitability	2	The City's existing discharge permit (TPDES Permit WQ0010353002) will need to be amended to include an additional outfall on the South Fork. Also, although the City's current Water Use Permit No. 4146 for LAH authorizes a maximum annual withdrawal of 35,000 ac-ft/yr, the City needs to ensure that the return flow discharges on the South Fork can be diverted and used.
Quantity	3	This strategy has the potential to produce 8,183 ac-ft/yr. Carriage losses will be 19%.
Quality	3	This water consists of treated effluent that is discharged, transported 36 miles down the South Fork, and impounded in LAH. The water will be blended into the lake water. Treatment will be advanced treatment with membranes.
Schedule	2	This strategy may take 9 to 12 years to acquire water rights permits, land for the pumping facilities, pipeline easements, and authorization by the TCEQ to begin construction.
Unit Cost	4	The unit cost of water for this strategy is $3.31/1,000 gal.
Project Cost	3	The project cost for this strategy is $65,018,000.
Annual Cost	1	The annual operational costs associated with this strategy are $8,833,000.

Raw Score	27
Weighted Score	22.5

Table 10.8 - RCWF Capacity Maintenance – Strategy Evaluation

Category	Rank	Reason for Ranking
Confidence	4	The likely success of this project is high since it maintains the capacity of an already existing water supply. All financial decisions for this strategy must be approved and implemented by the CRMWA board. Panhandle Groundwater Conservation District rules may change production strategies from the RCWF.
Reliability	5	This strategy relies on groundwater that should be available as needed.
Sustainability	4	Estimates vary as to the amount of available groundwater in the Ogallala Aquifer in Roberts County. Further data collection is needed to determine the exact saturated thickness. This water supply should last at least 60 years.
Permitability	5	Water well permits from the Panhandle Groundwater Conservation District will be necessary. Design and construction of public water supply wells and water transmission facilities must be approved by the TCEQ.
Quantity	3	This strategy has the potential to produce 7,252 ac-ft/yr.
Quality	4	The groundwater from Roberts County is high quality. The only treatment typically required is chlorination. However, Lubbock must treat the groundwater like surface water since the groundwater must pass through two open topped balancing reservoirs before it reaches Lubbock.
Schedule	5	Once all member cities agree to move forward with this strategy, it can be designed and completed in 3 years.
Unit Cost	5	The unit cost of water for this strategy is $0.49/1,000 gal.
Project Cost	5	The project cost for this strategy is $9,614,000.
Annual Cost	5	The annual operational costs associated with this strategy are $1,165,000.

Raw Score	45
Weighted Score	35.5

Table 10.9 - BCWF Capacity Maintenance – Strategy Evaluation

Category	Rank	Reason for Ranking
Confidence	5	The likely success of this project is high since it includes maintaining the capacity of an already existing water supply. This strategy has minimal legal/permitting issues, a relatively low unit/project/annual cost, and can be implemented quickly.
Reliability	5	This strategy relies on groundwater that should be available as needed.
Sustainability	2	With the estimated annual use of 10,000 ac-ft/yr, current modeling suggests that the BCWF should be sustainable for at least 40 years.
Permitability	5	Water well permits from the High Plains Underground Water Conservation District No. 1 will be necessary. Design and construction of public water supply wells and water transmission facilities must be approved by the TCEQ.
Quantity	2	This strategy will restore the BCWF to its full capacity, providing an incremental increase of 3,120 ac-ft/yr.
Quality	5	The groundwater from Bailey County is high quality. The only treatment required is chlorination.
Schedule	5	This strategy can be implemented in less than 3 years.
Unit Cost	4	The unit cost of water for this strategy is $2.36/1,000 gal.
Project Cost	5	The project cost for this strategy is $24,761,000.
Annual Cost	4	The annual operational costs associated with this strategy are $2,397,000.

Raw Score	42
Weighted Score	32.5

Table 10.10 - RCWF New Transmission Line to Aqueduct – Strategy Evaluation

Category	Rank	Reason for Ranking
Confidence	4	Any decision regarding the RCWF requires the consent of all CRMWA member cities. Many of the cities have expressed interest in this project as the large incremental increase in water supply will assist with the cities' growing water demands.
Reliability	5	This strategy relies on groundwater that should be available as needed.
Sustainability	3	Estimates vary as to the amount of water contained in the Ogallala Aquifer in Roberts County. Further data collection and aquifer modeling is needed to estimate saturated thickness and well field decline patterns.
Permitability	4	Water well permits from the Panhandle Groundwater Conservation District will be necessary. Design and construction of public water supply wells and water transmission facilities must be approved by the TCEQ. Furthermore, CRMWA must acquire easements for the new transmission line.
Quantity	5	This strategy has the potential to produce 21,583 ac-ft/yr.
Quality	4	The groundwater from Roberts County is high quality. The only treatment typically required is chlorination. However, Lubbock must treat the groundwater like surface water since the groundwater must pass through two open topped balancing reservoirs before it reaches Lubbock.
Schedule	4	Once all member cities agree to move forward with this strategy, it can be designed and completed in less than 6 years.
Unit Cost	4	The unit cost of water for this strategy is $2.29/1,000 gal.
Project Cost	1	The project cost for this strategy is $104,328,000.
Annual Cost	1	The annual operational costs associated with this strategy are $16,078,000.

Raw Score	35
Weighted Score	30.0

Table 10.11 - CRMWA to Aquifer Storage & Recovery – Strategy Evaluation

Category	Rank	Reason for Ranking
Confidence	2	ASR has not been attempted in the Lubbock area of the Ogallala Aquifer. Due to the many uncertainties in reliability, sustainability, and water losses during storage, confidence in this strategy is low. It is uncertain when excess water will be available in the CRMWA Aqueduct to use for ASR.
Reliability	1	This strategy seeks to store CRMWA water during the winter months so it can be used in the summer to meet peak demands. The amount of water available for storage is dependent upon the amount of excess capacity in the CRMWA Aqueduct.
Sustainability	1	Long-term sustainability of this strategy is dependent upon how CRMWA uses the capacity of the existing or future aqueducts that supply Lubbock with water. Important factors include member city allocations which are set annually and Lubbock's water demand/usage. These factors will likely change in future years creating some uncertainty.
Permitability	3	Both injection and recovery wells will need to be permitted by the High Plains Underground Water Conservation District No. 1. Design and construction of the public water supply transmission facilities must be approved by the TCEQ.
Quantity	3	This strategy has the potential to produce 6,090 ac-ft/yr.
Quality	5	Groundwater recovered from the Ogallala Aquifer is high quality. It should only require chlorination for treatment.
Schedule	4	It may take up to 6 years to complete the planning, design, and construction of this project.
Unit Cost	4	The unit cost of water for this strategy is $3.00/1,000 gal.
Project Cost	3	The project cost for this strategy is $59,949,000.
Annual Cost	3	The annual operational costs associated with this strategy are $5,957,000.

Raw Score	29
Weighted Score	21.5

Table 10.12 - South Lubbock Well Field – Strategy Evaluation

Category	Rank	Reason for Ranking
Confidence	1	The lack of available saturated thickness data, the low quality of water, and high costs of water treatment associated with this strategy create poor public perception and give City staff low confidence in this strategy.
Reliability	4	This strategy relies on groundwater that should be available as needed.
Sustainability	2	Even though this strategy is designed for peaking, requiring only 4 months of pumping during the year, concerns exist regarding the sustainability of the Ogallala Aquifer in this area of the City for 50 years or more. Additional information is needed to more fully evaluate the quantity of water available for this strategy.
Permitability	3	Water well permits from the High Plains Underground Water Conservation District No. 1 will be necessary. Design and construction of public water supply wells and water treatment facilities must be approved by the TCEQ. The City owns all of the properties and easements needed for this project, but pipeline construction under City streets will be costly and difficult.
Quantity	1	This strategy has the potential to produce 2,613 acre-feet per year.
Quality	2	The raw groundwater produced by this strategy will need advanced water treatment with RO to overcome relatively high salinity and the possibility of the groundwater being "under the influence" of surface water.
Schedule	4	It may take up to 6 years to complete the planning, design, and construction of this project.
Unit Cost	1	The unit cost of water for this strategy is $8.62/1,000 gal.
Project Cost	3	The project cost for this strategy is $56,468,000.
Annual Cost	2	The annual operational costs associated with this strategy are $7,340,000.

Raw Score	23
Weighted Score	17.5

Table 10.13 - Brackish Well Field – Strategy Evaluation

Category	Rank	Reason for Ranking
Confidence	1	The lack of available saturated thickness and production data, the low quality of water, and high costs of water treatment associated with this strategy creates poor public perception and give City staff low confidence in this strategy.
Reliability	2	This strategy relies completely upon groundwater. However, insufficient data exists to predict the reliability of the Dockum Aquifer in this area.
Sustainability	2	Estimates vary as to the amount of water contained in the Dockum Aquifer. Further data collection is needed to determine better estimates of saturated thicknesses and other hydrogeologic data.
Permitability	3	Water well permits from the High Plains Underground Water Conservation District No. 1 will be necessary. Design and construction of public water supply wells and water treatment facilities must be approved by the TCEQ. Brine concentrate injections wells must also be permitted through the TCEQ.
Quantity	1	This strategy has the potential to produce 1,120 ac-ft/yr.
Quality	2	The water available from this strategy is brackish and will require advanced treatment with RO before entering the City's raw water supply.
Schedule	3	It may take up to 9 years to complete the planning, design, and construction of this project.
Unit Cost	1	The unit cost of water for this strategy is $10.96/1,000 gal.
Project Cost	4	The project cost for this strategy is $33,494,000.
Annual Cost	4	The annual operational costs associated with this strategy are $3,999,000.

Raw Score	23
Weighted Score	16.5

Table 10.14 - Lake Alan Henry Phase 2 – Strategy Evaluation

Category	Rank	Reason for Ranking
Confidence	5	Phase 1 of the LAH water supply is already complete. Phase 2 expands the treatment and pumping capacity. Staff is confident that Phase 2 can be implemented successfully.
Reliability	5	The water used for this strategy will be 100% surface water. Water from this strategy should be available at all times and useful for peaking capacity also.
Sustainability	5	If precipitation patterns, land use trends, and the City's usage from the lake do not change in the coming decades, LAH should be sustainable for more than 80 years.
Permitability	5	The permitting issues associated with this project were addressed in Phase 1. No additional permitting requirements are anticipated with Phase 2. Design and construction of public water supply and treatment facilities must be approved by the TCEQ.
Quantity	3	This strategy has the potential to produce 8,000 ac-ft/yr of water.
Quality	3	Advanced treatment using membrane barriers was installed during Phase 1. Phase 2 will include the same type of treatment facilities.
Schedule	5	This strategy can be completed in less than 3 years.
Unit Cost	4	The unit cost of water for this strategy is $3.09/1,000 gal.
Project Cost	3	The project cost for this strategy is $65,710,996.
Annual Cost	1	The annual operational costs associated with this strategy are $8,047,000.

Raw Score	39
Weighted Score	33.0

Table 10.15 - Jim Bertram Lake 7 – Strategy Evaluation

Category	Rank	Reason for Ranking
Confidence	2	There is mixed public interest in this project. Some downstream water rights holders are opposed to the lake while others are in favor. Due to complex permitting issues, high project costs, and length of time required to plan and construct a reservoir, confidence levels are low.
Reliability	3	This strategy uses a combination of reclaimed water, state water/natural inflows, and playa lake developed water. Reclaimed water availability is dependent on City water usage and operational decisions at the wastewater treatment plant. State water/natural inflows and playa lake developed water are dependent upon precipitation.
Sustainability	4	This strategy relies heavily on City's reclaimed water to be viable. This supply should be available for at least 60 years unless the City seeks to use the reclaimed water for another beneficial purpose.
Permitability	2	Water Rights Application No. 5921 associated with Lake 7 is under technical review by the TCEQ. In addition, the TCEQ has received several requests for contested case hearings. It will take several more years before the permit can be issued. A USACE Section 404 permit will be required prior to commencing construction of Lake 7. Mitigation plans for the project's environmental impacts must be developed and agreed upon by the USACE and other state and federal agencies. The City must also acquire the property for the lake, dam, pump station, wildlife mitigation area, and pipeline easements.
Quantity	4	This strategy has the potential to produce 11,300 ac-ft/yr of water.
Quality	3	This strategy uses reclaimed water, state water/natural inflows, and playa lake developed water. Advanced treatment with membrane barriers is necessary.
Schedule	1	Due to the extensive amount of permitting issues, this strategy will take more than 12 years to permit, design, and construct.
Unit Cost	4	The unit cost of water for this strategy is $2.71/1,000 gal.
Project Cost	2	The project cost for this strategy is $88,328,000.
Annual Cost	1	The annual operational costs associated with this strategy are $9,965,000.

Raw Score	26
Weighted Score	22.5

Table 10.16 - Post Reservoir – Strategy Evaluation

Category	Rank	Reason for Ranking
Confidence	2	There is mixed public interest for this project. Some existing water rights holders may be opposed to the lake while some elected officials may be interested in economic development in Garza County. Moreover, due to complex permitting issues, high project costs, and length of time required to plan and construct a reservoir, confidence levels are low.
Reliability	3	This strategy uses a combination of reclaimed water, state water/natural inflows, and playa lake developed water. Reclaimed water availability is dependent on City water usage and operational decisions at the wastewater treatment plant. State water/natural inflows and playa lake developed water are dependent upon precipitation.
Sustainability	4	This strategy relies heavily on City's reclaimed water to be viable. This supply should be available for at least 60 years unless the City seeks to use the reclaimed water for another beneficial purpose.
Permitability	2	The City would need to obtain ownership of the TCEQ Certificate of Adjudication No. 3711 from the White River Municipal Water District in order to construct the reservoir. The permit will need to be amended so the City can divert sufficient water to make this strategy viable. In addition, a USACE Section 404 permit will be required prior to commencing construction of the Post Reservoir. Mitigation plans for the project's environmental impacts must be developed and agreed upon by the USACE and other state and resource agencies. The City must also acquire the property for the lake, dam, pump station, wildlife mitigation area, and pipeline easements.
Quantity	3	This strategy has the potential to produce 8,962 ac-ft/yr of water.
Quality	3	This strategy uses reclaimed water, state water/natural inflows, and playa lake developed water. Advanced treatment with membrane barriers is necessary.
Schedule	1	Due to the extensive amount of permitting issues, this strategy will take more than 12 years to permit, design, and construct.
Unit Cost	4	The unit cost of water for this strategy is $3.76/1,000 gal.
Project Cost	2	The project cost for this strategy is $98,963,000.
Annual Cost	1	The annual operational costs associated with this strategy are $10,975,000.

Raw Score	25
Weighted Score	21.5

Table 10.17 - North Fork Scalping Operation – Strategy Evaluation

Category	Rank	Reason for Ranking
Confidence	2	This strategy requires the City to file a new water rights permit application with the TCEQ. It is uncertain whether the TCEQ will grant any more permits on the North Fork. The water availability may be over allocated already. It is uncertain whether existing water rights holders would protest the application.
Reliability	2	The water used for this strategy is storm water and is, therefore, dependent upon precipitation events. Consequently, this is not the most reliable source of water. It will help "firm up" LAH's yield.
Sustainability	5	If precipitation patterns, land use, and senior water rights usage trends do not change in the coming decades, this project should be sustainable for more than 80 years.
Permitability	2	A water use permit authorized by the TCEQ will be required for the impoundment and diversion of storm water. A USACE Section 404 permit will also be required. The City will need to acquire property for the diversion facilities and pump station. In addition, pipeline utility easements will be necessary to construct a raw water transmission line to Gobbler Creek.
Quantity	3	This strategy has the potential to produce 8,725 ac-ft/yr.
Quality	3	This strategy is comprised of storm water flows that flow into LAH. Advanced treatment with membrane barriers is necessary.
Schedule	2	It may take up to 12 years to complete the planning, design, and construction of this project.
Unit Cost	3	The unit cost of water for this strategy is $5.35/1,000 gal.
Project Cost	1	The project cost for this strategy is $125,493,000.
Annual Cost	1	The annual operational costs associated with this strategy are $15,226,000.

Raw Score	24
Weighted Score	20.5

10.3 Strategy Rankings

Based on the aggregate score for each strategy, the strategies were compared and ranked. The water supply strategy ranking results by type of water supply (reclaimed water, surface water, and groundwater) are presented in Table 10.18. From this table the following general observations can be made:

- The highest ranked reclaimed water strategy is the North Fork Diversion at CR 7300;
- The highest ranked groundwater strategy is the RCWF Capacity Maintenance;
- The highest ranked surface water strategy is LAH Phase 2;
- Ogallala groundwater strategies generally have the highest rankings of all categories; and
- Surface water strategies tend to rank lower than strategies in other categories.

Table 10.19 provides a list of the strategies based on their respective rankings (highest to lowest). These rankings are based on the total weighted score for each strategy. From this table the following general observations can be made:

- The four top ranked strategies – RCWF Capacity Maintenance, LAH Phase 2, BCWF Capacity Maintenance, and RCWF New Transmission Line - are all associated with existing water supplies;
- The RCWF New Transmission Line provides the most incremental increase in water supply at 21,583 ac-ft/yr;
- The Brackish Well Field provides the least incremental increase in water supply at 1,120 ac-ft/yr;
- Four strategies have the same score – South Fork Diversion, North Fork Diversion to LAH Pump Station, Jim Bertram Lake 7, and Reclaimed Water to ASR;

Table 10.20 provides a graphical representation of the ranking of the strategies and the amount of additional water each strategy will yield.

Table 10.18 - Water Supply Strategy Ranking by Supply Type

Lubbock Water Supply Strategies	Present in the 2011 Region O Plan?	Incremental Capacity Increase (ac-ft/yr)	Unit Cost ($ per 1,000 gal)	Total Project Cost ($ in millions)	Annual Operational Cost ($ in millions)	Confidence	Reliability	Sustainability	Permitability	Quantity	Quality	Schedule	Unit Cost	Project Cost	Annual Cost	Raw Score	Weighted Score
Weight						1.0	1.0	1.0	1.0	1.0	0.5	0.5	1.0	0.5	0.5		
Reclaimed Water																	
North Fork Diversion at CR 7300	no	10,089	2.11	54.26	6.95	3	3	4	3	4	3	2	4	3	2	31	26.0
Direct Potable Reuse - NWTP	no	10,089	2.59	67.18	8.53	2	3	4	3	4	1	4	4	3	1	29	24.5
Direct Potable Reuse - SWTP	no	10,089	3.74	95.69	12.28	2	3	4	3	4	1	4	4	2	1	28	24.0
North Fork Diversion to LAH Pump Station	yes	7,510	3.09	52.75	7.56	2	3	4	2	3	3	1	4	3	2	27	22.5
Reclaimed Water to ASR	no	8,071	4.10	88.05	10.78	3	3	4	3	3	1	3	3	2	1	26	22.5
South Fork Discharge	no	8,183	3.31	65.02	8.83	2	3	4	2	3	3	2	4	3	1	27	22.5
Groundwater																	
RCWF Capacity Maintenance	yes	7,252	0.49	9.61	1.17	4	5	4	5	3	4	5	5	5	5	45	35.5
BCWF Capacity Maintenance	yes	3,120	2.36	24.76	2.40	5	5	2	5	2	5	5	4	5	4	42	32.5
RCWF - New Transmission Line	no	21,583	2.29	104.33	16.08	4	5	3	4	5	4	4	4	1	1	35	30.0
CRMWA to ASR	no	6,090	3.00	59.95	5.96	2	1	1	3	3	5	4	4	3	3	29	21.5
South Lubbock Well Field	no	2,613	8.62	56.47	7.34	1	4	2	3	1	2	4	1	3	2	23	17.5
Brackish Well Field	yes	1,120	10.96	33.49	4.00	1	2	2	3	1	2	3	1	4	4	23	16.5
Surface Water																	
LAH Phase 2	yes	8,000	3.09	65.71	8.05	5	5	5	5	3	3	5	4	3	1	39	33.0
Jim Bertram Lake 7	yes	11,300	2.71	88.33	9.97	2	3	4	2	4	3	1	4	2	1	26	22.5
Post Reservoir	yes	8,962	3.76	98.96	10.98	2	3	4	2	3	3	1	4	2	1	25	21.5
North Fork Scalping Operation	yes	8,725	5.35	125.49	15.23	2	2	5	2	3	3	2	3	1	1	24	20.5

Table 10.19 - Water Supply Strategy Ranking from Highest to Lowest

Lubbock Water Supply Strategies	Present in the 2011 Region O Plan?	Incremental Capacity Increase (ac-ft/yr)	Unit Cost ($ per 1,000 gal)	Total Project Cost ($ in millions)	Annual Operational Cost ($ in millions)	Confidence	Reliability	Sustainability	Permitability	Quantity	Quality	Schedule	Unit Cost	Project Cost	Annual Cost	Raw Score	Weighted Score
Weight						1.0	1.0	1.0	1.0	1.0	0.5	0.5	1.0	0.5	0.5		
RCWF Capacity Maintenance	yes	7,252	0.49	9.61	1.17	4	5	4	5	3	4	5	5	5	5	45	35.5
LAH Phase 2	yes	8,000	3.09	65.71	8.05	5	5	5	5	3	3	5	4	3	1	39	33.0
BCWF Capacity Maintenance	yes	3,120	2.36	24.76	2.40	5	5	2	5	2	5	5	4	5	4	42	32.5
RCWF - New Transmission Line	no	21,583	2.29	104.33	16.08	4	5	3	4	5	4	4	4	1	1	35	30.0
North Fork Diversion at CR 7300	no	10,089	2.11	54.26	6.95	3	3	4	3	4	3	2	4	3	2	31	26.0
Direct Potable Reuse - NWTP	no	10,089	2.59	67.18	8.53	2	3	4	3	4	1	4	4	3	1	29	24.5
Direct Potable Reuse - SWTP	no	10,089	3.74	95.69	12.28	2	3	4	3	4	1	4	4	2	1	28	24.0
South Fork Discharge	no	8,183	3.31	65.02	8.83	2	3	4	2	3	3	2	4	3	1	27	22.5
North Fork Diversion to LAH Pump Station	yes	7,510	3.09	52.75	7.56	2	3	4	2	3	3	1	4	3	2	27	22.5
Jim Bertram Lake 7	yes	11,300	2.71	88.33	9.97	2	3	4	2	4	3	1	4	2	1	26	22.5
Reclaimed Water to ASR	no	8,071	4.10	88.05	10.78	3	3	4	3	3	1	3	3	2	1	26	22.5
CRMWA to ASR	no	6,090	3.00	59.95	5.96	2	1	1	3	3	5	4	4	3	3	29	21.5
Post Reservoir	yes	8,962	3.76	98.96	10.98	2	3	4	2	3	3	1	4	2	1	25	21.5
North Fork Scalping Operation	yes	8,725	5.35	125.49	15.23	2	2	5	2	3	3	2	3	1	1	24	20.5
South Lubbock Well Field	no	2,613	8.62	56.47	7.34	1	4	2	3	1	2	4	1	3	2	23	17.5
Brackish Well Field	yes	1,120	10.96	33.49	4.00	1	2	2	3	1	2	3	1	4	4	23	16.5

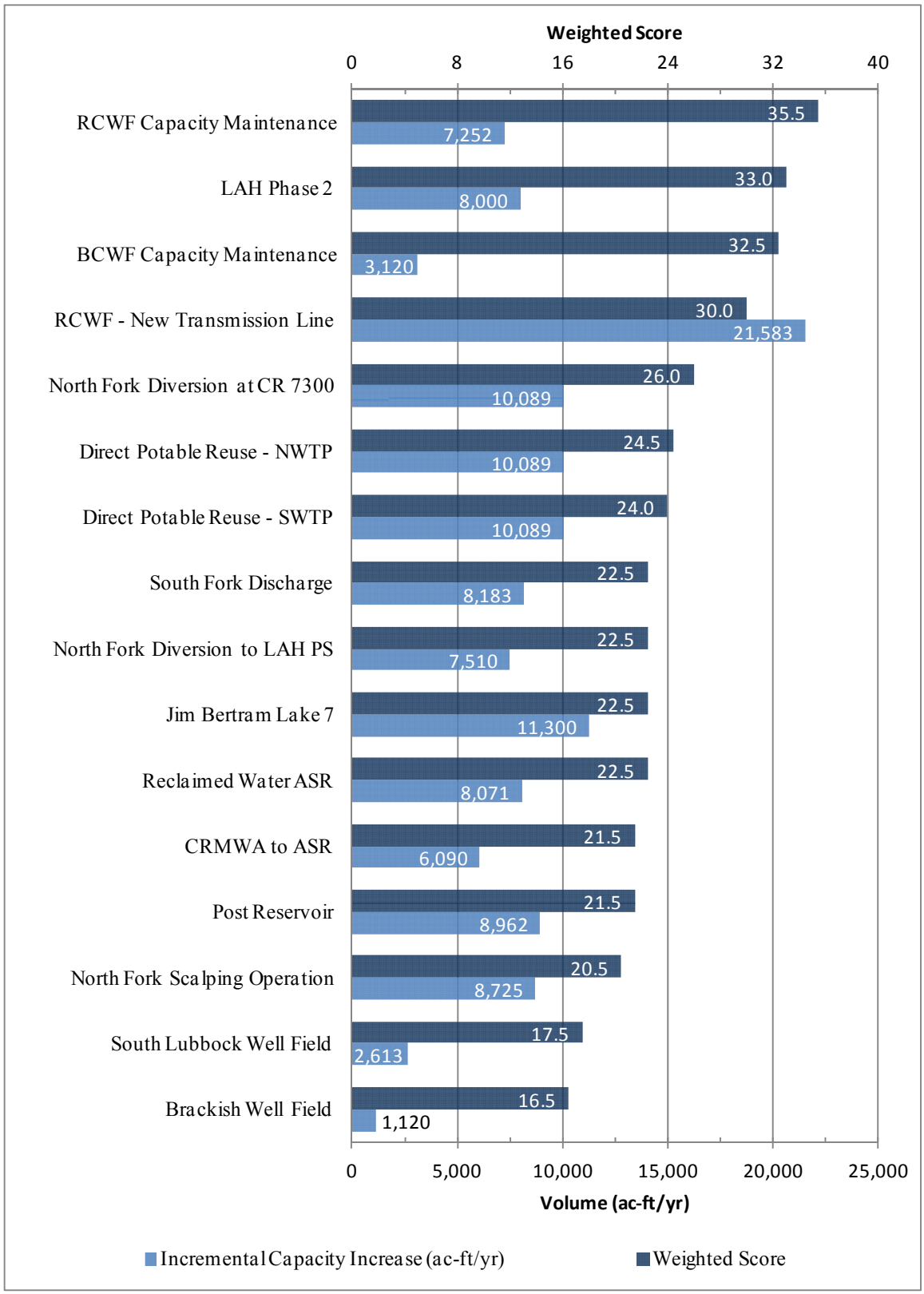


Figure 10.1 - Supply Strategy Ranking and Available Water

11.0 Water Supply Packages

In this section, various potential water supply strategies along with existing water supplies are combined into water supply package designed to supply the City's projected water demand over the next 100 years. Five different supply packages are presented and discussed in this section that depict a wide range of strategies that can be used to meet the Probable, Conservation, or Accelerated Growth Demands determined in Section 2. Conditions and assumptions common to all of the supply packages include:

- Incorporating existing water supplies discussed in Section 4;
- Giving priority to the highest ranked potential water supply strategies evaluated in Section 10 (see Table 10.19);
- Basing the year that a new strategy is implemented on when the Annual Demand projection line and the total available water supply intersect, or when the Peak Day Demand projection line and the peak supply intersect, whichever occurs first; and
- Projecting water demand and supply for a 100 year planning period.

Supply packages are evaluated and discussed in the following paragraphs.

11.1 Supply Package 1 - Baseline

This supply package is considered a baseline package that consists of the following supply strategies that will be necessary to meet the Probable Demand (orange line) over the next 100 years. The potential strategies used are described in the following sections:

Supply Strategy	Section
Direct Potable Reuse to NWTP	6.5
RCWF Capacity Maintenance	7.3
BCWF Initial Capacity Maintenance	7.4
BCWF Capacity Maintenance	7.4
RCWF New Transmission Line	7.5
LAH Phase 2	8.2

In this supply package, strategies are implemented or phased in as depicted in Figure 11.1. The individual and cumulative annual water supplies available from these strategies with respect to the estimated demand over the planning period are depicted in Figure 11.2. The individual and cumulative available peak supplies from these strategies with respect to the estimated peak demand are depicted in Figure 11.3.

2013	2013 - BCWF Initial Capacity Maintenance (ICM) 2017 - LAH Phase 2
2023	2023 - BCWF Capacity Maintenance (CM-1) 2025 - RCWF New Transmission Line
2033	
2043	
2053	2054 - Direct Potable Reuse to NWTP 2055 - RCWF Capacity Maintenance (CM-1)
2063	
2073	
2083	2085 – RCWF Capacity Maintenance (CM-2)
2093	
2103	
2113	

Figure 11.1 –Package 1: Strategy Implementation Schedule

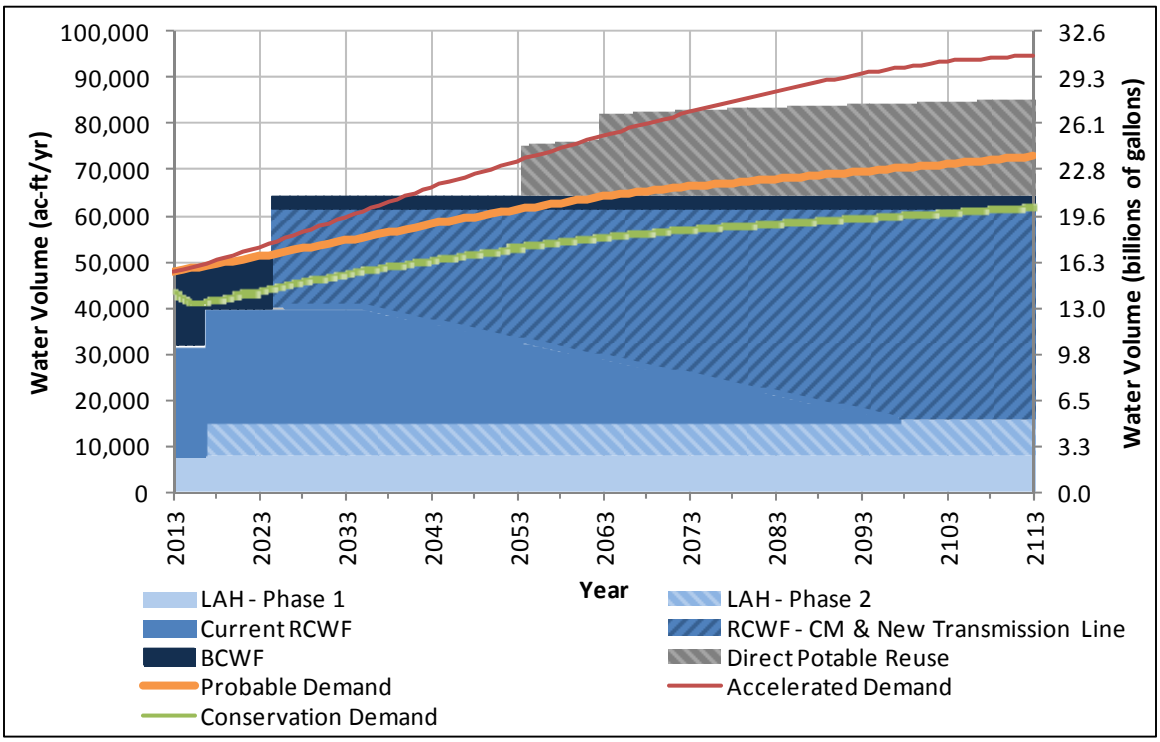


Figure 11.2 – Package 1: Annual Supply vs. Annual Demand Projections

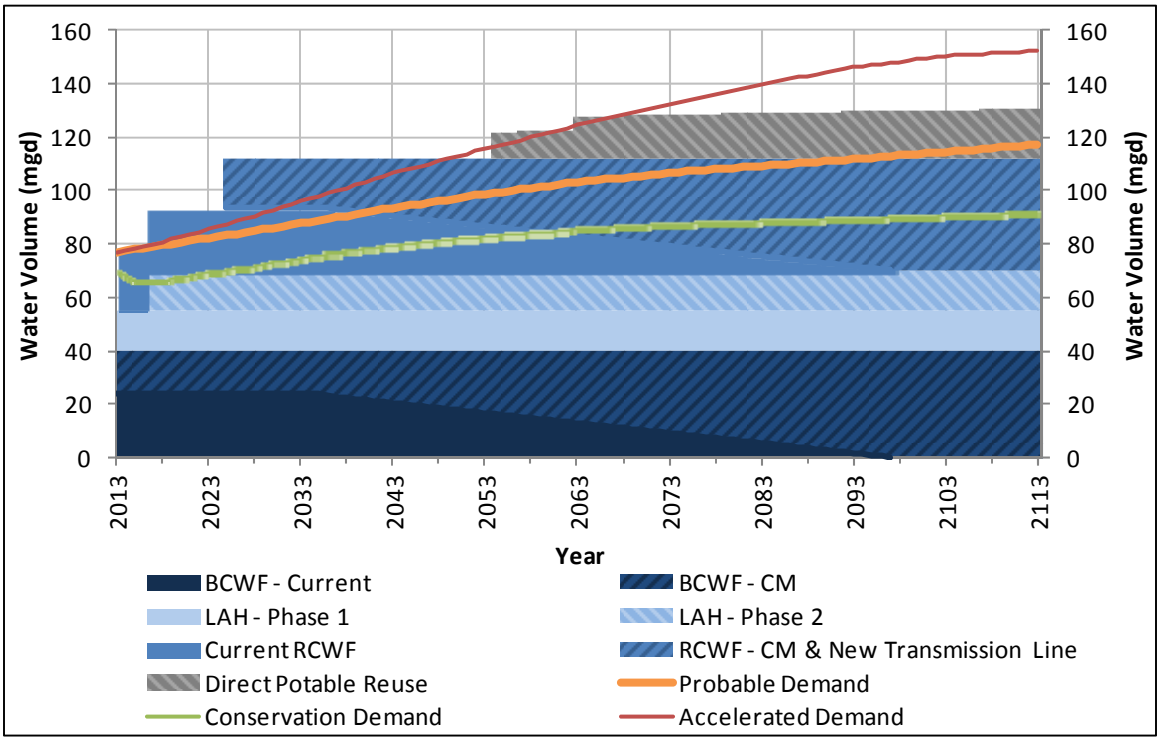


Figure 11.3 – Package 1: Peak Supply vs. Peak Demand Projections

BCWF Capacity Maintenance – This strategy includes implementing the BCWF Initial Capacity Maintenance strategy in 2013 as depicted in Figure 11.2. Due to a projected usage of the BCWF averaging 12,306 ac-ft/yr over a 12-year period, another group of wells (BCWF CM-1) is recommended in 2023. After the RCWF Transmission Line strategy is implemented in 2025, the BCWF is reserved for peaking capacity for the remainder of the planning period. The BCWF plays an important role in boosting Lubbock's total peaking capacity. BCWF should be capable of providing up to 40 mgd to meet peak demand for the remaining planning period (see Figure 11.3) if its annual usage remains below 3,000 ac-ft/yr as projected.

Lake Alan Henry Phase 2 – This strategy includes expanding the existing LAH infrastructure by 2017 by an additional 8,000 ac-ft/yr. Since this strategy includes pumping water from LAH at a rate equal to or less than the lake's safe yield, the lake should provide 16,000 ac-ft/yr of water supply to Lubbock for the duration of the planning period. LAH plays an important role in boosting Lubbock's total peaking capacity. Once Phase 2 is complete, LAH will be capable of providing up to 30 mgd to meet peak demand for the duration of the planning period (see Figure 11.3).

RCWF New Transmission Line – This strategy includes constructing a new transmission line from the RCWF to the CRMWA Aqueduct that will almost double the amount of water available (45,671 ac-ft/yr) from the RCWF to Lubbock by 2025. Since the RCWF production will decline over time, it is anticipated that additional wells will need to be added in 2055 and 2085 to maintain the necessary capacity to keep the transmission lines flowing full.

Direct Potable Reuse at the NWTP – This strategy includes implementing Direct Potable Reuse at the NWTP by 2054. Figures 11.2 and 11.3 depict this supply strategy using all of the Net Reclaimed Water available (21,057 ac-ft/yr by 2113) as discussed in Section 6.3.

11.2 Supply Package 2 – LAH Phase 2 Delayed

This supply package is similar to Package 1 except it delays the implementation of LAH Phase 2 from 2017 until 2031. In addition, this strategy uses an indirect reuse strategy (North Fork Diversion at CR 7300) instead of direct reuse of reclaimed water. This package consists of the following supply strategies that will be necessary to meet the Probable Demand (orange line) over the next 100 years. The potential strategies used are described in the following sections:

Supply Strategy	Section
North Fork Diversion at CR 7300	6.4
RCWF Capacity Maintenance	7.3
BCWF Initial Capacity Maintenance	7.4
BCWF Capacity Maintenance	7.4
RCWF New Transmission Line	7.5
LAH Phase 2	8.2

In this supply package, strategies are implemented or phased in as depicted in Figure 11.4. The individual and cumulative annual water supplies available from these strategies with respect to the estimated demand over the planning period are depicted in Figure 11.5. The individual and cumulative available peak supplies from these strategies with respect to the estimated peak demand are depicted in Figure 11.6.

2013	2013 - BCWF Initial Capacity Maintenance (ICM) 2017 - BCWF Capacity Maintenance (CM-1)
2023	2023 - BCWF Capacity Maintenance (CM-2) 2025 - RCWF New Transmission Line 2031 - LAH Phase 2
2033	
2043	
2053	2054 - North Fork Diversion at CR 7300 2055 - RCWF Capacity Maintenance (CM-1)
2063	
2073	
2083	2085 - RCWF Capacity Maintenance (CM-2)
2093	
2103	
2113	

Figure 11.4 – Package 2: Strategy Implementation Schedule

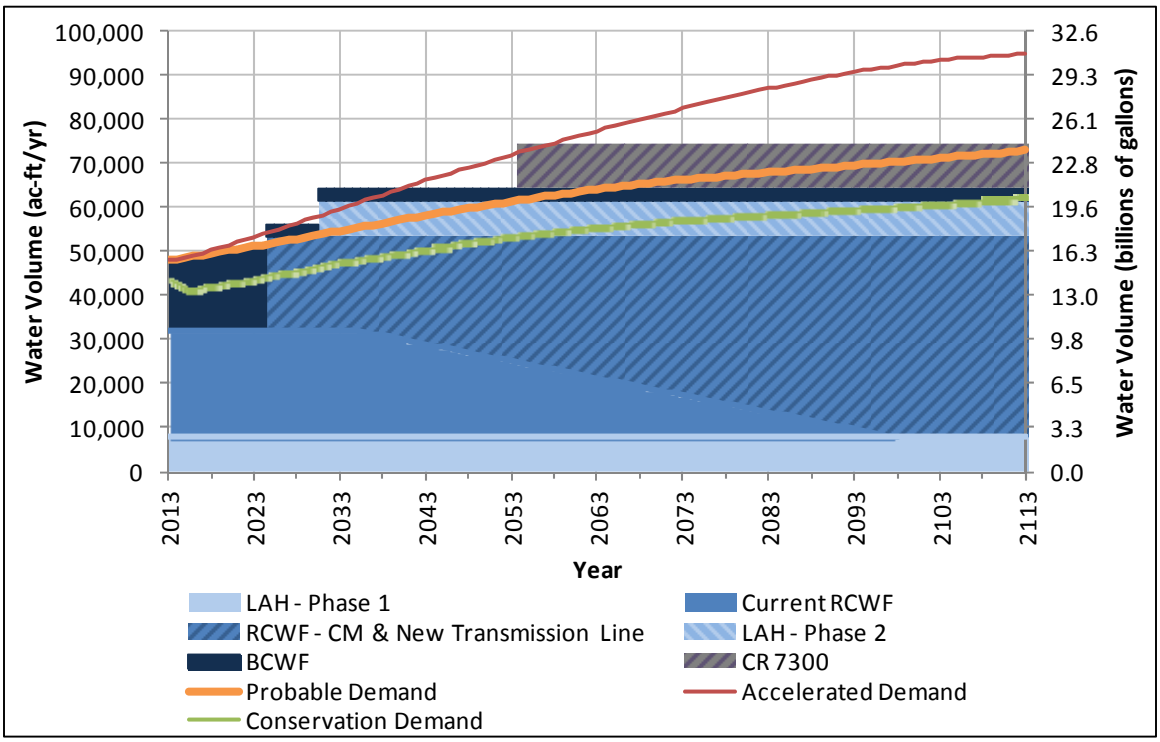


Figure 11.5 – Package 2: Annual Supply vs. Annual Demand Projections

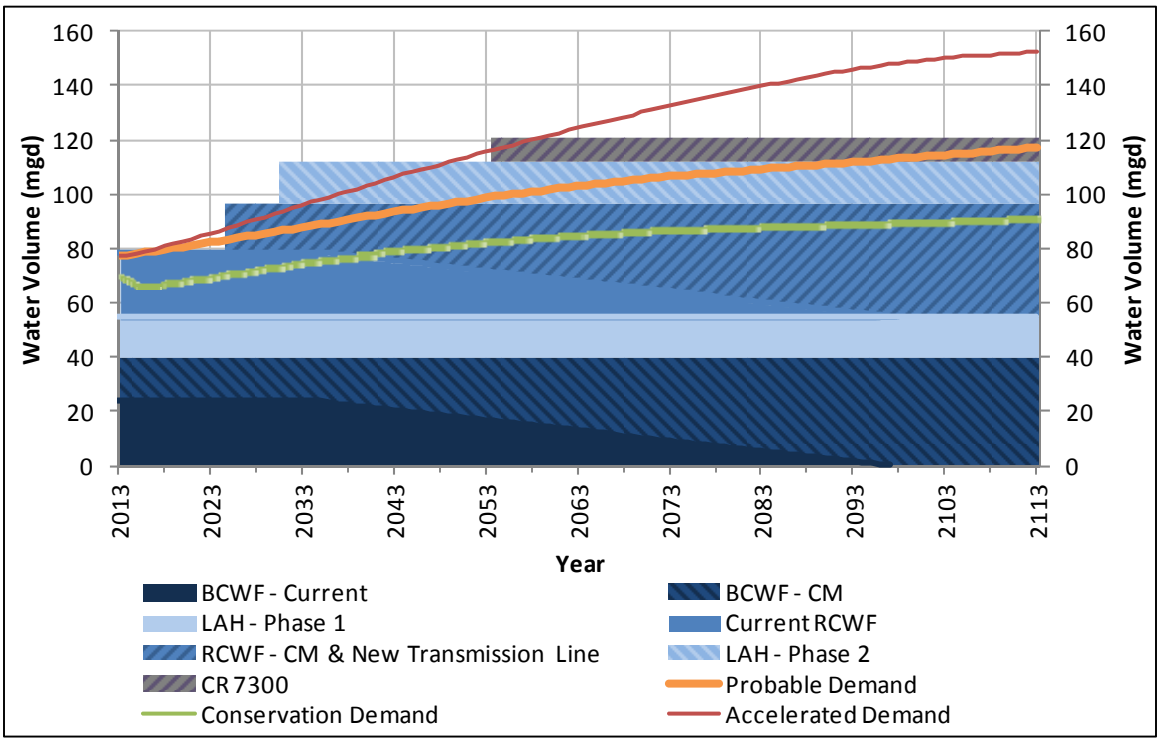


Figure 11.6 – Package 2: Peak Supply vs. Peak Demand Projections

BCWF Capacity Maintenance – This strategy includes implementing the BCWF Initial Capacity Maintenance strategy in 2013 as depicted in Figure 11.5. Due to a projected usage of the BCWF averaging 17,640 ac-ft/yr over a 12-year period, another group of wells is recommended in 2017 (BCWF CM-1) and 2023 (BCWF CM-2). After the RCWF Transmission Line strategy is implemented in 2025, the BCWF can be reserved for peaking capacity for the remaining planning period. The BCWF plays an important role in boosting Lubbock's total peaking capacity. BCWF should be capable of providing up to 40 mgd to meet peak demand for the remaining planning period (see Figure 11.6) if its annual usage remains below 3,000 ac-ft/yr.

RCWF New Transmission Line – This strategy includes constructing a new transmission line from the RCWF to the CRMWA Aqueduct that will almost double the amount of water available (45,671 ac-ft/yr) from the RCWF to the City by 2025. Since the well field production will decline over time, it is anticipated that additional wells will need to be added in 2055 and 2085 to maintain the necessary capacity to keep the transmission lines flowing full.

Lake Alan Henry Phase 2 – This strategy includes delaying the 8,000 ac-ft/yr expansion of the LAH infrastructure until 2031 as depicted in Figure 11.5. Since this strategy includes pumping water from LAH at a rate equal to or less than the lake's safe yield, the lake should provide 16,000 ac-ft/yr of water supply to Lubbock for the duration of the planning period. LAH plays an important role in boosting Lubbock's total peaking capacity. Once Phase 2 is complete, LAH will be capable of providing up to 30 mgd to meet peak demand for the duration of the planning period (see Figure 11.6).

North Fork Diversion at CR 7300 – This strategy includes implementing the North Fork Diversion at CR 7300 by 2054. Since this strategy includes capturing reclaimed water from the North Fork, this strategy should provide 10,089 ac-ft/yr of water supply to Lubbock for the duration of the planning period.

11.3 Supply Package 3 – RCWF Transmission Delayed

This supply package is similar to Package 1 except it delays the implementation of the RCWF New Transmission Line from 2025 until 2035. In addition, this package accelerates the implementation of direct reuse of reclaimed water from 2054 to 2020. This package consists of the following supply strategies that will be necessary to meet the Probable Demand (orange line) over the next 100 years. The potential strategies used are described in the following sections:

Supply Strategy	Section
Direct Potable Reuse to NWTP	6.5
RCWF Capacity Maintenance	7.3
BCWF Initial Capacity Maintenance	7.4
BCWF Capacity Maintenance	7.4
RCWF New Transmission Line	7.5
LAH Phase 2	8.2

In this supply package, strategies are implemented or phased in as depicted in Figure 11.7. The individual and cumulative annual water supplies available from these strategies with respect to the estimated demand over the planning period are depicted in Figure 11.8. The individual and cumulative available peak supplies from these strategies with respect to the estimated peak demand are depicted in Figure 11.9.

2013	2013 - BCWF Initial Capacity Maintenance (ICM) 2017 - LAH Phase 2 2020 - Direct Potable Reuse to NWTP
2023	2023 - BCWF Capacity Maintenance (CM-1) 2025 - RCWF Capacity Maintenance (CM-1)
2033	2033 - BCWF Capacity Maintenance (CM-2) 2035 - RCWF New Transmission Line
2043	
2053	
2063	2065 - RCWF Capacity Maintenance (CM-2)
2073	
2083	
2093	2095 - RCWF Capacity Maintenance (CM-3)
2103	
2113	

Figure 11.7 – Package 3: Strategy Implementation Schedule

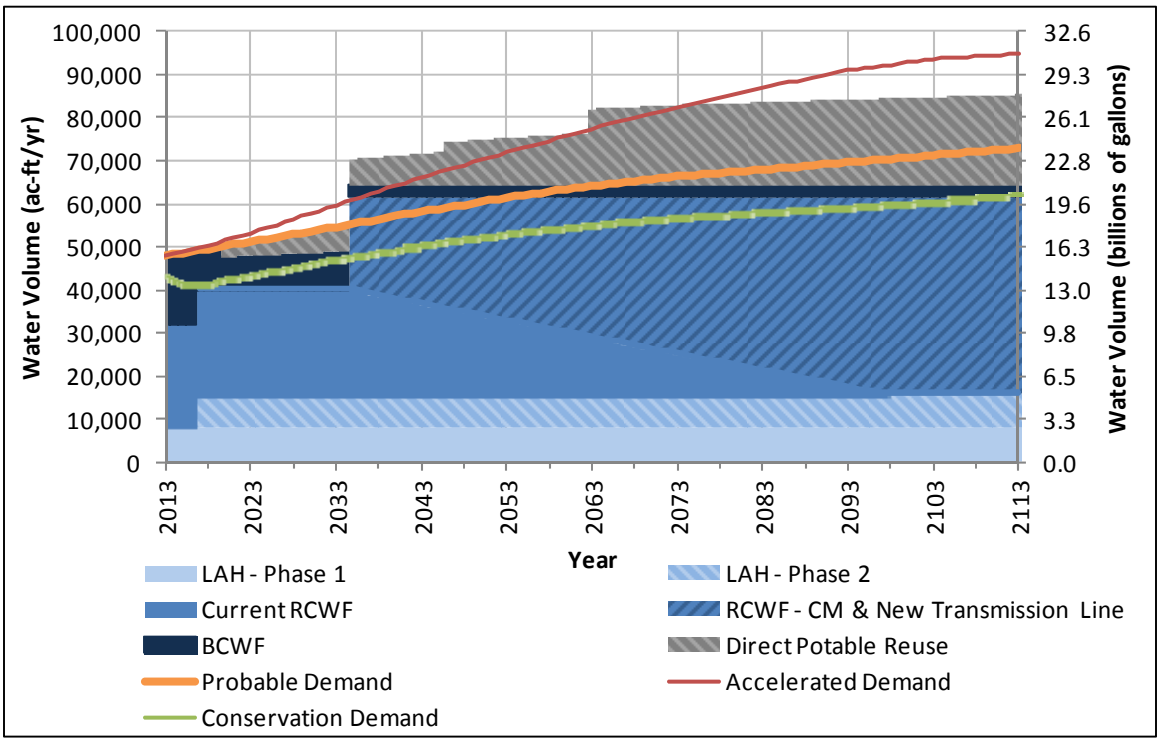


Figure 11.8 – Package 3: Annual Supply vs. Annual Demand Projections

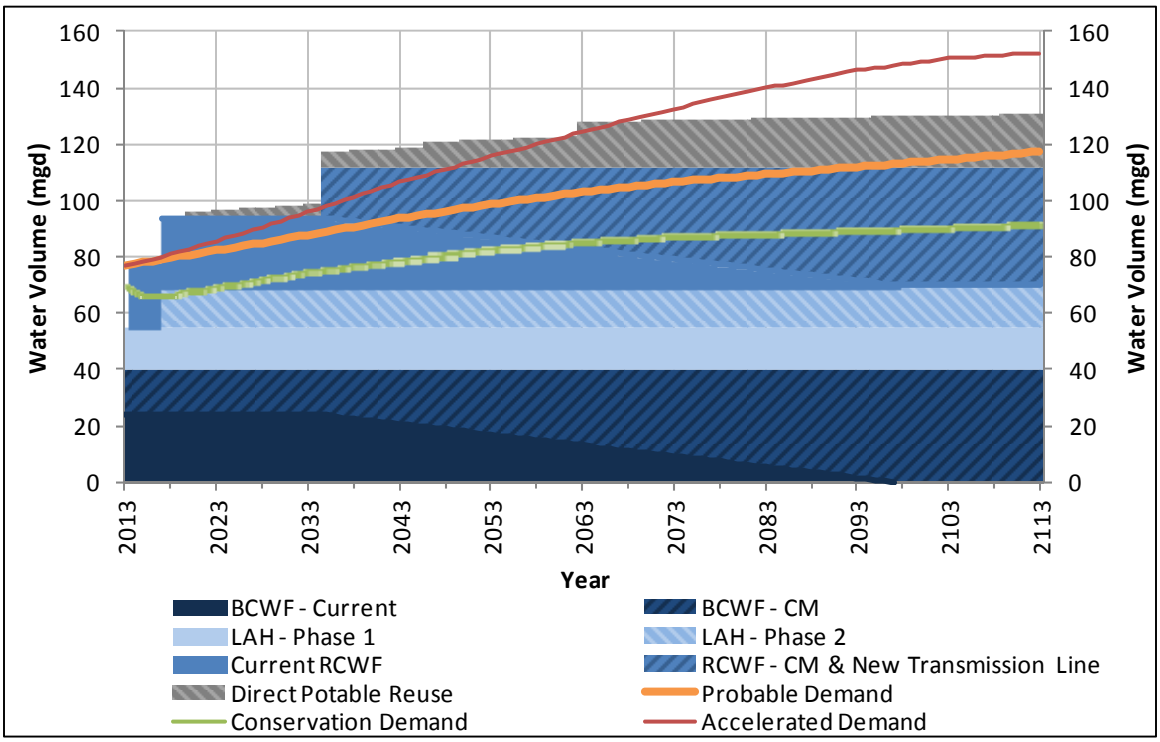


Figure 11.9 – Package 3: Peak Supply vs. Peak Demand Projections

BCWF Capacity Maintenance – This strategy includes implementing the BCWF Initial Capacity Maintenance strategy in 2013 as depicted in Figure 11.8. Due to a projected usage of the BCWF averaging 9,900 ac-ft/yr over a 22-year period, another group of wells is recommended in 2023 (BCWF CM-1) and 2033 (BCWF CM-2). After the RCWF Transmission Line strategy is implemented in 2035, the BCWF can be reserved for peaking capacity for the remaining planning period. The BCWF plays an important role in boosting Lubbock's total peaking capacity. BCWF should be capable of providing up to 40 mgd to meet peak demand for the remaining planning period (see Figure 11.9) if the annual usage remains less than 7,000 ac-ft/yr.

Lake Alan Henry Phase 2 – This strategy includes expanding the existing LAH infrastructure by 2017 by an additional 8,000 ac-ft/yr. Since this strategy includes pumping water from LAH at a rate equal to or less than the lake's safe yield, the lake should provide 16,000 ac-ft/yr of water supply to Lubbock for the duration of the planning period. LAH plays an important role in boosting Lubbock's total peaking capacity. Once Phase 2 is complete, LAH will be capable of providing up to 30 mgd to meet peak demand for the duration of the planning period (see Figure 11.9).

RCWF New Transmission Line – This strategy includes delaying the construction of the new transmission line from RCWF to the CRMWA Aqueduct until 2035. This strategy will almost double the amount of water available (45,671 ac-ft/yr) from the RCWF. Since the well field production will decline over time, it is anticipated that additional wells will need to be added in 2025, 2065, and 2095 to maintain the necessary capacity to keep the transmission lines flowing full.

Direct Potable Reuse at the NWTP – This strategy includes implementing direct potable reuse at the NWTP by 2020 as described in Section 6.5. Implementing this strategy earlier will reduce the need for the BCWF. Figures 11.8 and 11.9 depict this supply strategy using all of the Net Reclaimed Water available (21,057 ac-ft/yr by 2113) as discussed in Section 6.3.

11.4 Supply Package 4 – Aggressive Conservation

This supply package is different from Packages 1, 2, and 3 because its objective is to meet the Conservation Demand projections (green line) described in Section 2. Since the demand projections are less than the Probable Demand projections used in the first three packages, the implementation of the RCWF New Transmission Line is delayed indefinitely. The potential strategies used are described in the following sections:

Supply Strategy	Section
Direct Potable Reuse to NWTP	6.5
RCWF Capacity Maintenance	7.3
BCWF Initial Capacity Maintenance	7.4
BCWF Capacity Maintenance	7.4
LAH Phase 2	8.2

In this supply package, strategies are implemented or phased in as depicted in Figure 11.10. The individual and cumulative annual water supplies available from these strategies with respect to the estimated demand over the planning period are depicted in Figure 11.11. The individual and cumulative available peak supplies from these strategies with respect to the estimated peak demand are depicted in Figure 11.12.

2013	2013 - BCWF Initial Capacity Maintenance (ICM) 2017 - LAH Phase 2 2020 - Direct Potable Reuse to NWTP
2023	2023 - BCWF Capacity Maintenance (CM-1) 2025 - RCWF Capacity Maintenance (CM-1)
2033	
2043	
2053	2055 - RCWF Capacity Maintenance (CM-2)
2063	2063 – BCWF Capacity Maintenance (CM-2)
2073	
2083	2085 - RCWF Capacity Maintenance (CM-3)
2093	
2103	2103 - BCWF Capacity Maintenance (CM-3)
2113	

Figure 11.10 – Package 4: Strategy Implementation Schedule

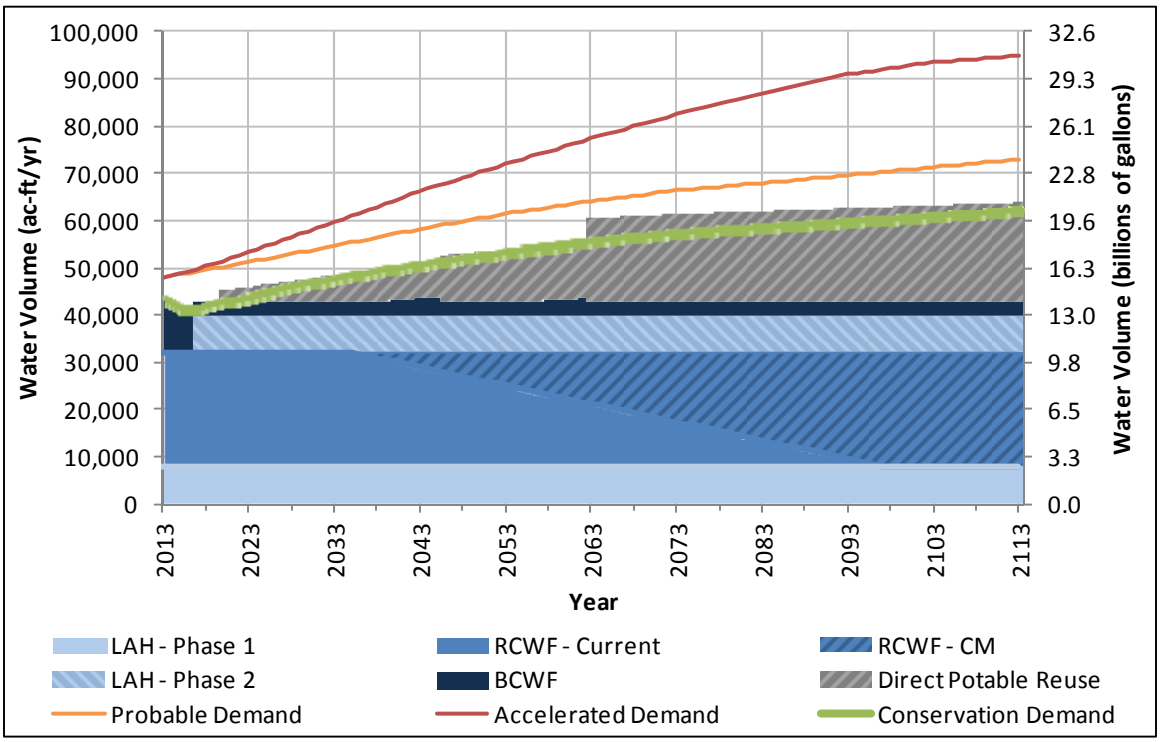


Figure 11.11 – Package 4: Annual Supply vs. Annual Demand Projections

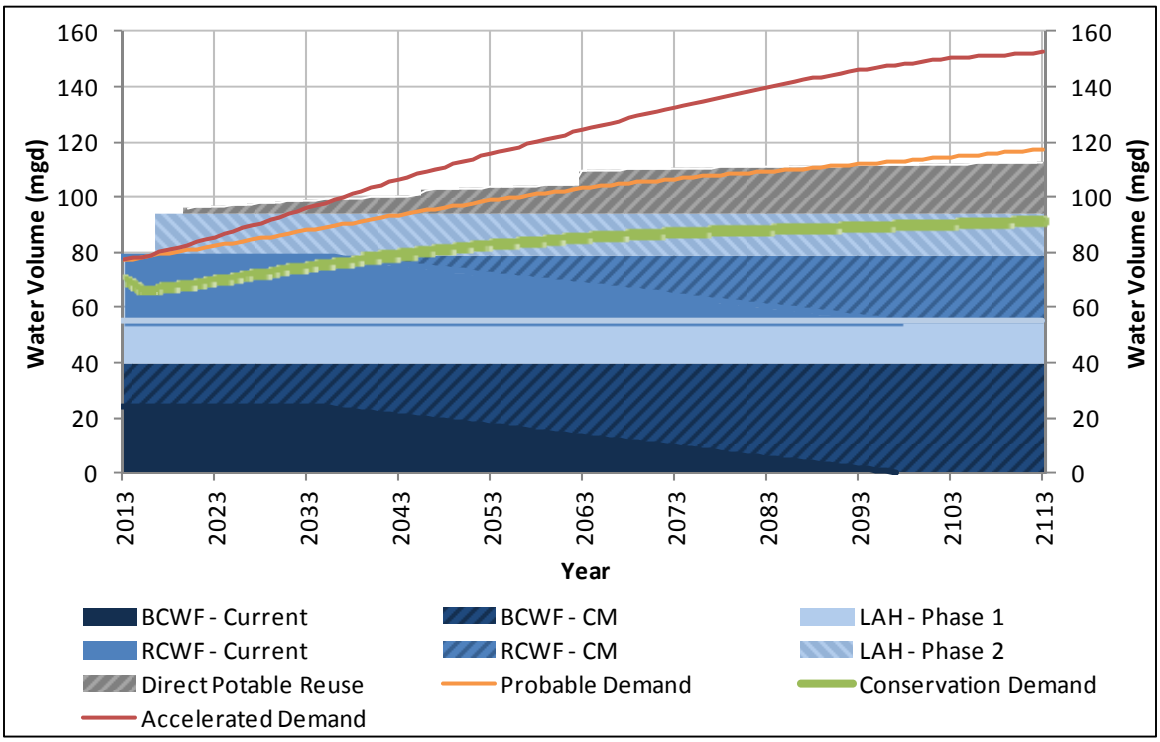


Figure 11.12 – Package 4: Peak Supply vs. Peak Demand Projections

BCWF Capacity Maintenance – This strategy includes implementing the BCWF Initial Capacity Maintenance strategy in 2013 as depicted in Figure 11.12. During the next four years (2013 through 2017) BCWF will have an average utilization of 10,233 ac-ft/yr. However, once LAH Phase 2 is implemented, the projected average utilization of the BCWF is 1,739 ac-ft/yr over a 66-year period. Due to the low utilization of BCWF, additional groups of wells are recommended in 2023, 2063, and 2103. After the LAH Phase 2 strategy is implemented in 2017, the BCWF can be reserved primarily for peaking capacity for the remaining planning period. The BCWF plays an important role in boosting Lubbock's total peaking capacity. BCWF should be capable of providing up to 40 mgd to meet peak demand for the remaining planning period (see Figure 11.13) if the annual usage remains less than 3,000 ac-ft/yr as projected.

Lake Alan Henry Phase 2 – This strategy includes expanding the existing LAH infrastructure by 2017 by an additional 8,000 ac-ft/yr. Since this strategy includes pumping water from LAH at a rate equal to or less than the lake's safe yield, the lake should provide 16,000 ac-ft/yr of water supply to Lubbock for the duration of the planning period. LAH plays an important role in boosting Lubbock's total peaking capacity. Once Phase 2 is complete, LAH will be capable of providing up to 30 mgd to meet peak demand for the duration of the planning period (see Figure 11.13).

RCWF Capacity Maintenance – This strategy only includes maintaining the existing transmission line from the RCWF. Since a new transmission line is not needed to meet the projected Conservation Demand, the well field production will decline more slowly extending the life of the RCWF. It is anticipated that over the planning period that additional wells will need to be added in 2025, 2055, and 2085 to maintain the necessary capacity to keep the transmission lines flowing full.

Direct Potable Reuse at the NWTP – This strategy includes implementing Direct Potable Reuse at the NWTP by 2020. Implementing this strategy earlier will reduce the demand for the BCWF. Figures 11.12 and 11.13 depict this supply strategy using all of the Net Reclaimed Water available (21,057 ac-ft/yr by 2113) as discussed in Section 6.3.

11.5 Supply Package 5 – Accelerated Growth

This supply package is different from Packages 1, 2, and 3 because its objective is to meet the Accelerated Growth Demand projections (red line) described in Section 2. Since the demand projections are greater than the Probable Demand projections used in the first three packages, several additional supply strategies must be implemented. The potential strategies used are described in the following sections:

Supply Strategy	Section
Direct Potable Reuse to NWTP	6.5
RCWF Capacity Maintenance	7.3
BCWF Initial Capacity Maintenance	7.4
BCWF Capacity Maintenance	7.4
RCWF New Transmission Line	7.5
Brackish Well Field	7.8
LAH Phase 2	8.2
Jim Bertram Lake 7	8.3
North Fork Scalping Operation	8.5

In this supply package, strategies are implemented or phased in as depicted in Figure 11.13. The individual and cumulative annual water supplies available from these strategies with respect to the estimated demand over the planning period are depicted in Figure 11.14. The individual and cumulative available peak supplies from these strategies with respect to the estimated peak demand are depicted in Figure 11.15.

2013	2013 - BCWF Initial Capacity Maintenance (ICM) 2017 - LAH Phase 2 2020 - Direct Potable Reuse to NWTP
2023	2023 - BCWF Capacity Maintenance (CM-1) 2025 - RCWF New Transmission Line
2033	
2043	
2053	2055 - North Fork Scalping Operation 2055 - RCWF Capacity Maintenance (CM-2)
2063	
2073	2079 – Jim Bertram Lake 7
2083	2085 - RCWF Capacity Maintenance (CM-3)
2093	2098 - Brackish Well Field
2103	
2113	

Figure 11.13 – Package 5: Strategy Implementation Schedule

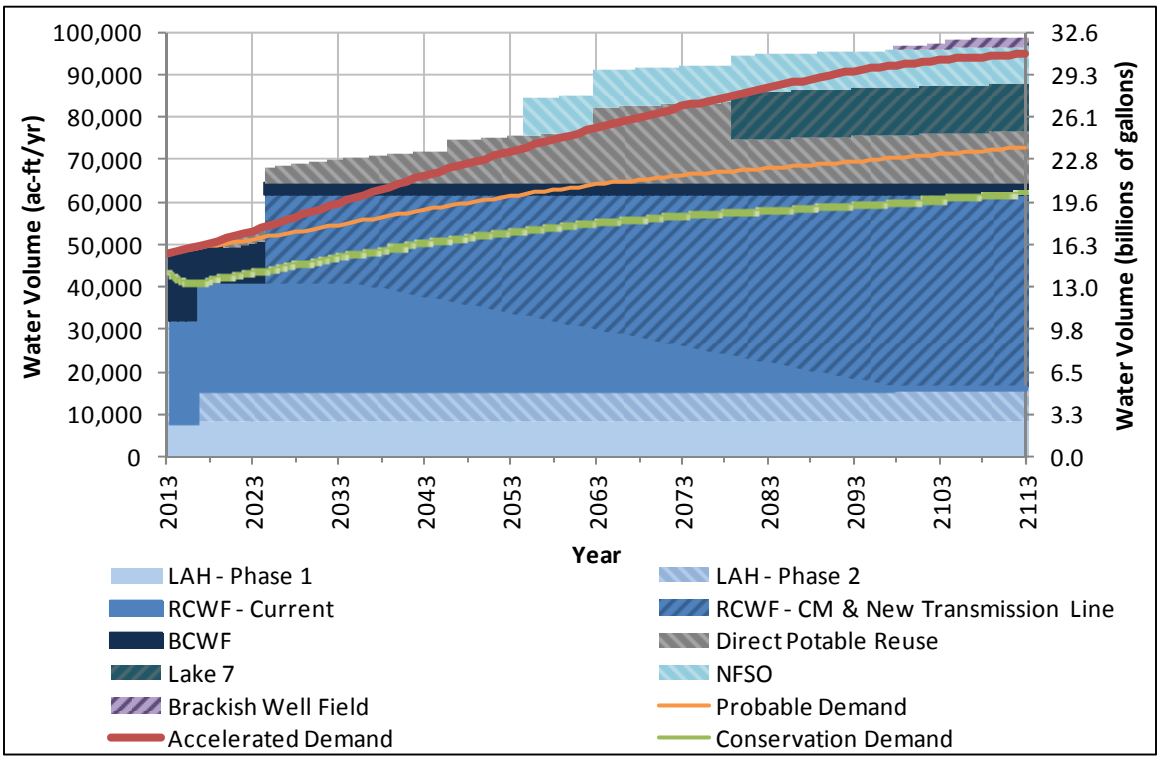


Figure 11.14 – Package 5: Annual Supply vs. Annual Demand Projections

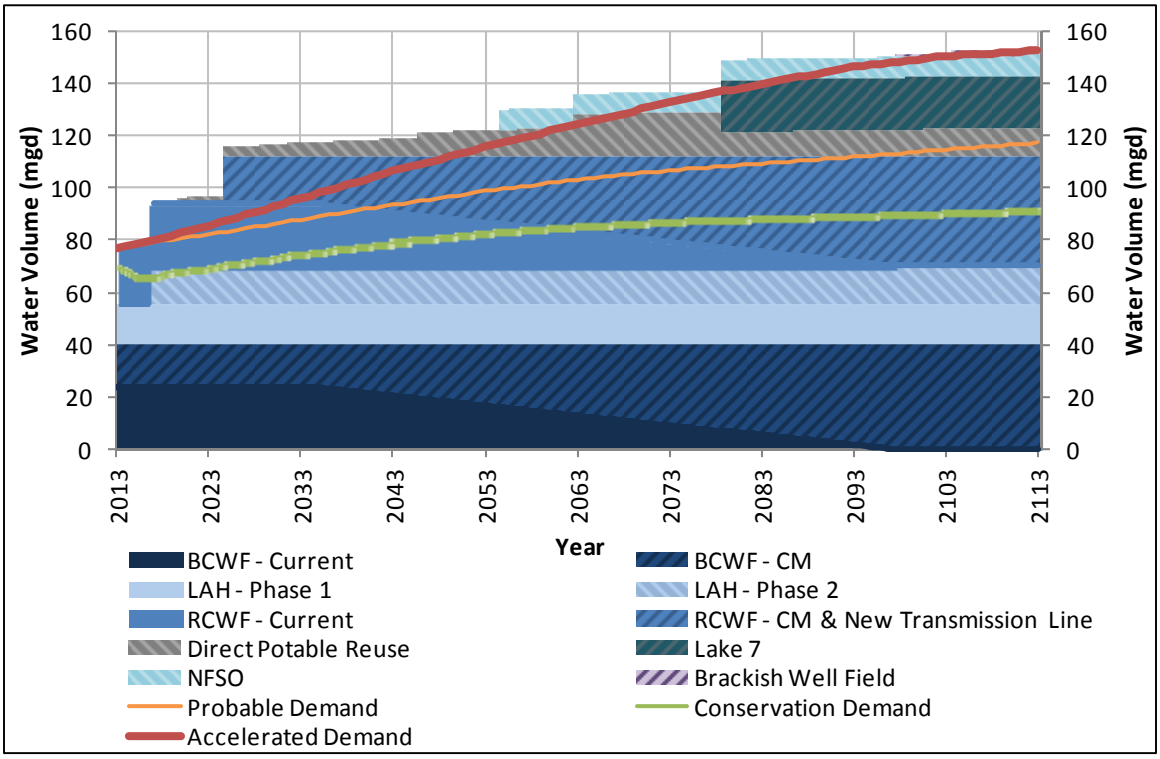


Figure 11.15 – Package 5: Peak Supply vs. Peak Demand Projections

BCWF Capacity Maintenance – This strategy includes implementing the BCWF Initial Capacity Maintenance strategy in 2013 as depicted in Figure 11.15. Due to a projected usage of the BCWF averaging 12,027 ac-ft/yr over a 12-year period, another group of wells (BCWF CM-1) is recommended in 2023. After the RCWF New Transmission Line strategy is implemented in 2025, the BCWF is reserved for peaking capacity for the remaining planning period. The BCWF plays an important role in boosting Lubbock's total peaking capacity. BCWF should be capable of providing up to 40 mgd to meet peak demand for the remaining planning period (see Figure 11.16) if the annual usage remains less than 3,000 ac-ft/yr as projected.

Lake Alan Henry Phase 2 – This strategy includes expanding the existing LAH infrastructure by 2017 by an additional 8,000 ac-ft/yr. Since this strategy includes pumping water from LAH at a rate equal to or less than the lake's safe yield, the lake should provide 16,000 ac-ft/yr of water supply to Lubbock for the duration of the planning period. LAH plays an important role in boosting Lubbock's total peaking capacity. Once Phase 2 is complete, LAH will be capable of providing up to 30 mgd to meet peak demand for the duration of the planning period (see Figure 11.16).

RCWF New Transmission Line – This strategy includes constructing a new transmission line from the RCWF to the CRMWA Aqueduct that will almost double the amount of water available (45,671 ac-ft/yr) from the RCWF to Lubbock by 2025. Since the well field production will decline over time, it is anticipated that additional wells will need to be added in 2055 and 2085 to maintain the necessary capacity to keep the transmission lines flowing full.

Direct Potable Reuse at the NWTP - This strategy includes implementing Direct Potable Reuse at the NWTP by 2020. Implementing this strategy earlier will reduce the demand for the BCWF. Figures 11.14 and 11.15 depict this supply strategy using all of the Net Reclaimed Water available as discussed in Section 6.3 until 2079 when Jim Bertram Lake 7 is completed. After 2079, this strategy must share the Net Reclaimed Water with Jim Bertram Lake 7.

North Fork Scalping Operation - This strategy includes implementing the North Fork Scalping Operation by 2055. Since this strategy includes pumping storm water flows from the North Fork, the strategy should provide 8,725 ac-ft/yr of water supply to Lubbock for the duration of the planning period.

Jim Bertram Lake 7 – This strategy includes constructing Lake 7 by 2079 with a safe yield of 11,300 ac-ft/yr with 7,300 ac-ft/yr coming from Lubbock's available Net Reclaimed Water as described in Section 8.3. Therefore, the Direct Potable Reuse at the NWTP strategy must be reduced from 18,968 to 10,067 ac-ft/yr in 2079. Since this strategy includes pumping water from Lake 7 at a rate equal to or less than the lake's safe yield, the lake should provide 11,300 ac-ft/yr of water supply to Lubbock for the duration of the planning period. Lake 7 plays an important role in boosting Lubbock's total peaking capacity. Once this strategy is complete, Lake 7 will be capable of providing up to 20 mgd to meet peak demand for the duration of the planning period (see Figure 11.16).

Brackish Well Field – This strategy includes constructing the Brackish Well Field at the SWTP site by 2098. Since this strategy includes groundwater pumped from the Dockum Aquifer, it is uncertain whether this strategy will be sustainable for the remaining 15 years of the planning period without the installation of additional wells.

11.6 Supply Package Schedule Comparison

Table 11.1 provides a comparison of the five supply packages discussed in this section. General observations concerning this comparison include:

- Many supply strategies are interchangeable. The attractiveness of each strategy may change over time. Implementation schedules may change based on a variety of unpredictable variables including climate conditions, population, per capita consumption, industry need, changes in regulatory environments, etc.

- New supply strategies must be implemented over the next 20 years to reduce the over-utilization of the BCWF;

- Delaying the implementation of LAH Phase 2 and/or the RCWF New Transmission Line (under Probable Demand conditions) threatens the sustainability of the BCWF as a viable peaking source.

- If Lubbock persists in its water conservation efforts, the implementation of the RCWF New Transmission Line strategy and/or other supply strategies can be delayed indefinitely;

- If accelerated growth occurs, several additional strategies will need to be implemented to meet the projected water demand in 2113;

- Direct reuse and indirect reuse strategies are interchangeable. However, the amount of reclaimed water available during the first couple of decades is small compared to what is available during the later decades of the planning period.

- Supply Packages 3 and 4 are identical during the first 20 years of the planning period.

Table 11.1 – Supply Package Schedule Comparison

Supply Package 1 Baseline	Supply Package 2 LAH Delayed	Supply Package 3 RCWF Line Delayed	Supply Package 4 Conservation	Supply Package 5 Accel. Growth
2013				
2013: BCWF - ICM 2017: LAH Phase 2	2013: BCWF - ICM 2017: BCWF CM-1	2013: BCWF - ICM 2017: LAH Phase 2 2020: Direct Reuse	2013: BCWF - ICM 2017: LAH Phase 2 2020: Direct Reuse	2013: BCWF - ICM 2017: LAH Phase 2 2020: Direct Reuse
2023				
2023: BCWF CM-1 2025: RCWF New Transmission Line	2023: BCWF CM-2 2025: RCWF New Transmission Line 2031: LAH Phase 2	2023: BCWF CM-1 2025: RCWF CM-1	2023: BCWF CM-1 2025: RCWF CM-1	2023: BCWF CM-1 2025: RCWF New Transmission Line
2033				
		2033: BCWF CM-2 2035: RCWF New Transmission Line		
2043				
2053				
2054: Direct Reuse 2055: RCWF CM-1	2054: North Fork Diversion at CR 7300 2055: RCWF CM-1		2055: RCWF CM-2	2055: North Fork Scalping Operation 2055: RCWF CM-2
2063				
		2065: RCWF CM-2	2063: BCWF CM-2	
2073				
				2079: Jim Bertram Lake 7
2083				
2085: RCWF CM-2	2085: RCWF CM-2		2085: RCWF CM-3	2085: RCWF CM-3
2093				
		2095: RCWF CM-3		2098: Brackish Well Field
2103				
			2103: BCWF CM-3	
2113				

Note: ICM = Initial Capacity Maintenance, CM-1 = Capacity Maintenance-1, CM-2 = Capacity Maintenance-2, etc.

12.0 Financial Impact

In Section 11, five recommended water supply packages are presented and discussed. This section evaluates the financial impact of each of the supply packages. The financial impact of each package is dependent upon the timing, order, capital cost, annual operating costs, and number of supply strategies implemented over the 100 year planning period. This financial evaluation should assist the City in developing a Capital Improvement Plan (CIP) for the recommended supply packages. The proposed implementation schedules can be adjusted in the future to meet the City's needs. The strategies may shift in order of implementation as the City's priorities change. The City should re-evaluate the proposed order before each strategy is implemented.

12.1 Net Present Value Analysis

HDR Engineering, Inc. prepared a present value (PV) analysis on each of the five water supply packages. Appendix E includes a memo explaining the primary assumptions for the PV analysis. These assumptions include inflation, discount, and bond interest rates. Rates used in calculating PVs are summarized in Table 12.1.

Table 12.1 – Present Value Analysis – Assumed Rates Used in Calculations

Time Period	Inflation Rate	Power Cost Inflation Rate	Discount Rate	Bond Rate
2014 – 2025	3.0%	1.0%	1.0%	5.1%
2026 – 2046	3.1%	2.8%	1.1%	5.1%
2047 – 2067	3.2%	3.8%	1.2%	5.1%
2068 – 2113	2.7%	4.8%	1.0%	5.1%

Inflated Project Costs

HDR Engineering, Inc. prepared inflated project costs for each of the five water supply packages shown in Table 12.2. These inflated costs account for estimated rates of inflation affecting future prices, using the rates shown in Table 12.1. Projects implemented later in the Plan have higher inflated costs than those implemented earlier. Table 12.2 lists the cost of projects if constructed today (Original Project Cost) and compares the inflated costs of those projects based upon their implementation date. Some of the original project costs differ from those presented in earlier sections as they have been adjusted in size and scope from the initial evaluation to meet the City's water supply needs in the year they are implemented.

Table 12.2 – Inflated Project Cost Comparison

		Package 1 Baseline		**Package 2** LAH Delayed		**Package 3** RCWF Delayed		**Package 4** Conservation		**Package 5** Accel. Growth	
Project Name	Original Project Cost ($ in millions)	Year Financed	Inflated Project Cost ($ in millions)	Year Financed	Inflated Project Cost ($ in millions)	Year Financed	Inflated Project Cost ($ in millions)	Year Financed	Inflated Project Cost ($ in millions)	Year Financed	Inflated Project Cost ($ in millions)
BCWF ICM	$19.04	2014	$19.04	2014	$19.04	2014	$19.04	2014	$19.04	2014	$19.04
BCWF CM-1	$5.72	2021	$7.04	2015	$5.89	2021	$7.04	2021	$7.04	2021	$7.04
BCWF CM-2	$5.72	.	.	2021	$7.04	2031	$9.51	2061	$24.10	.	.
BCWF CM-3	$5.72	.	.	.	.	.	.	2101	$72.14	.	.
Brackish Well Field	$58.23	.	.	.	.	.	.	.	.	2096	$642.34
Direct Potable Reuse to NWTP Phase 1	$100.23	2052	$317.95	.	.	2018	$112.81	2018	$112.81	2018	$112.81
Direct Potable Reuse to NWTP Phase 2	$83.51	2052	$264.92	.	.	2045	$212.75	2045	$212.75	2045	$212.75
Jim Bertram Lake 7	$88.33	.	.	.	.	.	.	.	.	2077	$586.86
LAH Phase 2	$65.71	2015	$67.68	2029	$102.75	2015	$67.68	2015	$67.68	2015	$67.68
North Fork Diversion at CR 7300	$54.26	.	.	2052	$172.13	.	.	.	.	.	.
North Fork Scalping Operation	$125.49	.	.	.	.	.	.	.	.	2053	$410.82
RCWF New Transmission Line	$104.33	2023	$136.12	2023	$136.12	2033	$184.29	.	.	2023	$136.12
RCWF CM-1 with 11 wells	$9.61	.	.	.	.	2023	$12.54	2023	$12.54	.	.
RCWF CM-2 with 11 wells	$9.61	.	.	.	.	.	.	2053	$31.47	.	.
RCWF CM-3 with 11 wells	$9.61	.	.	.	.	.	.	2083	$74.97	.	.
RCWF CM-1 with 20 wells	$18.44	2053	$60.36	2053	$60.36	2063	$82.69	.	.	2053	$60.36
RCWF CM-2 with 20 wells	$18.44	2083	$143.79	2083	$143.79	2093	$187.77	.	.	2083	$143.79

Note: ICM = Initial Capacity Maintenance, CM-1 = Capacity Maintenance-1, CM-2 = Capacity Maintenance-2, etc.

A summary of the PV Analysis is depicted in Table 12.3 and Figure 12.1. Based on this analysis, the PV of all five supply packages fall between $4 billion and $10 billion over the 100 year planning period.

Table 12.3 – Present Value Analysis Summary

Package	Total Package Cost (Current Dollars)	Total Package Cost (Inflated Dollars)	Total Cash Flow (Inflated Dollars)	Net PV of Cash Flow
Package 1	$ 415,417,000	$ 1,016,904,796	$ 14,669,595,197	$ 6,793,719,381
Package 2	$ 291,661,000	$ 647,127,226	$ 10,821,355,010	$ 4,975,451,844
Package 3	$ 430,754,000	$ 896,130,642	$ 14,887,481,747	$ 6,974,456,843
Package 4	$ 314,499,000	$ 634,548,574	$ 8,536,822,201	$ 4,131,248,530
Package 5	$ 687,463,000	$ 2,399,617,523	$ 21,657,599,118	$ 9,945,560,890

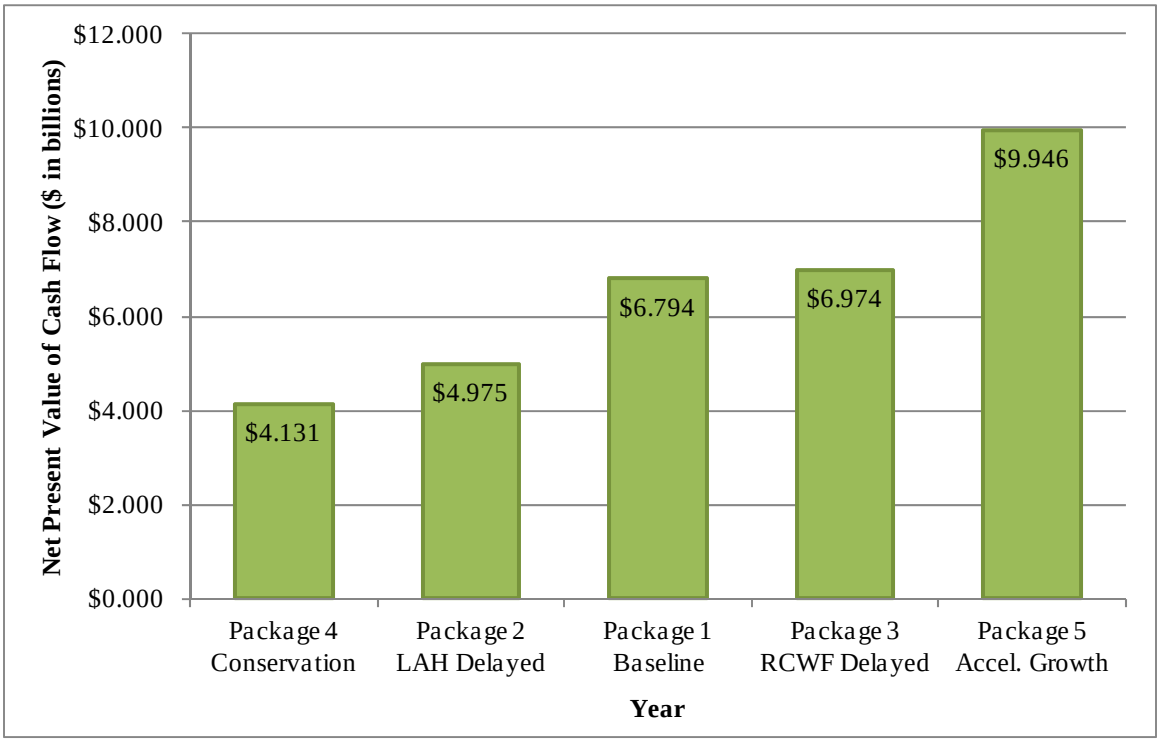


Figure 12.1 – Net Present Value Comparison for Supply Packages

As expected, Supply Package 4 is the least expensive alternative since it requires the fewest water supply strategies to meet the Conservation Demand projections. Similarly, Supply Package 5 is the most expensive alternative since it requires the implementation of the most water supply strategies in order to meet the Accelerated Demand projections.

Supply Packages 1, 2, and 3 are all based on satisfying the Probable Demand projections. Supply Package 2 is less expensive than Supply Packages 1 and 3 for several reasons. This package draws more heavily upon the existing BCWF supply for a longer period of time. However, heavy usage of the BCWF may not be sustainable. Package 1 implements LAH Phase 2 sooner in order to relieve BCWF. Package 3 implements direct reuse sooner in order to relieve BCWF.

12.2 12-Year Financial Model

In order to provide information for water rate planning, the City's Finance Department created a financial spreadsheet model for the Water Fund that extends over the 12 year short-term planning period. Models were developed for all five supply packages discussed in Section 11.

In each model, the volume rates increase more dramatically during the first part of the modeling period, because the City Council initiated a new water rate policy in 2012 to promote water conservation. Under this new policy, the base rates decrease over a three year period and the volume rates increase. For example, during this three year period, the base rate for a 3/4-inch water meter decreases from $21 to $7 per month. A rate structure comparison for Supply Package 1 is included in Appendix E-2 to demonstrate the variations in the base and volume rates due to this policy. Therefore, in the first few years of the modeling period the volume rates are affected by both the implementation of each supply package and the introduction of the new rate policy.

Financial models for each Supply Package are included in Appendix E-3 through E-6. One financial model (Appendix E-5) represents both Supply Packages 3 and 4 since the exact same projects are initiated during the same timeframes over the 12 year period. Variations between these two packages do not occur until 2033. Key drivers of these financial models include:

- Timing of debt issuance;
- Amount of cumulative debt service;
- Maintaining appropriable net assets at policy levels;
- Creating and funding a RCWF reserve to fund the new transmission line; and
- Increases in volume and/or base rates to meet additional revenue demands.

These financial models are used to estimate how much water rates will increase over the next 12 years in order to fund each of the supply packages. Figure 12.2 compares a 2013 monthly residential water bill for a 3/4-inch meter with projected water bills for each supply package in 2025 assuming an average consumption of 7,000 gallons/month.

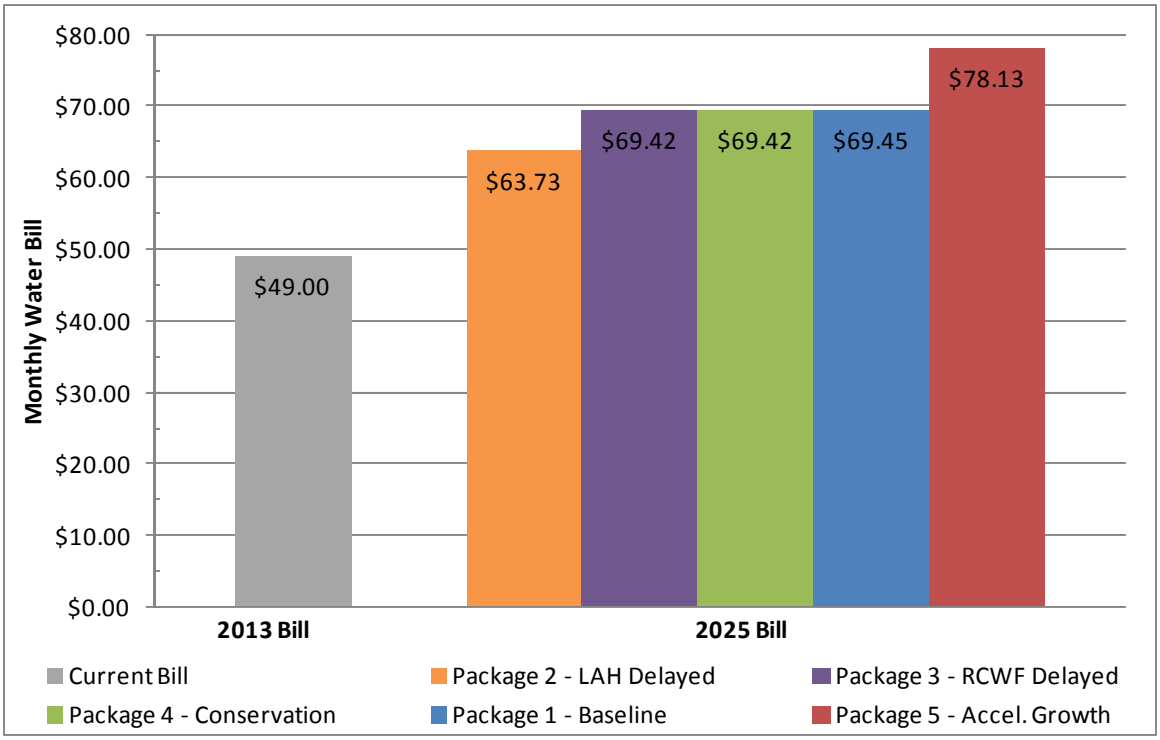


Figure 12.2 – Comparison of Average Monthly Water Bill for Supply Packages

Based on the water bill comparison in Figure 12.2, the following observations and conclusions can be made:

- During the short-term planning period, an average monthly water bill may increase by as much as $14 (30%) to $29 (59%) depending on which supply package is implemented.
- Supply Package 2 (LAH Phase 2 Delayed) includes the smallest increase in the water rates over the short-term planning period. Because this package relies heavily on the BCWF, fewer strategies are needed in the next 12 year period. However, this strategy becomes more costly over the 100 year planning period.
- While not the least expensive package in the short-term, Supply Package 4 (Conservation) is the least expensive package over the entire planning period (see

Figure 12.1). The savings to the customer will become more noticeable during the medium- and long-term planning periods.

- Supply Package 5 (Accelerated Growth) includes the most expensive increase in the water rates over the short-term and long-term planning periods.

Appendix A-1

Historic Data for the City of Lubbock

Year	Population (Cenus Data)	Growth Rate (Percent)	Gallons per Capita per Day (gpcd)	Water Demand (ac-ft/yr)	Peak Day Demand (mgd)	Average Annual Day (mg)	Peaking Factor
Data by Decade							
1910	1,938	n/a	.	.	.	.	.
1920	4,051	109.0	.	.	.	.	.
1930	20,520	406.5	.	.	.	.	.
1940	31,853	55.2	.	.	.	.	.
1950	71,747	125.2	.	.	.	.	.
1960	128,691	79.4	.	.	.	.	.
1970	149,101	15.9	.	.	.	.	.
1980	173,979	16.7	206	40,205	70.85	35.89	1.97
1990	186,206	7.0	192	40,086	79.00	35.79	2.21
2000	199,564	7.2	199	44,375	67.82	39.62	1.71
2010	229,573	15.0	143	36,890	50.38	32.93	1.53
Data by Year							
1910	1,938	8.54	.	.	.	.	.
1911	2,104	4.02	.	.	.	.	.
1912	2,188	4.35	.	.	.	.	.
1913	2,283	8.54	.	.	.	.	.
1914	2,478	8.54	.	.	.	.	.
1915	2,690	8.54	.	.	.	.	.
1916	2,920	8.54	.	.	.	.	.
1917	3,169	8.54	.	.	.	.	.
1918	3,440	8.54	.	.	.	.	.
1919	3,733	8.51	.	.	.	.	.
1920	4,051	17.62	.	.	.	.	.
1921	4,765	17.62	.	.	.	.	.
1922	5,604	17.62	.	.	.	.	.
1923	6,591	17.62	.	.	.	.	.
1924	7,753	17.62	.	.	.	.	.
1925	9,118	17.62	.	.	.	.	.
1926	10,725	17.62	.	.	.	.	.
1927	12,614	17.62	.	.	.	.	.
1928	14,836	17.62	.	.	.	.	.
1929	17,450	17.59	.	.	.	.	.
1930	20,520	4.50	.	.	.	.	.
1931	21,443	4.50	.	.	.	.	.
1932	22,407	4.50	.	.	.	.	.
1933	23,414	4.50	.	.	.	.	.
1934	24,467	4.50	.	.	.	.	.
1935	25,567	4.50	.	.	.	.	.
1936	26,716	4.50	.	.	.	.	.
1937	27,917	4.50	.	.	.	.	.
1938	29,173	4.50	.	.	.	.	.
1939	30,484	4.49	.	.	.	.	.
1940	31,853	8.46	.	.	.	.	.
1941	34,547	8.46	.	.	.	.	.
1942	37,470	8.46	.	.	.	.	.
1943	40,639	8.46	.	.	.	.	.
1944	44,077	8.46	.	.	.	.	.
1945	47,806	8.46	.	.	.	.	.
1946	51,849	8.46	.	.	.	.	.
1947	56,235	8.46	.	.	.	.	.
1948	60,992	8.46	.	.	.	.	.
1949	66,152	8.46	.	.	.	.	.
1950	71,747	6.02	.	.	.	.	.
1951	76,064	6.02	.	.	.	.	.
1952	80,641	6.02	.	.	.	.	.
1953	85,493	6.02	.	.	.	.	.
1954	90,638	6.02	.	.	.	.	.
1955	96,091	6.02	.	.	.	.	.
1956	101,873	6.02	.	.	.	.	.
1957	108,003	6.02	.	.	.	.	.
1958	114,501	6.02	.	.	.	.	.
1959	121,391	6.01	.	.	.	.	.
1960	128,691	1.48	.	.	.	.	.
1961	130,599	1.48	.	.	.	.	.
1962	132,536	1.48	.	.	.	.	.
1963	134,502	1.48	.	.	.	.	.
1964	136,496	1.48	.	.	.	.	.

Appendix A-1

Historic Data for the City of Lubbock

Year	Population (Cenus Data)	Growth Rate (Percent)	Gallons per Capita per Day (gpcd)	Water Demand (ac-ft/yr)	Peak Day Demand (mgd)	Average Annual Day (mg)	Peaking Factor
1965	138,521	1.48	.	.	.	.	.
1966	140,575	1.48	.	.	.	.	.
1967	142,660	1.48	.	.	.	.	.
1968	144,775	1.48	.	.	.	.	.
1969	146,922	1.48	.	.	.	.	.
1970	149,101	1.55	.	.	.	.	.
1971	151,420	1.55	.	.	.	.	.
1972	153,774	1.55	.	.	.	.	.
1973	156,165	1.55	.	.	.	.	.
1974	158,593	1.55	.	.	.	.	.
1975	161,059	1.55	.	.	.	.	.
1976	163,564	1.55	.	.	.	.	.
1977	166,107	1.55	.	.	.	.	.
1978	168,690	1.55	.	.	.	.	.
1979	171,313	1.56	.	.	.	.	.
1980	173,979	0.30	206	40,205	70.85	35.89	1.97
1981	174,508	0.30	184	35,928	68.48	32.07	2.13
1982	175,038	0.30	178	34,841	58.69	31.10	1.89
1983	175,569	0.30	208	40,835	n/a	36.46	n/a
1984	176,103	2.19	195	38,385	n/a	34.27	n/a
1985	179,953	0.34	180	36,305	65.18	32.41	2.01
1986	180,561	0.23	170	34,395	65.71	30.71	2.14
1987	180,973	0.70	168	34,057	57.01	30.40	1.87
1988	182,243	0.73	183	37,417	60.40	33.40	1.81
1989	183,573	1.43	196	40,233	69.12	35.92	1.92
1990	186,206	0.50	192	40,086	79.00	35.79	2.21
1991	187,137	0.19	176	36,930	67.38	32.97	2.04
1992	187,493	0.26	167	34,971	55.50	31.22	1.78
1993	187,981	1.09	181	38,096	58.35	34.01	1.72
1994	190,038	0.52	197	41,929	74.98	37.43	2.00
1995	191,020	1.07	213	45,491	79.54	40.61	1.96
1996	193,064	1.19	204	44,178	66.71	39.44	1.69
1997	195,367	0.67	185	40,408	63.37	36.07	1.76
1998	196,679	0.22	224	49,299	84.17	44.01	1.91
1999	197,117	1.24	188	41,429	68.93	36.99	1.86
2000	199,564	0.83	199	44,375	67.82	39.62	1.71
2001	201,217	0.39	191	43,078	73.09	38.46	1.90
2002	202,000	1.35	182	41,080	63.91	36.67	1.74
2003	204,737	0.76	190	43,626	73.61	38.95	1.89
2004	206,290	1.37	161	37,120	59.94	33.14	1.81
2005	209,120	0.99	168	39,302	64.97	35.09	1.85
2006	211,187	0.56	177	41,874	78.45	37.38	2.10
2007	212,365	1.17	136	32,456	51.77	28.97	1.79
2008	214,847	1.62	148	35,671	57.18	31.85	1.80
2009	218,327	6.85	145	35,434	54.23	31.63	1.71
2010	229,573	1.06	143	36,890	50.38	32.93	1.53
2011	236,111	0.69	178	47,024	64.11	41.25	1.53
2012	237,712	.	152	40,587	58.07	36.23	1.60

Appendix A-2

Population and Growth Rate Projections

Year	Population					Growth Rate (Percent)				
	Probable	Accelerated	2011 Region O Plan	2007 SWSP Medium	2007 SWSP High	Probable	Accelerated	2011 Region O Plan	2007 SWSP Medium	2007 SWSP High
Data by Decade										
2013	240,565	240,565	220,281	225,631	239,290	1.20	1.30	0.50	0.72	1.20
2023	271,042	281,945	230,143	241,149	269,568	1.20	1.70	0.31	0.62	1.20
2033	305,381	333,714	236,483	255,197	303,682	1.20	1.70	0.19	0.51	1.20
2043	330,710	375,993	240,563	267,400	342,118	0.80	1.20	0.13	0.41	1.20
2053	354,603	415,330	244,568	277,554	385,423	0.70	1.00	0.24	0.32	1.20
2063	376,463	454,260	n/a	285,840	434,215	0.60	0.90	n/a	0.25	1.20
2073	395,715	491,938	n/a	292,592	489,189	0.50	0.80	n/a	0.20	1.20
2083	411,832	527,479	n/a	298,076	551,127	0.40	0.70	n/a	0.15	1.20
2093	428,605	559,996	n/a	302,206	620,912	0.40	0.60	n/a	0.10	1.20
2103	446,061	585,712	n/a	305,367	699,539	0.40	0.45	n/a	0.10	1.20
2113	464,228	603,522	n/a	n/a	n/a	0.40	0.30	n/a	n/a	n/a
Data by Year										
2010	233,606	233,606	216,974	220,817	229,913	1.06	1.06	0.51	0.72	1.20
2011	236,111	236,111	218,076	222,410	233,656	0.69	0.69	0.51	0.72	1.20
2012	237,712	237,712	219,178	224,015	236,456	1.20	1.20	0.50	0.72	1.20
2013	240,565	240,565	220,281	225,631	239,290	1.20	1.30	0.50	0.72	1.20
2014	243,451	243,692	221,383	227,259	242,158	1.20	1.40	0.50	0.72	1.20
2015	246,373	247,104	222,485	228,899	245,060	1.20	1.50	0.50	0.72	1.20
2016	249,329	250,810	223,587	230,551	247,997	1.20	1.60	0.49	0.72	1.20
2017	252,321	254,823	224,689	232,214	250,970	1.20	1.70	0.49	0.72	1.20
2018	255,349	259,155	225,792	233,890	253,978	1.20	1.70	0.49	0.72	1.20
2019	258,413	263,561	226,894	235,577	257,022	1.20	1.70	0.49	0.50	1.20
2020	261,514	268,041	227,996	236,749	260,102	1.20	1.70	0.31	0.62	1.20
2021	264,652	272,598	228,712	238,207	263,220	1.20	1.70	0.31	0.62	1.20
2022	267,828	277,232	229,427	239,673	266,375	1.20	1.70	0.31	0.62	1.20
2023	271,042	281,945	230,143	241,149	269,568	1.20	1.70	0.31	0.62	1.20
2024	274,295	286,738	230,858	242,634	272,799	1.20	1.70	0.31	0.62	1.20
2025	277,586	291,613	231,574	244,128	276,069	1.20	1.70	0.31	0.62	1.20
2026	280,917	296,570	232,289	245,631	279,378	1.20	1.70	0.31	0.62	1.20
2027	284,288	301,612	233,005	247,144	282,727	1.20	1.70	0.31	0.62	1.20
2028	287,700	306,739	233,720	248,665	286,116	1.20	1.70	0.31	0.62	1.20
2029	291,152	311,954	234,436	250,197	289,546	1.20	1.70	0.31	0.45	1.20
2030	294,646	317,257	235,151	251,326	293,017	1.20	1.70	0.19	0.51	1.20
2031	298,182	322,650	235,595	252,610	296,530	1.20	1.70	0.19	0.51	1.20
2032	301,760	328,136	236,039	253,900	300,085	1.20	1.70	0.19	0.51	1.20
2033	305,381	333,714	236,483	255,197	303,682	1.20	1.70	0.19	0.51	1.20
2034	307,824	337,718	236,927	256,500	307,323	0.80	1.20	0.19	0.51	1.20
2035	310,287	341,771	237,371	257,810	311,007	0.80	1.20	0.19	0.51	1.20
2036	312,769	345,872	237,815	259,127	314,735	0.80	1.20	0.19	0.51	1.20
2037	315,271	350,023	238,259	260,451	318,509	0.80	1.20	0.19	0.51	1.20
2038	317,793	354,223	238,703	261,781	322,327	0.80	1.20	0.19	0.51	1.20
2039	320,336	358,474	239,147	263,118	326,191	0.80	1.20	0.19	0.40	1.20
2040	322,898	362,775	239,591	264,163	330,102	0.80	1.20	0.14	0.41	1.20
2041	325,482	367,129	239,915	265,238	334,060	0.80	1.20	0.14	0.41	1.20
2042	328,085	371,534	240,239	266,317	338,065	0.80	1.20	0.13	0.41	1.20
2043	330,710	375,993	240,563	267,400	342,118	0.80	1.20	0.13	0.41	1.20
2044	333,025	379,753	240,887	268,488	346,220	0.70	1.00	0.13	0.41	1.20
2045	335,356	383,550	241,211	269,580	350,371	0.70	1.00	0.13	0.41	1.20
2046	337,704	387,386	241,535	270,677	354,572	0.70	1.00	0.13	0.41	1.20
2047	340,068	391,259	241,859	271,778	358,823	0.70	1.00	0.13	0.41	1.20
2048	342,448	395,172	242,183	272,883	363,125	0.70	1.00	0.13	0.41	1.20
2049	344,845	399,124	242,507	273,993	367,479	0.70	1.00	0.13	0.33	1.20
2050	347,259	403,115	242,831	274,909	371,885	0.70	1.00	0.24	0.32	1.20
2051	349,690	407,146	243,410	275,788	376,344	0.70	1.00	0.24	0.32	1.20
2052	352,138	411,218	243,989	276,669	380,857	0.70	1.00	0.24	0.32	1.20
2053	354,603	415,330	244,568	277,554	385,423	0.70	1.00	0.24	0.32	1.20
2054	356,730	419,068	245,147	278,441	390,045	0.60	0.90	0.24	0.32	1.20
2055	358,871	422,839	245,727	279,331	394,722	0.60	0.90	0.24	0.32	1.20
2056	361,024	426,645	246,306	280,224	399,455	0.60	0.90	0.24	0.32	1.20
2057	363,190	430,485	246,885	281,120	404,245	0.60	0.90	0.23	0.32	1.20
2058	365,369	434,359	247,464	282,019	409,092	0.60	0.90	0.23	0.32	1.20
2059	367,561	438,268	248,043	282,920	413,998	0.60	0.90	0.23	0.27	1.20
2060	369,767	442,213	248,622	283,697	418,962	0.60	0.90	n/a	0.25	1.20

Appendix A-2

Population and Growth Rate Projections

Year	Population					Growth Rate (Percent)				
	Probable	Accelerated	2011 Region O Plan	2007 SWSP Medium	2007 SWSP High	Probable	Accelerated	2011 Region O Plan	2007 SWSP Medium	2007 SWSP High
2061	371,985	446,193	n/a	284,410	423,966	0.60	0.90	n/a	0.25	1.20
2062	374,217	450,208	n/a	285,124	429,070	0.60	0.90	n/a	0.25	1.20
2063	376,463	454,260	n/a	285,840	434,215	0.60	0.90	n/a	0.25	1.20
2064	378,345	457,894	n/a	286,558	439,422	0.50	0.80	n/a	0.25	1.20
2065	380,237	461,558	n/a	287,278	444,692	0.50	0.80	n/a	0.25	1.20
2066	382,138	465,250	n/a	287,999	450,025	0.50	0.80	n/a	0.25	1.20
2067	384,049	468,972	n/a	288,722	455,421	0.50	0.80	n/a	0.25	1.20
2068	385,969	472,724	n/a	289,448	460,883	0.50	0.80	n/a	0.25	1.20
2069	387,899	476,506	n/a	290,175	466,410	0.50	0.80	n/a	0.22	1.20
2070	389,838	480,318	n/a	290,824	472,003	0.50	0.80	n/a	0.20	1.20
2071	391,787	484,160	n/a	291,412	477,664	0.50	0.80	n/a	0.20	1.20
2072	393,746	488,033	n/a	292,002	483,392	0.50	0.80	n/a	0.20	1.20
2073	395,715	491,938	n/a	292,592	489,189	0.50	0.80	n/a	0.20	1.20
2074	397,298	495,381	n/a	293,184	495,056	0.40	0.70	n/a	0.20	1.20
2075	398,887	498,849	n/a	293,777	500,993	0.40	0.70	n/a	0.20	1.20
2076	400,483	502,341	n/a	294,371	507,001	0.40	0.70	n/a	0.20	1.20
2077	402,085	505,857	n/a	294,966	513,081	0.40	0.70	n/a	0.20	1.20
2078	403,693	509,398	n/a	295,563	519,235	0.40	0.70	n/a	0.20	1.20
2079	405,308	512,964	n/a	296,161	525,462	0.40	0.70	n/a	0.19	1.20
2080	406,929	516,555	n/a	296,709	531,764	0.40	0.70	n/a	0.15	1.20
2081	408,557	520,171	n/a	297,164	538,142	0.40	0.70	n/a	0.15	1.20
2082	410,191	523,812	n/a	297,619	544,596	0.40	0.70	n/a	0.15	1.20
2083	411,832	527,479	n/a	298,076	551,127	0.40	0.70	n/a	0.15	1.20
2084	413,479	530,643	n/a	298,533	557,737	0.40	0.60	n/a	0.15	1.20
2085	415,133	533,827	n/a	298,990	564,426	0.40	0.60	n/a	0.15	1.20
2086	416,793	537,030	n/a	299,449	571,196	0.40	0.60	n/a	0.15	1.20
2087	418,461	540,252	n/a	299,908	578,047	0.40	0.60	n/a	0.15	1.20
2088	420,134	543,494	n/a	300,368	584,980	0.40	0.60	n/a	0.15	1.20
2089	421,815	546,755	n/a	300,829	591,996	0.40	0.60	n/a	0.14	1.20
2090	423,502	550,035	n/a	301,261	599,096	0.40	0.60	n/a	0.10	1.20
2091	425,196	553,336	n/a	301,576	606,282	0.40	0.60	n/a	0.10	1.20
2092	426,897	556,656	n/a	301,891	613,553	0.40	0.60	n/a	0.10	1.20
2093	428,605	559,996	n/a	302,206	620,912	0.40	0.60	n/a	0.10	1.20
2094	430,319	562,516	n/a	302,522	628,360	0.40	0.45	n/a	0.10	1.20
2095	432,040	565,047	n/a	302,838	635,897	0.40	0.45	n/a	0.10	1.20
2096	433,768	567,590	n/a	303,155	643,524	0.40	0.45	n/a	0.10	1.20
2097	435,504	570,144	n/a	303,472	651,242	0.40	0.45	n/a	0.10	1.20
2098	437,246	572,709	n/a	303,789	659,054	0.40	0.45	n/a	0.10	1.20
2099	438,994	575,287	n/a	304,107	666,959	0.40	0.45	n/a	0.10	1.20
2100	440,750	577,875	n/a	304,411	674,959	0.40	0.45	n/a	0.10	1.20
2101	442,513	580,476	n/a	304,729	683,055	0.40	0.45	n/a	0.10	1.20
2102	444,284	583,088	n/a	305,048	691,248	0.40	0.45	n/a	0.10	1.20
2103	446,061	585,712	n/a	305,367	699,539	0.40	0.45	n/a	0.10	1.20
2104	447,845	587,469	n/a	305,687	707,930	0.40	0.30	n/a	0.10	1.20
2105	449,636	589,231	n/a	306,006	716,421	0.40	0.30	n/a	n/a	n/a
2106	451,435	590,999	n/a	n/a	n/a	0.40	0.30	n/a	n/a	n/a
2107	453,241	592,772	n/a	n/a	n/a	0.40	0.30	n/a	n/a	n/a
2108	455,054	594,550	n/a	n/a	n/a	0.40	0.30	n/a	n/a	n/a
2109	456,874	596,334	n/a	n/a	n/a	0.40	0.30	n/a	n/a	n/a
2110	458,701	598,123	n/a	n/a	n/a	0.40	0.30	n/a	n/a	n/a
2111	460,536	599,917	n/a	n/a	n/a	0.40	0.30	n/a	n/a	n/a
2112	462,378	601,717	n/a	n/a	n/a	0.40	0.30	n/a	n/a	n/a
2113	464,228	603,522	n/a	n/a	n/a	0.40	0.30	n/a	n/a	n/a

Appendix A-3

Per Capita Consumption and Water Demand Projections

Year	Gallons per Capita per Day (gpcd)					Water Demand (ac-ft/yr)					
	Conservation	Probable	2011 Region O Plan	2007 SWSP Medium	2007 SWSP High	Conservation	Probable	Accelerated	2011 Region O Plan	2007 SWSP Medium	2007 SWSP High
Data by Decade											
2013	160	178	204	200	200	43,115	47,965	47,965	50,353	50,548	53,608
2023	145	169	201	200	200	44,006	51,193	53,253	51,836	54,024	60,391
2033	140	160	198	200	200	47,921	54,639	59,709	52,471	57,171	68,033
2043	137	157	196	200	200	50,919	58,220	66,191	52,732	59,905	76,644
2053	135	155	195	200	200	53,569	61,422	71,940	53,420	62,180	86,346
2063	132	152	n/a	200	200	55,800	64,159	77,418	n/a	64,036	97,277
2073	130	150	n/a	200	200	57,548	66,356	82,491	n/a	65,549	109,592
2083	127	147	n/a	200	200	58,764	67,948	87,028	n/a	66,778	123,468
2093	125	145	n/a	200	200	60,005	69,578	90,907	n/a	67,703	139,102
2103	123	143	n/a	200	200	61,273	71,247	93,553	n/a	68,411	156,717
2113	120	140	n/a	n/a	n/a	62,567	72,956	94,847	n/a	n/a	n/a
Data by Year											
2010	141	141	205	200	200	36,890	36,890	36,890	49,824	49,469	51,507
2011	178	178	205	200	200	47,024	47,024	47,024	50,000	49,826	52,346
2012	152	152	204	200	200	40,587	40,587	40,587	50,177	50,186	52,973
2013	160	178	204	200	200	43,115	47,965	47,965	50,353	50,548	53,608
2014	156	177	204	200	200	42,541	48,279	48,326	50,529	50,912	54,250
2015	150	176	203	200	200	41,396	48,594	48,738	50,706	51,280	54,900
2016	149	175	203	200	200	41,692	48,912	49,202	50,882	51,650	55,558
2017	149	174	203	200	200	41,989	49,231	49,719	51,058	52,023	56,224
2018	148	173	203	200	200	42,289	49,553	50,292	51,234	52,398	56,898
2019	147	172	202	200	200	42,591	49,877	50,870	51,411	52,776	57,580
2020	146	171	202	200	200	42,896	50,203	51,456	51,587	53,039	58,270
2021	146	170	202	200	200	43,263	50,531	52,048	51,670	53,365	58,969
2022	145	170	201	200	200	43,633	50,861	52,647	51,753	53,694	59,676
2023	145	169	201	200	200	44,006	51,193	53,253	51,836	54,024	60,391
2024	144	168	201	200	200	44,383	51,528	53,866	51,919	54,357	61,115
2025	144	167	200	200	200	44,763	51,865	54,486	52,002	54,692	61,847
2026	143	166	200	200	200	45,146	52,204	55,113	52,084	55,028	62,589
2027	143	165	200	200	200	45,533	52,545	55,747	52,167	55,367	63,339
2028	142	164	200	200	200	45,922	52,888	56,388	52,250	55,708	64,098
2029	142	163	199	200	200	46,315	53,234	57,037	52,333	56,051	64,867
2030	142	162	199	200	200	46,712	53,582	57,694	52,416	56,304	65,644
2031	141	161	199	200	200	47,112	53,932	58,358	52,434	56,592	66,431
2032	141	161	198	200	200	47,515	54,284	59,029	52,453	56,881	67,228
2033	140	160	198	200	200	47,921	54,639	59,709	52,471	57,171	68,033
2034	140	159	198	200	200	48,213	54,987	60,327	52,490	57,463	68,849
2035	140	159	197	200	200	48,506	55,337	60,952	52,508	57,757	69,674
2036	139	159	197	200	200	48,802	55,690	61,584	52,526	58,052	70,510
2037	139	159	197	200	200	49,099	56,044	62,222	52,545	58,348	71,355
2038	139	158	197	200	200	49,397	56,401	62,866	52,563	58,646	72,210
2039	139	158	196	200	200	49,698	56,760	63,518	52,582	58,946	73,076
2040	138	158	196	200	200	50,000	57,121	64,176	52,600	59,180	73,952
2041	138	158	196	200	200	50,304	57,485	64,841	52,644	59,421	74,839
2042	138	157	196	200	200	50,611	57,851	65,512	52,688	59,663	75,736
2043	137	157	196	200	200	50,919	58,220	66,191	52,732	59,905	76,644
2044	137	157	196	200	200	51,178	58,532	66,745	52,776	60,149	77,563
2045	137	157	195	200	200	51,438	58,846	67,303	52,820	60,394	78,493
2046	137	156	195	200	200	51,700	59,162	67,866	52,864	60,639	79,434
2047	136	156	195	200	200	51,962	59,480	68,434	52,908	60,886	80,387
2048	136	156	195	200	200	52,227	59,799	69,006	52,952	61,134	81,350
2049	136	156	195	200	200	52,492	60,120	69,583	52,996	61,382	82,326
2050	136	155	195	200	200	52,759	60,443	70,165	53,040	61,587	83,313
2051	135	155	195	200	200	53,028	60,767	70,752	53,167	61,784	84,312
2052	135	155	195	200	200	53,298	61,094	71,344	53,293	61,982	85,323
2053	135	155	195	200	200	53,569	61,422	71,940	53,420	62,180	86,346
2054	135	154	195	200	200	53,788	61,690	72,470	53,546	62,379	87,381
2055	134	154	195	200	200	54,008	61,960	73,004	53,673	62,578	88,429
2056	134	154	194	200	200	54,228	62,231	73,542	53,799	62,778	89,489
2057	134	154	194	200	200	54,450	62,502	74,083	53,926	62,979	90,562
2058	134	153	194	200	200	54,673	62,776	74,629	54,052	63,180	91,648
2059	133	153	194	200	200	54,896	63,050	75,179	54,179	63,382	92,747
2060	133	153	194	200	200	55,121	63,326	75,732	54,305	63,556	93,859

Appendix A-3

Per Capita Consumption and Water Demand Projections

Year	Gallons per Capita per Day (gpcd)					Water Demand (ac-ft/yr)					
	Conservation	Probable	2011 Region O Plan	2007 SWSP Medium	2007 SWSP High	Conservation	Probable	Accelerated	2011 Region O Plan	2007 SWSP Medium	2007 SWSP High
2061	133	153	n/a	200	200	55,346	63,602	76,290	n/a	63,716	94,980
2062	133	152	n/a	200	200	55,572	63,880	76,852	n/a	63,876	96,124
2063	132	152	n/a	200	200	55,800	64,159	77,418	n/a	64,036	97,277
2064	132	152	n/a	200	200	55,972	64,376	77,911	n/a	64,197	98,443
2065	132	152	n/a	200	200	56,145	64,593	78,407	n/a	64,358	99,624
2066	132	151	n/a	200	200	56,319	64,811	78,906	n/a	64,520	100,818
2067	131	151	n/a	200	200	56,493	65,029	79,409	n/a	64,682	102,027
2068	131	151	n/a	200	200	56,667	65,248	79,914	n/a	64,845	103,251
2069	131	151	n/a	200	200	56,842	65,468	80,423	n/a	65,007	104,489
2070	131	150	n/a	200	200	57,018	65,689	80,935	n/a	65,153	105,742
2071	130	150	n/a	200	200	57,194	65,911	81,451	n/a	65,285	107,010
2072	130	150	n/a	200	200	57,371	66,133	81,969	n/a	65,417	108,294
2073	130	150	n/a	200	200	57,548	66,356	82,491	n/a	65,549	109,592
2074	130	149	n/a	200	200	57,669	66,513	82,934	n/a	65,682	110,907
2075	129	149	n/a	200	200	57,789	66,671	83,379	n/a	65,814	112,237
2076	129	149	n/a	200	200	57,910	66,830	83,827	n/a	65,947	113,583
2077	129	149	n/a	200	200	58,031	66,988	84,277	n/a	66,081	114,945
2078	129	148	n/a	200	200	58,153	67,147	84,729	n/a	66,215	116,323
2079	128	148	n/a	200	200	58,275	67,307	85,184	n/a	66,348	117,718
2080	128	148	n/a	200	200	58,397	67,466	85,642	n/a	66,471	119,130
2081	128	148	n/a	200	200	58,519	67,626	86,101	n/a	66,573	120,559
2082	128	148	n/a	200	200	58,641	67,787	86,564	n/a	66,675	122,005
2083	127	147	n/a	200	200	58,764	67,948	87,028	n/a	66,778	123,468
2084	127	147	n/a	200	200	58,887	68,109	87,409	n/a	66,880	124,949
2085	127	147	n/a	200	200	59,010	68,271	87,791	n/a	66,982	126,447
2086	127	147	n/a	200	200	59,133	68,433	88,174	n/a	67,085	127,964
2087	126	146	n/a	200	200	59,257	68,595	88,560	n/a	67,188	129,499
2088	126	146	n/a	200	200	59,381	68,758	88,947	n/a	67,291	131,052
2089	126	146	n/a	200	200	59,505	68,921	89,335	n/a	67,394	132,624
2090	126	146	n/a	200	200	59,630	69,085	89,726	n/a	67,491	134,215
2091	125	145	n/a	200	200	59,755	69,249	90,118	n/a	67,562	135,824
2092	125	145	n/a	200	200	59,880	69,413	90,512	n/a	67,632	137,453
2093	125	145	n/a	200	200	60,005	69,578	90,907	n/a	67,703	139,102
2094	125	145	n/a	200	200	60,131	69,743	91,169	n/a	67,774	140,771
2095	125	144	n/a	200	200	60,256	69,909	91,430	n/a	67,844	142,459
2096	124	144	n/a	200	200	60,383	70,075	91,693	n/a	67,915	144,168
2097	124	144	n/a	200	200	60,509	70,241	91,957	n/a	67,986	145,897
2098	124	144	n/a	200	200	60,635	70,408	92,221	n/a	68,057	147,647
2099	124	144	n/a	200	200	60,762	70,575	92,486	n/a	68,129	149,418
2100	123	143	n/a	200	200	60,889	70,742	92,751	n/a	68,197	151,210
2101	123	143	n/a	200	200	61,017	70,910	93,018	n/a	68,268	153,024
2102	123	143	n/a	200	200	61,145	71,078	93,285	n/a	68,339	154,859
2103	123	143	n/a	200	200	61,273	71,247	93,553	n/a	68,411	156,717
2104	122	142	n/a	200	200	61,401	71,416	93,682	n/a	68,483	158,596
2105	122	142	n/a	200	200	61,529	71,586	93,810	n/a	68,554	160,499
2106	122	142	n/a	n/a	n/a	61,658	71,756	93,939	n/a	n/a	n/a
2107	122	142	n/a	n/a	n/a	61,787	71,926	94,069	n/a	n/a	n/a
2108	121	141	n/a	n/a	n/a	61,916	72,097	94,198	n/a	n/a	n/a
2109	121	141	n/a	n/a	n/a	62,046	72,268	94,327	n/a	n/a	n/a
2110	121	141	n/a	n/a	n/a	62,176	72,439	94,457	n/a	n/a	n/a
2111	121	141	n/a	n/a	n/a	62,306	72,611	94,587	n/a	n/a	n/a
2112	121	141	n/a	n/a	n/a	62,436	72,784	94,717	n/a	n/a	n/a
2113	120	140	n/a	n/a	n/a	62,567	72,956	94,847	n/a	n/a	n/a

Appendix A-4

Peaking Factor, Average Annual Day, and Peak Day Demand

Year	Peaking Factor		Average Annual Day - AAD (mgd)			Peak Day Demand - PDD (mgd)				
	Conservation	Probable	Conservation	Probable	Accelerated	Conservation	Probable	Accelerated	2007 SWSP Medium	2007 SWSP High
Data by Decade										
2013	1.80	1.80	38.49	42.82	42.82	69.28	77.08	77.08	82.13	87.10
2023	1.78	1.80	39.29	45.70	47.54	70.10	82.26	85.57	87.78	98.12
2033	1.77	1.80	42.78	48.78	53.30	75.68	87.80	95.95	92.89	110.54
2043	1.75	1.80	45.46	51.98	59.09	79.71	93.56	106.37	97.33	124.53
2053	1.74	1.80	47.82	54.83	64.22	83.14	98.70	115.60	101.03	140.29
2063	1.72	1.80	49.81	57.28	69.11	85.85	103.10	124.41	104.05	158.05
2073	1.71	1.80	51.38	59.24	73.64	87.77	106.63	132.56	106.50	178.06
2083	1.69	1.80	52.46	60.66	77.69	88.85	109.19	139.85	108.50	200.61
2093	1.68	1.80	53.57	62.12	81.16	89.94	111.81	146.08	110.00	226.01
2103	1.66	1.80	54.70	63.61	83.52	91.04	114.49	150.33	111.15	254.63
2113	1.65	1.80	55.86	65.13	84.67	92.16	117.24	152.41	n/a	n/a
Data by Year										
2010	1.53	1.53	32.93	32.93	32.93	50.38	50.38	50.38	80.38	83.69
2011	1.53	1.53	41.98	41.98	41.98	64.11	64.11	64.11	80.96	85.05
2012	1.60	1.60	36.23	36.23	36.23	58.07	58.07	58.07	81.54	86.07
2013	1.80	1.80	38.49	42.82	42.82	69.28	77.08	77.08	82.13	87.10
2014	1.80	1.80	37.98	43.10	43.14	68.30	77.58	77.66	82.72	88.15
2015	1.80	1.80	36.96	43.38	43.51	66.40	78.09	78.32	83.32	89.20
2016	1.80	1.80	37.22	43.67	43.92	66.82	78.60	79.06	83.92	90.27
2017	1.79	1.80	37.49	43.95	44.39	67.24	79.11	79.90	84.53	91.35
2018	1.79	1.80	37.75	44.24	44.90	67.66	79.63	80.82	85.14	92.45
2019	1.79	1.80	38.02	44.53	45.41	68.09	80.15	81.75	85.75	93.56
2020	1.79	1.80	38.29	44.82	45.94	68.51	80.67	82.69	86.18	94.68
2021	1.79	1.80	38.62	45.11	46.47	69.04	81.20	83.64	86.71	95.81
2022	1.79	1.80	38.95	45.41	47.00	69.57	81.73	84.60	87.24	96.96
2023	1.78	1.80	39.29	45.70	47.54	70.10	82.26	85.57	87.78	98.12
2024	1.78	1.80	39.62	46.00	48.09	70.64	82.80	86.56	88.32	99.30
2025	1.78	1.80	39.96	46.30	48.64	71.18	83.34	87.55	88.86	100.49
2026	1.78	1.80	40.30	46.60	49.20	71.73	83.89	88.56	89.41	101.69
2027	1.78	1.80	40.65	46.91	49.77	72.28	84.44	89.58	89.96	102.91
2028	1.78	1.80	41.00	47.22	50.34	72.84	84.99	90.61	90.15	104.15
2029	1.78	1.80	41.35	47.52	50.92	73.40	85.54	91.66	91.07	105.39
2030	1.77	1.80	41.70	47.83	51.51	73.96	86.10	92.71	91.48	106.66
2031	1.77	1.80	42.06	48.15	52.10	74.53	86.67	93.78	91.95	107.94
2032	1.77	1.80	42.42	48.46	52.70	75.10	87.23	94.86	92.42	109.23
2033	1.77	1.80	42.78	48.78	53.30	75.68	87.80	95.95	92.89	110.54
2034	1.77	1.80	43.04	49.09	53.86	76.07	88.36	96.94	93.37	111.87
2035	1.77	1.80	43.30	49.40	54.41	76.47	88.92	97.95	93.84	113.21
2036	1.76	1.80	43.57	49.72	54.98	76.87	89.49	98.96	94.32	114.56
2037	1.76	1.80	43.83	50.03	55.55	77.27	90.06	99.99	94.80	115.94
2038	1.76	1.80	44.10	50.35	56.12	77.67	90.63	101.02	95.29	117.33
2039	1.76	1.80	44.37	50.67	56.71	78.07	91.21	102.07	95.78	118.73
2040	1.76	1.80	44.64	50.99	57.29	78.48	91.79	103.13	96.16	120.16
2041	1.76	1.80	44.91	51.32	57.89	78.89	92.38	104.20	96.55	121.60
2042	1.76	1.80	45.18	51.65	58.49	79.30	92.96	105.27	96.94	123.06
2043	1.75	1.80	45.46	51.98	59.09	79.71	93.56	106.37	97.33	124.53
2044	1.75	1.80	45.69	52.25	59.59	80.05	94.06	107.25	97.73	126.02
2045	1.75	1.80	45.92	52.53	60.08	80.39	94.56	108.15	98.13	127.53
2046	1.75	1.80	46.15	52.82	60.59	80.73	95.07	109.06	98.53	129.06
2047	1.75	1.80	46.39	53.10	61.09	81.07	95.58	109.97	98.93	130.61
2048	1.75	1.80	46.63	53.39	61.60	81.41	96.09	110.89	99.33	132.18
2049	1.74	1.80	46.86	53.67	62.12	81.75	96.61	111.82	99.73	133.76
2050	1.74	1.80	47.10	53.96	62.64	82.09	97.13	112.75	100.07	135.37
2051	1.74	1.80	47.34	54.25	63.16	82.44	97.65	113.69	100.39	136.99
2052	1.74	1.80	47.58	54.54	63.69	82.79	98.17	114.64	100.71	138.63
2053	1.74	1.80	47.82	54.83	64.22	83.14	98.70	115.60	101.03	140.29
2054	1.74	1.80	48.02	55.07	64.70	83.40	99.13	116.46	101.35	141.98
2055	1.74	1.80	48.21	55.31	65.17	83.67	99.57	117.31	101.68	143.68
2056	1.73	1.80	48.41	55.56	65.65	83.94	100.00	118.18	102.00	145.40
2057	1.73	1.80	48.61	55.80	66.14	84.21	100.44	119.05	102.33	147.15
2058	1.73	1.80	48.81	56.04	66.62	84.48	100.88	119.92	102.65	148.91
2059	1.73	1.80	49.01	56.29	67.12	84.75	101.32	120.81	102.98	150.70

Appendix A-4

Peaking Factor, Average Annual Day, and Peak Day Demand

Year	Peaking Factor		Average Annual Day - AAD (mgd)			Peak Day Demand - PDD (mgd)				
	Conservation	Probable	Conservation	Probable	Accelerated	Conservation	Probable	Accelerated	2007 SWSP Medium	2007 SWSP High
2060	1.73	1.80	49.21	56.53	67.61	85.03	101.76	121.70	103.27	152.50
2061	1.73	1.80	49.41	56.78	68.11	85.30	102.20	122.59	103.53	154.33
2062	1.72	1.80	49.61	57.03	68.61	85.57	102.65	123.50	103.79	156.13
2063	1.72	1.80	49.81	57.28	69.11	85.85	103.10	124.41	104.05	158.05
2064	1.72	1.80	49.97	57.47	69.55	86.04	103.45	125.20	104.31	159.95
2065	1.72	1.80	50.12	57.66	70.00	86.23	103.80	126.00	104.57	161.87
2066	1.72	1.80	50.28	57.86	70.44	86.42	104.15	126.80	104.83	163.81
2067	1.72	1.80	50.43	58.05	70.89	86.61	104.50	127.61	105.09	165.77
2068	1.72	1.80	50.59	58.25	71.34	86.80	104.85	128.42	105.36	167.76
2069	1.71	1.80	50.75	58.45	71.80	87.00	105.20	129.24	105.62	169.77
2070	1.71	1.80	50.90	58.64	72.25	87.19	105.56	130.06	105.86	171.81
2071	1.71	1.80	51.06	58.84	72.71	87.38	105.91	130.89	106.07	173.87
2072	1.71	1.80	51.22	59.04	73.18	87.58	106.27	131.72	106.29	175.95
2073	1.71	1.80	51.38	59.24	73.64	87.77	106.63	132.56	106.50	178.06
2074	1.71	1.80	51.48	59.38	74.04	87.88	106.88	133.27	106.72	180.20
2075	1.71	1.80	51.59	59.52	74.44	87.99	107.14	133.99	106.93	182.36
2076	1.70	1.80	51.70	59.66	74.84	88.09	107.39	134.70	107.15	184.55
2077	1.70	1.80	51.81	59.80	75.24	88.20	107.65	135.43	107.37	186.76
2078	1.70	1.80	51.92	59.95	75.64	88.31	107.90	136.15	107.58	189.00
2079	1.70	1.80	52.02	60.09	76.05	88.42	108.16	136.89	107.80	191.27
2080	1.70	1.80	52.13	60.23	76.46	88.52	108.41	137.62	108.00	193.56
2081	1.70	1.80	52.24	60.37	76.87	88.63	108.67	138.36	108.17	195.88
2082	1.70	1.80	52.35	60.52	77.28	88.74	108.93	139.10	108.33	198.23
2083	1.69	1.80	52.46	60.66	77.69	88.85	109.19	139.85	108.50	200.61
2084	1.69	1.80	52.57	60.80	78.03	88.96	109.45	140.46	108.67	203.02
2085	1.69	1.80	52.68	60.95	78.37	89.07	109.71	141.07	108.83	205.45
2086	1.69	1.80	52.79	61.09	78.72	89.17	109.97	141.69	109.00	207.92
2087	1.69	1.80	52.90	61.24	79.06	89.28	110.23	142.31	109.17	210.41
2088	1.69	1.80	53.01	61.38	79.41	89.39	110.49	142.93	109.33	212.93
2089	1.68	1.80	53.12	61.53	79.75	89.50	110.75	143.56	109.50	215.49
2090	1.68	1.80	53.23	61.68	80.10	89.61	111.02	144.18	109.66	218.07
2091	1.68	1.80	53.35	61.82	80.45	89.72	111.28	144.81	109.77	220.69
2092	1.68	1.80	53.46	61.97	80.80	89.83	111.54	145.45	109.89	223.33
2093	1.68	1.80	53.57	62.12	81.16	89.94	111.81	146.08	110.00	226.01
2094	1.68	1.80	53.68	62.26	81.39	90.05	112.07	146.50	110.12	228.72
2095	1.68	1.80	53.79	62.41	81.62	90.16	112.34	146.92	110.23	231.47
2096	1.67	1.80	53.91	62.56	81.86	90.27	112.61	147.35	110.35	234.24
2097	1.67	1.80	54.02	62.71	82.09	90.38	112.87	147.77	110.46	237.05
2098	1.67	1.80	54.13	62.86	82.33	90.49	113.14	148.19	110.58	239.90
2099	1.67	1.80	54.25	63.01	82.57	90.60	113.41	148.62	110.69	242.77
2100	1.67	1.80	54.36	63.15	82.80	90.71	113.68	149.05	110.81	245.68
2101	1.67	1.80	54.47	63.30	83.04	90.82	113.95	149.47	110.92	248.63
2102	1.67	1.80	54.59	63.45	83.28	90.93	114.22	149.90	111.04	251.61
2103	1.66	1.80	54.70	63.61	83.52	91.04	114.49	150.33	111.15	254.63
2104	1.66	1.80	54.82	63.76	83.63	91.15	114.76	150.54	111.27	257.69
2105	1.66	1.80	54.93	63.91	83.75	91.27	115.03	150.75	111.39	260.78
2106	1.66	1.80	55.04	64.06	83.86	91.38	115.31	150.95	n/a	n/a
2107	1.66	1.80	55.16	64.21	83.98	91.49	115.58	151.16	n/a	n/a
2108	1.66	1.80	55.28	64.36	84.09	91.60	115.85	151.37	n/a	n/a
2109	1.66	1.80	55.39	64.52	84.21	91.71	116.13	151.58	n/a	n/a
2110	1.65	1.80	55.51	64.67	84.33	91.82	116.41	151.79	n/a	n/a
2111	1.65	1.80	55.62	64.82	84.44	91.94	116.68	152.00	n/a	n/a
2112	1.65	1.80	55.74	64.98	84.56	92.05	116.96	152.20	n/a	n/a
2113	1.65	1.80	55.86	65.13	84.67	92.16	117.24	152.41	n/a	n/a

Appendix B-1

Current Annual and Peak Day Water Supply Projections

Year	Current Annual Supplies (ac-ft/yr)			Total Annual Water Supply (ac-ft/yr)	Current Peak Day Supplies (mgd)			Total Peak Day Supply (mgd)
	Roberts County Well Field	Bailey County Well Field	Lake Alan Henry		Roberts County Well Field	Bailey County Well Field	Lake Alan Henry	
Data by Decade								
2013	24,088	15,000	8,000	47,088	23.71	37.26	15.00	75.97
2023	24,088	12,500	8,000	44,588	23.71	29.86	15.00	68.57
2033	24,088	10,000	8,000	42,088	23.71	22.46	15.00	61.17
2043	20,990	7,500	8,000	36,490	20.61	15.06	15.00	50.67
2053	17,117	5,000	8,000	30,117	16.81	7.66	15.00	39.47
2063	13,245	0	8,000	21,245	13.01	0.00	15.00	28.01
2073	9,372	0	8,000	17,372	9.20	0.00	15.00	24.20
2083	5,499	0	8,000	13,499	5.40	0.00	15.00	20.40
2093	1,627	0	8,000	9,627	1.60	0.00	15.00	16.60
2103	0	0	8,000	8,000	0.00	0.00	15.00	15.00
2113	0	0	8,000	8,000	0.00	0.00	15.00	15.00
Data by Year								
2010	29,291	7,599	0	36,890	23.71	40.00	0.00	63.71
2011	26,195	20,829	0	47,024	23.71	40.00	0.00	63.71
2012	23,697	16,295	595	40,587	23.71	38.00	15.00	76.71
2013	24,088	15,000	8,000	47,088	23.71	37.26	15.00	75.97
2014	24,088	14,750	8,000	46,838	23.71	36.52	15.00	75.23
2015	24,088	14,500	8,000	46,588	23.71	35.78	15.00	74.49
2016	24,088	14,250	8,000	46,338	23.71	35.04	15.00	73.75
2017	24,088	14,000	8,000	46,088	23.71	34.30	15.00	73.01
2018	24,088	13,750	8,000	45,838	23.71	33.56	15.00	72.27
2019	24,088	13,500	8,000	45,588	23.71	32.82	15.00	71.53
2020	24,088	13,250	8,000	45,338	23.71	32.08	15.00	70.79
2021	24,088	13,000	8,000	45,088	23.71	31.34	15.00	70.05
2022	24,088	12,750	8,000	44,838	23.71	30.60	15.00	69.31
2023	24,088	12,500	8,000	44,588	23.71	29.86	15.00	68.57
2024	24,088	12,250	8,000	44,338	23.71	29.12	15.00	67.83
2025	24,088	12,000	8,000	44,088	23.71	28.38	15.00	67.09
2026	24,088	11,750	8,000	43,838	23.71	27.64	15.00	66.35
2027	24,088	11,500	8,000	43,588	23.71	26.90	15.00	65.61
2028	24,088	11,250	8,000	43,338	23.71	26.16	15.00	64.87
2029	24,088	11,000	8,000	43,088	23.71	25.42	15.00	64.13
2030	24,088	10,750	8,000	42,838	23.71	24.68	15.00	63.39
2031	24,088	10,500	8,000	42,588	23.71	23.94	15.00	62.65
2032	24,088	10,250	8,000	42,338	23.71	23.20	15.00	61.91
2033	24,088	10,000	8,000	42,088	23.71	22.46	15.00	61.17
2034	24,088	9,750	8,000	41,838	23.71	21.72	15.00	60.43
2035	24,088	9,500	8,000	41,588	23.71	20.98	15.00	59.69
2036	23,700	9,250	8,000	40,950	23.27	20.24	15.00	58.51
2037	23,313	9,000	8,000	40,313	22.89	19.50	15.00	57.39
2038	22,926	8,750	8,000	39,676	22.51	18.76	15.00	56.27
2039	22,539	8,500	8,000	39,039	22.13	18.02	15.00	55.15
2040	22,151	8,250	8,000	38,401	21.75	17.28	15.00	54.03
2041	21,764	8,000	8,000	37,764	21.37	16.54	15.00	52.91
2042	21,377	7,750	8,000	37,127	20.99	15.80	15.00	51.79
2043	20,990	7,500	8,000	36,490	20.61	15.06	15.00	50.67
2044	20,602	7,250	8,000	35,852	20.23	14.32	15.00	49.55
2045	20,215	7,000	8,000	35,215	19.85	13.58	15.00	48.43
2046	19,828	6,750	8,000	34,578	19.47	12.84	15.00	47.31
2047	19,441	6,500	8,000	33,941	19.09	12.10	15.00	46.19
2048	19,053	6,250	8,000	33,303	18.71	11.36	15.00	45.07
2049	18,666	6,000	8,000	32,666	18.33	10.62	15.00	43.95
2050	18,279	5,750	8,000	32,029	17.95	9.88	15.00	42.83
2051	17,892	5,500	8,000	31,392	17.57	9.14	15.00	41.71
2052	17,504	5,250	8,000	30,754	17.19	8.40	15.00	40.59
2053	17,117	5,000	8,000	30,117	16.81	7.66	15.00	39.47
2054	16,730	4,750	8,000	29,480	16.43	6.92	15.00	38.35
2055	16,343	4,500	8,000	28,843	16.05	6.18	15.00	37.23
2056	15,955	4,250	8,000	28,205	15.67	5.44	15.00	36.11
2057	15,568	4,000	8,000	27,568	15.29	4.70	15.00	34.99
2058	15,181	3,750	8,000	26,931	14.91	3.96	15.00	33.87
2059	14,794	3,500	8,000	26,294	14.53	3.22	15.00	32.75

Appendix B-1

Current Annual and Peak Day Water Supply Projections

Year	Current Annual Supplies (ac-ft/yr)			Total Annual Water Supply (ac-ft/yr)	Current Peak Day Supplies (mgd)			Total Peak Day Supply (mgd)
	Roberts County Well Field	Bailey County Well Field	Lake Alan Henry		Roberts County Well Field	Bailey County Well Field	Lake Alan Henry	
2060	14,406	3,250	8,000	25,656	14.15	2.48	15.00	31.63
2061	14,019	3,000	8,000	25,019	13.77	1.74	15.00	30.51
2062	13,632	0	8,000	21,632	13.39	0.00	15.00	28.39
2063	13,245	0	8,000	21,245	13.01	0.00	15.00	28.01
2064	12,857	0	8,000	20,857	12.63	0.00	15.00	27.63
2065	12,470	0	8,000	20,470	12.25	0.00	15.00	27.25
2066	12,083	0	8,000	20,083	11.87	0.00	15.00	26.87
2067	11,696	0	8,000	19,696	11.49	0.00	15.00	26.49
2068	11,308	0	8,000	19,308	11.10	0.00	15.00	26.10
2069	10,921	0	8,000	18,921	10.72	0.00	15.00	25.72
2070	10,534	0	8,000	18,534	10.34	0.00	15.00	25.34
2071	10,146	0	8,000	18,146	9.96	0.00	15.00	24.96
2072	9,759	0	8,000	17,759	9.58	0.00	15.00	24.58
2073	9,372	0	8,000	17,372	9.20	0.00	15.00	24.20
2074	8,985	0	8,000	16,985	8.82	0.00	15.00	23.82
2075	8,597	0	8,000	16,597	8.44	0.00	15.00	23.44
2076	8,210	0	8,000	16,210	8.06	0.00	15.00	23.06
2077	7,823	0	8,000	15,823	7.68	0.00	15.00	22.68
2078	7,436	0	8,000	15,436	7.30	0.00	15.00	22.30
2079	7,048	0	8,000	15,048	6.92	0.00	15.00	21.92
2080	6,661	0	8,000	14,661	6.54	0.00	15.00	21.54
2081	6,274	0	8,000	14,274	6.16	0.00	15.00	21.16
2082	5,887	0	8,000	13,887	5.78	0.00	15.00	20.78
2083	5,499	0	8,000	13,499	5.40	0.00	15.00	20.40
2084	5,112	0	8,000	13,112	5.02	0.00	15.00	20.02
2085	4,725	0	8,000	12,725	4.64	0.00	15.00	19.64
2086	4,338	0	8,000	12,338	4.26	0.00	15.00	19.26
2087	3,950	0	8,000	11,950	3.88	0.00	15.00	18.88
2088	3,563	0	8,000	11,563	3.50	0.00	15.00	18.50
2089	3,176	0	8,000	11,176	3.12	0.00	15.00	18.12
2090	2,789	0	8,000	10,789	2.74	0.00	15.00	17.74
2091	2,401	0	8,000	10,401	2.36	0.00	15.00	17.36
2092	2,014	0	8,000	10,014	1.98	0.00	15.00	16.98
2093	1,627	0	8,000	9,627	1.60	0.00	15.00	16.60
2094	1,240	0	8,000	9,240	1.22	0.00	15.00	16.22
2095	852	0	8,000	8,852	0.84	0.00	15.00	15.84
2096	465	0	8,000	8,465	0.46	0.00	15.00	15.46
2097	78	0	8,000	8,078	0.08	0.00	15.00	15.08
2098	0	0	8,000	8,000	0.00	0.00	15.00	15.00
2099	0	0	8,000	8,000	0.00	0.00	15.00	15.00
2100	0	0	8,000	8,000	0.00	0.00	15.00	15.00
2101	0	0	8,000	8,000	0.00	0.00	15.00	15.00
2102	0	0	8,000	8,000	0.00	0.00	15.00	15.00
2103	0	0	8,000	8,000	0.00	0.00	15.00	15.00
2104	0	0	8,000	8,000	0.00	0.00	15.00	15.00
2105	0	0	8,000	8,000	0.00	0.00	15.00	15.00
2106	0	0	8,000	8,000	0.00	0.00	15.00	15.00
2107	0	0	8,000	8,000	0.00	0.00	15.00	15.00
2108	0	0	8,000	8,000	0.00	0.00	15.00	15.00
2109	0	0	8,000	8,000	0.00	0.00	15.00	15.00
2110	0	0	8,000	8,000	0.00	0.00	15.00	15.00
2111	0	0	8,000	8,000	0.00	0.00	15.00	15.00
2112	0	0	8,000	8,000	0.00	0.00	15.00	15.00
2113	0	0	8,000	8,000	0.00	0.00	15.00	15.00

Appendix B-2
Current Annual Water Demand, Supply, and Net

Year	Annual Water Demand (ac-ft/yr)			Total Annual Water Supply (ac-ft/yr) (for details see Appendix B-1)	Annual Shortages/Surplus (ac-ft/yr)		
	Conservation	Probable	Accelerated		Conservation	Probable	Accelerated
Data by Decade							
2013	43,115	47,965	47,965	47,088	3,973	-877	-877
2023	44,006	51,193	53,253	44,588	581	-6,606	-8,665
2033	47,921	54,639	59,709	42,088	-5,834	-12,552	-17,621
2043	50,919	58,220	66,191	36,490	-14,429	-21,730	-29,702
2053	53,569	61,422	71,940	30,117	-23,452	-31,305	-41,823
2063	55,800	64,159	77,418	21,245	-34,555	-42,915	-56,174
2073	57,548	66,356	82,491	17,372	-40,176	-48,984	-65,119
2083	58,764	67,948	87,028	13,499	-45,264	-54,448	-73,529
2093	60,005	69,578	90,907	9,627	-50,378	-59,951	-81,281
2103	61,273	71,247	93,553	8,000	-53,273	-63,247	-85,553
2113	62,567	72,956	94,847	8,000	-54,567	-64,956	-86,847
Data by Year							
2010	36,890	36,890	36,890	36,890	0	0	0
2011	47,024	47,024	47,024	47,024	0	0	0
2012	40,587	40,587	40,587	40,587	0	0	0
2013	43,115	47,965	47,965	47,088	3,973	-877	-877
2014	42,541	48,279	48,326	46,838	4,296	-1,441	-1,489
2015	41,396	48,594	48,738	46,588	5,192	-2,006	-2,150
2016	41,692	48,912	49,202	46,338	4,646	-2,574	-2,864
2017	41,989	49,231	49,719	46,088	4,098	-3,144	-3,632
2018	42,289	49,553	50,292	45,838	3,548	-3,715	-4,454
2019	42,591	49,877	50,870	45,588	2,996	-4,289	-5,283
2020	42,896	50,203	51,456	45,338	2,442	-4,865	-6,118
2021	43,263	50,531	52,048	45,088	1,825	-5,443	-6,960
2022	43,633	50,861	52,647	44,838	1,205	-6,023	-7,809
2023	44,006	51,193	53,253	44,588	581	-6,606	-8,665
2024	44,383	51,528	53,866	44,338	-45	-7,190	-9,528
2025	44,763	51,865	54,486	44,088	-675	-7,777	-10,398
2026	45,146	52,204	55,113	43,838	-1,308	-8,366	-11,275
2027	45,533	52,545	55,747	43,588	-1,945	-8,957	-12,159
2028	45,922	52,888	56,388	43,338	-2,585	-9,551	-13,051
2029	46,315	53,234	57,037	43,088	-3,228	-10,146	-13,950
2030	46,712	53,582	57,694	42,838	-3,874	-10,744	-14,856
2031	47,112	53,932	58,358	42,588	-4,524	-11,344	-15,770
2032	47,515	54,284	59,029	42,338	-5,177	-11,947	-16,692
2033	47,921	54,639	59,709	42,088	-5,834	-12,552	-17,621
2034	48,213	54,987	60,327	41,838	-6,375	-13,149	-18,489
2035	48,506	55,337	60,952	41,588	-6,919	-13,750	-19,364
2036	48,802	55,690	61,584	40,950	-7,851	-14,739	-20,633
2037	49,099	56,044	62,222	40,313	-8,785	-15,731	-21,909
2038	49,397	56,401	62,866	39,676	-9,721	-16,725	-23,190
2039	49,698	56,760	63,518	39,039	-10,659	-17,721	-24,479
2040	50,000	57,121	64,176	38,401	-11,599	-18,720	-25,774
2041	50,304	57,485	64,841	37,764	-12,540	-19,721	-27,077
2042	50,611	57,851	65,512	37,127	-13,484	-20,724	-28,386
2043	50,919	58,220	66,191	36,490	-14,429	-21,730	-29,702
2044	51,178	58,532	66,745	35,852	-15,325	-22,680	-30,892
2045	51,438	58,846	67,303	35,215	-16,223	-23,631	-32,088
2046	51,700	59,162	67,866	34,578	-17,122	-24,584	-33,288
2047	51,962	59,480	68,434	33,941	-18,022	-25,539	-34,493
2048	52,227	59,799	69,006	33,303	-18,923	-26,496	-35,703
2049	52,492	60,120	69,583	32,666	-19,826	-27,454	-36,917
2050	52,759	60,443	70,165	32,029	-20,731	-28,414	-38,136
2051	53,028	60,767	70,752	31,392	-21,636	-29,376	-39,360
2052	53,298	61,094	71,344	30,754	-22,543	-30,339	-40,589
2053	53,569	61,422	71,940	30,117	-23,452	-31,305	-41,823
2054	53,788	61,690	72,470	29,480	-24,308	-32,210	-42,990
2055	54,008	61,960	73,004	28,843	-25,165	-33,117	-44,161
2056	54,228	62,231	73,542	28,205	-26,023	-34,025	-45,336
2057	54,450	62,502	74,083	27,568	-26,882	-34,934	-46,515
2058	54,673	62,776	74,629	26,931	-27,742	-35,845	-47,698
2059	54,896	63,050	75,179	26,294	-28,603	-36,756	-48,885
2060	55,121	63,326	75,732	25,656	-29,464	-37,669	-50,076

Appendix B-2
Current Annual Water Demand, Supply, and Net

Year	Annual Water Demand (ac-ft/yr)			Total Annual Water Supply (ac-ft/yr) (for details see Appendix B-1)	Annual Shortages/Surplus (ac-ft/yr)		
	Conservation	Probable	Accelerated		Conservation	Probable	Accelerated
2061	55,346	63,602	76,290	25,019	-30,327	-38,583	-51,271
2062	55,572	63,880	76,852	21,632	-33,941	-42,248	-55,220
2063	55,800	64,159	77,418	21,245	-34,555	-42,915	-56,174
2064	55,972	64,376	77,911	20,857	-35,115	-43,518	-57,054
2065	56,145	64,593	78,407	20,470	-35,675	-44,123	-57,937
2066	56,319	64,811	78,906	20,083	-36,236	-44,728	-58,824
2067	56,493	65,029	79,409	19,696	-36,797	-45,334	-59,713
2068	56,667	65,248	79,914	19,308	-37,359	-45,940	-60,606
2069	56,842	65,468	80,423	18,921	-37,921	-46,547	-61,502
2070	57,018	65,689	80,935	18,534	-38,484	-47,155	-62,402
2071	57,194	65,911	81,451	18,146	-39,048	-47,764	-63,304
2072	57,371	66,133	81,969	17,759	-39,612	-48,374	-64,210
2073	57,548	66,356	82,491	17,372	-40,176	-48,984	-65,119
2074	57,669	66,513	82,934	16,985	-40,684	-49,529	-65,949
2075	57,789	66,671	83,379	16,597	-41,192	-50,074	-66,782
2076	57,910	66,830	83,827	16,210	-41,700	-50,619	-67,617
2077	58,031	66,988	84,277	15,823	-42,209	-51,165	-68,454
2078	58,153	67,147	84,729	15,436	-42,717	-51,711	-69,294
2079	58,275	67,307	85,184	15,048	-43,226	-52,258	-70,136
2080	58,397	67,466	85,642	14,661	-43,735	-52,805	-70,980
2081	58,519	67,626	86,101	14,274	-44,245	-53,353	-71,827
2082	58,641	67,787	86,564	13,887	-44,754	-53,900	-72,677
2083	58,764	67,948	87,028	13,499	-45,264	-54,448	-73,529
2084	58,887	68,109	87,409	13,112	-45,775	-54,997	-74,297
2085	59,010	68,271	87,791	12,725	-46,285	-55,546	-75,066
2086	59,133	68,433	88,174	12,338	-46,796	-56,095	-75,837
2087	59,257	68,595	88,560	11,950	-47,307	-56,645	-76,609
2088	59,381	68,758	88,947	11,563	-47,818	-57,195	-77,384
2089	59,505	68,921	89,335	11,176	-48,330	-57,745	-78,160
2090	59,630	69,085	89,726	10,789	-48,841	-58,296	-78,937
2091	59,755	69,249	90,118	10,401	-49,353	-58,847	-79,717
2092	59,880	69,413	90,512	10,014	-49,866	-59,399	-80,498
2093	60,005	69,578	90,907	9,627	-50,378	-59,951	-81,281
2094	60,131	69,743	91,169	9,240	-50,891	-60,503	-81,929
2095	60,256	69,909	91,430	8,852	-51,404	-61,056	-82,578
2096	60,383	70,075	91,693	8,465	-51,917	-61,609	-83,228
2097	60,509	70,241	91,957	8,078	-52,431	-62,163	-83,879
2098	60,635	70,408	92,221	8,000	-52,635	-62,408	-84,221
2099	60,762	70,575	92,486	8,000	-52,762	-62,575	-84,486
2100	60,889	70,742	92,751	8,000	-52,889	-62,742	-84,751
2101	61,017	70,910	93,018	8,000	-53,017	-62,910	-85,018
2102	61,145	71,078	93,285	8,000	-53,145	-63,078	-85,285
2103	61,273	71,247	93,553	8,000	-53,273	-63,247	-85,553
2104	61,401	71,416	93,682	8,000	-53,401	-63,416	-85,682
2105	61,529	71,586	93,810	8,000	-53,529	-63,586	-85,810
2106	61,658	71,756	93,939	8,000	-53,658	-63,756	-85,939
2107	61,787	71,926	94,069	8,000	-53,787	-63,926	-86,069
2108	61,916	72,097	94,198	8,000	-53,916	-64,097	-86,198
2109	62,046	72,268	94,327	8,000	-54,046	-64,268	-86,327
2110	62,176	72,439	94,457	8,000	-54,176	-64,439	-86,457
2111	62,306	72,611	94,587	8,000	-54,306	-64,611	-86,587
2112	62,436	72,784	94,717	8,000	-54,436	-64,784	-86,717
2113	62,567	72,956	94,847	8,000	-54,567	-64,956	-86,847

Appendix B-3
Current Peak Day Demand, Supply, and Net

Year	Peak Day Demand (mgd)			Peak Day Supply (mgd) (for details see Appendix B-1)	Peak Day Shortages/Surpluses (mgd)		
	Conservation	Probable	Accelerated		Conservation	Probable	Accelerated
Data by Decade							
2013	69.28	77.08	77.08	75.97	6.69	-1.11	-1.11
2023	70.10	82.26	85.57	68.57	-1.53	-13.69	-17.00
2033	75.68	87.80	95.95	61.17	-14.51	-26.63	-34.78
2043	79.71	93.56	106.37	50.67	-29.04	-42.88	-55.69
2053	83.14	98.70	115.60	39.47	-43.67	-59.23	-76.13
2063	85.85	103.10	124.41	28.01	-57.84	-75.09	-96.40
2073	87.77	106.63	132.56	24.20	-63.57	-82.43	-108.35
2083	88.85	109.19	139.85	20.40	-68.45	-88.79	-119.45
2093	89.94	111.81	146.08	16.60	-73.34	-95.21	-129.49
2103	91.04	114.49	150.33	15.00	-76.04	-99.49	-135.33
2113	92.16	117.24	152.41	15.00	-77.16	-102.24	-137.41
Data by Year							
2010	50.38	50.38	50.38	63.71	13.33	13.33	13.33
2011	64.11	64.11	64.11	63.71	-0.40	-0.40	-0.40
2012	58.07	58.07	58.07	76.71	18.64	18.64	18.64
2013	69.28	77.08	77.08	75.97	6.69	-1.11	-1.11
2014	68.30	77.58	77.66	75.23	6.93	-2.35	-2.43
2015	66.40	78.09	78.32	74.49	8.09	-3.60	-3.83
2016	66.82	78.60	79.06	73.75	6.93	-4.85	-5.31
2017	67.24	79.11	79.90	73.01	5.77	-6.10	-6.89
2018	67.66	79.63	80.82	72.27	4.61	-7.36	-8.55
2019	68.09	80.15	81.75	71.53	3.44	-8.62	-10.22
2020	68.51	80.67	82.69	70.79	2.28	-9.88	-11.90
2021	69.04	81.20	83.64	70.05	1.01	-11.15	-13.59
2022	69.57	81.73	84.60	69.31	-0.26	-12.42	-15.29
2023	70.10	82.26	85.57	68.57	-1.53	-13.69	-17.00
2024	70.64	82.80	86.56	67.83	-2.81	-14.97	-18.73
2025	71.18	83.34	87.55	67.09	-4.09	-16.25	-20.46
2026	71.73	83.89	88.56	66.35	-5.38	-17.54	-22.21
2027	72.28	84.44	89.58	65.61	-6.67	-18.83	-23.97
2028	72.84	84.99	90.61	64.87	-7.97	-20.12	-25.74
2029	73.40	85.54	91.66	64.13	-9.27	-21.41	-27.53
2030	73.96	86.10	92.71	63.39	-10.57	-22.71	-29.32
2031	74.53	86.67	93.78	62.65	-11.88	-24.02	-31.13
2032	75.10	87.23	94.86	61.91	-13.19	-25.32	-32.95
2033	75.68	87.80	95.95	61.17	-14.51	-26.63	-34.78
2034	76.07	88.36	96.94	60.43	-15.64	-27.93	-36.51
2035	76.47	88.92	97.95	59.69	-16.78	-29.23	-38.26
2036	76.87	89.49	98.96	58.51	-18.35	-30.98	-40.45
2037	77.27	90.06	99.99	57.39	-19.87	-32.67	-42.59
2038	77.67	90.63	101.02	56.27	-21.40	-34.36	-44.75
2039	78.07	91.21	102.07	55.15	-22.92	-36.06	-46.92
2040	78.48	91.79	103.13	54.03	-24.45	-37.76	-49.09
2041	78.89	92.38	104.20	52.91	-25.98	-39.46	-51.28
2042	79.30	92.96	105.27	51.79	-27.51	-41.17	-53.48
2043	79.71	93.56	106.37	50.67	-29.04	-42.88	-55.69
2044	80.05	94.06	107.25	49.55	-30.50	-44.51	-57.70
2045	80.39	94.56	108.15	48.43	-31.96	-46.13	-59.72
2046	80.73	95.07	109.06	47.31	-33.41	-47.76	-61.75
2047	81.07	95.58	109.97	46.19	-34.87	-49.39	-63.78
2048	81.41	96.09	110.89	45.07	-36.34	-51.02	-65.82
2049	81.75	96.61	111.82	43.95	-37.80	-52.66	-67.87
2050	82.09	97.13	112.75	42.83	-39.26	-54.30	-69.92
2051	82.44	97.65	113.69	41.71	-40.73	-55.94	-71.98
2052	82.79	98.17	114.64	40.59	-42.20	-57.58	-74.06
2053	83.14	98.70	115.60	39.47	-43.67	-59.23	-76.13
2054	83.40	99.13	116.46	38.35	-45.05	-60.78	-78.11
2055	83.67	99.57	117.31	37.23	-46.44	-62.34	-80.08
2056	83.94	100.00	118.18	36.11	-47.83	-63.89	-82.07
2057	84.21	100.44	119.05	34.99	-49.22	-65.45	-84.06
2058	84.48	100.88	119.92	33.87	-50.61	-67.01	-86.06
2059	84.75	101.32	120.81	32.75	-52.01	-68.57	-88.06
2060	85.03	101.76	121.70	31.63	-53.40	-70.13	-90.07

Appendix B-3
Current Peak Day Demand, Supply, and Net

Year	Peak Day Demand (mgd)			Peak Day Supply (mgd) (for details see Appendix B-1)	Peak Day Shortages/Surpluses (mgd)		
	Conservation	Probable	Accelerated		Conservation	Probable	Accelerated
2061	85.30	102.20	122.59	30.51	-54.79	-71.70	-92.09
2062	85.57	102.65	123.50	28.39	-57.19	-74.26	-95.11
2063	85.85	103.10	124.41	28.01	-57.84	-75.09	-96.40
2064	86.04	103.45	125.20	27.63	-58.41	-75.82	-97.57
2065	86.23	103.80	126.00	27.25	-58.98	-76.55	-98.75
2066	86.42	104.15	126.80	26.87	-59.56	-77.28	-99.93
2067	86.61	104.50	127.61	26.49	-60.13	-78.01	-101.12
2068	86.80	104.85	128.42	26.10	-60.70	-78.75	-102.31
2069	87.00	105.20	129.24	25.72	-61.27	-79.48	-103.51
2070	87.19	105.56	130.06	25.34	-61.85	-80.21	-104.71
2071	87.38	105.91	130.89	24.96	-62.42	-80.95	-105.92
2072	87.58	106.27	131.72	24.58	-62.99	-81.69	-107.14
2073	87.77	106.63	132.56	24.20	-63.57	-82.43	-108.35
2074	87.88	106.88	133.27	23.82	-64.06	-83.06	-109.45
2075	87.99	107.14	133.99	23.44	-64.54	-83.69	-110.54
2076	88.09	107.39	134.70	23.06	-65.03	-84.33	-111.64
2077	88.20	107.65	135.43	22.68	-65.52	-84.96	-112.75
2078	88.31	107.90	136.15	22.30	-66.01	-85.60	-113.85
2079	88.42	108.16	136.89	21.92	-66.49	-86.24	-114.96
2080	88.52	108.41	137.62	21.54	-66.98	-86.87	-116.08
2081	88.63	108.67	138.36	21.16	-67.47	-87.51	-117.20
2082	88.74	108.93	139.10	20.78	-67.96	-88.15	-118.32
2083	88.85	109.19	139.85	20.40	-68.45	-88.79	-119.45
2084	88.96	109.45	140.46	20.02	-68.94	-89.43	-120.44
2085	89.07	109.71	141.07	19.64	-69.43	-90.07	-121.43
2086	89.17	109.97	141.69	19.26	-69.91	-90.71	-122.43
2087	89.28	110.23	142.31	18.88	-70.40	-91.35	-123.43
2088	89.39	110.49	142.93	18.50	-70.89	-91.99	-124.43
2089	89.50	110.75	143.56	18.12	-71.38	-92.63	-125.44
2090	89.61	111.02	144.18	17.74	-71.87	-93.28	-126.45
2091	89.72	111.28	144.81	17.36	-72.36	-93.92	-127.46
2092	89.83	111.54	145.45	16.98	-72.85	-94.56	-128.47
2093	89.94	111.81	146.08	16.60	-73.34	-95.21	-129.49
2094	90.05	112.07	146.50	16.22	-73.83	-95.86	-130.28
2095	90.16	112.34	146.92	15.84	-74.32	-96.50	-131.09
2096	90.27	112.61	147.35	15.46	-74.81	-97.15	-131.89
2097	90.38	112.87	147.77	15.08	-75.30	-97.80	-132.69
2098	90.49	113.14	148.19	15.00	-75.49	-98.14	-133.19
2099	90.60	113.41	148.62	15.00	-75.60	-98.41	-133.62
2100	90.71	113.68	149.05	15.00	-75.71	-98.68	-134.05
2101	90.82	113.95	149.47	15.00	-75.82	-98.95	-134.47
2102	90.93	114.22	149.90	15.00	-75.93	-99.22	-134.90
2103	91.04	114.49	150.33	15.00	-76.04	-99.49	-135.33
2104	91.15	114.76	150.54	15.00	-76.15	-99.76	-135.54
2105	91.27	115.03	150.75	15.00	-76.27	-100.03	-135.75
2106	91.38	115.31	150.95	15.00	-76.38	-100.31	-135.95
2107	91.49	115.58	151.16	15.00	-76.49	-100.58	-136.16
2108	91.60	115.85	151.37	15.00	-76.60	-100.85	-136.37
2109	91.71	116.13	151.58	15.00	-76.71	-101.13	-136.58
2110	91.82	116.41	151.79	15.00	-76.82	-101.41	-136.79
2111	91.94	116.68	152.00	15.00	-76.94	-101.68	-137.00
2112	92.05	116.96	152.20	15.00	-77.05	-101.96	-137.20
2113	92.16	117.24	152.41	15.00	-77.16	-102.24	-137.41

Appendix C-1
Lubbock Water Rate Structure, 1980-2012

Decreasing Block Rate Structure					
Effective Dates		Base Rate + first 1,000 Gallons	2,000 - 49,000 Gallons Water Rate per 1,000 Gallons	50,000 - 250,000 Gallons Water Rate per 1,000 Gallons	> 250,000 Gallons Water Rate per 1,000 Gallons
Start	End				
1980	1983	4.50	0.93	0.80	0.75
1983	1987	5.46	1.13	0.97	0.91
1987	1989	6.21	1.13	0.97	0.91
1989	1990	6.76	1.28	1.12	1.06
1990	1992	7.31	1.53	1.37	1.31

Uniform Rate Structure						
Effective Dates		Base Rate for 3/4" Meter	Base Rate for 1" Meter	Single-Family Water Rate per 1,000 Gallons	Commercial Water Rate per 1,000 Gallons	Irrigation Water Rate per 1,000 Gallons
Start	End					
1992	1993	7.31	9.31	1.34	1.23	1.68
1993	1994	7.68	9.78	1.41	1.29	1.76
1994	1999	8.06	10.26	1.48	1.36	1.85
1999	2000	8.30	10.57	1.52	1.40	1.85
2000	2001	8.63	10.99	1.58	1.46	1.85
2001	2002	8.89	11.32	1.63	1.50	1.91
2002	2003	9.16	11.66	1.68	1.55	1.96
2003	2004	9.43	12.01	1.73	1.60	2.02
2004	2005	10.01	12.74	1.83	1.69	2.14
2005	2006	11.11	14.14	2.03	1.88	2.38

Conservation Block Rate Structure						
Effective Dates		Base Rate for 3/4" Meter	Base Rate for 1" Meter	Block 1 (0 - AWC) Water Rate per 1,000 Gallons	Block 2 (AWC - 40,000) Water Rate per 1,000 Gallons	Block 3 (AWC + 40,000) & Up Water Rate per 1,000 Gallons
Start	End					
2006	2007	7.66	12.79	2.09	2.61	3.61
2007	2008	8.89	14.84	2.42	3.03	4.19
2008	2010	18.00	30.05	2.67	4.29	5.93
2010	2011	24.00	40.06	2.67	4.29	5.93
2011	2012	28.00	46.74	2.67	4.29	5.93
2012	2013	21.00	35.06	4.00	5.46	6.55

Appendix C-2

Residential Water Bill Comparison for Major Texas Cities During January 2012 for 5/8" or 3/4" Meters

	City	Water Used (gallons)						
		0	5,000	10,000	20,000	30,000	40,000	50,000
Monthly Residential Water Bill ($)	Amarillo	11.89	16.13	26.73	54.43	82.13	123.13	164.13
	Arlington	8.57	17.47	27.57	59.52	93.62	134.42	175.22
	Austin(R)	16.60	28.18	48.42	142.77	258.47	380.37	502.27
	Brownsville	9.93	18.42	27.85	54.67	88.27	121.87	155.47
	Corpus Christi	8.72	19.99	42.54	102.44	168.21	248.07	327.93
	Dallas(R)	5.79	15.86	32.61	87.01	149.51	212.01	274.51
	El Paso*	10.70	14.68	24.58	73.69	138.79	203.89	268.99
	Fort Worth(R)*	7.55	20.30	37.19	77.27	128.30	181.50	234.70
	Garland(R)	12.00	27.59	45.79	92.14	148.44	204.74	261.04
	Grand Prairie	11.08	17.76	33.56	65.16	119.46	173.76	228.06
	Houston	3.99	21.89	41.23	97.00	161.80	226.60	291.40
	Irving(S)	9.00	16.46	35.11	74.61	119.51	164.41	209.31
	Laredo	8.20	13.11	21.66	39.46	58.46	78.46	99.46
	Lubbock	21.00	41.00	65.38	119.98	174.58	229.18	287.05
	Pasadena	10.50	18.75	33.13	71.63	111.63	156.63	201.63
	Plano	16.93	18.49	28.54	48.64	88.84	129.04	169.24
	San Antonio(R)	10.01	20.02	33.62	79.81	151.32	222.83	294.34

[R] = City has 5/8" *and* 3/4" meters - 3/4" rate used in calculations * = AWC of 7,000 gal [S] = summer rates

Appendix C-3

Public-School Program Lessons

Lesson Title	Grade(s)	Description
Blue Stuff	K-2	Students will learn the difference between salt and fresh water. Discusstion will focus on how much water exists on the planet vs. how much we can actually use for drinking,farming, etc.
Cloudy Days	K-2	The presenter will discuss the water cycle and provide an illustration of the whole process step by step. The students will learn by participating in the discussion.
Tale of Two Droplets	K-2	A video tells the adventures of Drippy and Dropper, a couple of water drops that travel through a day with Jeremy. As the day progresses, we learn more ways to save water.
Make-a-Tree	K-2	Students will learn the basic process creation, as well as the many ways that paper can be reused and then recycled.
Sources of Resources	K-2	Students will be able to identify the natural resource that many common items are created from.
Mask of Trash	K-2	Students will become aware of their role in practicing the Four Rs, thereby becoming good stewards of our natural resources.
Bird Feeder	K-2	Students will create a decorated bird feeder to use at home and to teach parents about recycling.
Recycle Relay	K-2	Following a brief introduction into recycling, students will get hands on experience sorting recyclables in a fast past relay race.
Water Bracelet	K-5	Students will learn the terms and definitions associated with the water cycle and how the water cycle is impacted by actions on earth.
Fred the Fish	3-12	The water we use has to come from somewhere. The process of the water traveling from the source to the end point can be quite an adventure.
Edible Aquifer	3-12	Students will learn what an aquifer is and how the Ogallala benefits the City of Lubbock.
Water Treatment Video	3-12	Students will be able to identify the different steps involved with the process of providing clean drinking water.
Examining Effluent	3-12	Students will learn what effluent is and how Lubbock uses it to benefit local and area residents.
What's in your Water?	3-12	Students will understand the concepts fo solubility, dissolving, solutions, and mixtures.
The Best Fisherman	3-12	Students will learn about conservation, natural resources, and renewable resources while developing and understanding of resource manangement.
Water Shortages	3-12	Students will be able to define water shortage, discuss solutions to water shortages, be able to explain water solutions explore locally.
Edible Landfill	3-12	Students will learn appropriate vocabulary as well as the design of the landfill
Garbage Pizza	3-12	Students will construct a garbage pizza to represent all the trash thrown away. Students will learn the composition and the proportion of the types of trash that enter the landfill and will classify recyclable materials and analyze how personal choices make a difference.
Blow Wind Blow	3-12	Students will learn the vocabulary of wind energy, the concept behind the technology and the story of wind usage, past to future endeavors.

Appendix C-4

Conservation Calculations:

More Stringent Seasonal Water Restrictions Strategy

A. Program Details:

Implement a year round outdoor water use restriction that limits each facility to watering landscape with irrigation systems to two days per week on specified days. The suggested landscape application should be less than 1.5 inches per week.

B. Water Savings:

See the chart below for the breakdown of the City's annual water usage by tier (compiled from a study the City completed using Fiscal Year 2008-2009 data).

Tier	Annual Water Usuage (%)
Block 1	70.69%
Block 2	21.94%
Block 3	7.37%
Total	**100.00%**

B.1	Non-essential water: (Block 2 + Block 3)	=	29.31%
B.2	Percent from Block 2: (Block 2 / B.1)	=	74.85%
B.3	Percent from Block 3: (Block 3 / B.1)	=	25.15%

In the summer months (April-September), the average water consumption (gallons per capita per day - gpcd) in Lubbock is much higher than in the winter months (October - March). The charts below show the 5-year average monthly gpcd.

	Seasonal Irrigation Months	Average gpcd
	April	148
	May	166
	June	190
	July	189
	August	199
	September	167
B.4	**Average**	**177**

	Non-Seasonal Irrigation Months	Average gpcd
	January	117
	February	120
	March	130
	October	151
	November	131
	December	121
B.5	**Average**	**128**

	Seasonal, non-essential water used: (B.4 - B.5)	=	48	gpcd
B.6		=	6,104	ac-ft/yr
		=	1,989,020,472	gallons

B.7 City staff estimate of percent reduction in Seasonal Water Usage under this strategy: 15%

B.8	Total Water Conserved: (B.6 x B.7)	=	916	ac-ft/yr
		=	298,353,071	gallons
	Amount Conserved in Block 2: (B.8 x B.2)	=	685	ac-ft/yr
		=	223,332,186	gallons
	Amount Conserved in Block 3: (B.8 x B.3)	=	230	ac-ft/yr
		=	75,020,885	gallons

Appendix C-4

Conservation Calculations:

More Stringent Seasonal Water Restrictions Strategy

D. Revenue Impact:

Change in Annual Revenue

Water Saved (gallons)	Tier	Rate per 1,000 gallons	Change in Annual Revenue
223,332,186	Block 2	$5.46	-$1,219,394
75,020,885	Block 3	$6.55	-$491,387
Total			-$1,710,781

Appendix C-5

Conservation Calculations:

Increase Non-Essential Water Volume Rates Strategy

A. Program Details:

A.1	Increase in water rates for Blocks 2 and 3:	10%
A.2	Decrease in non-essential water demand:	3%

	Current Rate	Incremental Rate Change	Proposed Rate
Block 1	$4.00	$0.00	$4.00
Block 2	$5.46	$0.55	$6.01
Block 3	$6.55	$0.66	$7.21

B. Water Savings:

Recall the breakdown of water usage by Blocks developed in Appendix O-1:

B.1	Percent of non-essential water use	=	29.31%	
B.2	Percent of non-essential use from Block 2	=	74.85%	
B.3	Percent of non-essential use from Block 3	=	25.15%	
B.4	City's five year (2007-11) avg water demand	=	37,375	ac-ft/yr
B.5	Annual non-essential water use (B.4 x B.1)	=	10,955	ac-ft/yr
		=	3,569,575,820	gallons

Water Saved with this Strategy:

B.6	Total Water Conserved: (B.5 x A.2)	=	329	ac-ft/yr
B.7	Amount Conserved in Block 2: (B.6 x B.2)	=	246	ac-ft/yr
		=	80,160,178	gallons
B.8	Amount Conserved in Block 3: (B.6 x B.3)	=	83	ac-ft/yr
		=	26,927,097	gallons

C. Program Costs:

This strategy would not cost additional funds for the City to implement and administer. Using volume rates to promote water conservation does not require the City to make an investment of time or capital to enforce water usage.

D. Revenue Impact:

Revenue Lost

	Water Saved (gallons)	Tier	Proposed Rate per Thousand Gallon	Revenue Lost
	80,160,178	Block 2	$6.01	-$481,442
	26,927,097	Block 3	$7.21	-$194,010
D.1	**Total**			-$675,452

Appendix C-5

Conservation Calculations:

Increase Non-Essential Water Volume Rates Strategy

This strategy estimates 3% of the water used in Blocks 2 and 3 will be conserved. The City will collect additional revenue on the remaining 97% of water used in these tiers.

D.2	Water Earning Revenue: (B.5 - B.6)	=	10,626	ac-ft/yr
D.3	Amount Earned from Block 2: (D.2 x B.2)	=	7,954	ac-ft/yr
		=	2,591,845,741	gallons
D.4	Amount Earned from Block 3: (D.2 x B.3)	=	2,672	ac-ft/yr
		=	870,642,804	gallons

Revenue Gained

	Water Used (gallons)	Tier	Rate Increase per Thousand Gallons	Revenue Gained
	2,591,845,741	Block 2	$0.55	$1,415,148
	870,642,804	Block 3	$0.66	$570,271
D.5	**Total**			$1,985,419

Revenue Gained + Revenue Lost = Change in Annual Revenue

= D.1 + D.5

Change in Annual Revenue

Water Conserved	Change in Annual Revenue
329 ac-ft/yr	$1,309,967

Appendix C-6

Conservation Calculations:

Toilet Replacement Rebate for Schools and Universities

A. Program Details:

$90 rebate to replace old toilets with new high-efficiency toilets in Lubbock public schools and university dorms.

B. Water Savings:

In 1991, the Texas legislature passed the Water Saving Performance Standards (Senate Bill 587), which placed stringent water-use standards on indoor plumbing equipment. Toilets sold in Texas prior to January 1, 1992 used between 3.0 to 8.0 gallons per flush (gpf), whereas toilets installed after January 1, 1992 were required to use 1.6 gpf or less. Many of the toilets in Lubbock schools and university dorms are older models that use between 3.0 and 5.0 gpf.

Water Savings per Toilet

Facility	Old Model (estimated gpf)	New Model (gpf)	Water Savings (gpf)
LISD	5.0	1.6	3.4
Texas Tech Dormitories	3.5	1.6	1.9

The 1999 AWWA study "Residential End Uses of Water" found that the average person flushes the toilet:

5.0 times per day while at home (TTU dorms)

From this data, it is estimated that an average person will flush the toilet:

2.5 times per day while at school/work (LISD)

Total Program Water Savings

Facility	Number of People	Flushes per Day	Water Savings per Flush (gpf)	Water Saved per Year* (gallons)	Water Saved per Year* (ac-ft)
LISD	32,084	2.5	3.4	74,655,458	229.1
Texas Tech Dormitories	6,746	5.0	1.9	17,543,816	53.8
TOTAL				92,199,274	282.9

* Dorms and public schools are only in normal use for 9 months of the year

C. Program Costs:

See the chart below for the total number of toilets needing to be replaced.

Facility	Number of Toilets
LISD	3,177
Texas Tech Dormitories	1,290
TOTAL	**4,467**

Appendix C-6

Conservation Calculations:

Toilet Replacement Rebate for Schools and Universities

Cost to Implement Program

Rebate		Total Number of Toilets	Cost to Implement Program
$90.00	per toilet	4,467	$402,030

D. Revenue Impact:

All water saved with this strategy is expected to be from Block 1.

Change in Annual Revenue

Water Saved (gallons)	Tier	Rate	Change in Annual Revenue
92,199,274	Block 1	$4.00	-$368,797

Appendix C-7

Conservation Calculations:

Washing Machine Rebate

A. Program Details:

Offer $300 rebates to replace old commercial washing machines with new high-efficiency machines, and $150 rebates to replace old residential washing machines in apartment complexes and university dorms with new high-efficiency residential machines.

B. Water Savings:

See the chart below for the estimated number of commercial washing machines in Lubbock.

	Type of Facility	Number of Washing Machines
	Coin-Operated Laundromats	540
	Dry-Cleaners with Washers	120
B.1	**TOTAL**	**660**

According to a study published by Western Resource Advocates in 2008 called "Smart Savings Water Conservation: Measures that Make ¢ents," conversion from an older commercial washing machine model to a newer model can save:

B.2 37,800 gallons of water per machine per year

Annual Water Savings for Commercial Retrofit:

Water Conserved: (B.1 x B.2) = 24,948,000 gallons

= 76.6 ac-ft/yr

See the chart below for the estimated number of apartment washing machines in Lubbock.

	Type of Facility	Number of Washing Machines
	Apartment Complexes	1,600
	Texas Tech Dormitory	171
B.3	**TOTAL**	**1,771**

In the 2008 article "Smart Savings Water Conservation: Measures that Make ¢ents" referenced above, it is found that conversion from an older residential washing machine model to a newer model can save:

8,500 gallons of water per machine per year

However, residential washing machines typically serve a family of 4-5. In dormitories and apartment complexes, a single machine will often serve 6-10 people. Therefore, the annual savings per machine has been adjusted to:

B.4 15,000 gallons of water per machine per year

Annual Water Savings for Apartment/Dormitory Retorofit:

Water Conserved: (B.3 x B.4) = 26,565,000 gallons

= 81.5 ac-ft/yr

Total Water Savings

Retrofit	Water Saved (gallons)	Water Saved (ac-ft/yr)
Commercial	24,948,000	76.6
Apartments / Dormitories	26,565,000	81.5
TOTAL	**51,513,000**	**158.1**

Appendix C-7

Conservation Calculations:

Washing Machine Rebate

C. Program Costs:

Cost to Implement Program

Rebate		Number of Machines	Cost to Implement Program
$300.00	for a commercial machine	660	$198,000
$150.00	for a residential machine	1,771	$265,650
Total		**2,431**	$463,650

D. Revenue Impact:

All water saved with this strategy is expected to be from Block 1.

Change in Annual Revenue

Water Saved (gallons)	Tier	Rate per Thousand Gallons	Change in Annual Revenue
51,513,000	Block 1	$4.00	-$206,052

Appendix C-8

Conservation Calculations:

Residential Showerhead Rebate

A. Program Details:

Offer $10 rebates to residential Lubbock Water Utility customers who purchase and install low flow showerheads.

B. Water Savings:

B.1	2010 City of Lubbock Population	=	229,573	
B.2	Residential Water Connections in Lubbock	=	68,529	

Average Number of People per Household in Lubbock:

B.3	People per Household: (B.1 ÷ B.2)	=	3.35	people her household

The 1992 Water Saving Performance Standards require that all showerheads meet 2.5 gpm flow rates. Prior to 1992, most showerheads were built with a 3.0 gpm or higher flow rate.

Water Savings per Showerhead (data from: 1999 AWWA study "Residential End Uses of Water")

B.4	Average gpcd for non-low flow showerheads	=	13.3	gpcd
B.5	Average gpcd for low flow showerheads	=	8.8	gpcd

Water used per household per day with non-low flow devices:

B.6	(B.4 x B.3)	=	44.6	gallons per day

Water used per household per day with low flow devices:

B.7	(B.5 x B.3)	=	29.5	gallons per day
B.8	Total Water Conserved per day: (B.6 - B.7)	=	15.1	gallons per day

Participation Rate:

B.9	Percent of households expected to participate	=	10%	
B.10	Number of Participating Households: (B.2 x B.9)	=	6,853	

Annual Water Savings:

	Total Water Conserved: (B.8 x B.10 x 365 days)	=	37,707,365	gallons/yr
		=	115.7	ac-ft/yr

C. Program Costs:

Cost to Implement Program

Rebate		Number of Showerheads	Program Cost
$10.00	per showerhead	6,853	$68,529

D. Revenue Impact:

All water saved with this strategy is expected to be from Block 1.

Change in Annual Revenue

Water Saved (tgals)	Tier	Rate	Change in Annual Revenue
37,720	Block 1	$4.00	-$150,880

Appendix C-9

Conservation Calculations:

Landscape Rebate

A. Program Details:

Offer a $0.25 rebate per 1 ft^2 of traditional grass lawn that is removed and replaced with trees and Smartscape or Xeriscape.

B. Water Savings:

In the summer months (May-September), the average volume of water used per residence in Lubbock is much higher than in the winter months (October - April). The chart below shows the 4-year (2008-2011) average monthly volume of water consumed per residential connection in the City of Lubbock (data from LP&L).

	Month	Avg Residential Seasonal Monthly Water Used (gallons)
	April	7,994
	May	8,896
	June	10,915
	July	11,240
	August	10,995
	September	10,228
B.1	**Avg Month**	**10,455**

	Month	Avg Residential Non-Seasonal Monthly Water Used (gallons)
	January	6,450
	February	5,758
	March	6,195
	October	7,860
	November	6,613
	December	6,125
B.2	**Avg Month**	**6,500**

B.3	Seasonal, non-essential water used: (B.1 - B.2)	=	3,955	gallons

The City, along with the Lubbock Master Gardners Association, recommends applying 1.5 inches of water per week to grass lawns.

	conversion factor: 1.604 inches per ft^2	=	1.00	gallon per ft^2
B.4	1.5 inches per ft^2	=	0.94	gallons per ft^2 per week
B.5	B.4 x 4 weeks	=	3.74	gallons per ft^2 per month

According to LP&L data in June 2012, there are 68,529 residential water connections in the City of Lubbock.

	Expected participation rate	=	10%	
B.6	Number of participating households	=	6,853	households
B.7	Estimated area converted to xeriscape per hosuehold	=	450	ft^2

Total estimated area of grass lawn removed due to this strategy:

B.8	(B.6 * B.7)	=	3,083,805	ft^2 converted to Xeriscape

The literature suggests that xeriscaping a yard can conserve between 30% - 75% of the water used for outdoor irrigation. Without West Texas data, we can only estimate the water savings that would be experienced in this area. In this analysis, a 50% water savings rate is used.

	50% x 1.5 inches per ft^2	=	0.75	in/ft^2
B.9		=	0.468	gallons/ft^2
B.10	Water Conserved per week: (B.8 x B.9)	=	1,443,221	gallons/week

Appendix C-9

Conservation Calculations:

Landscape Rebate

Recall the breakdown of water usage by tier developed in Appendix C-4:

B.11	Percent of non-essential water use	=	29.31%
B.12	Percent of non-essential use from Block 2	=	74.85%
B.13	Percent of non-essential use from Block 3	=	25.15%

Water Saved with this Strategy:

B.14	Total Water Conserved: (B.10 x 4 wks x 6 mos)	=	34,637,298	gallons/yr
		=	106.3	ac-ft/yr
	Amount Conserved in Block 2: (B.14 x B.12)	=	25,927,749	gallons
		=	79,569.2	ac-ft/yr
	Amount Conserved in Block 3: (B.13 x B.12)	=	8,709,549	gallons
		=	26,728.6	ac-ft/yr

C. Program Costs:

Cost to Implement Program

Rebate		ft^2 Converted	Program Cost
$0.25	for 1 ft^2	3,083,805	$770,951

D. Revenue Impact:

Change in Annual Revenue

Water Saved (gallons)	Tier	Rate per thousand gallon	Change in Annual Revenue
25,927,749	Block 2	$5.46	-$141,566
8,709,549	Block 3	$6.55	-$57,048
Total			-$198,613

Appendix D-1

Gross Reclaimed Water Projections

Year	Reclaimed Water Population			Reclaimed Water Gallons per Capita per Day (gpcd)			Effluent Flows (mgd)		
	Probable (for details see Section 6.3)	Canyon Lakes Water Reuse Project	2009 Wastewater Master Plan	Probable	Canyon Lakes Water Reuse Project	2009 Wastewater Master Plan	Probable	Canyon Lakes Water Reuse Project	2009 Wastewater Master Plan
Data by Decade									
2013	236,458	236,740	232,467	80	85	95	18.90	20.12	22.08
2023	266,415	262,286	255,477	78	85	95	20.91	22.29	24.27
2033	300,168	290,589	279,396	77	85	95	23.12	24.70	26.54
2043	325,064	321,946	305,556	76	85	95	24.57	27.37	29.03
2053	348,549	356,686	334,169	74	85	95	25.84	30.32	31.75
2063	370,036	.	.	73	.	.	26.89	.	.
2073	388,959	.	.	71	.	.	27.70	.	.
2083	404,801	.	.	70	.	.	28.24	.	.
2093	421,288	.	.	68	.	.	28.78	.	.
2103	438,446	.	.	67	.	.	29.31	.	.
2113	456,302	.	.	65	.	.	29.84	.	.
Historic Data									
1995	191,020	191,020	191,020	109			20.80		
1996	193,064	193,064	193,064	102			19.67		
1997	195,367	195,367	195,367	96			18.83		
1998	196,679	196,679	196,679	103			20.22		
1999	197,117	197,117	197,117	94			18.59		
2000	199,564	199,564	199,864	106			21.06		
2001	201,217	201,217	201,217	99			19.91		
2002	202,000	202,000	202,000	98			19.82		
2003	204,737	204,737	204,737	89			18.27		
2004	206,290	206,290	206,290	97			20.06		
2005	209,120	209,120	209,120	95			19.93		
2006	211,187	211,187	211,487	97			20.40		
2007	212,365	212,365	215,015	92			19.56		
2008	214,847	214,847	218,542	91			19.65		
2009	218,327	218,327	222,070	87			19.06		
2010	229,573	229,573	225,597	85			19.53		
2011	231,938	231,938	227,887	80			18.47		
2012	233,654	234,327	230,177	80			18.71		
Data by Year									
2013	236,458	236,740	232,467	80	85	95	18.90	20.12	22.08
2014	239,295	239,179	234,757	80	85	95	19.10	20.33	22.30
2015	242,167	241,642	237,047	80	85	95	19.29	20.54	22.52
2016	245,073	244,131	239,337	80	85	95	19.49	20.75	22.74
2017	248,014	246,646	241,627	79	85	95	19.68	20.96	22.95
2018	250,990	249,186	243,917	79	85	95	19.88	21.18	23.17
2019	254,002	251,753	246,207	79	85	95	20.08	21.40	23.39
2020	257,050	254,346	248,497	79	85	95	20.29	21.62	23.61
2021	260,134	256,965	250,824	79	85	95	20.49	21.84	23.83
2022	263,256	259,612	253,150	79	85	95	20.70	22.07	24.05
2023	266,415	262,286	255,477	78	85	95	20.91	22.29	24.27
2024	269,612	264,988	257,803	78	85	95	21.12	22.52	24.49

Appendix D-1

Gross Reclaimed Water Projections

Year	Reclaimed Water Population			Reclaimed Water Gallons per Capita per Day (gpcd)			Effluent Flows (mgd)		
	Probable (for details see Section 6.3)	Canyon Lakes Water Reuse Project	2009 Wastewater Master Plan	Probable	Canyon Lakes Water Reuse Project	2009 Wastewater Master Plan	Probable	Canyon Lakes Water Reuse Project	2009 Wastewater Master Plan
2025	272,847	267,717	260,130	78	85	95	21.34	22.76	24.71
2026	276,122	270,475	262,456	78	85	95	21.55	22.99	24.93
2027	279,435	273,260	264,783	78	85	95	21.77	23.23	25.15
2028	282,788	276,075	267,109	78	85	95	21.99	23.47	25.38
2029	286,182	278,919	269,436	78	85	95	22.21	23.71	25.60
2030	289,616	281,791	271,762	77	85	95	22.44	23.95	25.82
2031	293,091	284,694	274,307	77	85	95	22.66	24.20	26.06
2032	296,608	287,626	276,851	77	85	95	22.89	24.45	26.30
2033	300,168	290,589	279,396	77	85	95	23.12	24.70	26.54
2034	302,569	293,582	281,940	77	85	95	23.26	24.95	26.78
2035	304,990	296,606	284,485	77	85	95	23.41	25.21	27.03
2036	307,429	299,661	287,029	77	85	95	23.55	25.47	27.27
2037	309,889	302,747	289,574	76	85	95	23.69	25.73	27.51
2038	312,368	305,866	292,118	76	85	95	23.84	26.00	27.75
2039	314,867	309,016	294,663	76	85	95	23.98	26.27	27.99
2040	317,386	312,199	297,207	76	85	95	24.13	26.54	28.23
2041	319,925	315,415	299,990	76	85	95	24.27	26.81	28.50
2042	322,484	318,663	302,773	76	85	95	24.42	27.09	28.76
2043	325,064	321,946	305,556	76	85	95	24.57	27.37	29.03
2044	327,340	325,262	308,339	75	85	95	24.69	27.65	29.29
2045	329,631	328,612	311,122	75	85	95	24.82	27.93	29.56
2046	331,938	331,997	313,905	75	85	95	24.94	28.22	29.82
2047	334,262	335,416	316,688	75	85	95	25.07	28.51	30.09
2048	336,602	338,871	319,471	75	85	95	25.20	28.80	30.35
2049	338,958	342,361	322,254	75	85	95	25.32	29.10	30.61
2050	341,331	345,888	325,037	75	85	95	25.45	29.40	30.88
2051	343,720	349,450	328,081	74	85	95	25.58	29.70	31.17
2052	346,126	353,050	331,125	74	85	95	25.71	30.01	31.46
2053	348,549	356,686	334,169	74	85	95	25.84	30.32	31.75
2054	350,640	360,360	337,213	74	85	95	25.94	30.63	32.04
2055	352,744	364,072	340,257	74	85	95	26.04	30.95	32.32
2056	354,861	367,821	343,300	74	85	95	26.15	31.26	32.61
2057	356,990	371,610	346,344	74	85	95	26.25	31.59	32.90
2058	359,132	375,438	349,388	73	85	95	26.36	31.91	33.19
2059	361,287	379,305	352,432	73	85	95	26.47	32.24	33.48
2060	363,454	383,211	355,476	73	85	95	26.57	32.57	33.77
2061	365,635	.	.	73	.	.	26.68	.	.
2062	367,829	.	.	73	.	.	26.78	.	.
2063	370,036	.	.	73	.	.	26.89	.	.
2064	371,886	.	.	73	.	.	26.97	.	.
2065	373,745	.	.	72	.	.	27.05	.	.
2066	375,614	.	.	72	.	.	27.13	.	.
2067	377,492	.	.	72	.	.	27.21	.	.
2068	379,380	.	.	72	.	.	27.29	.	.
2069	381,277	.	.	72	.	.	27.37	.	.
2070	383,183	.	.	72	.	.	27.46	.	.

Appendix D-1

Gross Reclaimed Water Projections

Year	Reclaimed Water Population			Reclaimed Water Gallons per Capita per Day (gpcd)			Effluent Flows (mgd)		
	Probable (for details see Section 6.3)	Canyon Lakes Water Reuse Project	2009 Wastewater Master Plan	Probable	Canyon Lakes Water Reuse Project	2009 Wastewater Master Plan	Probable	Canyon Lakes Water Reuse Project	2009 Wastewater Master Plan
2071	385,099	.	.	72	.	.	27.54	.	.
2072	387,024	.	.	71	.	.	27.62	.	.
2073	388,959	.	.	71	.	.	27.70	.	.
2074	390,515	.	.	71	.	.	27.75	.	.
2075	392,077	.	.	71	.	.	27.81	.	.
2076	393,646	.	.	71	.	.	27.86	.	.
2077	395,220	.	.	71	.	.	27.92	.	.
2078	396,801	.	.	70	.	.	27.97	.	.
2079	398,388	.	.	70	.	.	28.02	.	.
2080	399,982	.	.	70	.	.	28.08	.	.
2081	401,582	.	.	70	.	.	28.13	.	.
2082	403,188	.	.	70	.	.	28.19	.	.
2083	404,801	.	.	70	.	.	28.24	.	.
2084	406,420	.	.	70	.	.	28.29	.	.
2085	408,046	.	.	69	.	.	28.35	.	.
2086	409,678	.	.	69	.	.	28.40	.	.
2087	411,317	.	.	69	.	.	28.45	.	.
2088	412,962	.	.	69	.	.	28.51	.	.
2089	414,614	.	.	69	.	.	28.56	.	.
2090	416,272	.	.	69	.	.	28.62	.	.
2091	417,937	.	.	69	.	.	28.67	.	.
2092	419,609	.	.	68	.	.	28.72	.	.
2093	421,288	.	.	68	.	.	28.78	.	.
2094	422,973	.	.	68	.	.	28.83	.	.
2095	424,665	.	.	68	.	.	28.88	.	.
2096	426,363	.	.	68	.	.	28.94	.	.
2097	428,069	.	.	68	.	.	28.99	.	.
2098	429,781	.	.	68	.	.	29.04	.	.
2099	431,500	.	.	67	.	.	29.10	.	.
2100	433,226	.	.	67	.	.	29.15	.	.
2101	434,959	.	.	67	.	.	29.20	.	.
2102	436,699	.	.	67	.	.	29.26	.	.
2103	438,446	.	.	67	.	.	29.31	.	.
2104	440,199	.	.	67	.	.	29.36	.	.
2105	441,960	.	.	67	.	.	29.42	.	.
2106	443,728	.	.	66	.	.	29.47	.	.
2107	445,503	.	.	66	.	.	29.52	.	.
2108	447,285	.	.	66	.	.	29.58	.	.
2109	449,074	.	.	66	.	.	29.63	.	.
2110	450,870	.	.	66	.	.	29.68	.	.
2111	452,674	.	.	66	.	.	29.73	.	.
2112	454,485	.	.	66	.	.	29.79	.	.
2113	456,302	.	.	65	.	.	29.84	.	.

Appendix D-2

Net Reclaimed Water Projections

Year	Reclaimed Water Projections (mgd)					
	Probable Gross Effluent Flows	Contractual		Operational		Probable Net Effluent Flows
		Xcel	Private Cotton Farmers	LLAS	HLAS	
Data by Decade						
2013	18.90	9.00	0	4.00	4.00	1.90
2023	20.91	16.00	0	2.00	0.00	2.91
2033	23.12	16.00	0	2.00	0.00	5.12
2043	24.57	16.00	0	2.00	0.00	6.57
2053	25.84	14.00	0	2.00	0.00	9.84
2063	26.89	9.00	0	2.00	0.00	15.89
2073	27.70	9.00	0	2.00	0.00	16.70
2083	28.24	9.00	0	2.00	0.00	17.24
2093	28.78	9.00	0	2.00	0.00	17.78
2103	29.31	9.00	0	2.00	0.00	18.31
2113	29.84	9.00	0	2.00	0.00	18.84
Data by Year						
2010	19.53	9.00	0	4.00	4.00	2.53
2011	18.47	9.00	0	4.00	4.00	1.47
2012	18.71	9.00	0	4.00	4.00	1.71
2013	18.90	9.00	0	4.00	4.00	1.90
2014	19.10	9.00	0	4.00	4.00	2.10
2015	19.29	9.00	0	4.00	4.00	2.29
2016	19.49	9.00	0	4.00	4.00	2.49
2017	19.68	9.00	0	4.00	4.00	2.68
2018	19.88	9.00	0	4.00	4.00	2.88
2019	20.08	9.00	0	4.00	4.00	3.08
2020	20.29	16.00	0	2.00	0	2.29
2021	20.49	16.00	0	2.00	0	2.49
2022	20.70	16.00	0	2.00	0	2.70
2023	20.91	16.00	0	2.00	0	2.91
2024	21.12	16.00	0	2.00	0	3.12
2025	21.34	16.00	0	2.00	0	3.34
2026	21.55	16.00	0	2.00	0	3.55
2027	21.77	16.00	0	2.00	0	3.77
2028	21.99	16.00	0	2.00	0	3.99
2029	22.21	16.00	0	2.00	0	4.21
2030	22.44	16.00	0	2.00	0	4.44
2031	22.66	16.00	0	2.00	0	4.66
2032	22.89	16.00	0	2.00	0	4.89
2033	23.12	16.00	0	2.00	0	5.12
2034	23.26	16.00	0	2.00	0	5.26
2035	23.41	16.00	0	2.00	0	5.41
2036	23.55	16.00	0	2.00	0	5.55
2037	23.69	16.00	0	2.00	0	5.69
2038	23.84	16.00	0	2.00	0	5.84
2039	23.98	16.00	0	2.00	0	5.98
2040	24.13	16.00	0	2.00	0	6.13
2041	24.27	16.00	0	2.00	0	6.27
2042	24.42	16.00	0	2.00	0	6.42
2043	24.57	16.00	0	2.00	0	6.57
2044	24.69	16.00	0	2.00	0	6.69
2045	24.82	16.00	0	2.00	0	6.82
2046	24.94	14.00	0	2.00	0	8.94
2047	25.07	14.00	0	2.00	0	9.07
2048	25.20	14.00	0	2.00	0	9.20
2049	25.32	14.00	0	2.00	0	9.32
2050	25.45	14.00	0	2.00	0	9.45
2051	25.58	14.00	0	2.00	0	9.58
2052	25.71	14.00	0	2.00	0	9.71
2053	25.84	14.00	0	2.00	0	9.84
2054	25.94	14.00	0	2.00	0	9.94
2055	26.04	14.00	0	2.00	0	10.04
2056	26.15	14.00	0	2.00	0	10.15
2057	26.25	14.00	0	2.00	0	10.25
2058	26.36	14.00	0	2.00	0	10.36

Appendix D-2

Net Reclaimed Water Projections

Year	Reclaimed Water Projections (mgd)					
	Probable Gross Effluent Flows	Contractual		Operational		Probable Net Effluent Flows
		Xcel	Private Cotton Farmers	LLAS	HLAS	
2059	26.47	14.00	0	2.00	0	10.47
2060	26.57	14.00	0	2.00	0	10.57
2061	26.68	14.00	0	2.00	0	10.68
2062	26.78	14.00	0	2.00	0	10.78
2063	26.89	9.00	0	2.00	0	15.89
2064	26.97	9.00	0	2.00	0	15.97
2065	27.05	9.00	0	2.00	0	16.05
2066	27.13	9.00	0	2.00	0	16.13
2067	27.21	9.00	0	2.00	0	16.21
2068	27.29	9.00	0	2.00	0	16.29
2069	27.37	9.00	0	2.00	0	16.37
2070	27.46	9.00	0	2.00	0	16.46
2071	27.54	9.00	0	2.00	0	16.54
2072	27.62	9.00	0	2.00	0	16.62
2073	27.70	9.00	0	2.00	0	16.70
2074	27.75	9.00	0	2.00	0	16.75
2075	27.81	9.00	0	2.00	0	16.81
2076	27.86	9.00	0	2.00	0	16.86
2077	27.92	9.00	0	2.00	0	16.92
2078	27.97	9.00	0	2.00	0	16.97
2079	28.02	9.00	0	2.00	0	17.02
2080	28.08	9.00	0	2.00	0	17.08
2081	28.13	9.00	0	2.00	0	17.13
2082	28.19	9.00	0	2.00	0	17.19
2083	28.24	9.00	0	2.00	0	17.24
2084	28.29	9.00	0	2.00	0	17.29
2085	28.35	9.00	0	2.00	0	17.35
2086	28.40	9.00	0	2.00	0	17.40
2087	28.45	9.00	0	2.00	0	17.45
2088	28.51	9.00	0	2.00	0	17.51
2089	28.56	9.00	0	2.00	0	17.56
2090	28.62	9.00	0	2.00	0	17.62
2091	28.67	9.00	0	2.00	0	17.67
2092	28.72	9.00	0	2.00	0	17.72
2093	28.78	9.00	0	2.00	0	17.78
2094	28.83	9.00	0	2.00	0	17.83
2095	28.88	9.00	0	2.00	0	17.88
2096	28.94	9.00	0	2.00	0	17.94
2097	28.99	9.00	0	2.00	0	17.99
2098	29.04	9.00	0	2.00	0	18.04
2099	29.10	9.00	0	2.00	0	18.10
2100	29.15	9.00	0	2.00	0	18.15
2101	29.20	9.00	0	2.00	0	18.20
2102	29.26	9.00	0	2.00	0	18.26
2103	29.31	9.00	0	2.00	0	18.31
2104	29.36	9.00	0	2.00	0	18.36
2105	29.42	9.00	0	2.00	0	18.42
2106	29.47	9.00	0	2.00	0	18.47
2107	29.52	9.00	0	2.00	0	18.52
2108	29.58	9.00	0	2.00	0	18.58
2109	29.63	9.00	0	2.00	0	18.63
2110	29.68	9.00	0	2.00	0	18.68
2111	29.73	9.00	0	2.00	0	18.73
2112	29.79	9.00	0	2.00	0	18.79
2113	29.84	9.00	0	2.00	0	18.84

HDR | ONE COMPANY *Many Solutions*℠

Memo

To: Aubrey Spear, P.E. Kelly Baker	
From: Grady Reed David D. Dunn, P.E.	Project: City of Lubbock Present Value Analysis
CC:	
Date: November 5, 2012	Job No: 100815

Document3

RE: Primary Assumptions for Present Value Analysis of Strategic Water Supply Plan

The memo will briefly describe the primary assumptions that HDR will make for the City of Lubbock present value analysis. The model will extend to the year 2113, and will allow the user to break certain future assumptions into four (4) time periods with a different value given in each period. As with any long range model, major assumptions for future variables must be made. The longer the forecast period (in this case 100 years), the greater the uncertainty in predicting what the values for certain variables may be. HDR has made assumptions regarding the future general rate of inflation, interest rates for bonds, discount rate, and a separate rate of inflation for power costs. These assumptions are presented in more detail below.

Rate of Inflation

HDR has based the projected rate of inflation on the historical Engineering News Record (ENR) Construction Cost Index (CCI). The CCI calculates how much it would cost to purchase a basket of goods (including labor) related to construction projects relative to a base year. From these data, it is possible to determine how much, on a percentage basis, construction costs have risen from year to year. Over the last 20 years, the average annual increase in the CCI has been 3.2%. The increase for 2011 was near the average at 3.0%.

HDR has broken the 100-year forecast period into four time blocks as follows: 1) 2014 to 2025 (or near-term); 2) 2026 to 2046; 3) 2047 to 2067; and 4) 2068 to 2113. The recommended inflation rate for each time period is shown below, which is a screen capture from the spreadsheet model. Note that cells highlighted in yellow are user input cells which can be easily changed should a different set of assumptions be chosen.

Years		Years		Years		Years	
2014	2025	2026	2046	2047	2067	2068	2113
3.0%		3.1%		3.2%		2.7%	

HDR has kept the near-term rate of inflation equal to the rate of increase for 2011, while in the longer term (years 2047 to 2067) the 20-year average was used. After that time period,

the rate of inflation was reduced to help avoid potentially over-inflating the costs of projects that would not be built until the end of the projection period.

Discount Rate

HDR has based the projected discount rate on the market yield for U.S. Treasury securities with a 30-year maturity. This would represent what the City of Lubbock would expect to earn on funds invested rather than spent to construct projects. Like the CCI index above, this value has seen tremendous fluctuations in the past, and it is difficult to project future values within any confidence. Over the last 20 years, the average annual market return for T-bills has been 5.7%, while the return in 2011 was only 3.9%.

HDR has broken the 100-year forecast period into the same four time blocks as detailed above. The recommended discount rates for these time periods are shown below.

Years		Years		Years		Years	
2014	2025	2026	2046	2047	2067	2068	2113
4.3%		5.3%		5.7%		5.1%	

HDR has kept the near-term discount rate slightly higher than the market return for 2011. After that, the discount rate would gradually increase to the 20 year average of 5.7% before dropping in the last time period to match the reduction in the rate of inflation.

Rate of Inflation for Power Cost

HDR has based the projected rate of inflation for power cost on the Annual Electric Power Industry report compiled by the U.S. Energy Information Administration (EIA). Over the last 10 years, the average annual increase in the price for power associated with industrial customers has been 3.8%, while the increase in 2011 was only 0.8%.

The recommended rate of inflation for power cost is shown below.

Years		Years		Years		Years	
2014	2025	2026	2046	2047	2067	2068	2113
1.0%		2.8%		3.8%		4.8%	

HDR has kept the near-term price increase slightly higher than the increase for 2011. After that, the annual price increase would gradually increase to the 20 year average of 3.8% for years 2047 to 2067 and then increase an additional percentage point in the final year grouping. The table below shows what the projected power cost would be per kWh.

2014	2025	2046	2067	2113
$ 0.08	$ 0.09	$ 0.16	$ 0.35	$ 3.01

As with the other variables, there have been large changes in the annual percent change in power prices over the past 10 years. This will likely continue into the future; however, it is felt that long-term electricity costs will continue to increase as inflation increases and as more stringent regulations are placed upon the power industry.

Bond Interest Rate

The recommended bond interest rate for all bonds issued during the planning period is 5.1%. This is consistent with a 20-year average market yield for a 20-year municipal general obligation bond for a municipality with a AA rating. Bond issue rates will vary from year to year and have varied greatly in the past; however, for purposes of this analysis is it recommended to simply use the 20-year average throughout the 100-year forecast period.

Appendix E-2

12 Year Financial Water rate Model
Rate Policy Comparison - Package 1

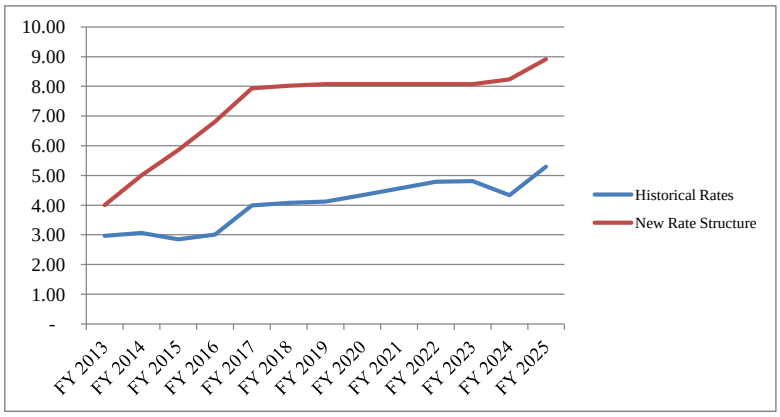
Volume Rates

Block	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
						Historical Rates							
Block 1	2.96	3.07	2.85	3.01	3.99	4.07	4.12	4.33	4.56	4.79	4.81	4.34	5.29
Block 2	4.75	4.92	4.57	4.84	6.40	6.54	6.62	6.95	7.32	7.69	7.72	6.96	8.50
Block 3	6.57	6.81	6.32	6.69	8.85	9.04	9.15	9.61	10.13	10.63	10.68	9.63	11.75
						New Rate Structure							
Block 1	4.00	5.00	5.85	6.82	7.94	8.02	8.08	8.08	8.08	8.08	8.08	8.24	8.92
Block 2	5.46	6.82	7.98	9.30	10.83	10.94	11.02	11.02	11.02	11.02	11.02	11.24	12.17
Block 3	6.55	8.18	9.57	11.15	12.99	13.12	13.22	13.22	13.22	13.22	13.22	13.49	14.60

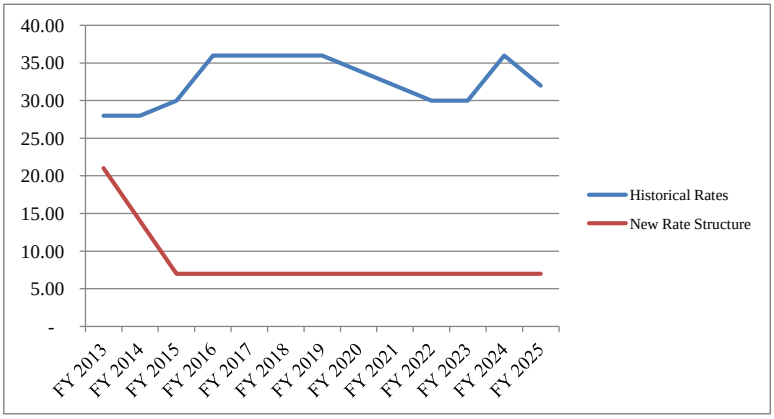
Base Charges

Meter Size	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
						Historical Rates							
0.75	28.00	28.00	30.00	36.00	36.00	36.00	36.00	34.00	32.00	30.00	30.00	36.00	32.00
						New Rate Structure							
0.75	21.00	14.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00

Volume Rate Comparison - Block 1



Base Rate Comparison - 0.75" Meter



Appendix E-3 - Inflated Cost Tables - Package 1: Baseline

Table 1. Inflated Project Cost*

Project Name	Original Project Cost	Year Financed	0	1	2	3	4	5	6	7	8	9	10	11
			2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BCWF Initial Capacity Maintenance (ICM)	$ 19,038,000	2014	$ 19,038,000											
LAH Phase 2	$ 65,711,000	2015		$ 67,682,330										
BCWF Capacity Maintenance (CM-1)	$ 5,723,000	2021								$ 7,038,568				
RCWF New Transmission Line	$ 104,328,000	2023										$ 136,124,377		
Direct Potable Reuse to NWTP (Phase 1)	$ 100,228,000	2052												
RCWF Capacity Maintenance (20 wells) #1	$ 18,439,000	2053												
RCWF Capacity Maintenance (20 wells) #2	$ 18,439,000	2083												
Direct Potable Reuse to NWTP (Phase 2)	$ 83,511,000	2052												

* Assumes an inflation rate of:

Years		Years		Years		Years	
2014	2025	2026	2046	2047	2067	2068	2113
3.0%		3.1%		3.2%		2.7%	

Table 4. Inflated O&M Cost (excludes power)*

Project Name	Original O&M Cost	Year Operational	0	1	2	3	4	5	6	7	8	9	10	11
			2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BCWF Initial Capacity Maintenance (ICM)	$ 133,000	2014	$ 133,000	$ 136,990	$ 141,100	$ 145,333	$ 149,693	$ 154,183	$ 158,809	$ 163,573	$ 168,480	$ 173,535	$ 178,741	$ 184,103
LAH Phase 2	$ 554,000	2017				$ 605,371	$ 623,532	$ 642,238	$ 661,505	$ 681,350	$ 701,791	$ 722,844	$ 744,530	$ 766,866
BCWF Capacity Maintenance (CM-1)	$ 40,000	2023										$ 52,191	$ 53,757	$ 55,369
RCWF New Transmission Line	$ 958,000	2025												$ 1,326,096
Direct Potable Reuse to NWTP (Phase 1)	$ 4,028,000	2054												
RCWF Capacity Maintenance (20 wells) #1	$ 344,000	2055												
RCWF Capacity Maintenance (20 wells) #2	$ 344,000	2085												
Direct Potable Reuse to NWTP (Phase 2)	$ 4,165,000	2054												
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total			**$ 133,000**	**$ 136,990**	**$ 141,100**	**$ 750,703**	**$ 773,225**	**$ 796,421**	**$ 820,314**	**$ 844,923**	**$ 870,271**	**$ 948,570**	**$ 977,027**	**$ 2,332,434**

* Assumes an inflation rate of:

Years		Years		Years		Years	
2014	2025	2026	2046	2047	2067	2068	2113
3.0%		3.1%		3.2%		2.7%	

Table 6. Inflated Power Cost*

Project Name	Total Project Power Consumption (KwH/year)	Year Operational	0	1	2	3	4	5	6	7	8	9	10	11
			2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BCWF Initial Capacity Maintenance (ICM)	1,416,554	2014	$ 113,324	$ 114,458	$ 115,602	$ 116,758	$ 117,926	$ 119,105	$ 120,296	$ 121,499	$ 122,714	$ 123,941	$ 125,181	$ 126,432
LAH Phase 2	21,516,191	2017				$ 1,773,452	$ 1,791,187	$ 1,809,099	$ 1,827,190	$ 1,845,462	$ 1,863,916	$ 1,882,555	$ 1,901,381	$ 1,920,395
BCWF Capacity Maintenance (CM-1)	272,804	2023										$ 23,869	$ 24,108	$ 24,349
RCWF New Transmission Line	71,004,097	2025												$ 5,069,890
Direct Potable Reuse to NWTP (Phase 1)	3,111,111	2054												
RCWF Capacity Maintenance (20 wells) #1	8,985,068	2055												
RCWF Capacity Maintenance (20 wells) #2	8,985,068	2085												
Direct Potable Reuse to NWTP (Phase 2)	1,544,444	2054												
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total			**$ 113,324**	**$ 114,458**	**$ 115,602**	**$ 1,890,210**	**$ 1,909,113**	**$ 1,928,204**	**$ 1,947,486**	**$ 1,966,961**	**$ 1,986,630**	**$ 2,030,365**	**$ 2,050,669**	**$ 7,141,065**

* Assumes an inflation rate of:

Years		Years		Years		Years	
2014	2025	2026	2046	2047	2067	2068	2113
1.0%		2.8%		3.8%		4.8%	

Appendix E-3
12 Year Financial Water Rate Model
Package 1 - Baseline

	Actual FY 2012	Proposed FY 2013	Forecast FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Revenues														
Interest Revenues	123,300	-	117,665	192,350	249,874	279,919	350,692	441,534	615,440	705,027	837,294	1,033,828	1,256,763	703,654
Revenue from Rentals	150,907	150,000	151,500	153,015	154,545	156,091	157,652	159,228	160,820	162,429	164,053	165,693	167,350	169,024
Revenue From Junk Sales	179,598	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Revenue From Metered Services	72,229,022	71,307,350	73,689,716	74,517,636	83,569,152	97,035,741	100,955,740	102,710,356	103,858,022	104,898,256	105,941,470	106,995,117	109,719,596	118,202,340
Revenue from Dept Operations	1,804,781	2,370,550	2,417,961	2,466,320	2,515,647	2,565,960	2,617,279	2,669,624	2,723,017	2,777,477	2,833,027	2,889,687	2,947,481	3,006,431
Transfers From Other Funds	129,387	130,701	130,604	131,438	131,994	133,371	133,229	133,868	134,368	135,224	135,042	33,855	33,696	-
Total Funding Sources	74,616,994	74,008,601	76,557,446	77,510,760	86,671,212	100,221,082	104,264,592	106,164,610	107,541,667	108,728,412	109,960,887	111,168,181	114,174,886	122,131,449
Expenditures														
Total Salaries	5,200,189	5,741,134	5,855,957	5,973,076	6,092,538	6,214,388	6,338,676	6,465,450	6,594,759	6,726,654	6,861,187	6,998,411	7,138,379	7,281,147
Total Benefits	2,777,464	3,120,784	3,301,475	3,497,607	3,710,673	3,942,311	4,194,324	4,468,694	4,767,600	5,093,437	5,448,840	5,836,704	6,260,214	6,722,872
Total Supplies	1,467,367	1,823,797	1,860,273	1,897,479	1,935,428	1,974,137	2,013,619	2,053,892	2,094,970	2,136,869	2,179,606	2,223,199	2,267,663	2,313,016
Total Maintenance	2,444,534	2,952,901	3,011,959	3,072,198	3,133,642	3,196,315	3,260,241	3,325,446	3,391,955	3,459,794	3,528,990	3,599,569	3,671,561	3,744,992
CRMWA Delivery Charges	4,885,692	5,740,990	5,855,810	5,972,926	6,092,385	6,214,232	6,338,517	6,465,287	6,594,593	6,726,485	6,861,014	6,998,235	7,138,199	7,280,963
Electric Utility Charges	2,177,657	3,742,558	3,783,617	3,825,127	3,867,093	3,909,519	3,952,410	3,995,773	4,039,610	4,083,929	4,128,734	4,174,030	4,219,824	4,266,119
Total Professional Services / Training	994,884	989,060	1,008,841	1,029,018	1,049,598	1,070,590	1,092,002	1,113,842	1,136,119	1,158,841	1,182,018	1,205,659	1,229,772	1,254,367
Total Scheduled Charges	1,086,404	1,162,810	1,186,066	1,209,787	1,233,983	1,258,663	1,283,836	1,309,513	1,335,703	1,362,417	1,389,665	1,417,459	1,445,808	1,474,724
Total Other Charges	170,283	22,200	268,968	274,544	280,261	2,664,944	2,706,848	2,749,626	2,793,300	2,837,895	2,883,432	3,005,997	3,055,299	9,501,654
Total Capital Outlay	454,836	405,000	413,100	421,362	429,789	438,385	447,153	456,096	465,218	474,522	484,012	493,693	503,567	513,638
O&M Costs Related to Package 1	-	-	133,000	136,990	141,100	750,703	773,225	796,421	820,314	844,923	870,271	948,570	977,027	2,332,434
Power Costs Related to Package 1	-	-	113,324	114,458	115,602	1,890,210	1,909,113	1,928,204	1,947,486	1,966,961	1,986,630	2,030,365	2,050,669	7,141,065
Total Transfers	10,706,068	11,854,757	12,230,115	12,516,413	13,302,014	14,358,058	14,851,012	15,222,868	15,571,081	15,915,843	16,271,555	16,634,210	17,113,536	17,898,821
Total Other Expenditures	86,871	-	-	-	-	-	-	-	-	-	-	-	-	-
Pay-As-You-Go Funding in CIP	800,000	420,000	500,000	500,000	-	-	-	-	-	-	-	-	-	-
Existing Debt Service	37,969,278	39,702,132	39,733,583	39,571,380	39,565,945	39,570,757	39,378,464	38,891,551	36,041,669	33,915,669	30,143,255	29,260,833	29,163,992	28,355,961
Less: Interest Earnings on Bond Proceeds	(113,595)	(93,796)	(122,353)	(310,202)	(298,753)	(264,618)	(148,520)	(66,400)	(20,300)	(42,231)	(28,154)	(639,811)	(417,156)	(208,578)
Less: Build America Bond Subsidy	(1,596,635)	(1,595,060)	(1,595,060)	(1,595,060)	(1,595,060)	(1,595,060)	(1,553,801)	(1,469,108)	(1,378,945)	(1,283,891)	(1,184,636)	(1,078,400)	(964,761)	(838,095)
New Debt Service - Current CIP Projections	-	-	-	2,067,586	4,912,718	6,437,856	7,782,587	8,982,197	8,982,197	8,982,197	8,982,197	8,982,197	8,982,197	8,156,138
New Debt Service - Related to Package 1	-	-	-	1,532,925	6,982,652	6,982,652	6,982,652	6,982,652	6,982,652	6,982,652	7,549,392	7,549,392	15,946,659	15,946,659
RCWF Transmission Line - Pay-As-You-Go Funding in CIP	-	-	-	-	-	-	-	-	-	-	-	-	31,835,384	-
Existing Master Lease	823,931	900,990	844,998	956,700	1,044,185	1,143,629	1,281,979	1,156,219	902,335	772,075	596,196	381,116	212,487	91,349
Total Expenditures	70,335,227	76,890,256	78,383,674	82,664,315	91,995,793	100,157,672	102,884,337	104,828,221	103,062,315	102,115,040	100,134,207	100,021,427	141,830,319	123,229,247
Total Expenditures (Over)/Under Revenues	4,281,767	(2,881,655)	(1,826,228)	(5,153,555)	(5,324,581)	63,410	1,380,255	1,336,389	4,479,352	6,613,372	9,826,680	11,146,754	(27,655,433)	(1,097,798)
Net Asset Calculation														
Appropriable Net Assets:	43,177,960	40,296,304	38,470,076	33,316,522	27,991,941	28,055,351	29,435,605	30,771,994	35,251,346	41,864,718	51,691,398	62,838,152	35,182,719	34,084,921
Less: Reserve for RCWF Tranmission Line	-	-	-	-	-	-	-	(1,147,621)	(5,265,406)	(11,542,654)	(21,031,021)	(31,835,384)	-	-
Less: Appropriable Net Asset Policy	(18,546,178)	(18,456,975)	(19,064,794)	(19,284,243)	(21,559,836)	(24,939,448)	(25,932,668)	(26,384,802)	(26,685,465)	(26,959,540)	(27,234,637)	(27,512,624)	(28,208,607)	(30,344,449)
Total Appropriable Net Assets	24,631,782	21,839,329	19,405,282	14,032,279	6,432,105	3,115,903	3,502,938	3,239,571	3,300,475	3,362,524	3,425,740	3,490,143	6,974,112	3,740,472
Coverage	1.33	1.15	1.19	1.10	1.09	1.20	1.23	1.23	1.31	1.37	1.47	1.51	1.31	1.23
Base rate as a % of debt service	101.09%	82.12%	57.39%	29.54%	19.91%	19.51%	19.26%	19.17%	20.42%	21.48%	23.19%	23.83%	20.26%	21.06%
Rate Analysis	December	December	December	December	December	December	December	December	December	December	December	December	December	December
Base Rate	28.00	21.00	14.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Tier 1	0.00%	49.81%	25.00%	17.00%	16.50%	16.50%	1.00%	0.75%	0.00%	0.00%	0.00%	0.00%	2.00%	8.25%
Tier 2	0.00%	27.34%	25.00%	17.00%	16.50%	16.50%	1.00%	0.75%	0.00%	0.00%	0.00%	0.00%	2.00%	8.25%
Tier 3	0.00%	10.48%	25.00%	17.00%	16.50%	16.50%	1.00%	0.75%	0.00%	0.00%	0.00%	0.00%	2.00%	8.25%

The proposed rate structure incorporated in this model is subject to change depending on many variables. Some of these variables may include: water volumes, interest rates, commodity prices, inflation rates, the operational impact of new facilities, and changes in the cost or priority of capital projects.

Appendix E-3
12 Year Financial Water Rate Model
Package 1 - Baseline

Base Charges

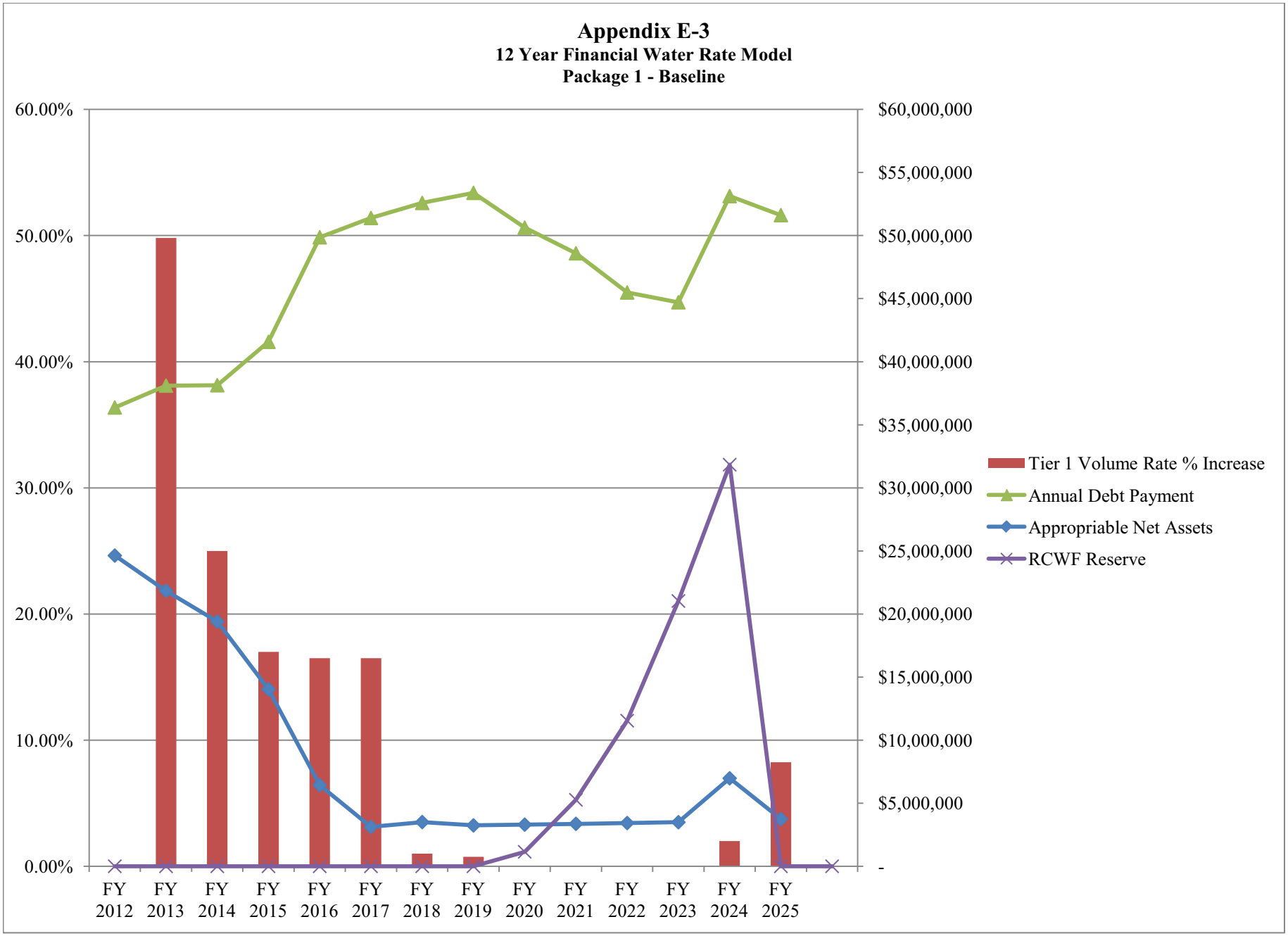
Meter Size	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
0.75	$ 8.89	18.00	18.00	24.00	28.00	21.00	14.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
1.00	14.84	30.05	30.05	40.06	46.74	35.06	23.37	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69
1.50	29.59	59.91	59.91	79.88	93.20	69.90	46.60	23.30	23.30	23.30	23.30	23.30	23.30	23.30	23.30	23.30	23.30	23.30
2.00	47.56	96.30	96.30	128.40	149.80	112.35	74.90	37.45	37.45	37.45	37.45	37.45	37.45	37.45	37.45	37.45	37.45	37.45
3.00	94.81	191.97	191.97	255.96	298.61	223.96	149.31	74.65	74.65	74.65	74.65	74.65	74.65	74.65	74.65	74.65	74.65	74.65
4.00	148.12	299.91	299.91	399.87	466.52	349.89	233.26	116.63	116.63	116.63	116.63	116.63	116.63	116.63	116.63	116.63	116.63	116.63
6.00	296.16	599.65	599.65	799.53	932.79	699.59	466.39	233.20	233.20	233.20	233.20	233.20	233.20	233.20	233.20	233.20	233.20	233.20
8.00	473.87	959.47	959.47	1,279.29	1,492.50	1,119.38	746.25	373.13	373.13	373.13	373.13	373.13	373.13	373.13	373.13	373.13	373.13	373.13
10.00	681.26	1,379.38	1,379.38	1,839.17	2,145.70	1,609.28	1,072.85	536.43	536.43	536.43	536.43	536.43	536.43	536.43	536.43	536.43	536.43	536.43

Volume Rates

Block	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
1	$ 2.42	2.67	2.67	2.67	2.67	4.00	5.00	5.85	6.82	7.94	8.02	8.08	8.08	8.08	8.08	8.08	8.24	8.92
2	3.03	4.29	4.29	4.29	4.29	5.46	6.82	7.98	9.30	10.83	10.94	11.02	11.02	11.02	11.02	11.02	11.24	12.17
3	4.19	5.93	5.93	5.93	5.93	6.55	8.18	9.57	11.15	12.99	13.12	13.22	13.22	13.22	13.22	13.22	13.49	14.60

Sample Bill (Average User based on 7,000 gallons per month)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
.75" meter	$ 25.83	36.69	36.69	42.69	46.69	49.00	49.00	47.95	54.71	62.58	63.13	63.56	63.56	63.56	63.56	63.56	64.69	69.45
% increase		42.0%	0.0%	16.4%	9.4%	4.9%	0.0%	-2.1%	14.1%	14.4%	0.9%	0.7%	0.0%	0.0%	0.0%	0.0%	1.8%	7.4%
1" meter	$ 31.78	48.74	48.74	58.75	65.43	63.06	58.37	52.64	59.39	67.26	67.82	68.24	68.24	68.24	68.24	68.24	69.37	74.13
% increase		53.4%	0.0%	20.6%	11.4%	-3.6%	-7.4%	-9.8%	12.8%	13.3%	0.8%	0.6%	0.0%	0.0%	0.0%	0.0%	1.7%	6.9%


Appendix E-3
12 Year Financial Water Rate Model
Package 1 - Baseline
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
$60,000,000
$55,000,000
$50,000,000
$45,000,000
$40,000,000
$35,000,000
$30,000,000
$25,000,000
$20,000,000
$15,000,000
$10,000,000
$5,000,000
-
FY 2012
FY 2013
FY 2014
FY 2015
FY 2016
FY 2017
FY 2018
FY 2019
FY 2020
FY 2021
FY 2022
FY 2023
FY 2024
FY 2025
Tier 1 Volume Rate % Increase
Annual Debt Payment
Appropriable Net Assets
RCWF Reserve

Appendix E-4 - Inflated Cost Tables - Package 2: LAH Phase 2 Delayed

Table 1. Inflated Project Cost*

Project Name	Original Project Cost	Year Financed	0	1	2	3	4	5	6	7	8	9	10	11
			2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BCWF Initial Capacity Maintenance (ICM)	$ 19,038,000	2014	$ 19,038,000											
BCWF Capacity Maintenance (CM-1)	$ 5,723,000	2015		$ 5,894,690										
BCWF Capacity Maintenance (CM-2)	$ 5,723,000	2021								$ 7,038,568				
RCWF New Transmission Line	$ 104,328,000	2023										$ 136,124,377		
LAH Phase 2	$ 65,711,000	2029												
North Fork Diversion at CR 7300	$ 54,260,000	2052												
RCWF Capacity Maintenance (20 wells) #1	$ 18,439,000	2053												
RCWF Capacity Maintenance (20 wells) #2	$ 18,439,000	2083												

* Assumes an inflation rate of:

Years		Years		Years		Years	
2014	2025	2026	2046	2047	2067	2068	2113
3.0%		3.1%		3.2%		2.7%	

Table 4. Inflated O&M Cost (excludes power)*

Project Name	Original O&M Cost	Year Operational	0	1	2	3	4	5	6	7	8	9	10	11
			2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BCWF Initial Capacity Maintenance (ICM)	$ 133,000	2014	$ 133,000	$ 136,990	$ 141,100	$ 145,333	$ 149,693	$ 154,183	$ 158,809	$ 163,573	$ 168,480	$ 173,535	$ 178,741	$ 184,103
BCWF Capacity Maintenance (CM-1)	$ 40,000	2017				$ 43,709	$ 45,020	$ 46,371	$ 47,762	$ 49,195	$ 50,671	$ 52,191	$ 53,757	$ 55,369
BCWF Capacity Maintenance (CM-2)	$ 40,000	2023										$ 52,191	$ 53,757	$ 55,369
RCWF New Transmission Line	$ 958,000	2025												$ 1,326,096
LAH Phase 2	$ 554,000	2031												
North Fork Diversion at CR 7300	$ 1,775,000	2054												
RCWF Capacity Maintenance (20 wells) #1	$ 344,000	2055												
RCWF Capacity Maintenance (20 wells) #2	$ 344,000	2085												
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total			**$ 133,000**	**$ 136,990**	**$ 141,100**	**$ 189,042**	**$ 194,713**	**$ 200,554**	**$ 206,571**	**$ 212,768**	**$ 219,151**	**$ 277,917**	**$ 286,254**	**$ 1,620,938**

* Assumes an inflation rate of:

Years		Years		Years		Years	
2014	2025	2026	2046	2047	2067	2068	2113
3.0%		3.1%		3.2%		2.7%	

Table 6. Inflated Power Cost*

Project Name	Total Project Power Consumption (KwH/year)	Year Operational	0	1	2	3	4	5	6	7	8	9	10	11
			2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BCWF Initial Capacity Maintenance (ICM)	1,416,554	2014	$ 113,324	$ 114,458	$ 115,602	$ 116,758	$ 117,926	$ 119,105	$ 120,296	$ 121,499	$ 122,714	$ 123,941	$ 125,181	$ 6,322
BCWF Capacity Maintenance (CM-1)	272,804	2017				$ 22,486	$ 22,710	$ 22,938	$ 23,167	$ 23,399	$ 23,633	$ 23,869	$ 24,108	$ 1,217
BCWF Capacity Maintenance (CM-2)	272,804	2023										$ 23,869	$ 24,108	$ 1,217
RCWF New Transmission Line	71,004,097	2025												$ 6,337,362
LAH Phase 2	21,516,191	2031												
North Fork Diversion at CR 7300	7,058,755	2054												
RCWF Capacity Maintenance (20 wells) #1	8,985,068	2055												
RCWF Capacity Maintenance (20 wells) #2	8,985,068	2085												
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total			**$ 113,324**	**$ 114,458**	**$ 115,602**	**$ 139,244**	**$ 140,636**	**$ 142,043**	**$ 143,463**	**$ 144,898**	**$ 146,347**	**$ 171,679**	**$ 173,396**	**$ 6,346,118**

* Assumes an inflation rate of:

Years		Years		Years		Years	
2014	2025	2026	2046	2047	2067	2068	2113
1.0%		2.8%		3.8%		4.8%	

Appendix E-4
12 Year Financial Water Rate Model
Package 2 - LAH Phase 2 Delayed

	Actual FY 2011	Budget FY 2012	Proposed FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
				----------Forecast----------											
Revenues															
Interest Revenues	$ 58,048	123,300	-	117,665	183,607	214,254	238,818	329,094	434,166	616,359	714,200	854,455	1,058,715	1,288,622	676,457
Revenue from Rentals	150,012	150,907	150,000	151,500	153,015	154,545	156,091	157,652	159,228	160,820	162,429	164,053	165,693	167,350	169,024
Revenue From Junk Sales	153,657	179,598	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Revenue From Metered Services	72,759,888	72,229,022	71,307,350	71,829,354	71,492,069	79,123,518	89,496,702	92,006,652	92,928,372	93,859,309	94,799,556	95,741,783	96,693,433	99,884,976	108,096,536
Revenue from Dept Operations	2,485,058	1,804,781	2,370,550	2,417,961	2,466,320	2,515,647	2,565,960	2,617,279	2,669,624	2,723,017	2,777,477	2,833,027	2,889,687	2,947,481	3,006,431
Transfers From Other Funds	129,025	129,387	130,701	130,604	131,438	131,994	133,371	133,229	133,868	134,368	135,224	135,042	33,855	33,696	-
Total Funding Sources	75,735,688	74,616,994	74,008,601	74,697,084	74,476,449	82,189,958	92,640,941	95,293,906	96,375,258	97,543,874	98,638,886	99,778,360	100,891,384	104,372,124	111,998,448
Expenditures															
Total Salaries	4,654,712	5,200,189	5,741,134	5,855,957	5,973,076	6,092,538	6,214,388	6,338,676	6,465,450	6,594,759	6,726,654	6,861,187	6,998,411	7,138,379	7,281,147
Total Benefits	2,159,808	2,777,464	3,120,784	3,301,475	3,497,607	3,710,673	3,942,311	4,194,324	4,468,694	4,767,600	5,093,437	5,448,840	5,836,704	6,260,214	6,722,872
Total Supplies	1,520,589	1,467,367	1,823,797	1,860,273	1,897,479	1,935,428	1,974,137	2,013,619	2,053,892	2,094,970	2,136,869	2,179,606	2,223,199	2,267,663	2,313,016
Total Maintenance	2,842,909	2,444,534	2,952,901	3,011,959	3,072,198	3,133,642	3,196,315	3,260,241	3,325,446	3,391,955	3,459,794	3,528,990	3,599,569	3,671,561	3,744,992
CRMWA Delivery Charges	5,312,866	4,885,692	5,740,990	5,855,810	5,972,926	6,092,385	6,214,232	6,338,517	6,465,287	6,594,593	6,726,485	6,861,014	6,998,235	7,138,199	7,280,963
Electric Utility Charges	2,118,296	2,177,657	3,742,558	3,783,617	3,825,127	3,867,093	3,909,519	3,952,410	3,995,773	4,039,610	4,083,929	4,128,734	4,174,030	4,219,824	4,266,119
Total Professional Services / Training	1,015,940	994,884	989,060	1,008,841	1,029,018	1,049,598	1,070,590	1,092,002	1,113,842	1,136,119	1,158,841	1,182,018	1,205,659	1,229,772	1,254,367
Total Scheduled Charges	863,885	1,086,404	1,162,810	1,186,066	1,209,787	1,233,983	1,258,663	1,283,836	1,309,513	1,335,703	1,362,417	1,389,665	1,417,459	1,445,808	1,474,724
Total Other Charges	37,661	170,283	22,200	268,968	274,544	280,261	352,316	359,860	367,598	375,535	383,677	392,029	476,657	487,253	7,995,211
Total Capital Outlay	395,276	454,836	405,000	413,100	421,362	429,789	438,385	447,153	456,096	465,218	474,522	484,012	493,693	503,567	513,638
O&M Costs Related to Package 2	-	-	-	133,000	136,990	141,100	189,042	194,713	200,554	206,571	212,768	219,151	277,917	286,254	1,620,938
Power Costs Related to Package 2	-	-	-	113,324	114,458	115,602	139,244	140,636	142,043	143,463	144,898	146,347	171,679	173,396	6,346,118
Total Transfers	9,807,941	10,706,068	11,854,757	12,118,493	12,334,355	13,033,138	13,903,250	14,312,771	14,635,506	14,971,213	15,310,471	15,660,604	16,017,602	16,525,370	17,290,841
Total Other Expenditures	104,728	86,871	-	-	-	-	-	-	-	-	-	-	-	-	-
Pay-As-You-Go Funding in CIP	150,000	800,000	420,000	500,000	500,000	-	-	-	-	-	-	-	-	-	-
Existing Debt Service	32,391,445	37,969,278	39,702,132	39,733,583	39,571,380	39,565,945	39,570,757	39,378,464	38,891,551	36,041,669	33,915,669	30,143,255	29,260,833	29,163,992	28,355,961
Less: Interest Earnings on Bond Proceeds	(246,406)	(113,595)	(93,796)	(122,353)	(161,912)	(175,177)	(171,937)	(148,520)	(66,400)	(20,300)	(42,231)	(28,154)	(614,801)	(400,483)	(200,241)
Less: Build America Bond Subsidy	(2,441,327)	(1,596,635)	(1,595,060)	(1,595,060)	(1,595,060)	(1,595,060)	(1,595,060)	(1,553,801)	(1,469,108)	(1,378,945)	(1,283,891)	(1,184,636)	(1,078,400)	(964,761)	(838,095)
New Debt Service - Current CIP Projections	-	-	-	-	2,067,586	4,912,718	6,437,856	7,782,587	8,982,197	8,982,197	8,982,197	8,982,197	8,982,197	8,982,197	8,156,138
New Debt Service - Related to Package 2	-	-	-	-	1,532,925	2,007,560	2,007,560	2,007,560	2,007,560	2,007,560	2,007,560	2,574,300	2,574,300	10,635,934	10,635,934
RCWF Transmission Line - Pay-As-You-Go Funding in CIP	-	-	-	-	-	-	-	-	-	-	-	-	-	36,003,740	-
Existing Master Lease	891,029	823,931	900,990	844,998	956,700	1,044,185	1,143,629	1,281,979	1,156,219	902,335	772,075	596,196	381,116	212,487	91,349
Total Expenditures	61,579,352	70,335,227	76,890,256	78,272,052	82,630,546	86,875,401	90,195,197	92,677,028	94,501,712	92,651,825	91,626,141	89,565,357	89,396,058	134,980,366	114,305,993
Total Expenditures (Over)/Under Revenues	$ 14,156,336	4,281,767	(2,881,655)	(3,574,968)	(8,154,098)	(4,685,443)	2,445,744	2,616,878	1,873,546	4,892,049	7,012,744	10,213,004	11,495,326	(30,608,242)	(2,307,545)
Net Asset Calculation															
Appropriable Net Assets:	$ 38,896,193	43,177,960	40,296,305	36,721,337	28,567,239	23,881,796	26,327,540	28,944,418	30,817,964	35,710,013	42,722,757	52,935,761	64,431,087	33,822,845	31,515,300
Less: Reserve for RCWF Transmission Line	-	-	-	-	-	-	-	-	(3,639,086)	(8,223,750)	(14,925,367)	(24,825,305)	(36,003,740)	-	-
Less: Appropriable Net Asset Policy	(18,848,740)	(18,546,178)	(18,456,975)	(18,599,704)	(18,527,851)	(20,448,427)	(23,054,688)	(23,695,396)	(23,939,306)	(24,185,787)	(24,434,865)	(24,684,716)	(24,937,204)	(25,749,952)	(27,817,998)
Total Appropriable Net Assets	$ 20,047,454	24,631,782	21,839,330	18,121,633	10,039,388	3,433,369	3,272,852	5,249,022	3,239,572	3,300,476	3,362,525	3,425,740	3,490,144	8,072,894	3,697,302
Coverage	1.65	1.33	1.15	1.14	1.03	1.10	1.26	1.27	1.25	1.34	1.40	1.52	1.57	1.36	1.22
Base rate as a % of debt service	93.64%	101.09%	82.12%	57.39%	29.54%	22.11%	21.60%	21.27%	21.13%	22.64%	23.94%	26.03%	26.81%	22.51%	23.48%
Rate Analysis	December	December	December	December	December	December	December	December	December	December	December	December	December	December	December
Base Rate	$ 24.00	28.00	21.00	14.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Tier 1	0.00%	0.00%	49.81%	20.00%	16.00%	15.00%	13.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.00%	8.75%
Tier 2	0.00%	0.00%	27.34%	20.00%	16.00%	15.00%	13.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.00%	8.75%
Tier 3	0.00%	0.00%	10.48%	20.00%	16.00%	15.00%	13.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.00%	8.75%

The proposed rate structure incorporated in this model is subject to change depending on many variables. Some of these variables may include: water volumes, interest rates, commodity prices, inflation rates, the operational impact of new facilities, and changes in the cost or priority of capital projects.

Appendix E-4
12 Year Financial Water Rate Model
Package 2 - LAH Phase 2 Delayed

Base Charges

Meter Size	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
0.75	$ 8.89	18.00	18.00	24.00	28.00	21.00	14.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
1.00	14.84	30.05	30.05	40.06	46.74	35.06	23.37	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69
1.50	29.59	59.91	59.91	79.88	93.20	69.90	46.60	23.30	23.30	23.30	23.30	23.30	23.30	23.30	23.30	23.30	23.30	23.30
2.00	47.56	96.30	96.30	128.40	149.80	112.35	74.90	37.45	37.45	37.45	37.45	37.45	37.45	37.45	37.45	37.45	37.45	37.45
3.00	94.81	191.97	191.97	255.96	298.61	223.96	149.31	74.65	74.65	74.65	74.65	74.65	74.65	74.65	74.65	74.65	74.65	74.65
4.00	148.12	299.91	299.91	399.87	466.52	349.89	233.26	116.63	116.63	116.63	116.63	116.63	116.63	116.63	116.63	116.63	116.63	116.63
6.00	296.16	599.65	599.65	799.53	932.79	699.59	466.39	233.20	233.20	233.20	233.20	233.20	233.20	233.20	233.20	233.20	233.20	233.20
8.00	473.87	959.47	959.47	1,279.29	1,492.50	1,119.38	746.25	373.13	373.13	373.13	373.13	373.13	373.13	373.13	373.13	373.13	373.13	373.13
10.00	681.26	1,379.38	1,379.38	1,839.17	2,145.70	1,609.28	1,072.85	536.43	536.43	536.43	536.43	536.43	536.43	536.43	536.43	536.43	536.43	536.43

Volume Rates

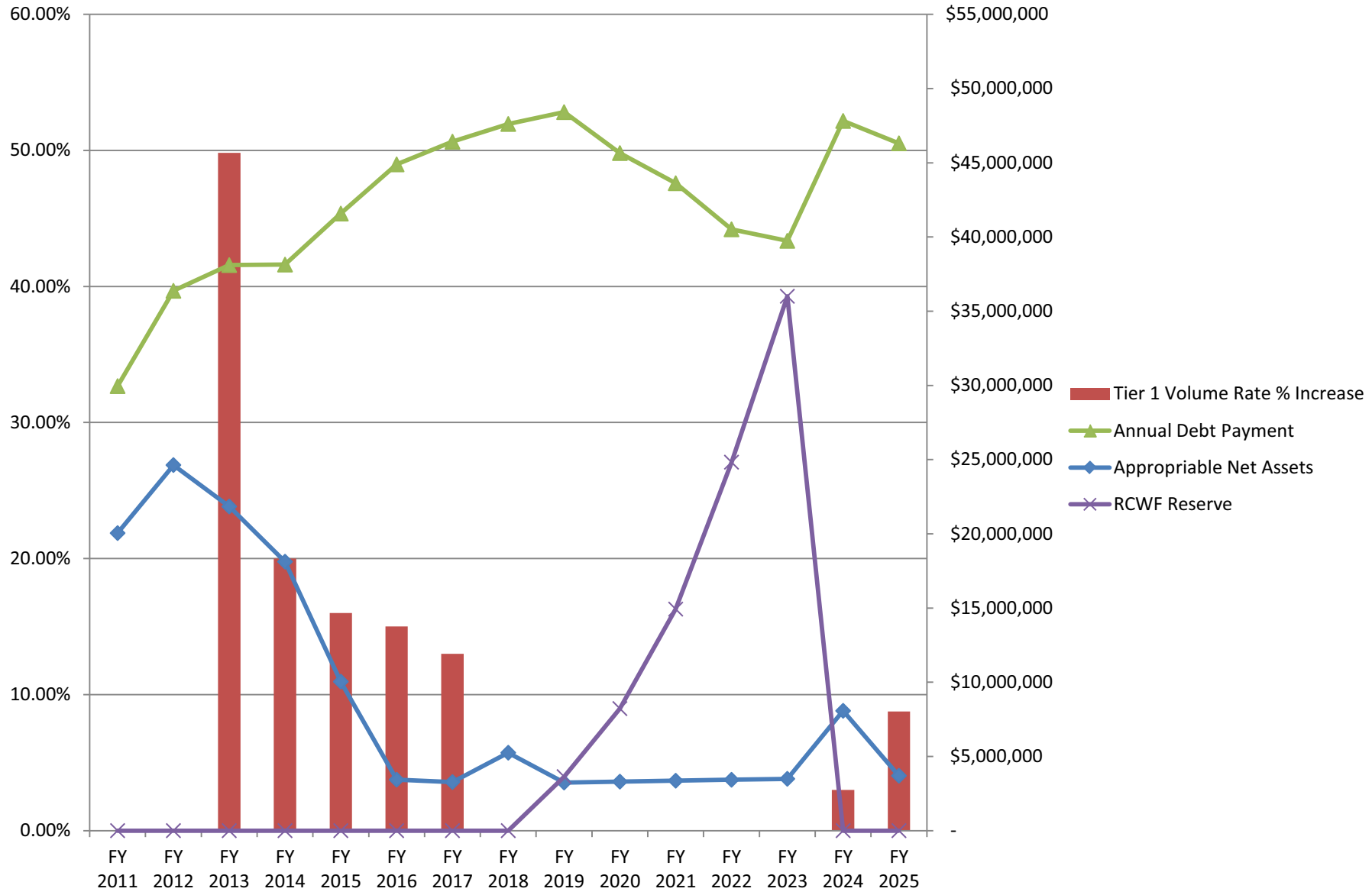
Block	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
1	$ 2.42	2.67	2.67	2.67	2.67	4.00	4.80	5.57	6.40	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.45	8.10
2	3.03	4.29	4.29	4.29	4.29	5.46	6.55	7.60	8.74	9.87	9.87	9.87	9.87	9.87	9.87	9.87	10.17	11.06
3	4.19	5.93	5.93	5.93	5.93	6.55	7.86	9.11	10.48	11.84	11.84	11.84	11.84	11.84	11.84	11.84	12.20	13.26

Sample Bill (Average User based on 7,000 gallons per month)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
.75" meter	$ 25.83	36.69	36.69	42.69	46.69	49.00	47.60	45.98	51.82	57.65	57.65	57.65	57.65	57.65	57.65	57.65	59.17	63.73
% increase		42.0%	0.0%	16.4%	9.4%	4.9%	-2.9%	-3.4%	12.7%	11.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.6%	7.7%
1" meter	$ 31.78	48.74	48.74	58.75	65.43	63.06	56.97	50.66	56.51	62.33	62.33	62.33	62.33	62.33	62.33	62.33	63.85	68.42
% increase		53.4%	0.0%	20.6%	11.4%	-3.6%	-9.7%	-11.1%	11.5%	10.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.4%	7.1%

Appendix E-4

12 Year Financial Water rate Model
Package 2 - LAH Phase 2 Delayed



Appendix E-5 - Inflated Cost Tables - Package 3: RCWF New Transmission Line Delayed

Table 1. Inflated Project Cost*

Project Name	Original Project Cost	Year Financed	0	1	2	3	4	5	6	7	8	9	10	11
			2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BCWF Initial Capacity Maintenance (ICM)	$ 19,038,000	2014	$ 19,038,000											
LAH Phase 2	$ 65,711,000	2015		$ 67,682,330										
Direct Potable Reuse to NWTP (Phase 1)	$ 100,228,000	2018					$ 112,807,497							
BCWF Capacity Maintenance (CM-1)	$ 5,723,000	2021								$ 7,038,568				
RCWF Capacity Maintenance (11 wells) #1	$ 9,614,000	2023										$ 12,544,089		
BCWF Capacity Maintenance (CM-2)	$ 5,723,000	2031												
RCWF New Transmission Line	$ 104,328,000	2033												
RCWF Capacity Maintenance (20 wells) #1	$ 18,439,000	2063												
RCWF Capacity Maintenance (20 wells) #2	$ 18,439,000	2093												
Direct Potable Reuse to NWTP (Phase 2)	$ 83,511,000	2045												

* Assumes an inflation rate of:

Years		Years		Years		Years	
2014	2025	2026	2046	2047	2067	2068	2113
3.0%		3.1%		3.2%		2.7%	

Table 4. Inflated O&M Cost (excludes power)*

Project Name	Original O&M Cost	Year Operational	0	1	2	3	4	5	6	7	8	9	10	11
			2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BCWF Initial Capacity Maintenance (ICM)	$ 133,000	2014	$ 133,000	$ 136,990	$ 141,100	$ 145,333	$ 149,693	$ 154,183	$ 158,809	$ 163,573	$ 168,480	$ 173,535	$ 178,741	$ 184,103
LAH Phase 2	$ 554,000	2017				$ 605,371	$ 623,532	$ 642,238	$ 661,505	$ 681,350	$ 701,791	$ 722,844	$ 744,530	$ 766,866
Direct Potable Reuse to NWTP (Phase 1)	$ 4,028,000	2020							$ 4,809,643	$ 4,953,932	$ 5,102,550	$ 5,255,626	$ 5,413,295	$ 5,575,694
BCWF Capacity Maintenance (CM-1)	$ 40,000	2023										$ 52,191	$ 53,757	$ 55,369
RCWF Capacity Maintenance (11 wells) #1	$ 68,000	2025												$ 94,128
BCWF Capacity Maintenance (CM-2)	$ 40,000	2033												
RCWF New Transmission Line	$ 958,000	2035												
RCWF Capacity Maintenance (20 wells) #1	$ 344,000	2065												
RCWF Capacity Maintenance (20 wells) #2	$ 344,000	2095												
Direct Potable Reuse to NWTP (Phase 2)	$ 4,165,000	2047												
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total			**$ 133,000**	**$ 136,990**	**$ 141,100**	**$ 750,703**	**$ 773,225**	**$ 796,421**	**$ 5,629,957**	**$ 5,798,855**	**$ 5,972,821**	**$ 6,204,196**	**$ 6,390,322**	**$ 6,676,160**

* Assumes an inflation rate of:

Years		Years		Years		Years	
2014	2025	2026	2046	2047	2067	2068	2113
3.0%		3.1%		3.2%		2.7%	

Table 6. Inflated Power Cost*

Project Name	Total Project Power Consumption (KwH/year)	Year Operational	0	1	2	3	4	5	6	7	8	9	10	11
			2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BCWF Initial Capacity Maintenance (ICM)	1,416,554	2014	$ 113,324	$ 114,458	$ 115,602	$ 116,758	$ 117,926	$ 119,105	$ 120,296	$ 121,499	$ 122,714	$ 123,941	$ 125,181	$ 126,432
LAH Phase 2	21,516,191	2017				$ 1,773,452	$ 1,791,187	$ 1,809,099	$ 1,827,190	$ 1,845,462	$ 1,863,916	$ 1,882,555	$ 1,901,381	$ 1,920,395
Direct Potable Reuse to NWTP (Phase 1)	3,111,111	2020							$ 67,635	$ 74,182	$ 80,853	$ 87,650	$ 94,575	$ 101,908
BCWF Capacity Maintenance (CM-1)	272,804	2023										$ 23,869	$ 24,108	$ 24,349
RCWF Capacity Maintenance (11 wells) #1	3,239,034	2025												$ 260,186
BCWF Capacity Maintenance (CM-2)	272,804	2033												
RCWF New Transmission Line	71,004,097	2035												
RCWF Capacity Maintenance (20 wells) #1	8,985,068	2065												
RCWF Capacity Maintenance (20 wells) #2	8,985,068	2095												
Direct Potable Reuse to NWTP (Phase 2)	1,544,444	2047												
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total			**$ 113,324**	**$ 114,458**	**$ 115,602**	**$ 1,890,210**	**$ 1,909,113**	**$ 1,928,204**	**$ 2,015,121**	**$ 2,041,143**	**$ 2,067,483**	**$ 2,118,016**	**$ 2,145,244**	**$ 2,433,269**

* Assumes an inflation rate of:

Years		Years		Years		Years	
2014	2025	2026	2046	2047	2067	2068	2113
1.0%		2.8%		3.8%		4.8%	

Assumes a current power cost of: $ 0.08 per KwH

Appendix E-5 - Inflated Cost Tables - Package 4: Conservation

Table 1. Inflated Project Cost*

Project Name	Original Project Cost	Year Financed	0	1	2	3	4	5	6	7	8	9	10	11
			2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BCWF Initial Capacity Maintenance (ICM)	$ 19,038,000	2014	$ 19,038,000											
LAH Phase 2	$ 65,711,000	2015		$ 67,682,330										
Direct Potable Reuse to NWTP (Phase 1)	$ 100,228,000	2018					$ 112,807,497							
BCWF Capacity Maintenance (CM-1)	$ 5,723,000	2021								$ 7,038,568				
RCWF Capacity Maintenance (11 wells) #1	$ 9,614,000	2023										$ 12,544,089		
RCWF Capacity Maintenance (11 wells) #2	$ 9,614,000	2053												
BCWF Capacity Maintenance (CM-2)	$ 5,723,000	2061												
RCWF Capacity Maintenance (11 wells) #3	$ 9,614,000	2083												
BCWF Capacity Maintenance (CM-3)	$ 5,723,000	2101												
Direct Potable Reuse to NWTP (Phase 2)	$ 83,511,000	2045												

* Assumes an inflation rate of:

Years		Years		Years		Years	
2014	2025	2026	2046	2047	2067	2068	2113
3.0%		3.1%		3.2%		2.7%	

Table 4. Inflated O&M Cost (excludes power)*

Project Name	Original O&M Cost	Year Operational	0	1	2	3	4	5	6	7	8	9	10	11
			2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BCWF Initial Capacity Maintenance (ICM)	$ 133,000	2014	$ 133,000	$ 136,990	$ 141,100	$ 145,333	$ 149,693	$ 154,183	$ 158,809	$ 163,573	$ 168,480	$ 173,535	$ 178,741	$ 184,103
LAH Phase 2	$ 554,000	2017				$ 605,371	$ 623,532	$ 642,238	$ 661,505	$ 681,350	$ 701,791	$ 722,844	$ 744,530	$ 766,866
Direct Potable Reuse to NWTP (Phase 1)	$ 4,028,000	2020							$ 4,809,643	$ 4,953,932	$ 5,102,550	$ 5,255,626	$ 5,413,295	$ 5,575,694
BCWF Capacity Maintenance (CM-1)	$ 40,000	2023										$ 52,191	$ 53,757	$ 55,369
RCWF Capacity Maintenance (11 wells) #1	$ 68,000	2025												$ 94,128
RCWF Capacity Maintenance (11 wells) #2	$ 68,000	2055												
BCWF Capacity Maintenance (CM-2)	$ 40,000	2063												
RCWF Capacity Maintenance (11 wells) #3	$ 68,000	2085												
BCWF Capacity Maintenance (CM-3)	$ 40,000	2103												
Direct Potable Reuse to NWTP (Phase 2)	$ 4,165,000	2047												
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total			**$ 133,000**	**$ 136,990**	**$ 141,100**	**$ 750,703**	**$ 773,225**	**$ 796,421**	**$ 5,629,957**	**$ 5,798,855**	**$ 5,972,821**	**$ 6,204,196**	**$ 6,390,322**	**$ 6,676,160**

* Assumes an inflation rate of:

Years		Years		Years		Years	
2014	2025	2026	2046	2047	2067	2068	2113
3.0%		3.1%		3.2%		2.7%	

Table 6. Inflated Power Cost*

Project Name	Total Project Power Consumption (KwH/year)	Year Operational	0	1	2	3	4	5	6	7	8	9	10	11
			2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BCWF Initial Capacity Maintenance (ICM)	1,416,554	2014	$ 113,324	$ 114,458	$ 115,602	$ 23,352	$ 23,585	$ 23,821	$ 24,059	$ 24,300	$ 24,543	$ 24,788	$ 25,036	$ 25,286
LAH Phase 2	21,516,191	2017				$ 1,773,452	$ 1,791,187	$ 1,809,099	$ 1,827,190	$ 1,845,462	$ 1,863,916	$ 1,882,555	$ 1,901,381	$ 1,920,395
Direct Potable Reuse to NWTP (Phase 1)	3,111,111	2020							$ 67,635	$ 74,182	$ 80,853	$ 87,650	$ 94,575	$ 101,908
BCWF Capacity Maintenance (CM-1)	272,804	2023										$ 4,774	$ 4,822	$ 4,870
RCWF Capacity Maintenance (11 wells) #1	3,239,034	2025												$ 289,095
RCWF Capacity Maintenance (11 wells) #2	3,239,034	2055												
BCWF Capacity Maintenance (CM-2)	272,804	2063												
RCWF Capacity Maintenance (11 wells) #3	3,239,034	2085												
BCWF Capacity Maintenance (CM-3)	272,804	2103												
Direct Potable Reuse to NWTP (Phase 2)	1,544,444	2047												
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total			**$ 113,324**	**$ 114,458**	**$ 115,602**	**$ 1,796,804**	**$ 1,814,772**	**$ 1,832,920**	**$ 1,918,884**	**$ 1,943,944**	**$ 1,969,312**	**$ 1,999,768**	**$ 2,025,814**	**$ 2,341,554**

* Assumes an inflation rate of:

Years		Years		Years		Years	
2014	2025	2026	2046	2047	2067	2068	2113
1.0%		2.8%		3.8%		4.8%	

Assumes a current power cost of: $ 0.08 per KwH

Appendix E-5
12 Year Financial Water Rate Model
Packages 3

	Actual FY 2011	Budget FY 2012	Proposed FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
				----------Forecast----------											
Revenues															
Interest Revenues	$ 58,048	123,300	-	117,665	201,094	308,755	443,930	649,640	934,272	718,950	673,607	660,969	705,546	758,169	783,794
Revenue from Rentals	150,012	150,907	150,000	151,500	153,015	154,545	156,091	157,652	159,228	160,820	162,429	164,053	165,693	167,350	169,024
Revenue From Junk Sales	153,657	179,598	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Revenue From Metered Services	72,759,888	72,229,022	71,307,350	75,550,078	81,000,501	92,606,261	104,866,176	109,638,082	112,402,897	113,789,125	114,928,670	116,072,189	117,227,143	118,393,646	119,571,815
Revenue from Dept Operations	2,485,058	1,804,781	2,370,550	2,417,961	2,466,320	2,515,647	2,565,960	2,617,279	2,669,624	2,723,017	2,777,477	2,833,027	2,889,687	2,947,481	3,006,431
Transfers From Other Funds	129,025	129,387	130,701	130,604	131,438	131,994	133,371	133,229	133,868	134,368	135,224	135,042	33,855	33,696	-
Total Funding Sources	75,735,688	74,616,994	74,008,601	78,417,808	84,002,368	95,767,202	108,215,528	113,245,882	116,349,889	117,576,280	118,727,406	119,915,279	121,071,925	122,350,342	123,581,064
Expenditures															
Total Salaries	4,654,712	5,200,189	5,741,134	5,855,957	5,973,076	6,092,538	6,214,388	6,338,676	6,465,450	6,594,759	6,726,654	6,861,187	6,998,411	7,138,379	7,281,147
Total Benefits	2,159,808	2,777,464	3,120,784	3,301,475	3,497,607	3,710,673	3,942,311	4,194,324	4,468,694	4,767,600	5,093,437	5,448,840	5,836,704	6,260,214	6,722,872
Total Supplies	1,520,589	1,467,367	1,823,797	1,860,273	1,897,479	1,935,428	1,974,137	2,013,619	2,053,892	2,094,970	2,136,869	2,179,606	2,223,199	2,267,663	2,313,016
Total Maintenance	2,842,909	2,444,534	2,952,901	3,011,959	3,072,198	3,133,642	3,196,315	3,260,241	3,325,446	3,391,955	3,459,794	3,528,990	3,599,569	3,671,561	3,744,992
CRMWA Delivery Charges	5,312,866	4,885,692	5,740,990	5,855,810	5,972,926	6,092,385	6,214,232	6,338,517	6,465,287	6,594,593	6,726,485	6,861,014	6,998,235	7,138,199	7,280,963
Electric Utility Charges	2,118,296	2,177,657	3,742,558	3,783,617	3,825,127	3,867,093	3,909,519	3,952,410	3,995,773	4,039,610	4,083,929	4,128,734	4,174,030	4,219,824	4,266,119
Total Professional Services / Training	1,015,940	994,884	989,060	1,008,841	1,029,018	1,049,598	1,070,590	1,092,002	1,113,842	1,136,119	1,158,841	1,182,018	1,205,659	1,229,772	1,254,367
Total Scheduled Charges	863,885	1,086,404	1,162,810	1,186,066	1,209,787	1,233,983	1,258,663	1,283,836	1,309,513	1,335,703	1,362,417	1,389,665	1,417,459	1,445,808	1,474,724
Total Other Charges	37,661	170,283	22,200	268,968	274,544	280,261	2,664,944	2,706,848	2,749,626	7,670,578	7,866,009	8,066,835	8,349,274	8,563,170	9,137,584
Total Capital Outlay	395,276	454,836	405,000	413,100	421,362	429,789	438,385	447,153	456,096	465,218	474,522	484,012	493,693	503,567	513,638
O&M Costs Related to Packages 3 & 4	-	-	-	133,000	136,990	141,100	750,703	773,225	796,421	5,629,957	5,798,855	5,972,821	6,204,196	6,390,322	6,676,160
Power Costs Related to Packages 3 & 4	-	-	-	113,324	114,458	115,602	1,890,210	1,909,113	1,928,204	2,015,121	2,041,143	2,067,483	2,118,016	2,145,244	2,433,269
Total Transfers	9,807,941	10,706,068	11,854,757	12,341,736	12,905,910	13,847,773	14,837,725	15,389,890	15,833,984	16,173,158	16,515,783	16,868,819	17,228,435	17,604,063	17,985,798
Total Other Expenditures	104,728	86,871	-	-	-	-	-	-	-	-	-	-	-	-	-
Pay-As-You-Go Funding in CIP	150,000	800,000	420,000	500,000	500,000	-	-	-	-	-	-	-	-	-	-
Existing Debt Service	32,391,445	37,969,278	39,702,132	39,733,583	39,571,380	39,565,945	39,570,757	39,378,464	38,891,551	36,041,669	33,915,669	30,143,255	29,260,833	29,163,992	28,355,961
Less: Interest Earnings on Bond Proceeds	(246,406)	(113,595)	(93,796)	(122,353)	(310,202)	(298,753)	(264,618)	(639,443)	(393,682)	(183,941)	(42,231)	(28,154)	(89,342)	(50,176)	(25,088)
Less: Build America Bond Subsidy	(2,441,327)	(1,596,635)	(1,595,060)	(1,595,060)	(1,595,060)	(1,595,060)	(1,595,060)	(1,553,801)	(1,469,108)	(1,378,945)	(1,283,891)	(1,184,636)	(1,078,400)	(964,761)	(838,095)
New Debt Service - Current CIP Projections	-	-	-	-	2,067,586	4,912,718	6,437,856	7,782,587	8,982,197	8,982,197	8,982,197	8,982,197	8,982,197	8,982,197	8,156,138
New Debt Service - Related to Packages 3 & 4	-	-	-	-	1,532,925	6,982,652	6,982,652	6,982,652	13,570,771	13,570,771	13,570,771	14,137,511	14,137,511	15,147,551	15,147,551
Package 3 - Pay-As-You-Go Funding in CIP	-	-	-	-	-	-	-	-	30,987,022	-	-	-	-	-	-
Existing Master Lease	891,029	823,931	900,990	844,998	956,700	1,044,185	1,143,629	1,281,979	1,156,219	902,335	772,075	596,196	381,116	212,487	91,349
Total Expenditures	61,579,352	70,335,227	76,890,256	78,495,296	83,053,811	92,541,552	100,637,339	102,932,291	142,687,197	119,843,426	119,359,328	117,686,396	118,440,794	121,069,076	121,972,465
Total Expenditures (Over)/Under Revenues	$ 14,156,336	4,281,767	(2,881,655)	(77,488)	948,557	3,225,650	7,578,189	10,313,590	(26,337,308)	(2,267,146)	(631,922)	2,228,883	2,631,131	1,281,266	1,608,598
Net Asset Calculation															
Appropriable Net Assets:	$ 38,896,193	43,177,960	40,296,305	40,218,817	41,167,374	44,393,024	51,971,214	62,284,804	35,947,496	33,680,350	33,048,428	35,277,312	37,908,442	39,189,708	40,798,307
Less: Reserve for Packages 3 & 4 Debt Service	-	-	-	(17,597,336)	(17,156,288)	(17,445,886)	(21,916,728)	(30,987,022)	-	-	-	-	-	-	-
Less: Appropriable Net Asset Policy	(18,848,740)	(18,546,178)	(18,456,975)	(19,529,885)	(20,904,959)	(23,819,113)	(26,897,057)	(28,103,253)	(28,807,937)	(29,168,241)	(29,467,144)	(29,767,317)	(30,070,631)	(30,377,119)	(30,686,817)
Total Appropriable Net Assets	$ 20,047,454	24,631,782	21,839,330	3,091,597	3,106,127	3,128,026	3,157,429	3,194,529	7,139,558	4,512,109	3,581,285	5,509,995	7,837,811	8,812,589	10,111,489
Coverage	1.65	1.33	1.15	1.24	1.25	1.26	1.35	1.40	1.27	1.17	1.21	1.28	1.29	1.27	1.29
Base rate as a % of debt service	93.64%	101.09%	82.12%	57.39%	29.54%	19.91%	19.51%	19.26%	17.06%	18.06%	18.92%	20.25%	20.77%	20.57%	21.39%
Rate Analysis	December	December	December	December	December	December	December	December	December	December	December	December	December	December	December
Base Rate	$ 24.00	28.00	21.00	14.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Tier 1	0.00%	0.00%	49.81%	30.00%	25.00%	17.50%	12.50%	2.25%	1.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Tier 2	0.00%	0.00%	27.34%	30.00%	25.00%	17.50%	12.50%	2.25%	1.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Tier 3	0.00%	0.00%	10.48%	30.00%	25.00%	17.50%	12.50%	2.25%	1.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

The proposed rate structure incorporated in this model is subject to change depending on many variables. Some of these variables may include: water volumes, interest rates, commodity prices, inflation rates, the operational impact of new facilities, and changes in the cost or priority of capital projects.

Appendix E-5
12 Year Financial Water Rate Model
Packages 3 and 4

Base Charges

Meter Size	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
0.75	$ 8.89	18.00	18.00	24.00	28.00	21.00	14.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
1.00	14.84	30.05	30.05	40.06	46.74	35.06	23.37	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69
1.50	29.59	59.91	59.91	79.88	93.20	69.90	46.60	23.30	23.30	23.30	23.30	23.30	23.30	23.30	23.30	23.30	23.30	23.30
2.00	47.56	96.30	96.30	128.40	149.80	112.35	74.90	37.45	37.45	37.45	37.45	37.45	37.45	37.45	37.45	37.45	37.45	37.45
3.00	94.81	191.97	191.97	255.96	298.61	223.96	149.31	74.65	74.65	74.65	74.65	74.65	74.65	74.65	74.65	74.65	74.65	74.65
4.00	148.12	299.91	299.91	399.87	466.52	349.89	233.26	116.63	116.63	116.63	116.63	116.63	116.63	116.63	116.63	116.63	116.63	116.63
6.00	296.16	599.65	599.65	799.53	932.79	699.59	466.39	233.20	233.20	233.20	233.20	233.20	233.20	233.20	233.20	233.20	233.20	233.20
8.00	473.87	959.47	959.47	1,279.29	1,492.50	1,119.38	746.25	373.13	373.13	373.13	373.13	373.13	373.13	373.13	373.13	373.13	373.13	373.13
10.00	681.26	1,379.38	1,379.38	1,839.17	2,145.70	1,609.28	1,072.85	536.43	536.43	536.43	536.43	536.43	536.43	536.43	536.43	536.43	536.43	536.43

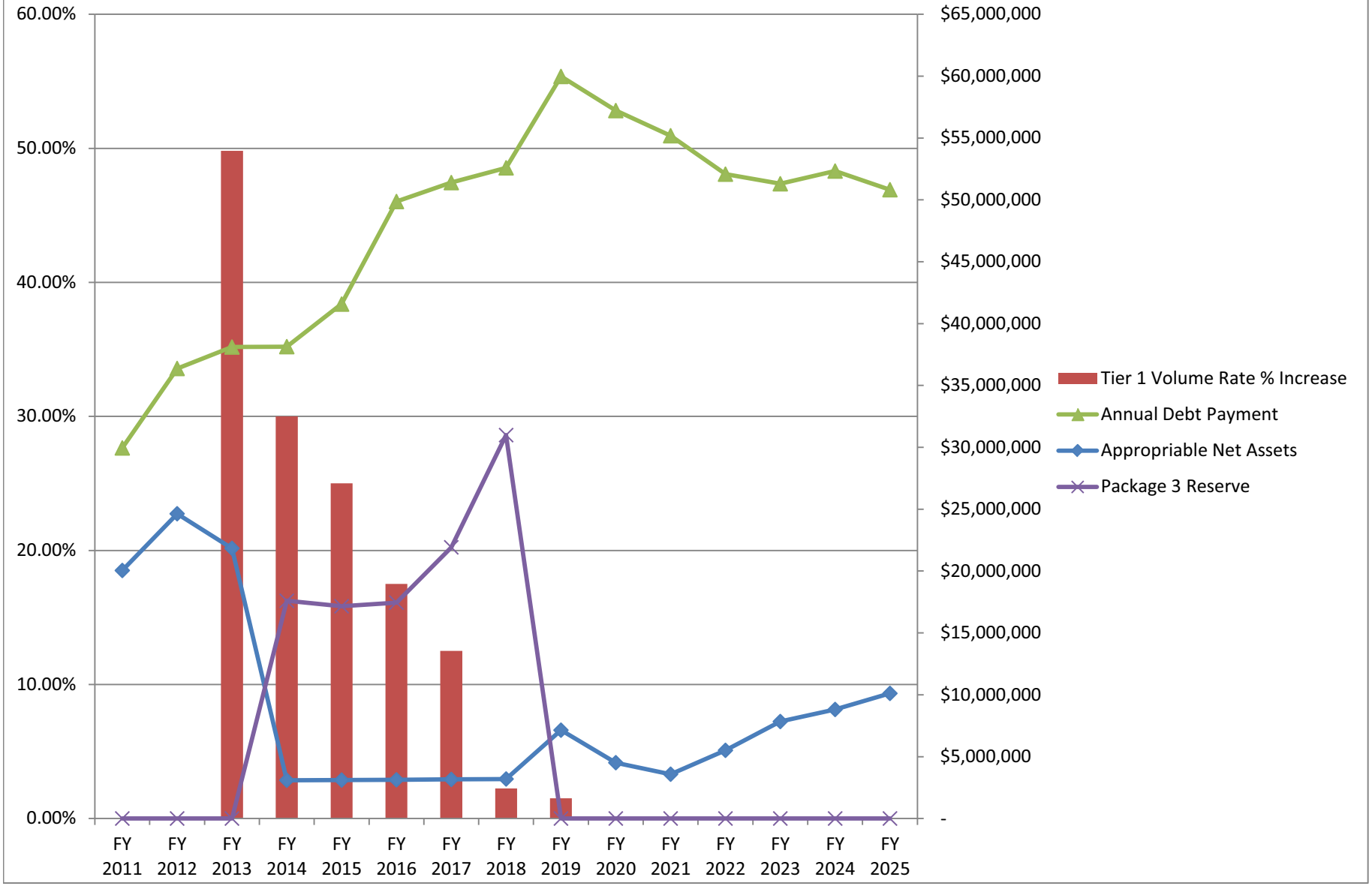
Volume Rates

Block	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
1	$ 2.42	2.67	2.67	2.67	2.67	4.00	5.20	6.50	7.64	8.59	8.79	8.92	8.92	8.92	8.92	8.92	8.92	8.92
2	3.03	4.29	4.29	4.29	4.29	5.46	7.09	8.87	10.42	11.72	11.99	12.17	12.17	12.17	12.17	12.17	12.17	12.17
3	4.19	5.93	5.93	5.93	5.93	6.55	8.51	10.64	12.50	14.06	14.38	14.59	14.59	14.59	14.59	14.59	14.59	14.59

Sample Bill (Average User based on 7,000 gallons per month)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
.75" meter	$ 25.83	36.69	36.69	42.69	46.69	49.00	50.40	52.50	60.46	67.15	68.50	69.42	69.42	69.42	69.42	69.42	69.42	69.42
% increase		42.0%	0.0%	16.4%	9.4%	4.9%	2.9%	4.2%	15.2%	11.1%	2.0%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1" meter	$ 31.78	48.74	48.74	58.75	65.43	63.06	59.77	57.19	65.15	71.83	73.18	74.11	74.11	74.11	74.11	74.11	74.11	74.11
% increase		53.4%	0.0%	20.6%	11.4%	-3.6%	-5.2%	-4.3%	13.9%	10.3%	1.9%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Appendix E-5
12 Year Financial Water Rate Model
Packages 3 & 4



Appendix E-6 - Inflated Cost Tables - Package 5: Accelerated Growth

Table 1. Inflated Project Cost*

Project Name	Original Project Cost	Year Financed	0	1	2	3	4	5	6	7	8	9	10	11
			2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BCWF Initial Capacity Maintenance (ICM)	$ 19,038,000	2014	$ 19,038,000											
LAH Phase 2	$ 65,711,000	2015		$ 67,682,330										
Direct Potable Reuse to NWTP (Phase 1)	$ 100,228,000	2018					$ 112,807,497							
BCWF Capacity Maintenance (CM-1)	$ 5,723,000	2021								$ 7,038,568				
RCWF New Transmission Line	$ 104,328,000	2023										$ 136,124,377		
North Fork Scalping Operation	$ 125,493,000	2053												
RCWF Capacity Maintenance (20 wells) #1	$ 18,439,000	2053												
Canyon Lake 7	$ 88,328,000	2077												
RCWF Capacity Maintenance (20 wells) #2	$ 18,439,000	2083												
Brackish Well Field at SWTP	$ 58,225,000	2096												
Direct Potable Reuse to NWTP (Phase 2)	$ 83,511,000	2045												

* Assumes an inflation rate of:	Years		Years		Years		Years	
	2014	2025	2026	2046	2047	2067	2068	2113
	3.0%		3.1%		3.2%		2.7%	

Table 4. Inflated O&M Cost (excludes power)*

Project Name	Original O&M Cost	Year Operational	0	1	2	3	4	5	6	7	8	9	10	11
			2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BCWF Initial Capacity Maintenance (ICM)	$ 133,000	2014	$ 133,000	$ 136,990	$ 141,100	$ 145,333	$ 149,693	$ 154,183	$ 158,809	$ 163,573	$ 168,480	$ 173,535	$ 178,741	$ 184,103
LAH Phase 2	$ 554,000	2017				$ 605,371	$ 623,532	$ 642,238	$ 661,505	$ 681,350	$ 701,791	$ 722,844	$ 744,530	$ 766,866
Direct Potable Reuse to NWTP (Phase 1)	$ 4,028,000	2020							$ 4,809,643	$ 4,953,932	$ 5,102,550	$ 5,255,626	$ 5,413,295	$ 5,575,694
BCWF Capacity Maintenance (CM-1)	$ 40,000	2023										$ 52,191	$ 53,757	$ 55,369
RCWF New Transmission Line	$ 958,000	2025												$ 1,326,096
North Fork Scalping Operation	$ 2,350,000	2055												
RCWF Capacity Maintenance (20 wells) #1	$ 344,000	2055												
Canyon Lake 7	$ 2,202,000	2079												
RCWF Capacity Maintenance (20 wells) #2	$ 344,000	2085												
Brackish Well Field at SWTP	$ 1,889,000	2098												
Direct Potable Reuse to NWTP (Phase 2)	$ 4,165,000	2047												
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total			**$ 133,000**	**$ 136,990**	**$ 141,100**	**$ 750,703**	**$ 773,225**	**$ 796,421**	**$ 5,629,957**	**$ 5,798,855**	**$ 5,972,821**	**$ 6,204,196**	**$ 6,390,322**	**$ 7,908,128**

* Assumes an inflation rate of:	Years		Years		Years		Years	
	2014	2025	2026	2046	2047	2067	2068	2113
	3.0%		3.1%		3.2%		2.7%	

Table 6. Inflated Power Cost*

Project Name	Total Project Power Consumption (KwH/year)	Year Operational	0	1	2	3	4	5	6	7	8	9	10	11
			2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BCWF Initial Capacity Maintenance (ICM)	1,416,554	2014	$ 113,324	$ 114,458	$ 115,602	$ 116,758	$ 117,926	$ 119,105	$ 120,296	$ 121,499	$ 122,714	$ 123,941	$ 125,181	$ 6,322
LAH Phase 2	21,516,191	2017				$ 1,773,452	$ 1,791,187	$ 1,809,099	$ 1,827,190	$ 1,845,462	$ 1,863,916	$ 1,882,555	$ 1,901,381	$ 1,920,395
Direct Potable Reuse to NWTP (Phase 1)	3,111,111	2020							$ 67,635	$ 74,182	$ 80,853	$ 87,650	$ 94,575	$ 101,908
BCWF Capacity Maintenance (CM-1)	272,804	2023										$ 23,869	$ 24,108	$ 1,217
RCWF New Transmission Line	71,004,097	2025												$ 5,069,890
North Fork Scalping Operation	26,373,064	2055												
RCWF Capacity Maintenance (20 wells) #1	8,985,068	2055												
Canyon Lake 7	4,133,147	2079												
RCWF Capacity Maintenance (20 wells) #2	8,985,068	2085												
Brackish Well Field at SWTP	4,108,890	2098												
Direct Potable Reuse to NWTP (Phase 2)	1,544,444	2047												
0			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total			**$ 113,324**	**$ 114,458**	**$ 115,602**	**$ 1,890,210**	**$ 1,909,113**	**$ 1,928,204**	**$ 2,015,121**	**$ 2,041,143**	**$ 2,067,483**	**$ 2,118,016**	**$ 2,145,244**	**$ 7,099,731**

* Assumes an inflation rate of:	Years		Years		Years		Years	
	2014	2025	2026	2046	2047	2067	2068	2113
	1.0%		2.8%		3.8%		4.8%	

Assumes a current power cost of: $ 0.08 per KwH

Appendix E-6
12 Year Financial Water Rate Model
Package 5 - Accelerated Growth

	Actual FY 2011	Budget FY 2012	Proposed FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
				----------Forecast----------											
Revenues															
Interest Revenues	$ 58,048	123,300	-	117,665	201,094	291,535	375,001	493,798	697,020	965,291	964,619	1,066,741	1,295,454	1,558,934	861,113
Revenue from Rentals	150,012	150,907	150,000	151,500	153,015	154,545	156,091	157,652	159,228	160,820	162,429	164,053	165,693	167,350	169,024
Revenue From Junk Sales	153,657	179,598	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Revenue From Metered Services	72,759,888	72,229,022	71,307,350	75,550,078	78,557,846	87,733,205	99,004,866	106,032,915	112,127,305	118,507,294	123,396,243	128,115,134	129,981,555	132,299,182	134,867,561
Revenue from Dept Operations	2,485,058	1,804,781	2,370,550	2,417,961	2,466,320	2,515,647	2,565,960	2,617,279	2,669,624	2,723,017	2,777,477	2,833,027	2,889,687	2,947,481	3,006,431
Transfers From Other Funds	129,025	129,387	130,701	130,604	131,438	131,994	133,371	133,229	133,868	134,368	135,224	135,042	33,855	33,696	-
Total Funding Sources	75,735,688	74,616,994	74,008,601	78,417,808	81,559,713	90,876,926	102,285,289	109,484,872	115,837,045	122,540,790	127,485,991	132,363,997	134,416,244	137,056,643	138,954,128
Expenditures															
Total Salaries	4,654,712	5,200,189	5,741,134	5,855,957	5,973,076	6,092,538	6,214,388	6,338,676	6,465,450	6,594,759	6,726,654	6,861,187	6,998,411	7,138,379	7,281,147
Total Benefits	2,159,808	2,777,464	3,120,784	3,301,475	3,497,607	3,710,673	3,942,311	4,194,324	4,468,694	4,767,600	5,093,437	5,448,840	5,836,704	6,260,214	6,722,872
Total Supplies	1,520,589	1,467,367	1,823,797	1,860,273	1,897,479	1,935,428	1,974,137	2,013,619	2,053,892	2,094,970	2,136,869	2,179,606	2,223,199	2,267,663	2,313,016
Total Maintenance	2,842,909	2,444,534	2,952,901	3,011,959	3,072,198	3,133,642	3,196,315	3,260,241	3,325,446	3,391,955	3,459,794	3,528,990	3,599,569	3,671,561	3,744,992
CRMWA Delivery Charges	5,312,866	4,885,692	5,740,990	5,855,810	5,972,926	6,092,385	6,214,232	6,338,517	6,465,287	6,594,593	6,726,485	6,861,014	6,998,235	7,138,199	7,280,963
Electric Utility Charges	2,118,296	2,177,657	3,742,558	3,783,617	3,825,127	3,867,093	3,909,519	3,952,410	3,995,773	4,039,610	4,083,929	4,128,734	4,174,030	4,219,824	4,266,119
Total Professional Services / Training	1,015,940	994,884	989,060	1,008,841	1,029,018	1,049,598	1,070,590	1,092,002	1,113,842	1,136,119	1,158,841	1,182,018	1,205,659	1,229,772	1,254,367
Total Scheduled Charges	863,885	1,086,404	1,162,810	1,186,066	1,209,787	1,233,983	1,258,663	1,283,836	1,309,513	1,335,703	1,362,417	1,389,665	1,417,459	1,445,808	1,474,724
Total Other Charges	37,661	170,283	22,200	268,968	274,544	280,261	2,664,944	2,706,848	2,749,626	7,670,578	7,866,009	8,066,835	8,349,274	8,563,170	15,036,014
Total Capital Outlay	395,276	454,836	405,000	413,100	421,362	429,789	438,385	447,153	456,096	465,218	474,522	484,012	493,693	503,567	513,638
O&M Costs Related to Package 5	-	-	-	133,000	136,990	141,100	750,703	773,225	796,421	5,629,957	5,798,855	5,972,821	6,204,196	6,390,322	7,908,128
Power Costs Related to Package 5	-	-	-	113,324	114,458	115,602	1,890,210	1,909,113	1,928,204	2,015,121	2,041,143	2,067,483	2,118,016	2,145,244	7,099,731
Total Transfers	9,807,941	10,706,068	11,854,757	12,341,736	12,759,351	13,554,356	14,481,910	15,164,229	15,803,214	16,471,028	17,041,298	17,615,742	18,029,094	18,486,442	18,908,182
Total Other Expenditures	104,728	86,871	-	-	-	-	-	-	-	-	-	-	-	-	-
Pay-As-You-Go Funding in CIP	150,000	800,000	420,000	500,000	500,000	-	-	-	-	-	-	-	-	-	-
Existing Debt Service	32,391,445	37,969,278	39,702,132	39,733,583	39,571,380	39,565,945	39,570,757	39,378,464	38,891,551	36,041,669	33,915,669	30,143,255	29,260,833	29,163,992	28,355,961
Less: Interest Earnings on Bond Proceeds	(246,406)	(113,595)	(93,796)	(122,353)	(310,202)	(298,753)	(264,618)	(825,365)	(517,630)	(245,915)	(42,231)	(28,154)	(583,639)	(379,708)	(189,854)
Less: Build America Bond Subsidy	(2,441,327)	(1,596,635)	(1,595,060)	(1,595,060)	(1,595,060)	(1,595,060)	(1,595,060)	(1,553,801)	(1,469,108)	(1,378,945)	(1,283,891)	(1,184,636)	(1,078,400)	(964,761)	(838,095)
New Debt Service - Current CIP Projections	-	-	-	-	2,067,586	4,912,718	6,437,856	7,782,587	8,982,197	8,982,197	8,982,197	8,982,197	8,982,197	8,982,197	8,156,138
New Debt Service - Related to Package 5	-	-	-	-	1,532,925	6,982,652	6,982,652	6,982,652	16,065,822	16,065,822	16,065,822	16,632,562	16,632,562	24,276,011	24,276,011
Package 5 - Pay-As-You-Go Funding in CIP	-	-	-	-	-	-	-	-	-	-	-	-	-	41,197,337	-
Existing Master Lease	891,029	823,931	900,990	844,998	956,700	1,044,185	1,143,629	1,281,979	1,156,219	902,335	772,075	596,196	381,116	212,487	91,349
Total Expenditures	61,579,352	70,335,227	76,890,256	78,495,296	82,907,252	92,248,136	100,281,525	102,520,709	114,040,507	122,574,373	122,379,893	120,928,369	121,242,206	171,947,719	143,655,403
Total Expenditures (Over)/Under Revenues	$ 14,156,336	4,281,767	(2,881,655)	(77,488)	(1,347,539)	(1,371,209)	2,003,764	6,964,164	1,796,538	(33,583)	5,106,098	11,435,628	13,174,038	(34,891,076)	(4,701,275)
Net Asset Calculation															
Appropriable Net Assets:	$ 38,896,193	43,177,960	40,296,305	40,218,817	38,871,278	37,500,069	39,503,833	46,467,996	48,264,534	48,230,951	53,337,049	64,772,677	77,946,715	43,055,639	38,354,363
Less: Reserve for Package 5 Debt Service	-	-	-	-	-	-	-	(16,071,506)	(16,285,923)	(14,582,693)	(18,390,487)	(28,568,883)	(41,197,337)	-	-
Less: Appropriable Net Asset Policy	(18,848,740)	(18,546,178)	(18,456,975)	(19,529,885)	(20,294,295)	(22,600,849)	(25,431,729)	(27,201,961)	(28,739,039)	(30,347,783)	(31,584,037)	(32,778,053)	(33,259,234)	(33,853,503)	(34,510,754)
Total Appropriable Net Assets	$ 20,047,454	24,631,782	21,839,330	20,688,933	18,576,983	14,899,220	14,072,104	3,194,529	3,239,572	3,300,476	3,362,525	3,425,740	3,490,144	9,202,135	3,843,610
Coverage	1.65	1.33	1.15	1.24	1.19	1.17	1.24	1.34	1.21	1.20	1.30	1.44	1.49	1.32	1.16
Base rate as a % of debt service	93.64%	101.09%	82.12%	57.39%	29.54%	19.91%	19.51%	19.26%	16.38%	17.31%	18.10%	19.33%	19.80%	17.51%	18.13%
Rate Analysis	December	December	December	December	December	December	December	December	December	December	December	December	December	December	December
Base Rate	$ 24.00	28.00	21.00	14.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Tier 1	0.00%	0.00%	49.81%	30.00%	20.00%	15.00%	12.50%	5.50%	5.00%	5.00%	3.00%	3.00%	0.00%	1.00%	1.00%
Tier 2	0.00%	0.00%	27.34%	30.00%	20.00%	15.00%	12.50%	5.50%	5.00%	5.00%	3.00%	3.00%	0.00%	1.00%	1.00%
Tier 3	0.00%	0.00%	10.48%	30.00%	20.00%	15.00%	12.50%	5.50%	5.00%	5.00%	3.00%	3.00%	0.00%	1.00%	1.00%

The proposed rate structure incorporated in this model is subject to change depending on many variables. Some of these variables may include: water volumes, interest rates, commodity prices, inflation rates, the operational impact of new facilities, and changes in the cost or priority of capital projects.

Appendix E-6
12 Year Financial Water Rate Model
Package 5 - Accelerated Growth

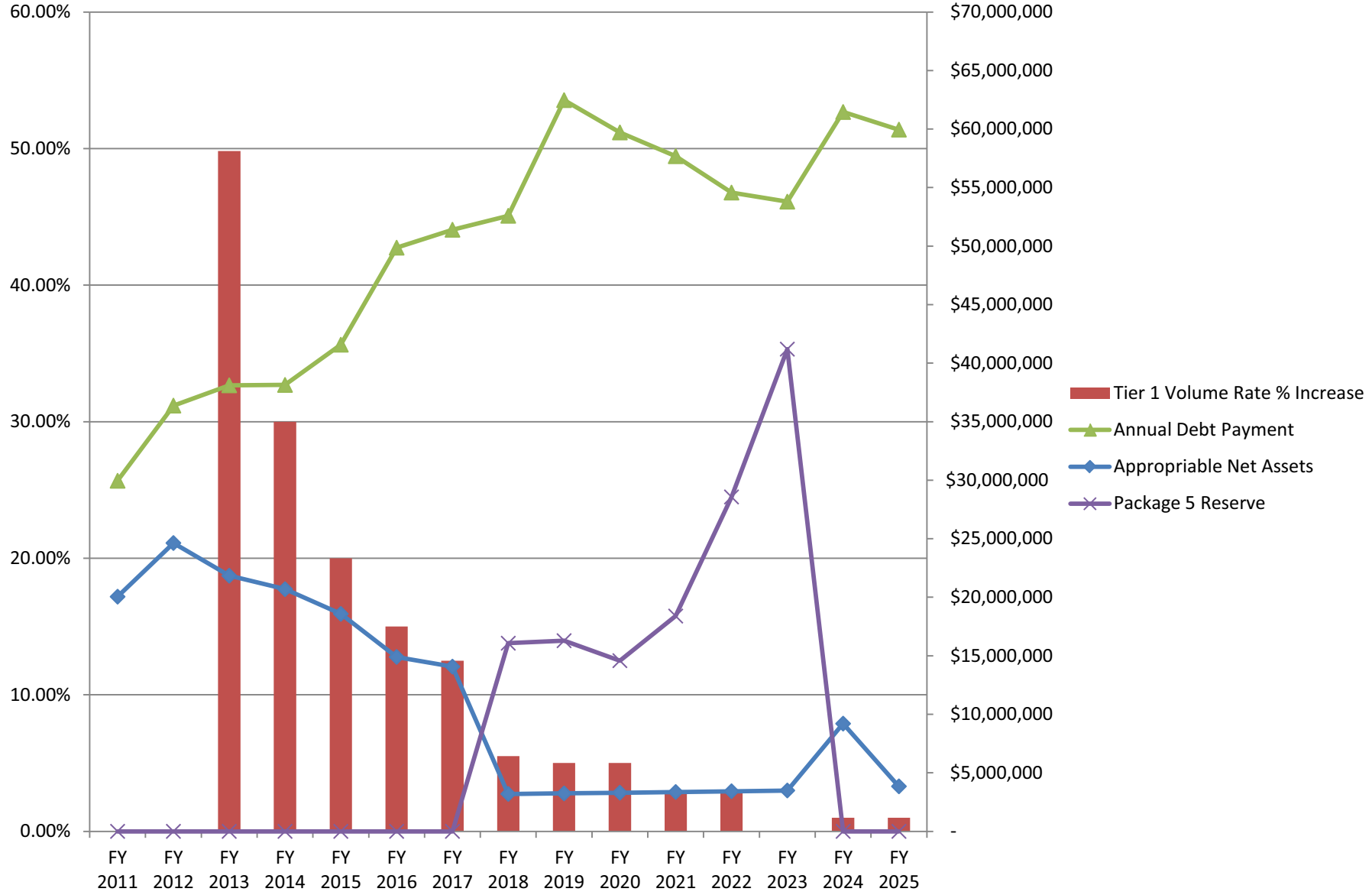
Base Charges

Meter Size	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
0.75	$ 8.89	18.00	18.00	24.00	28.00	21.00	14.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
1.00	14.84	30.05	30.05	40.06	46.74	35.06	23.37	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69
1.50	29.59	59.91	59.91	79.88	93.20	69.90	46.60	23.30	23.30	23.30	23.30	23.30	23.30	23.30	23.30	23.30	23.30	23.30
2.00	47.56	96.30	96.30	128.40	149.80	112.35	74.90	37.45	37.45	37.45	37.45	37.45	37.45	37.45	37.45	37.45	37.45	37.45
3.00	94.81	191.97	191.97	255.96	298.61	223.96	149.31	74.65	74.65	74.65	74.65	74.65	74.65	74.65	74.65	74.65	74.65	74.65
4.00	148.12	299.91	299.91	399.87	466.52	349.89	233.26	116.63	116.63	116.63	116.63	116.63	116.63	116.63	116.63	116.63	116.63	116.63
6.00	296.16	599.65	599.65	799.53	932.79	699.59	466.39	233.20	233.20	233.20	233.20	233.20	233.20	233.20	233.20	233.20	233.20	233.20
8.00	473.87	959.47	959.47	1,279.29	1,492.50	1,119.38	746.25	373.13	373.13	373.13	373.13	373.13	373.13	373.13	373.13	373.13	373.13	373.13
10.00	681.26	1,379.38	1,379.38	1,839.17	2,145.70	1,609.28	1,072.85	536.43	536.43	536.43	536.43	536.43	536.43	536.43	536.43	536.43	536.43	536.43

Volume Rates

Block	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
1	$ 2.42	2.67	2.67	2.67	2.67	4.00	5.20	6.24	7.18	8.07	8.52	8.94	9.39	9.67	9.96	9.96	10.06	10.16
2	3.03	4.29	4.29	4.29	4.29	5.46	7.09	8.51	9.79	11.01	11.62	12.20	12.81	13.19	13.59	13.59	13.73	13.86
3	4.19	5.93	5.93	5.93	5.93	6.55	8.51	10.21	11.74	13.21	13.94	14.64	15.37	15.83	16.30	16.30	16.47	16.63

Sample Bill (Average User based on 7,000 gallons per month)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
.75" meter	$ 25.83	36.69	36.69	42.69	46.69	49.00	50.40	50.68	57.23	63.51	66.62	69.60	72.73	74.70	76.73	76.73	77.43	78.13
% increase		42.0%	0.0%	16.4%	9.4%	4.9%	2.9%	0.6%	12.9%	11.0%	4.9%	4.5%	4.5%	2.7%	2.7%	0.0%	0.9%	0.9%
1" meter	$ 31.78	48.74	48.74	58.75	65.43	63.06	59.77	55.37	61.92	68.20	71.30	74.29	77.42	79.39	81.42	81.42	82.12	82.82
% increase		53.4%	0.0%	20.6%	11.4%	-3.6%	-5.2%	-7.4%	11.8%	10.1%	4.6%	4.2%	4.2%	2.5%	2.6%	0.0%	0.9%	0.9%

Appendix E-6
12 Year Financial Water Rate Model
Package 5 - Accelerated Growth