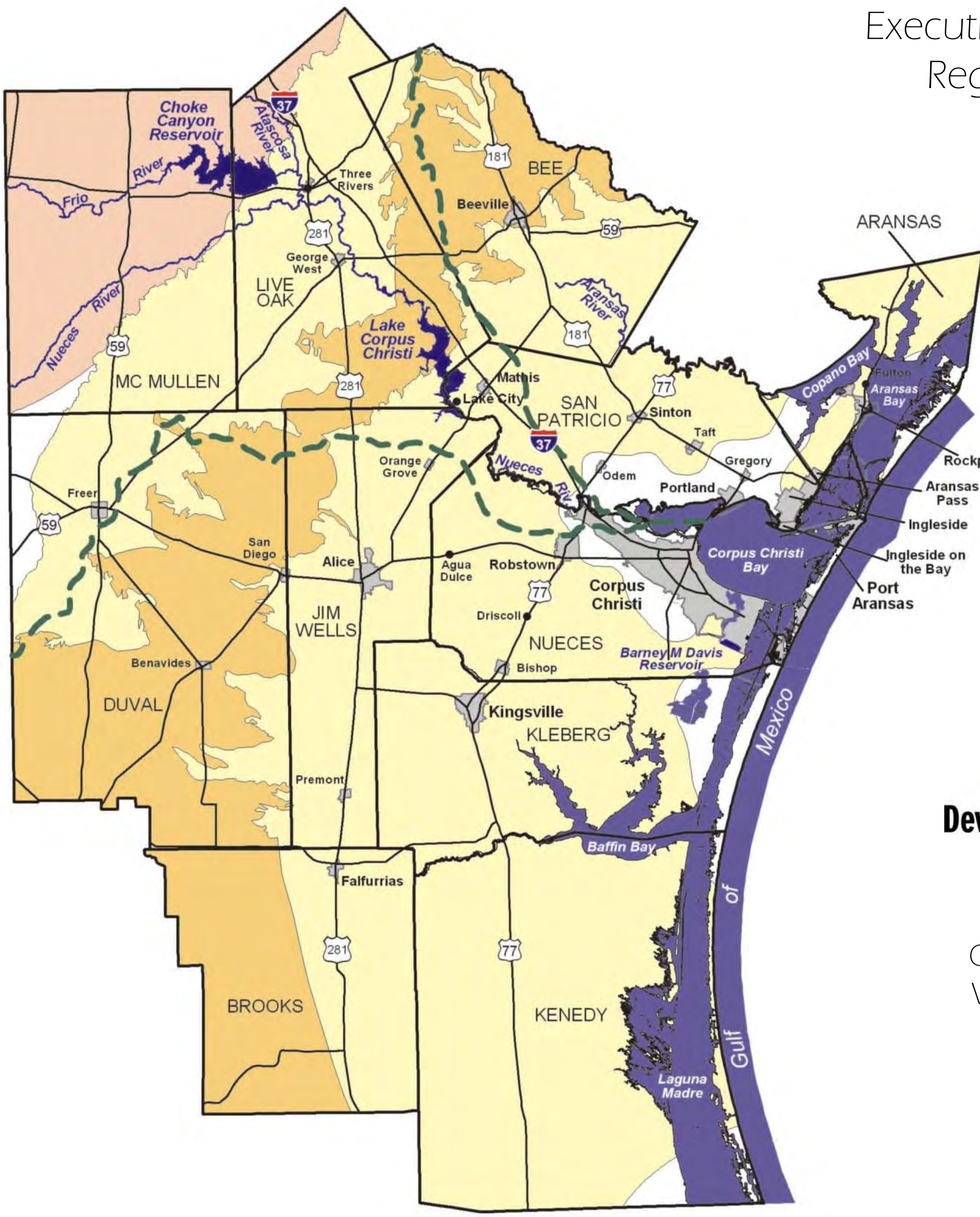
Coastal Bend Regional Water Planning Area Region N

Executive Summary and Regional Water Plan

December 2015



Prepared for:

Texas Water Development Board

Prepared by:

Coastal Bend Regional Water Planning Group

With administration by:

Nueces River Authority

With technical assistance by:

HDR Engineering, Inc.

Coastal Bend Regional Water Planning Area

2016 Regional Water Plan

Acknowledgements

The thoughtful consideration, input, public service, and direction of the members of the Coastal Bend Regional Water Planning Group is gratefully acknowledged in producing the water plan for this diverse planning area.

Coastal Bend Regional Water Planning Group

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Co-Chair	Ms. Carola Serrato, South Texas Water	Water Utilities Representative
Co-Chair	Mr. Scott Bledsoe III, Live Oak UWCD	Water Districts Representative
Secretary	Mr. Lonnie Stewart	GMA 13
	Mr. Joe Almaraz, Valero	Industry Representative
	Mr. Chuck Burns, Rancher	Agricultural Representative
	Ms. Teresa Carrillo, Coastal Bend Bays	Environmental Representative
	Mr. Bill Dove	Small Business Representative
	Mr. Lavoyger J. Durham	Counties Representative
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	Mr. Andy Garza	GMA 16
	Mr. Bill Hennings	Other
	Dr. Pancho Hubert, Tejas Veterinary Clinic	Small Business Representative
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	Mr. Robert Kunkel, Lyondell Basell	Industry Representative
	Mr. Martin Ornelas	Public Representative
	Mr. Thomas M. Reding, Jr., Nueces River Authority	River Authorities Representative
	Mr. Charles Ring	Agricultural Representative
	Mr. Mark Scott, City of Corpus Christi Councilmember	Municipal Representative
	Mr. Bill Stockton	Counties Representative
	Mr. Mark Sugarek	GMA 15
	Mr. Jace Tunnell, Mission-Aransas National Estuarine Research Reserve	Environmental Representative

Non-Voting Members

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Ms. Nelda Barrera	Texas Department of Agriculture
Dr. Jim Tolan	Texas Parks and Wildlife Department
Mr. Tomas Dominguez	USDA – NRCS
Mr. Con Mims, Nueces River Authority	South Central Texas RWPG
Mr. Robert Fulbright	Rio Grande RWPG
Mr. Haskell Simon	Lower Colorado RWPG

The efforts, long hours, and diligence is specially noted and appreciated of these individuals:

Ms. Rocky Freund, Deputy Executive Director	Nueces River Authority
Ms. Frankie Kruckemeyer	Nueces River Authority

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Coastal Bend Regional Water Planning Area

Regional Water Planning Group

2016 Regional Water Plan

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Mr. Joe Almaraz, Industries

Mr. Chuck Burns, Agriculture

Ms. Teresa Carrillo, Environmental

Mr. Bill Dove, Small Business

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Mr. Bill Hennings, Other

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Mr. Robert Kunkel, Industry

Mr. Martin Ornelas, Public

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Mr. Charles Ring, Agriculture

Mr. Mark Scott, Municipal

Mr. Bill Stockton, Counties

Mr. Mark Sugarek, GMA 15

Mr. Jace Tunnell, Environmental

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Coastal Bend Regional Water Planning Area

Regional Water Plan

This Regional Water Plan is released for planning purposes on December 1, 2015 by HDR Engineering, Inc., 8404 Indian Hills Dr., Omaha, NE 68114, Texas Registered Firm F-754 and the following individuals presented below.

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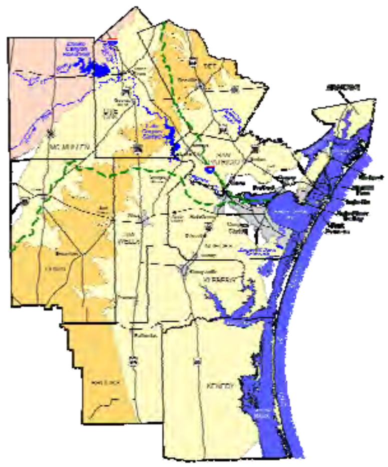
Coastal Bend
Regional Water Planning Area
Region N

Executive Summary and
Regional Water Plan



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December 2015

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List of Acronyms

ac-ft	acre-feet
ac-ft/yr	acre-feet per year
ASR	Aquifer Storage and Recovery
BBASC	Basin and Bay Area Stakeholder Committee
BBEST	Basin and Bay Expert Science Team
BEG	Bureau of Economic Geology
BMPs	Best Management Practices
BOD_5	Biochemical Oxygen Demand (5-Day)
BRACS	Brackish Resource Aquifer Characterization System
C/BOD_5	Carbonaceous Biochemical Oxygen Demand (5-Day)
CA	Certificate of Adjudication
$CaCO_3$	Calcium Carbonate
CBBEP	Coastal Bend Bays and Estuaries Program
CBRWPG	Coastal Bend Regional Water Planning Group
CCR	Choke Canyon Reservoir
CCR/LCC	Choke Canyon Reservoir/Lake Corpus Christi
CCWSM	Corpus Christi Water Supply Model
cfs	cubic feet per second
CFU	Colony Forming Units
CGCGAM	Central Gulf Coast Groundwater Availability Model
DBPs	Disinfection Byproducts
DCPs	Drought Contingency Plans
DFCs	Desired Future Conditions
DOR	Drought of Record
DPC	Drought Preparedness Council
EDAP	Economic Development Assistance Program
EFAG	Environmental Flows Advisory Group
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ft-msl	feet mean sea level
GAM	Groundwater Availability Model
GBRA	Guadalupe-Blanco River Authority
GCD	Groundwater Conservation District
GIS	Geographic Information System
GLO	General Land Office
GMA	Groundwater Management Area
gpcd	gallons per capita per day
gpd	gallons per day
gpm	gallons per minute

GSA WAM	Guadalupe - San Antonio River Basin Water Availability Model
GW	groundwater
HAA	Haloacetic Acid
HB	House Bill
kWh or kW-hr	kilowatt-hour
LCC	Lake Corpus Christi
LEPA	Low Energy Precision Application
LESA	Low Elevation Spray Application
LNRA	Lavaca-Navidad River Authority
LOUWCD	Live Oak Underground Water Conservation District
LSI	Langlier Saturation Index
MAG	Modeled Available Groundwater
MBTA	Migratory Bird Treaty Act
MCL	Maximum Contaminant Level
mg/L	milligrams per liter
mgd or MGD	million gallons per day
mi	mile
ml or mL	milliliter
mo	month
MRP	Mary Rhodes Pipeline
MSA	Metropolitan Statistical Area
msl	mean sea level
MUD	Municipal Utility District
MWD	Municipal Water District
N/A	not available or not applicable
NCWC&ID#3	Nueces County Water Control and Improvement District #3
NDD	Natural Diversity Database
NEAC	Nueces Estuary Advisory Council
NPDES	National Pollutant Discharge Elimination System
NRA	Nueces River Authority
NTU	Nephelometric Turbidity Units
NUBAY	Lower Nueces River Basin and Estuary Model
O&M	Operation and Maintenance
OCR	Off-Channel Reservoir
OFCU	Oil Field Cleanup
PPD	Pounds per day
psi	pounds per square inch
REIS	Regional Economic Information System
RO	Reverse Osmosis
ROI	Return on Investment
RWP	Regional Water Plan

RWPG	Regional Water Planning Group
SAC	Science Advisory Committee
SB1	Senate Bill 1
SB3	Senate Bill 3
SMART	Salinity Monitoring and Real Time Inflow Management
SPMWD	San Patricio Municipal Water District
STWA	South Texas Water Authority
SW	surface water
SWQM	Surface Water Quality Monitoring
TAC	Technical Advisory Committee
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TDS	Total Dissolved Solids
THM	Trihalomethane
TPDES	Texas Pollutant Discharge Elimination System
TPWD	Texas Parks and Wildlife Department
TSS	Total Suspended Solids
TWC	Texas Water Code
TWDB	Texas Water Development Board
TXNDD	Texas Natural Diversity Database
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USFWS	United States Fish & Wildlife Service
USGS	United States Geological Survey
UWCD	Underground Water Conservation District
WAM	Water Availability Model
WCID	Water Control and Improvement District
WMS	Water Management Strategies
WRAP	Water Rights Analysis Package
WSC	Water Supply Corporation
WTP	Water Treatment Plant
WUG	Water User Group
WWP	Wholesale Water Provider
WWTP	Wastewater Treatment Plant
yr	year

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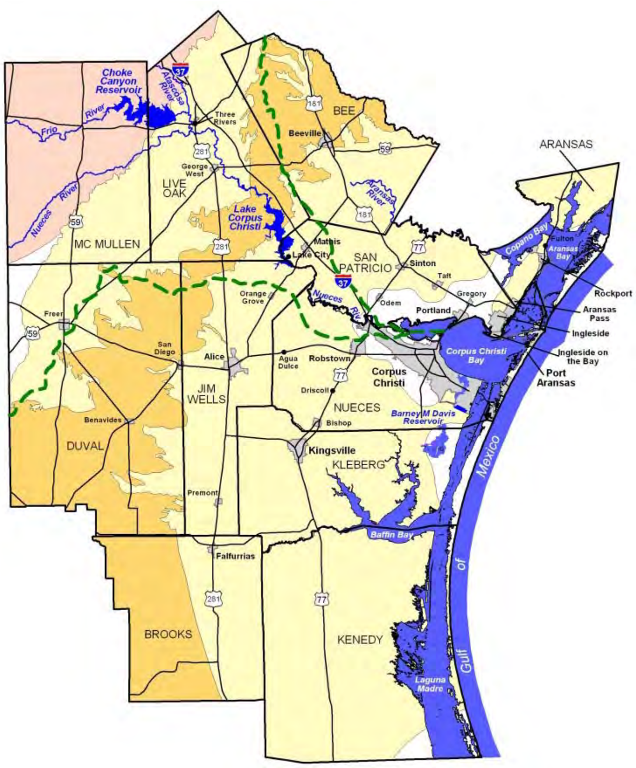

Executive Summary

Executive Summary

ES.1 Background

Since 1957, the Texas Water Development Board (TWDB) has been charged with preparing a comprehensive and flexible long-term plan for the development, conservation, and management of the State's water resources. The current state water plan, *Water for Texas, January 2012*, was produced by the TWDB and based on approved regional water plans pursuant to requirements of Senate Bill 1 (SB1), enacted in 1997 by the 75th Legislature. As stated in SB1, the purpose of the regional water planning effort is to:

> "Provide for the orderly development, management, and conservation of water resources and preparation for and response to drought conditions in order that sufficient water will be available at a reasonable cost to ensure public health, safety, and welfare; further economic development; and protect the agricultural and natural resources of that particular region."

SB1 also provides that future regulatory and financing decisions of the Texas Commission on Environmental Quality (TCEQ) and the TWDB be consistent with approved regional plans.

The TWDB divided the state into 16 planning regions and appointed members to the regional planning groups. As shown is Figure ES.1, the Coastal Bend Region (Region N) includes 11 counties. The Coastal Bend Regional Water Planning Group (CBRWPG) has a total of 21 voting members. The members represent 13 interests or stakeholders (Agriculture, Counties, Electric Generating Utilities, Environmental, Groundwater Management Areas, Industries, Municipalities, Other, Public, River Authorities, Small Business, Water Districts, and Water Utilities), serve without pay, and are responsible for the development of the Coastal Bend Regional Water Plan (Table ES.1). The following members have served since inception of the CBRWPG in the late 1990s: Mr. Scotty Bledsoe, Mr. Robert Kunkel, and Ms. Carola Serrato.

The CBRWPG adopted bylaws to govern its operations and, in accordance with its bylaws, selected the Nueces River Authority to serve as its administrative agency.

Pursuant to Regional and State Water Planning Guidelines (Texas Administrative Code, Title 31, Part 10, Chapters 357 and 358), the CBRWPG developed the 2001, 2006, 2011 Regional Water Plans, which were then integrated into Water for Texas – 2002, 2007, and 2012 respectively, by the TWDB. The 2016 Coastal Bend Regional Water Plan, of which this Executive Summary is a part, represents the fourth update of a plan as presently required to occur on a five-year cycle. The TWDB will integrate this Regional Water Plan into a State Water Plan to be issued in 2017.

This executive summary and the accompanying *Regional Water Plan* convey water supply planning information, projected population and water demands, projected needs in the region, proposed water management strategies to meet those needs, and other findings. Table ES-2 shows the contents of the plan.

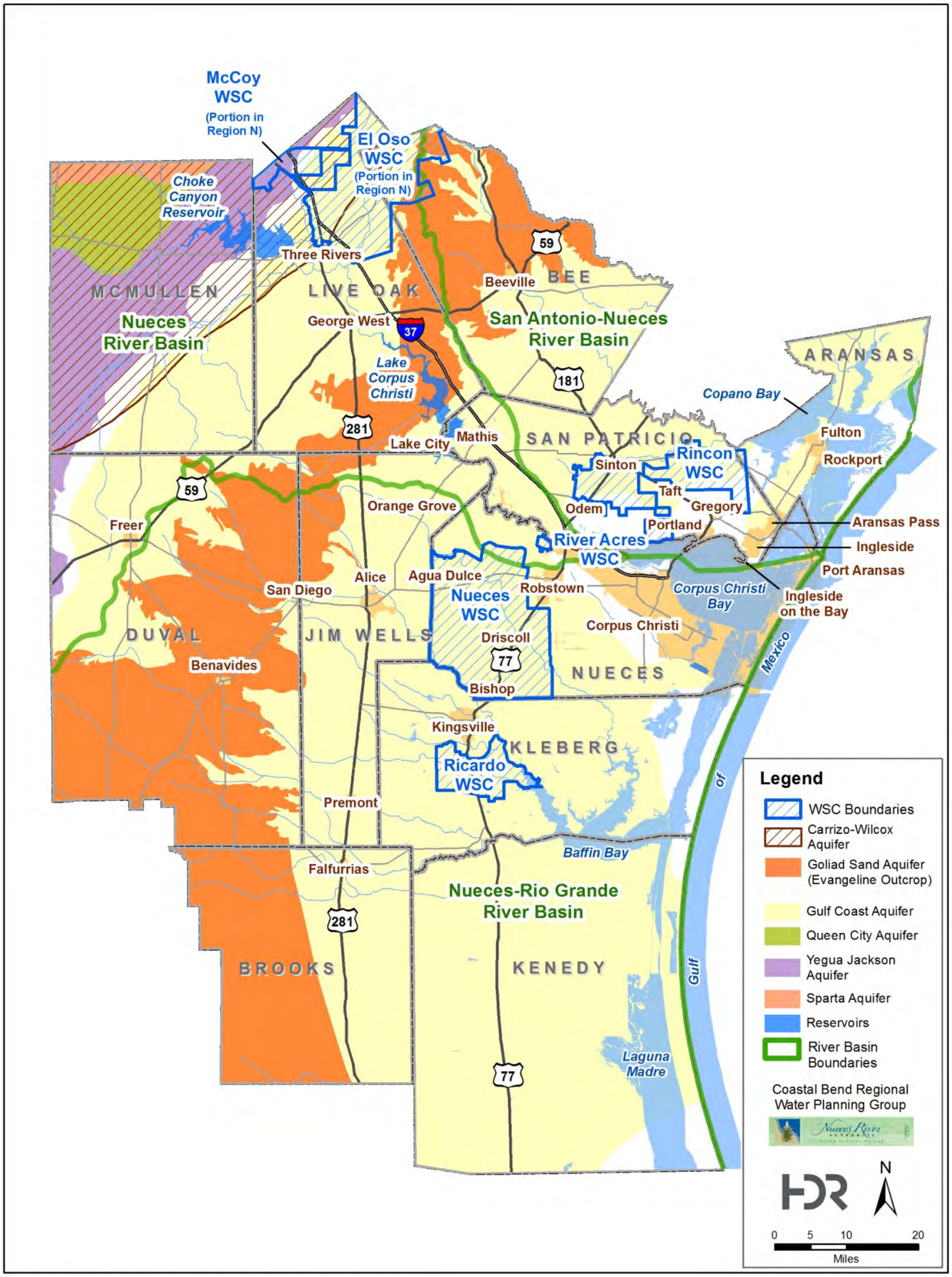

Figure ES.1.
Coastal Bend Regional Water Planning Area

Table ES.1.
Coastal Bend RWPG Members[1]

Interest Group	***Name***	***Entity***
	Voting Members	
Agriculture	Mr. Charles Ring Mr. Chuck Burns	 Rancher
Counties	Mr. Bill Stockton Mr. Lavoyger J. Durham	
Electric Generating Utilities	Mr. Gary Eddins	
Environmental	Ms. Teresa Carrillo	Coastal Bend Bays Foundation
	Mr. Jace Tunnell	Mission-Aransas National Estuarine Research Reserve
Groundwater Management Areas	Mr. Lonnie Stewart, Secretary	GMA 13
	Mr. Mark Sugarek	GMA 15
	Mr. Andy Garza	GMA 16
Industries	Mr. Joe Almaraz Mr. Robert Kunkel	Valero Lyondell Basell
Municipalities	Mr. Mark Scott	City of Corpus Christi Councilmember
Other	Mr. Bill Hennings	
Public	Mr. Lindsey Koenig	
	Mr. Martin Ornelas	
River Authorities	Mr. Thomas M. Reding, Jr., Executive Committee	Nueces River Authority
Small Business	Dr. Pancho Hubert, Executive Committee	
	Mr. Bill Dove	
Water Districts	Mr. Scott Bledsoe III, Co-Chair	Live Oak UWCD
Water Utilities	Ms. Carola Serrato, Co-Chair	South Texas Water Authority
	Non-Voting Members	
	Ms. Connie Townsend	Texas Water Development Board
	Ms. Nelda Barrera	Texas Department of Agriculture
	Dr. Jim Tolan	Texas Parks and Wildlife Department
	Mr. Tomas Dominguez	USDA – NRCS
Liaison, South Central Texas RWPG	Mr. Con Mims	Nueces River Authority
Liaison, Rio Grande RWPG	Mr. Robert Fulbright	
Liaison, Lower Colorado RWPG	Mr. Haskell Simon	
Staff	Ms. Rocky Freund	Nueces River Authority

[1] The following individuals were not active during adoption of the 2016 Plan, but served as a CBRWPG member during development of the plan: Mr. Tom Ballou (Industries, resigned January 2015), Mr. Billy Dick (Municipalities, resigned November 2013), Mr. Pearson Knolle (Small Business, resigned August 2012), Mr. Bernard Paulson (Other, resigned June 2013).

Table ES.2. Plan Structure

	Contents
Volume I	Executive Summary, Regional Water Plan, and Appendices
	Executive Summary
Chapter 1	Planning Area Description
Chapter 2	Population and Water Demand Projections
Chapter 3	Water Supply Analysis
Chapter 4	Comparison of Water Demands with Water Supplies to Determine Needs
Chapter 5	Water Management Strategies and Evaluations
5D.1	Municipal Water Conservation
5D.2	Irrigation Water Conservation
5D.3	Manufacturing Water Conservation and Nueces River Water Quality Issues
5D.4	Mining Water Conservation
5D.5	Reclaimed Wastewater Supplies and Reuse
5D.6	Modify Existing Reservoir Operating Policy and Safe Yield Analyses
5D.7	Gulf Coast Aquifer Supplies
5D.8	Brackish Groundwater Desalination
5D.9	Seawater Desalination and Variable Salinity Program
5D.10	Potential Water System Interconnections
5D.11	Local Balancing Storage Reservoir
5D.12	Lavaca Off-Channel Reservoir Project
5D.13	GBRA Lower Basin Storage Project
5D.14	SPMWD- Industrial Water Treatment Plant Improvements
5D.15	O.N. Stevens Water Treatment Plant Improvements
Chapter 6	Impacts of Regional Water Plan and Consistency with Protection of Resources
Chapter 7	Drought Response Information, Activities, and Recommendations
Chapter 8	Regulatory, Administrative, and Legislative Recommendations
Chapter 9	Infrastructure Financing
Chapter 10	Public Participation, Adoption, Submittal, and Approval of Regional Plan
Chapter 11	Implementation and Comparison of Plan to Previous Regional Water Plans

Copies are filed at each County Clerk's office and at one public library in each county. Copies of individual sections can be obtained by calling the Nueces River Authority at (361) 653-2110.

In addition to the work contained in the *Regional Water Plan*, a Technical Memorandum was submitted to the TWDB on July 30, 2014, including database (DB17) reports requested in the scope of work.

ES.2 Description of the Region

The area represented by the Coastal Bend Region includes the following counties: Aransas, Bee, Brooks, Duval, Jim Wells, Kenedy, Kleberg, Live Oak, McMullen, Nueces, and San Patricio (Figure ES.1). The Coastal Bend Region has four regional Wholesale Water Providers: the City of Corpus Christi (City), San Patricio Municipal Water District (SPMWD), South Texas Water Authority (STWA), and Nueces County Water Control and Improvement District #3 (Nueces County WCID #3). The City, the largest of the four, sells water to two of the other regional water providers — SPMWD and STWA. The City and the SPMWD distribute water to cities, water districts, and water supply corporations for residential, commercial, and industrial customers. STWA provides water to cities and water supply corporations that supply both residential and commercial customers within the western portion of Nueces County as well as Kleberg County. The smallest regional wholesale water provider, Nueces County WCID #3, provides water to the City of Robstown and other rural municipal entities in the western portion of Nueces County. The major water demand areas are primarily municipal systems in the greater Corpus Christi area, as well as large industrial (manufacturing, steam-electric, and mining) users primarily located along the Corpus Christi and La Quinta Ship Channels. Based on state surveys of industrial water use, industries in the Coastal Bend area are very efficient in their water use. For example, petroleum refineries in the Coastal Bend area use on average 60 percent less water to produce a barrel of refined crude oil than refineries in the Houston/Beaumont area.

The Coastal Bend Region depends mostly on surface water sources for municipal and industrial water supply use. The three major surface water supply sources include the Choke Canyon Reservoir/Lake Corpus Christi System (CCR/LCC System) in the Nueces River Basin, Lake Texana on the Navidad River in Jackson County, and Mary Rhodes Pipeline Phase II (MRP Phase II) to the Colorado River. The MRP Phase II project is in the process of being completed and anticipated to deliver water supplies by the end of 2015. The MRP Phase II project is included as a current supply[2] as part of the regional water system. The water quality of these sources is generally good. However, there are some areas of concern, specifically within the Lower Nueces River and the Calallen Pool, where the bulk of the region's water supply intakes are located which is addressed in Chapter 5D.3.

There are some areas in the region that are dependent on groundwater. There are two major aquifers that lie beneath the region — the Carrizo-Wilcox and Gulf Coast Aquifers. The Gulf Coast Aquifer underlies all counties within the Coastal Bend Region and yields moderate to large amounts of both fresh and slightly saline water. The Carrizo-Wilcox Aquifer only underlies parts of McMullen, Live Oak, and Bee Counties and contains moderate to large amounts of either fresh or slightly saline water. The Yegua-Jackson is an official minor aquifer and covers parts of McMullen, Live Oak, and Duval counties within the Coastal Bend Region. The Queen City and Sparta Aquifers are minor aquifers and cover parts of McMullen County.

[2] As approved by TWDB staff in January 2015. This provision is consistent with TWDB which states in the General Guidelines for RWP Development, Section 3.1, that "existing supplies must be connected and able to convey water to the water user group (WUG) or anticipated that the WUG will have access by the conclusion of the current planning cycle (by 2016)".

In 2007, the estimated population for the Coastal Bend Region was 549,686 with a regional average per capita income of $27,518, ranging from $20,887 in Bee County to $33,970 in Nueces County.[3] By 2013, the population of the Coastal Bend Region was 581,100 with a regional average per capita income of $45,522, ranging from $31,135 in Bee County to $71,840 in McMullen County.[4] Much of the increase in per capita income during this time is attributable to increased Eagle Ford shale production and industrial growth activities. The Corpus Christi Metropolitan Statistical Area, consisting of Aransas, Nueces, and San Patricio Counties, accounts for 76 percent of the Coastal Bend Region's population and 71 percent of the total personal income. In 2013, the total personal income in the Coastal Bend Region was nearly $26.5 billion[5], representing an increase of $9.2 billion (or 53% increase) over 2007 estimates.

The primary economic activities within the Coastal Bend Region include oil/gas production and refining, petrochemical manufacturing, military installations, retail and wholesale trade, agriculture, and service industries including health services, tourism/recreation industries, and governmental agencies. In 2012, these industries employed over 180,000 people in the Coastal Bend Region with annual earnings over $7 billion.[6] The services sector had the biggest economic impact in 2012, with an economic contribution of $3.3 billion, while employing 57% of the total workforce within the Region. Educational services, the largest economic service industry contributor, generated nearly $1.3 billion in compensation to employees in 2012.

ES.3 Population and Water Demand Projections

For the 2016 Coastal Bend Regional Water Plan, the TWDB issued new population and water demand projections based on 2010 Census data. The CBRWPG requested population revisions for Aransas, Nueces, and San Patricio counties and water demands for municipal, irrigation, manufacturing, and mining water users for most counties in the 11-county region. The TWDB approved the CBRWPG-requested revisions for non-municipal entities (irrigation, manufacturing, and mining). This is discussed further in Chapter 2.1. In all other cases, the population and water demand projections remained identical to the projections developed by the TWDB. The TWDB provided population projections for cities with a population greater than 500, water supply corporations and special utility districts using volumes of 280 ac-ft or more in 2000, and 'county-other' to capture those people living outside the cities or water utility service areas for each county. Water demand projections were developed by type of use: municipal for cities and water supply corporations/special utility districts (along with a 'county-other' for each county), and countywide for manufacturing, steam-electric, mining, irrigation, and livestock.

[3] U.S. Department of Commerce Bureau of Economic Analysis, REIS Database, 2007.
[4] U.S. Department of Commerce Bureau of Economic Analysis, REIS Database, 2013.
[5] Total personal income includes net earnings, dividends, and personal transfer receipts. Personal transfer receipts are government payments to individuals, including retirement and disability insurance and medical services.
[6] U.S. Department of Commerce Bureau of Economic Analysis, REIS Database, 2007.

ES.4 Population Projections

Figure ES.2 illustrates population growth in the entire Coastal Bend Region for 2010 and projected growth for 2020, 2030, 2040, 2050, 2060 and 2070. In 2070, the population of the Coastal Bend Regional Water Planning Area is projected to be 744,544.

As can be seen in Figure ES.3, the average annual growth rate of the region over the 50-year planning period is 0.46 percent. Brooks, Jim Wells, Kleberg, and McMullen Counties have growth rates higher than the regional average, while the other counties have lower growth rates than the average. These annual growth rates were based on TWDB projections, and if projected industrial growth occurs then the actual annual growth rates are expected to be higher, especially in San Patricio and Nueces counties.

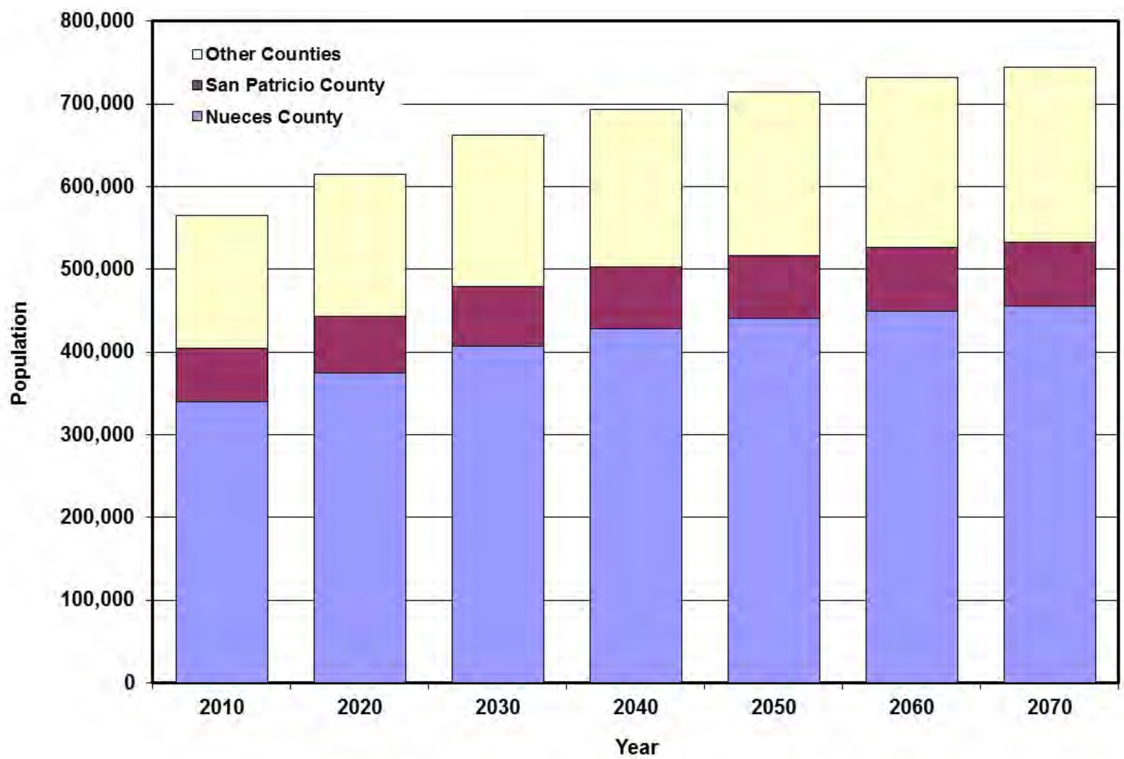

Figure ES.2.
Historical and Projected Coastal Bend Regional Water Planning Area Population

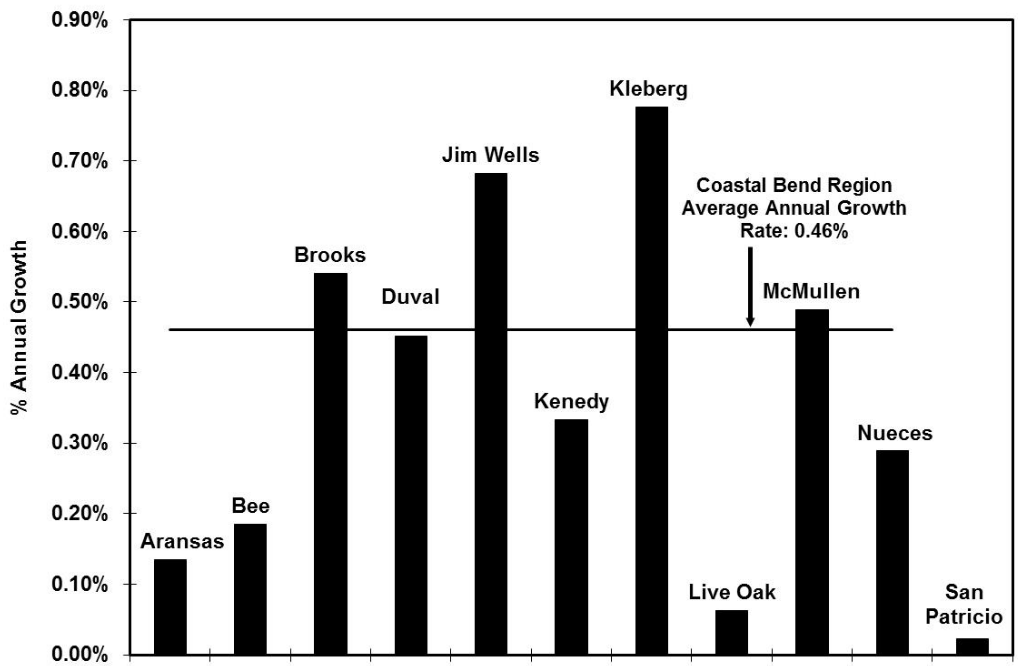

Figure ES.3.
Percent Annual Population Growth Rate for 2020 through 2070 by County

ES.5 Water Demand Projections

Water demand projections have been compiled for six categories of water use: 1) Municipal; 2) Manufacturing; 3) Steam-Electric Power; 4) Mining; 5) Irrigation; and 6) Livestock.

Water User Groups

Each of these consumptive water uses is termed a "water user group" according to SB1. Incorporated cities and County-Other category are water user groups within the Municipal Use category. County-Other category includes persons residing outside of cities and also outside water utility boundaries. Water demand projections and supplies have been estimated for all water user groups.

Total water use for the region is projected to increase from 187,788 ac-ft in 2010 to 343,244 ac-ft in 2070, a 82.7 percent increase. The six types of water use and associated demands are shown in Figure ES.4. In the future, the region's industrial water use is anticipated to grow significantly from 27 percent of total water demand in 2010 to 49 percent of total water demand by 2070. The projected trend in total water use from 2020 to 2070 is shown in Figure ES.5. Municipal, manufacturing, steam-electric, and irrigation water use are all projected to increase, mining water use is projected to decrease, while livestock use is unchanged.

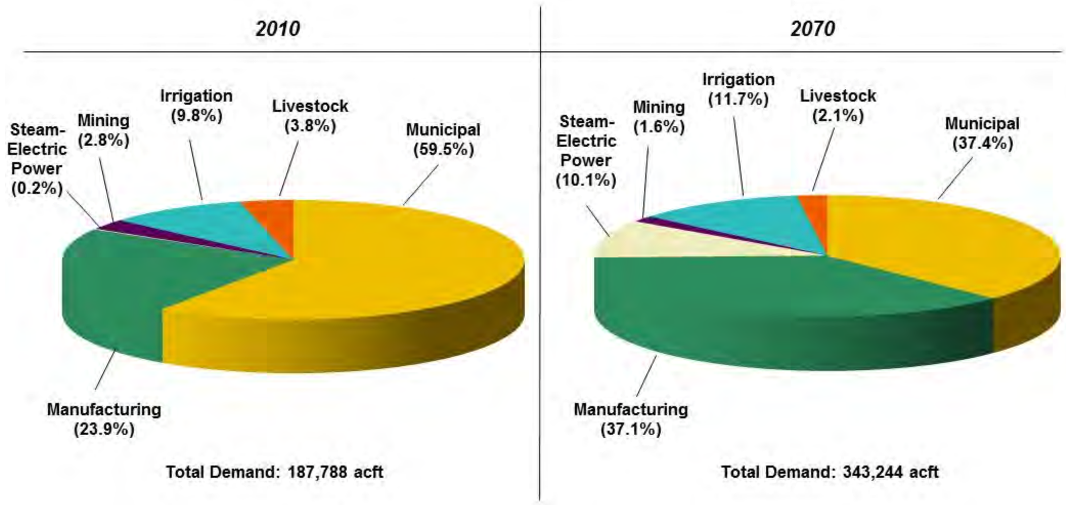

Figure ES.4.
Total Water Demand by Type of Use

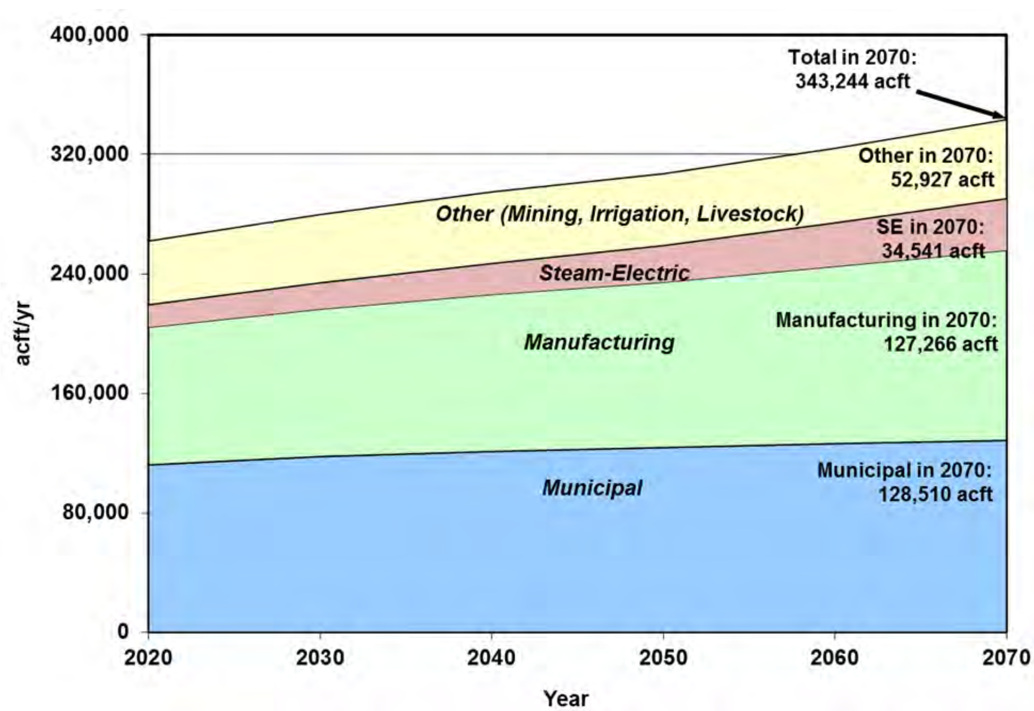

Figure ES.5.
Projected Total Water Demand

ES.6 Water Supply

ES.6.1 Surface Water Supplies

Streamflow in the Nueces River and its tributaries, along with reservoirs in the Nueces River Basin and interbasin transfers from Lake Texana and the Colorado River, comprise the most significant supply of surface water in the Coastal Bend Region. Water rights associated with major water supply reservoirs are owned by the City of Corpus Christi and the Nueces River Authority. The western and southern parts of the region are heavily dependent on groundwater sources, due to limited access to surface water supplies.

Municipal Use and Water Conservation

The 6.3 percent projected increase in municipal water demand over the 50-year planning horizon is lower than the projected population increase of 21.1 percent due to expected savings in per capita water use resulting from water conservation. Average per capita municipal water use in 2011 was 171 gallons per capita per day and is projected to decrease to 153 gallons per capita per day by 2070 due to built-in savings for low flow plumbing fixtures. This results in a reduction of 5,868 ac-ft/yr in municipal water demand from 2020 to 2070 for population estimated in 2020.

Many entities within the Coastal Bend Region obtain surface water through water supply contracts. The City is the largest provider of water supply contracts in the Coastal Bend Region with 219,000 ac-ft/yr raw water safe yield available from its CCR/LCC/Texana/MRP Phase II reservoir system (2020 sediment conditions).[7] Run-of-river water rights provide 3,455 ac-ft/yr of reliable water for Nueces County WCID #3 and the City of Three Rivers. Other surface water supplies are provided by on-farm local sources and reuse.

In addition to raw water supply contracts and/or availability, total surface water supplies are constrained based on existing water treatment plant capacities as discussed in Chapter 4. As shown in Table ES.3, total surface water from all surface water sources in year 2070 is 219,138 ac-ft/yr, of which 93 percent is provided by the City's supplies.

Table ES.3.
Surface Water Supply in 2070 (ac-ft)

Municipal	102,961
Manufacturing	85,913
Steam-Electric	27,648
Mining	756
Irrigation	0
Livestock	1,860
Total	**219,138**

Note: This table considers both treatment plant capacity and raw water constraints.

[7] The City of Corpus Christi holds a contract with the Lavaca-Navidad River Authority to provide a base amount of 41,840 ac-ft/yr and a maximum of 12,000 ac-ft/yr on an interruptible basis from Lake Texana to the City, in addition to rights on the Colorado River (MRP Phase II) up to 35,000 ac-ft/yr. The safe yield estimate includes system operation of CCR/LCC/Texana/MRP Phase II supplies with a 125,000 ac-ft reserve during drought of record conditions.

ES.6.2 Groundwater Supplies

Two major aquifers and three minor aquifers underlie parts of the Coastal Bend Planning Region (Figure ES.1) and have a combined reliable yield of 226,966 ac-ft/yr in 2070 based on modeled available groundwater (MAG) estimates provided by the TWDB for CBRWPG use. The projected groundwater use in 2070 is 89,568 ac-ft/yr for current water users, or 96,598 ac-ft/yr if recommended water management strategies are implemented.[8] About 70% of the additional, unassigned groundwater supplies that are deemed available in the region after projected groundwater use and water management strategies are considered, are located in the Gulf Coast Aquifer in Kenedy and Kleberg Counties.[9] The two major aquifers include the Gulf Coast Aquifer, which supplies 97% of the groundwater supplies in the region, and the Carrizo-Wilcox Aquifer, which supplies water to the northwest portion of the region in parts of McMullen, Live Oak, and Bee Counties (Figure ES.1). Groundwater supplies are based on MAG estimates and well capacities. In the northwestern part of the region, the Carrizo-Wilcox is a prolific aquifer with lesser quality water in most areas. The Yegua-Jackson, Queen City, and Sparta aquifers are minor aquifers relied on for very small amounts of local supply in McMullen County.

ES.6.3 Total Supplies

Total water use from each water source is summarized in Table ES.4. No supplies are over allocated. The total existing water supplies, including both groundwater and surface water supplies, by water user category and decade is summarized in Table ES.5. Pertinent database tables (DB17) required for inclusion by TWDB guidance are included in the Appendix.

ES.6.4 Water Quality

Previous studies by the U.S. Geological Survey and others show a significant increase in the concentration of dissolved minerals occurring in the Lower Nueces River between Lake Corpus Christi and the Calallen Saltwater Barrier Dam, where the vast majority of the Region's surface water is diverted.[10] Figure ES.6 shows that median chloride concentrations at the Calallen Pool near the City of Corpus Christi's O.N. Stevens Water Treatment Plant (WTP) intake (155 mg/L) are about 2 times the level of chlorides in water released from Lake Corpus Christi (80 mg/L). The results of these studies indicate that on the average about 60 percent of the increase in chlorides occurs upstream of the Calallen Pool and about 40 percent of the increase within the pool. Currently, the Nueces River Authority and others are conducting watershed protection plans and other studies to identify and recommended strategies to improve Lower Nueces River water quality.

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[8] Based on recommended water management strategies, which are constrained by modeled available groundwater (MAG) limits.

[9] Total regional groundwater surplus is 130,256 ac-ft/yr in 2070 based on MAG. Of which, Kenedy County has 50,699 ac-ft/yr and Kleberg County has 40,370 ac-ft/yr (or 91,069 ac-ft/yr total) of groundwater available.

[10] USGS studies report average chloride concentrations in the Calallen Pool are about 2 times the level of chlorides in water released from Lake Corpus Christi.

Table ES.4.
Total Source Water Availability and Supply by Source (ac-ft)

	2020	2030	2040	2050	2060	2070
Total Source Water Availability						
CCR/LCC/Texana/MRP2 System	219,000	218,000	217,000	216,000	215,000	214,000
Run-of-River (Firm Yield)	3,455	3,455	3,455	3,455	3,455	3,455
Stock Ponds/On-site/Reuse	5,688	5,688	5,688	5,688	5,688	5,688
Gulf Coast- Groundwater	222,025	222,001	222,001	221,949	221,949	221,949
Carrizo Wilcox- Groundwater	4,612	4,612	4,612	4,612	4,612	4,612
Queen City- Groundwater	136	136	136	136	136	136
Sparta- Groundwater	90	90	90	90	90	90
Yegua Jackson- Groundwater	179	179	179	179	179	179
Existing Water Supply[1]						
CCR/LCC/Texana/MRP Phase II[2]	211,540	211,749	211,778	211,747	211,958	212,235
Run-of-River	3,455	3,455	3,455	3,455	3,455	3,455
Stock Ponds/On-site/Reuse	3,448	3,448	3,448	3,448	3,448	3,448
Gulf Coast- Groundwater	87,719	87,719	87,719	87,719	87,719	87,719
Carrizo Wilcox- Groundwater	1,849	1,849	1,849	1,849	1,849	1,849
Queen City- Groundwater	—	—	—	—	—	—
Sparta- Groundwater	—	—	—	—	—	—
Yegua Jackson- Groundwater	—	—	—	—	—	—

[1] The existing supply takes into consideration physical, treatment, and legal (contractual) constraints.

[2] Shows CCR/LCC/Texana/MRP Phase II supplies fully allocated, which creates a surplus for Nueces County-Manufacturing during 2020 to 2040 time frame. For DB17, only enough supplies were allocated to Nueces County-Manufacturing to meet the projected demands which allows the non-allocated water to be used as a source for the O.N. Stevens WTP water management strategy.

Table ES.5.
Summary of Total Existing Water Supplies by Water User Category (ac-ft)

	2020	2030	2040	2050	2060	2070
Municipal	121,325	126,237	129,055	131,192	133,340	135,037
Manufacturing	118,111	110,735	104,753	98,731	94,925	91,948
Steam-Electric	15,038	17,582	20,681	24,461	26,221	27,648
Mining	9,864	9,993	10,087	10,161	10,270	10,400
Irrigation	36,367	36,367	36,367	36,367	36,367	36,367
Livestock	7,306	7,306	7,306	7,306	7,306	7,306
Total	**308,011**	**308,220**	**308,249**	**308,218**	**308,429**	**308,706**

Note: This table considers physical and legal (contractual) constraints.

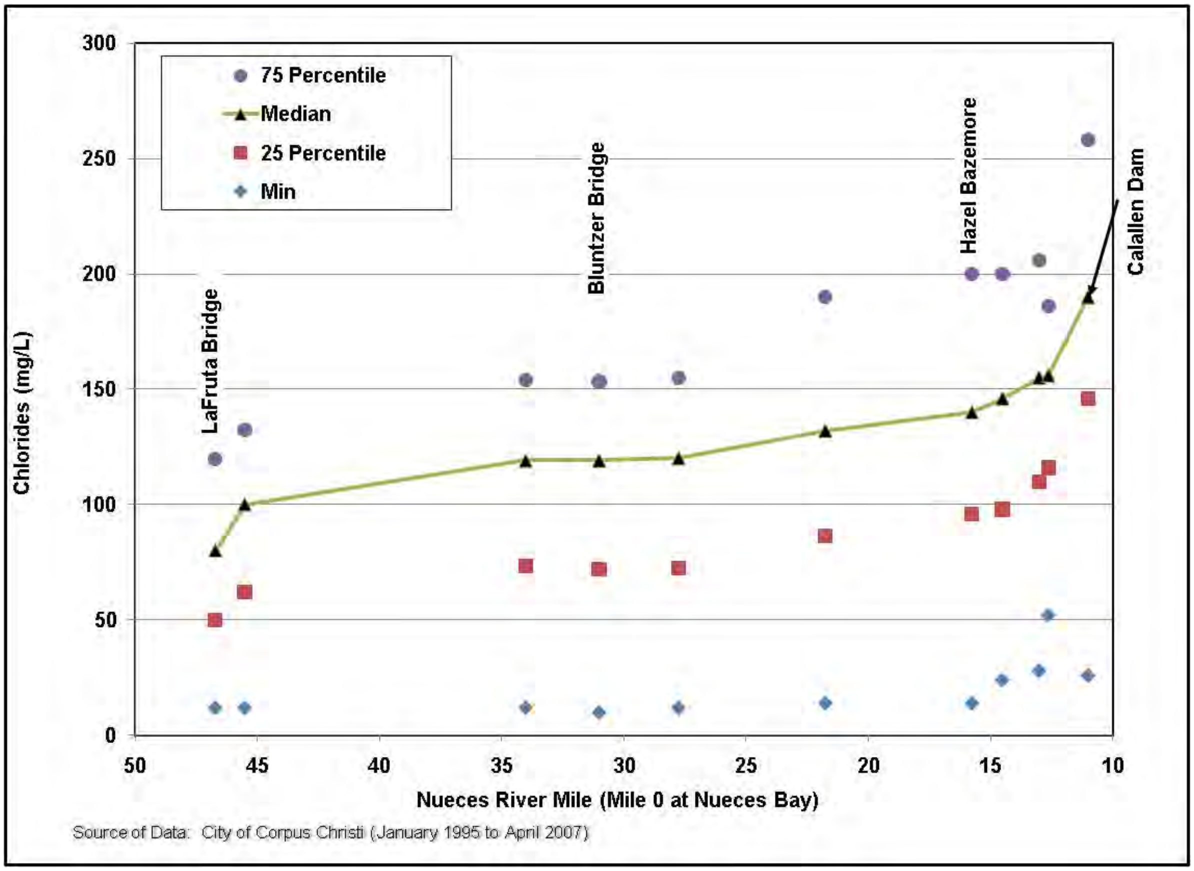


Figure ES.6.
Summary of Historical Data – Chloride Content of the Lower Nueces River, Segment 2102

Potential sources of minerals to the Calallen Pool include saltwater intrusion, groundwater seepage, and upstream sources of contamination from abandoned wells in adjacent oil fields and gravel washing operations. Previous 2001 and 2006 Plans included results of a Nueces River sampling program confirming the increase in mineral concentrations. The results of this sampling program strongly suggested that poor quality groundwater is entering the river and resulting in the increase. The effect of the high dissolved solids concentrations is two-fold and includes an increase in industrial water demands due to accelerated buildup of minerals in industrial cooling facilities, as well as high levels of chlorides and bromides, which sometimes exceed drinking water standards. An assessment was conducted during development of the 2011 Plan to evaluate water quality in Lake Corpus Christi and downstream Lower Nueces River segment to Calallen Pool (Section 5D.3). A water management strategy for potential interconnections to the Mary Rhodes Pipeline was also evaluated to provide water supplies from Lake Texana for industries with intakes located in the Calallen Pool to reduce water quality fluctuations in their water supply as is currently experienced with supplies from the Lower Nueces River (Chapter 5D.3.6.6). Improvements in water quality will result in reduced levels of water consumption from industrial processes and provide additional water conservation for the region. Reductions in chloride and bromide levels will help ensure Safe Drinking Water Act requirements can be achieved without having to resort to expensive treatment methods.

Groundwater supplies are generally of good water quality. However, some areas in the region have slightly brackish groundwater (TDS ≈ 1,000 to 1,500 mg/L). In previous studies, several small rural utilities have had water quality concerns associated with salinity and other water quality constituents. For these systems, brackish groundwater desalination or potential system interconnections to neighboring water utilities may be considered in the future.

ES.6.5 Supply and Demand Comparison

The CBRWPG identified 2 individual cities and 6 non-municipal water user groups that showed unmet needs during drought of record supply conditions during the 50-year planning horizon. Figure ES.7 shows these water user groups with shortages for both 2040 and 2070 timeframes.

Five of the 11 counties in the region have a projected shortage in at least one of the water user groups in the county. These are Duval, Jim Wells, McMullen, Nueces and San Patricio. None of the water user groups in Aransas, Bee, Brooks, Kenedy, Kleberg, or Live Oak Counties have projected shortages.

Constraints on Water Supply

Water supplies are also affected by contractual arrangements and infrastructure constraints. Expiring contracts, insufficient well capacity, and water treatment plant capacity — each of these supply constraints was taken into account in estimating water supplies available to water user groups. Consequently, the water supply listed for a given city may be less than the quantity in their water purchase contract or water right.

ES.6.6 Additional Plan Information

Although the majority of the plan is focused on assessing supplies (Chapter 3), identifying needs (Chapter 4), and evaluating water management strategies to address projected shortages (Chapter 5), there are additional report sections of interest. Chapter 6 summarizes the impact of water management strategies on key parameters of water quality in the region. Chapter 7 presents drought response information for the region and activities and recommendations to mitigate future drought impacts on water supply. Chapter 8 presents legislative recommendations and unique stream segments/reservoirs from the CBRWPG. Chapter 10 summarizes the public participation process, regional meetings held, and CBRWPG approval of the regional plan on April 9, 2015. Chapter 11 compares this plan to previous plans.

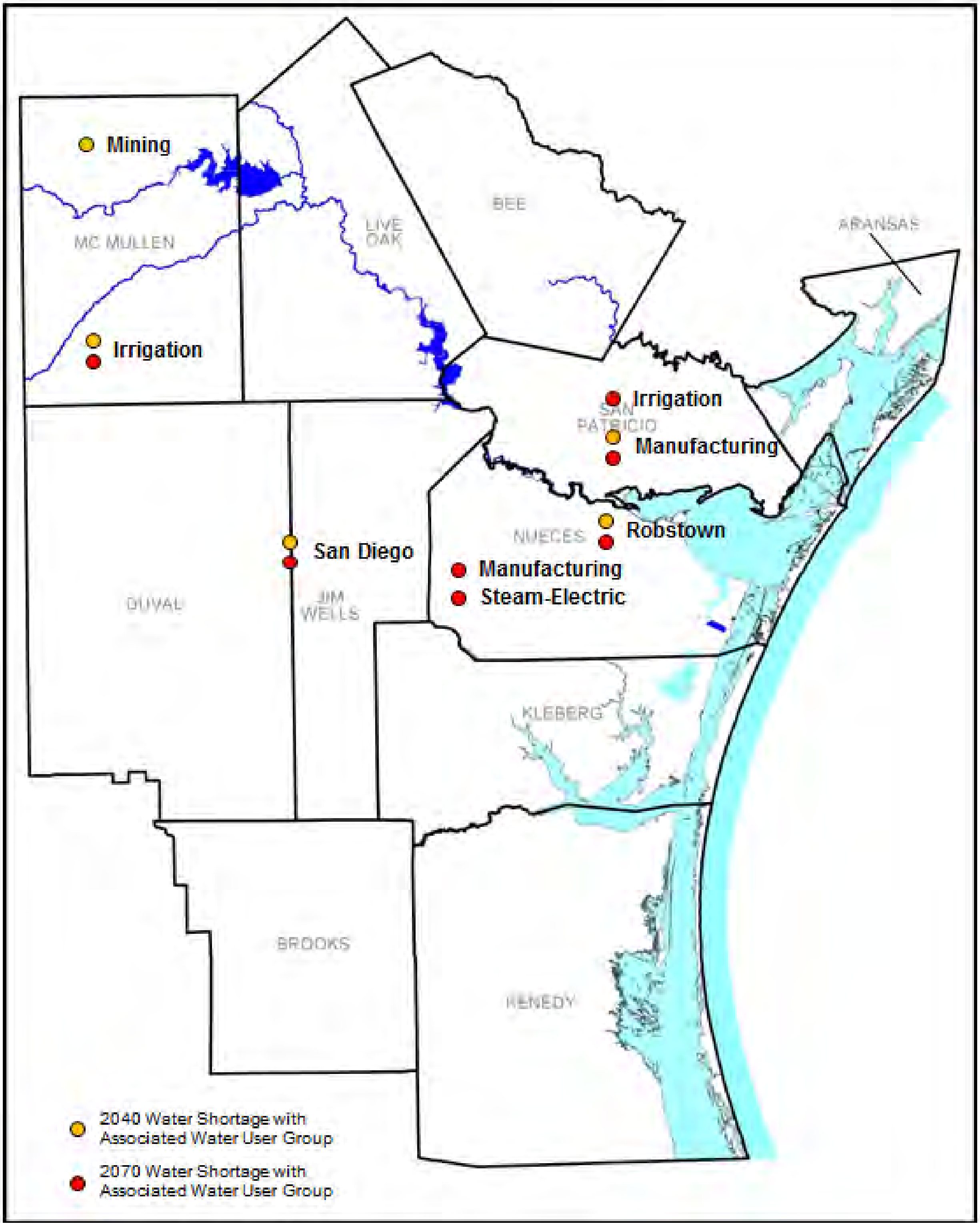


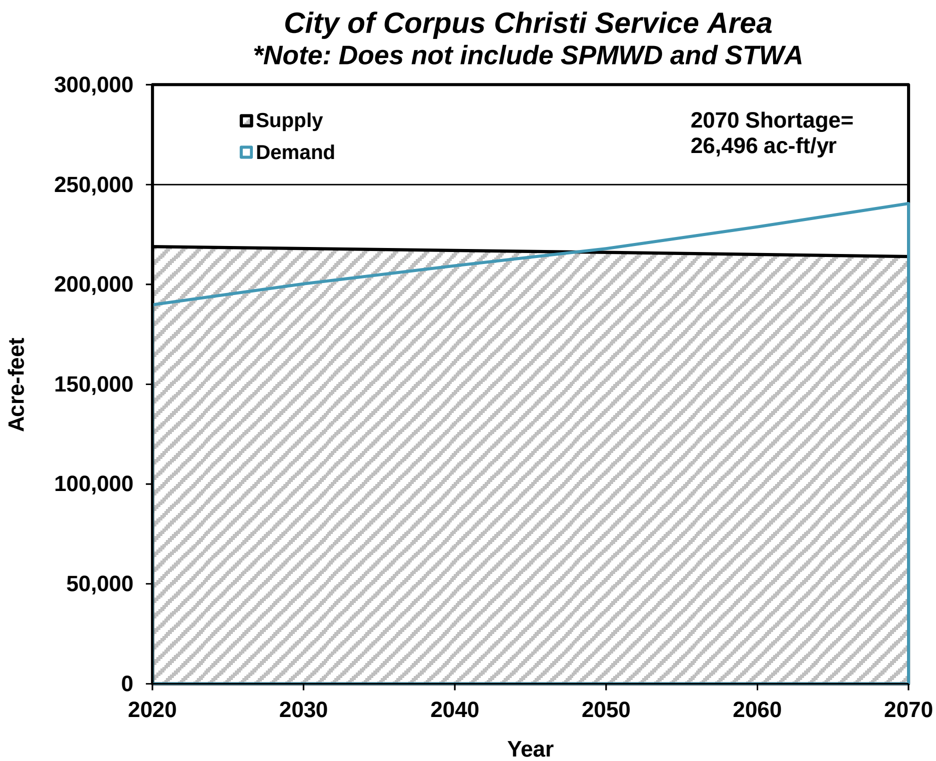
Figure ES.7.
Location and Type of Use for 2040 and 2070 Water Supply Shortage

ES.7 Wholesale Water Providers

There are four wholesale water providers (WWPs) in the Region: the City, SPMWD, STWA, and Nueces County WCID #3. In 2010, the City supplied about 59 percent of the Region's overall demands[11], and SPMWD (a major customer of the City) supplied about 10 percent of the Region's demands. Both STWA and Nueces County WCID #3 combined provided less than 3 percent of the Region's water demand. Groundwater supplied about 26 percent of the overall regional water demand. Figure ES.8 shows a comparison of water demands to currently available water supplies for each of these providers. The City needs additional water treatment plant capacity beginning before 2050 to effectively utilize raw water supplies. SPMWD needs additional water treatment plant capacity beginning before 2020, although it has raw water contracts for up to 51,200 ac-ft/yr from the City. STWA has sufficient supplies to meet their projected customer demands to 2070. Nueces County WCID #3 needs terminal storage by 2020 to firm up its run-of-the-river rights during drought conditions to meet customer needs through 2070.

For municipal water user groups relying on surface water supplies from the City's CCR/LCC/Texana/MRP Phase II system, shortages are not expected during the 2020 through 2070 time frame. All shortages during the projection period are placed on industrial water user groups. By 2070, the City of Corpus Christi as a WWP is estimated to need 26,496 ac-ft of additional water supply based on existing treatment plant and raw water supply constraints. SPMWD Service Area is estimated to need 18,529 ac-ft of additional water supply based on existing treatment plant and raw water supply constraints, and of this amount 16,764 ac-ft is attributed to raw water supply shortages. If the City continues to serve as a regional wholesale water provider to provide adequate supplies to also meet SPMWD and STWA customer water demands, then a raw water shortage does not occur until a few years before 2050. An additional raw water supply of 10,824 ac-ft/yr is needed by 2050 and 43,260 ac-ft by 2070. Surface water allocation for WWPs is discussed in Section 4.2.

[11] There is a discrepancy between 2010 diversions reported on the Nueces River Authority website for the CCR/LCC/Texana system and TWDB water use survey reports. The TWDB water use survey reports an additional 27,317 acft of surface water use in 2010 that does not seem to match local records.



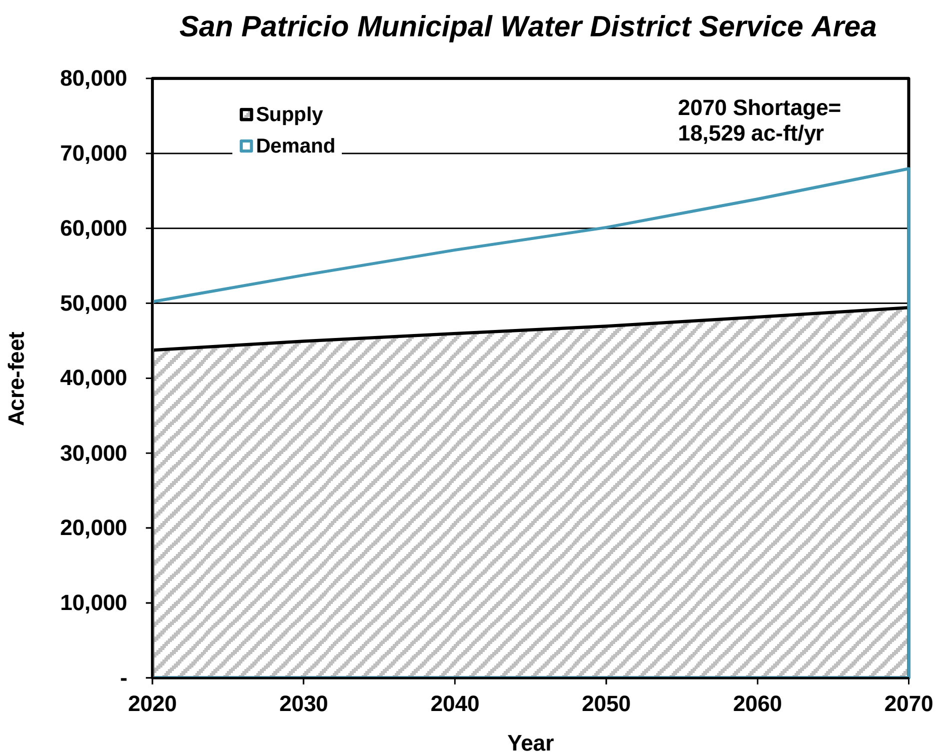


Figure ES.8.
Water Supply vs. Demand for Major Water Providers Water Plan Findings and Recommendations
(Page 1 of 2)

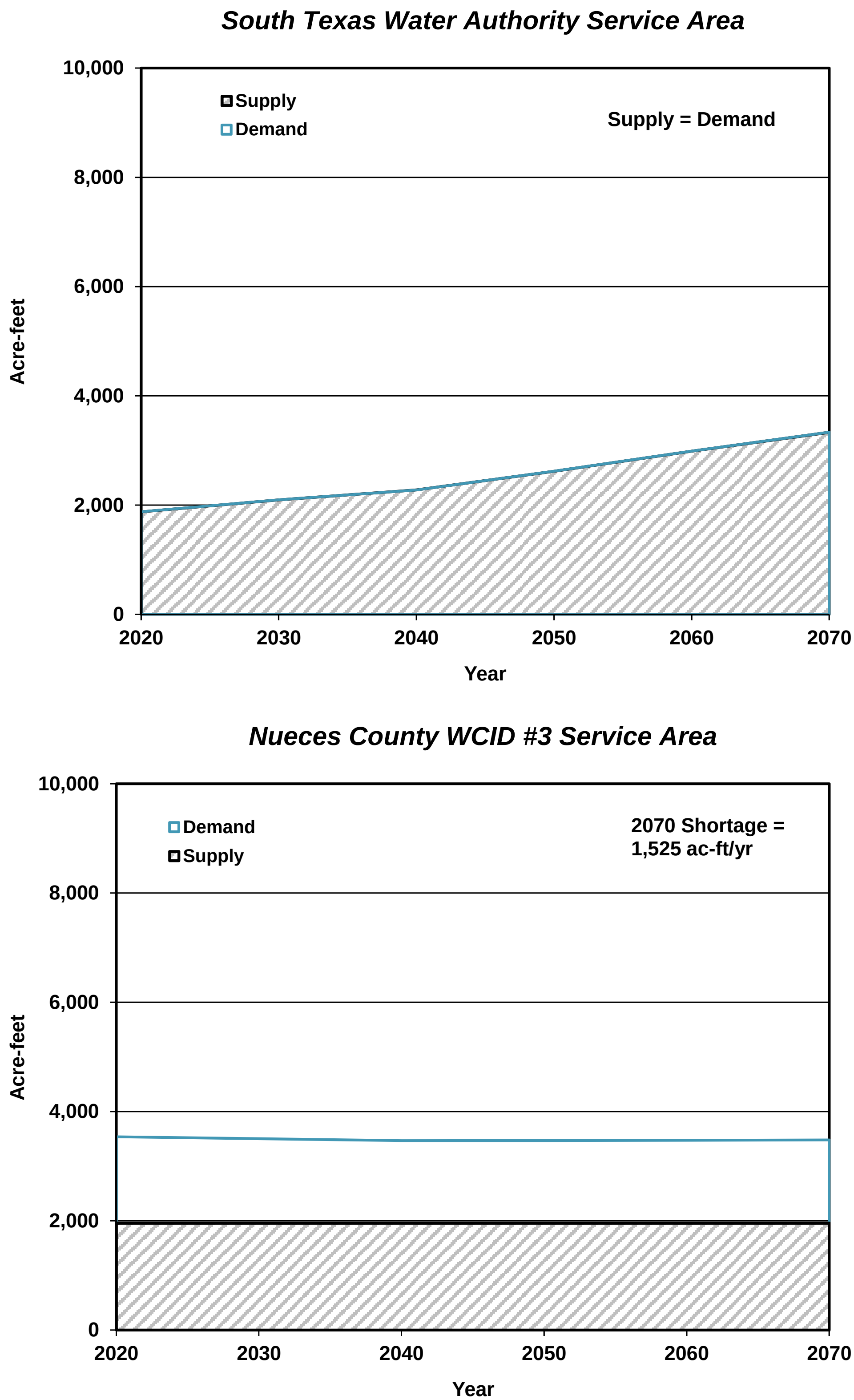


Figure ES.8.
Water Supply vs. Demand for Major Water Providers Water Plan
Findings and Recommendations
(Page 2 of 2)

ES.8 Water Supply Strategies to Meet Needs

Numerous water management strategies were identified by the CBRWPG as potentially feasible to meet water supply shortages. Each strategy was evaluated by the consultant team and compared to criteria adopted by the CBRWPG. The Coastal Bend Regional Water Plan includes recommended water management strategies that emphasize water conservation and reuse; maximize utilization of available resources, water rights, and reservoirs; engage the efficiency of conjunctive use of surface and groundwater; and limit depletion of storage in aquifers. The strategies identified as potentially feasible are tabulated in Tables ES.6 and ES.7. Table ES.6 summarizes potential strategies for the City's Service Area, while Table ES.7 summarizes strategies to other service areas. Additionally, Figure ES.9 provides a graphical comparison of unit costs and quantities of water provided for selected strategies evaluated. Section 5D contains sections discussing each of these possible strategies in detail.

Table ES.8 summarizes findings and recommendations for every water user group, including those with projected water shortages. The table also lists each municipality and water user group by county. Water demands are listed for years 2020, 2040, and 2070. Shortages are listed for years 2020, 2040, and 2070, along with recommended actions to meet these shortages.

The TWDB plans to conduct a second tiered water need analysis after implementation of conservation and reuse strategies. The results of this analysis were unavailable at the time of development of the draft plan, but will be included in the final plan.

The recommended water supply plans are presented by county in greater detail in Chapter 5. Water management strategies recommended in the Coastal Bend Region could produce new supplies in excess of the projected regional need of 50,950 ac-ft in Year 2070. Supplies exceed shortages in case water growth patterns and demands exceed TWDB projections or supplies are reduced under current interbasin water supply contracts.

Table ES.9 summarizes those strategies that are recommended in the regional water plan. Total estimated project cost (in September 2013 dollars) for the recommended water management strategies for the Coastal Bend Region is $561,260,000. Table ES.10 summarizes alternative water management strategies developed as part of the planning process.

Table ES.6.
Potential Water Management Strategies to Meet Long-Term Needs for Wholesale Water Providers

WMS ID	*Water Management Strategy*	*Additional Water Supply (ac-ft/yr)*	*Total Project Cost*	*Annual Cost*	*Unit Cost of Additional Treated Water ($ per ac-ft/yr)*	*Degree of Water Quality Improvement*	*Environmental Issues/ Special Concerns*
5D.1	**Municipal Water Conservation**	up to 17,034	Variable; Regional cost up to 8,226,575[1]	Variable	$470-$510	No Change	Possible reduction in return flows to bay and estuary
5D.3	**Manufacturing Water Conservation**						
3-1	Blending of MRP Phase II	up to 1,497	Not Applicable	Not Applicable	Not Applicable[2]	Significant Improvement	None
3-2	Outlet works to remove high TDS from Calallen Pool	627-869	$3,151,000	$287,000	$699-$827[3]	Significant Improvement	None
3-3	Intake Modifications	836-1,158	$8,535,000	$832,000	$1,205-$1,364[3]	Significant Improvement	None
3-4	Pipeline from LCC to Calallen	19,600-23,100	$190,005,000	$19,541,000	$1,215-$1,366[3]	Significant Improvement	Potentially significant environmental impacts; construction and maintenance of pipeline corridors
5D.5	**Reclaimed Wastewater Supplies[4]**	Up to 20,178	$21,292,000 to $52,097,000	$1,997,000 to $11,641,000	$577 to $892	No Change	Potential reduction of freshwater inflows to estuary; construction and maintenance of pipeline corridors
5D.6	**Modify Existing Reservoir Operating Policy and Safe Yield Analysis**	None	None	None	None	No Change	None
5D.7	**Gulf Coast Aquifer Supplies (Blending)**	707 to 28,155	$4,630,000 to $110,706,000	$514,000 to $14,772,000	$525 to $1,129	Slight fluctuations and deterioration possible	Requires blending with 22,850 to 48,047 ac-ft of treated surface water for total water demand of 51,005 ac-ft for SPMWD customers in 2070. Requires blending with 2,627 ac-ft of treated surface water for total water demand of 3,334 ac-ft for STWA customers in 2070.
5D.8	**Brackish Groundwater Desalination**	12,000 to 24,000	$98,267,000 to $129,433,000	$15,028,000 to $20,470,000	$853 to $1,252	Variable. Low to significant Improvement[5]	Brine from desalt plant requires disposal; construction and maintenance of pipeline corridor
5D.9	**Seawater Desalination and Variable Salinity Program**	22,420	$248,000,000	$31,797,560 to $32,515,000	$1,418 to $1,450	Variable. Low to significant Improvement[5]	Brine from desalt plant requires disposal; construction and maintenance of pipeline corridor
5D.11	**Local Balancing Storage Reservoir**	1,583	$8,182,000	$732,000	$831[3]	No Change	Construction and maintenance of pipeline corridors and terminal storage
5D.12	**Lavaca Off-Channel Reservoir**	16,963	$177,485,000	$14,704,000	$1,236[3]	No Change	Direct impact to around 3,000 acres
5D.13	**GBRA Lower Basin Storage Project**	20,000	$72,546,000	$8,849,000	$811[3]	Slight Improvement	Interregional coordination; inter-basin transfer likely needed
5D.14	**SPMWD WTP Improvements**	18,529	$58,366,000	$14,997,000	$809	No change	None
5D.15	**O.N. Stevens WTP Improvements**	up to 28,025	$44,029,540	$5,681,000	$572	No change	None

[1] Assumes unit costs of $470 to $510/ac-ft.
[2] Cost of Manufacturing Water Conservation not determined.
[3] Cost has been adjusted to include treatment. Cost for treatment is estimated at $369 per acft.
[4] Includes Portland Reuse (2 mgd) and Greenwood WWTP reuse strategies.
[5] Depends on the amount of raw water that bypasses treatment for blending with desalinated water to stabilize and prevent corrosivity in the pipeline conveyance system. At larger ratios of bypassed water to desalinated water, the degree of water quality improvement over current supplies is diminished.

Table ES.7.
Potential Water Management Strategies to Meet Long-Term Needs for Local Service Areas

WMS	Water Management Strategy	Additional Water Supply (ac-ft/yr)	Total Project Cost	Annual Cost	Unit Cost of Additional Treated Water ($ per ac-ft/yr)	Degree of Water Quality Improvement	Environmental Issues/ Special Concerns
5D.1	**Municipal Water Conservation**	up to 17,034	Variable; Regional Cost up to $8,226,575[1]	Variable	$470-$510	No Change	Possible reduction in return flows to bay and estuary
	Pipeline Replacement- Alice	up to 576	$21,384,000	$2,138,400	$62,120	No Change	None
5D.2	**Irrigation Water Conservation**	up to 2,803	Variable; Regional Cost up to $642,804	Variable	$230[2]	No Change	None
5D.4	**Mining Water Conservation**	up to 357	Highly Variable	Highly Variable	Variable	No Change	None
5D.5	**Reclaimed Wastewater Supplies-City of Alice**	897	$8,661,000 to $10,838,000	$1,185,000 to $1,366,000	$1,321 to $1,523	Some Degradation	Potential reduction of freshwater inflows to San Fernando Creek and Baffin Bay; construction and maintenance of pipeline corridors
5D.7	**Gulf Coast Aquifer Supplies**						
	Drill additional well for non-municipal users	Variable, ranges from 43 to 966	Variable; up to $1,685,000[3]	Variable; up to $189,000[3]	Variable, from $159[2] to $302[2]	Some Degradation	Minor impacts
	San Diego	158	$940,000	$106,000	$671	Some Degradation	Minor impacts
	Beeville	Up to 1,797 with both projects	Variable; up to $5,038,000[4]	Variable; up to $751,000[4]	$135 to $484	Some Improvement	Minor impacts
5D.8	**Brackish Groundwater Desalination (Alice)**	3,363	$33,277,000	$4,956,000	$1,474	Variable. Low to significant Improvement[5]	Brine from desalt plant requires disposal by evaporation, deep well injection, blending, or discharging to saltwater body
5D.10	**Potential System Interconnections**						
	Duval County	1,072 to 2,708	Up to $34,786,000	Up to $5,677,000	$1,301 to $2,096	Some Negative Impact	Construction and maintenance of pipeline corridor
	Jim Wells County	494 to 929	Up to $9,398,000	Up to $1,678,000	$1,806 to $2,235	Some Negative Impact	Construction and maintenance of pipeline corridor
	Brooks County	2,844	$21,117,000	$4,340,000	$1,526	Some Negative Impact	Construction and maintenance of pipeline corridor
	STWA to Jim Wells/Brooks County	3,024	$34,899,000	$6,166,000	$2,039	Some Negative Impact	Construction and maintenance of pipeline corridor
	San Patricio County	125-1,507	$1,833,000 to $5,545,000	$259,000 to $1,630,000	$1,082 to$2,072	Some Negative Impact	Construction and maintenance of pipeline corridor
	Alice to STWA	2,800	$5,866,000	$3,746,000	$1,158	No change	Construction and maintenance of pipeline corridor

[1] Assumes unit costs of $470 to $510 per ac-ft.
[2] Unit cost for raw water supplies.
[3] Costs based on drilling 3 wells for McMullen County-Mining.
[4] Costs to implement both Chase Field and 0.3 mgd irrigation well conversion project.
[5] Depends on the amount of raw water that bypasses treatment for blending with desalinated water. At larger ratios of bypassed water to desalinated water, the degree of water quality improvement over current supplies is diminished.

Table ES.8.
Water Plan Summary for Coastal Bend Region

County/Water User Group	Demand (ac-ft)			Need (Shortage) (ac-ft)			Recommended Management Strategies to Meet Need (Shortage)
	2020	2040	2070	2020	2040	2070	
Aransas County	**See Section 4.3.1**						**See Section 5B.2**
Aransas Pass (P)	110	106	104	none	none	none	
Fulton	278	275	275	none	none	none	Additional municipal water conservation
Rockport	1,677	1,652	1,646	none	none	none	Additional municipal water conservation
County-Other	1,446	1,362	1,342	none	none	None	
Manufacturing	137	147	172	none	none	none	
Steam-Electric	0	0	0	none	none	none	
Mining	10	5	5	none	none	none	
Irrigation	0	0	0	none	none	none	
Livestock	44	44	44	none	none	none	
Bee County	**See Section 4.3.2**						**See Section 5B.3**
Beeville	2,925	2,976	2,960	none	none	none	Additional municipal water conservation, Chase Field Project, Well conversion project
El Oso WSC (P)	83	85	80	none	none	none	Additional municipal water conservation
County-Other	2,725	2,751	2,721	none	none	none	
Manufacturing	1	1	1	none	none	none	
Steam-Electric	0	0	0	none	none	none	
Mining	472	428	318	none	none	none	
Irrigation	4,751	5,796	7,985	none	none	none	
Livestock	930	930	930	none	none	none	
Brooks County	**See Section 4.3.3**						**See Section 5B.4**
Falfurrias	1,677	1,755	1,915	none	none	None	Additional municipal water conservation
County-Other	326	370	449	none	none	none	
Manufacturing	0	0	0	none	none	none	
Steam-Electric	0	0	0	none	none	none	
Mining	357	340	298	none	none	none	
Irrigation	1,800	1,985	2,297	none	none	none	
Livestock	620	620	620	none	none	none	
Duval County	**See Section 4.3.4**						**See Section 5B.5**
Benavides	236	250	272	none	none	none	Additional municipal water conservation
Freer	650	691	754	none	none	none	Additional municipal water conservation
San Diego (P)	724	765	832	none	(40)	(107)	Additional municipal water conservation, Additional Gulf Coast Aquifer Supplies
County-Other	549	568	610	none	none	none	
Duval County (cont.)	**See Section 4.3.4**						**See Section 5B.5**
Manufacturing	0	0	0	none	none	none	
Steam-Electric	0	0	0	none	none	none	
Mining	1,388	1,352	1,104	none	none	none	
Irrigation	3,004	3,312	3,834	none	none	none	
Livestock	754	754	754	none	none	none	
Jim Wells County	**See Section 4.3.5**						**See Section 5B.6**
Alice	4,192	4,643	5,421	none	none	none	Additional municipal water conservation, pipeline replacement program, brackish groundwater desalination, STWA Interconnection, reuse of reclaimed wastewater supplies
Orange Grove	376	422	494	none	none	none	Additional municipal water conservation
Premont	710	792	929	none	none	none	Additional municipal water conservation
San Diego (P)	186	205	240	none	(16)	(51)	Additional municipal water conservation, additional Gulf Coast Aquifer Supplies
County-Other	2,634	2,890	3,360	none	none	none	
Manufacturing	0	0	0	none	none	none	
Steam-Electric	0	0	0	none	none	none	
Mining	71	55	17	none	none	none	
Irrigation	2,500	2,756	3,191	none	none	none	
Livestock	1,029	1,029	1,029	none	none	none	

Table ES-8 (Continued)

County/Water User Group	Demand (ac-ft)			Need (Shortage) (ac-ft)			Recommended Management Strategies to Meet Need (Shortage)
	2020	2040	2070	2020	2040	2070	
Kenedy County	**See Section 4.3.6**						**See Section 5B.7**
County-Other	244	262	264	none	none	none	Additional municipal water conservation
Manufacturing	0	0	0	none	none	none	
Steam-Electric	0	0	0	none	none	none	
Mining	118	92	27	none	none	none	
Irrigation	0	0	0	none	none	none	
Livestock	644	644	644	none	none	none	
Kleberg County	**See Section 4.3.7**						**See Section 5B.8**
Kingsville	4,232	4,738	5,636	none	none	none	
Ricardo WSC	341	382	454	none	none	none	
County-Other	601	679	817	none	none	none	Additional municipal water conservation
Manufacturing	0	0	0	none	none	none	
Steam-Electric	0	0	0	none	none	none	
Mining	357	340	298	none	none	none	
Irrigation	600	662	766	none	none	none	
Livestock	1,276	1,276	1,276	none	none	none	
Live Oak County	**See Section 4.3.8**						**See Section 5B.9**
El Oso WSC (P)	143	137	129	none	none	none	Additional municipal water conservation
George West	454	433	428	none	none	none	Additional municipal water conservation
McCoy WSC	22	21	20	none	none	none	
Three Rivers	325	309	305	none	none	none	Additional municipal water conservation
County-Other	802	768	758	none	none	none	
Manufacturing	2,024	2,089	2,333	none	none	none	
Steam-Electric	0	0	0	none	none	none	
Mining	814	907	332	none	none	none	
Irrigation	2,200	2,426	2,808	none	none	none	
Livestock	933	933	933	none	none	none	
McMullen County	**See Section 4.3.9**						**See Section 5B.10**
County-Other	97	91	90	none	none	none	
Manufacturing	0	0	0	none	none	none	
Steam-Electric	0	0	0	none	none	none	
Mining	4,268	4,754	1,305	(2,733)	(3,219)	none	Mining water conservation, Additional Gulf Coast Aquifer supplies
Irrigation	40	44	51	(40)	(44)	(51)	Irrigation water conservation, Additional Gulf Coast Aquifer supplies
Livestock	355	355	355	none	none	none	
Nueces County	**See Section 4.3.10**						**See Section 5B.11**
Agua Dulce	132	143	150	none	none	none	
Aransas Pass (P)	3	3	3	none	none	none	
Bishop	594	646	682	none	none	none	Additional municipal water conservation
Corpus Christi	64,816	71,270	75,058	none	none	none	Additional municipal water conservation
Driscoll	105	113	118	none	none	none	
Nueces WSC	333	368	388	none	none	none	
Port Aransas	2,251	2,548	2,703	none	none	none	Additional municipal water conservation
River Acres WSC	426	463	486	none	none	none	Additional municipal water conservation
Robstown	2,957	2,848	2,839	(1,583)	(1,511)	(1,525)	Additional municipal water conservation, Local balancing storage reservoir
County-Other	1,554	1,901	2,093	none	none	none	

Table ES-8 (Continued)

County/Water User Group	Demand (ac-ft)			Need (Shortage) (ac-ft)			Recommended Management Strategies to Meet Need (Shortage)
	2020	2040	2070	2020	2040	2070	
Nueces County (cont.)	**See Section 4.3.10**						**See Section 5B.11**
Manufacturing	50,276	56,500	67,769	none	none	(19,603)	Manufacturing water conservation, O.N. Stevens WTP improvements, Additional reuse of reclaimed wastewater supplies, Seawater desalination, GBRA Lower Basin Project
Steam-Electric	15,038	20,681	34,541	none	none	(6,893)	Manufacturing water conservation, O.N. Stevens WTP improvements, Additional reuse of reclaimed wastewater supplies, Seawater desalination, GBRA Lower Basin Project
Mining	724	947	1,260	none	none	none	
Irrigation	439	484	560	none	none	none	
Livestock	315	315	315	none	none	none	
San Patricio County	**See Section 4.3.11**						**See Section 5B.12**
Aransas Pass (P)	1,131	1,149	1,176	none	none	none	
Gregory	339	348	361	none	none	none	Additional municipal water conservation
Ingleside	1,051	1,060	1,083	none	none	none	
Ingleside On The Bay	77	78	79	none	none	none	
Lake City	64	64	66	none	none	none	
Mathis	670	672	691	none	none	none	
Odem	379	384	394	none	none	none	
Portland	2,631	2,698	2,770	none	none	none	Additional municipal water conservation
Rincon WSC	346	359	369	none	none	none	
Sinton	1,409	1,463	1,507	none	none	none	Additional municipal water conservation
Taft	464	469	484	none	none	none	
County-Other	1,584	1,647	1,705	none	none	none	
Manufacturing	39,737	46,416	56,991	(6,451)	(11,126)	(18,529)	Manufacturing water conservation, SPMWD Industrial WTP improvements, Portland reuse of reclaimed wastewater supplies, Seawater desalination, GBRA Lower Basin Project
Steam-Electric	0	0	0	none	none	none	
Mining	372	440	533	none	none	none	
Irrigation	11,085	13,525	18,632	none	none	(4,191)	Irrigation water conservation, Additional Gulf Coast Aquifer supplies
Livestock	406	406	406	none	none	none	
Total Needs by Water User Type							
Municipal	112,081	121,072	128,510	(1,583)	(1,567)	(1,683)	Municipal water conservation, Irrigation water conservation, Manufacturing water conservation, Mining water conservation, Additional reuse of reclaimed wastewater supplies, Additional Gulf Coast Aquifer Supplies, Brackish groundwater desalination, seawater desalination, Water system interconnections, Local balancing storage reservoir, GBRA Lower Basin Storage, SPMWD Industrial WTP improvements, O.N. Stevens WTP improvements
Manufacturing	92,175	105,153	127,266	(6,451)	(11,126)	(38,132)	
Steam-Electric	15,038	20,681	34,541	none	none	(6,893)	
Mining	8,951	9,660	5,497	(2,733)	(3,219)	none	
Irrigation	26,419	30,990	40,124	(40)	(44)	(4,242)	
Livestock	7,306	7,306	7,306	none	none	none	
Region N Total	261,970	294,862	343,244	**(10,807)**	**(15,956)**	**(50,950)**	

(P) = Partial listing – water user group is in multiple counties.

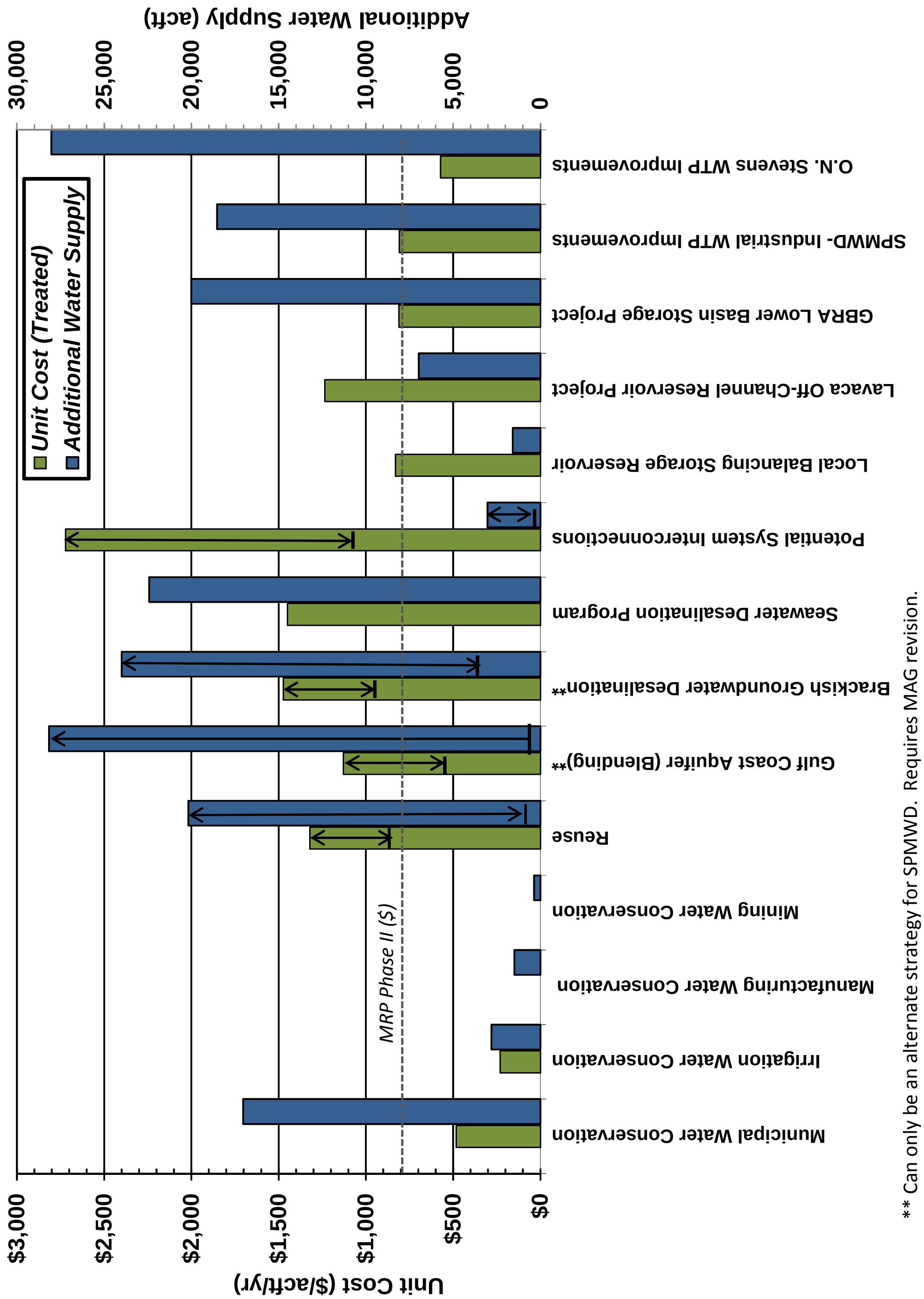


Figure ES.9.
Comparison of Unit Costs and Water Supply Quantities for Potential Water Management Strategies for Coastal Bend

Table ES.9.
Summary of Recommended Water Management Strategies in the Coastal Bend Region

ID	Recommended Water Management Strategy	Total Capital Costs	First Decade Estimated Unit Cost ($/ac-ft/yr)	Last Decade Estimated Unit Cost ($/ac-ft/yr)	Water Yield (ac-ft/yr) 2020	2030	2040	2050	2060	2070	First Decade of Imple-mentation
5D.1	**Municipal Water Conservation**										
	Alice	N/A	$510	$510	143	462	812	838	876	916	2020
	Alice- Pipeline Replacement Program	$21,384,000	$62,120	$0	0	173	460	576	576	576	2030
	Beeville	N/A	$500	$500	117	333	542	710	706	707	2020
	Benavides	N/A	$500	$0	4	0	0	0	0	0	2020
	Bishop	N/A	$510	$510	16	39	27	23	23	23	2020
	Corpus Christi	N/A	$470	$470	2,305	7,354	10,985	10,667	10,765	10,898	2020
	County-Other, Kleberg	N/A	$510	$510	13	24	15	15	14	15	2020
	County-Other, Kenedy	N/A	$500	$500	17	40	60	79	97	113	2020
	El Oso WSC	N/A	$500	$500	20	35	50	51	41	41	2020
	Falfurrias	N/A	$500	$500	91	224	360	508	649	786	2020
	Freer	N/A	$510	$500	24	73	124	168	171	175	2020
	Fulton	N/A	$510	$510	12	33	46	44	44	44	2020
	George West	N/A	$500	$500	15	46	44	40	39	39	2020
	Gregory	N/A	$510	$510	8	11	6	6	5	5	2020
	Orange Grove	N/A	$500	$500	18	49	83	120	159	183	2020
	Port Aransas	N/A	$510	$510	160	374	589	792	985	1,161	2020
	Portland	N/A	$510	$0	74	49	0	0	0	0	2020
	Premont	N/A	$500	$500	31	87	149	221	289	303	2020
	River Acres WSC	N/A	$510	$510	9	0	0	0	0	0	2020
	Robstown	N/A	$510	$510	125	336	532	748	884	884	2020
	Rockport	N/A	$510	$510	66	192	172	159	156	156	2020
	San Diego	N/A	$500	$500	29	94	117	117	119	122	2020
	Sinton	N/A	$510	$510	62	170	277	385	447	451	2020
	Three Rivers	N/A	$500	$500	11	22	15	11	11	11	2020
5D.2	**Irrigation Conservation**										
	McMullen County	N/A	$230	$230	1	2	3	5	6	8	2020
	San Patricio County	N/A	$230	$230	0	0	0	1,494	2,063	2,795	2050
5D.3	**Manufacturing Conservation**										
	Manufacturing (San Patricio and Nueces), S&E (Nueces)	N/A	N/A	N/A	1,081	1,164	1,247	1,331	1,414	1,497	2020
5D.4	**Mining Water Conservation**										
	McMullen County	N/A	N/A	N/A	106	240	357	262	231	196	2020
5D.5	**Reclaimed Wastewater Supplies and Reuse**										
	Manufacturing (Nueces), S&E	$52,097,000	$577	$361	0	20,178	20,178	20,178	20,178	20,178	2030
	Manufacturing- San Patricio	$21,292,000	$892	$96	$892	$892	$96	$96	$96	$96	2020
	City of Alice-nonpotable	$8,661,000	$1,321	$512	0	897	897	897	897	897	2030
5D.6	**Modify Existing Reservoir Operating Policy and Safe Yield Analyses**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	—
5D.7	**Gulf Coast Aquifer Groundwater Supplies (Local)**										
	McMullen County-Irrigation	$129,000	$302	$47	43	43	43	43	43	43	2020
	McMullen County-Mining	$1,685,000	$196	$50	966	966	966	966	966	966	2020
	San Patricio County-Irrigation	$1,156,000	$159	$21	0	0	0	703	703	703	2050
	City of San Diego	$940,000	$671	$171	0	158	158	158	158	158	2030
	City of Beeville-Chase Field	$4,777,000	$484	$209	1,457	1,457	1,457	1,457	1,457	1,457	2020
	City of Beeville-Irrigation Well to Municipal Conversion	$261,000	$135	$135	340	340	340	340	340	340	2020
5D.8	**Brackish Groundwater Desalination**										
	City of Alice	$33,277,000	$1,474	$646	3,363	3,363	3,363	3,363	3,363	3,363	2020
5D.9	**Seawater Desalination and Variable Salinity Program**	$248,000,000	$1,418 - $1,450	$550	0	22,420	22,420	22,420	22,420	22,420	2030
5D.10	**Potential Water System Interconnections**										
	STWA to City of Alice	$5,866,000	$1,158	$983	2,800	2,800	2,800	2,800	2,800	2,800	2020
5D.11	**Local Balancing Storage Reservoir**										
	City of Robstown (project by Nueces County WCID #3)	$8,182,000	$831	$67	1,583	1,583	1,583	1,583	1,583	1,583	2020
5D.13	**GBRA Lower Basin Storage Project**	$72,546,000 (Region N share)	$811	$532	0	20,000	20,000	20,000	20,000	20,000	2030
5D.14	**SPMWD-Industrial Water Treatment Plant Improvements**	$58,366,000	$809	$546	18,529	18,529	18,529	18,529	18,529	18,529	2020
5D.15	**O.N. Stevens Water Treatment Plant Improvements**	$44,029,540	$572	$0	28,025	17.696	7,643	N/A	N/A	N/A	2020

N/A = Not Applicable

Table ES.10.
Summary of Alternative Water Management Strategies in the Coastal Bend Region

ID	Alternative Water Management Strategy	Total Capital Costs	First Decade Estimated Unit Cost ($/ac-ft/yr)	Water Yield (ac-ft/yr)						First Decade of Implementation
				2020	2030	2040	2050	2060	2070	
5D.8	**Brackish Groundwater Desalination (Regional)**	$142,632,000	$916	0	0	24,000	24,000	24,000	24,000	2030
Note: Permitting required for project. Groundwater supplies needed for the project exceed the MAG in San Patricio County.										

Future projects involving authorization from either the TCEQ and/or TWDB, which are not specifically addressed in the plan, are considered to be consistent with the plan under the following circumstances:

- TWDB receives applications for financial assistance for many types of water supply projects, including water conservation, and when appropriate, wastewater reuse strategies. Other projects involve repairing, replacing, or expanding treatment plants, pump stations, pipelines, and water storage facilities. The CBRWPG considers projects that do not involve the development of or connection to a new water source to be consistent with the regional water plan even though not specifically recommended in the plan.
- TCEQ considers water rights applications for various types of uses (e.g., recreation, navigation, irrigation, hydroelectric power, industrial, recharge, municipal, and others). Many of these applications are for small amounts of water, some are temporary, and some are even non-consumptive. Because waters of the Nueces River Basin are fully appropriated to the City of Corpus Christi and others, any new water rights application for consumptive water use from this Basin will need to protect the existing water rights or provide appropriate mitigation to existing water right owners. Throughout the Coastal Bend Region, the types of small projects that may arise are so unpredictable that the CBRWPG is of the opinion that each project should be considered by the TWDB and TCEQ on their merits, and that the Legislature foresaw this situation and provided appropriate language for each agency to deal with it.

  (Note: The provision related to TCEQ is found in Texas Water Code §11.134. It provides that the Commission shall grant an application to appropriate surface water, including amendments, only if the proposed appropriator addresses a water supply need in a manner consistent with an approved regional water plan. TCEQ may waive this requirement if conditions warrant. For TWDB funding, Texas Water Code §16.053(j) states that after January 5, 2002, TWDB may provide financial assistance to a water supply project only after the Board determines that the needs to be addressed by the project will be addressed in a manner that is consistent with that appropriate regional water plan. The TWDB may waive this provision if conditions warrant.)

ES.9 Social and Economic Impacts of Not Meeting Projected Water Needs

At the request of the CBRWPG during their February 2015 meeting, the Nueces River Authority submitted a request for the TWDB to conduct a socioeconomic impact analysis of not meeting needs in the Coastal Bend Region. Socioeconomic impacts of unmet needs were evaluated by the TWDB and costs were provided to represent impacts of leaving water needs entirely unmet for each water use category and as an aggregate for the region under a repeat of the drought of record. The TWDB's socioeconomic impact analysis represents a snapshot of socioeconomic impacts that may occur during a single year during a drought of record within each of the planning decades. The TWDB's analysis for Region N is included in Appendix 2.

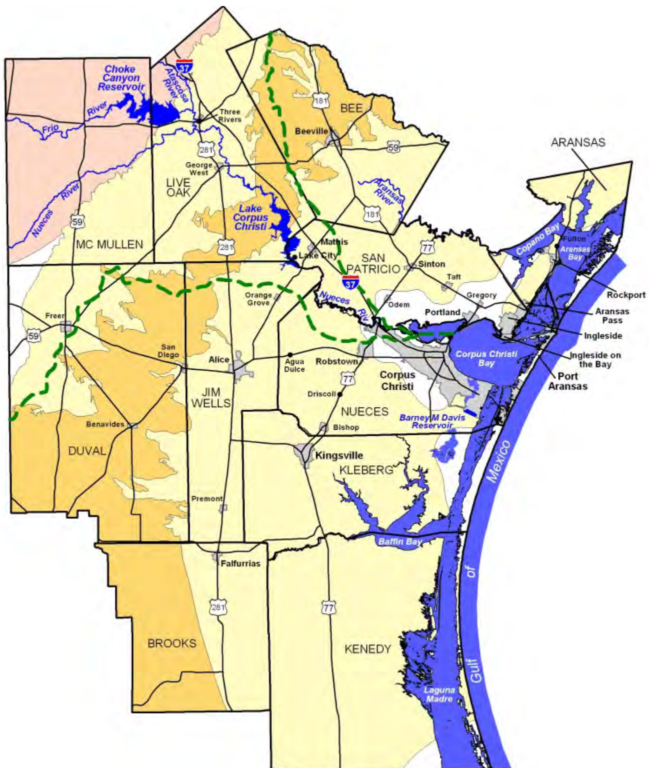
The estimated effect of projected water shortages upon income in the region, are $4,492 million per year in 2020, $5,487 million per year in 2040, and $1,715 million per year in 2070. If the water needs are left entirely unmet, the level of shortage in 2020 results in 24,000 fewer jobs than would be expected if the water needs of 2020 are fully met. The gap in job growth due to water shortages grows to 5,430 fewer jobs by 2040 and 1,540 few jobs by 2070.

ES.10 Unmet Water Needs

The CBRWPG evaluated numerous water management strategies to meet projected water needs and assimilated feedback from WUGs to reflect local plans. There were, however, two water user groups that reported unmet needs after considering water conservation and local strategies. In both cases, future potential supplies were constrained by modeled available groundwater (MAG) limits. Unmet needs identified in the plan are presented in Table ES.11.

Table ES.11.
Preliminary Unmet Needs Identified in the Plan (ac-ft/yr)

Water User Group	*Unmet Need (ac-ft/yr)*					
	2020	*2030*	*2040*	*2050*	*2060*	*2070*
McMullen County- Mining	1,661	2,063	1,896	-	-	-
San Patricio County- Irrigation	-	-	-	-	-	693



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Planning Area Description

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Chapter 1: Planning Area Description

1.1 Current Water Use and Major Water Demand Centers

The area represented by the Coastal Bend Regional Water Planning Group ("Region N" or "Coastal Bend Region") includes the following counties: Aransas, Bee, Brooks, Duval, Jim Wells, Kenedy, Kleberg, Live Oak, McMullen, Nueces, and San Patricio. Most of the water supplies for the region are provided from surface water in the Choke Canyon/Lake Corpus Christi/Texana/Mary Rhodes Phase II system through the City of Corpus Christi or customer contracts, while others rely on groundwater supplies (Figure 1.1).

Municipal and industrial water use accounts for the greatest amount of water demand in the Coastal Bend Region, totaling 83.4 percent of the region's total water use of 186,560 ac-ft in 2012 (Figure 1.2). The major water demand areas are primarily municipal systems in the greater Corpus Christi area, as well as large industrial (manufacturing, steam-electric, and mining) users located along the Corpus Christi and La Quinta Ship Channels. Agriculture (irrigation and livestock) is the third largest category of water use in the region (Figure 1.2). Based on recent water use records, the City of Corpus Christi provides supplies for about 67 percent of the municipal and industrial water demand in the region (not including supplies to SPMWD or STWA).

1.2 Wholesale Water Providers

The Coastal Bend Region has four regional wholesale water providers: the City of Corpus Christi; San Patricio Municipal Water District (SPMWD); South Texas Water Authority (STWA); and Nueces County Water Control and Improvement District #3 (NCWC&ID#3). The City of Corpus Christi, the largest of the four, sells water to two of the other regional water providers — SPMWD and STWA. The City of Corpus Christi and the SPMWD distribute water to cities, water districts, and water supply corporations which in turn provide water to residential, commercial, and industrial customers. SPMWD also sells water directly to large industrial facilities located in San Patricio County on the La Quinta Ship Channel. STWA provides water to cities and water supply corporations that supply both residential and commercial customers within the western portion of Nueces County as well as Kleberg County. The smallest regional wholesale water provider, NCWC&ID#3, provides water to the City of Robstown and other municipal entities within the western portion of Nueces County.

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Figure 1.1.
Water Providers in the Planning Region

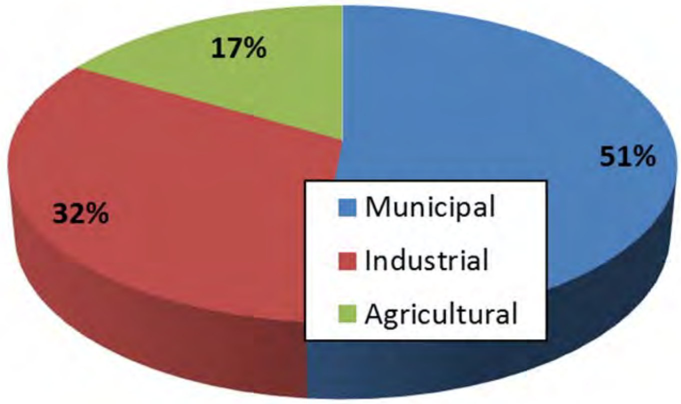

Figure 1.2.
2012 Water Use in the Coastal Bend Regional Water Planning Area = 186,560 ac-ft

1.3 Water Supplies and Quality

1.3.1 Surface Water Sources

The Coastal Bend Region depends mostly on surface water sources for municipal and industrial water supply use. The three major surface water resources include the Choke Canyon Reservoir/ Lake Corpus Christi System (CCR/LCC System) in the Nueces River Basin, Lake Texana on the Navidad River in Jackson County and water supply from the Garwood water rights located on the Colorado River in Matagorda County transported through the Mary Rhodes Phase II pipeline. Collectively this system is referred to as the CCR/LCC/Texana/MRP Phase II system. Water supply from Lake Texana is transported to the Coastal Bend Region via the Mary Rhodes Pipeline and provides the Coastal Bend Region with 41,840 acre-feet per year (ac-ft/yr) and 12,000 ac-ft/yr on an interruptible basis, according to the contract between the City of Corpus Christi and the Lavaca-Navidad River Authority (LNRA).[1] The City of Corpus Christi also owns the Garwood water right in the Colorado River Basin totaling 35,000 ac-ft. Under current drought conditions with a safe yield reserve of approximately one-year of regional demand, the Garwood water right supplies a minimum of 27,000 ac-ft to the City of Corpus Christi system through an additional pipeline.[2] Based on 2020 sediment conditions and Phase IV operating policy, including the 2001 Agreed Order governing freshwater pass-throughs to the Nueces Estuary, the CCR/LCC System with supplies from Lake Texana and the Colorado River through Garwood water rights (MRP Phase II project) has an annual safe yield of 219,000 ac-ft in 2020. The annual safe yield assumes 125,000 ac-ft remains in CCR/LCC system storage (i.e. storage reserve of about a one-year demand) during the critical month of the drought of record. The Coastal Bend Regional Water Planning Group adopted the use of safe yield for supply planning, instead of the firm yield of 259,000 ac-ft/yr with zero storage during historical drought of record conditions as recommended by TWDB guidance documents.

[1] The base permit of 41,840 ac-ft/yr is subject to call-back for up to 10,400 ac-ft/yr for Jackson County uses.
[2] Based on updates to the Corpus Christi Water Supply Model to include Colorado WAM 1940-2013 update and placing the drought of 2011-2013 on the Colorado on the modeled drought of record in the Nueces.

The Nueces River Authority's 2013 Basin Summary Report[3] compiled information on 12 water quality parameters for 54 segments in the San Antonio-Nueces Coastal Basin, the Nueces River Basin, the Nueces-Rio Grande Coastal Basin, and the adjacent bays and estuaries. The report compiled results from 303(d) List of Impaired Waters and 305(b) Water Quality Inventory for a 7-year period from December 1, 2003 through November 30, 2010 and found that the water quality is generally good. However, there are some areas of concern. A few stream segments within the region, as well as local bays and estuaries, had elevated levels of dissolved solids, nutrients, bacteria, and low dissolved oxygen levels (Table 1.1).

The water quality of the water from Lake Texana has been reported as good. In fact, it exceeds the general quality of the water supply from the Nueces River Basin and has less Total Dissolved Solids (TDS) than the Nueces River water. However, because Lake Texana water is blended with Nueces River water prior to treatment, the higher Total Suspended Solids (TSS) levels in the Lake Texana water and the pH difference between the two different sources requires precise controls during the treatment process.

1.3.2 Groundwater Sources

Some areas in the region are dependent on groundwater. There are two major aquifers that lie beneath the region — the Carrizo-Wilcox and Gulf Coast Aquifers (Figure 1.1). The Carrizo-Wilcox Aquifer contains moderate to large amounts of either fresh or slightly saline water. Slightly saline water is defined as water that contains 1,000 to 3,000 milligrams per liter (mg/L) of dissolved solids. Although this aquifer reaches from the Rio Grande River north into Arkansas, it only underlies parts of McMullen and Live Oak Counties within the Coastal Bend Region. In this downdip portion of the Carrizo-Wilcox Aquifer, the water is softer, hotter (140 degrees Fahrenheit), and contains more dissolved solids.

The Gulf Coast Aquifer underlies all counties within the Coastal Bend Region and yields moderate to large amounts of both fresh and slightly saline water. The Gulf Coast Aquifer, extending from Northern Mexico to Florida, is comprised of five aquifer formations: Catahoula, Jasper, Burkeville, Evangeline, and Chicot. The Evangeline and Chicot Aquifers are the uppermost water formations within the Gulf Coast Aquifer System and, consequently, are the formations utilized most commonly. The Evangeline portion of the Gulf Coast Aquifer features the highly transmissive Goliad Sands. The Chicot portion of the Gulf Coast Aquifer is comprised of many different geologic formations; however, the Beaumont and Lissie Formations are predominant in the Chicot Aquifer within the Coastal Bend area. The Burkeville Aquifer is predominantly clay, and therefore provides limited water supplies. The Texas Water Development Board (TWDB) developed a Central Gulf Coast Groundwater Availability Model (CGCGAM) and then revised the portion over Region N referred to as the Groundwater Management Area 16 (GMA 16) Groundwater Flow Model which is used to determine groundwater availability. The TWDB GMA 16 Groundwater Flow Model includes six aquifer layers: Layers 1-4 representing the Gulf Coast Aquifer (Jasper, Burkeville, Evangeline, and

[3] Nueces River Authority, "2013 Basin Summary Report for San Antonio-Nueces Coastal Basin, Nueces River Basin, and Nueces-Rio Grande Coastal Basin," August 2013.

Table 1.1.
Water Quality Concerns

Surface Water Resource (stream segment number)	*Water Quality Concerns*	*Water Quality Impairments*
Mission River Tidal *(2001)*		Bacteria
Aransas River Tidal *(2003)*		Bacteria
Aransas River Above Tidal *(2003)*	Low dissolved oxygen, bacteria, nitrates, total phosphorus	
Aransas Creek *(2004A)*	Low dissolved oxygen	Bacteria
Poesta Creek *(2004B)*	Low dissolved oxygen, bacteria	TDS
Nueces River Tidal *(2101)*	Chlorophyll-a	
Nueces River Below Lake Corpus Christi *(2102)*	Chlorophyll-a	Total dissolved solids
Lake Corpus Christi *(2103)*	Chlorophyll-a, total phosphorus	Total dissolved solids
Nueces River Above Frio River *(2104)*	Low dissolved oxygen, impaired fish community, impaired macrobenthic community	
Nueces River/Lower Frio River *(2106)*		Total dissolved solids
Atascosa River *(2107)*	Low dissolved oxygen, chlorophyll-a, impaired habitat	Low dissolved oxygen, bacteria, impaired macrobenthic community, impaired fish community
San Miguel River *(2108)*		Bacteria
Choke Canyon Reservoir *(2116)*	Chlorophyll-a	
Frio River Above Choke Canyon Reservoir *(2117)*	Low dissolved oxygen, bacteria, nitrates	Bacteria
Petronila Creek Tidal *(2203)*	Chlorophyll-a	Bacteria
Petronila Creek Above Tidal *(2204)*	Chlorophyll-a	Chloride, sulfate, total dissolved solids
San Antonio Bay/Hynes Bay (2462)	Chlorophyll-a	Bacteria in oyster waters
Aransas Bay (2471)		Bacteria at recreational beaches
Little Bay (2471A)	Chlorophyll-a	
Copano Bay (2472)		Bacteria in oyster waters
St. Charles Bay (2473)	Low dissolved oxygen	
Corpus Christi Bay (2481)	Bacteria at recreational beaches	Bacteria at recreational beaches
Nueces Bay (2482)		Zinc in edible tissue
Redfish Bay (2483)		Bacteria in oyster waters
Conn Brown Harbor (2483A)	Copper in water	Copper in water
Corpus Christi Inner Harbor (2484)	Ammonia, chlorophyll-a, nitrates	
Oso Bay (2485)	Low dissolved oxygen, chlorophyll-a, total phosphorus	Low dissolved oxygen, bacteria in oyster waters
Oso Creek (2485A)	Low dissolved oxygen, chlorophyll-a, nitrates, total phosphorus	Bacteria
Unnamed Tributary (2485B)	Total phosphorus	
West Oso Creek (2485D)	Total phosphorus	
Laguna Madre (2491)	Low dissolved oxygen, chlorophyll-a, nitrates	Low dissolved oxygen, bacteria, bacteria in oyster waters
Baffin Bay / Alazan Bay / Cayodel Grullo / Laguna Salada (2492)	Chlorophyll-a	
San Fernando Creek (2492A)	Chlorophyll-a, nitrates, total phoshorus	Bacteria

Source: Nueces River Authority 2013 Basin Summary Report - San Antonio-Nueces Coastal Basin, Nueces River Basin, and Nueces-Rio Grande Coastal Basin, 2013.
Note: The 2013 Assessment included data from December 1, 2003 through November 30, 2010.

Chicot), Layer 5 representing the Yegua-Jackson Aquifer System, and Layer 6 aggregating Queen-City, Sparta, and Carrizo-Wilcox Aquifer System.

Within Texas, the Houston area is the largest user of the Gulf Coast Aquifer. Due to growing population and water demand in that area, over-pumping of the aquifer has resulted in subsidence of up to 9 feet being recorded in Harris County. While not as severe as in the Houston area, subsidence has been reported within the Gulf Coast Aquifer in the Coastal Bend Region. In 1979, the Texas Department of Water Resources developed a Gulf Coast Aquifer Model to evaluate pumpage, water level drawdowns, and subsidence for the 10-year period of 1960 through 1969 for Houston, Jackson-Wharton Counties, and Kingsville areas. The objective of the study was to compare modeled results to historical water level declines and subsidence.[4] Areas in Kleberg County have recorded a 0.5-foot drop in elevation due to pumping of the Gulf Coast Aquifer. However, due to the increase in surface water use within Kleberg County, water levels of the aquifer are rising and the rate of subsidence has diminished. Water quality in the shallower parts of the aquifer is generally good; however, there is saltwater intrusion occurring in the southeast portion of the aquifer along the coastline. It should also be noted that the water quality deteriorates moving southwestward towards the Texas-Mexico border.

The Yegua-Jackson is an official minor aquifer and covers parts of McMullen, Live Oak, and Bee counties within the Coastal Bend Region.

1.3.3 Major Springs

There are no major springs in the Coastal Bend Region. Due to most areas having an underlying impervious clay layer, there has not been much opportunity for springs to form in the Coastal Bend Region. According to *Springs of Texas - Volume I* by Gunnar Brune, there are 18 small springs in the Coastal Bend Region with flows between 0.28 and 2.8 cfs and a number of these springs produce saline, hard, alkaline spring water. These are the largest documented springs in the Coastal Bend Region.

1.3.4 Reuse

There is currently limited reuse occurring within the Region. According to historical data provided to the TWDB, about 1,588 ac-ft of wastewater is being reused for manufacturing purposes in Nueces and San Patricio Counties. The City of Corpus Christi also provides reuse to a cemetery, three golf courses, Champions Park, Corpus Christi Country Club, and the Naval Air Station. Additional reuse options are recommended to meet future water needs, as described in Chapter 5D.5.

1.4 Social and Economic Aspects

In 2013, the population of the Coastal Bend Region was estimated to be 581,100 with a regional average per capita income of $45,522, ranging from $31,135 in Bee County to $71,840 in

[4] “Groundwater Availability in Texas,” Texas Department of Water Resources, Report 238, September 1979.

McMullen County.[5] The Corpus Christi Metropolitan Statistical Area (MSA), consisting of Aransas, Nueces, and San Patricio Counties, accounts for 76 percent of the Coastal Bend Region's population and 71 percent of the total personal income. In 2013, the total personal income in the Coastal Bend Region was nearly $26.5 billion (Figure 1.3).

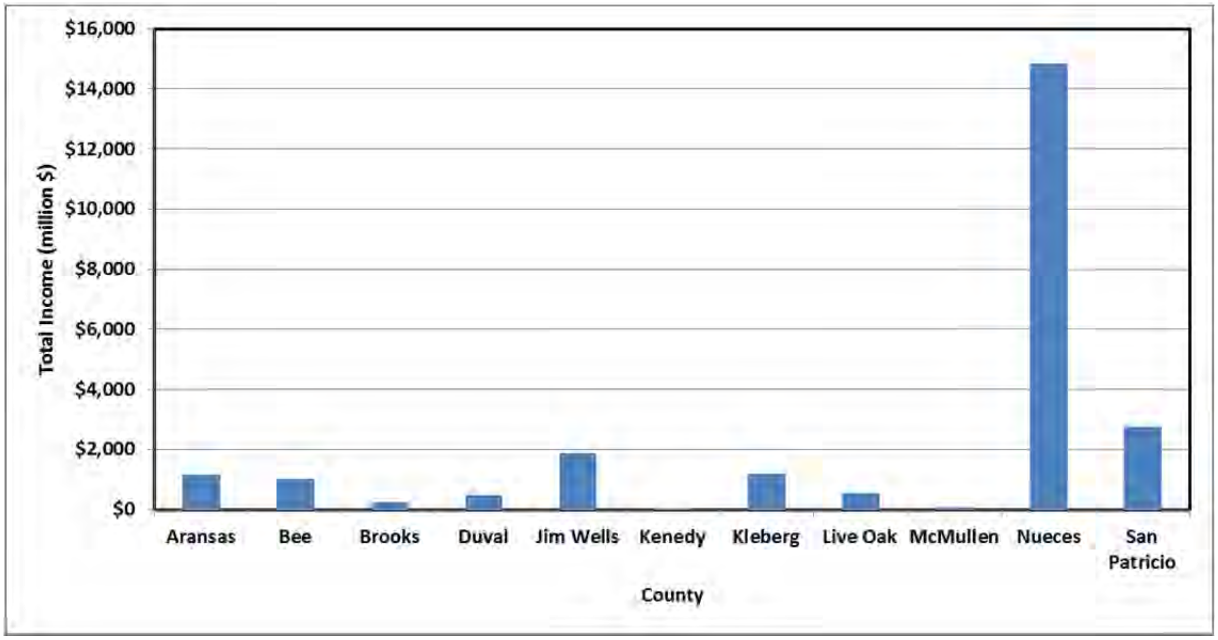

Figure 1.3.
Total Personal Income (Earnings) in 2013 by County

The primary economic activities within the Coastal Bend Region include oil/gas production and refining, petrochemical manufacturing, military installations, retail and wholesale trade, agriculture, and service industries including health services, tourism/recreation industries, and governmental agencies. In 2012, these industries employed over 180,000 people in the Coastal Bend Region with annual compensation to employees of over $7.0 billion (Figures 1.4 and 1.5).[6] The service industries sector had the biggest economic impact in 2012, with a total compensation to employees of economic contribution of $3.5 billion, while employing 60% of the total workforce within the Region (Figures 1.4 and 1.5). The service industries sector includes information, finance and insurance, real estate, educational, and health care and social assistance businesses. Health care, the largest economic service industry contributor, generated nearly $1.3 billion in compensation to employees in 2012 for the Coastal Bend Region.

[5] U.S. Department of Commerce Bureau of Economic Analysis, Regional Economic Information System (REIS) Database, 2013.
[6] 2012 County Business Patterns.

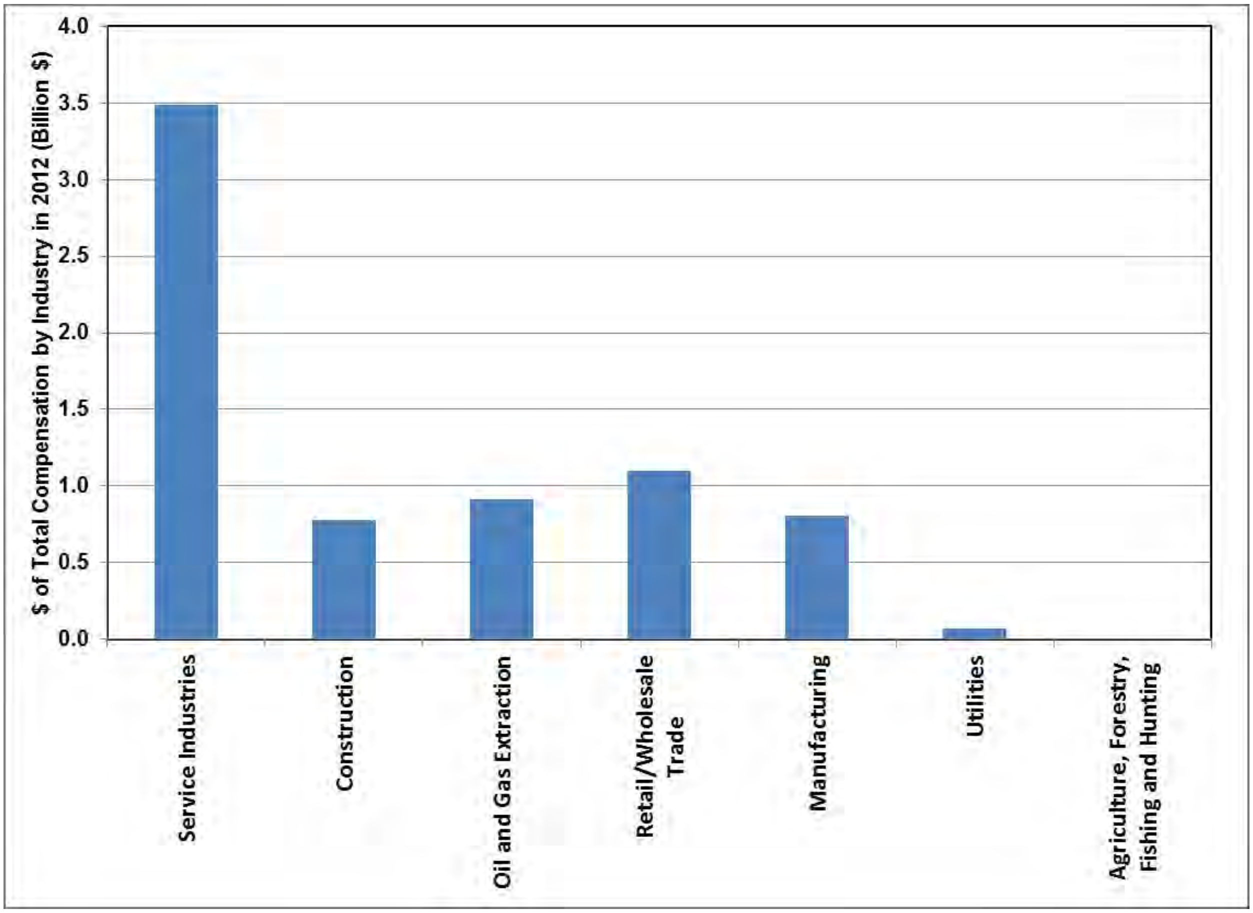

Figure 1.4.
Total Compensation to Coastal Bend Region in 2012 by Sector

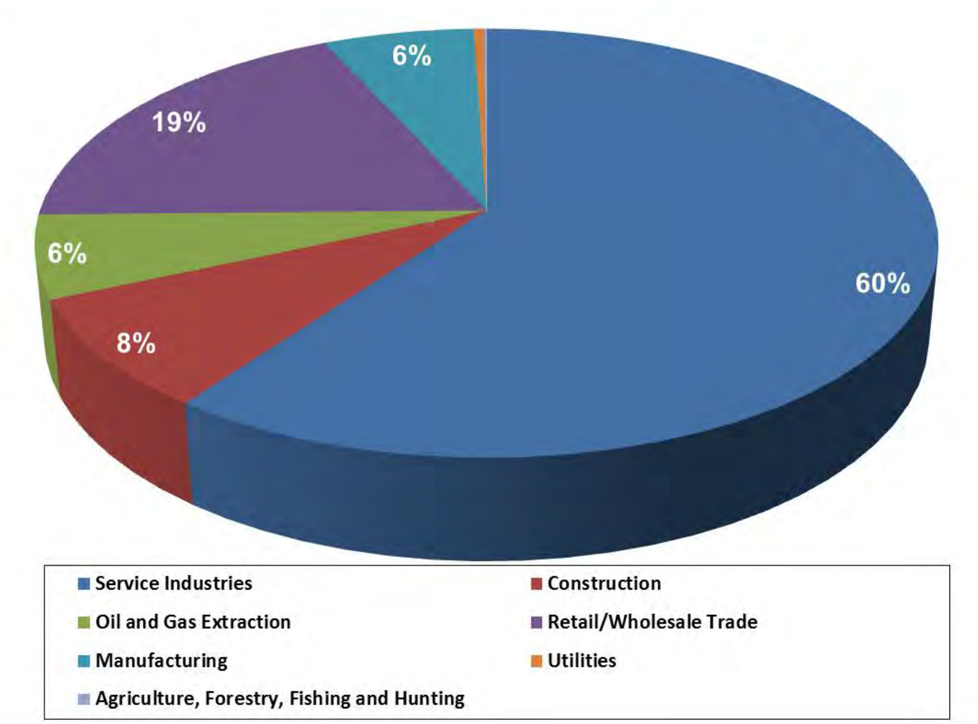

Figure 1.5.
2012 Percentages of Major Employment by Sector in the Coastal Bend Region

The retail/wholesale trade sector is also a large contributor to the local economy. In 2012, 19% of the local workforce was employed by this sector, receiving total compensation of $1.1 billion (Figures 1.4 and 1.5). Oil and gas extraction activities employee over 11,000 people within the region and general annual compensation to employees of nearly $1.0 billion (Figures 1.4 and 1.5)

Agriculture accounts for a major portion of the land use within the Coastal Bend Region. Of the cultivated land in 2012, over 98 percent was dryland farmed and approximately 18,551 acres of cultivated land was irrigated (Table 1.2). The dominant crops of the region are corn, wheat, sorghum, cotton, and hay. Livestock is a major agricultural product of the Coastal Bend Region. In 2012, livestock products made up 47.2 percent of the total market value of agriculture products.[7]

Fishing is another industry that adds to the economic value of the Coastal Bend Region. In 2012, reported bay and gulf commercial fishing generated about $45 million in sales and value to the Region.[8] Overall impact to the State's economy of commercial fishing, sport fishing and other recreational activities has been estimated by the TWDB to be $875 million per year for the 352,000-acre Nueces Estuary System.

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[7] 2012 Census of Agriculture.
[8] County Business Patterns, 2012.

Table 1.2.
Coastal Bend Regional Water Planning Area Agriculture Statistics – 2012

Counties	Region	Aransas	Bee	Brooks	Duval	Jim Wells	Kenedy	Kleberg	Live Oak	McMullen	Nueces	San Patricio
Total Cropland (acres)	1,110,658	2,590	70,387	25,988	59,968	192,026	3,102	71,238	55,742	19,318	362,586	247,713
Irrigated Cropland (acres)	18,551	10	5,131	1,070	N/A	4,795	660	112	734	N/A	432	5,607
Irrigated Cropland/Total Cropland	1.7%	0.4%	7.3%	4.1%	N/A	2.5%	21.3%	0.2%	1.3%	N/A	0.1%	2.3%
Total Market Value of Agricultural Product ($1,000)	372,878	1,075	26,044	50,768	14,803	82,856	N/A	N/A	17,913	8,336	84,868	86,215
Market Value of Crop Products Sold ($1,000)	196,713	198	9,939	547	956	35,240	N/A	N/A	2,836	430	78,243	68,324
Market Value of Livestock Products Sold ($1,000)	176,166	877	16,105	50,221	13,847	47,616	N/A	N/A	15,077	7,906	6,626	17,891
Crop Products/Total Agricultural Products	52.8%	18.4%	38.2%	1.1%	6.5%	42.5%	N/A	N/A	15.8%	5.2%	92.2%	79.2%
Livestock Products/Total Agricultural Products	47.2%	81.6%	61.8%	98.9%	93.5%	57.5%	N/A	N/A	84.2%	94.8%	7.8%	20.8%

N/A = Not Available
Source: 2012 Agricultural Census

1.5 Identified Threats to Agricultural and Natural Resources

The Coastal Bend Region's agricultural business relies on groundwater for irrigation and water for livestock. During previous planning efforts, the Coastal Bend Regional Water Planning Group identified continuing groundwater depletion as a threat to agricultural and natural resources. The Coastal Bend Region also recognizes the following additional potential threats to agricultural and natural resources:

- Shortage of freshwater and economically accessible groundwater attributable to increased irrigation demands.
- Shortage of freshwater and economically accessible groundwater attributable to development of natural gas from the shale in the Eagleford Group and water demands associated with hydraulic fracturing of wells.
- Deterioration of surface water quality associated with sand and gravel operations and other activities.
- Deterioration of groundwater quality and increasing concerns of possible arsenic and uranium contamination attributable to uranium mining activities.
- Impacts of potential off-channel reservoir on terrestrial wildlife habitats.
- Potential impacts to threatened, endangered, and other species of concern.
- Potential impacts of brush control and other land management practices as currently considered in Federal studies.
- Abandoned wells (oil, gas, and water).

These threats are considered for each water management strategy, and when applicable, are specifically addressed in Chapter 5D.

1.6 Resource Aspects and Threatened, Endangered, and Rare Species of the Coastal Bend Region

While the Coastal Bend Region is known for its valuable mineral resources, especially oil and gas, this area also contains a rich diversity of living natural resources. The Coastal Bend Region contains three distinct natural regions; the South Texas Brush Country which characterizes the inland portion of the region, the Coastal Sand Plains along the southern coastline, and the Gulf Coast Prairies and Marshes along the northern coastline (Figure 1.6).

Regional water plan guidelines require the additional reporting of environmental factors for water management strategies. These factors include any possible effects to wildlife habitat, cultural resources, environmental water needs, and inflows to bays and estuaries. Each water management strategy summary (Chapter 5D) includes a discussion of these environmental considerations and potential impacts associated with project implementation.

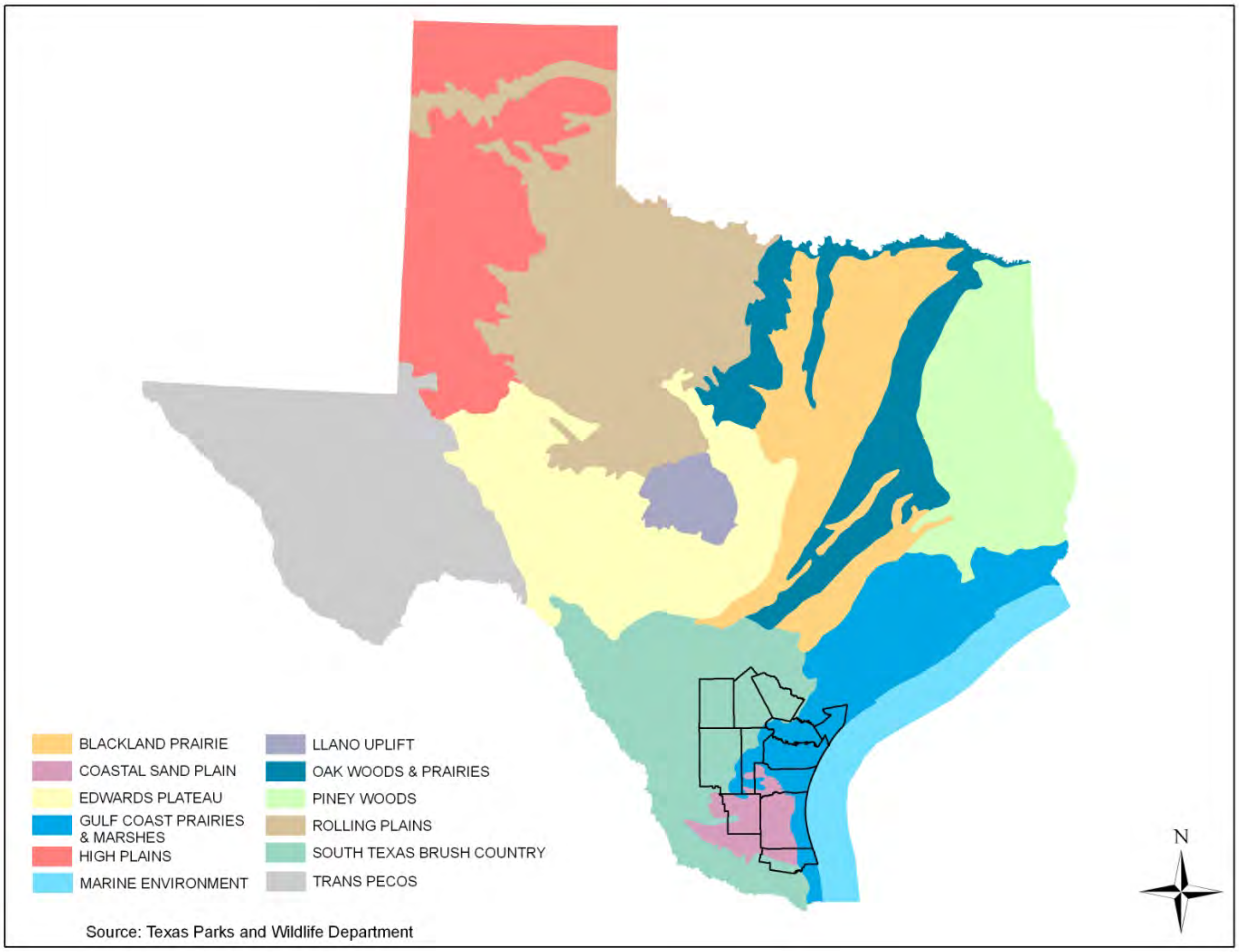

Figure 1.6.
Natural Regions of Texas

Because the Coastal Bend Region is located along many migratory flyways, birds comprise a major portion of the wildlife population found within the area. The area provides many birds unique nesting and forage resources within its coastal prairies, wetlands, and riverine ecosystems. The brown pelican, which was delisted as a federally endangered species in 2009, utilizes the Coastal Bend's natural resources year-round while the endangered whooping crane is only found seasonally.

The Coastal Bend Region provides habitat for numerous state- and federally-listed endangered and threatened species. These listed species include birds, amphibians, reptiles, fish, mammals, and vascular plants (Table 1.3). Texas Parks and Wildlife and U.S. Fish and Wildlife Service - Southwest Region Ecological Service maintain maps identifying potential habitats (by county) of each endangered or threatened species. These potential habitats are considered for each water management strategy and when possibly impacted, are noted in the appropriate water management strategy summary (Chapter 5D).

Table 1.3. Endangered and Threatened Species of the Coastal Bend Region

Common Name	Scientific Name	County for which Species is Listed	Federal Status	State Status
Atlantic Hawksbill Sea Turtle	*Eretmochelys imbricata*	Aransas, Kenedy, Kleberg, Nueces, San Patricio	Endangered	Endangered
American Peregrine Falcon	*Falco peregrinus anatum*	Nesting/Migrant in Aransas, Bee, Brooks, Duval, Jim Wells, Kenedy, Kleberg, Live Oak, McMullen, Nueces, San Patricio	—	Threatened
Black bear	*Ursus americanus*	Historic in Aransas, Duval, and McMullen	Threatened	Threatened
Black lace cactus	*Echinocereus reichenbachii*	Jim Wells, Kleberg	Endangered	Endangered
Black-spotted newt	*Notophthalmus meridionalis*	Aransas, Bee, Brooks, Duval, Jim Wells, Kenedy, Kleberg, Live Oak, McMullen, Nueces, San Patricio	—	Threatened
Black-striped snake	*Coniophanes imperialis*	Kenedy	—	Threatened
Cactus Ferruginous Pygmy-Owl	*Glaucidium brasilianum cactorum*	Brooks, Kenedy	—	Threatened
Coues' rice rat	*Oryzomys couesi*	Kenedy	—	Threatened
Eskimo Curlew	*Numenius borealis*	Historic in Aransas, Kenedy, Kleberg, Nueces, San Patricio	Endangered	Endangered
Golden orb	*Quadrula aurea*	Live Oak, McMullen, San Patricio	—	Threatened
Green sea turtle	*Chelonia mydas*	Aransas, Kenedy, Kleberg, Nueces, San Patricio	Threatened	Threatened
Interior Least Tern	*Sterna antillarum athalassos*	Live Oak, McMullen	Endangered	Endangered
Jaguar	*Panthera onca*	Brooks, Kenedy, Kleberg	Endangered	Endangered
Jaguarundi	*Herpailurus yaguarondi*	Aransas, Brooks, Kenedy, Kleberg, Live Oak, San Patricio	Endangered	Endangered
Kemp's Ridley sea turtle	*Lepidochelys kempii*	Aransas, Kenedy, Kleberg, Nueces, San Patricio	Endangered	Endangered
Leatherback sea turtle	*Dermochelys coriacea*	Aransas, Kenedy, Kleberg, Nueces, San Patricio	Endangered	Endangered
Loggerhead sea turtle	*Caretta caretta*	Aransas, Kenedy, Kleberg, Nueces, San Patricio	Threatened	Threatened
Louisiana black bear	*Ursus americanus luteolus*	Historic in Aransas	Threatened	Threatened
Mexican treefrog	*Smilisca baudinii*	Kenedy	—	Threatened
Northern Aplomado Falcon	*Falco femoralis septentrionalis*	Migrant in Aransas, Brooks, Jim Wells, Kenedy, Kleberg, Nueces, San Patricio	Endangered	Endangered
Northern Beardless-Tyrannulet	*Camptostoma imberbe*	Brooks, Kenedy, Kleberg	—	Threatened
Northern cat-eyed snake	*Leptodeira septentrionalis septentrionalis*	Brooks, Kenedy, Kleberg	—	Threatened

Common Name	Scientific Name	County for which Species is Listed	Federal Status	State Status
Ocelot	*Leopardus pardalis*	Aransas, Bee, Brooks, Duval, Jim Wells, Kenedy, Kleberg, Live Oak, McMullen, Nueces, San Patricio	Endangered	Endangered
Opossum pipefish	*Microphis brachyurus*	Aransas, Kenedy, Kleberg, Nueces, San Patricio	—	Threatened
Piping Plover	*Charadrius melodus*	Migrant in Aransas, Kenedy, Kleberg, Nueces, San Patricio	Threatened	Threatened
Red wolf	*Canis rufus*	Historic in Aransas, Bee, Jim Wells, Kenedy, Kleberg, Live Oak, McMullen, Nueces, San Patricio	Endangered	Endangered
Reddish Egret	*Egretta rufescens*	Aransas, Kenedy, Kleberg, Nueces, San Patricio	—	Threatened
Reticulate collared lizard	*Crotaphytus reticulatus*	Duval, Jim Wells, Live Oak, McMullen Counties	—	Threatened
Rose-throated Becard	*Pachyramphus aglaiae*	Kenedy	—	Threatened
Sheep frog	*Hypopachus variolosus*	Aransas, Bee, Brooks, Duval, Jim Wells, Kenedy, Kleberg, Live Oak, Nueces, San Patricio	—	Threatened
Slender rushpea	*Hoffmannseggia tenella*	Kleberg, Nueces	Endangered	Endangered
Smalltooth Sawfish	*Pristis pectinata*	Aransas, Kenedy, Kleberg, Nueces, San Patricio	Endangered	Endangered
Sooty Tern	*Sterna fuscata*	Aransas, Kenedy, Kleberg, Nueces, San Patricio	—	Threatened
South Texas ambrosia	*Ambrosia cheiranthifolia*	Jim Wells, Kleberg, Nueces	Endangered	Endangered
South Texas siren	*Siren sp.1*	Jim Wells, Kenedy, Kleberg, San Patricio	—	Threatened
Southern yellow bat	*Lasiurus ega*	Brooks, Kenedy, Kleberg, Nueces, San Patricio	—	Threatened
Texas Botteri's Sparrow	*Aimophila botterii texana*	Brooks, Duval, Jim Wells, Kenedy, Kleberg, Nueces	—	Threatened
Texas horned lizard	*Phrynosoma cornutum*	Aransas, Bee, Brooks, Duval, Jim Wells, Kenedy, Kleberg, Live Oak, McMullen, Nueces, San Patricio	—	Threatened
Texas indigo snake	*Drymarchon melanurus erebennus*	Bee, Brooks, Duval, Jim Wells, Kenedy, Kleberg, Live Oak , McMullen, Nueces, San Patricio	—	Threatened
Texas scarlet snake	*Cemophora coccinea lineri*	Aransas, Brooks, Jim Wells, Kenedy, Kleberg, Nueces, San Patricio	—	Threatened
Texas tortoise	*Gopherus berlandieri*	Aransas, Bee, Brooks, Duval, Jim Wells, Kenedy, Kleberg, Live Oak, McMullen, Nueces, San Patricio	—	Threatened
Timber rattlesnake	*Crotalus horridus*	Aransas, San Patricio	—	Threatened
Tropical Parula	*Parula pitiayumi*	Kenedy	—	Threatened

Common Name	**Scientific Name**	**County for which Species is Listed**	**Federal Status**	**State Status**
Walkers's manioc	*Manihot walkerae*	Duval	Endangered	Endangered
West Indian manatee	*Trichechus manatus*	Aransas, Kenedy, Kleberg, Nueces, San Patricio	Endangered	Endangered
White-faced Ibis	*Plegadis chihi*	Aransas, Bee, Duval, Jim Wells, Kenedy, Kleberg, Live Oak, Nueces, San Patricio	—	Threatened
White-nosed coati	*Nasua narica*	Aransas, Bee, Brooks, Duval, Jim Wells, Kenedy, Kleberg, Nueces, San Patricio	—	Threatened
White-tailed hawk	*Buteo albicaudatus*	Nesting/migrant in Aransas, Bee, Brooks, Jim Wells, Kenedy, Kleberg, Live Oak , Nueces, San Patricio	—	Threatened
Whooping Crane	*Grus americana*	Resident in Aransas, Migrant in Bee, Jim Wells, Kenedy, Kleberg, Live Oak, McMullen, Nueces, San Patricio	Endangered	Endangered
Wood Stork	*Mycteria Americana*	Migrant in Aransas, Bee, Brooks, Duval, Jim Wells, Kenedy, Kleberg, Live Oak, McMullen, Nueces, San Patricio	—	Threatened
Zone-tailed Hawk	*Buteo albonotatus*	Kenedy	—	Threatened

Source: TPWD, Annotated County List of Rare Species, Aransas, Bee, Brooks, Duval, Jim Wells, Kleberg, Kenedy, Live Oak, McMullen, Nueces, and San Patricio Counties (updated February 2015).

— Not Federally Listed as Endangered or Threatened

Bay and estuary systems depend on freshwater inflows for maintaining habitats and productivity. Freshwater inflows provide a mixing gradient that establishes a range of salinity, as well as nutrients that are important to the productivity of estuarine systems. In addition, freshwater inflows deposit sediments, which help maintain the deltas and barrier islands that protect the bays and marshes. Without freshwater inflows, many plant and animal species could not survive. In accordance with an order issued by the Texas Commission on Environmental Quality (TCEQ) in 1995, and the subsequent 2001 Agreed Order amendment, Choke Canyon Reservoir and Lake Corpus Christi are operated in such a way as to "pass-through" a certain target amount of water each month to the Nueces Bay and Estuary. This water provides the important freshwater inflows needed by the Nueces Estuary based on maximum harvest studies and inflow recommendations.

According to the TPWD[9], the maximum harvest flow to the Nueces Bay and Estuary produced slightly higher harvests of red drum, black drum, spotted sea trout, and brown shrimp but slightly decreased amounts of blue crab.

[9] Texas Parks and Wildlife Department, "Freshwater Inflow Recommendation for the Nueces Estuary," September 2002.

1.7 Water Quality Initiatives

The Clean Water Act of 1972 established a Federal program for restoring, maintaining, and protecting the nation's water resources. The Clean Water Act remains focused on eliminating discharge of pollutants into water resources and making rivers and streams fishable and swimmable. Water quality standards are to be met by industries, states, and communities under the Clean Water Act. Since the enactment of the Clean Water Act, more than two-thirds of the nation's waters have become fishable and swimmable, as well as a noticeable decrease of wetland and soil loss. One aspect of the Clean Water Act is the National Pollutant Discharge Elimination System (NPDES). This program regulates and monitors pollutant discharges into water resources. Whereas in the past the Environmental Protection Agency and the State of Texas each required separate permits to discharge (one under NPDES and one under state law), recently, the State of Texas has received delegation to administer a joint "TPDES" program.

In 1998, the Clean Water Action Plan (Plan) was initiated to meet the original goals of the Clean Water Act. The main priority of this Plan is to identify watersheds and their level of possible concern. The identification of these concerns has been defined within the Texas Unified Watershed Assessment (Assessment). Each watershed was then placed into one of four defined categories — Category I: Watersheds in need of restoration; Category II: Watersheds in need of preventive action to sustain water quality; Category III: Pristine Watersheds; and Category IV: Watersheds with insufficient data. Within the Nueces River Basin some areas of concern have been placed on the Clean Water Act 303(d) medium priority list; consequently both TCEQ and the Environmental Protection Agency are targeting these areas as a Category I.

The State of Texas has initiated other water quality programs. The Texas Clean Rivers Act of 1991 created the Clean Rivers Program within TCEQ. The purpose of this program is to maintain and improve the water quality of the State of Texas's river basins with aid from river authorities and municipalities. The Clean Rivers Program encourages public education, watershed planning, and water conservation, as well as provides technical assistance to identify pollutants and improve water quality in contaminated areas.

In the Coastal Bend Region, the Nueces River Authority (NRA) and TCEQ share the responsibility for surface water monitoring under the Clean Rivers Program. Surface water monitoring within the Coastal Bend Region focuses on freshwater stream segments within the Nueces River Basin, as well as local coastal waters. Each year, NRA and TCEQ coordinate sampling stations and divide stream segment stations between each other in order to eliminate sampling duplication. TCEQ and NRA work together to create the 305(b) Water Quality Inventory Report, which provides an overview of the status of surface waters in the Nueces River Basin and Nueces Coastal Basins. The TCEQ is responsible for administering the Total Maximum Daily Load Program, which addresses the water quality concerns of highest priority as identified in the 305(b) list. Under both the Clean Water Act and the Clean Rivers Program, surface waters must be sampled and monitored for identification of pollutants and possible areas of concern. Currently, certain water segments within the Nueces River Basin are posing some concerns (Table 1.1).

1.8 2011 Coastal Bend Regional Water Plan

Senate Bill 1 was enacted by the 75th Session of the Texas Legislature in 1997. It specified that water plans be developed for regions of Texas and provided that future regulatory and financing decisions of the TCEQ and the TWDB be consistent with approved regional water plans. Furthermore, Senate Bill 1 specified that regional water planning groups submit a regional water plan by January 2001, and at least as frequently as every 5 years thereafter, for TWDB approval and inclusion in the state water plan.

In September 2010, the Coastal Bend Region submitted a plan for a 50-year planning period from 2010 to 2060 (2011 Coastal Bend Regional Water Plan), which consisted of water supply planning information, projected needs in the Region, and the Region's proposed water plans to meet needs. The total population of the Coastal Bend Region was projected to increase from 617,143 in 2010 to 885,665 by 2060. Similarly, the total water demand was projected to increase from 232,503 ac-ft to 324,938 ac-ft by 2060. There were 18 individual cities and water user groups (i.e. non-municipal water users, such as industrial and agricultural users) that showed projected needs during the 50-year planning horizon. Water management strategies were identified by the CBRWPG to potentially meet water supply shortages. The TWDB evaluated social and economic impacts of not meeting projected water needs, which was included in the 2011 Coastal Bend Regional Water Plan.

1.9 2012 State Water Plan

In Water for Texas 2012 (State Plan), the TWDB utilized information and recommendations from the 16 individual 2011 Regional Water Plans developed by the Regional Water Planning Groups established under Senate Bill 1. In the State Plan, TWDB acknowledges that each Regional Water Planning Group identified many of the same basic recommendations to meet future water demands. These recommendations include: continue regional planning funding, support for groundwater conservation districts, brush control, water reuse, continued support of groundwater availability modeling, conservation education, ongoing funding for groundwater supply projects, and support of alternative water management strategies.

The TWDB included the projects recommended by the CBRWPG including two proposed off-channel reservoirs, groundwater development, interbasin transfers of surface water from the Colorado River Basin, and conservation. Implementing all recommended strategies in the Coastal Bend Plan would result in 156,326 ac-ft of additional water supplies in 2060 at a total capital cost of $656.1 million. Selected major projects in the plan include:

- O.N. Stevens Water Treatment Plan Improvements that would provide up to 42,329 ac-ft of surface water starting in 2010 with a capital cost of $31 million;
- Garwood (Mary Rhodes Phase II) Pipeline that would provide 35,000 ac-ft of surface water starting in 2020 with a capital costs of $113 million;
- Off-Channel Reservoir near Lake Corpus Christi that would provide 30,340 ac-ft of water starting in the year 2030 with a capital cost of $301 million; and

- Construction of the Lavaca River Off-Channel Diversion and Off-Channel Project that would provide 16,242 ac-ft of water to Region N in 2060 with a capital cost of $139 million for Region N's portion of total project costs.

1.10 Local and Previous Regional Water Plans

The following is a summary of major planning efforts in the Coastal Bend Planning Region during the past several years.

In 2010, the City of Corpus Christi began the initial steps in planning and designing the pipeline to deliver the Mary Rhodes Phase II project. In September 2011, they completed the preliminary phase of the project, and in October 2013 they completed the design phase of the project. The proposed pipeline will tie into the City's Mary Rhodes Pipeline (also known as the Texana Pipeline), which currently transports water from Lake Texana to the Coastal Bend Region. The water transported via the Mary Rhodes Phase II pipeline will be used by the City of Corpus Christi customers including various municipal and industrial customers.

The City of Corpus Christi is conducting a 30-month initiative to design, construct, and operate a demonstration desalination plant for industrial and drinking water supply purposes. The objectives of this program are to evaluate feasibility and develop cost estimates, to test emerging technologies and to identify and assess site options and requirements for a full-scale facility. The initiative will provide site-specific facts about desalination technology options, possible source water quality, energy requirements, environmental impacts, possible beneficial uses of by-product brine, and cost estimates for implementing a large-scale facility. The project will include selection of a demonstration plant site and construction of a facility capable of producing about 200,000 gallons per day. Any future full-scale facility would have a larger capacity, likely producing as much as 20 million gallons per day or more. The program will look at the feasibility of processing variable amounts of lower salinity brackish groundwater and seawater in the same facility.

The Corpus Christi ASR Conservation District was created in 2005. The District is located in Aransas, Kleberg, Nueces, and San Patricio Counties. There are currently no ASR facilities in operation within the District. However, ASR has been evaluated as part of three prior studies sponsored by the City. Use of ASR was originally proposed as part of a desalination facility to be constructed on North Padre Island to supplement existing City supplies. Initial recovery rates in excess of 10 million gallons per day were postulated based on desktop studies. The second study and preliminary evaluations, including hydrogeologic exploration and testing completed on North Padre and Mustang Islands, appear to validate the feasibility of ASR operations, albeit at somewhat lower recovery pumping rates than initially anticipated. The City's study recommended development of up to two ASR wellfields on North Padre and Mustang Islands with a total recovery rate of 7.5 mgd. Total target storage volume for the two ASR wellfields on the Island is approximately 1,200 million gallons, or about 3,700 ac-ft. This volume would allow recovery from ASR storage at a rate of about 7.5 mgd for a period of about 5 months. The third study by the City extended its evaluation of ASR to the mainland in the 2005 report prepared by LNV Engineering, Inc. The criteria used in this evaluation included development of approximately 40 mgd of recovery capacity over a period of five months. This recovery rate would be sufficient to allow the City to remove one treatment train at its O.N. Stevens Water Treatment Plant from service for this period of time. Additional ASR facilities could be constructed to expand ASR operations as needed. Total target storage volume for the mainland ASR wellfields under these recovery assumptions is approximately 6,100 million gallons, or about 19,000 ac-ft.

The City of Alice and the City of Beeville are currently developing water supply plans to diversify their water supplies and augment existing surface water supplies from the City of Corpus Christi during times of drought.

The Nueces Estuary Advisory Council (NEAC) was created by an Agreed Order issued in 1992 to assess the effectiveness of water management strategies and operations of the CCR/LCC system pursuant to the latest TCEQ Agreed Order (now, 2001 version). In 2007, Senate Bill 3 (SB3) of the 80th Texas Legislature established a process for developing and implementing environmental flow standards applicable to major river basins and estuarine systems across the State of Texas. The legislation identified seven basins and bay systems in Texas to be given priority for completion under SB3. Schedules were established for the selection of stakeholder and science teams to represent these basin and bay systems and for the completion of environmental flow recommendations and flow standards. The river basin and bay system consisting of the Nueces River and Corpus Christi and Baffin Bays was identified as one of these priority basin and bay systems. The process began with convening of the Environmental Flows Advisory Group (EFAG) in 2008. The EFAG appointed the Science Advisory Committee (SAC) in 2009 and NEAC was expanded and additional stakeholder representatives appointed to become the Basin and Bay Area Stakeholder Committees (BBASC). The BBASCs then selected a Basin and Bay Expert Science Team (BBEST), whose role was to develop environmental flow recommendations for their basin and bay system based on the best available science according to TWC Chapter 11.02362(o). The BBASC then reviewed the recommendations and considered them in conjunction with other factors, including the present and future needs for water for other uses related to water supply planning. The basin and bay area stakeholders committee developed recommendations regarding environmental flow standards and strategies to meet environmental flow standards and submitted those recommendations to the commission and the advisory group. Finally, the TCEQ considered the BBEST recommendations, BBASC recommendations and other factors including economic factors and human, as well as other competing needs for water in adopting environmental flow standards (TWC Chapter 11.471(b)).

In 2013, the LNRA published its 2013 Lavaca Basin Highlights report. This report focuses primarily on water quality issues within the basin. This report concluded that water quality has remained relatively good throughout the Lavaca River Basin. LNRA has also studied a potential desalinization project. This project has two potential locations, both located in southern Jackson County near the Formosa Plant. The potential plant could treat brackish groundwater for a supply to the Formosa Plant and to others located along FM 1593.

The San Patricio Municipal Water District recently completed a study to determine potential future demands on the District. The study reported that the District has been in recent negotiations with several potential large industrial companies to provide a source of process water. This study determined that the combination of numerous large volume users, population growth in the surrounding communities and support service companies within the District could mean a growth in peak water demand of 30 mgd. Further, approximately 26 mgd of additional raw water transmission and treatment capacity would be required by 2017 based on industrial growth projections.

In 2001, the SPMWD performed a study that examined developing brackish groundwater supplies in San Patricio and Aransas Counties. The report concluded that SPMWD is faced with increasing demand for potable water from municipal and industrial clients and that there could be potential future shortfalls of available raw water resources to meet those demands. The SPMWD is evaluating additional water supply options to supplement its contracted surface water supplies with the City of Corpus Christi. The proposed plans could include supplemental ground water sources through construction of several wells or well fields and treatment facilities. The SPMWD may also cooperate with Sherwin Alumina and the City of Portland to construct a reuse pipeline from the City to the industry location and provide water for irrigation.

The Coastal Bend Bays and Estuaries Program (CBBEP) has developed the Coastal Bend Bays Plan[10] (Bays Plan) for the Coastal Bend Region. This plan is a long-term, comprehensive management plan designed to restore, maintain, and protect the Coastal Bend Region's bay and estuary ecosystems. Included within the Bays Plan is the allowance for coordination with the Regional Water Planning Group. The CBBEP does not possess taxing, federal, state, or local authority. Rather the CBBEP coordinates the implementation of the Bays Plan by providing limited amounts of technical and financial assistance towards meeting operating goals. The CBBEP has recently completed several studies related to bays and estuaries within the region including report concerning the Rincon pipeline (2012), a 2011 Ecosystem Management Initiative, Nueces BBEST recommendations (2012), and a Salinity Monitoring and Real Time Inflow Management (SMART) study in 2014 which may provide useful information on the flow necessary to maintain salinity targets.

1.11 Identified Historic Drought(s) of Record within the Planning Area

In terms of severity and duration, the drought from 1992-2002 is considered the drought of record for the Region N Planning area. The critical drawdown was 51 months from June 1992 to August 1996 during which time the reservoirs in the Lower Nueces basin went from full to a minimum storage of 25.5% before inflows restored lake storage. From 1994 to 1996, average annual inflows into LCC and CCR were 114,000 ac-ft[11] (40% less, or 78,000 ac-ft less) than the inflows from 1954-1956 that would have reached LCC and CCR.

The most recent drought beginning in 2007 has been discussed but not confirmed as the new drought of record for Region N. The lowest recorded annual inflow into the LCC and CCR system in the Nueces Basin occurred in 2011 at 11,800 ac-ft. The three year average annual inflow from 2009 to 2011 was 119,000 ac-ft, which is slightly above the 1994-1996 conditions.[12]

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[10] "Coastal Bend Bays Plan," Coastal Bend Bays and Estuaries Program, August 1998.
[11] Minimum annual inflow during this time was 83,677 ac-ft/yr (1995 calendar year).
[12] The three year period from 2009 to 2011 is the lowest three year inflow period from 2007-2014.

1.12 Groundwater Conservation Districts

The Texas Legislature authorized in 1947 the creation of groundwater conservation districts to conserve and protect groundwater and later recognized them in 1997 as the "preferred method of determining, controlling, and managing groundwater resources." According to Texas Water Code statue, the purpose of groundwater districts is to provide for the conservation, preservation, protection, and recharge of underground water and prevent waste and control subsidence caused by pumping water.[13] There are ten counties in the 11-county Coastal Bend Region that contain groundwater conservation districts: Bee, Brooks, Duval, Jim Wells, Kleberg, Live Oak, McMullen, Nueces, Kenedy, and San Patricio (Figure 1.7). Information regarding groundwater conservation districts, including contact list, can be found on the TWDB website (http://www.twdb.state.tx.us/GwRD/GCD/gcdhome.htm).

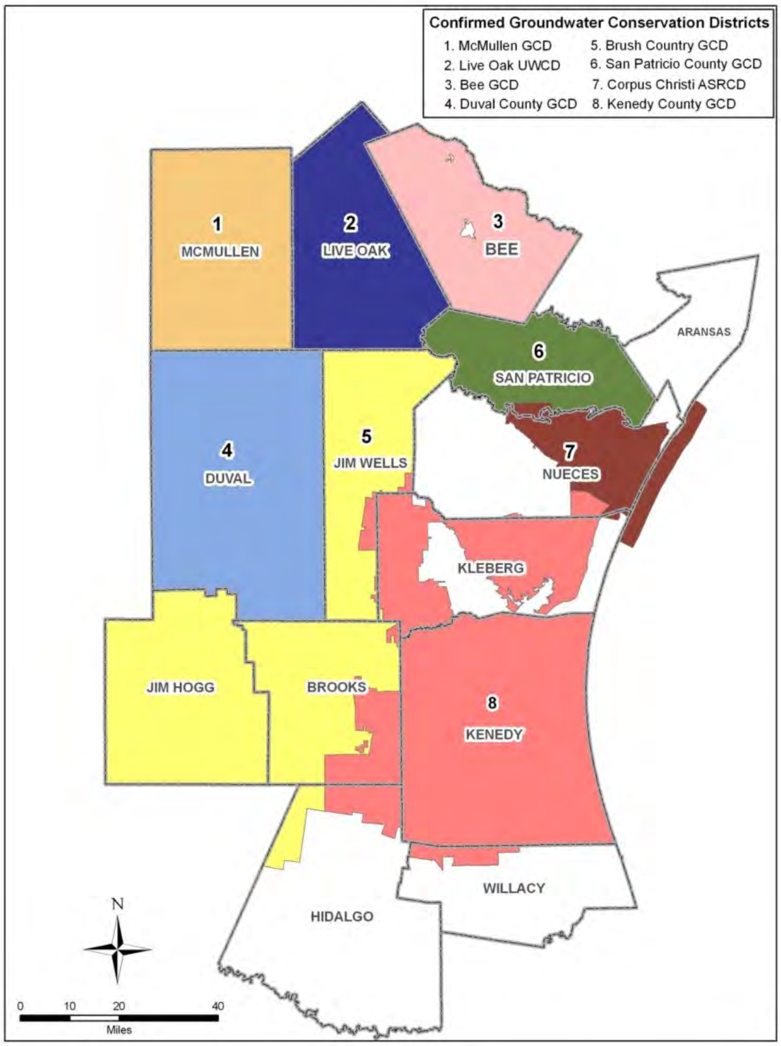

Figure 1.7.
Groundwater Conservation Districts in Region N

[13] Texas Water Code § 36.0015.

1.12.1 Bee Groundwater Conservation District

The Bee Groundwater Conservation District was created and adopted Management Rules in September 2002. The latest Management Plan was adopted in September 2013. The Rules require registration for all existing and future wells in the District. The District imposes spacing and production limitations on new users and limits pumping to 10 gallons/minute per acre owned or operated at a maximum annual production of 1 ac-ft per acre.

1.12.2 Brush Country Groundwater Conservation District

Brush Country Groundwater Conservation District was created by the 81st Texas Legislature in 2009 and includes Brooks and Jim Wells Counties within the Coastal Bend Region, as well as Jim Hogg County and a portion of Hidalgo County in Region M. Current rules and the District's management plan were adopted in 2013.

1.12.3 Corpus Christi Aquifer Storage and Recovery Conservation District

The Corpus Christi Aquifer Storage and Recovery Conservation District was created in 2005 by the 79th Texas Legislature. The District is located in Aransas, Kleberg, Nueces, and San Patricio Counties. As with other GCDs, the major purposes of the District are to: 1) provide for conservation, preservation, protection, and recharge; 2) prevent waste; and 3) control land surface subsidence. The primary objective of the District is to facilitate the operation of aquifer storage and recovery operations by the City of Corpus Christi. The District adopted an updated Management Plan in April 2014.

1.12.4 Duval County Groundwater Conservation District

The Duval County GCD was created in 2005 by the 79th Texas Legislature. The District was approved by voters in 2009. The District adopted rules in 2010 and a Management Plan in 2012.

1.12.5 Live Oak Underground Water Conservation District

The Live Oak Underground Water Conservation District (LOUWCD) was created June 14, 1989 and confirmed November 7, 1989. The District adopted Management Rules in June 1998 and last amended the Rules in 2011. The Rules require registration for all existing and future wells in the District. The District imposes spacing and production limitations on new users and limits pumping to 10 gallons/minute per acre at a maximum annual production of 8 ac-ft per acre. The District does not allow operation of Aquifer Storage and Recovery projects.

The Live Oak Underground Water Conservation District Management Plan was amended and last adopted, by unanimous vote of all directors, on November 10, 2010.

1.12.6 McMullen Groundwater Conservation District

The McMullen Groundwater Conservation District was created and published District Rules in November 1999. The Rules, last amended in September 2012, require registration for all existing and future wells in the District. The District imposes spacing and production limitations on new users and limits pumping to 10 gallons/minute per acre owned or operated at a maximum annual production of 1 ac-ft per acre. The District does not allow operation of Aquifer Storage and Recovery projects.

1.12.7 Kenedy County Groundwater Conservation District

Kenedy County Groundwater Conservation District was created in 2003 and includes all of Kenedy County and parts of Brooks, Jim Wells, Kleberg, and Nueces Counties. The Rules, last amended in July 2012, require registration for all existing and future wells in the District. The District imposes spacing and production limitations on new users and limits annual production to 0.75 acre-inch/acre/year.

1.12.8 San Patricio County Groundwater Conservation District

The San Patricio County GCD was created by the 79th Texas Legislature in 2005. The San Patricio County GCD adopted a Management Plan and Rules in 2012. Permits are required from the San Patricio County GCD prior to drilling or operating wells that can produce in excess of 25,000 gallons per day (17.4 gallons per minute). The District imposes spacing and production limitations on new users and limits annual production to 1.25 ac-ft per acre owned.

1.13 Groundwater Management Areas

TWDB General Guidelines for Regional Water Plan Development offer the following with regard to evaluation of groundwater availability: "Groundwater availability shall be based on the Modeled Available Groundwater (MAG) volumes that may be produced on an average annual basis to achieve Desired Future Conditions (DFCs) as adopted by Groundwater Management Areas (GMAs)."

- Groundwater is regulated locally by groundwater conservation districts except in locations that do not have a district. Districts may issue permits that regulate pumping of groundwater and spacing of wells within their jurisdictions. Multiple districts within a single GMA determine the DFCs of relevant aquifers within that area. DFCs are the desired, quantified conditions of groundwater resources, such as water levels, water quality, or volumes at a specified time or times in the future or in perpetuity.
- There are three GMAs within the Coastal Bend Planning Area: 1) GMA 13 (portion of McMullen County); 2) GMA 15 (portion of Bee County); and 3) GMA 16 (all 11 Coastal Bend Planning Area Counties).
- TWDB staff has translated DFCs into MAG volumes using approved Groundwater Available Models (GAMs) (or other approaches if a GAM is not applicable). A MAG volume is the amount of groundwater production, on an average annual basis, that will achieve a DFC. The DFC in a specific location may not be achieved if groundwater production exceeds the MAG volume over the long term.

Therefore, in the regional water planning process, total anticipated groundwater production in any planning decade may not exceed the MAG volume in any county-aquifer location (total groundwater production includes quantities associated with both existing supplies and any recommended water management strategies). This prevents regional water planning groups from recommending water management strategies with supply volumes that would result in exceeding (i.e. "overdrafting") approved MAG volumes.

1.14 Current Status of Water Resources Planning and Management

Currently, the Coastal Bend Region is planning to meet future water demands in a number of ways. The City of Corpus Christi contracted with LNRA to receive 41,840 ac-ft from Lake Texana, which is delivered to the Region via the Mary Rhodes Pipeline. In 2002, LNRA submitted an application to TCEQ for an amendment to their water right, which would allow LNRA to divert an additional 7,500 ac-ft of interruptible water to the Region. In July 2003, the LNRA entered into an agreement with the City of Corpus Christi to provide the Region an additional 4,500 ac-ft of water on an interruptible basis. This resulted in a total interruptible supply of 12,000 ac-ft provided to the Region from Lake Texana. In addition, the City of Corpus Christi purchased 35,000 ac-ft of water rights from the Garwood Irrigation Company to be transported to the Coastal Bend Region via the Mary Rhodes Phase II project.

For rural municipal communities and non-municipal water users that have historically used groundwater supplies, the current MAGs indicate that in most cases, groundwater is available to meet local demands in the future.

1.15 Assessment of Water Conservation and Drought Preparation

Besides extensive studies of the Coastal Bend Region's water needs and future resources, much of the Region has implemented the City of Corpus Christi's Water Conservation and Drought Contingency Plan. The City of Corpus Christi's Water Conservation Plan[14], updated in November 2013, focuses on two goals: 1) to reduce summertime peak pumping; and 2) to reduce overall per capita consumption by 1 percent per year from the City's consumption of 205 gallons per capita per day (gpcd) in 2012 to 195 gpcd by 2018 and 184 by 2023.[15] The plan provides everyday water conservation tips, including plumbing codes and retrofit programs, and educational demonstrations and programs for the public. The City's Drought Contingency Plan is implemented when current water supplies are threatened. The Drought Contingency Plan, also updated in November 2013, is initiated as the percentage of combined storage of the CCR/LCC System decreases and includes water reduction targets based on storage levels. Specific drought contingency measures for the other three wholesale water providers (SPMWD, STWA, and NCWCID #3) and other water users in the Coastal Bend Region are included in Chapter 7.

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[14] City of Corpus Christi Water Conservation and Drought Contingency Plan, Amended November 20, 2013.
[15] Note: The calculation of per capita consumption in the Water Conservation Plan is different than the per capita calculations provided by the TWDB for regional water planning.

In addition, during severe drought conditions, both municipal and wholesale customers are subject to water allocation from the City of Corpus Christi. In turn, wholesale customers are responsible to impose similar allocations on their customers. The City's Water Conservation Plan includes water conservation targets and goals for their wholesale customers.

The City of Corpus Christi's Water Conservation Plan recognizes its long-held conservation-based water rate structure, universal metering and a meter repair/replacement program, and leak detection program. Other programs outlined within the water conservation plan are such practices as reuse and recycling of wastewater and greywater, the establishment of landscape ordinances, and an outlined procedure to determine and control unaccounted-for water loss. The City of Corpus Christi's Water Conservation Plan not only recognizes the ongoing water conservation practices within the City of Corpus Christi service area but it also defined water conservation goals. City of Corpus Christi water conservation goals include:

- Reduce the City's per capita water use by 1% per year;
- Limit unaccounted-for water from the City's system to no more than 10 percent (based on a moving 5-year average); and
- Assist City customers in continuing efforts toward water conservation.

The TCEQ provides guidance for Water Conservation and Drought Contingency Plans in 30 TAC Chapter 288, which requires "specific, quantified 5- and 10-year targets for water savings to be included in all water conservation plans to be submitted to the TCEQ no later than May 1, 2005 and every five-years thereafter." In addition to the City of Corpus Christi plan outlined above, the following entities have provided a TCEQ approved water conservation plan and/or drought contingency plan to the Coastal Bend RWPG:

- City of Alice;
- City of Aransas Pass;
- City of Beeville;
- City of Ingleside;
- City of Kingsville;
- City of Odem;
- City of Orange Grove;
- City of Portland;
- City of Robstown;
- City of Rockport;
- City of San Diego;
- City of Taft;
- City of Three Rivers;
- El Oso WSC;
- McCoy WSC;
- NCWCID#3;
- Nueces WSC;
- Ricardo WSC;
- Rincon WSC;
- River Acres WSC;
- San Patricio MWD; and
- South Texas Water Authority.

Additional water conservation and drought contingency information for the Coastal Bend Region is included in Chapter 5D.1 and Chapter 7, respectively. A copy of drought contingency plans provided to the Nueces River Authority can be accessed at: https://www.nueces-ra.org/CP/RWPG/dcp.php

1.16 TWDB Water Loss Audit Data

In accordance with 31 TAC 357.30, the Coastal Bend 2016 Regional Water Plan includes water loss information compiled by the TWDB from water loss audits performed by retail public utilities of the Coastal Bend Regional Water Planning Area pursuant to Chapter 358.6 of this title (relating to Water Loss Audits).

The 2010 Water Loss Data presented herein were submitted to the TWDB by water utilities in Texas as required by HB 3338 of the 78th Texas Legislature. HB 3338 required the TWDB to compile the information included in the water audits by type of retail public utility and by regional water planning area, and provide that information to the regional water planning groups for use in their regional water plan. The water loss data presented below were acquired as part of the 2010 Water Loss Audit reporting requirements. The methodology used relies upon self-reporting data provided by public utilities, and due to this, the self-reported data may be suspect and in need of further refinement.

The TWDB provided the list of 26 public utilities of the Coastal Bend Regional Water Planning Region that filed a water loss audit report. Table 1.4 summarizes a portion of that data for each of the 26 entities. This table shows the total population served, total water volume input into the system, total water loss, percent loss, and the value of water loss in dollars.

The cutoff point the TWDB uses for inclusion of a water utility as a Water User Group (WUG) member for which population projections and water demand projections are made for regional planning is 280 ac-ft of deliveries during the first year of the planning period, which in the present case is 2010. Of the 26 public utilities that responded to the water loss survey, ten reported having delivered less than 280 ac-ft in 2010, and sixteen reported having delivered more than 280 ac-ft in 2010.

The 26 water utilities that responded to the water loss survey reported having served 426,261 people in 2010 (about 75 percent of the 2010 regional population) (Table 1.4). Total reported water input into the systems was 90,650 ac-ft, with a reported quantity of water loss of 6,393 ac-ft. The quantity of water loss, as a percent of estimated total input water volume is calculated at about 7.1 percent for the region as a whole.

In addition, in accordance with 31 TAC 357.30, the regional water planning group has considered strategies to water losses identified in the audits located in Chapter 5D.1.

Table 1.4. Summary of Water Loss Survey, 2010

No.	Utility Name	Retail Pop Served	System Input Volume (acft)	Water Loss (acft)	Water Loss (%)	Total Cost Of Loss ($)
Utilities with Input Volumes of Less Than 280 acft/yr						
1	ARANSAS BAY UTILITIES	680	49	5	10.2%	2,373
2	BAFFIN BAY WSC	1,099	124	92	74.2%	44,880
3	CITY OF INGLESIDE ON THE BAY	659	66	4	6.1%	4,913
4	CITY OF PREMONT	200	45	17	37.8%	6,058
5	COPANO HEIGHTS WATER CO	193	15	1	6.7%	2,110
6	COPANO RIDGE SUBDIVISION	653	39	4	10.3%	6,042
7	FALFURRIAS UTILITY BOARD ENCINO	297	36	3	8.3%	5,476
8	NUECES COUNTY WCID #5	810	95	11	11.6%	8,121
9	RICARDO WSC	2,631	253	43	17.0%	37,636
10	TYNAN WSC	93	20	5	25.0%	-
Subtotal for Utilities with Less Than 280 acft/yr		**7,315**	**742**	**185**	**24.9%**	**117,609**
Utilities with Input Volumes of More Than 280 acft/yr						
11	CITY OF ALICE	19,010	3,578	816	22.8%	629,561
12	CITY OF BISHOP	3,300	565	189	33.5%	196,755
13	CITY OF CORPUS CHRISTI	297,500	70,310	4,107	5.8%	2,131,681
14	CITY OF GREGORY	2,055	310	2	0.6%	21,355
15	CITY OF INGLESIDE	8,829	1,029	154	15.0%	157,754
16	CITY OF ODEM	2,500	301	32	10.6%	108,439
17	CITY OF ORANGE GROVE	1,330	295	63	21.4%	132,805
18	CITY OF PORTLAND	18,000	2,046	175	8.6%	147,843
19	CITY OF ROCKPORT PUBLIC WATER	28,671	3,066	335	10.9%	303,060
20	CITY OF TAFT	5,117	455	41	9.0%	59,188
21	CITY OF THREE RIVERS	2,729	2,125	71	3.3%	161,162
22	FALFURRIAS UTILITY BOARD	7,194	1,315	197	15.0%	237,640
23	HOLIDAY BEACH WSC	2,040	764	258	33.8%	89,044
24	NUECES COUNTY WCID #3	14,751	1,517	(343)	-22.6%	176,767
25	NUECES COUNTY WCID 4	3,601	1,930	95	4.9%	84,762
26	NUECES WSC	2,319	302	16	5.3%	12,959
Subtotal for Utilities with More Than 280 acft/yr		**418,946**	**89,908**	**6,208**	**6.9%**	**4,650,775**
TOTAL		**426,261**	**90,650**	**6,393**	**7.1%**	**4,768,384**

*Note: The water losses in this table include real and apparent losses.

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Population and Water Demand Projections [31 TAC §357.31]

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Chapter 2: Population and Water Demand Projections

2.1 Introduction

For the 2016 Coastal Bend Regional Water Plan (Plan), the TWDB issued new population and water demand projections based on 2010 Census data. The Coastal Bend RWPG reviewed the projections provided by the TWDB and requested the following revisions:

- Increases in population projections for Aransas, Nueces, and San Patricio County entities most likely to be impacted with projected industrial growth. The water user groups where increases in population projections were requested included: Aransas Pass, Corpus Christi (2020 only), Fulton, Gregory, Ingleside, Ingleside on the Bay, Odem, Portland, Port Aransas, Rincon WSC, Rockport, and Taft;
- Increases in water demand for municipal water users in Aransas, Nueces, and San Patricio Counties (listed above) based on current use and local economic forecasts;
- Increases in irrigation water demand for Brooks, Duval, Jim Wells, Kleberg, Live Oak, McMullen, and Nueces Counties to better align with current and anticipated water use based on groundwater conservation district information and FSA-provided irrigated acreage estimates;
- Increases in manufacturing water demand in San Patricio County based on new industry requests for water service and San Patricio Municipal Water District's water planning report; and
- Increases in mining water demand in Live Oak and McMullen Counties for Eagleford shale mining activities based on information provided by local groundwater conservation districts.

The TWDB considered the Coastal Bend RWPG population and water demand requests and approved all non-municipal revision requests for Irrigation, Manufacturing, and Mining water demand projections to match those requested by the Coastal Bend RWPG. The TWDB did not approve the Coastal Bend RWPG- recommended increases in population and municipal water demand projections. Although this section presents TWDB-approved population and water demand projections for the region, it is estimated that municipal water use in Aransas, San Patricio, and Nueces Counties will exceed projections as discussed in the needs analysis (Chapter 4) and water supply plans (Chapter 5).

The TWDB- developed population projections for cities with a population greater than 500, water supply corporations and special utility districts using volumes of 280 ac-ft or more in 2010, and 'county-other' to capture those people living outside the cities or water utility service areas for each county. Water demand projections were developed by type of use: municipal for cities and water supply corporations/special utility districts (along with a 'county-other' for each county), and countywide for manufacturing, steam-electric, mining, irrigation, and livestock. This section presents these figures for the 11-county Coastal Bend Regional Water Planning

Area. These counties are located within three river basins: the Nueces River Basin, the San Antonio-Nueces Coastal Basin, and the Nueces-Rio Grande Coastal Basin (Figure 2.1). The population projections are a consensus-based "most-likely" scenario of growth, based on recent and prospective growth trends as determined by state agencies and key interest groups. The demand projections for each type of water use were made under various assumptions that will be addressed in each water-use section below.

This chapter contains population and water demand projections for each municipal, manufacturing, mining, irrigation, and livestock water demand projections by county and river basin.

2.2 Population Projections

From 1990 to 2010, the population in the 11-county region grew by 71,775 (from 492,829 to 564,604), an increase of 14.6 percent (0.68 percent compound annual growth), as shown in Table 2.1. This compares with a statewide increase in population of 48 percent (1.98 percent annually). The majority of the growth occurred in Nueces and San Patricio Counties, the two largest counties in the region by population. Combined, they accounted for 77 percent of the total increase, and in 2010 their populations totaled 71.7 percent of the region. In 2010, 60.3 percent of the region's total population lived in Nueces County, 11.5 percent in San Patricio County, 7.2 percent in Jim Wells County, 5.7 percent in Kleberg County, 5.6 percent in Bee County, and 9.7 percent in the remaining six counties combined.

The population in the 11-county region is projected to increase by 179,940 from 2010 to 2070, an increase of 31.9 percent (0.46 percent annually), as shown in Table 2.1. This compares to a statewide projected population growth in the same period of 103 percent (1.19 percent annually). The total population for the region in 2010 was 2.2 percent of the 25.15 million population statewide. It declines slightly by 2070, to 1.5 percent of the projected 51.04 million statewide totals. In 2070, it is projected that 61.3 percent of the region's population will live in Nueces County, 10.4 percent in San Patricio County, 6.8 percent in Kleberg County, 8.2 percent in Jim Wells County, and less than 5.0 percent in each of the remaining seven counties. Figure 2-2 shows the trend in population for the region over the planning period.

Kleberg, Jim Wells, Brooks and Nueces Counties are the fastest growing counties in the region, with future projections growing at an annual rate higher than the regional average of 0.46 percent (Figure 2.3). The population growth in those counties accounts for 79 percent of the total increase over the next 60 years. The growth rate for all counties in Region N is projected to be positive over the next 60 years.

Corpus Christi and Kingsville are the two largest cities in the region, accounting for 58.7 percent of the total population in 2010, increasing to 60.5 percent of the total in 2070. Population projections for the 46 cities, water supply corporations, and 'county-other' users in the region are shown in Table 2.2. County-Other category includes persons residing outside of cities and also outside water utility boundaries. Population for water user groups by county and river basin are included in the Appendix.

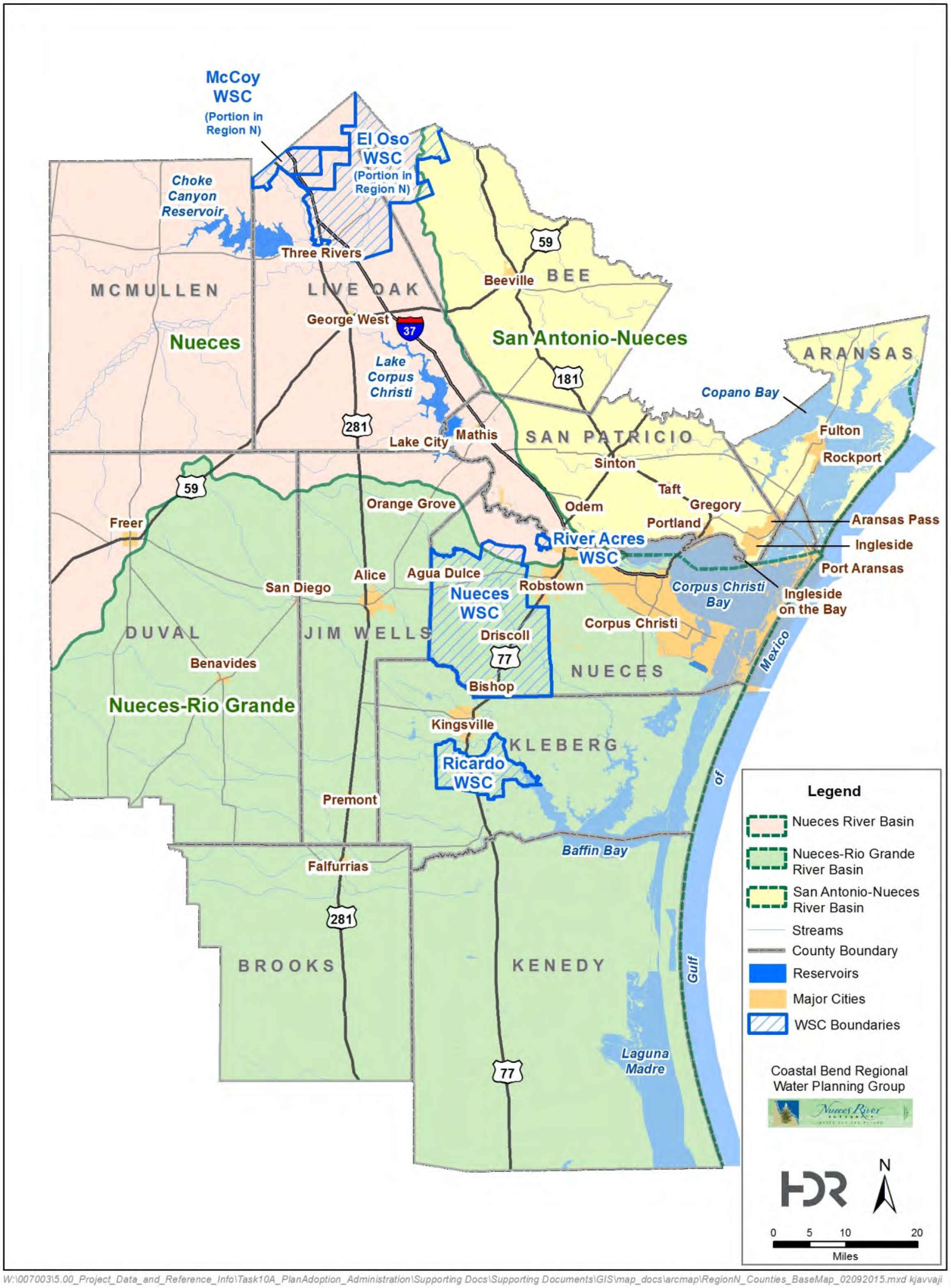

Figure 2.1.
Coastal Bend Region River Basin Boundaries

Table 2.1.
Coastal Bend Region Population (by County and River Basin)

	Historical			Projections [1]						Percent Growth[2]	Percent Growth[2]
County	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**	**1990-2010**	**2010-70**
Aransas	17,892	22,497	23,158	24,463	24,991	24,937	25,102	25,103	25,104	1.30%	0.13%
Bee	25,135	32,359	31,861	33,478	34,879	35,487	35,545	35,579	35,590	1.19%	0.18%
Brooks	8,204	7,976	7,223	7,783	8,252	8,722	9,181	9,595	9,979	-0.63%	0.54%
Duval	12,918	13,120	11,782	12,715	13,470	14,098	14,644	15,080	15,435	-0.46%	0.45%
Jim Wells	37,679	39,326	40,838	44,987	48,690	52,052	55,533	58,600	61,410	0.40%	0.68%
Kenedy	460	414	416	463	498	504	507	508	508	-0.50%	0.33%
Kleberg	30,274	31,549	32,061	35,567	38,963	42,202	45,324	48,251	50,989	0.29%	0.78%
Live Oak	9,556	12,309	11,531	11,683	11,690	11,690	11,690	11,690	11,690	0.94%	0.02%
McMullen	817	851	707	734	734	734	734	734	734	-0.72%	0.06%
Nueces	291,145	313,645	340,223	374,157	407,534	428,513	440,797	449,936	456,056	0.78%	0.49%
San Patricio	58,749	67,138	64,804	68,760	72,114	74,043	75,451	76,405	77,049	0.49%	0.29%
Total for Region	**492,829**	**541,184**	**564,604**	**614,790**	**661,815**	**692,982**	**714,508**	**731,481**	**744,544**	**0.68%**	**0.46%**
River Basin											
Nueces	40,062	56,482	56,460	60242	64003	66445	68053	69273	70159	1.73%	0.36%
Nueces-Rio Grande	360,810	372,608	400,869	437397	475839	502344	520818	535709	547316	0.53%	0.52%
San Antonio-Nueces	91,957	112,094	107,276	117151	121973	124193	125637	126499	127069	0.77%	0.28%
Total for Region	**492,829**	**541,184**	**564,604**	**614,790**	**661,815**	**692,982**	**714,508**	**731,481**	**744,544**	**0.68%**	**0.46%**
Total for Texas	**16,986,510**	**20,851,790**	**25,145,561**	**29,510,184**	**33,628,653**	**37,736,338**	**41,928,264**	**46,354,818**	**51,040,173**	**1.98%**	**1.19%**

[1] Projections from Texas Water Development Board
[2] Compound annual growth rate

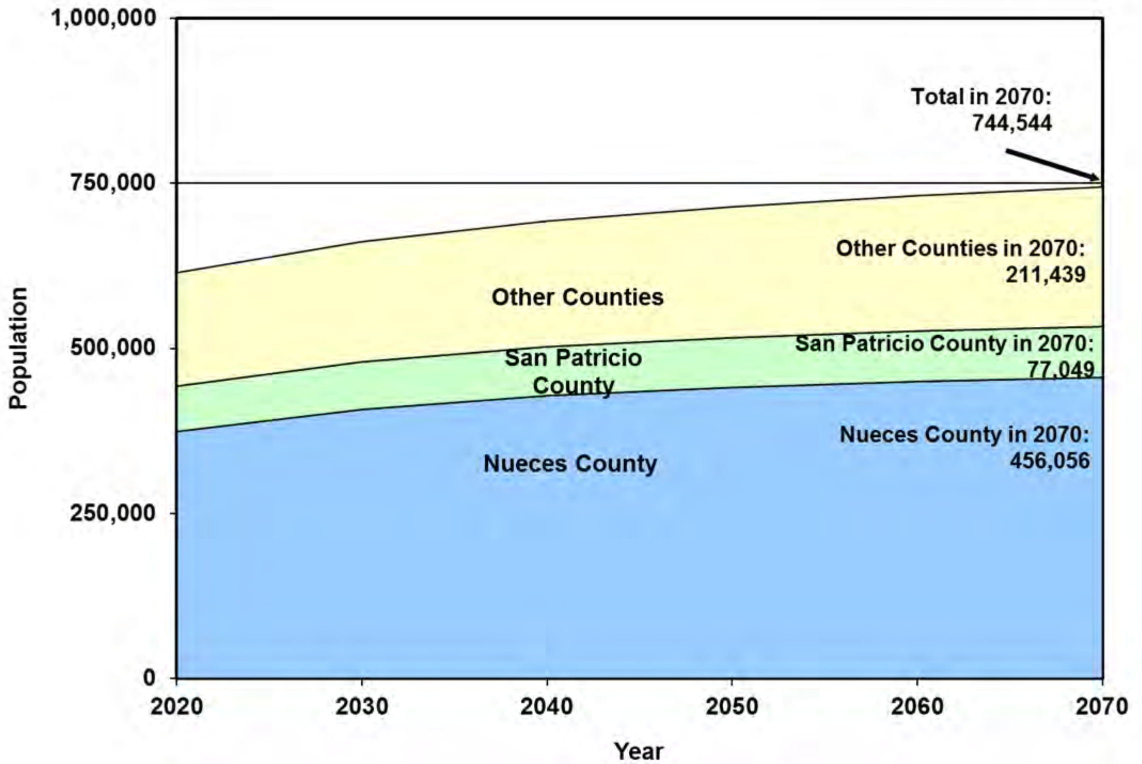

Figure 2.2.
Coastal Bend Region Population

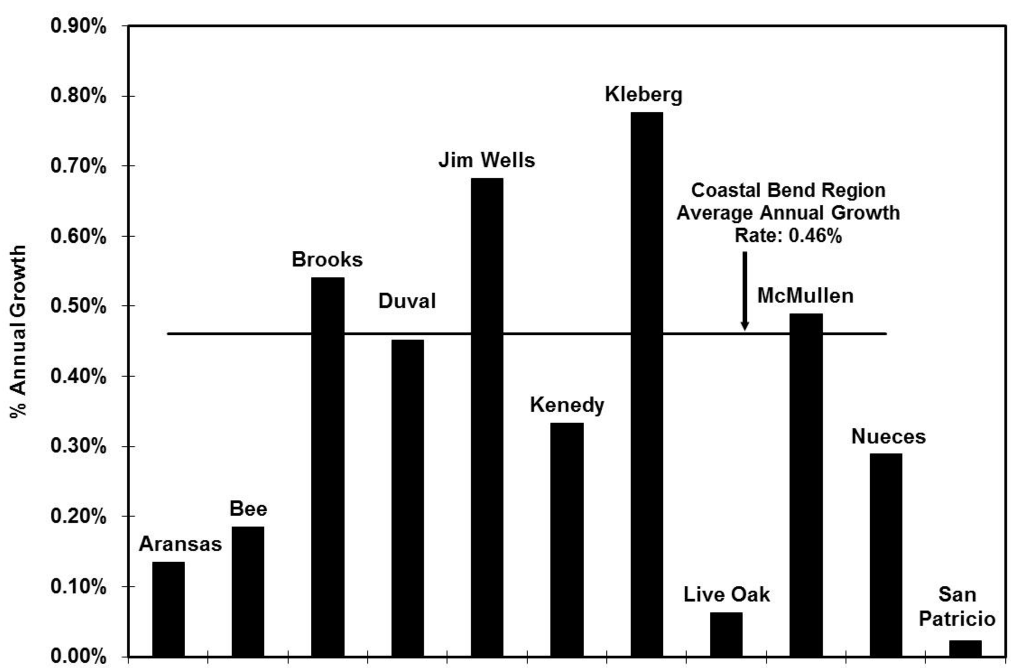

Figure 2.3.
Percent Annual Population Growth Rate for 2010 through 2070 by County

Table 2.2. Coastal Bend Region Population (by City/County)

City/County	Historical 1990	Historical 2000	Historical 2010	Projections[1] 2020	Projections[1] 2030	Projections[1] 2040	Projections[1] 2050	Projections[1] 2060	Projections[1] 2070	Percent Growth[2] 1980-10	Percent Growth[2] 2010-70
ARANSAS PASS (P)	912	867	724	765	782	780	785	785	785	-1.15%	0.13%
FULTON	763	1,553	1,358	1,435	1,466	1,463	1,472	1,473	1,473	N/A	0.14%
ROCKPORT	5,355	7,385	8,766	9,260	9,460	9,440	9,502	9,503	9,503	2.49%	0.13%
COUNTY-OTHER	10,862	12,692	12,310	13,003	13,283	13,254	13,343	13,342	13,343	0.63%	0.13%
Aransas County	*17,892*	*22,497*	*23,158*	*24,463*	*24,991*	*24,937*	*25,102*	*25,103*	*25,104*	*1.30%*	*0.13%*
BEEVILLE	13,547	13,129	12,863	13,516	14,082	14,327	14,351	14,365	14,369	-0.26%	0.18%
EL OSO WSC (P)	271	320	367	386	402	409	410	410	410	N/A	0.18%
COUNTY-OTHER	11,317	18,910	18,631	19,576	20,395	20,751	20,784	20,804	20,811	2.52%	0.18%
Bee County	*25,135*	*32,359*	*31,861*	*33,478*	*34,879*	*35,487*	*35,545*	*35,579*	*35,590*	*1.19%*	*0.18%*
FALFURRIAS	5,788	5,297	4,981	5,217	5,414	5,612	5,805	5,979	6,141	-0.75%	0.35%
COUNTY-OTHER	2,416	2,679	2,242	2,566	2,838	3,110	3,376	3,616	3,838	-0.37%	0.90%
Brooks County	*8,204*	*7,976*	*7,223*	*7,783*	*8,252*	*8,722*	*9,181*	*9,595*	*9,979*	*-0.63%*	*0.54%*
BENAVIDES	1,788	1,686	1,362	1,470	1,558	1,630	1,693	1,744	1,785	-1.35%	0.45%
FREER	3,271	3,241	2,818	3,042	3,222	3,372	3,503	3,607	3,692	-0.74%	0.45%
SAN DIEGO (P)	4,109	3,928	3,588	3,873	4,103	4,294	4,460	4,593	4,701	-0.68%	0.45%
COUNTY-OTHER	3,750	4,265	4,014	4,330	4,587	4,802	4,988	5,136	5,257	0.34%	0.45%
Duval County	*12,918*	*13,120*	*11,782*	*12,715*	*13,470*	*14,098*	*14,644*	*15,060*	*15,435*	*-0.46%*	*0.45%*
ALICE	19,788	19,010	19,104	21,045	22,778	24,350	25,979	27,414	28,728	-0.18%	0.68%
ORANGE GROVE	1,175	1,288	1,318	1,452	1,572	1,680	1,793	1,892	1,982	0.58%	0.68%
PREMONT	2,914	2,772	2,653	2,923	3,164	3,382	3,608	3,807	3,990	-0.47%	0.68%
SAN DIEGO (P)	874	825	900	992	1,074	1,148	1,224	1,292	1,354	0.15%	0.68%
COUNTY-OTHER	12,928	15,431	16,863	18,575	20,102	21,492	22,929	24,195	25,356	1.34%	0.68%
Jim Wells County	*37,679*	*39,326*	*40,838*	*44,987*	*48,690*	*52,052*	*55,533*	*58,600*	*61,410*	*0.40%*	*0.68%*
COUNTY-OTHER	460	414	416	463	498	504	507	508	508	-0.50%	0.33%
Kenedy County	*460*	*414*	*416*	*463*	*498*	*504*	*507*	*508*	*508*	*-0.50%*	*0.33%*
KINGSVILLE	25,276	25,575	26,213	29,080	31,857	34,505	37,057	39,450	41,689	0.18%	0.78%
RICARDO WSC	1,503	2,301	2,631	2,919	3,198	3,464	3,720	3,960	4,185	N/A	0.78%
COUNTY-OTHER	3,495	3,673	3,217	3,568	3,908	4,233	4,547	4,841	5,115	-0.41%	0.78%
Kleberg County	*30,274*	*31,549*	*32,061*	*35,567*	*38,963*	*42,202*	*45,324*	*48,251*	*50,989*	*0.29%*	*0.78%*

Table 2.2. (Continued)
Coastal Bend Region Population (by City/County)

City/County	Historical 1990	Historical 2000	Historical 2010	Projections[1] 2020	Projections[1] 2030	Projections[1] 2040	Projections[1] 2050	Projections[1] 2060	Projections[1] 2070	Percent Growth[2] 1980-10	Percent Growth[2] 2010-70
EL OSO (P)	812	1,000	652	661	661	661	661	661	661	-1.09%	0.02%
GEORGE WEST	2,586	2,524	2,445	2,478	2,479	2,479	2,479	2,479	2,479	-0.28%	0.02%
MCCOY WSC (P)	185	443	169	172	172	172	172	172	172	-0.45%	0.03%
THREE RIVERS	1,889	1,878	1,848	1,873	1,874	1,874	1,874	1,874	1,874	-0.11%	0.02%
COUNTY-OTHER	4,084	6,464	6,417	6,499	6,504	6,504	6,504	6,504	6,504	2.29%	0.02%
Live Oak County	*9,556*	*12,309*	*11,531*	*11,683*	*11,690*	*11,690*	*11,690*	*11,690*	*11,690*	*0.94%*	*0.02%*
COUNTY-OTHER	817	851	707	734	734	734	734	734	734	-0.72%	0.06%
McMullen County	*817*	*851*	*707*	*734*	*734*	*734*	*734*	*734*	*734*	*-0.72%*	*0.06%*
AGUA DULCE	794	737	812	892	972	1,022	1,052	1,073	1,088	0.11%	0.49%
ARANSAS PASS (P)	22	70	14	15	16	17	18	18	18	-2.23%	0.42%
BISHOP	3,337	3,305	3,134	3,446	3,754	3,947	4,060	4,144	4,201	-0.31%	0.49%
CORPUS CHRISTI	257,453	277,450	305,215	335,657	365,599	384,420	395,440	403,638	409,129	0.85%	0.49%
DRISCOLL	688	825	739	812	885	930	957	977	990	0.36%	0.49%
NUECES COUNTY WSC			2,322	2,553	2,781	2,924	3,008	3,070	3,112	N/A	0.49%
PORT ARANSAS	2,233	3,370	3,480	3,827	4,168	4,383	4,508	4,602	4,664	2.24%	0.49%
RIVER ACRES WSC	2,130	2,750	2,421	2,662	2,899	3,049	3,136	3,201	3,245	0.64%	0.49%
ROBSTOWN	12,849	12,727	11,487	12,467	12,467	12,467	12,467	12,467	12,467	-0.56%	0.14%
COUNTY-OTHER	11,639	12,411	10,599	11,826	13,993	15,354	16,151	16,746	17,142	-0.47%	0.80%
Nueces County	*291,145*	*313,645*	*340,223*	*374,157*	*407,534*	*428,513*	*440,797*	*449,936*	*456,056*	*0.78%*	*0.49%*
ARANSAS PASS (P)	6,246	7,201	7,466	7,922	8,309	8,531	8,693	8,803	8,877	0.90%	0.29%
GREGORY	2,458	2,318	1,907	2,024	2,123	2,179	2,221	2,249	2,268	-1.26%	0.29%
INGLESIDE	5,696	9,388	9,387	9,961	10,446	10,726	10,930	11,068	11,161	2.53%	0.29%
INGLESIDE ON THE BAY	529	659	615	653	685	703	717	726	732	0.76%	0.29%
LAKE CITY	465	526	509	541	567	582	593	601	606	0.45%	0.29%
MATHIS	5,423	5,034	4,942	5,244	5,500	5,647	5,754	5,827	5,876	-0.46%	0.29%
ODEM	2,366	2,499	2,389	2,535	2,659	2,730	2,782	2,817	2,841	0.05%	0.29%
PORTLAND	12,224	14,827	15,099	16,021	16,803	17,252	17,580	17,802	17,953	1.06%	0.29%
RINCON WSC			3,243	3,441	3,609	3,706	3,776	3,824	3,856	N/A	0.29%
SINTON	5,549	5,676	5,665	6,011	6,305	6,473	6,596	6,680	6,736	0.10%	0.29%
TAFT	3,222	3,396	3,048	3,235	3,392	3,483	3,549	3,594	3,624	-0.28%	0.29%
COUNTY-OTHER	14,571	15,614	10,534	11,172	11,716	12,031	12,260	12,414	12,519	-1.61%	0.29%
San Patricio County	*58,749*	*67,138*	*64,804*	*68,760*	*72,114*	*74,043*	*75,451*	*76,405*	*77,049*	*0.49%*	*0.29%*
Total For Region	**492,829**	**541,184**	**564,604**	**614,790**	**661,815**	**692,982**	**714,508**	**731,481**	**744,544**	**0.68%**	**0.46%**

Notes:
[1] Projections from Texas Water Development Board (P) Partial
[2] Compound annual growth rate

2.3 Water Demand Projections

The TWDB water demand projections have been compiled for each type of consumptive water use: municipal, manufacturing, steam-electric power, mining, irrigation, and livestock. In these consumptive types of water use there is a "loss" in water. In non-consumptive water use, such as navigation, hydroelectric generating, or recreation, there is little or no water loss. As shown in Table 2.3, total water use for the region is projected to increase by 155,456 ac-ft/yr between 2010 and 2070, from 187,788 ac-ft/yr to 343,244 ac-ft/yr, an 82.7 percent rise. Municipal, manufacturing, steam-electric, irrigation, and mining water use are all projected to increase, while livestock use is unchanged. The trend in projected total water use for the region is shown in Figure 2.4. In 2010, 59.5 percent of the total water use was for municipal purposes, 23.9 percent for manufacturing, 0.2 percent for steam-electric water, 2.8 percent for mining, 9.8 percent for irrigation, and 3.8 percent for livestock. In 2070, municipal use as a percentage of the total is projected to decrease to 37.4 percent, manufacturing use to increase to 37.1 percent, steam-electric water use to increase to 10.1 percent, mining use to decrease to 1.6 percent, irrigation water use to increase to 11.7 percent, and livestock use to decrease to 2.1 percent. Municipal water demand projections include water conservation attributed to updated plumbing code savings. These components of total water use for 2010 and 2070 are shown in Figure 2.5.

Table 2.3.
Coastal Bend Region Total Water Demand by Type of Use and River Basin (ac-ft/yr)

	----- Historical ---		---------- Projections[1] ----------					
Water Use	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Municipal	98,573	111,854	112,081	117,701	121,072	123,698	126,343	128,510
Manufacturing	54,481	44,820	92,175	98,724	105,153	110,754	118,723	127,266
Steam-Electric	8,799	388	15,038	17,582	20,681	24,461	29,067	34,541
Mining	12,397	5,255	8,951	9,821	9,660	7,206	6,157	5,497
Irrigation	21,971	18,398	26,419	28,604	30,990	33,595	36,441	40,124
Livestock	8,838	7,073	7,306	7,306	7,306	7,306	7,306	7,306
Total for Region	**205,059**	**187,788**	**261,970**	**279,738**	**294,862**	**307,020**	**324,037**	**343,244**
River Basin								
Nueces	38,217	41,313	57,633	61,542	64,870	67,544	71,288	75,514
Nueces-Rio Grande	136,744	107,039	149,323	159,451	168,071	175,001	184,701	195,649
San Antonio-Nueces	30,098	39,435	55,014	58,745	61,921	64,474	68,048	72,081
Total for Region	**205,059**	**187,788**	**261,970**	**279,738**	**294,862**	**307,020**	**324,037**	**343,244**

[1] Projections from Texas Water Development Board

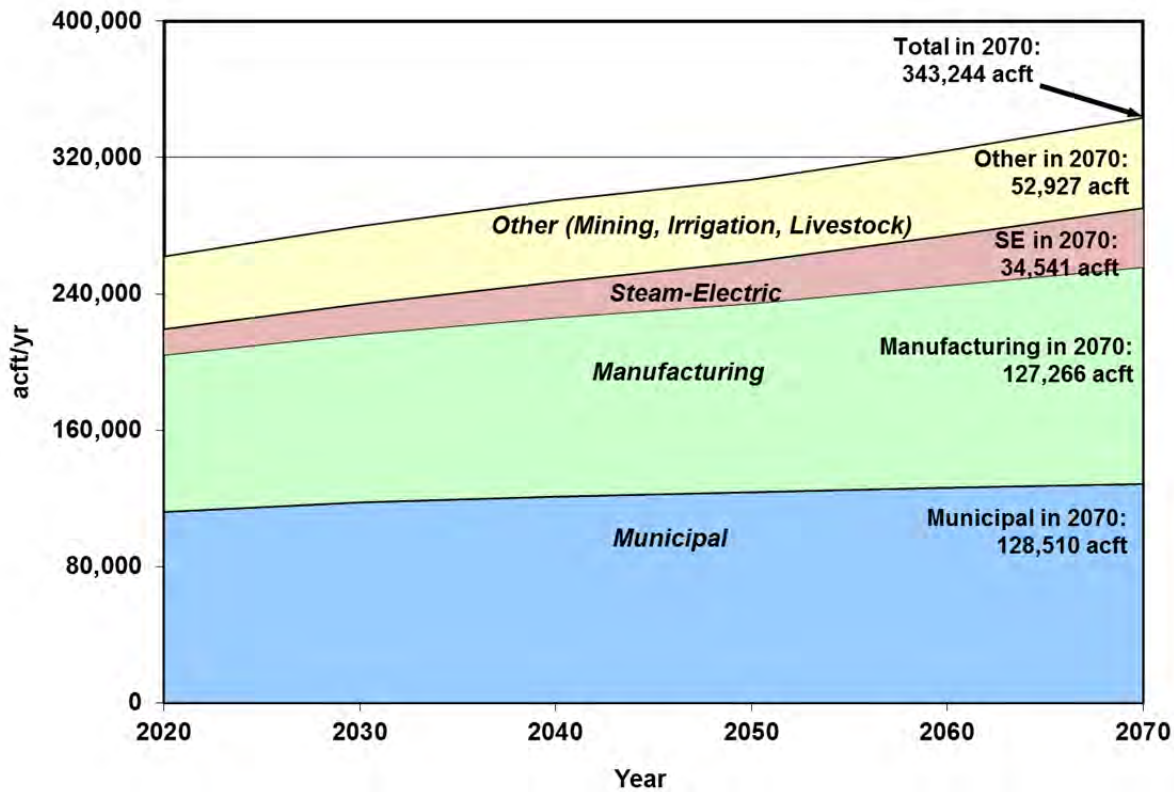

Figure 2.4.
Coastal Bend Region Water Demand

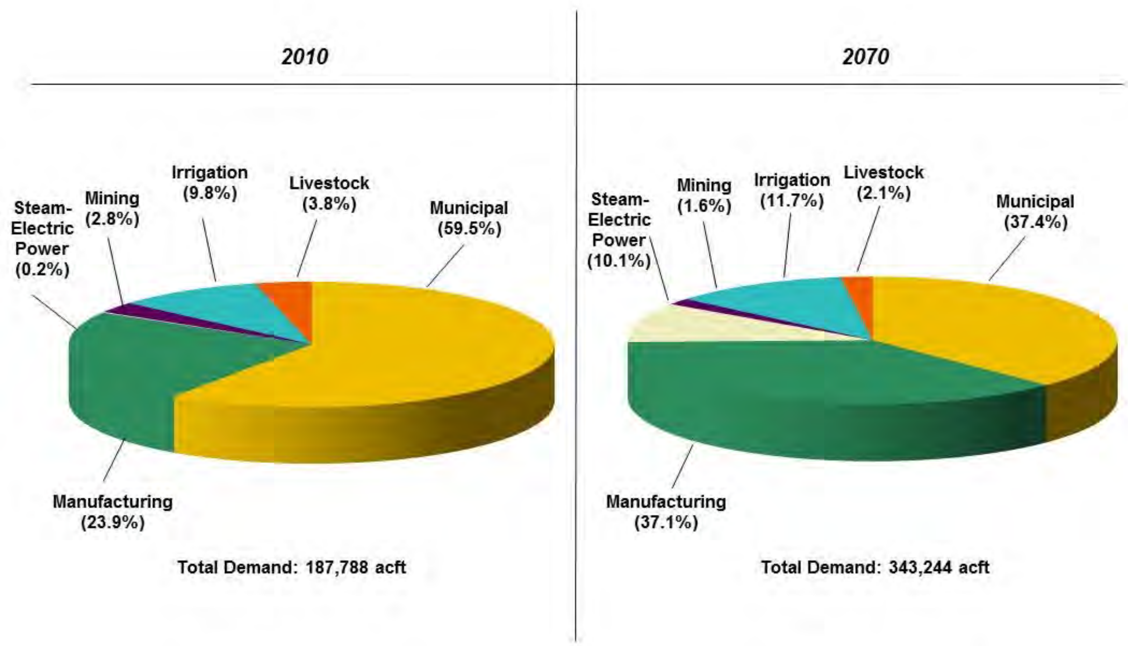

Figure 2.5.
Total Water Demand by Type of Use

The Coastal Bend Region is located within three river basins: the Nueces River Basin, the San Antonio-Nueces Coastal Basin, and the Nueces-Rio Grande Coastal Basin. Total water demand in each basin is shown in Table 2.3.

2.3.1 Municipal Water Demand

Water that is used by households (e.g., drinking, bathing, food preparation, dishwashing, laundry, flushing toilets, lawn watering and landscaping, swimming pools and hot tubs) commercial establishments (e.g., restaurants, car washes, hotels, laundromats, and office buildings) and for fire protection, public recreation and sanitation are all referred to as municipal water. This type of water must meet safe drinking water standards as specified by Federal and State laws and regulations.

The TWDB computes the municipal water demand projections by multiplying the projected population of an entity by the entity's projected per capita water use, adjusted for conservation savings. Again, projected population is the "most-likely" scenario. The projected per capita water use takes into account current plumbing fixtures as well as water savings due to plumbing fixture requirements identified in the Texas Health and Safety Code, Chapter 372. Any additional changes in plumbing fixtures to promote more aggressive water savings beyond those realized in the Texas Health and Safety Code, would be expected to reduce projected water demands. The projected per capita water use is an "expected" scenario of water conservation including installation of water-efficient plumbing fixtures as defined by the 1991 State Water-Efficient Plumbing Act. In all cases, applying this conservation scenario to the per capita use results in a declining per capita water use over time.

In 2010 total reported municipal use in the Coastal Bend Region was 111,854 ac-ft/yr[1]. Nueces and San Patricio Counties accounted for 76.7 percent of the total. Municipal use is projected to increase 14.9 percent to 128,510 ac-ft by year 2070 (Table 2.4). Kenedy, Jim Wells and Kleberg Counties will experience the largest increases, 142.2 percent, 71.3 percent, and 68.6 percent, respectively. By 2070, Nueces and San Patricio Counties will account for 74.1 percent of the total municipal water use in the region (Figure 2.6).

Generally, the increase in water use for the entities in the region is less than their respective increases in population (i.e., low flow plumbing fixtures). This is attributable to a declining per capita water use, which includes conservation built-in the TWDB demand projections. Per capita water use in Corpus Christi is projected to decline 10 percent, from 182 gallons per capita daily (gpcd) in 2011 to 164 gpcd in 2070. The average per capita water use of all municipal water user groups in the Coastal Bend Region was 171 gpcd in 2011, which is projected to decline to 153 gpcd in 2070 with conservation built-in the TWDB demand projections. Additional water conservation recommended by the Coastal Bend Regional Water Planning Group for select municipal water user group entities is described in 5D.1. Municipal water use projections for the 46 entities in the region are presented in Table 2.5.

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[1] TWDB Water Use Survey, 2010.

Table 2.4.
Coastal Bend Region Municipal Water Demand by County (ac-ft/yr)

County	Historical		Projections[1]					
	2000	2010	2020	2030	2040	2050	2060	2070
Aransas	3,314	3,986	3,511	3,482	3,395	3,376	3,367	3,367
Bee	4,220	6,062	5,733	5,824	5,812	5,769	5,759	5,761
Brooks	1,970	1,842	2,003	2,059	2,125	2,210	2,289	2,364
Duval	2,323	1,947	2,159	2,219	2,274	2,348	2,412	2,468
Jim Wells	8,562	6,193	8,098	8,537	8,952	9,464	9,968	10,444
Kenedy	46	109	244	261	262	263	264	264
Kleberg	5,415	4,033	5,174	5,481	5,799	6,158	6,539	6,907
Live Oak	1,990	1,649	1,746	1,702	1,668	1,649	1,640	1,640
McMullen	135	156	97	94	91	90	90	90
Nueces	61,725	77,024	73,171	77,719	80,303	81,882	83,417	84,520
San Patricio	8,873	8,853	10,145	10,323	10,391	10,489	10,598	10,685
Total for Region	**98,573**	**111,854**	**112,081**	**117,701**	**121,072**	**123,698**	**126,343**	**128,510**

[1] Projections from Texas Water Development Board

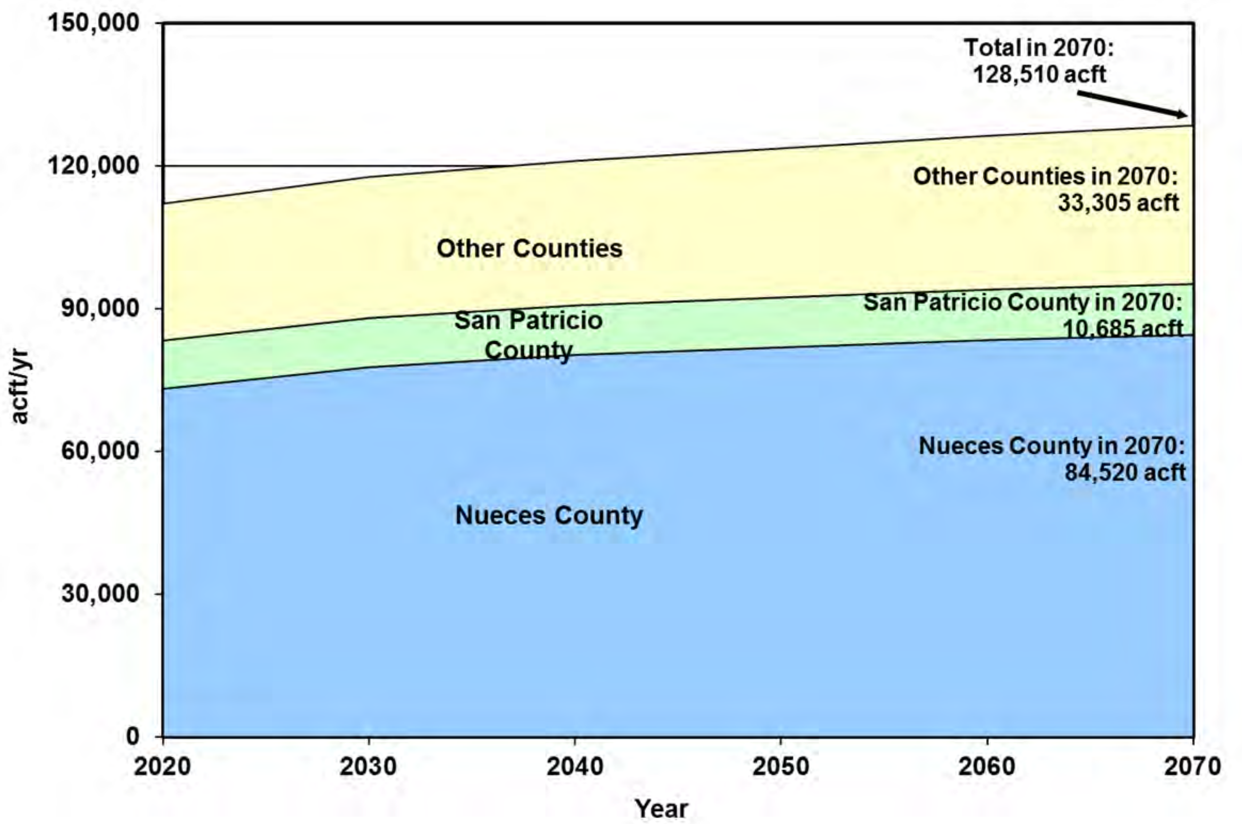

Figure 2.6.
Coastal Bend Region Municipal Water Demand

Table 2.5.
Coastal Bend Region Municipal Water Demand by City/County (ac-ft/yr)

City/County	*Historical*		*Projections*[1]					
	2000	*2010*	*2020*	*2030*	*2040*	*2050*	*2060*	*2070*
Aransas Pass (P)	146	92	110	108	106	105	104	104
Fulton	261	236	278	279	275	275	275	275
Rockport	1,357	1,422	1,677	1,680	1,652	1,649	1,646	1,646
County-Other	1,550	2,236	1,446	1,415	1,362	1,347	1,342	1,342
Aransas County	*3,314*	*3,986*	*3,511*	*3,482*	*3,395*	*3,376*	*3,367*	*3,367*
Beeville	2,529	2,333	2,925	2,978	2,976	2,961	2,959	2,960
El Oso (P)	60	72	83	85	85	84	80	80
County-Other	1,631	3,658	2,725	2,761	2,751	2,724	2,720	2,721
Bee County	*4,220*	*6,062*	*5,733*	*5,824*	*5,812*	*5,769*	*5,759*	*5,761*
Falfurrias	1,661	1,346	1,677	1,712	1,755	1,813	1,865	1,915
County-Other	309	496	326	347	370	397	424	449
Brooks County	*1,970*	*1,842*	*2,003*	*2,059*	*2,125*	*2,210*	*2,289*	*2,364*
Benavides	315	327	236	242	250	259	266	272
Freer	624	584	650	672	691	717	737	754
San Diego (P)	471	509	724	746	765	791	813	832
County-Other	913	527	549	559	568	581	596	610
Duval County	*2,323*	*1,947*	*2,159*	*2,219*	*2,274*	*2,348*	*2,412*	*2,468*
Alice	5,281	3,443	4,192	4,425	4,643	4,912	5,175	5,421
Orange Grove	353	246	376	400	422	447	471	494
Premont	807	437	710	752	792	841	886	929
San Diego (P)	99	128	186	196	205	217	229	240
County-Other	2,022	1,939	2,634	2,764	2,890	3,047	3,207	3,360
Jim Wells County	*8,562*	*6,193*	*8,098*	*8,537*	*8,952*	*9,464*	*9,968*	*10,444*
County-Other	46	109	244	261	262	263	264	264
Kenedy County	*46*	*109*	*244*	*261*	*262*	*263*	*264*	*264*
Kingsville	4,440	3,202	4,232	4,483	4,738	5,025	5,336	5,636
Ricardo WSC	296	248	341	361	382	405	430	454
County-Other	679	583	601	637	679	728	773	817
Kleberg County	*5,415*	*4,033*	*5,174*	*5,481*	*5,799*	*6,158*	*6,539*	*6,907*
El Oso WSC (P)	189	166	143	139	137	135	129	129
George West	642	471	454	443	433	429	428	428
McCoy WSC	50	50	22	21	21	20	20	20
Three Rivers	425	316	325	316	309	305	305	305
County-Other	684	646	802	783	768	760	758	758
Live Oak County	*1,990*	*1,649*	*1,746*	*1,702*	*1,668*	*1,649*	*1,640*	*1,640*
County-Other	135	156	97	94	91	90	90	90
McMullen County	*135*	*156*	*97*	*94*	*91*	*90*	*90*	*90*
Agua Dulce	115	124	132	139	143	145	148	150
Aransas Pass (P)	12	2	3	3	3	3	3	3
Bishop	459	443	594	628	646	660	673	682

City/County	***Historical***		***Projections***[1]					
	2000	***2010***	***2020***	***2030***	***2040***	***2050***	***2060***	***2070***
Corpus Christi	55,629	67,323	64,816	68,931	71,270	72,680	74,064	75,058
Driscoll	97	105	105	110	113	114	116	118
Nueces WSC		143	333	355	368	376	383	388
Port Aransas	1,601	1,851	2,251	2,434	2,548	2,614	2,667	2,703
River Acres WSC [2]	314	357	426	450	463	470	479	486
Robstown [2]	2,153	2,919	2,957	2,897	2,848	2,843	2,839	2,839
County-Other	1,345	3,757	1,554	1,772	1,901	1,977	2,045	2,093
Nueces County	*61,725*	*77,024*	*73,171*	*77,719*	*80,303*	*81,882*	*83,417*	*84,520*
Aransas Pass (P)	1,210	949	1,131	1,148	1,149	1,155	1,167	1,176
Gregory	249	266	339	344	348	354	358	361
Ingleside	873	1,028	1,051	1,062	1,060	1,064	1,074	1,083
Ingleside On The Bay	74	69	77	78	78	78	79	79
Lake City	70	66	64	65	64	64	65	66
Mathis	671	668	670	676	672	679	685	691
Odem	319	235	379	384	384	387	391	394
Portland	1,976	2,046	2,631	2,684	2,698	2,718	2,747	2,770
Rincon WSC		442	346	355	359	363	366	369
Sinton	1,036	1,416	1,409	1,448	1,463	1,478	1,495	1,507
Taft	559	434	464	470	469	475	480	484
County-Other	1,836	1,234	1,584	1,609	1,647	1,674	1,691	1,705
San Patricio County	*8,873*	*8,853*	*10,145*	*10,323*	*10,391*	*10,489*	*10,598*	*10,685*
Total for Region	**98,573**	**111,854**	**112,081**	**117,701**	**121,072**	**123,698**	**126,343**	**128,510**

[1] Projections from Texas Water Development Board
(P) Partial
[2] These entities rely on supplies delivered by NCWC&ID#3. NCWC&ID#3 diverts water from the Lower Nueces River and conveys supplies through an unlined canal. By lining the canals, the amount of water necessary for diversion by NCWC&ID#3 to meet customer needs could be reduced.

2.3.2 Manufacturing Water Demand

Manufacturing is an integral part of the Texas economy, and for many industries, water plays a key role in the manufacturing process. Some of these processes require direct consumption of water as part of the products; others consume very little water but use a large quantity for cleaning and cooling. Whether the water is a product component or used to transport waste heat and materials, it is considered manufacturing water use. The water-using manufacturers in the 11-county Coastal Bend Region are food processing, chemicals, petroleum refining, stone and concrete, fabricated metal, and electronic and electrical equipment. Of these industries present in the region, chemicals and petroleum refining are the largest and biggest water users.

The TWDB projected manufacturing water demand by using TWDB 2004-2008 Water Use Survey data, taking industry-specific water demand coefficients adjusted for water-use efficiencies (recycling/reuse), and applying them to growth trends for each industry. These growth trends assume expansion of existing capacity and building of new facilities and continuation of historical trends of interaction between oil price changes and industrial activity. The decadal rate of change from the 2011 Plan was then applied to the new base to project future manufacturing water demands through 2070.

In 2010, total manufacturing water use for Coastal Bend Region was 44,820 ac-ft. Nueces and San Patricio Counties accounted for 91.8 percent of this total (Table 2.6). Manufacturing use is projected to be 92,725 ac-ft in 2020 and 127,266 ac-ft in 2070, a 38 percent increase. In 2070, Nueces and San Patricio Counties are projected to account for 98 percent of the total manufacturing water use in the region (Figure 2.7).

Table 2.6.
Coastal Bend Region Manufacturing Water Demand by County and River Basin (ac-ft/yr)

County	Historical*		Projections[1]					
	2000	2010	2020	2030	2040	2050	2060	2070
Aransas	235	0	137	142	147	151	161	172
Bee	1	0	1	1	1	1	1	1
Brooks	0	0	0	0	0	0	0	0
Duval	0	0	0	0	0	0	0	0
Jim Wells[2]	0	79	0	0	0	0	0	0
Kenedy	0	0	0	0	0	0	0	0
Kleberg[2]	0	1,275	0	0	0	0	0	0
Live Oak	1,767	2,124	2,024	2,058	2,089	2,114	2,221	2,333
McMullen[2]	0	219	0	0	0	0	0	0
Nueces	39,763	33,517	50,276	53,425	56,500	59,150	63,313	67,769
San Patricio	12,715	7,606	39,737	43,098	46,416	49,338	53,027	56,991
Total for Region	**54,481**	**44,820**	**92,175**	**98,724**	**105,153**	**110,754**	**118,723**	**127,266**

[1] Projections from Texas Water Development Board
[2] Historical manufacturing water demands were reported for Jim Wells, Kleberg, and McMullen counties but not included in TWDB demand projections from 2020-2070. According to TWDB staff, mining and manufacturing demands are often considered interchangeably. No manufacturing water use was reported for Jim Wells County in 2013. In future water planning cycles, manufacturing water demands for Jim Wells, Kleberg, and McMullen counties should be revisited to avoid underestimating supplies that might be needed.
* Self Reported Use

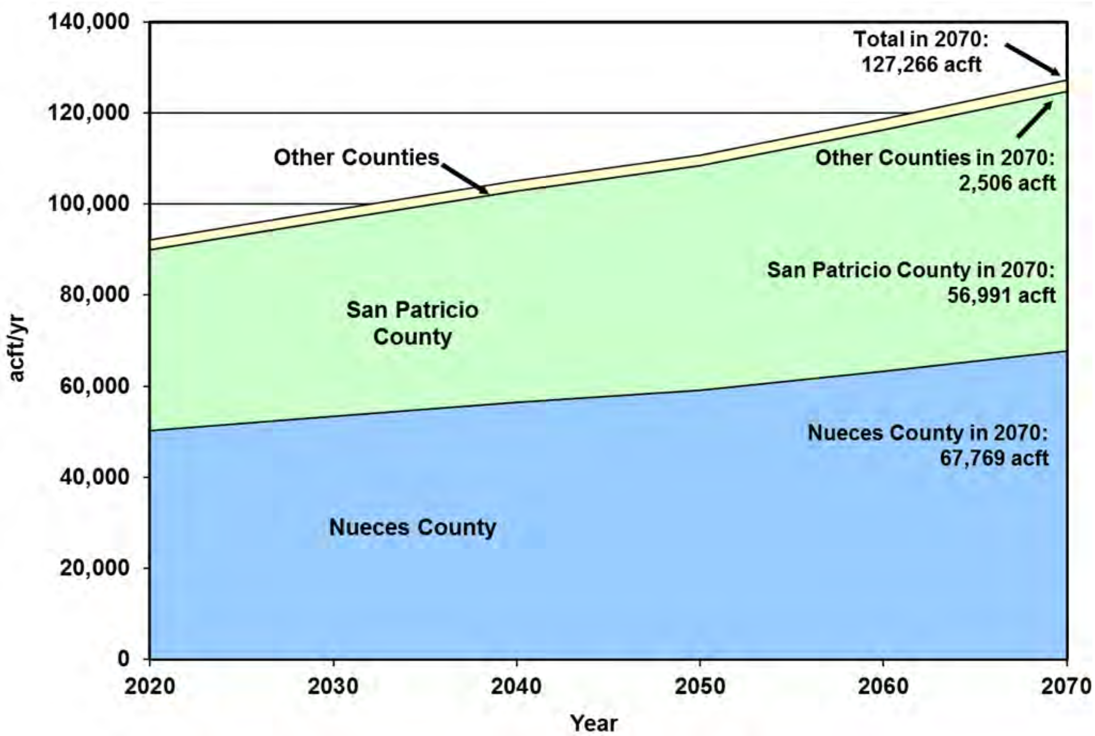

Figure 2.7.
Coastal Bend Region Manufacturing Water Demand

Petroleum refining is one of the largest industries in the region, accounting for about 60 percent of all manufacturing water use. Corpus Christi, in Nueces County, is home to nearly 13 percent of Texas' petroleum refining capacity. The refineries in the Corpus Christi area have implemented significant water conservation and water use efficiency improvement programs. These refineries use between 35 and 46 gallons of water per barrel of crude petroleum refined, compared to the State average of 100 gallons per barrel refined.[2]

2.3.3 Steam-Electric Water Demand

The TWDB and Bureau of Economic Geology (BEG) released a report entitled "Water Demand Projections for Power Generation in Texas" on August 31, 2008. This report in addition to 2011 Regional Water Plans projections and recent data from the Public Utilities Commission of Texas were used to develop steam-electric demand projections for the 2016 Plan.

Projections for steam-electric power water demand are based on power generation projections — determined by population and manufacturing growth — and on generating capacity and water use for that projected capacity. The steam-electric generation process uses water in boilers and for cooling the generating equipment. The usual practice is to use freshwater with a very low concentration of dissolved solids for boiler feed water and to use either freshwater or

[2] "Report of Water Use for Refineries and Selected Cities in Texas, 1976-1987," South Texas Water Authority, Kingsville, Texas, 1990.

saline water for power plant cooling purposes. At two of the three plants located in Corpus Christi in Nueces County, freshwater is used for the boiler feed and seawater is used for cooling. The Nueces Bay Power Station is not currently operating. The use of saltwater for cooling at Topaz (formerly AEP-CPL's) Barney Davis Power Station saves approximately 6,300 ac-ft/yr in freshwater (1999 figures). At the third plant, Lon C. Hill, fresh water is used for the boiler feed and cooling. Table 2.7 shows that in 2010, 388 ac-ft/yr of water was used. The 388 ac-ft/yr figure is self reported and downloaded from the TWDB water use survey in 2015. It should be noted that this value is only 5% of the reported value in 2000 of 8,799 ac-ft/yr, and may be an anomaly. According to AEP[3], approximately two-thirds of water used in Year 2000 was forced evaporation of saltwater. In 2070, steam-electric demands for freshwater are projected to be 34,541 ac-ft/yr (Figure 2.8). For projected water demands from 2020 to 2070, the projected fresh water use is estimated to be over three-quarters of the total projected steam- electric water demand.[4]

Table 2.7.
Coastal Bend Region Steam-Electric Water Demand by County and River Basin (ac-ft/yr)

County	Historical*		Projections[1]					
	2000	2010	2020	2030	2040	2050	2060	2070
Aransas	0	0	0	0	0	0	0	0
Bee	0	0	0	0	0	0	0	0
Brooks	0	0	0	0	0	0	0	0
Duval	0	0	0	0	0	0	0	0
Jim Wells	0	0	0	0	0	0	0	0
Kenedy	0	0	0	0	0	0	0	0
Kleberg	0	0	0	0	0	0	0	0
Live Oak	0	0	0	0	0	0	0	0
McMullen	0	0	0	0	0	0	0	0
Nueces	8,799	388	15,038	17,582	20,681	24,461	29,067	34,541
San Patricio	0	0	0	0	0	0	0	0
Total for Region	**8,799**	**388**	**15,038**	**17,582**	**20,681**	**24,461**	**29,067**	**34,541**

[1] Projections from Texas Water Development Board
* Self Reported Use

[3] Correspondence with Greg Carter, AEP-CPL.
[4] TWDB, "Power Generation Water Use in Texas for the Years 2000 Through 2060", January 2003.

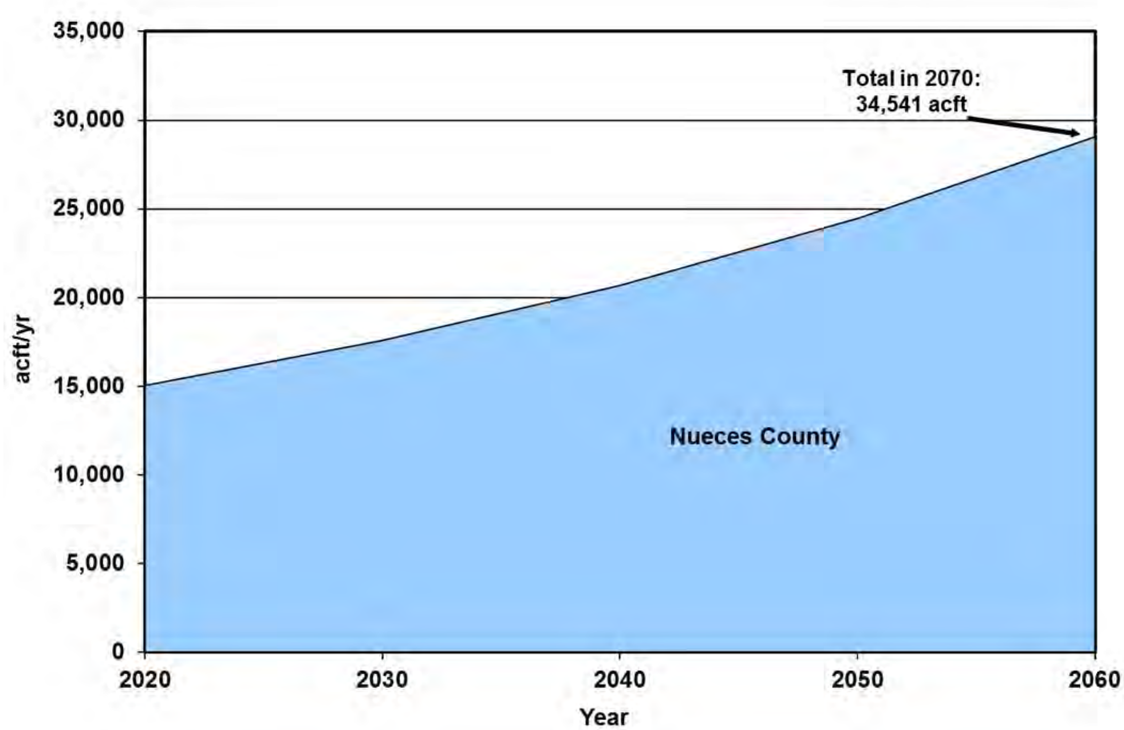

Figure 2.8.
Coastal Bend Region Steam-Electric Water Demand

2.3.4 Mining Water Demand

Projections for mining water demand are based on projected production of mineral commodities, and historic rates of water use, moderated by water requirements of technological processes used in mining.

The development of natural gas from the shale in the Eagleford Group is active in several counties in the Coastal Bend Region, especially Live Oak and McMullen Counties. Water demands associated with these mining activities impacts local groundwater use. The Coastal Bend Regional Water Planning Group prepared alternate mining water demand projections for McMullen and Live Oak counties to account for increased potential future Eagleford activities through Year 2040 based on information from local groundwater conservation districts. These higher alternate mining water demand projections were approved by the TWDB for planning use, as shown in Table 2.8. Uranium mining is in the initial phases of exploration in Live Oak County and is anticipated to use additional groundwater supplies. The impacts of developing gas wells in the Eagleford shale and uranium mining activities on groundwater supplies in the Coastal Bend Region should continue to be considered in future planning efforts.

Table 2.8.
Coastal Bend Region Mining Water Demand by County and River Basin (ac-ft/yr)

County	Historical*		Projections[1]					
	2000	2010	2020	2030	2040	2050	2060	2070
Aransas	81	19	10	7	5	5	5	5
Bee	29	384	472	458	428	372	338	318
Brooks	127	334	357	360	340	324	308	298
Duval	4,544	1,594	1,388	1,444	1,352	1,241	1,165	1,104
Jim Wells	347	49	71	74	55	40	26	17
Kenedy	1	82	118	123	92	68	43	27
Kleberg	2,627	558	357	360	340	324	308	298
Live Oak	3,105	118	814	917	907	729	492	332
McMullen	176	440	4,268	4,804	4,754	2,622	1,850	1,305
Nueces	1,275	1,369	724	853	947	1,021	1,130	1,260
San Patricio	85	308	372	421	440	460	492	533
Total for Region	**12,397**	**5,255**	**8,951**	**9,821**	**9,660**	**7,206**	**6,157**	**5,497**

[1] Projections from Texas Water Development Board
* Self Reported Use

In 2010 for the 11 counties of the Coastal Bend Planning Area, 5,255 ac-ft was used in the mining of sand, gravel, and in the production of crude oil. Water is required in the mining of these minerals either for processing, leaching to extract certain ores, controlling dust at the plant site, or for reclamation. Duval, McMullen and Nueces Counties accounted for 64.7 percent of the 2010 total use (Table 2.8). Mining water use in 2020 is expected to be 8,951 ac-ft and is projected to increase 7.9 percent to 9,660 ac-ft in 2040 before decreasing 43 percent to 5,497 from 2040 to 2070. Duval, McMullen, and Nueces, will account for 66.7 percent of the 2070 total use (Figure 2.9). The drop in projected demands is attributable to estimates of Eagleford activities slowing down after 2040, however future trends are difficult to predict considering technology enhancements and energy market.

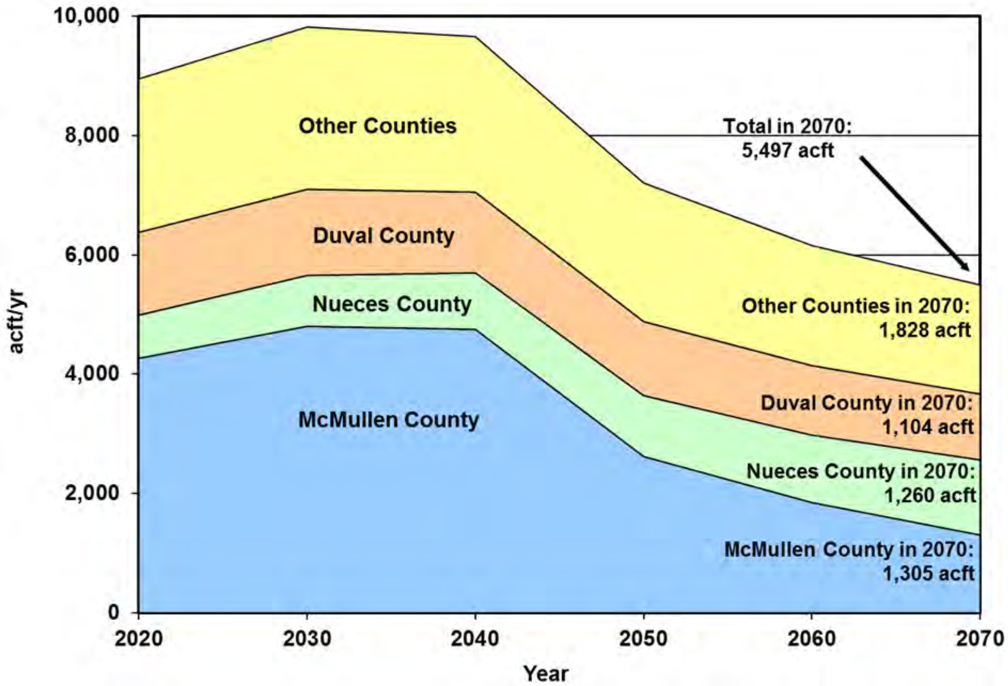

Figure 2.9.
Coastal Bend Region Mining Water Demand

2.3.5 Irrigation Water Demand

Irrigated crop production in Coastal Bend Region is projected in 9 of the 11 counties. Irrigation surveys[5] by the Natural Resource Conservation Service reported 23,975 acres of irrigated farmland in 2000, with over 97 percent irrigated with groundwater. In 2012, over 98% of cultivated land was dryland farmed and approximately 18,551 acres was irrigated. The region receives on average about 29.2 inches of rainfall per year, which is generally adequate for dry-land crops. Major crops include corn, cotton, sorghum, hay and wheat.

The irrigation water demand projections are based on specific assumptions regarding crop prices, crop yields, agricultural policy, and technological advances in irrigation systems. The TWDB estimated 2010 total irrigated water use in the Coastal Bend Region at 18,398 ac-ft based on self reported irrigation water use surveys (Table 2.9). Bee and San Patricio Counties accounted for 63 percent of that total. Irrigated water use is projected to increase by 51.9 percent from 2020 to 2070, or 26,419 ac-ft to 40,124 ac-ft (Figure 2.10). This increase is attributable to a projected increase is the number of acres being irrigated within the region. It should be noted that in Bee and Live Oak Counties, most irrigation occurs in the southern portion of those counties in the more productive Evangeline layers of the Gulf Coast Aquifer.

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[5] Surveys of Irrigation in Texas, TWDB Report 347, August 2001.

Table 2.9.
Coastal Bend Region Irrigation Water Demand by County and River Basin (ac-ft/yr)

County	Historical*		Projections[1]					
	2000	2010	2020	2030	2040	2050	2060	2070
Aransas	0	0	0	0	0	0	0	0
Bee	2,798	4,425	4,751	5,248	5,796	6,403	7,073	7,985
Brooks	25	803	1,800	1,890	1,985	2,084	2,188	2,297
Duval	4,524	1,642	3,004	3,154	3,312	3,478	3,651	3,834
Jim Wells	3,731	1,574	2,500	2,625	2,756	2,894	3,039	3,191
Kenedy	107	0	0	0	0	0	0	0
Kleberg	1,002	576	600	630	662	695	729	766
Live Oak	3,539	700	2,200	2,310	2,426	2,547	2,674	2,808
McMullen	0	0	40	42	44	46	49	51
Nueces	1,680	1,503	439	461	484	508	534	560
San Patricio	4,565	7,175	11,085	12,244	13,525	14,940	16,504	18,632
Total for Region	**21,971**	**18,398**	**26,419**	**28,604**	**30,990**	**33,595**	**36,441**	**40,124**

[1] Projections from Texas Water Development Board
* Self Reported Use

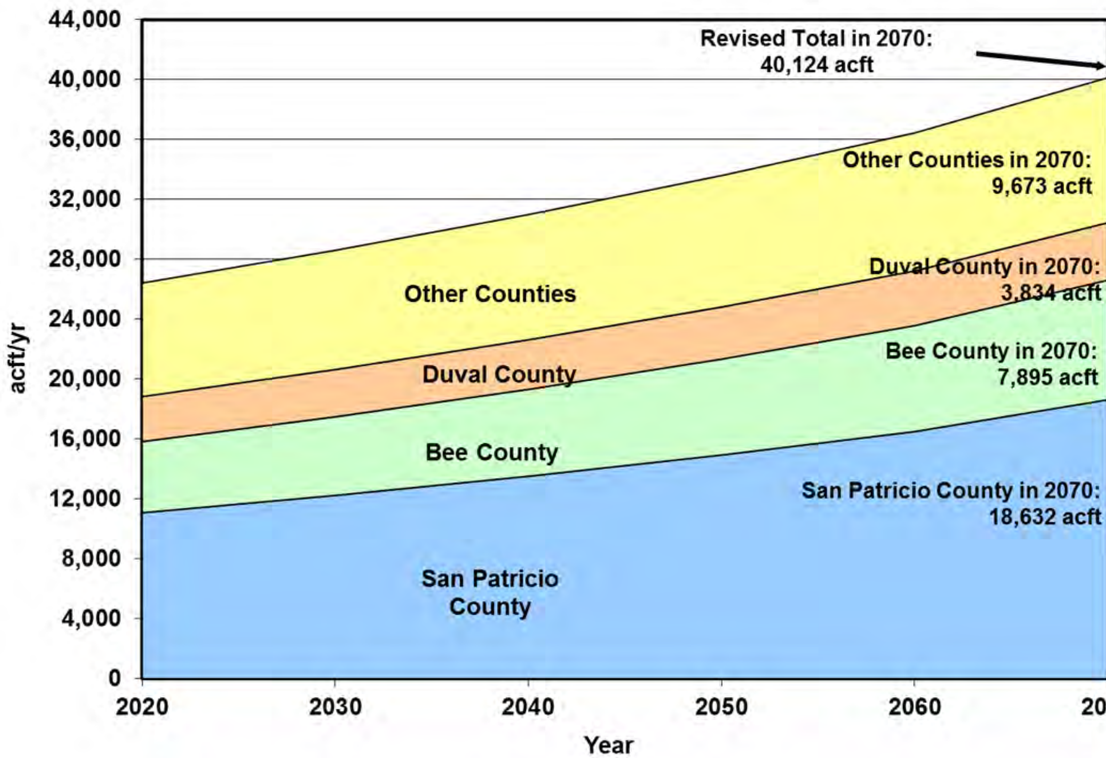

Figure 2.10.
Coastal Bend Region Irrigation Water Demand

2.3.6 Livestock Water Demand

In the 11-county Coastal Bend Region, the principal livestock type is beef cattle, with some dairy herds. Livestock drinking water is obtained from wells, stock watering tanks that are dug/ constructed on the ranches, and streams that flow through the ranches.

The livestock water demand projections are based upon estimates of the maximum carrying capacity of the rangeland of the area and the estimated number of gallons of water per head of livestock per day. In 2010, livestock water use for the Coastal Bend region was reported as 7,073 ac-ft: 10.3 percent in Kleberg County, 11.9 percent in Kenedy County, 15.9 percent in Jim Wells County, 16.2 percent in Bee County, and 45.7 percent in the remaining counties. From 2010 to 2070, water use for livestock use is projected by the TWDB to remain constant at 7,306 ac-ft (Table 2.10 and Figure 2.11).

Table 2.10.
Coastal Bend Region Livestock Water Demand by County and River Basin (ac-ft/yr)

County	*Historical**		*Projections*[1]					
	2000	*2010*	*2020*	*2030*	*2040*	*2050*	*2060*	*2070*
Aransas	23	63	44	44	44	44	44	44
Bee	995	1,147	930	930	930	930	930	930
Brooks	747	449	620	620	620	620	620	620
Duval	873	710	754	754	754	754	754	754
Jim Wells	1,064	1,122	1,029	1,029	1,029	1,029	1,029	1,029
Kenedy	901	840	644	644	644	644	644	644
Kleberg	1,900	726	1,276	1,276	1,276	1,276	1,276	1,276
Live Oak	833	779	933	933	933	933	933	933
McMullen	659	464	355	355	355	355	355	355
Nueces	279	324	315	315	315	315	315	315
San Patricio	564	449	406	406	406	406	406	406
Total for Region	**8,838**	**7,073**	**7,306**	**7,306**	**7,306**	**7,306**	**7,306**	**7,306**

[1] Projections from Texas Water Development Board
* Self Reported Use

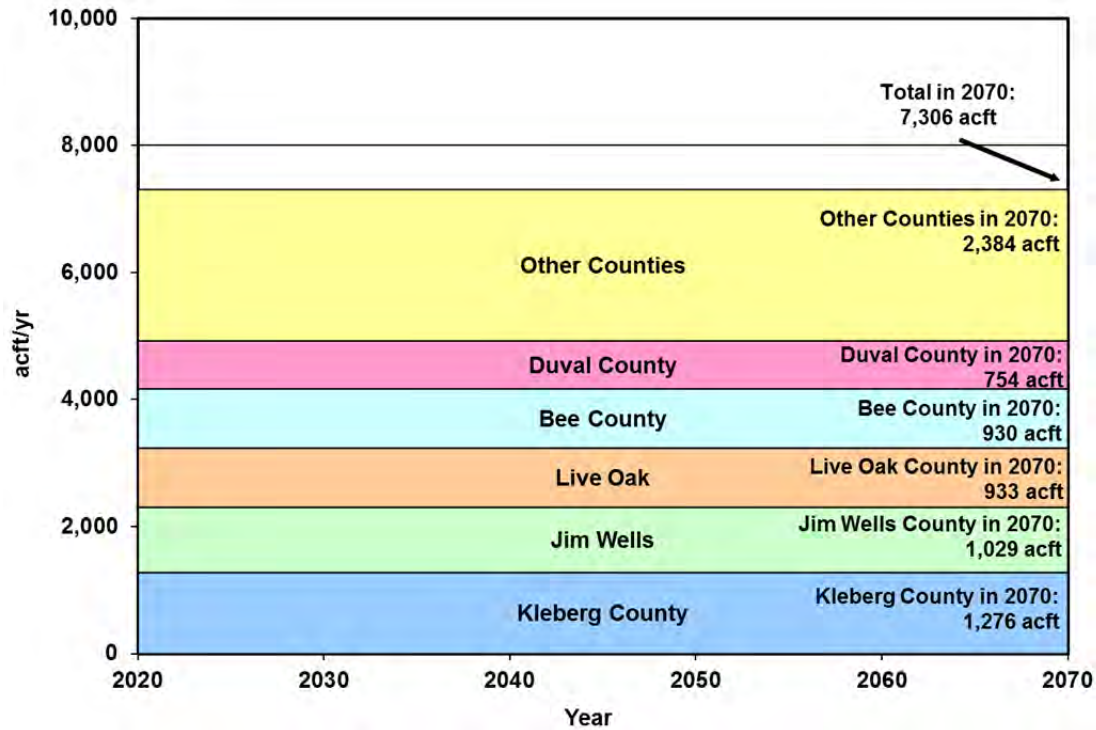

Figure 2.11.
Coastal Bend Region Livestock Water Demand

2.4 Water Demand Projections for Wholesale Water Providers

There are four regional wholesale water providers in the Coastal Bend Region: the City of Corpus Christi, SPMWD, STWA, and Nueces WCID #3. The City of Corpus Christi provides water to SPMWD and STWA, as shown in Table 2.11. The City of Corpus Christi is contracted to provide 51,200 ac-ft/yr to SPMWD (up to 41,200 ac-ft/yr of raw water and 10,000 ac-ft/yr of treated water supplies) and meet demands of STWA and their customers. For the 2016 Plan, water supply constraints are considered based on system yield (raw water) or water treatment plant capacity (treated water), whichever is the most constraining. Accordingly, the water demands for each wholesale water provider and their customers are shown in Table 2.11 and are categorized according to raw or treated water demands for ease of comparison to supplies discussed in Chapters 3 and 4. The City of Corpus Christi and SPMWD provide both raw and treated water supplies to their customers. STWA solely provides treated water supplies to its customers. Nueces County WCID #3 provides a majority of treated water supplies to its customers and also provides a small amount of raw water for local irrigation uses.

Table 2.11.
Coastal Bend Region Water Demand Projections for Wholesale Water Providers

Wholesale Water Provider (Water User/County)	2020 (ac-ft/yr)	2030 (ac-ft/yr)	2040 (ac-ft/yr)	2050 (ac-ft/yr)	2060 (ac-ft/yr)	2070 (ac-ft/yr)
CITY OF CORPUS CHRISTI						
Raw Water Demand						
Municipal						
Jim Wells County						
City of Alice	4,192	4,425	4,643	4,912	5,175	5,421
Bee County						
City of Beeville	2,925	2,978	2,976	2,961	2,959	2,960
San Patricio County						
City of Mathis	670	676	672	679	685	691
San Patricio MWD *(based on water supply contract)*	41,200	41,200	41,200	41,200	41,200	41,200
Live Oak County						
City of Three Rivers	3,363	3,363	3,363	3,363	3,363	3,363
Non-Municipal						
Nueces County						
Manufacturing	8,854	9,484	10,099	10,629	11,461	12,353
Steam Electric	15,038	17,582	20,681	24,461	29,067	34,541
Total Raw Water Demand	**76,242**	**79,708**	**83,634**	**88,205**	**93,910**	**100,529**
Treated Water Demand						
Nueces County						
Port Aransas	1,035	1,120	1,172	1,202	1,227	1,243
City of Corpus Christi	64,816	68,931	71,270	72,680	74,064	75,058
County-Other[1,2]	166	166	166	166	166	166
San Patricio County						
San Patricio MWD	10,000	10,000	10,000	10,000	10,000	10,000
Kleberg County						
South Texas Water Authority *(based on water supply contract)*	1,876	2,095	2,277	2,620	2,988	3,334
Non-Municipal						
Manufacturing (Nueces County)	35,416	37,935	40,395	42,515	45,846	49,410
Mining (Nueces County)	220	349	443	517	626	756
Manufacturing (*Remaining Need*)	*0*	*0*	*0*	*1,905*	*10,981*	*19,603*
Total Raw Water Demand	**113,529**	**120,596**	**125,723**	**129,700**	**134,917**	**139,967**
Total Water Demand	**189,771**	**200,304**	**209,357**	**217,905**	**228,827**	**240,496**
River Basin						
Nueces	41,750	44,067	46,059	47,939	50,342	52,909
Nueces- Rio Grande	108,169	114,173	119,333	124,206	130,431	137,083
San Antonio- Nueces	39,852	42,064	43,965	45,760	48,054	50,504
Total Water Demand	**189,771**	**200,304**	**209,357**	**217,905**	**228,827**	**240,496**

Wholesale Water Provider (Water User/County)	*2020 (ac-ft/yr)*	*2030 (ac-ft/yr)*	*2040 (ac-ft/yr)*	*2050 (ac-ft/yr)*	*2060 (ac-ft/yr)*	*2070 (ac-ft/yr)*
SAN PATRICIO MUNICIPAL WATER DISTRICT						
Raw Water Demand						
San Patricio County						
Non-Municipal						
Manufacturing (*San Patricio County*)	11,783	12,791	13,787	14,663	15,770	16,959
Total Raw Water Demand	**11,783**	**12,791**	**13,787**	**14,663**	**15,770**	**16,959**
Treated Water Demand						
Municipal						
Nueces County						
City of Aransas Pass	3	3	3	3	3	3
Port Aransas	1,216	1,314	1,376	1,412	1,440	1,460
San Patricio County						
City of Aransas Pass	1,131	1,148	1,149	1,155	1,167	1,176
City of Gregory	339	344	348	354	358	361
City of Ingleside	1,051	1,062	1,060	1,064	1,074	1,083
City of Ingleside on the Bay	77	78	78	78	79	79
City of Portland	2,631	2,684	2,698	2,718	2,747	2,770
City of Odem	379	384	384	387	391	394
Rincon WSC	346	355	359	363	366	369
City of Taft	464	470	469	475	480	484
County-Other[2]	156	181	219	246	263	277
Aransas County						
City of Aransas Pass	110	108	106	105	104	104
City of Fulton	278	279	275	275	275	275
City of Rockport	1,608	1,611	1,583	1,580	1,577	1,577
County-Other[3]	1,125	1,094	1,041	1,026	1,021	1,021
Municipal Treated Water Demand	10,914	11,115	11,148	11,241	11,345	11,433
Non-Municipal						
Manufacturing (*San Patricio County*)	27,494	29,847	32,169	34,215	36,797	39,572
Industrial Treated Water Demand	**31,957**	**32,158**	**32,191**	**32,284**	**32,388**	**32,476**
Total Water Demand	**50,191**	**53,753**	**57,104**	**60,119**	**63,912**	**67,964**
River Basin						
Nueces	18,067	18,439	18,424	18,381	18,333	18,293
Nueces- Rio Grande	0	0	0	0	0	0
San Antonio- Nueces	32,124	35,314	38,680	41,738	45,579	49,671
Total Water Demand	**50,191**	**53,753**	**57,104**	**60,119**	**63,912**	**67,964**

Wholesale Water Provider (Water User/County)	*2020 (ac-ft/yr)*	*2030 (ac-ft/yr)*	*2040 (ac-ft/yr)*	*2050 (ac-ft/yr)*	*2060 (ac-ft/yr)*	*2070 (ac-ft/yr)*
SOUTH TEXAS WATER AUTHORITY						
Municipal						
Nueces County						
City of Agua Dulce	132	139	143	145	148	150
City of Driscoll	105	110	113	114	116	118
Nueces WSC	333	355	368	376	383	388
City of Bishop	352	386	404	418	431	440
County-Other[2,4]	155	177	190	198	205	209
Kleberg County						
City of Kingsville	458	567	677	964	1,275	1,575
Ricardo WSC	341	361	382	405	430	454
Total Water Demand (All Treated)	**1,876**	**2,095**	**2,277**	**2,620**	**2,988**	**3,334**
River Basin						
Nueces	0	0	0	0	0	0
Nueces- Rio Grande	1,876	2,095	2,277	2,620	2,988	3,334
San Antonio- Nueces	0	0	0	0	0	0
Total Water Demand	**1,876**	**2,095**	**2,277**	**2,620**	**2,988**	**3,334**
NUECES COUNTY WCID #3						
Nueces County						
North San Pedro[5]	155	155	155	155	155	155
City of Robstown	2,957	2,897	2,848	2,843	2,839	2,839
River Acres WSC	426	450	463	470	479	486
Total Water Demand (All Treated)	**3,538**	**3,502**	**3,466**	**3,468**	**3,473**	**3,480**
River Basin						
Nueces	584	608	621	628	637	644
Nueces- Rio Grande	2,954	2,894	2,845	2,840	2,836	2,836
San Antonio- Nueces	0	0	0	0	0	0
Total Water Demand	**3,538**	**3,502**	**3,466**	**3,468**	**3,473**	**3,480**

[1] Includes Violet WSC.
[2] Wholesale water provider does not meet full demand (i.e. additional supply from groundwater)
[3] Includes Taft Southwest, Rincon WSC, and Seaboard WSC.
[4] May include water demands for Coastal Bend Youth City, and Nueces County WCID #5.
[5] Limited by contract. May opt to increase contract amount to cover needs.

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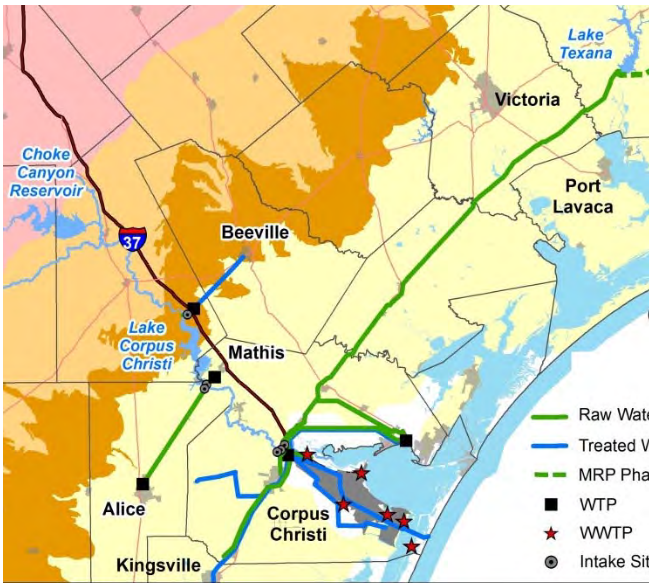

3

Water Supply Analysis

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Chapter 3: Water Supply Analysis

3.1 Surface Water Supplies

The Coastal Bend Region is located within three river basins: the Nueces River Basin, the San Antonio-Nueces Coastal Basin, and the Nueces-Rio Grande Coastal Basin (Figure 3.1). Streamflows in the two coastal basins are highly variable and intermittent and do not supply large quantities of water. However, streamflow in the Nueces River and its tributaries, along with municipal and industrial water rights in the Nueces River Basin, comprise a significant supply of water used in the Coastal Bend Region, as this basin drains about 17,000 square miles. These water rights provide authorization for an owner to divert, store and use the water; however, it does not guarantee that a dependable supply will be available from their source. The availability of water to a water right is dependent on several factors including hydrologic conditions (i.e. rainfall, runoff, springflows), priority date of the water right, quantity of authorized storage, and any special conditions associated with the water right (e.g., instream flow conditions, maximum diversion rate). Because the Nueces River Basin is subject to periods of significant drought and low flows, storage is very important to help “firm up” water rights.

3.1.1 Texas Water Right System

The State of Texas owns the surface water within the state watercourses and is responsible for the appropriation of these waters. Surface water is currently allocated by the Texas Commission on Environmental Quality (TCEQ) for the use and benefit of all people of the State. Texas water law is based on the riparian and prior appropriation doctrines. The riparian doctrine extends from the Spanish and Mexican governments that ruled Texas prior to 1836. After 1840, the riparian doctrine provided landowners the rights to make reasonable use of water for irrigation or for other consumptive uses. In 1889, the prior appropriation doctrine was first adopted by Texas, which is based on the concept of “first in time is first in right”. Over the years, the riparian and prior appropriation doctrines resulted in a system that was very difficult to manage. Various types of water rights existed simultaneously and many rights were unrecorded. In 1967, the Texas Legislature passed the Water Rights Adjudication Act that merged the riparian water rights into the prior appropriation system, creating a unified water permit system.

The adjudication process took many years, stretching into the late 1980s before it was finally completed. In the end, Certificates of Adjudication were issued for entities recognized as having legitimate water rights. Today, individuals or groups seeking a new water right must submit an application to the TCEQ. The TCEQ determines if the water right will be issued and under what conditions. The water rights grant a certain quantity of water to be diverted and/or stored, a priority date, and often come with some restrictions on when and how the right may be utilized. Restrictions may include a maximum diversion rate and/or an instream flow restriction to protect existing water rights and provide environmental protection.

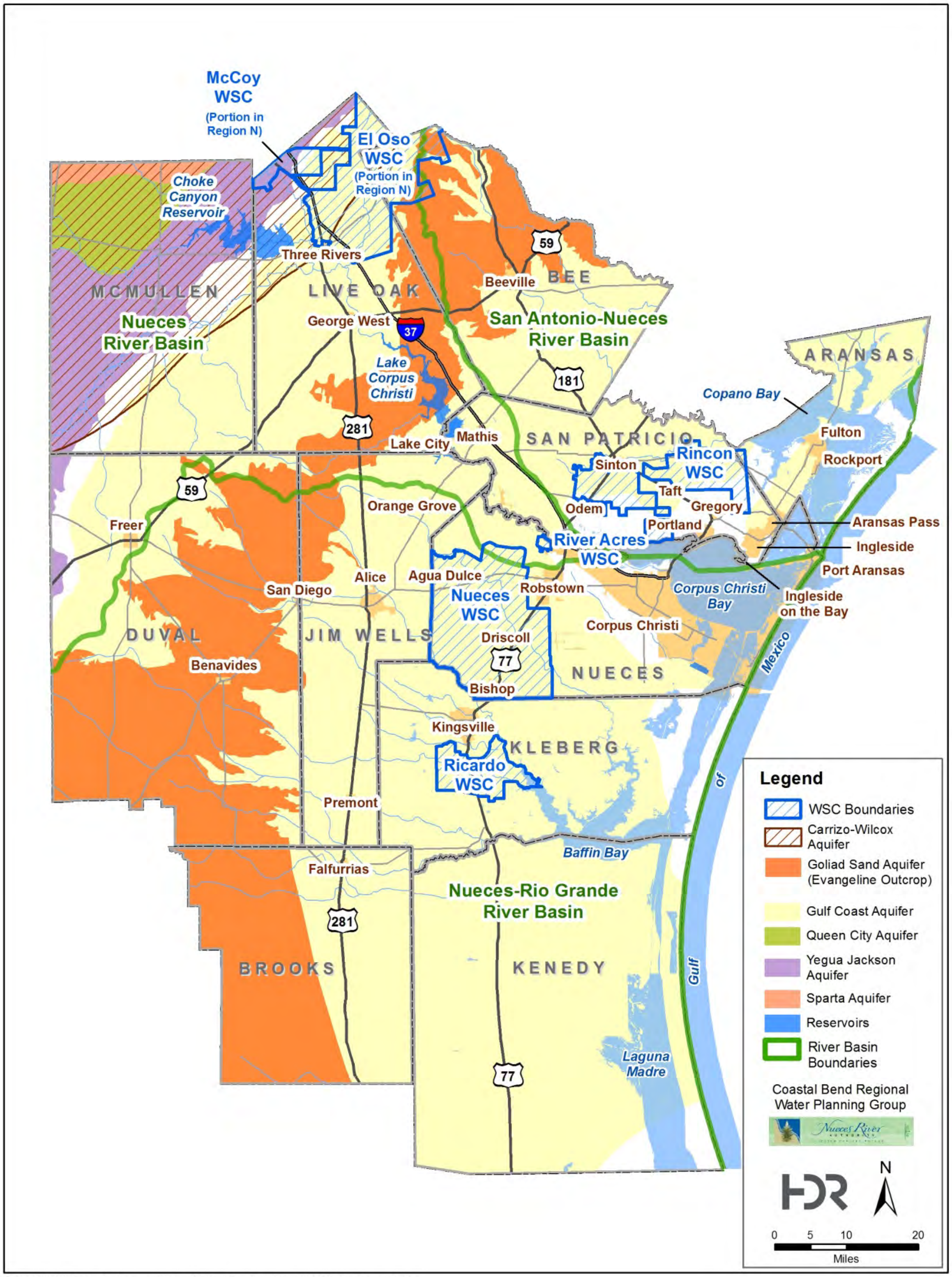

Figure 3.1.
Watershed Boundaries and Aquifer Location Map

The priority date of a water right is essential to the operation of the water rights system. Each right is issued a priority date based on the date of first capture, or the appropriation date. The established priority system must be adhered to by all water right holders when diverting or storing water for use. A right holder must pass all water to downstream senior water rights when conditions are such that the senior water rights would not be satisfied otherwise. Other restrictions may include a maximum diversion rate and instream flow restrictions to protect existing water rights and provide environmental flows for instream needs and needs of estuary systems, although most water rights issued prior to 1985 do not include such conditions. An important exception to the rule is Certificate of Adjudication Number (CA#) 21-3214 for Choke Canyon Reservoir, which represents approximately 75% of the Nueces River Basin water rights and requires instream flows and freshwater flows for the Nueces Estuary. Operations of the CCR/LCC System are governed, in part, by CA #21-3214, within which Special Conditions B and E state:

B. (Part)
"Owners shall provide not less than 151,000 ac-ft of water per annum for the estuaries by a combination of releases and spills from the reservoir system at Lake Corpus Christi Dam and return flows to the Nueces and Corpus Christi Bays and other receiving estuaries."

E.
"Owners shall continuously maintain a minimum flow of 33 cubic feet per second below the dam at Choke Canyon Reservoir."

Special Condition B of CA #21-3214 further states:
"Water provided to the estuaries from the reservoir system under this paragraph shall be released in such quantities and in accordance with such operational procedures as may be ordered by the Commission."

Hence, the certificate provided for a means to further establish specific rules governing operations of the CCR/LCC System with respect to maintaining freshwater inflows to the Nueces Estuary.

To address concerns about the health of the Nueces Estuary, a Technical Advisory Committee (TAC) chaired by the TCEQ was formed in 1990 to establish operational guidelines for the CCR/LCC System and desired monthly freshwater inflows to the Nueces Estuary. These operational guidelines were summarized in the 1992 Interim Order.[1]

The 1992 Interim Order established a monthly schedule of desired freshwater inflows to Nueces Bay to be satisfied by spills, return flows, runoff below Lake Corpus Christi, and/or dedicated releases from the CCR/LCC System. Mechanisms for relief from reservoir releases under the Interim Order were based on inflow banking, monthly salinity variation in upper Nueces Bay, and implementation of drought contingency measures tied to CCR/LCC System Storage.

The Nueces Estuary Advisory Council (NEAC) was formed under the 1992 Interim Order and charged with continued study of the interdependent relationship between the firm yield of the CCR/LCC System and the health of the Nueces Estuary. One of NEAC's primary goals was to

[1] Texas Water Commission, Interim Order Establishing Operational Procedures Pertaining to Special Condition B, Certificate of Adjudication No. 21-3214, held by the City of Corpus Christi, et al., March 9, 1992.

evaluate the 1992 Interim Order and other alternative release policies and recommend a more permanent reservoir operations plan for providing freshwater inflows to the Nueces Estuary. This goal was to be achieved within 5 years of NEAC's formation.

The goal of recommending a more permanent reservoir operations plan was fulfilled on April 28, 1995, when the TCEQ issued an order regarding reservoir operations for freshwater inflows to the Nueces Estuary, known as the 1995 Agreed Order.[2] This Agreed Order is very similar to the Interim Order, with one major exception — monthly releases (pass-throughs) to the estuary were limited to CCR/LCC System inflows and stored water is not required to meet estuary freshwater flow needs.

On April 17, 2001, the TCEQ issued an amendment to the 1995 Agreed Order to revise operational procedures in accordance with revisions requested by the City of Corpus Christi. Changes included: 1) passage of inflows to Nueces Bay and Estuary at 40 percent and 30 percent reservoir system capacity upon institution of mandatory outdoor watering restrictions; 2) calculating reservoir system storage capacity based on most recently completed bathymetric surveys; and 3) provisions for operating Rincon Bayou diversions and conveyance facility from Calallen Pool to enhance the amount of freshwater to the Nueces Bay and Delta. All CCR/LCC System yield analyses included supplies from Lake Texana and MRP Phase II presented as part of this study were performed using the 2001 Agreed Order.

3.1.2 Types of Water Rights

There are various types of water rights. Water rights are characterized as Certificates of Adjudication, permits, short-term permits, or temporary permits. Certificates of Adjudication were issued in perpetuity for approved claims during the adjudication process. This type of water right was generally issued based on historical use rather than water availability. As a consequence, the amount of water to which rights on paper are entitled to generally exceeds the amount of water available during a drought. The TCEQ issues new permits generally when normal flows are sufficient to meet 75 percent of the requested amount 75 percent of the time. Permits, like Certificates of Adjudication, are issued in perpetuity and may be bought and sold like other property interests. Short-term permits may be issued by the TCEQ in areas where waters are fully appropriated, but not yet being fully used. Term permits are usually issued for 10 years and may be renewed if, after 10 years, water in the basin is still not being fully used by other water right holders. Temporary permits are issued for up to 3 years. Temporary permits are issued mainly for roadway and other construction projects, where water is used to suppress dust, to compact soils, and to start the growth of new vegetation.

Water rights can include the right to divert and/or store the appropriated water. A run-of-river water right provides for the diversion of streamflows and generally does not include a significant storage volume for use during dry periods. A run-of-river right may be limited by streamflow, pumping rate, or diversion location.

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[2] Texas Commission on Environmental Quality (TCEQ), Agreed Order Establishing Operational Procedures Pertaining to Special Condition B, Certificate of Adjudication No. 21-3214, held by City of Corpus Christi, et al., April 28, 1995.

Water rights, which include provisions for storage of water, allow a water right holder to impound streamflows for use at a later time. The storage provides water for use during dry periods, when water may not be available due to hydrologic conditions or because flows are required to be passed to downstream senior water rights.

While most water rights are diverted and used within the river basin of origin, water rights that divert from one river basin to another basin require an interbasin transfer permit. Several types of transfers that receive special consideration and simplified process include emergency transfers, transfers of water from a river basin for use in an adjoining coastal basin (such as from the Nueces River Basin to either the San Antonio-Nueces or the Nueces-Rio Grande Coastal Basins), diversions of less than 3,000 ac-ft/yr, and diversions within any city or county that has any portion in the basin of origin.

The annual availability of a water right is typically considered in terms of firm yield or safe yield supply. According to the TCEQ, the firm yield is defined as "that amount of water, based upon a simulation utilizing historic streamflows, that the reservoir could have produced annually if it had been in place during the worst drought of record."[3] The water rights of Nueces County WCID #3 and small run-of river rights on the Nueces Basin (less than 2,000 ac-ft/yr) are based on firm yield analyses.

Safe yield supply represents a more conservative approach to determining minimum annual availability in areas where the severity of droughts is uncertain. Safe yield supply is the amount of water that can be withdrawn from a reservoir such that a given volume remains in reservoir storage during the critical month of the drought of record. The surface water availabilities for the largest water rights in the Nueces Basin (i.e. City of Corpus Christi and their customers) are based on safe yield analyses and assume a reserve of 125,000 ac-ft (i.e. 1 year demand on the regional water system) for future drought conditions.[4]

3.1.3 Water Rights in the Nueces River Basin

A total of 307 water rights exist in the Nueces River Basin with a total authorized diversion and consumptive use of 589,507 ac-ft/yr.[5] It is important to note that a small percentage of the water rights make up a large percentage of the authorized diversion volume. In the Nueces River Basin, four water rights (1.5 percent) make up 483,444 ac-ft/yr (89.5 percent) of the authorized diversion volume as shown in Figure 3.2. Of these, three water rights are in the Coastal Bend Region and account for 455,444 ac-ft/yr of the 483,444 ac-ft/yr total. The remaining 303 water rights primarily consist of small municipal, industrial, irrigation and recharge rights distributed throughout the river basin. Municipal and industrial diversion rights represent 76 percent of all

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[3] TCEQ, "A Regulatory Guidance Document for Applications to Divert, Store, or Use State Water," RG-141, June 1995.
[4] On November 14, 2013, the Coastal Bend Regional Water Planning Group adopted a 1-year safe yield analysis for the City of Corpus Christi and their customers (i.e. LCC/CCR/Lake Texana/MRP Phase II System). The TWDB approved safe yield use for planning purposes in the 2016 Plan.
[5] The number of water rights and corresponding authorized diversion amounts are based on the Texas Commission on Environmental Quality's Water Rights Database, 2013.

Major Water Rights*					
Water Right #	**Owner**	**Diversion Rights (acft/yr)**	**Consumptive Rights (acft/yr)**	**Storage Rights**	**Notes**
2464	City of Corpus Christi	304,898	304,898	300,000 1,175	Lake Corpus Christi Calallen Reservoir
3214	City of Corpus Christi, Nueces River Authority	139,000	139,000	700,000	Choke Canyon Reservoir
3082	Zavala-Dimmit Co. WCID #1	28,000	28,000	5,633	
2466	Nueces County WCID #3	11,546	11,546	0	
*Authorized Annual Diversions > 10,000 acft. Major water rights information obtained from the TCEQ.					

Figure 3.2.
Location of Major Water Rights in the Nueces River Basin

authorized diversion rights in the Nueces River Basin. Based in large part on water stored in the CCR/LCC System, which is subsequently delivered via the Nueces River to Calallen Dam at Corpus Christi for diversion, the City of Corpus Christi and the NRA hold 98 percent of these municipal and industrial rights in the *basin*.[6] With the inclusion of the municipal water rights held by the Nueces County WCID #3, diverted from the Nueces River upstream of the Calallen Dam, the Coastal Bend Region includes over 99 percent of the Nueces River Basin municipal and industrial surface water rights permits. Table 3.1 summarizes the surface water rights in the Nueces River Basin included in the Coastal Bend Planning Region.

Table 3.1.
Nueces River Basin Water Rights in the Coastal Bend Region

Water Right No.	Name	Annual Diversion Volume (ac-ft/yr)	Reservoir Storage Capacity (ac-ft)	Priority Date	Type of Use	Facility	County
2464	City of Corpus Christi	304,898	301,175	12/1913[1]	Municipal (51%) Industrial (49%) Irrigation (minimal) Mining (minimal)	Lake Corpus Christi (300,000 ac-ft) and Calallen Dam (1,175 ac-ft)	Nueces
2465A	Realty Traders & Exchange, Inc.	20	580	10/1952	Irrigation		San Patricio
2465B	Wayne Shambo	140	580	10/1952	Irrigation		San Patricio
2466	Nueces Co. WCID #3	11,546	0	2/1909[1]	Municipal (37%) Irrigation (63%)		Nueces
2467	Garnett T. & Patsy A. Brooks	221	0	2/1964	Irrigation		San Patricio
2468	CE Coleman Estate	27	0	2/1964	Irrigation		Nueces
2469	Ila M. Noakes Lindgreen	101	0	2/1964	Irrigation		Nueces
3141	Randy J. Corporron, et al.	8	0	12/1965	Irrigation		McMullen
3142	WL Flowers Machine & Welding Co.	132	100	12/1958	Irrigation		McMullen
3143	Ted W. True, et al.	220	40	12/1958	Irrigation		McMullen
3144	Harold W. Nix, et ux.	0	285	2/1969	Recreation		McMullen
3204	Richard P. Horton	233	0	12/1963	Irrigation		McMullen
3205	Richard P. Horton	103	122	12/1963	Irrigation		McMullen
3206	James L. House Trust	123	0	12/1966	Irrigation		McMullen
3214	Nueces River Authority and City of Corpus Christi	139,000	700,000	7/1976	Municipal (43%) Industrial (57%) Irrigation (minimal)	Choke Canyon Reservoir	Nueces/ Live Oak
3215	City of Three Rivers	1,500	2,500	9/1914	Municipal (47%) Irrigation (53%)		Live Oak
4402	City of Taft	600	0	9/1983	Irrigation		San Patricio
5065	Diamond Shamrock Refining[2]	0	0	6/1986	Irrigation		Live Oak
5145	San Miguel Electric Co-Op, Inc.	300	335	12/1990	Industrial		McMullen
	TOTAL	**459,172**					

[1] Water right with multiple priority dates. Earliest date shown in table.
[2] Diamond Shamrock irrigation right is used for irrigation from onsite process water return flows. In effect, this permit is for a reuse project.

[6] The Nueces River Authority's water right is for 20% of Choke Canyon Reservoir.

3.1.4 Coastal Basins

In addition to the Nueces River Basin, the Coastal Bend Regional Planning Area includes portions of two coastal river basins in Texas: the San Antonio-Nueces Coastal Basin and the Nueces-Rio Grande Coastal Basin. The San Antonio-Nueces Coastal Basin is located on the Texas Coast between the Nueces and Guadalupe-San Antonio River Basin. The drainage area of the basin is approximately 2,652 square miles, and it drains surface water runoff into Copano and Aransas Bays. The Nueces-Rio Grande Coastal Basin is located on the southern side of the Coastal Bend Region between the Nueces and Rio Grande Coastal Basins. This basin drains approximately 10,442 square miles into the Laguna Madre Estuary system. Combined, there are approximately 99 water rights in these two coastal basins authorizing diversions of about 1,838,600 ac-ft/yr.[7] Approximately 1,738,000 ac-ft (94 percent) of the combined authorized diversions are from within the Coastal Bend Region Planning Area, and of these rights, 1,699,000 ac-ft (98 percent) are industrial diversions for steam-electric and manufacturing processes from the bays and saline water bodies along the coast. Most of this water is used for cooling purposes and is returned to the source. Based on the size and locations of the remaining freshwater rights in these coastal basins and on the lack of a major river or reservoir in these basins, there are few of these freshwater rights that are sustainable throughout an extended drought. For this reason, no firm yield supplies were available from the San Antonio-Nueces Coastal Basin or Nueces-Rio Grande Basin to meet water supply needs for water users in the Coastal Bend Region.

3.1.5 Interbasin Transfer Permits

A number of interbasin transfer permits exist in the Coastal Bend Regional Planning Area. These permits include authorizations for diversions from river basins north of the planning region into the Nueces River Basin. Both major interbasin transfer permits provide water to the City of Corpus Christi and include supplies from the Lavaca-Navidad and Colorado River Basins. The City of Corpus Christi benefits from an interbasin transfer permit[8] and a contract with the LNRA to divert 41,840 ac-ft/yr on a firm basis and up to 12,000 ac-ft/yr on an interruptible basis from Lake Texana in the Lavaca-Navidad River Basin to the City's O.N. Stevens Water Treatment Plant.[9] This water is delivered to the City via the Mary Rhodes Pipeline (MRP), which became operational in 1998. In addition, the pipeline will also deliver MRP Phase II supplies from the Colorado River to the City by the end of 2015 through a second interbasin transfer permit owned by the City of Corpus Christi. This permit[10] allows the diversion of up to 35,000 ac-ft/yr of run-of-river water on the Colorado River. Analyses of this water right, one of the most senior in the Colorado River Basin, indicate that most of the time the full 35,000 ac-ft/yr is available from this run-of-river right.[11]

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[7] The number of water rights and corresponding authorized diversion amounts are based on the Texas Commission on Environmental Quality's Water Rights Database dated November 2003.
[8] TCEQ, Certificate of Adjudication No. 16-2095C, held by Lavaca-Navidad River Authority and Texas Water Development Board (TWDB), October 21, 1996.
[9] A call-back provision is included in the LNRA- Corpus Christi contract for water needs in Jackson County.
[10] TCEQ, Certificate of Adjudication No. 14-5434B, held by the City of Corpus Christi (via the Garwood Irrigation Company), October 13, 1998.
[11] Based on Corpus Christi Water Supply Model simulations conducted in February 2015 which placed the recent drought on the Colorado (2011-2013) on drought of record conditions in the Nueces Basin (1994-1996).

Based on results of a water availability analysis using information from the updated Colorado WAM (1940-2013) and simulating the most recent drought in the Colorado WAM (2011-2013) to coincide with the drought of record simulated in the Corpus Christi Water Supply Model (1994-1996), the MRP Phase II supplies adds 27,000 to 29,000 ac-ft/yr to the safe yield during drought conditions. Table 3.2 summarizes the major inter-basin transfer permits in the region.

Table 3.2.
Summary of Major Interbasin Transfer Permits in the Coastal Bend Region

River Basin of Origin	Name of Interbasin Transfer Permit Holder	Description	Authorized Diversion (ac-ft/yr)	Priority Date
Lavaca-Navidad	LNRA	Transfer from Lake Texana to adjacent river basins including the Nueces River Basin.	53,840[1]	5/1972
Colorado	City of Corpus Christi	Transfer from Garwood Irrigation Co. water right to the City of Corpus Christi.	35,000	11/1900

[1] City of Corpus Christi currently holds a contract with the Lavaca-Navidad River Authority to provide 41,840 ac ft/yr and a maximum of 12,000 ac-ft/yr on an interruptible basis from Lake Texana to the City.

3.1.6 Water Supply Contracts

Many entities within the Coastal Bend Region obtain surface water through water supply contracts. These supplies are usually obtained from entities that have surface water rights to provide a specified or unspecified quantity of water each year to a buyer for an established unit price. The City of Corpus Christi is the largest provider of water supply contracts in the Coastal Bend Region. The City of Corpus Christi supplies water from the CCR/LCC System, water from Lake Texana via the Mary Rhodes Pipeline, and water from the Colorado River via MRP Phase II to two major wholesale customers: SPMWD and STWA. Each of these major wholesale customers in turn sells water to other entities within their service area. In addition to the two major wholesale customers, the City of Corpus Christi also provides wholesale raw surface water to a number of industrial customers.

The City of Corpus Christi has contractual obligations to provide consumptive water use plus up to 10% growth each year to City of Alice, City of Beeville, City of Mathis, Port Aransas, Violet WSC, and STWA. The City of Corpus Christi is contracted to provide up to 3,363 ac-ft/yr to City of Three Rivers and up to 51,200 ac-ft/yr to San Patricio Municipal Water District (up to 41,200 ac-ft/yr of raw water and 10,000 ac-ft/yr of treated water supplied). Furthermore, the City of Corpus Christi provides raw and treated water supply to meet needs of Manufacturing, Mining, and Steam and Electric water users in Nueces County. SPMWD and STWA meet water needs of their customers (Figure 3.3). Within the Coastal Bend Region, the Nueces County WCID #3 also provides wholesale water supplies through contracts with a number of small municipalities, water supply corporations, and irrigators. Nueces County WCID #3 meets water needs of City of Robstown and North San Pedro subdivision through run-of-the-river rights on the Nueces River and has contractual obligations to provide up to 291 ac-ft/yr to River Acres WSC.

Figure 3.3 summarizes the major contract relationships in the Coastal Bend Region.

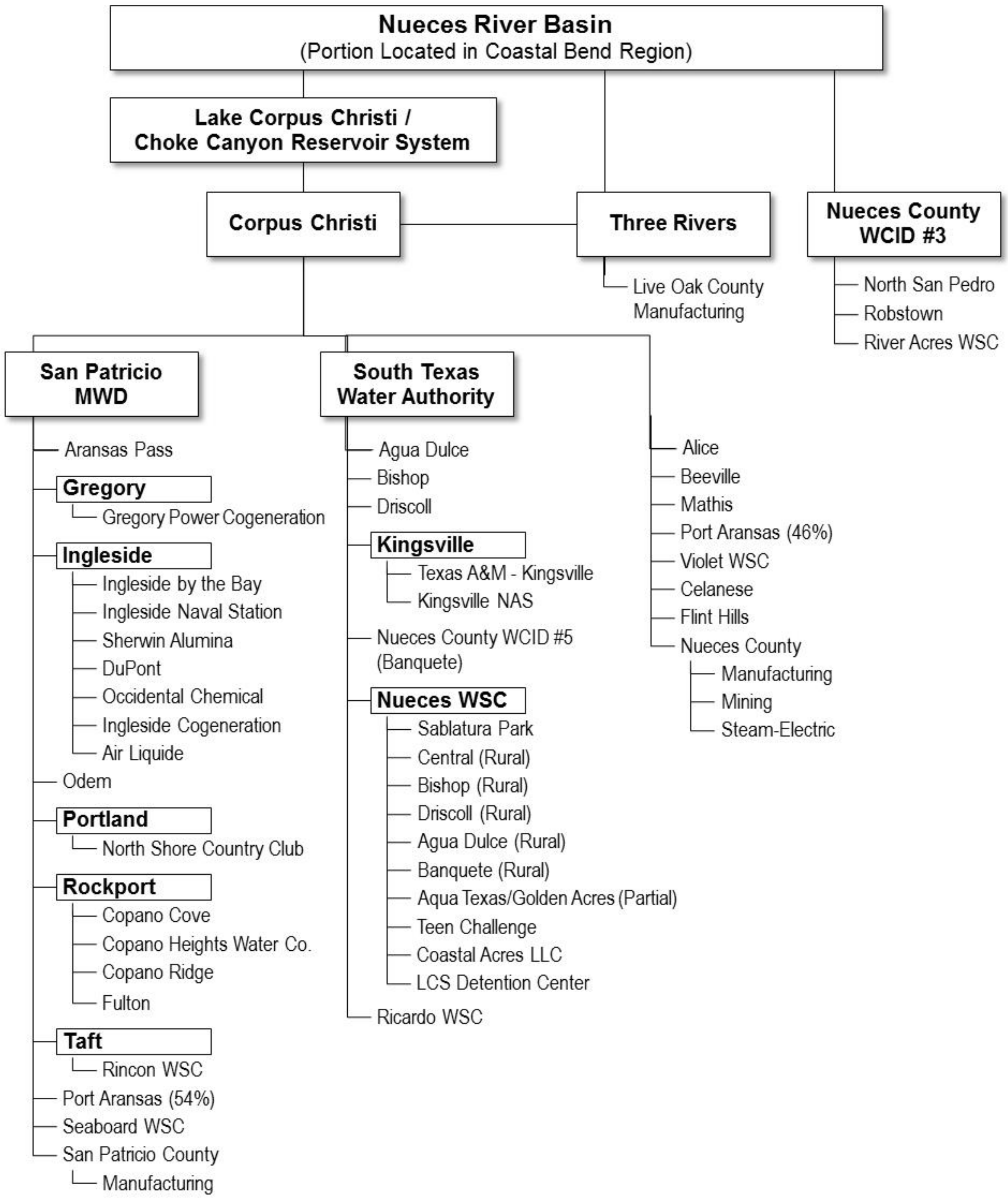

Figure 3.3.
Major Surface Water Supply Contract Relationships in the Coastal Bend Region

Figure 3.4 presents water supply systems in the Coastal Bend Region. These relationships will be revisited in Chapter 4, when comparisons of supplies and demands in the region are presented.

3.1.7 Wholesale Water Providers

The Coastal Bend Region has four Wholesale Water Providers. The TCEQ defines Wholesale Water Providers as "any entity that has contracts to sell more than 1,000 ac-ft of water whole-sale in a given year." These include the City of Corpus Christi, SPMWD, STWA, and Nueces County WCID #3. Based on recent water use records, the City of Corpus Christi supplies about 59 percent of the water demand in the region (not including supplies to SPMWD or STWA). SPMWD and STWA purchase 100 percent of their water from the City of Corpus Christi. The SPMWD subsequently treats and distributes water to numerous entities and supplies about 10 percent of the municipal and industrial water demand in the region. Both STWA and Nueces County WCID #3 provide less than 3 percent of the municipal and industrial water demand in the region. As for water supply planning, each Water User Group in the region was analyzed to the same level of detail to ensure that the needs of the entire region are met. If in the future the CBRWPG deems it necessary, the CBRWPG reserves the right to revisit wholesale water provider designations during subsequent planning efforts.

3.2 Reliability of Surface Water Supply

Hydrologic conditions are a primary factor that affects the reliability of a water right. Severe drought periods have been experienced in all areas of the Coastal Bend Region. Recurring droughts are common in the region with significant drought periods occurring in the 1950s, 1960s, 1980s, 1990s, and current. As shown in Figure 3.5, recent studies indicate that the 1990s drought appears to be the most severe on record for the CCR/LCC System, decreasing average annual flows by 78,000 ac-ft/yr (40 percent) when compare to flows in the 1950s. Additional details regarding droughts in the region are discussed in Chapter 7.

Municipal and industrial water suppliers typically require a very high degree of reliability for their water sources. In most cases, interruptions to water supply are not acceptable, requiring the reliability of the supply to be 100 percent of the time. Municipal and industrial supplies are commonly based on firm yield; however, safe yield analyses are becoming commonly used in anticipation of future droughts greater in severity than the worst drought of record. Since each drought in the Nueces River Basin is more severe than previous droughts (Figure 3.5), the Coastal Bend Region has adopted use of safe yield analyses for supply from the CCR/LCC/ Lake Texana/MRP Phase II System. On February 22, 2012, the TWDB approved continued use of safe yield for development of the 2016 Plan for surface water supplies from the CCR/LCC/Lake Texana/MRP Phase II System. For the 2016 Plan, the safe yield reserve was increased from 75,000 ac-ft (2011 Plan) to 125,000 ac-ft on the basis of current drought conditions and future drought uncertainty. The CCR/LCC/Texana/MRP Phase II system, during drought of record conditions, results in a safe yield supply of 219,000 ac-ft in 2020 which reduces to 214,000 ac-ft by 2070 because of reservoir sedimentation.

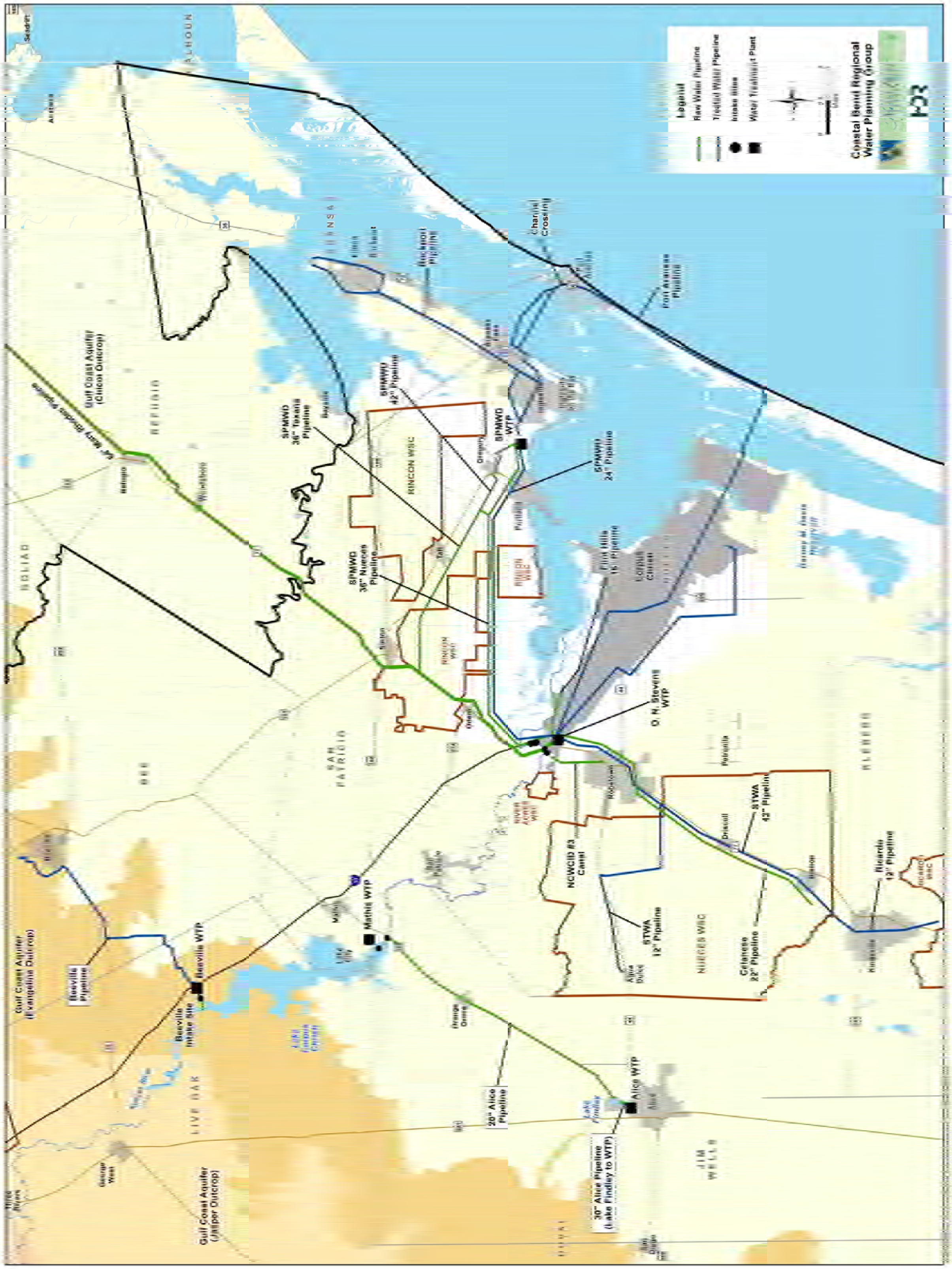

Figure 3.4.
Coastal Bend Water Supply System

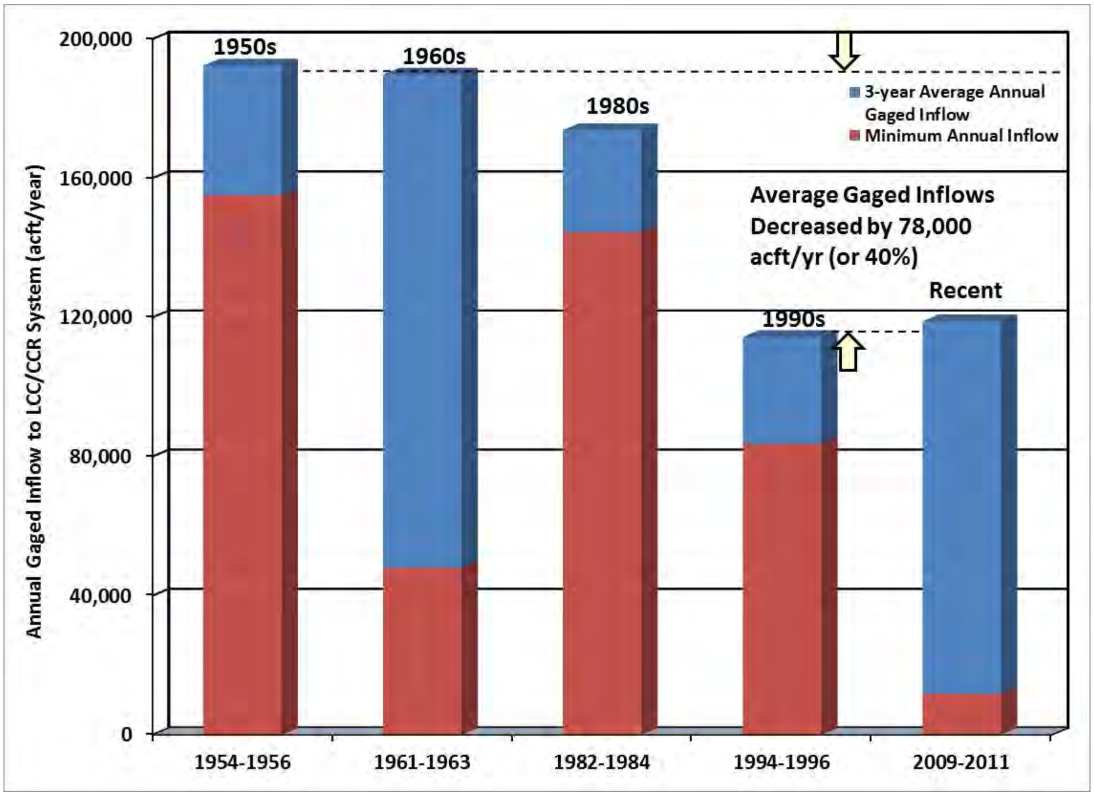

Figure 3.5.
3-Year Reservoir Inflows

For reservoirs, the safe yield may decrease over time as a result of sedimentation. When a reservoir is constructed on a stream channel, the sediment carried by the stream accumulates on the bottom of the reservoir. This accumulation reduces the volume of water that can be stored in the reservoir, which in turn reduces the firm yield available for diversion. Sedimentation rates for the CCR/LCC System have been measured over a period of time and estimated sedimentation rates are well documented.[12] It is estimated that the CCR/LCC System capacity will be reduced by 47,850 ac-ft due to sediment accumulations between 2020 and 2070.[13] For the 50-year planning period, the reduction in safe yield for future sedimentation was considered. Safe yield for the CCR/LCC System is presented for both the year 2020 and for the year 2070.

For Nueces County WCID #3 and smaller run-of-river water rights in the Nueces River Basin, firm yield supplies was based on the minimum annual supply that could be diverted over a historical period of record limited by minimum month conditions in accordance with TWDB guidelines. Run-of-river availabilities were simulated for these water users using an unmodified Nueces WAM Run 3, which determined monthly availability subject to water right priority and hydrologic conditions. Minimum month conditions were assessed within the context of use-appropriate monthly percentage of the annual firm diversion. When the full amount sought was not available for a given month, storage was identified as a water management strategy to

[12] Ibid.
[13] Calculation based on annual sedimentation rate of 717 ac-ft/yr for LCC and 240 ac-ft/yr for CCR.

bridge potential seasonal water shortages to avoid overestimating the reliability of run-of-river water during drought.

3.3 Surface Water Availability

Two computer models were used to evaluate the water rights in the Nueces River Basin and within the Coastal Bend Region. The first model was a version of the Water Rights Analysis Package (WRAP) computer model developed by HDR Engineering, Inc. (HDR) for the TCEQ as part of its Water Availability Modeling (WAM) Program.[14] The WRAP model is designed for use as a water resources management tool. The model can be used to evaluate the reliability of existing water rights and to determine unappropriated streamflow potentially available for a new water right permit. WRAP simulates the management and use of streamflow and reservoirs over a historical period of record, adhering to the water right priority system. The second model used in determining surface water rights availability in the Nueces River Basin was the City of Corpus Christi Water Supply Model [formerly known as the Lower Nueces River Basin and Estuary Model (NUBAY)] developed under previous studies.[15] The City of Corpus Christi Water Supply Model focuses on the operations of the CCR/LCC/Lake Texana/MRP Phase II System and is capable of simulating this system subject to the City of Corpus Christi's Phased Operations Plan and the 2001 Agreed Order governing freshwater inflow passage to the Nueces Estuary. The City of Corpus Christi Water Supply Model, authorized for use by the TWDB in February 2012, was used to estimate the safe yield of the CCR/LCC/Lake Texana/ MRP Phase II System and the TCEQ WAM WRAP Model was used to determine the firm yield availability of water to all other rights on the Nueces River and its tributaries within the Coastal Bend Region. A summary of the water rights and yield availability is presented in Table 3.3.

Local supplies[16] are used in the plan to meet livestock needs only. All other surface water supplies are based on water rights and supply availability during the drought of record as discussed previously in Section 3.2. The volume of local supply available to livestock users is based on the percent of surface water used to meet demands after considering 2010 groundwater use reported by the TWDB, as discussed later in Section 4.2. Table 3.4 shows the amount of local supplies by decade for each livestock-county user, which totals 1,860 ac-ft/yr for the region.

There are two counties in Region N that currently report reuse. Nueces County- manufacturing reports using 1,140 ac-ft/yr; and San Patricio County- manufacturing reports using 448 ac-ft/yr based on information provided by the TWDB.

The surface water supplies described above serve as a basis for the supply and demand comparisons in Chapter 4.

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[14] HDR, "Water Availability in the Nueces River Basin," TCEQ, October 1999.
[15] HDR, Op. Cit., January 1999.
[16] The TWDB defines local supplies in Exhibit C- First Amended General Guidelines for Regional Water Plan Development (October 2012) as "limited, unnamed individual surface water supplies that, separately, are available only to particular non-municipal WUGs".

Table 3.3. Surface Water Rights Availability Nueces River Basin Water Rights in the Coastal Bend Region

Water Right Owner	*Annual Permitted Diversion Volume (ac-ft/yr)*	*Yield[1] (ac-ft)*	*Type Of Use*	*Priority Date*	*County*
City of Corpus Christi and Nueces River Authority	497,738[2]	200,000[3]	Municipal & Industrial	12/1913[4]	Nueces
		14	Irrigation	12/1913	Nueces
		12	Mining	12/1913	Nueces
		200	Irrigation	12/1913	Live Oak
Reality Traders & Exchange, Inc.	20	0	Irrigation	10/1952	San Patricio
Wayne Shambo	140	0	Irrigation	10/1952	San Patricio
Nueces Co. WCID #3	4,246 7,300 11,546	3,665 3,438 7,103	Municipal Irrigation	2/1909[4]	Nueces
Garnett T. & Patsy A. Brooks	221	0	Irrigation	2/1964	San Patricio
CE Coleman Estate	27	0	Irrigation	2/1964	Nueces
Ila M. Noakes Lindgreen	101	0	Irrigation	2/1964	Nueces
Randy J. Corporron, et al.	8	0	Irrigation	12/1965	McMullen
WL Flowers Machine & Welding Co.	132	6	Irrigation	12/1958	McMullen
Ted W. True, et al.	220	0	Irrigation	12/1958	McMullen
Harold W Nix, et ux.	0	0	Recreation	2/1969	McMullen
Richard P. Horton	336	0	Irrigation	12/1963	McMullen
James L. House Trust	123	0	Irrigation	12/1966	McMullen
City of Three Rivers	700 800 1,500	700 800 1,500	Municipal Industrial	9/1914	Live Oak
City of Taft	600	0	Irrigation	9/1983	San Patricio
Diamond Shamrock Refining	0[5]	0	Irrigation	6/1986	Live Oak
San Miguel Electric Co-Op, Inc.	300	0	Industrial	12/1990	McMullen
Muriell E. McNeill	64	0	Irrigation	9/1989	Live Oak
City of Mathis	50	0	Irrigation	11/1996	San Patricio
TOTAL	**513,126**	**208,835**			

[1] Firm yield computed assuming 2060 sediment accumulation in all reservoirs.
[2] Corpus Christi annual permitted diversion includes CCR/LCC System (443,898 ac-ft/yr) and LNRA contracts with Corpus Christi (41,840 ac-ft/yr) and a maximum 12,000 ac-ft/yr from Lake Texana on an interruptible basis.
[3] Corpus Christi minimum annual supply equals computed 2060 safe yield of the CCR/LCC System with Lake Texana water as per HDR, March 2005.
[4] Water right with multiple priority dates. Earliest date shown in table.
[5] Diamond Shamrock irrigation right is for irrigation from on-site process water return flows. In effect, this permit is for a reuse project.

Table 3.4.
Livestock Local Surface Water Supplies (ac-ft/yr)

County	*2020*	*2030*	*2040*	*2050*	*2060*	*2070*
Aransas	21	21	21	21	21	21
Bee	464	464	464	464	464	464
Brooks	160	160	160	160	160	160
Duval	148	148	148	148	148	148
Jim Wells	402	402	402	402	402	402
Kenedy	0	0	0	0	0	0
Kleberg	0	0	0	0	0	0
Live Oak	252	252	252	252	252	252
McMullen	262	262	262	262	262	262
Nueces	36	36	36	36	36	36
San Patricio	115	115	115	115	115	115
Total	1,860	1,860	1,860	1,860	1,860	1,860

3.4 Groundwater Availability

The Coastal Bend Region includes parts of five aquifers — two major (Gulf Coast and Carrizo-Wilcox Aquifers) and three minor (Yegua-Jackson, Queen City and Sparta Aquifers). Figure 3.1 shows the locations of the major aquifers. According to TWDB guidelines, regional water planning groups are to use Modeled Available Groundwater (MAG) values developed by the Groundwater Management Areas (GMAs) and TWDB as groundwater supply availability estimates for the 2016 Regional Water Plan. All Region N counties are located within three Groundwater Management Areas as follows:

- GMA 13- McMullen County,
- GMA 15- Aransas and Bee County (portion); and
- GMA 16- Remaining Region N counties.

MAGs have been developed through the GMA process for primary groundwater supply aquifers in Region N. A couple of minor aquifers areas identified in the previous 2011 Plan were designated as 'non-relevant' by the groundwater conservation districts during the process of identifying desired future conditions (DFCs) by Groundwater Management Area. Since DFCs were not set, a MAG value was not provided for two areas in the Coastal Bend Region: Bee (Carrizo Wilcox aquifer) and Live Oak County (Carrizo Wilcox aquifer). The TWDB developed DFC-compatible groundwater availability numbers for some non-relevant areas during the same model runs that produced the MAGs, but these were not developed for the Carrizo Wilcox Aquifer in Bee and Live Oak Counties. However, groundwater does exist in these non-relevant areas which are relied upon by water user groups. The groundwater availability adopted by the CBRWPG in June 2013 includes 394 acft/yr of supply available from the Carrizo Wilcox Aquifer in Bee County; and 2,399 acft/yr available from the Carrizo Wilcox Aquifer in Live Oak County, a portion of which is currently used by McCoy WSC. These groundwater availability estimates were developed during a previous planning cycle and met Coastal Bend RWPG criteria for drawdown and water quality using the region-specific, groundwater model which simulated this availability after considering on-going, current groundwater use.

Of the five aquifers, the Gulf Coast Aquifer underlies all 11 counties in the planning region, is the primary groundwater resource in the Coastal Bend Region, and is estimated to constitute 97 percent of the region's groundwater availability according to MAG. The Carrizo Wilcox underlies 3 counties and is estimated to constitute about 2 percent of the groundwater availability.

3.4.1 Gulf Coast Aquifer

The Gulf Coast Aquifer underlies all counties within the Coastal Bend Region and yields moderate to large amounts of fresh and slightly saline water. The Gulf Coast Aquifer, extending from Northern Mexico to Florida, is comprised of five water-bearing formations: Catahoula, Jasper, Burkeville Confining System, Evangeline, and Chicot. The Evangeline and Chicot Aquifers are the uppermost water-bearing formations, are the most productive and, consequently, are the formations utilized most commonly. The Evangeline Aquifer of the Gulf Coast Aquifer System features the highly transmissive Goliad Sands. The Chicot Aquifer is comprised of many different geologic formations; however, the Beaumont and Lissie Formations are predominant in the Coastal Bend Area. The Burkeville Confining System is a limited water-bearing formation and characterized as containing substantial amounts of clay.

A CGCGAM was developed by the TWDB to simulate steady-state, predevelopment and developed flow in the Gulf Coast Aquifer along the south Texas Gulf Coast and to assist in the determination of groundwater availability for the region, however it had model limitations and was not considered to satisfactorily represent the Gulf Coast Aquifer in GMA 16, which covers the majority of the Coastal Bend Area. For this reason, the TWDB issued a Groundwater Management Area 16 Groundwater Flow Model for the Coastal Bend Region. This model was used to evaluate DFCs and set MAGs for the region.

3.4.2 Carrizo-Wilcox Aquifer

Three counties within the Coastal Bend Region have Carrizo-Wilcox Aquifer reserves available to them. The Carrizo-Wilcox Aquifer contains moderate to large amounts of either fresh or slightly saline water. Slightly saline water is defined as water that contains 1,000 to 3,000 mg/L of dissolved solids. Although this aquifer reaches from the Rio Grande River north into Arkansas, it only underlies parts of McMullen, Live Oak, and Bee Counties within the Coastal Bend Region. In this downdip portion of the Carrizo-Wilcox Aquifer, the water is soft, hot (140 degrees Fahrenheit), and contains more dissolved solids than in updip parts of the aquifer. Long-term groundwater available from the Carrizo-Wilcox in the region is summarized in Table 3.5.

Table 3.5. Groundwater Availability and Use from Aquifers within the Coastal Bend Region

County Name	Basin Name	Aquifer Name	TWDB Provided MAG for 2016 Region N Plan (ac-ft/yr)					
			2020	2030	2040	2050	2060	2070
ARANSAS	SAN ANTONIO-NUECES	GULF COAST	1,862	1,862	1,862	1,862	1,862	1,862
BEE	NUECES	CARRIZO	394	394	394	394	394	394
BEE	SAN ANTONIO-NUECES	GULF COAST	19,382	19,358	19,358	19,306	19,306	19,306
BEE	NUECES	GULF COAST	792	792	792	792	792	792
BROOKS	NUECES-RIO GRANDE	GULF COAST	15,595	15,595	15,595	15,595	15,595	15,595
DUVAL	NUECES	GULF COAST	364	364	364	364	364	364
DUVAL	NUECES-RIO GRANDE	GULF COAST	13,699	13,699	13,699	13,699	13,699	13,699
JIM WELLS	NUECES	GULF COAST	3,962	3,962	3,962	3,962	3,962	3,962
JIM WELLS	NUECES-RIO GRANDE	GULF COAST	23,924	23,924	23,924	23,924	23,924	23,924
KENEDY	NUECES-RIO GRANDE	GULF COAST	51,778	51,778	51,778	51,778	51,778	51,778
KLEBERG	NUECES-RIO GRANDE	GULF COAST	50,701	50,701	50,701	50,701	50,701	50,701
LIVE OAK	SAN ANTONIO-NUECES	GULF COAST	57	57	57	57	57	57
LIVE OAK	NUECES	GULF COAST	11,377	11,377	11,377	11,377	11,377	11,377
LIVE OAK	NUECES	CARRIZO	2,399	2,399	2,399	2,399	2,399	2,399
MCMULLEN	NUECES	CARRIZO	1,819	1,819	1,819	1,819	1,819	1,819
MCMULLEN	NUECES	GULF COAST	510	510	510	510	510	510
MCMULLEN	NUECES	QUEEN CITY	136	136	136	136	136	136
MCMULLEN	NUECES	SPARTA	90	90	90	90	90	90
MCMULLEN	NUECES	YEGUA-JACKSON	179	179	179	179	179	179
NUECES	SAN ANTONIO-NUECES	GULF COAST	179	179	179	179	179	179
NUECES	NUECES	GULF COAST	946	946	946	946	946	946
NUECES	NUECES-RIO GRANDE	GULF COAST	7,884	7,884	7,884	7,884	7,884	7,884
SAN PATRICIO	SAN ANTONIO-NUECES	GULF COAST	15,145	15,145	15,145	15,145	15,145	15,145
SAN PATRICIO	NUECES	GULF COAST	3,868	3,868	3,868	3,868	3,868	3,868
TOTAL GROUNDWATER AVAILABILITY (ac-ft/yr)			**227,042**	**227,018**	**227,018**	**226,966**	**226,966**	**226,966**

3.4.3 Queen City and Sparta Aquifers

The Queen City and Sparta Aquifers are classified by the TWDB as minor aquifers and underlie McMullen County. The Queen City is a thick sand and sandy clay aquifer and runs from its southern boundary in Frio and LaSalle Counties northeasterly towards Louisiana. The Queen City Aquifer supplies small to moderate amounts of either fresh or slightly saline water in the Coastal Bend Region. The Sparta Aquifer is composed of interbedded sands and clays that yield small to moderate quantities with fresh to slightly saline quality.

3.4.4 Yegua- Jackson

The Yegua-Jackson aquifer is classified by the TWDB as minor aquifer and underlies McMullen County. The Yegua- Jackson geologic unit consists of interbedded sand, silt, and clay layers. Most water is produced from the sand units, which water is either fresh or slightly saline.

3.5 Assigning Surface and Groundwater Supplies to Water User Groups

Current water supplies were assigned to be consistent with TWDB and Texas Administrative Code guidance. Source water availability was limited according to minimum month drought of record conditions for surface water supplies and modeled available groundwater estimates for groundwater supplies. Additionally, legal and physical constraints were used to determine the amount available to water user groups and wholesale water providers. Water user groups that receive water from wholesale water providers or another water user group were limited according by contract, if applicable. Details of the water supply allocation methodology are included in Chapter 4.2.

Current reuse information was obtained from the TWDB and by contacting wholesale water providers for consideration in development of the 2016 Plan. A discussion of current reuse amounts is included in Chapter 5D.5. Delineation of direct and indirect reuse was not provided.

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4

Identification of Water Needs

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Chapter 4: Identification of Water Needs

4.1 Introduction

In this chapter, the demand projections from Chapter 2 and the supply projections from Chapter 3 are brought together to estimate projected water needs in the Coastal Bend Region for the next 50 years. As a recap, Chapter 2 presented demand projections for six types of use: municipal, manufacturing, steam-electric, mining, irrigation, and livestock. Municipal water demand projections are shown for each city with a population of more than 500 and for County-Other users in each county. Chapter 3 presented surface water availability by water right and groundwater availability and projected use by aquifer.

For each of the 11 counties in the Coastal Bend Region there is a summary page that highlights specific supply and demand information in Chapter 4.3, followed by two tables. The first table contains supply and demand comparisons for the six types of water use; the second table contains supply and demand comparisons for the municipal water user groups in the county.

Chapter 4.6 summarizes the water supply and demand picture for the entire region, focusing on those cities and other users that have immediate and/or long-term needs.

4.2 Allocation Methodology

Existing water supply was determined as the maximum amount of water available from existing sources during drought of record conditions, subject to physical transmission and/or treatment plant constraints and contract limits.

Surface water and groundwater availability was allocated among the six user groups using the methods explained below.

4.2.1 Surface Water Allocation

Surface water in the region that is available to meet projected demands consists of the safe yield of the regional reservoir system, dependable supply of run-of-river water rights through drought of record conditions, and local on-farm sources. Surface water rights were allocated as supplies according to their stated type of use: municipal, industrial (manufacturing, steam-electric, and mining), and irrigation. Municipal supply was further allocated among cities and other municipal water supply entities. This was done by obtaining water seller information (i.e. which wholesale water providers resell water to other water supply entities) and water purchase contract limits between buyers and sellers, provided by the TWDB and Wholesale Water Providers. In most cases, for those cities purchasing water on a wholesale basis the contract amount remains constant through 2070. It was also assumed that water associated with a wholesaler that is not resold remains as an available supply to the wholesaler. In the case where a wholesaler's supply is deficient to meet its own demands and contract requirements, a shortage would be expected for their non-municipal customers. Also in the case of surface water, the available supplies were compared to the water treatment plant (WTP) capacities shown in Table 4.1.

Table 4.1.
Water Treatment Plant Capacities for Region N Water User Groups

Entity	*Normal Rated Design Flow (mgd)*	*Average Day WTP Capacity (mgd)*	*Average Day WTP Capacity (ac-ft/yr)*
City of Beeville	6.4	5.2	5,833
City of Alice	8.7	6.7	7,560
City of Mathis	2.2	1.7	1,877
City of Three Rivers	3.0	2.1	2,399
Nueces County WCID #3	6.6	5.0	5,605
City of Corpus Christi	159.0	113.6	127,314
San Patricio Municipal Water District*	33.6	20.3	22,702

*Note: Includes municipal (potable) average day capacity of 10.4 mgd (11,658 ac-ft/yr) and industrial treatment plant average day capacity of 9.8 mgd (11,043 ac-ft/yr).

If the total available surface water supplies were greater than treatment plant capacity, the supplies were constrained by the treatment plant capacity. A detailed explanation of water demand and supplies for Wholesale Water Providers is described in Chapter 4.4. Figure 4.1 presents major contract relationships in the Coastal Bend Region and Figure 4.2 shows how the surface water in the Coastal Bend Region is distributed.

Two situations deserve special attention regarding raw water supplies for the region. The City of Corpus Christi (City) has 214,000 ac-ft in available safe yield supply in 2070, through its own water right in the Nueces Basin from the CCR/LCC System, a contract with the Lavaca-Navidad River Authority for a base amount of 41,840 ac-ft/yr and up to 12,000 ac-ft on an interruptible basis from Lake Texana, and 27,000 ac-ft/yr from the City's Garwood water rights. These supplies are referred to collectively as supplies from the CCR/LCC/Texana/MRP Phase II System.

From this availability Corpus Christi supplies its municipal customers throughout the Coastal Bend Region and manufacturing, mining, and steam-electric customers in Nueces County (Figure 4.1). San Patricio Municipal Water District (SPMWD) has a contract to buy 51,200 ac-ft of raw and treated water from the City of Corpus Christi and provides water to municipal customers in Aransas, Nueces and San Patricio Counties, as well as manufacturing needs in San Patricio County. South Texas Water Authority (STWA) supplies municipal and rural customers in Nueces and Kleberg Counties. Nueces County WCID #3 supplies municipal customers in Nueces County.

The final process in the allocation of surface water supplies was to examine the available WTP capacity for each entity with a WTP and compare that capacity to existing raw water supplies. The WTP capacity was calculated based on average day production using a peaking factor based on recent water use records and feedback from the utility. If the WTP capacity was insufficient to treat the existing raw water supplies, then surface water supplies to that entity were limited to the current WTP treatment capacity. Current WTP capacities are shown in Table 4.1.

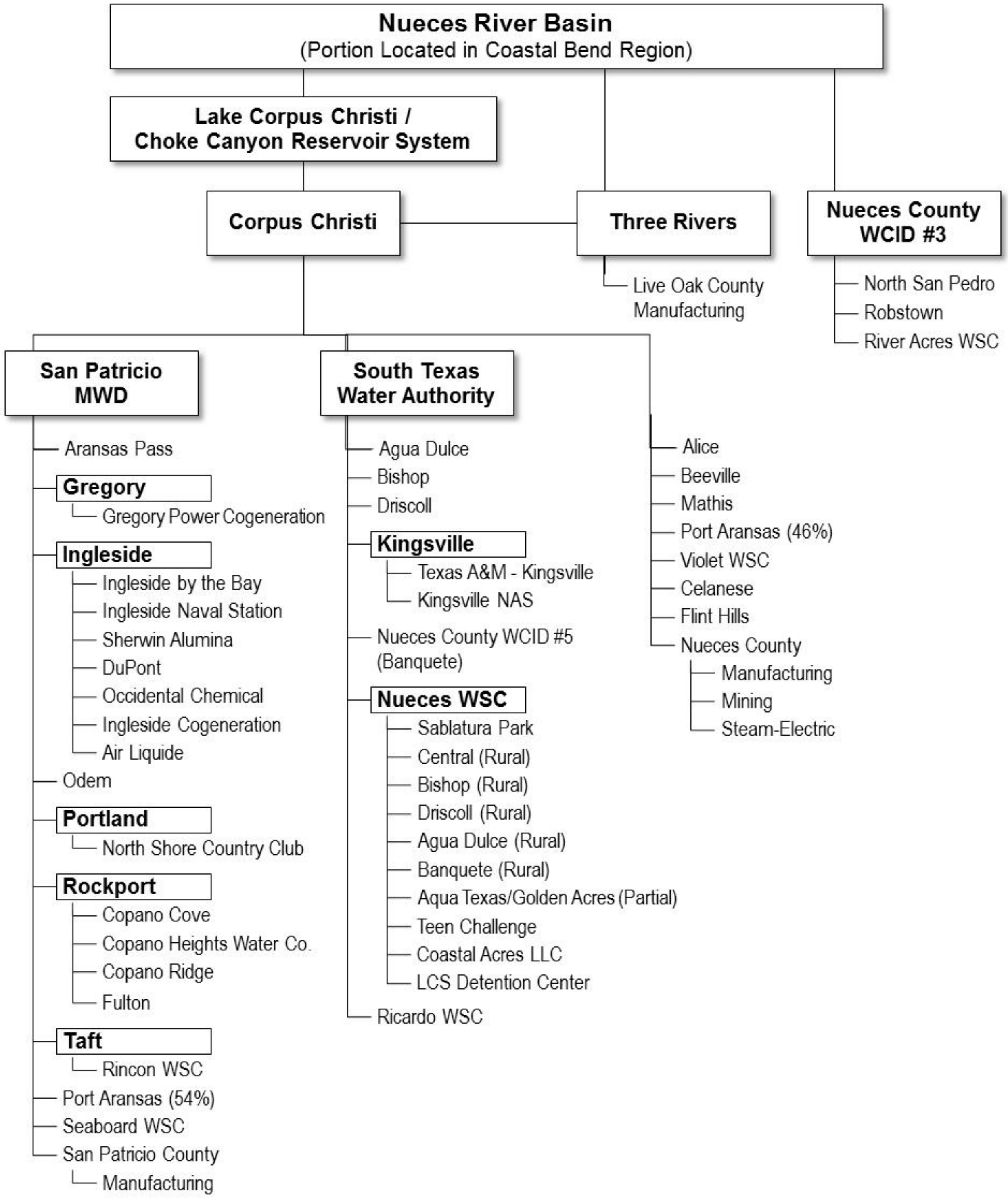

Figure 4.1.
Major Contract Relationships in the Coastal Bend Region

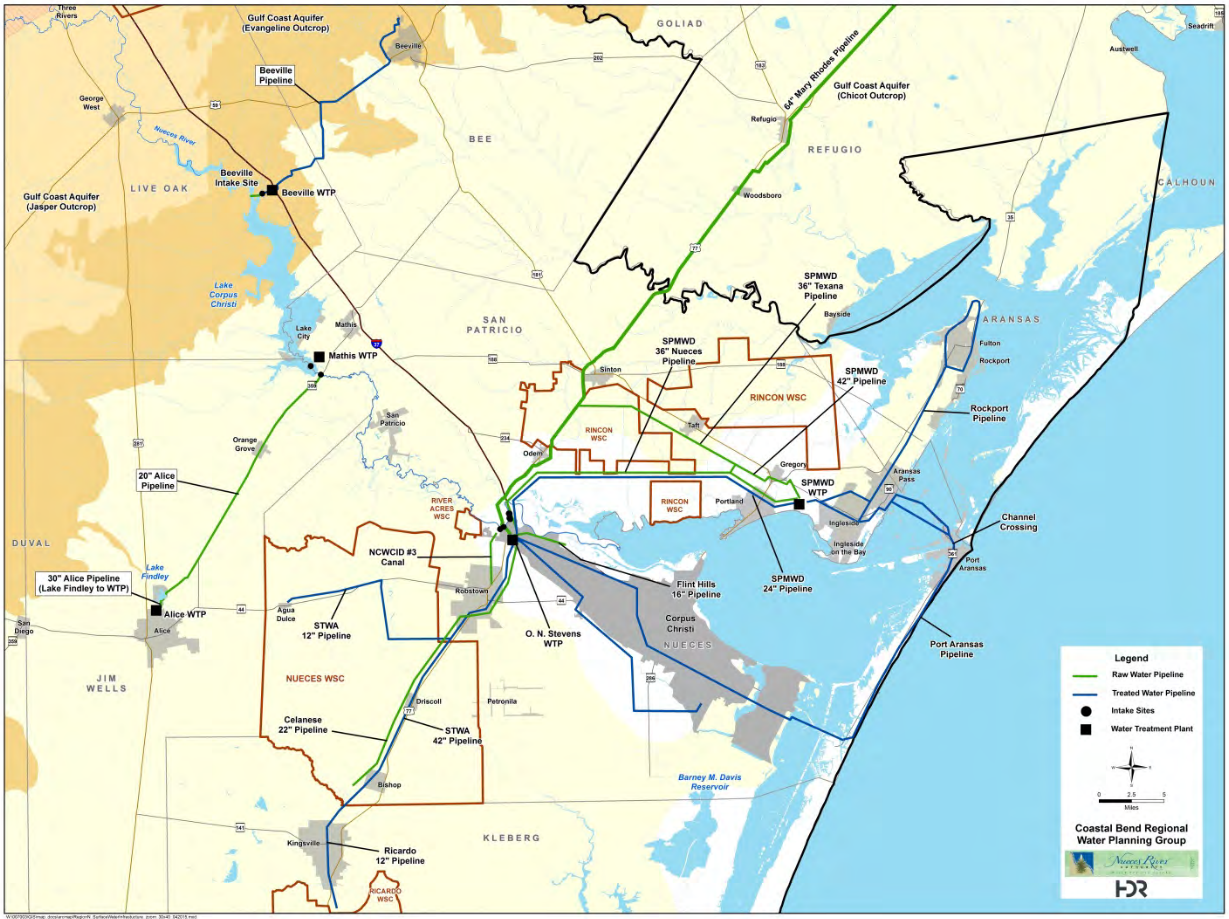

Figure 4.2.
Distribution of Surface Water in the Coastal Bend Region

Local surface water supply from stock ponds and streams is available to meet livestock needs when groundwater supplies are insufficient to meet those demands. Generally, these ponds are not large enough to require a water rights permit (>200 ac-ft of storage).

4.2.2 Groundwater Allocation

TWDB General Guidelines for Regional Water Plan Development offer the following with regard to evaluation of groundwater availability: "Groundwater availability shall be based on the Modeled Available Groundwater (MAG) volumes that may be produced on an average annual basis to achieve Desired Future Conditions (DFCs) as adopted by Groundwater Management Areas (GMAs)."

Groundwater is regulated locally by groundwater conservation districts except in locations that do not have a district. Districts may issue permits that regulate pumping of groundwater and spacing of wells within their jurisdictions. Multiple districts within a single GMA determine the DFCs of relevant aquifers within that area. DFCs are the desired, quantified conditions of groundwater resources, such as water levels, water quality, or volumes at a specified time or times in the future or in perpetuity. There are three GMAs within the Coastal Bend Planning Area: 1) GMA 13 (McMullen County); 2) GMA 15 (Bee County); and 3) GMA 16 (all 11 Coastal Bend Planning Area Counties).

TWDB staff has translated DFC's into MAG volumes using approved Groundwater Available Models (GAMs) (or other approaches if a GAM is not applicable). A MAG volume is the amount of groundwater production, on an average annual basis, that will achieve a DFC. The DFC at a specific location may not be achieved if groundwater production exceeds the MAG volume over the long term.

Therefore, in the regional water planning process, total anticipated groundwater production in any planning decade may not exceed the MAG volume in any county-aquifer location (total groundwater production includes quantities associated with both existing supplies and any recommended water management strategies). This prevents regional water planning groups from recommending water management strategies with supply volumes that would result in exceeding (i.e. "overdrafting") approved MAG volumes. Groundwater supply was generally allocated in the following manner:

Municipal Use

- For cities, groundwater supply was based upon projected water use or well capacity reported to TCEQ, whichever is less.
- For rural areas, well capacities were estimated as the highest groundwater usage from 2000- 2011.

Irrigation Use

- Irrigation supply was estimated as either the projected demand in each decade or well capacity, whichever is less. The well capacity was estimated as the amount of water used by irrigators in 2010. For Bee and San Patricio Counties, the well capacity was assumed to be equal to the maximum annual pumping during the 2000 to 2010 time period based on TWDB records. The well capacities for Bee and San Patricio Counties were set equal to 8,025 ac-ft/yr and 14,441 ac-ft/yr, respectively. Actual well capacity pumping constraints may be different than those estimated based on previous maximum annual irrigation water use. Most irrigation water in the Coastal Bend Region is applied during growing seasons, and therefore wells may be capable of providing additional supplies for peak use conditions.

Manufacturing Use

- The manufacturing well capacity was generally estimated as 130 percent of the 2010 usage from the Gulf Coast Aquifer. Groundwater supply was based on projected water use or estimated well capacities, whichever is less.

Mining Use

- The mining supply was estimated as either the projected demand in each decade or well capacity, whichever is less. A portion of the projected water demand in Nueces County is met with surface water supplies.

Livestock Use

- The groundwater supply for livestock was calculated based on 2010 groundwater use reported by TWDB, represented as a percent of total groundwater used to meet demands. This percent of groundwater used is applied to each livestock demand by decade. The remaining demand is met with local surface water supplies.

4.3 County Summaries – Comparison of Demand to Supply

4.3.1 Comparison of Demand to Supply – Aransas County

A summary of population, water demands, water supply, and shortages are shown by decade for the 2020 through 2070 period in Table 4.2 for all categories of water use. Table 4.3 includes a summary of municipal demands.

Demands

- For the period 2020 to 2070, municipal demand decreases from 3,511 ac-ft in 2020 to 3,376 ac-ft in 2050 and to 3,367 ac-ft in 2070. Due to anticipated industrial growth in the area, Aransas County municipal water use will likely be higher than the TWDB approved municipal water demand projections shown in this section. Although the TWDB approved increases in San Patricio and Nueces industrial water demands, it rejected the proposed CBRWPG-approved increases in projected Aransas County municipal water demands.
- Manufacturing demand increases from 137 ac-ft to 172 ac-ft from 2020 to 2070.
- Mining demand decreases from 10 to 5 ac-ft from 2020 to 2070.
- There is no irrigation demand projected; livestock demand is constant at 44 ac-ft/yr.

Supplies

- Surface water from the CCR/LCC/Texana/MRP Phase II System is supplied to municipalities via the SPMWD.
- Groundwater supplies are from the Gulf Coast Aquifer.
- Surface water for livestock needs is provided from on-farm and local sources.

Comparison of Demand to Supply

- There are adequate supplies available to meet all projected demands through the planning period.

Table 4.2. Aransas County Population, Water Supply, and Water Demand Projections

	Population Projection	2020	2030	2040	2050	2060	2070
		24,463	24,991	24,937	25,102	25,103	25,104
	Supply and Demand by Type of Use	**Year**					
		2020 (ac-ft)	**2030 (ac-ft)**	**2040 (ac-ft)**	**2050 (ac-ft)**	**2060 (ac-ft)**	**2070 (ac-ft)**
Municipal	Municipal Demand (See Table 4.3)	3,511	3,482	3,395	3,376	3,367	3,367
	Municipal Existing Supply						
	Groundwater	390	390	390	390	390	390
	Surface water	3,121	3,092	3,005	2,986	2,977	2,977
	Total Existing Municipal Supply	3,511	3,482	3,395	3,376	3,367	3,367
	Municipal Balance	0	0	0	0	0	0
Industrial	Manufacturing Demand	137	142	147	151	161	172
	Manufacturing Existing Supply						
	Groundwater	265	265	265	265	265	265
	Surface water	0	0	0	0	0	0
	Total Manufacturing Supply	265	265	265	265	265	265
	Manufacturing Balance	128	123	118	114	104	93
	Steam-Electric Demand	0	0	0	0	0	0
	Steam-Electric Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	0	0	0	0	0	0
	Total Steam-Electric Supply	0	0	0	0	0	0
	Steam-Electric Balance	0	0	0	0	0	0
	Mining Demand	10	7	5	5	5	5
	Mining Existing Supply						
	Groundwater	10	10	10	10	10	10
	Surface water	0	0	0	0	0	0
	Total Mining Supply	10	10	10	10	10	10
	Mining Balance	0	3	5	5	5	5
Agriculture	Irrigation Demand	0	0	0	0	0	0
	Irrigation Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	0	0	0	0	0	0
	Total Irrigation Supply	0	0	0	0	0	0
	Irrigation Balance	0	0	0	0	0	0
	Livestock Demand	44	44	44	44	44	44
	Livestock Existing Supply						
	Groundwater	23	23	23	23	23	23
	Surface water	21	21	21	21	21	21
	Total Livestock Supply	44	44	44	44	44	44
	Livestock Balance	0	0	0	0	0	0
Total	Municipal and Industrial Demand	3,658	3,631	3,547	3,532	3,533	3,544
	Existing Municipal and Industrial Supply						
	Groundwater	665	665	665	665	665	665
	Surface water	3,121	3,092	3,005	2,986	2,977	2,977
	Total Municipal and Industrial Supply	3,786	3,757	3,670	3,651	3,642	3,642
	Municipal and Industrial Balance	128	126	123	119	109	98
	Agriculture Demand	44	44	44	44	44	44
	Existing Agricultural Supply						
	Groundwater	23	23	23	23	23	23
	Surface water	21	21	21	21	21	21
	Total Agriculture Supply	44	44	44	44	44	44
	Agriculture Balance	0	0	0	0	0	0
	Total Demand	3,702	3,675	3,591	3,576	3,577	3,588
	Total Supply						
	Groundwater	688	688	688	688	688	688
	Surface water	3,142	3,113	3,026	3,007	2,998	2,998
	Total Supply	3,830	3,801	3,714	3,695	3,686	3,686
	Total Balance	128	126	123	119	109	98

Table 4.3.
Aransas County Municipal Water Demand and Supply by City/County (ac-ft)

City/County	*2020*	*2030*	*2040*	*2050*	*2060*	*2070*
Aransas Pass						
Demand	110	108	106	105	104	104
Supply	110	108	106	105	104	104
Groundwater	—	—	—	—	—	—
Surface Water	110	108	106	105	104	104
Balance	—	—	—	—	—	—
Fulton						
Demand	278	279	275	275	275	275
Supply	278	279	275	275	275	275
Groundwater	—	—	—	—	—	—
Surface Water	278	279	275	275	275	275
Balance	—	—	—	—	—	—
Rockport						
Demand	1,677	1,680	1,652	1,649	1,646	1,646
Supply	1,677	1,680	1,652	1,649	1,646	1,646
Groundwater	69	69	69	69	69	69
Surface Water	1,608	1,611	1,583	1,580	1,577	1,577
Balance	—	—	—	—	—	—
County-Other						
Demand	1,446	1,415	1,362	1,347	1,342	1,342
Supply	1,446	1,415	1,362	1,347	1,342	1,342
Groundwater	321	321	321	321	321	321
Surface Water	1,125	1,094	1,041	1,026	1,021	1,021
Balance	—	—	—	—	—	—
County Total						
Demand	3,511	3,482	3,395	3,376	3,367	3,367
Supply	3,511	3,482	3,395	3,376	3,367	3,367
Groundwater	390	390	390	390	390	390
Surface Water	3,121	3,092	3,005	2,986	2,977	2,977
Balance	—	—	—	—	—	—

4.3.2 Comparison of Demand to Supply – Bee County

A summary of population, water demands, water supply, and shortages are shown by decade for the 2020 through 2070 period in Table 4.4 for all categories of water use. Table 4.5 includes a summary of municipal demands.

Demands

- For the period 2020 to 2070, municipal demand increases from 5,733 ac-ft in 2020 to 5,769 ac-ft in 2050, then decreases to 5,761 ac-ft in 2070.
- Manufacturing demand is constant at 1 ac-ft from 2020 to 2070.
- Mining demand decreases from 472 ac-ft in 2020 to 318 ac-ft in 2070.
- For the period 2020 to 2070, irrigation demand increases from 4,751 ac-ft to 7,985 ac-ft; livestock demand is constant at 930 ac-ft.

Supplies

- Surface water is provided to the City of Beeville from the CCR/LCC/Texana/MRP Phase II System.
- Surface water for livestock needs is provided from on-farm/local sources.
- Groundwater supplies are from the Gulf Coast Aquifer and limited by water well capacity which was estimated based on TWDB historical water use records from 2000-2011. There is sufficient MAG available.
- Groundwater supply for irrigation was set equal to the maximum historical pumpage (i.e. estimated well capacity).

Comparison of Demand to Supply

- There are adequate supplies available to meet all projected demands through the planning period.

Table 4.4.
Bee County Population, Water Supply, and Water Demand Projections

	Population Projection	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
		33,478	34,879	35,487	35,545	35,579	35,590
	Supply and Demand by Type of Use	**Year**					
		2020 (ac-ft)	**2030 (ac-ft)**	**2040 (ac-ft)**	**2050 (ac-ft)**	**2060 (ac-ft)**	**2070 (ac-ft)**
Municipal	Municipal Demand (See Table 4.5)	5,733	5,824	5,812	5,769	5,759	5,761
	Municipal Existing Supply						
	Groundwater	2,913	2,913	2,913	2,913	2,913	2,913
	Surface water	2,925	2,978	2,976	2,961	2,959	2,960
	Total Existing Municipal Supply	5,838	5,891	5,889	5,874	5,872	5,873
	Municipal Balance	105	67	77	105	113	112
Industrial	Manufacturing Demand	1	1	1	1	1	1
	Manufacturing Existing Supply						
	Groundwater	1	1	1	1	1	1
	Surface water	0	0	0	0	0	0
	Total Manufacturing Supply	1	1	1	1	1	1
	Manufacturing Balance	0	0	0	0	0	0
	Steam-Electric Demand	0	0	0	0	0	0
	Steam-Electric Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	0	0	0	0	0	0
	Total Steam-Electric Supply	0	0	0	0	0	0
	Steam-Electric Balance	0	0	0	0	0	0
	Mining Demand	472	458	428	372	338	318
	Mining Existing Supply						
	Groundwater	510	510	510	510	510	510
	Surface water	0	0	0	0	0	0
	Total Mining Supply	510	510	510	510	510	510
	Mining Balance	38	52	82	138	172	192
Agriculture	Irrigation Demand	4,751	5,248	5,796	6,403	7,073	7,985
	Irrigation Existing Supply						
	Groundwater	8,025	8,025	8,025	8,025	8,025	8,025
	Surface water	0	0	0	0	0	0
	Total Irrigation Supply	8,025	8,025	8,025	8,025	8,025	8,025
	Irrigation Balance	3,274	2,777	2,229	1,622	952	40
	Livestock Demand	930	930	930	930	930	930
	Livestock Existing Supply						
	Groundwater	466	466	466	466	466	466
	Surface water	464	464	464	464	464	464
	Total Livestock Supply	930	930	930	930	930	930
	Livestock Balance	0	0	0	0	0	0
Total	Municipal and Industrial Demand	6,206	6,283	6,241	6,142	6,098	6,080
	Existing Municipal and Industrial Supply						
	Groundwater	3,424	3,424	3,424	3,424	3,424	3,424
	Surface water	2,925	2,978	2,976	2,961	2,959	2,960
	Total Municipal and Industrial Supply	6,349	6,402	6,400	6,385	6,383	6,384
	Municipal and Industrial Balance	143	119	159	243	285	304
	Agriculture Demand	5,681	6,178	6,726	7,333	8,003	8,915
	Existing Agricultural Supply						
	Groundwater	8,491	8,491	8,491	8,491	8,491	8,491
	Surface water	464	464	464	464	464	464
	Total Agriculture Supply	8,955	8,955	8,955	8,955	8,955	8,955
	Agriculture Balance	3,274	2,777	2,229	1,622	952	40
	Total Demand	11,887	12,461	12,967	13,475	14,101	14,995
	Total Supply						
	Groundwater	11,915	11,915	11,915	11,915	11,915	11,915
	Surface water	3,389	3,442	3,440	3,425	3,423	3,424
	Total Supply	15,304	15,357	15,355	15,340	15,338	15,339
	Total Balance	3,417	2,896	2,388	1,865	1,237	344

Table 4.5. Bee County Municipal Water Demand and Supply by City/County (ac-ft)

City/County	2020	2030	2040	2050	2060	2070
Beeville						
Demand	2,925	2,978	2,976	2,961	2,959	2,960
Supply	2,925	2,978	2,976	2,961	2,959	2,960
Groundwater	—	—	—	—	—	—
Surface Water	2,925	2,978	2,976	2,961	2,959	2,960
Balance	—	—	—	—	—	—
El Oso WSC						
Demand	83	85	85	84	80	80
Supply	143	143	143	143	143	143
Groundwater	143	143	143	143	143	143
Surface Water	—	—	—	—	—	—
Balance	60	58	58	59	63	63
County-Other						
Demand	2,725	2,761	2,751	2,724	2,720	2,721
Supply	2,770	2,770	2,770	2,770	2,770	2,770
Groundwater	2,770	2,770	2,770	2,770	2,770	2,770
Surface Water	—	—	—	—	—	—
Balance	45	9	19	46	50	49
County Total						
Demand	5,733	5,824	5,812	5,769	5,759	5,761
Supply	5,838	5,891	5,889	5,874	5,872	5,873
Groundwater	2,913	2,913	2,913	2,913	2,913	2,913
Surface Water	2,925	2,978	2,976	2,961	2,959	2,960
Balance	105	67	77	105	113	112

4.3.3 Comparison of Demand to Supply – Brooks County

A summary of population, water demands, water supply, and shortages are shown by decade for the 2020 through 2070 period in Table 4.6 for all categories of water use. Table 4.7 includes a summary of municipal demands.

Demands

- For the period 2020 to 2070, municipal demand increases from 2,003 ac-ft in 2020 to 2,210 ac-ft in 2050 and to 2,364 ac-ft in 2070.
- Mining demand decreases from 357 ac-ft to 298 ac-ft from 2020 to 2070.
- For the period 2020 to 2070, irrigation demand increases from 1,800 ac-ft to 2,297 ac-ft; livestock demand is constant at 620 ac-ft.

Supplies

- Surface water for livestock needs is provided from on-farm/local sources.
- Groundwater supplies are from the Gulf Coast Aquifer.

Comparison of Demand to Supply

- There are sufficient municipal, industrial, and agricultural supplies through 2070.

Table 4.6.
Brooks County Population, Water Supply, and Water Demand Projections

		2020	2030	2040	2050	2060	2070
Population Projection		7,783	8,252	8,722	9,181	9,595	9,979
Supply and Demand by Type of Use		**Year**					
		2020 (ac-ft)	**2030 (ac-ft)**	**2040 (ac-ft)**	**2050 (ac-ft)**	**2060 (ac-ft)**	**2070 (ac-ft)**
Municipal	Municipal Demand (See Table 4.7)	2,003	2,059	2,125	2,210	2,289	2,364
	Municipal Existing Supply						
	Groundwater	3,147	3,147	3,147	3,147	3,147	3,147
	Surface water	0	0	0	0	0	0
	Total Existing Municipal Supply	3,147	3,147	3,147	3,147	3,147	3,147
	Municipal Balance	1,144	1,088	1,022	937	858	783
Industrial	Manufacturing Demand	0	0	0	0	0	0
	Manufacturing Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	0	0	0	0	0	0
	Total Manufacturing Supply	0	0	0	0	0	0
	Manufacturing Balance	0	0	0	0	0	0
	Steam-Electric Demand	0	0	0	0	0	0
	Steam-Electric Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	0	0	0	0	0	0
	Total Steam-Electric Supply	0	0	0	0	0	0
	Steam-Electric Balance	0	0	0	0	0	0
	Mining Demand	357	360	340	324	308	298
	Mining Existing Supply						
	Groundwater	360	360	360	360	360	360
	Surface water	0	0	0	0	0	0
	Total Mining Supply	360	360	360	360	360	360
	Mining Balance	3	0	20	36	52	62
Agriculture	Irrigation Demand	1,800	1,890	1,985	2,084	2,188	2,297
	Irrigation Existing Supply						
	Groundwater	2,300	2,300	2,300	2,300	2,300	2,300
	Surface water	0	0	0	0	0	0
	Total Irrigation Supply	2,300	2,300	2,300	2,300	2,300	2,300
	Irrigation Balance	500	410	315	216	112	3
	Livestock Demand	620	620	620	620	620	620
	Livestock Existing Supply						
	Groundwater	460	460	460	460	460	460
	Surface water	160	160	160	160	160	160
	Total Livestock Supply	620	620	620	620	620	620
	Livestock Balance	0	0	0	0	0	0
Total	Municipal and Industrial Demand	2,360	2,419	2,465	2,534	2,597	2,662
	Existing Municipal and Industrial Supply						
	Groundwater	3,507	3,507	3,507	3,507	3,507	3,507
	Surface water	0	0	0	0	0	0
	Total Municipal and Industrial Supply	3,507	3,507	3,507	3,507	3,507	3,507
	Municipal and Industrial Balance	1,147	1,088	1,042	973	910	845
	Agriculture Demand	2,420	2,510	2,605	2,704	2,808	2,917
	Existing Agricultural Supply						
	Groundwater	2,760	2,760	2,760	2,760	2,760	2,760
	Surface water	160	160	160	160	160	160
	Total Agriculture Supply	2,920	2,920	2,920	2,920	2,920	2,920
	Agriculture Balance	500	410	315	216	112	3
	Total Demand	4,780	4,929	5,070	5,238	5,405	5,579
	Total Supply						
	Groundwater	6,267	6,267	6,267	6,267	6,267	6,267
	Surface water	160	160	160	160	160	160
	Total Supply	6,427	6,427	6,427	6,427	6,427	6,427
	Total Balance	1,647	1,498	1,357	1,189	1,022	848

Table 4.7.
Brooks County Municipal Water Demand and Supply by City/County (ac-ft)

City/County	2020	2030	2040	2050	2060	2070
Falfurrias						
Demand	1,677	1,712	1,755	1,813	1,865	1,915
Supply	2,697	2,697	2,697	2,697	2,697	2,697
Groundwater	2,697	2,697	2,697	2,697	2,697	2,697
Surface Water	—	—	—	—	—	—
Balance	1,020	985	942	884	832	782
County-Other						
Demand	326	347	370	397	424	449
Supply	450	450	450	450	450	450
Groundwater	450	450	450	450	450	450
Surface Water	—	—	—	—	—	—
Balance	124	103	80	53	26	1
County Total						
Demand	2,003	2,059	2,125	2,210	2,289	2,364
Supply	3,147	3,147	3,147	3,147	3,147	3,147
Groundwater	3,147	3,147	3,147	3,147	3,147	3,147
Surface Water	—	—	—	—	—	—
Balance	1,144	1,088	1,022	937	858	783

4.3.4 Comparison of Demand to Supply – Duval County

A summary of population, water demands, water supply, and shortages are shown by decade for the 2020 through 2070 period in Table 4.8 for all categories of water use. Table 4.9 includes a summary of municipal demands.

Demands

- For the period 2020 to 2070, municipal demand increases from 2,159 ac-ft in 2020 to 2,348 ac-ft in 2050 then to 2,468 ac-ft in 2070.
- Mining demand decreases from 1,388 ac-ft in 2020, to 1,241 ac-ft in 2050, to 1,104 ac-ft in 2070.
- For the period 2020 to 2070, irrigation demand increases from 3,004 ac-ft to 3,834 ac-ft; livestock demand is constant at 754 ac-ft.

Supplies

- Surface water for livestock needs is provided from on-farm/local sources.
- Groundwater supplies are from the Gulf Coast Aquifer.

Comparison of Demand to Supply

- Due to water well capacity limitations, the City of San Diego is projected to have a water shortage of 21 ac-ft/yr beginning in 2030, increasing to 107 ac-ft/yr in 2070.

Table 4.8. Duval County Population, Water Supply, and Water Demand Projections

	Population Projection	2020	2030	2040	2050	2060	2070
		12,715	13,470	14,098	14,644	15,080	15,435
	Supply and Demand by Type of Use	**Year**					
		2020 (ac-ft)	**2030 (ac-ft)**	**2040 (ac-ft)**	**2050 (ac-ft)**	**2060 (ac-ft)**	**2070 (ac-ft)**
Municipal	Municipal Demand (See Table 4.9)	2,159	2,219	2,274	2,348	2,412	2,468
	Municipal Existing Supply						
	Groundwater	2,674	2,674	2,674	2,674	2,674	2,674
	Surface water	0	0	0	0	0	0
	Total Existing Municipal Supply	2,674	2,674	2,674	2,674	2,674	2,674
	Municipal Balance	515	455	400	326	262	206
Industrial	Manufacturing Demand	0	0	0	0	0	0
	Manufacturing Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	0	0	0	0	0	0
	Total Manufacturing Supply	0	0	0	0	0	0
	Manufacturing Balance	0	0	0	0	0	0
	Steam-Electric Demand	0	0	0	0	0	0
	Steam-Electric Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	0	0	0	0	0	0
	Total Steam-Electric Supply	0	0	0	0	0	0
	Steam-Electric Balance	0	0	0	0	0	0
	Mining Demand	1,388	1,444	1,352	1,241	1,165	1,104
	Mining Existing Supply						
	Groundwater	4,656	4,656	4,656	4,656	4,656	4,656
	Surface water	0	0	0	0	0	0
	Total Mining Supply	4,656	4,656	4,656	4,656	4,656	4,656
	Mining Balance	3,268	3,212	3,304	3,415	3,491	3,552
Agriculture	Irrigation Demand	3,004	3,154	3,312	3,478	3,651	3,834
	Irrigation Existing Supply						
	Groundwater	3,900	3,900	3,900	3,900	3,900	3,900
	Surface water	0	0	0	0	0	0
	Total Irrigation Supply	3,900	3,900	3,900	3,900	3,900	3,900
	Irrigation Balance	896	746	588	422	249	66
	Livestock Demand	754	754	754	754	754	754
	Livestock Existing Supply						
	Groundwater	606	606	606	606	606	606
	Surface water	148	148	148	148	148	148
	Total Livestock Supply	754	754	754	754	754	754
	Livestock Balance	0	0	0	0	0	0

	Supply and Demand by Type of Use	***Year 2020 (ac-ft)***	***2030 (ac-ft)***	***2040 (ac-ft)***	***2050 (ac-ft)***	***2060 (ac-ft)***	***2070 (ac-ft)***
Total	Municipal and Industrial Demand	3,547	3,663	3,626	3,589	3,577	3,572
	Existing Municipal and Industrial Supply						
	Groundwater	7,330	7,330	7,330	7,330	7,330	7,330
	Surface water	0	0	0	0	0	0
	Total Municipal and Industrial Supply	7,330	7,330	7,330	7,330	7,330	7,330
	Municipal and Industrial Balance	3,783	3,667	3,704	3,741	3,753	3,758
	Agriculture Demand	3,758	3,908	4,066	4,232	4,405	4,588
	Existing Agricultural Supply						
	Groundwater	4,506	4,506	4,506	4,506	4,506	4,506
	Surface water	148	148	148	148	148	148
	Total Agriculture Supply	4,654	4,654	4,654	4,654	4,654	4,654
	Agriculture Balance	896	746	588	422	249	66
	Total Demand	7,305	7,571	7,692	7,821	7,982	8,160
	Total Supply						
	Groundwater	11,836	11,836	11,836	11,836	11,836	11,836
	Surface water	148	148	148	148	148	148
	Total Supply	11,984	11,984	11,984	11,984	11,984	11,984
	Total Balance	4,679	4,413	4,292	4,163	4,002	3,824

Table 4.9.
Duval County Municipal Water Demand and Supply by City/County (ac-ft)

City/County	*2020*	*2030*	*2040*	*2050*	*2060*	*2070*
Benavides						
Demand	236	242	250	259	266	272
Supply	368	368	368	368	368	368
Groundwater	368	368	368	368	368	368
Surface Water	—	—	—	—	—	—
Balance	132	126	118	109	102	96
Freer						
Demand	650	672	691	717	737	754
Supply	931	931	931	931	931	931
Groundwater	931	931	931	931	931	931
Surface Water	—	—	—	—	—	—
Balance	281	259	240	214	194	177
San Diego						
Demand	724	746	765	791	813	832
Supply	725	725	725	725	725	725
Groundwater	725	725	725	725	725	725
Surface Water	—	—	—	—	—	—
Balance	1	(21)	(40)	(66)	(88)	(107)
County-Other						
Demand	549	559	568	581	596	610
Supply	650	650	650	650	650	650
Groundwater	650	650	650	650	650	650
Surface Water	—	—	—	—	—	—
Balance	101	91	82	69	54	40
County Total						
Demand	2,159	2,219	2,274	2,348	2,412	2,468
Supply	2,674	2,674	2,674	2,674	2,674	2,674
Groundwater	2,674	2,674	2,674	2,674	2,674	2,674
Surface Water	—	—	—	—	—	—
Balance	515	455	400	326	262	206

4.3.5 Comparison of Demand to Supply – Jim Wells County

A summary of population, water demands, water supply, and shortages are shown by decade for the 2020 through 2070 period in Table 4.10 for all categories of water use. Table 4.11 includes a summary of municipal demands.

Demands

- For the period 2020 to 2070, municipal demand increases from 8,098 ac-ft in 2020 to 9,464 ac-ft in 2050, then to 10,444 ac-ft in 2070.
- Mining demand decreases from 71 ac-ft in 2020 to 17 ac-ft in 2070.
- For the period 2020 to 2070, irrigation demand increases from 2,500 ac-ft to 3,191 ac-ft; livestock demand is constant at 1,029 ac-ft.

Supplies

- Surface water is provided to the City of Alice from the CCR/LCC/Texana/MRP Phase II System; livestock needs are met with on-farm/local sources.
- Groundwater supplies are from the Gulf Coast Aquifer. San Diego groundwater supply is obtained from Duval County.

Comparison of Demand to Supply

- There are sufficient municipal supplies available through 2070 for Alice, Orange Grove, and Premont.
- Due to water well capacity limitations, the City of San Diego is projected to have a water shortage of 7 ac-ft/yr beginning in 2030, increasing to 51 ac-ft/yr in 2070.
- There are sufficient water supplies through 2070 to meet projected mining, irrigation, and livestock demands.

Table 4.10.
Jim Wells County Population, Water Supply, and Water Demand Projections

	Population Projection	2020	2030	2040	2050	2060	2070
		44,987	48,690	52,052	55,533	58,600	61,410
	Supply and Demand by Type of Use	**Year**					
		2020 (ac-ft)	**2030 (ac-ft)**	**2040 (ac-ft)**	**2050 (ac-ft)**	**2060 (ac-ft)**	**2070 (ac-ft)**
Municipal	Municipal Demand (See Table 4.11)	8,098	8,537	8,952	9,464	9,968	10,444
	Municipal Existing Supply						
	Groundwater	6,254	6,254	6,254	6,254	6,254	6,254
	Surface water	4,192	4,425	4,643	4,912	5,175	5,421
	Total Existing Municipal Supply	10,446	10,679	10,897	11,166	11,429	11,675
	Municipal Balance	2,348	2,142	1,945	1,702	1,461	1,231
Industrial	Manufacturing Demand	0	0	0	0	0	0
	Manufacturing Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	0	0	0	0	0	0
	Total Manufacturing Supply	0	0	0	0	0	0
	Manufacturing Balance	0	0	0	0	0	0
	Steam-Electric Demand	0	0	0	0	0	0
	Steam-Electric Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	0	0	0	0	0	0
	Total Steam-Electric Supply	0	0	0	0	0	0
	Steam-Electric Balance	0	0	0	0	0	0
	Mining Demand	71	74	55	40	26	17
	Mining Existing Supply						
	Groundwater	74	74	74	74	74	74
	Surface water	0	0	0	0	0	0
	Total Mining Supply	74	74	74	74	74	74
	Mining Balance	3	0	19	34	48	57
Agriculture	Irrigation Demand	2,500	2,625	2,756	2,894	3,039	3,191
	Irrigation Existing Supply						
	Groundwater	3,300	3,300	3,300	3,300	3,300	3,300
	Surface water	0	0	0	0	0	0
	Total Irrigation Supply	3,300	3,300	3,300	3,300	3,300	3,300
	Irrigation Balance	800	675	544	406	261	109
	Livestock Demand	1,029	1,029	1,029	1,029	1,029	1,029
	Livestock Existing Supply						
	Groundwater	627	627	627	627	627	627
	Surface water	402	402	402	402	402	402
	Total Livestock Supply	1,029	1,029	1,029	1,029	1,029	1,029
	Livestock Balance	0	0	0	0	0	0
Total	Municipal and Industrial Demand	8,169	8,611	9,007	9,504	9,994	10,461
	Existing Municipal and Industrial Supply						
	Groundwater	6,328	6,328	6,328	6,328	6,328	6,328
	Surface water	4,192	4,425	4,643	4,912	5,175	5,421
	Total Municipal and Industrial Supply	10,520	10,753	10,971	11,240	11,503	11,749
	Municipal and Industrial Balance	2,351	2,142	1,964	1,736	1,509	1,288
	Agriculture Demand	3,529	3,654	3,785	3,923	4,068	4,220
	Existing Agricultural Supply						
	Groundwater	3,927	3,927	3,927	3,927	3,927	3,927
	Surface water	402	402	402	402	402	402
	Total Agriculture Supply	4,329	4,329	4,329	4,329	4,329	4,329
	Agriculture Balance	800	675	544	406	261	109
	Total Demand	11,698	12,265	12,792	13,427	14,062	14,681
	Total Supply						
	Groundwater	10,255	10,255	10,255	10,255	10,255	10,255
	Surface water	4,594	4,827	5,045	5,314	5,577	5,823
	Total Supply	14,849	15,082	15,300	15,569	15,832	16,078
	Total Balance	3,151	2,817	2,508	2,142	1,770	1,397

Table 4.11.
Jim Wells County Municipal Water Demand and Supply by City/County (ac-ft)

City/County	2020	2030	2040	2050	2060	2070
Alice						
Demand	4,192	4,425	4,643	4,912	5,175	5,421
Supply	4,192	4,425	4,643	4,912	5,175	5,421
Groundwater	—	—	—	—	—	—
Surface Water	4,192	4,425	4,643	4,912	5,175	5,421
Balance	—	—	—	—	—	—
Orange Grove						
Demand	376	400	422	447	471	494
Supply	827	827	827	827	827	827
Groundwater	827	827	827	827	827	827
Surface Water	—	—	—	—	—	—
Balance	451	427	405	380	356	333
Premont						
Demand	710	752	792	841	886	929
Supply	1,808	1,808	1,808	1,808	1,808	1,808
Groundwater	1,808	1,808	1,808	1,808	1,808	1,808
Surface Water	—	—	—	—	—	—
Balance	1,098	1,056	1,016	967	922	879
San Diego						
Demand	186	196	205	217	229	240
Supply	189	189	189	189	189	189
Groundwater	189	189	189	189	189	189
Surface Water	—	—	—	—	—	—
Balance	3	(7)	(16)	(28)	(40)	(51)
County-Other						
Demand	2,634	2,764	2,890	3,047	3,207	3,360
Supply	3,430	3,430	3,430	3,430	3,430	3,430
Groundwater	3,430	3,430	3,430	3,430	3,430	3,430
Surface Water	—	—	—	—	—	—
Balance	796	666	540	383	223	70
County Total						
Demand	8,098	8,537	8,952	9,464	9,968	10,444
Supply	10,446	10,679	10,897	11,166	11,429	11,675
Groundwater	6,254	6,254	6,254	6,254	6,254	6,254
Surface Water	4,192	4,425	4,643	4,912	5,175	5,421
Balance	2,348	2,142	1,945	1,702	1,461	1,231

4.3.6 Comparison of Demand to Supply – Kenedy County

A summary of population, water demands, water supply, and shortages are shown by decade for the 2020 through 2070 period in Table 4.12 for all categories of water use. Table 4.13 includes a summary of municipal demands.

Demands

- For the period 2020 to 2070, municipal demand increases from 244 ac-ft in 2020 to 264 ac-ft in 2070.
- Mining demand decreases from 118 ac-ft in 2020 to 27 ac-ft in 2070.
- Livestock demand is constant at 644 ac-ft.

Supplies

- Surface water for livestock needs is provided from on-farm and local sources.
- Groundwater supplies are from the Gulf Coast Aquifer.

Comparison of Demand to Supply

- All municipal, industrial, and agriculture demands are met through 2070.

Table 4.12.
Kenedy County Population, Water Supply, and Water Demand Projections

	Population Projection	2020	2030	2040	2050	2060	2070
		463	498	504	507	508	508
	Supply and Demand by Type of Use	Year					
		2020 (ac-ft)	2030 (ac-ft)	2040 (ac-ft)	2050 (ac-ft)	2060 (ac-ft)	2070 (ac-ft)
Municipal	Municipal Demand (See Table 4.13)	244	261	262	263	264	264
	Municipal Existing Supply						
	Groundwater	305	305	305	305	305	305
	Surface water	0	0	0	0	0	0
	Total Existing Municipal Supply	305	305	305	305	305	305
	Municipal Balance	61	44	43	42	41	41
Industrial	Manufacturing Demand	0	0	0	0	0	0
	Manufacturing Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	0	0	0	0	0	0
	Total Manufacturing Supply	0	0	0	0	0	0
	Manufacturing Balance	0	0	0	0	0	0
	Steam-Electric Demand	0	0	0	0	0	0
	Steam-Electric Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	0	0	0	0	0	0
	Total Steam-Electric Supply	0	0	0	0	0	0
	Steam-Electric Balance	0	0	0	0	0	0
	Mining Demand	118	123	92	68	43	27
	Mining Existing Supply						
	Groundwater	130	130	130	130	130	130
	Surface water	0	0	0	0	0	0
	Total Mining Supply	130	130	130	130	130	130
	Mining Balance	12	7	38	62	87	103
Agriculture	Irrigation Demand	0	0	0	0	0	0
	Irrigation Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	0	0	0	0	0	0
	Total Irrigation Supply	0	0	0	0	0	0
	Irrigation Balance	0	0	0	0	0	0
	Livestock Demand	644	644	644	644	644	644
	Livestock Existing Supply						
	Groundwater	644	644	644	644	644	644
	Surface water	0	0	0	0	0	0
	Total Livestock Supply	644	644	644	644	644	644
	Livestock Balance	0	0	0	0	0	0
Total	Municipal and Industrial Demand	362	384	354	331	307	291
	Existing Municipal and Industrial Supply						
	Groundwater	435	435	435	435	435	435
	Surface water	0	0	0	0	0	0
	Total Municipal and Industrial Supply	435	435	435	435	435	435
	Municipal and Industrial Balance	73	51	81	104	128	144
	Agriculture Demand	644	644	644	644	644	644
	Existing Agricultural Supply						
	Groundwater	644	644	644	644	644	644
	Surface water	0	0	0	0	0	0
	Total Agriculture Supply	644	644	644	644	644	644
	Agriculture Balance	0	0	0	0	0	0
	Total Demand	1,006	1,028	998	975	951	935
	Total Supply						
	Groundwater	1,079	1,079	1,079	1,079	1,079	1,079
	Surface water	0	0	0	0	0	0
	Total Supply	1,079	1,079	1,079	1,079	1,079	1,079
	Total Balance	73	51	81	104	128	144

Table 4.13.
Kenedy County Municipal Water Demand and Supply by City/County (ac-ft)

City/County	2020	2030	2040	2050	2060	2070
County-Other						
Demand	244	261	262	263	264	264
Supply	305	305	305	305	305	305
Groundwater	305	305	305	305	305	305
Surface Water	—	—	—	—	—	—
Balance	61	44	43	42	41	41
County Total						
Demand	244	261	262	263	264	264
Supply	305	305	305	305	305	305
Groundwater	305	305	305	305	305	305
Surface Water	—	—	—	—	—	—
Balance	61	44	43	42	41	41

4.3.7 Comparison of Demand to Supply – Kleberg County

A summary of population, water demands, water supply, and shortages are shown by decade for the 2020 through 2070 period in Table 4.14 for all categories of water use. Table 4.15 includes a summary of municipal demands.

Demands

- For the period 2020 to 2070, municipal demand increases from 5,174 ac-ft in 2020 to 6,907 ac-ft in 2070.
- Mining demand decreases from 357 ac-ft in 2020 to 324 ac-ft in 2050 to 298 ac-ft in 2070.
- For the period 2020 to 2070, irrigation demand increases from 600 ac-ft to 766 ac-ft; livestock demand is constant at 1,276 ac-ft.

Supplies

- Surface water is supplied to municipal users from the CCR/LCC/Texana/MRP Phase II System via the STWA; some livestock needs are met with on farm/local sources.
- Groundwater supplies are from the Gulf Coast Aquifer and limited by water well capacity which was estimated based on TWDB historical water use records from 2000-2011. There is sufficient MAG available.

Comparison of Demand to Supply

- The City of Kingsville supplies its own groundwater and purchases surface water from the STWA and has no projected shortages through 2070.
- There are sufficient municipal, mining, irrigation, and livestock supplies through 2070.

Table 4.14.
Kleberg County Population, Water Supply, and Water Demand Projections

	Population Projection	2020	2030	2040	2050	2060	2070
		35,567	38,963	42,202	45,324	48,251	50,989
	Supply and Demand by Type of Use	**Year**					
		2020 (ac-ft)	**2030 (ac-ft)**	**2040 (ac-ft)**	**2050 (ac-ft)**	**2060 (ac-ft)**	**2070 (ac-ft)**
Municipal	Municipal Demand (See Table 4.15)	5,174	5,481	5,799	6,158	6,539	6,907
	Municipal Existing Supply						
	Groundwater	7,763	7,763	7,763	7,763	7,763	7,763
	Surface water	799	928	1,059	1,369	1,705	2,029
	Total Existing Municipal Supply	8,562	8,691	8,822	9,132	9,468	9,792
	Municipal Balance	3,388	3,210	3,023	2,974	2,929	2,885
Industrial	Manufacturing Demand	0	0	0	0	0	0
	Manufacturing Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	0	0	0	0	0	0
	Total Manufacturing Supply	0	0	0	0	0	0
	Manufacturing Balance	0	0	0	0	0	0
	Steam-Electric Demand	0	0	0	0	0	0
	Steam-Electric Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	0	0	0	0	0	0
	Total Steam-Electric Supply	0	0	0	0	0	0
	Steam-Electric Balance	0	0	0	0	0	0
	Mining Demand	357	360	340	324	308	298
	Mining Existing Supply						
	Groundwater	380	380	380	380	380	380
	Surface water	0	0	0	0	0	0
	Total Mining Supply	380	380	380	380	380	380
	Mining Balance	23	20	40	56	72	82
Agriculture	Irrigation Demand	600	630	662	695	729	766
	Irrigation Existing Supply						
	Groundwater	800	800	800	800	800	800
	Surface water	0	0	0	0	0	0
	Total Irrigation Supply	800	800	800	800	800	800
	Irrigation Balance	200	170	138	105	71	34
	Livestock Demand	1,276	1,276	1,276	1,276	1,276	1,276
	Livestock Existing Supply						
	Groundwater	1,276	1,276	1,276	1,276	1,276	1,276
	Surface water	0	0	0	0	0	0
	Total Livestock Supply	1,276	1,276	1,276	1,276	1,276	1,276
	Livestock Balance	0	0	0	0	0	0
Total	Municipal and Industrial Demand	5,531	5,841	6,139	6,482	6,847	7,205
	Existing Municipal and Industrial Supply						
	Groundwater	8,143	8,143	8,143	8,143	8,143	8,143
	Surface water	799	928	1,059	1,369	1,705	2,029
	Total Municipal and Industrial Supply	8,942	9,071	9,202	9,512	9,848	10,172
	Municipal and Industrial Balance	3,411	3,230	3,063	3,030	3,001	2,967
	Agriculture Demand	1,876	1,906	1,938	1,971	2,005	2,042
	Existing Agricultural Supply						
	Groundwater	2,076	2,076	2,076	2,076	2,076	2,076
	Surface water	0	0	0	0	0	0
	Total Agriculture Supply	2,076	2,076	2,076	2,076	2,076	2,076
	Agriculture Balance	200	170	138	105	71	34
	Total Demand	7,407	7,747	8,077	8,453	8,852	9,247
	Total Supply						
	Groundwater	10,219	10,219	10,219	10,219	10,219	10,219
	Surface water	799	928	1,059	1,369	1,705	2,029
	Total Supply	11,018	11,147	11,278	11,588	11,924	12,248
	Total Balance	3,611	3,400	3,201	3,135	3,072	3,001

Table 4.15.
Kleberg County Municipal Water Demand and Supply by City/County (ac-ft)

City/County	2020	2030	2040	2050	2060	2070
Kingsville						
Demand	4,232	4,483	4,738	5,025	5,336	5,636
Supply	4,588	4,697	4,807	5,094	5,405	5,705
Groundwater	4,130	4,130	4,130	4,130	4,130	4,130
Surface Water	458	567	677	964	1,275	1,575
Balance	356	214	69	69	69	69
Ricardo WSC						
Demand	341	361	382	405	430	454
Supply	341	361	382	405	430	454
Groundwater	—	—	—	—	—	—
Surface Water	341	361	382	405	430	454
Balance	—	—	—	—	—	—
County-Other						
Demand	601	637	679	728	773	817
Supply	3,633	3,633	3,633	3,633	3,633	3,633
Groundwater	3,633	3,633	3,633	3,633	3,633	3,633
Surface Water	—	—	—	—	—	—
Balance	3,032	2,996	2,954	2,905	2,860	2,816
County Total						
Demand	5,174	5,481	5,799	6,158	6,539	6,907
Supply	8,562	8,691	8,822	9,132	9,468	9,792
Groundwater	7,763	7,763	7,763	7,763	7,763	7,763
Surface Water	799	928	1,059	1,369	1,705	2,029
Balance	3,388	3,210	3,023	2,974	2,929	2,885

4.3.8 Comparison of Demand to Supply – Live Oak County

A summary of population, water demands, water supply, and shortages are shown by decade for the 2020 through 2070 period in Table 4.16 for all categories of water use. Table 4.17 includes a summary of municipal demands.

Demands

- For the period 2020 to 2070, municipal demand decreases from 1,746 ac-ft in 2020 to 1,649 ac-ft in 2050 then to 1,640 ac-ft in 2070.
- Manufacturing demands increase from 2,024 ac-ft in 2020 to 2,333 ac-ft in 2070.
- Mining demand decreases from 814 ac-ft to 332 ac-ft from 2020 to 2070.
- For the period 2020 to 2070, irrigation demand increases from 2,200 ac-ft to 2,808 ac-ft; livestock demand is constant at 933 ac-ft.

Supplies

- Surface water is supplied from the CCR/LCC/Texana/MRP Phase II System and City of Three Rivers water rights on the Nueces River firm supply of 700 ac-ft/yr; some livestock needs are met with on-farm/local sources.
- Groundwater supplies are from the Carrizo-Wilcox and Gulf Coast Aquifers.

Comparison of Demand to Supply

- Three Rivers has a surplus of 824 ac-ft in 2020 and 844 ac-ft in 2070.
- There are no projected water shortages in the County through the planning period.

Table 4.16.
Live Oak County Population, Water Supply, and Water Demand Projections

	Population Projection	2020	2030	2040	2050	2060	2070
		11,683	11,690	11,690	11,690	11,690	11,690
	Supply and Demand by Type of Use	Year					
		2020 (ac-ft)	2030 (ac-ft)	2040 (ac-ft)	2050 (ac-ft)	2060 (ac-ft)	2070 (ac-ft)
Municipal	Municipal Demand (See Table 4.17)	1,746	1,702	1,668	1,649	1,640	1,640
	Municipal Existing Supply						
	Groundwater	2,809	2,809	2,809	2,809	2,809	2,809
	Surface water	700	700	700	700	700	700
	Total Existing Municipal Supply	3,509	3,509	3,509	3,509	3,509	3,509
	Municipal Balance	1,763	1,807	1,841	1,860	1,869	1,869
Industrial	Manufacturing Demand	2,024	2,058	2,089	2,114	2,221	2,333
	Manufacturing Existing Supply						
	Groundwater	891	891	891	891	891	891
	Surface water	4,163	4,163	4,163	4,163	4,163	4,163
	Total Manufacturing Supply	5,054	5,054	5,054	5,054	5,054	5,054
	Manufacturing Balance	3,030	2,996	2,965	2,940	2,833	2,721
	Steam-Electric Demand	0	0	0	0	0	0
	Steam-Electric Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	0	0	0	0	0	0
	Total Steam-Electric Supply	0	0	0	0	0	0
	Steam-Electric Balance	0	0	0	0	0	0
	Mining Demand	814	917	907	729	492	332
	Mining Existing Supply						
	Groundwater	920	920	920	920	920	920
	Surface water	0	0	0	0	0	0
	Total Mining Supply	920	920	920	920	920	920
	Mining Balance	106	3	13	191	428	588
Agriculture	Irrigation Demand	2,200	2,310	2,426	2,547	2,674	2,808
	Irrigation Existing Supply						
	Groundwater	2,900	2,900	2,900	2,900	2,900	2,900
	Surface water	0	0	0	0	0	0
	Total Irrigation Supply	2,900	2,900	2,900	2,900	2,900	2,900
	Irrigation Balance	700	590	474	353	226	92
	Livestock Demand	933	933	933	933	933	933
	Livestock Existing Supply						
	Groundwater	681	681	681	681	681	681
	Surface water	252	252	252	252	252	252
	Total Livestock Supply	933	933	933	933	933	933
	Livestock Balance	0	0	0	0	0	0
Total	Municipal and Industrial Demand	4,584	4,677	4,664	4,492	4,353	4,305
	Existing Municipal and Industrial Supply						
	Groundwater	4,620	4,620	4,620	4,620	4,620	4,620
	Surface water	4,863	4,863	4,863	4,863	4,863	4,863
	Total Municipal and Industrial Supply	9,483	9,483	9,483	9,483	9,483	9,483
	Municipal and Industrial Balance	4,899	4,806	4,819	4,991	5,130	5,178
	Agriculture Demand	3,133	3,243	3,359	3,480	3,607	3,741
	Existing Agricultural Supply						
	Groundwater	3,581	3,581	3,581	3,581	3,581	3,581
	Surface water	252	252	252	252	252	252
	Total Agriculture Supply	3,833	3,833	3,833	3,833	3,833	3,833
	Agriculture Balance	700	590	474	353	226	92
	Total Demand	7,717	7,920	8,023	7,972	7,960	8,046
	Total Supply						
	Groundwater	8,201	8,201	8,201	8,201	8,201	8,201
	Surface water	5,115	5,115	5,115	5,115	5,115	5,115
	Total Supply	13,316	13,316	13,316	13,316	13,316	13,316
	Total Balance	5,599	5,396	5,293	5,344	5,356	5,270

Table 4.17.
Live Oak County Municipal Water Demand and Supply by City/County (ac-ft)

City/County	2020	2030	2040	2050	2060	2070
El Oso WSC						
Demand	143	139	137	135	129	129
Supply	451	451	451	451	451	451
Groundwater	451	451	451	451	451	451
Surface Water	—	—	—	—	—	—
Balance	308	312	314	316	322	322
George West						
Demand	454	443	433	429	428	428
Supply	877	877	877	877	877	877
Groundwater	877	877	877	877	877	877
Surface Water	—	—	—	—	—	—
Balance	423	434	444	448	449	449
McCoy WSC						
Demand	22	21	21	20	20	20
Supply	30	30	30	30	30	30
Groundwater	30	30	30	30	30	30
Surface Water	—	—	—	—	—	—
Balance	8	9	9	10	10	10
Three Rivers						
Demand	325	316	309	305	305	305
Supply	1,149	1,149	1,149	1,149	1,149	1,149
Groundwater	449	449	449	449	449	449
Surface Water	700	700	700	700	700	700
Balance	824	833	840	844	844	844
County-Other						
Demand	802	783	768	760	758	758
Supply	1,002	1,002	1,002	1,002	1,002	1,002
Groundwater	1,002	1,002	1,002	1,002	1,002	1,002
Surface Water	—	—	—	—	—	—
Balance	200	219	234	242	244	244
County Total						
Demand	1,746	1,702	1,668	1,649	1,640	1,640
Supply	3,509	3,509	3,509	3,509	3,509	3,509
Groundwater	2,809	2,809	2,809	2,809	2,809	2,809
Surface Water	700	700	700	700	700	700
Balance	1,763	1,807	7,841	1,860	1,869	1,869

4.3.9 Comparison of Demand to Supply – McMullen County

A summary of population, water demands, water supply, and shortages are shown by decade for the 2020 through 2070 period in Table 4.18 for all categories of water use. Table 4.19 includes a summary of municipal demands.

Demands

- For the period 2020 to 2070, municipal demand decreases from 97 ac-ft in 2020 to 90 ac-ft in 2070.
- Mining demand decreases from 4,268 ac-ft to 1,305 ac-ft from 2020 to 2070.
- Irrigation demand increases from 40 ac-ft to 51 ac-ft from 2020 to 2070.
- Livestock demand is constant at 355 ac-ft.

Supplies

- Groundwater supplies are from the Carrizo-Wilcox and Gulf Coast Aquifers.
- Surface water for livestock needs is met by on-farm/local sources.

Comparison of Demand to Supply

- All municipal and livestock demands are met through 2070.
- There is a projected mining water shortage of 2,733 ac-ft/yr in 2020, decreasing to 315 ac-ft/yr in 2060. In 2070, mining shows a surplus of 230 ac-ft.
- There is not a supply source identified for the irrigation demands, resulting in an irrigation shortage in all decades.

Table 4.18. McMullen County Population, Water Supply, and Water Demand Projections

	Population Projection	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
		734	734	734	734	734	734
	Supply and Demand by Type of Use	**Year**					
		2020 (ac-ft)	**2030 (ac-ft)**	**2040 (ac-ft)**	**2050 (ac-ft)**	**2060 (ac-ft)**	**2070 (ac-ft)**
Municipal	Municipal Demand (See Table 4.19)	97	94	91	90	90	90
	Municipal Existing Supply						
	Groundwater	546	546	546	546	546	546
	Surface water	0	0	0	0	0	0
	Total Existing Municipal Supply	546	546	546	546	546	546
	Municipal Balance	449	452	455	456	456	456
Industrial	Manufacturing Demand	0	0	0	0	0	0
	Manufacturing Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	0	0	0	0	0	0
	Total Manufacturing Supply	0	0	0	0	0	0
	Manufacturing Balance	0	0	0	0	0	0
	Steam-Electric Demand	0	0	0	0	0	0
	Steam-Electric Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	0	0	0	0	0	0
	Total Steam-Electric Supply	0	0	0	0	0	0
	Steam-Electric Balance	0	0	0	0	0	0
	Mining Demand	4,268	4,804	4,754	2,622	1,850	1,305
	Mining Existing Supply						
	Groundwater	1,535	1,535	1,535	1,535	1,535	1,535
	Surface water	0	0	0	0	0	0
	Total Mining Supply	1,535	1,535	1,535	1,535	1,535	1,535
	Mining Balance	(2,733)	(3,269)	(3,219)	(1,087)	(315)	230
Agriculture	Irrigation Demand	40	42	44	46	49	51
	Irrigation Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	0	0	0	0	0	0
	Total Irrigation Supply	0	0	0	0	0	0
	Irrigation Balance	(40)	(42)	(44)	(46)	(49)	(51)
	Livestock Demand	355	355	355	355	355	355
	Livestock Existing Supply						
	Groundwater	93	93	93	93	93	93
	Surface water	262	262	262	262	262	262
	Total Livestock Supply	355	355	355	355	355	355
	Livestock Balance	0	0	0	0	0	0
Total	Municipal and Industrial Demand	4,365	4,898	4,845	2,712	1,940	1,395
	Existing Municipal and Industrial Supply						
	Groundwater	2,081	2,081	2,081	2,081	2,081	2,081
	Surface water	0	0	0	0	0	0
	Total Municipal and Industrial Supply	2,081	2,081	2,081	2,081	2,081	2,081
	Municipal and Industrial Balance	(2,284)	(2,817)	(2,764)	(631)	141	686
	Agriculture Demand	395	397	399	401	404	406
	Existing Agricultural Supply						
	Groundwater	93	93	93	93	93	93
	Surface water	262	262	262	262	262	262
	Total Agriculture Supply	355	355	355	355	355	355
	Agriculture Balance	(40)	(42)	(44)	(46)	(49)	(51)
	Total Demand	4,760	5,295	5,244	3,113	2,344	1,801
	Total Supply						
	Groundwater	2,174	2,174	2,174	2,174	2,174	2,174
	Surface water	262	262	262	262	262	262
	Total Supply	2,436	2,436	2,436	2,436	2,436	2,436
	Total Balance	(2,324)	(2,859)	(2,808)	(677)	92	635

Table 4.19.
McMullen County Municipal Water Demand and Supply by City/County (ac-ft)

City/County	2020	2030	2040	2050	2060	2070
County-Other						
Demand	97	94	91	90	90	90
Supply	546	546	546	546	546	546
Groundwater	546	546	546	546	546	546
Surface Water	—	—	—	—	—	—
Balance	449	452	455	456	456	456
County Total						
Demand	97	94	91	90	90	90
Supply	546	546	546	546	546	546
Groundwater	546	546	546	546	546	546
Surface Water	—	—	—	—	—	—
Balance	449	452	455	456	456	456

4.3.10 Comparison of Demand to Supply – Nueces County

A summary of population, water demands, water supply, and shortages are shown by decade for the 2020 through 2070 period in Table 4.20 for all categories of water use. Table 4.21 includes a summary of municipal demands.

Demands

- For the period 2020 to 2070, municipal demand increases from 73,171 ac-ft in 2020 to 84,520 ac-ft in 2070. Due to anticipated industrial growth in the area, Nueces County municipal water use will likely be higher than TWDB approved municipal demand projections shown in this section. Although the TWDB approved increases in San Patricio and Nueces industrial water demands, it rejected the proposed CBRWPG-approved increases in Nueces County municipal water demands which will likely occur.
- Manufacturing demand increases from 50,276 ac-ft in 2020 to 67,769 ac-ft in 2070.
- Mining demand increases from 724 ac-ft in 2020 to 1,260 ac-ft in 2070; steam-electric demand increases from 15,038 ac-ft in 2020 to 34,541 ac-ft in 2070. Steam-Electric water demands include Lon Hill and potential, future steam-electric power plants as accounted for by TWDB studies.
- For the period 2020 to 2070, irrigation demand increases from 439 ac-ft to 560 ac-ft; livestock demand is constant at 315 ac-ft.

Supplies

- Surface water is supplied from the CCR/LCC/Texana/MRP Phase II System, SPMWD, STWA, and Nueces County WCID #3; some livestock needs are met with on-farm/local sources.
- Groundwater supplies are from the Gulf Coast Aquifer.

Comparison of Demand to Supply

- Robstown has shortages from 2020 to 2070, with the greatest shortage of 1,583 ac-ft in 2020. Shortages are attributed to NCWC&ID#3 water supply limits during drought of record conditions. A small, local balancing storage reservoir is recommended for Nueces County WCID #3 use during drought events to firm up water to meet Robstown and other customers needs in full through 2070.
- County-Other receives water supplies from the City of Corpus Christi, STWA, and Nueces County WCID #3.
- Manufacturing has shortages ranging from 1,905 ac-ft/yr in 2050 to 19,603 ac-ft/yr in 2070. The shortages are attributable to both raw water and water treatment plant constraints.
- Steam-Electric has shortages ranging from 2,846 ac-ft/yr in 2060 to 19,603 ac-ft/yr in 2070. The shortages are attributable to both raw water and water treatment plant constraints.
- Mining is not projected to have a shortage during the planning period.
- There are sufficient irrigation and livestock supplies through 2070.

Table 4.20. Nueces County Population, Water Supply, and Water Demand Projections

	Population Projection	2020	2030	2040	2050	2060	2070
		374,157	407,534	428,513	440,797	449,936	456,056
	Supply and Demand by Type of Use	Year					
		2020 (ac-ft)	2030 (ac-ft)	2040 (ac-ft)	2050 (ac-ft)	2060 (ac-ft)	2070 (ac-ft)
Municipal	Municipal Demand (See Table 4.21)	73,171	77,719	80,303	81,882	83,417	84,520
	Municipal Existing Supply						
	Groundwater	1,808	1,808	1,808	1,808	1,808	1,808
	Surface water	70,268	74,656	77,160	78,669	80,138	81,190
	Total Existing Municipal Supply	72,076	76,464	78,968	80,477	81,946	82,998
	Municipal Balance	(1,095)	(1,255)	(1,335)	(1,405)	(1,471)	(1,522)
Industrial	Manufacturing Demand	50,276	53,425	56,500	59,150	63,313	67,769
	Manufacturing Existing Supply						
	Groundwater	4,866	4,866	4,866	4,866	4,866	4,866
	Surface water	74,639	66,255	59,277	52,379	47,466	43,300
	Total Manufacturing Supply	79,505	71,121	64,143	57,245	52,332	48,166
	Manufacturing Balance	29,229	17,696	7,643	(1,905)	(10,981)	(19,603)
	Steam-Electric Demand	15,038	17,582	20,681	24,461	29,067	34,541
	Steam-Electric Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	15,038	17,582	20,681	24,461	26,221	27,648
	Total Steam-Electric Supply	15,038	17,582	20,681	24,461	26,221	27,648
	Steam-Electric Balance	0	0	0	0	(2,846)	(6,893)
	Mining Demand	724	853	947	1,021	1,130	1,260
	Mining Existing Supply						
	Groundwater	504	504	504	504	504	504
	Surface water	220	349	443	517	626	756
	Total Mining Supply	724	853	947	1,021	1,130	1,260
	Mining Balance	0	0	0	0	0	0
Agriculture	Irrigation Demand	439	461	484	508	534	560
	Irrigation Existing Supply						
	Groundwater	701	701	701	701	701	701
	Surface water	0	0	0	0	0	0
	Total Irrigation Supply	701	701	701	701	701	701
	Irrigation Balance	262	240	217	193	167	141
	Livestock Demand	315	315	315	315	315	315
	Livestock Existing Supply						
	Groundwater	279	279	279	279	279	279
	Surface water	36	36	36	36	36	36
	Total Livestock Supply	315	315	315	315	315	315
	Livestock Balance	0	0	0	0	0	0
Total	Municipal and Industrial Demand	139,209	149,579	158,431	166,514	176,927	188,090
	Existing Municipal and Industrial Supply						
	Groundwater	7,178	7,178	7,178	7,178	7,178	7,178
	Surface water	160,165	158,842	157,561	156,026	154,451	152,894
	Total Municipal and Industrial Supply	167,343	166,020	164,739	163,204	161,629	160,072
	Municipal and Industrial Balance	28,134	16,441	6,308	(3,310)	(15,298)	(28,018)
	Agriculture Demand	754	776	799	823	849	875
	Existing Agricultural Supply						
	Groundwater	980	980	980	980	980	980
	Surface water	36	36	36	36	36	36
	Total Agriculture Supply	1,016	1,016	1,016	1,016	1,016	1,016
	Agriculture Balance	262	240	217	193	167	141
	Total Demand	139,963	150,355	159,230	167,337	177,776	188,965
	Total Supply						
	Groundwater	8,158	8,158	8,158	8,158	8,158	8,158
	Surface water	160,201	158,878	157,597	156,062	154,487	152,930
	Total Supply	168,359	167,036	165,755	164,220	162,645	161,088
	Total Balance	28,396	16,681	6,525	(3,117)	(15,131)	(27,877)

Table 4.21.
Nueces County Municipal Water Demand and Supply by City/County (ac-ft)

City/County	*2020*	*2030*	*2040*	*2050*	*2060*	*2070*
Agua Dulce						
Demand	132	139	143	145	148	150
Supply	132	139	143	145	148	150
Groundwater	—	—	—	—	—	—
Surface Water	132	139	143	145	148	150
Balance	—	—	—	—	—	—
Aransas Pass						
Demand	3	3	3	3	3	3
Supply	3	3	3	3	3	3
Groundwater	—	—	—	—	—	—
Surface Water	3	3	3	3	3	3
Balance	—	—	—	—	—	—
Bishop						
Demand	594	628	646	660	673	682
Supply	594	628	646	660	673	682
Groundwater	242	242	242	242	242	242
Surface Water	352	386	404	418	431	440
Balance	—	—	—	—	—	—
Corpus Christi						
Demand	64,816	68,931	71,270	72,680	74,064	75,058
Supply	64,816	68,931	71,270	72,680	74,064	75,058
Groundwater	—	—	—	—	—	—
Surface Water	64,816	68,931	71,270	72,680	74,064	75,058
Balance	—	—	—	—	—	—
Driscoll						
Demand	105	110	113	114	116	118
Supply	105	110	113	114	116	118
Groundwater	—	—	—	—	—	—
Surface Water	105	110	113	114	116	118
Balance	—	—	—	—	—	—
Nueces WSC						
Demand	333	355	368	376	383	388
Supply	333	355	368	376	383	388
Groundwater	—	—	—	—	—	—
Surface Water	333	355	368	376	383	388
Balance	—	—	—	—	—	—
Port Aransas						
Demand	2,251	2,434	2,548	2,614	2,667	2,703
Supply	2,251	2,434	2,548	2,614	2,667	2,703
Groundwater	—	—	—	—	—	—
Surface Water	2,251	2,434	2,548	2,614	2,667	2,703
Balance	—	—	—	—	—	—

City/County	***2020***	***2030***	***2040***	***2050***	***2060***	***2070***
River Acres WSC						
Demand	426	450	463	470	479	486
Supply	426	450	463	470	479	486
Groundwater	—	—	—	—	—	—
Surface Water	426	450	463	470	479	486
Balance	—	—	—	—	—	—
Robstown						
Demand	2,957	2,897	2,848	2,843	2,839	2,839
Supply	1,374	1,350	1,337	1,330	1,321	1,314
Groundwater	—	—	—	—	—	—
Surface Water	1,374	1,350	1,337	1,330	1,321	1,314
Balance	(1,583)	(1,547)	(1,511)	(1,513)	(1,518)	(1,525)
County-Other						
Demand	1,554	1,772	1,901	1,977	2,045	2,093
Supply	2,042	2,064	2,077	2,085	2,092	2,096
Groundwater	1,566	1,566	1,566	1,566	1,566	1,566
Surface Water	476	498	511	519	526	530
Balance	488	292	176	108	47	3
County Total						
Demand	73,171	77,719	80,303	81,882	83,417	84,520
Supply	72,076	76,464	78,968	80,477	81,946	82,998
Groundwater	1,808	1,808	1,808	1,808	1,808	1,808
Surface Water	70,268	74,656	77,160	78,669	80,138	81,190
Balance	(1,095)	(1,255)	(1,335)	(1,405)	(1,471)	(1,522)

4.3.11 Comparison of Demand to Supply – San Patricio County

A summary of population, water demands, water supply, and shortages are shown by decade for the 2020 through 2070 period in Table 4.22 for all categories of water use. Table 4.23 includes a summary of municipal demands.

Demands

- For the period 2020 to 2070, municipal demand increases from 10,145 ac-ft in 2020 to 10,685 ac-ft in 2070. Due to anticipated industrial growth in the area, San Patricio County municipal water use will likely be higher than the TWDB approved municipal water demand projections shown in this section. Although the TWDB approved increases in San Patricio and Nueces industrial water demands, it rejected the proposed CBRWPG-approved increases in projected San Patricio County municipal water demands.
- Manufacturing demand increases from 39,737 ac-ft in 2020 to 56,991 ac-ft in 2070.
- Mining increases from 372 ac-ft in 2020 to 533 ac-ft in 2070.
- For the period 2020 to 2070, irrigation demand increases from 11,085 ac-ft to 18,632 ac-ft; livestock demand is constant at 406 ac-ft.

Supplies

- Surface water is supplied from the CCR/LCC/Texana/MRP Phase II System; the SPMWD has a contract to purchase 51,200 ac-ft of water annually from the City of Corpus Christi; some livestock demands are met with on-farm/local sources.
- Groundwater supplies are from the Gulf Coast Aquifer.
- Groundwater supply for irrigation was set equal to the maximum historical pumping (i.e. estimated well capacity).

Comparison of Demand to Supply

- There are no projected municipal shortages during the planning period.
- Supplies for irrigation are constrained by well capacity, resulting in an irrigation shortage of 499 ac-ft/yr in 2050, increasing to 4,191 ac-ft/yr in 2070.
- There are sufficient mining supplies through the year 2070.
- Manufacturing has projected shortages from 6,451 ac-ft/yr in 2020 to 18,529 ac-ft in 2070 as a result of both raw water constraints and treatment plants' constraints.

Table 4.22. San Patricio County Population, Water Supply, and Water Demand Projections

	Population Projection	2020	2030	2040	2050	2060	2070
		68,760	72,114	74,043	75,451	76,405	77,049
	Supply and Demand by Type of Use	**Year**					
		2020 (ac-ft)	**2030 (ac-ft)**	**2040 (ac-ft)**	**2050 (ac-ft)**	**2060 (ac-ft)**	**2070 (ac-ft)**
Municipal	Municipal Demand (See Table 4.23)	10,145	10,323	10,391	10,489	10,598	10,685
	Municipal Existing Supply						
	Groundwater	3,467	3,467	3,467	3,467	3,467	3,467
	Surface water	7,244	7,382	7,436	7,519	7,610	7,684
	Total Existing Municipal Supply	10,711	10,849	10,903	10,986	11,077	11,151
	Municipal Balance	566	526	512	497	479	466
Industrial	Manufacturing Demand	39,737	43,098	46,416	49,338	53,027	56,991
	Manufacturing Existing Supply						
	Groundwater	12	12	12	12	12	12
	Surface water	33,274	34,282	35,278	36,154	37,261	38,450
	Total Manufacturing Supply	33,286	34,294	35,290	36,166	37,273	38,462
	Manufacturing Balance	(6,451)	(8,804)	(11,126)	(13,172)	(15,754)	(18,529)
	Steam-Electric Demand	0	0	0	0	0	0
	Steam-Electric Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	0	0	0	0	0	0
	Total Steam-Electric Supply	0	0	0	0	0	0
	Steam-Electric Balance	0	0	0	0	0	0
	Mining Demand	372	421	440	460	492	533
	Mining Existing Supply						
	Groundwater	565	565	565	565	565	565
	Surface water	0	0	0	0	0	0
	Total Mining Supply	565	565	565	565	565	565
	Mining Balance	193	144	125	105	73	32
Agriculture	Irrigation Demand	11,085	12,244	13,525	14,940	16,504	18,632
	Irrigation Existing Supply						
	Groundwater	14,441	14,441	14,441	14,441	14,441	14,441
	Surface water	0	0	0	0	0	0
	Total Irrigation Supply	14,441	14,441	14,441	14,441	14,441	14,441
	Irrigation Balance	3,356	2,197	916	(499)	(2,063)	(4,191)
	Livestock Demand	406	406	406	406	406	406
	Livestock Existing Supply						
	Groundwater	291	291	291	291	291	291
	Surface water	115	115	115	115	115	115
	Total Livestock Supply	406	406	406	406	406	406
	Livestock Balance	0	0	0	0	0	0
Total	Municipal and Industrial Demand	50,254	53,842	57,247	60,287	64,117	68,209
	Existing Municipal and Industrial Supply						
	Groundwater	4,044	4,044	4,044	4,044	4,044	4,044
	Surface water	40,518	41,664	42,714	43,673	44,871	46,134
	Total Municipal and Industrial Supply	44,562	45,708	46,758	47,717	48,915	50,178
	Municipal and Industrial Balance	(5,692)	(8,134)	(10,489)	(12,570)	(15,202)	(18,031)
	Agriculture Demand	11,491	12,650	13,931	15,346	16,910	19,038
	Existing Agricultural Supply						
	Groundwater	14,732	14,732	14,732	14,732	14,732	14,732
	Surface water	115	115	115	115	115	115
	Total Agriculture Supply	14,847	14,847	14,847	14,847	14,847	14,847
	Agriculture Balance	3,356	2,197	916	(499)	(2,063)	(4,191)
	Total Demand	61,745	66,492	71,178	75,633	81,027	87,247
	Total Supply						
	Groundwater	18,776	18,776	18,776	18,776	18,776	18,776
	Surface water	40,633	41,779	42,829	43,788	44,986	46,249
	Total Supply	59,409	60,555	61,605	62,564	63,762	65,025
	Total Balance	(2,336)	(5,937)	(9,573)	(13,069)	(17,265)	(22,222)

Table 4.23.
San Patricio County Municipal Water Demand and Supply by City/County (ac-ft)

City/County	2020	2030	2040	2050	2060	2070
Aransas Pass						
Demand	1,131	1,148	1,149	1,155	1,167	1,176
Supply	1,131	1,148	1,149	1,155	1,167	1,176
Groundwater	—	—	—	—	—	—
Surface Water	1,131	1,148	1,149	1,155	1,167	1,176
Balance	—	—	—	—	—	—
Gregory						
Demand	339	344	348	354	358	361
Supply	339	344	348	354	358	361
Groundwater	—	—	—	—	—	—
Surface Water	339	344	348	354	358	361
Balance	—	—	—	—	—	—
Ingleside						
Demand	1,051	1,062	1,060	1,064	1,074	1,083
Supply	1,051	1,062	1,060	1,064	1,074	1,083
Groundwater	—	—	—	—	—	—
Surface Water	1,051	1,062	1,060	1,064	1,074	1,083
Balance	—	—	—	—	—	—
Ingleside on the Bay						
Demand	77	78	78	78	79	79
Supply	77	78	78	78	79	79
Groundwater	—	—	—	—	—	—
Surface Water	77	78	78	78	79	79
Balance	—	—	—	—	—	—
Lake City						
Demand	64	65	64	64	65	66
Supply	70	70	70	70	70	70
Groundwater	70	70	70	70	70	70
Surface Water	—	—	—	—	—	—
Balance	6	5	6	6	5	4
Mathis						
Demand	670	676	672	679	685	691
Supply	670	676	672	679	685	691
Groundwater	—	—	—	—	—	—
Surface Water	670	676	672	679	685	691
Balance	—	—	—	—	—	—
Odem						
Demand	379	384	384	387	391	394
Supply	379	384	384	387	391	394
Groundwater	—	—	—	—	—	—
Surface Water	379	384	384	387	391	394
Balance	—	—	—	—	—	—

City/County	2020	2030	2040	2050	2060	2070
Portland						
Demand	2,631	2,684	2,698	2,718	2,747	2,770
Supply	2,631	2,684	2,698	2,718	2,747	2,770
Groundwater	—	—	—	—	—	—
Surface Water	2,631	2,684	2,698	2,718	2,747	2,770
Balance	—	—	—	—	—	—
Rincon WSC						
Demand	346	355	359	363	366	369
Supply	346	355	359	363	366	369
Groundwater	—	—	—	—	—	—
Surface Water	346	355	359	363	366	369
Balance	—	—	—	—	—	—
Sinton						
Demand	1,409	1,448	1,463	1,478	1,495	1,507
Supply	1,969	1,969	1,969	1,969	1,969	1,969
Groundwater	1,969	1,969	1,969	1,969	1,969	1,969
Surface Water	—	—	—	—	—	—
Balance	560	521	506	491	474	462
Taft						
Demand	464	470	469	475	480	484
Supply	464	470	469	475	480	484
Groundwater	—	—	—	—	—	—
Surface Water	464	470	469	475	480	484
Balance	—	—	—	—	—	—
County-Other						
Demand	1,584	1,609	1,647	1,674	1,691	1,705
Supply	1,584	1,609	1,647	1,674	1,691	1,705
Groundwater	1,428	1,428	1,428	1,428	1,428	1,428
Surface Water	156	181	219	246	263	277
Balance	—	—	—	—	—	—
County Total						
Demand	10,145	10,323	10,391	10,489	10,598	10,685
Supply	10,711	10,849	10,903	10,986	11,077	11,151
Groundwater	3,467	3,467	3,467	3,467	3,467	3,467
Surface Water	7,244	7,382	7,436	7,519	7,610	7,684
Balance	566	526	512	497	479	466

4.3.12 Wholesale Water Providers – Comparison of Demand and Supply

The Coastal Bend Region has four wholesale water providers. These include the City of Corpus Christi, SPMWD, STWA, and Nueces County WCID #3.

The City of Corpus Christi provides water to SPMWD and STWA, who then supply water to their customers, as shown in Figure 4.1. SPMWD receives up to 51,200 ac-ft/yr of raw and treated water from the City according to their contract. The most typical contract between the City and its customers includes providing water at the greater amount supplied in previous years plus 10 percent. When projecting customer supplies (2020 to 2070), it was assumed that either: 1) supply increased each year by 10 percent; or 2) supply was equal to demand, whichever is less.

4.3.13 Safe Yield Supply to Demands

The Coastal Bend Region adopted use of safe yield supply for the three largest wholesale water providers: City of Corpus Christi, SPMWD, and STWA and their customers. The safe yield supplies assume a reserve of 125,000 ac-ft (i.e. 1 year regional system demand) as a drought management strategy to plan for future droughts greater than the drought of record. Table 4.24 shows the safe yield water supply for each Wholesale Water Provider, the amount of water supplied to each customer, and resulting water surplus or shortage after meeting customer needs. This analysis is shown for both the raw water and treated water components of the City of Corpus Christi and SPMWD customer systems. However, treated and raw water shortages are not additive, but are instead shown in the table only to differentiate raw water source shortages. As discussed earlier, the larger of the raw water or treated water plant capacity shortages by decade are used for planning purposes. STWA and their customers receive only treated water supplies. The City of Corpus Christi water supply for 2020 is 219,000 ac-ft, which includes supplies from the CCR/LCC System, a base amount of 41,840 ac-ft/yr and interruptible supplies from Lake Texana during the drought of record, and a supply of 27,000 ac-ft/yr from the City owned Garwood water rights. This System supply diminishes to 214,000 ac-ft by 2070 because of reservoir sedimentation.

Table 4.24. Wholesale Water Provider Surface Water Allocation

Wholesale Water Provider (Water User/County)	*2020*	*2030*	*2040*	*2050*	*2060*	*2070*
City of Corpus Christi						
Raw Water Supply/Needs Analysis						
Safe Yield Supply (CCR/LCC/Texana/MRP Phase II System)	**219,000**	**218,000**	**217,000**	**216,000**	**215,000**	**214,000**
Current Treatment Capacity[1]	127,314	127,317	127,314	127,314	127,314	127,314
Raw Water Available for Sales	91,686	90,686	89,686	88,686	87,686	86,686
Raw Water Contract Sales						
Municipal						
Jim Wells County						
City of Alice	4,192	4,425	4,643	4,912	5,175	5,421
Bee County						
City of Beeville	2,925	2,978	2,976	2,961	2,959	2,960
San Patricio County						
City of Mathis	670	676	672	679	685	691
SPMWD	41,200	41,200	41,200	41,200	41,200	41,200
Live Oak County						
City of Three Rivers	3,363	3,363	3,363	3,363	3,363	3,363
Non-Municipal						
Manufacturing (Nueces County)[2]	8,854	9,484	10,099	10,629	11,461	12,353
Steam-Electric (Nueces County)[8]	15,038	17,582	20,681	24,461	29,067	34,541
Total Raw Water Demand	**76,242**	**79,708**	**83,634**	**88,205**	**93,910**	**100,529**
Raw Water Surplus/Shortage	**15,444**	**10,978**	**6,052**	**481**	**(6,224)**	**(13,843)**
Treated Water Supply/Needs Analysis						
O.N. Stevens WTP Capacity[1]	**127,314**	**127,314**	**127,314**	**127,314**	**127,314**	**127,314**
Treated Water Contract Sales						
Municipal						
San Patricio County						
San Patricio MWD[3]	10,000	10,000	10,000	10,000	10,000	10,000
Nueces County						
Port Aransas[4]	1,035	1,120	1,172	1,202	1,227	1,243
City of Corpus Christi	64,816	68,931	71,270	72,680	74,064	75,058
County-Other[5,6]	166	166	166	166	166	166
Kleberg County						
South Texas Water Authority	1,876	2,095	2,277	2,620	2,988	3,334
Non-Municipal						
Mining (Nueces County)[5]	220	349	443	517	626	756
Manufacturing (Nueces County)[7]	35,416	37,935	40,395	42,515	45,846	49,410
Total Treated Water Demand	**113,529**	**120,596**	**125,723**	**129,700**	**134,917**	**139,967**
Treated Water Surplus/Shortage (applied to Nueces County Manufacturing and Steam-Electric)	**13,785**	**6,718**	**1,591**	**(2,386)**	**(7,603)**	**(12,653)**
Total Water Supply/Needs Analysis						
Safe Yield Supply (CCR/LCC/Texana/MRP Phase II System)	**219,000**	**218,000**	**217,000**	**216,000**	**215,000**	**214,000**
Total Raw Water and Treated Water Demands	**189,771**	**200,304**	**209,357**	**217,905**	**228,827**	**240,496**
Total Water Surplus/Shortage	**29,229**	**17,696**	**7,643**	**(1,905)**	**(13,827)**	**(26,496)**

Wholesale Water Provider (Water User/County)	***2020***	***2030***	***2040***	***2050***	***2060***	***2070***
San Patricio Municipal Water District						
Raw Water Supply/Needs Analysis						
Contract Purchases from City of Corpus Christi	**51,200**	**51,200**	**51,200**	**51,200**	**51,200**	**51,200**
Current Industrial Treatment Capacity[9]	11,043	11,043	11,043	11,043	11,043	11,043
Potable-Municipal Treatment Capacity[9]	11,658	11,658	11,658	11,658	11,658	11,658
Purchased Treated Water from City	10,000	10,000	10,000	10,000	10,000	10,000
Total Treated Water Supply	32,701	32,701	32,701	32,701	32,701	32,701
Raw Water Available for Sales	18,499	18,499	18,499	18,499	18,499	18,499
Raw Water Contract Sales						
Non-Municipal						
Manufacturing (San Patricio County)	11,783	12,791	13,787	14,663	15,770	16,959
Total Raw Water Demand	**11,783**	**12,791**	**13,787**	**14,663**	**15,770**	**16,959**
Raw Water Surplus/Shortage	**6,716**	**5,708**	**4,712**	**3,836**	**2,729**	**1,540**
Treated Water Supply/Needs Analysis						
Potable-Municipal Treated Water Supply	**11,658**	**11,658**	**11,658**	**11,658**	**11,658**	**11,658**
Industrial Treated Water Supply	**21,043**	**21,043**	**21,043**	**21,043**	**21,043**	**21,043**
Treated Water Contract Sales						
Municipal						
Nueces County						
City of Aransas Pass	3	3	3	3	3	3
Port Aransas[4]	1,216	1,314	1,376	1,412	1,440	1,460
San Patricio County						
City of Aransas Pass	1,131	1,148	1,149	1,155	1,167	1,176
City of Gregory	339	344	348	354	358	361
City of Ingleside	1,051	1,062	1,060	1,064	1,074	1,083
City of Ingleside on the Bay	77	78	78	78	79	79
City of Portland	2,631	2,684	2,698	2,718	2,747	2,770
City of Odem	379	384	384	387	391	394
City of Taft	464	470	469	475	480	484
Rincon WSC	346	355	359	363	366	369
County-Other	1,125	1,094	1,041	1,026	1,021	1,021
Aransas County						
City of Aransas Pass	110	108	106	105	104	104
City of Fulton	278	279	275	275	275	275
City of Rockport	1,608	1,611	1,583	1,580	1,577	1,577
County-Other	1,125	1,094	1,041	1,026	1,021	1,021
Municipal Treated Water Demand	10,914	11,115	11,148	11,241	11,345	11,433
Non-Municipal						
Manufacturing (San Patricio County)[10]	27,494	29,847	32,169	34,215	36,797	39,572
Industrial Treated Water Demand	27,494	29,847	32,169	34,215	36,797	39,572
Municipal Treated Water Surplus/Shortage	744	543	510	417	313	225
Industrial Treated Water Surplus/Shortage	(6,451)	(8,804)	(11,126)	(13,172)	(15,754)	(18,529)

Wholesale Water Provider (Water User/County)	***2020***	***2030***	***2040***	***2050***	***2060***	***2070***
Total Water Supply/Needs Analysis						
Total Water Supply	51,200	51,200	51,200	51,200	51,200	51,200
Total Raw Water and Treated Water Demands	50,191	53,753	57,104	60,119	63,912	67,964
Total Water Surplus/Shortage	1,009	(2,553)	(5,904)	(8,919)	(12,712)	(16,764)
South Texas Water Authority						
Total Surface Water Right	0	0	0	0	0	0
Contract Purchases	1,876	2,095	2,277	2,620	2,988	3,334
Contract Sales						
Municipal						
Nueces County						
City of Agua Dulce	132	139	143	145	148	150
City of Driscoll	105	110	113	114	116	118
City of Bishop	352	386	404	418	431	440
Nueces WSC	333	355	368	376	383	388
County-Other[5,11]	155	177	190	198	205	209
Kleberg County						
City of Kingsville	458	567	677	964	1275	1575
Ricardo WSC	341	361	382	405	430	454
Total Contract Sales	**1,876**	**2,095**	**2,277**	**2,620**	**2,988**	**3,334**
Surplus/Shortage	—	—	—	—	—	—
Nueces County WCID #3						
Total Surface Water Right (firm yield)	1,955	1,955	1,955	1,955	1,955	1,955
Contract Sales						
Municipal						
Nueces County						
Wholesale Water Provider (Water User/County)	2020	2030	2040	2050	2060	2070
County-Other[5,12]	155	155	155	155	155	155
City of Robstown	2,957	2,897	2,848	2,843	2,839	2,839
River Acres WSC	426	450	463	470	479	486
Total Contract Sales	3,538	3,502	3,466	3,468	3,473	3,480
Surplus/Shortage	(1,583)	(1,547)	(1,511)	(1,513)	(1,518)	(1,525)

[1] Average day treatment capacity calculated as 159 mgd with a peaking capacity of 1.4:1 (159 mgd/1.4 = 113.6 mgd or 127,248 ac-ft/yr). The max day to average day (peaking factor) of 1.4 is the average peaking factor of the plant for the time period 2004 to 2009.
[2] Calculated based on 20% of the Nueces County Manufacturing demand being for raw water per historical use.
[3] Corpus Christi's contract with San Patricio MWD specifies that 10,000 ac-ft/yr will be treated water, the remaining 41,200 ac-ft/yr is raw water.
[4] Port Aransas receives water from the City of Corpus Christi and SPMWD. According to historical use, the City provides about 46% of the supply to Port Aransas with the remaining 54% met by SPMWD.
[5] Wholesale water provider does not meet full demand (i.e. additional supply from groundwater).
[6] Includes Violet WSC.
[7] Calculated based on 80% of the Nueces County Manufacturing demand being for treated water per historical use.
[8] Steam-Electric water demands include Lon Hill and potential, future steam-electric power plants as accounted by TWDB studies.
[9] SPMWD has a potable (municipal) water treatment plant with 20.0 mgd design capacity and an industrial water treatment plant capacity of 12.7 mgd. Average day municipal treatment capacity is calculated as 10.4 mgd after considering a peaking capacity of 2.01:1, or 11,658 ac-ft/yr. Average day industrial treatment capacity calculated as 12.7 mgd with a peaking capacity of 1.29:1 (12.7 mgd/1.29 = 9.9 mgd), or 11,043 ac-ft/yr.
[10] Remaining Manufacturing demand (San Patricio County) after accounting for raw water sales.
[11] Includes KB Foundation/IFS, Nueces County WCID #5 and other rural water users.
[12] Includes San Pedro subdivision.

The City of Corpus Christi, after meeting demands and/or contracts with its customers, has raw water supply shortages in 2060 and 2070, indicating a need for increased source water supplies. In addition, beginning in 2050, the City has shortages associated with the treated water customers, indicating that the current treatment plant capacity is not sufficient to meet future treated water needs. The shortages are applied to industrial users in Nueces County (Manufacturing and Steam-Electric), as shown in Table 4.20. SPMWD, authorized to receive 51,200 ac-ft/yr of water from the City of Corpus Christi, meets the demands of its customers and has a raw water surplus throughout the planning period. SPMWD has shortages associated with industrial treated water supplies beginning in 2020, indicating that the current industrial treatment plant capacity is not sufficient to meet future treated water needs. SPMWD's shortages are applied to San Patricio County Manufacturing as shown in Table 4.22. STWA receives treated water supplies to meet the demands of its customers, consistent with the terms of the present contracts, and has no projected shortages. Nueces County WCID #3 receives supply through run-of-river water rights and is projected to have a shortage in all decades attributed to a lack of sufficient firm yield during drought of record conditions. This shortage was applied to the City of Robstown, although it is likely to be met with Nueces County WCID #3 improvements.

4.3.14 Region Summary

When comparing total available supplies to total demands, the region shows a current surplus until 2060. By the year 2060, a shortage of 15,496 ac-ft exists and increases to a shortage of 34,426 ac-ft by 2070 (Table 4.25 and Figure 4.3). A portion of this shortage is associated with treatment plant capacity constraints and is not necessarily a raw water shortage (for example, see Table 4.24).

Municipal and Industrial Summary

On a regional basis, Municipal and Industrial entities (Manufacturing, Steam-Electric, and Mining) show a surplus of 36,205 ac-ft in 2020, although there are anticipated shortages for some municipal entities at this time due to lack of local well capacity. Due primarily to increasing manufacturing demands, there are shortages of 1,462 ac-ft by 2050 for municipal and industrial users increasing to 30,669 ac-ft by 2070. Shortages in supplies provided by the CCR/LCC/Texana/MRP Phase II System were accumulated in industrial (mining, steam-electric, and/or manufacturing) demands in San Patricio and Nueces Counties.

Municipal demands account for approximately 37 percent of total demands in the region in 2070. Surface water accounts for approximately 76 percent of 2070 municipal supplies, with groundwater accounting for 24 percent. Although there is a region-wide municipal surplus, there are some cities that are experiencing near- and/or long-term shortages. These shortages are summarized in Table 4.26.

Manufacturing demands account for 37 percent of total demands in 2070. The majority of these demands, 98 percent, are in Nueces and San Patricio Counties. Aransas, Bee, and Live Oak Counties make up the remaining 2 percent. Surface water supplies provide 93 percent of total manufacturing supplies in 2070; groundwater 7 percent. Region-wide there is a manufacturing supply deficit of 400 ac-ft in 2040 increasing to 35,318 ac-ft by 2070.

Table 4.25.
Coastal Bend Region Summary Population, Water Supply, and Water Demand Projections

Population Projection	2020	2030	2040	2050	2060	2070
	614,790	661,815	692,982	714,508	731,481	744,544

	Supply and Demand by Type of Use	2020 (ac-ft)	2030 (ac-ft)	2040 (ac-ft)	2050 (ac-ft)	2060 (ac-ft)	2070 (ac-ft)
Municipal	Municipal Demand (See Table 4.3)	112,081	117,701	121,072	123,698	126,343	128,510
	Municipal Existing Supply						
	Groundwater	32,076	32,076	32,076	32,076	32,076	32,076
	Surface water	89,249	94,161	96,979	99,116	101,264	102,961
	Total Existing Municipal Supply	121,325	126,237	129,055	131,192	133,340	135,037
	Municipal Balance	9,244	8,536	7,983	7,494	6,997	6,527
Industrial	Manufacturing Demand	92,175	98,724	105,153	110,754	118,723	127,266
	Manufacturing Existing Supply	0					
	Groundwater	6,035	6,035	6,035	6,035	6,035	6,035
	Surface water	112,076	104,700	98,718	92,696	88,890	85,913
	Total Manufacturing Supply	118,111	110,735	104,753	98,731	94,925	91,948
	Manufacturing Balance	25,936	12,011	(400)	(12,023)	(23,798)	(35,318)
	Steam-Electric Demand	15,038	17,582	20,681	24,461	29,067	34,541
	Steam-Electric Existing Supply						
	Groundwater	0	0	0	0	0	0
	Surface water	15,038	17,582	20,681	24,461	26,221	27,648
	Total Steam-Electric Supply	15,038	17,582	20,681	24,461	26,221	27,648
	Steam-Electric Balance	0	0	0	0	(2,846)	(6,893)
	Mining Demand	8,951	9,821	9,660	7,206	6,157	5,497
	Mining Existing Supply						
	Groundwater	9,644	9,644	9,644	9,644	9,644	9,644
	Surface water	220	349	443	517	626	756
	Total Mining Supply	9,864	9,993	10,087	10,161	10,270	10,400
	Mining Balance	913	172	427	2,955	4,113	4,903
Agriculture	Irrigation Demand	26,419	28,604	30,990	33,595	36,441	40,124
	Irrigation Existing Supply						
	Groundwater	36,367	36,367	36,367	36,367	36,367	36,367
	Surface water	0	0	0	0	0	0
	Total Irrigation Supply	36,367	36,367	36,367	36,367	36,367	36,367
	Irrigation Balance	9,948	7,763	5,377	2,772	(74)	(3,757)
	Livestock Demand	7,306	7,306	7,306	7,306	7,306	7,306
	Livestock Existing Supply						
	Groundwater	5,446	5,446	5,446	5,446	5,446	5,446
	Surface water	1,860	1,860	1,860	1,860	1,860	1,860
	Total Livestock Supply	7,306	7,306	7,306	7,306	7,306	7,306
	Livestock Balance	0	0	0	0	0	0
Total	Municipal and Industrial Demand	228,245	243,828	256,566	266,119	280,290	295,814
	Existing Municipal and Industrial Supply						
	Groundwater	47,755	47,775	47,775	47,775	47,775	47,775
	Surface water	216,583	216,792	216,821	216,790	217,001	217,278
	Total Municipal and Industrial Supply	264,450	264,659	264,688	264,657	264,868	265,145
	Municipal and Industrial Balance	36,093	20,719	8,010	(1,574)	(15,534)	(30,781)
	Agriculture Demand	33,725	35,910	38,296	40,901	43,747	47,430
	Existing Agricultural Supply						
	Groundwater	41,813	41,813	41,813	41,813	41,813	41,813
	Surface water	1,860	1,860	1,860	1,860	1,860	1,860
	Total Agriculture Supply	43,673	43,673	43,673	43,673	43,673	43,673
	Agriculture Balance	9,948	7,763	5,377	2,772	(74)	(3,757)
	Total Demand	261,970	279,738	294,862	307,020	324,037	343,244
	Total Supply						
	Groundwater	89,568	89,568	89,568	89,568	89,568	89,568
	Surface water	218,443	218,652	218,681	218,650	218,861	219,138
	Total Supply	308,011	308,220	308,249	308,218	308,429	308,706
	Total Balance	46,041	28,482	13,387	1,198	(15,608)	(34,538)

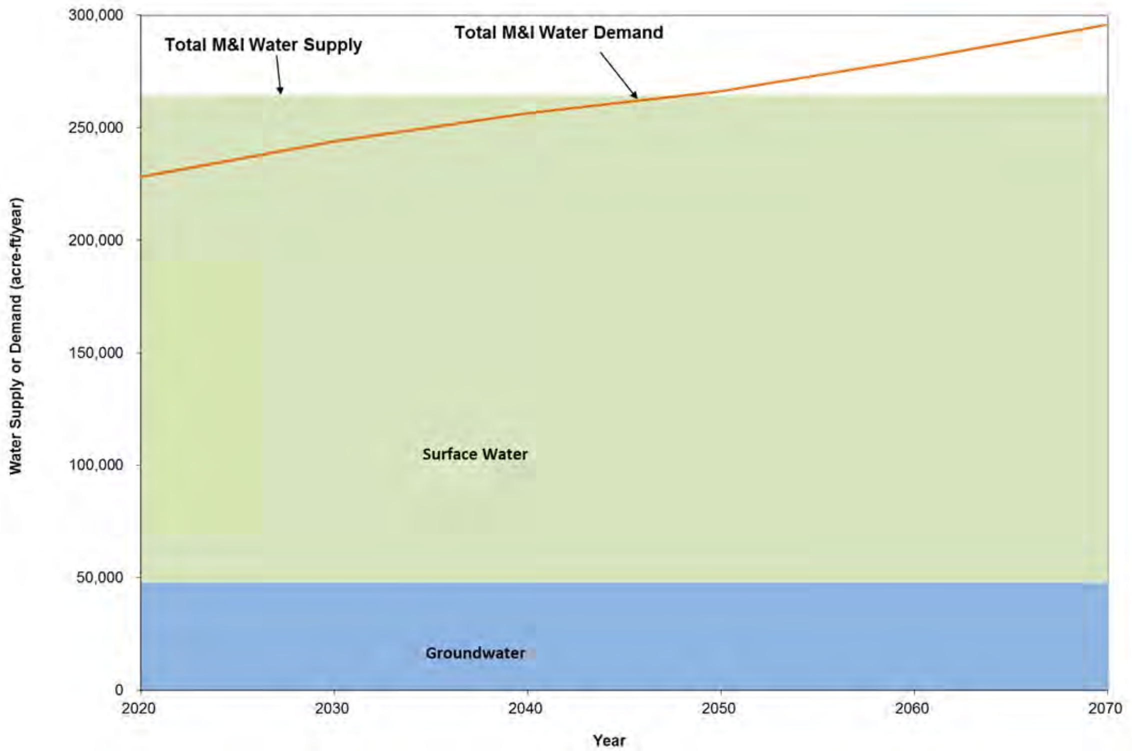

Figure 4.3.
Municipal and Industrial Supply and Demand

Table 4.26.
Cities/County-Other with Projected Water Shortages

County/City	***Projected Shortages (ac-ft)***		
	2020	***2040***	***2070***
Duval County			
San Diego	—	(40)	(107)
Jim Wells County			
San Diego	—	(16)	(51)
Nueces County			
Robstown	(1,583)	(1,511)	(1,525)

Nueces County shows manufacturing shortages beginning between 2040 and 2050; and San Patricio shows manufacturing shortages beginning in 2020 associated with water treatment plant constraints. In 2070, Nueces and San Patricio Counties have shortages of 19,603 ac-ft and 18,529 ac-ft, respectively (Table 4.27).

Table 4.27.
Manufacturing with Projected Water Shortages

County	***Projected Shortages (ac-ft)***		
	2020	***2040***	***2070***
Nueces County	—	—	(19,603)
San Patricio County	(6,451)	(11,126)	(18,529)

As for the remaining industrial demands, there are insufficient surface water supplies to meet steam-electric demands, all of which is in Nueces County, beginning in 2060. Steam-Electric in Nueces County is projected to have a shortage of 2,846 ac-ft/yr in 2060, increasing to 6,893 ac-ft/yr in 2070 (Table 4.28).

Table 4.28.
Steam-Electric with Projected Water Shortages

County	***Projected Shortages (ac-ft)***		
	2020	***2040***	***2070***
Nueces County	—	—	(6,893)

The regional mining demand, 5,497 ac-ft, accounts for only 2 percent of total demand in 2070. Region-wide there is sufficient groundwater to meet mining demands. McMullen County shows immediate and long-term shortages from 2020 to 2060. Mining shortages are summarized in Table 4.29.

Table 4.29.
Mining with Projected Water Shortages

County	***Projected Shortages (ac-ft)***		
	2020	***2040***	***2070***
McMullen	(2,733)	(3,219)	—

Agriculture Summary

Due to increasing irrigation demands and limited current well capacity, irrigation is showing a current surplus of 9,948 ac-ft in 2020 and a shortage of 3,757 ac-ft in 2070.[1] Irrigation demand increases over the 50-year planning period and in 2070 represents 12 percent of total demand. Groundwater accounts for 100 percent of the total projected irrigation water supply. Irrigation shortages are summarized in Table 4.30.

Table 4.30.
Irrigation with Projected Water Shortages

County/City	***Projected Shortages (ac-ft)***		
	2020	***2040***	***2070***
McMullen	(40)	(44)	(51)
San Patricio County	—	—	(4,191)

Livestock demand remains constant at 7,306 ac-ft over the 50-year planning period and in 2070 represents 2 percent of total demand. For each county, groundwater was allocated based on 2010 use. Surface water supplies were assumed to consist of local, on-farm sources and used to meet demands.

Summary

Overall, the Coastal Bend Region has sufficient supplies to meet the demands of the six water user group categories through 2050. However, as discussed in the previous section, various water user groups are showing shortages throughout the 50-year planning period. Water groups with shortages in 2040 and 2070 are presented in Figure 4.4.

[1] Irrigation shortages on a regional basis are reduced by surpluses in other counties. However, it is more appropriate in Region N to consider irrigation shortages on a county-wide basis where the demands occur, since most irrigation water supplies are from local groundwater wells and it is often costly and impractical to transport irrigation water supplies across county lines.

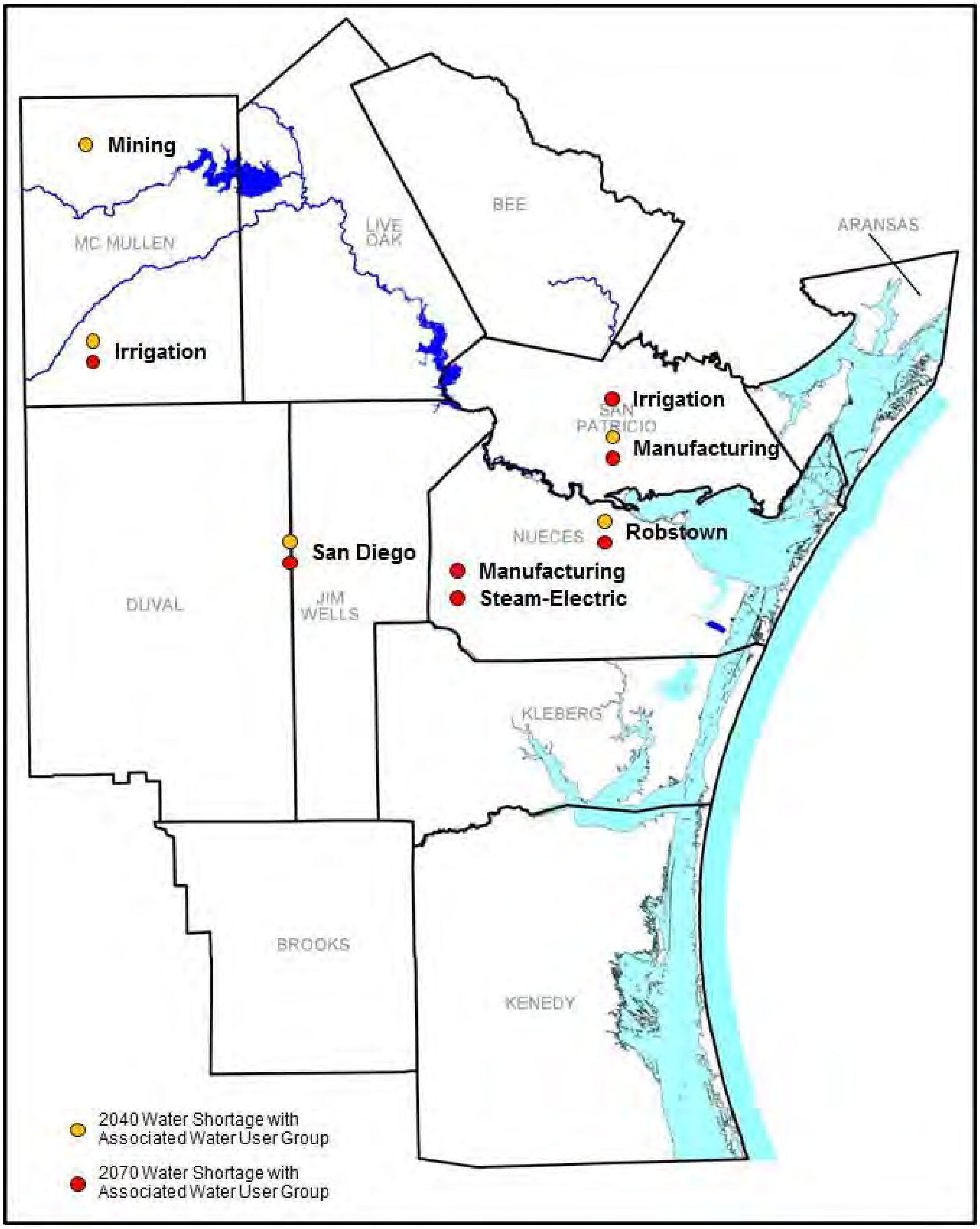

Figure 4.4.
Location and Type of Use for 2040 and 2070 Water Supply Shortages

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5

Water Management Strategies

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Chapter 5: Water Management Strategies

5A.1 Identification of Potentially Feasible Water Management Strategies

The Coastal Bend Regional Water Planning group identified and evaluated potentially feasible water management strategies for each water user group and wholesale water provider in the region, particularly for those water user groups with shortages projected during the planning period. As required by Texas Water Code, the Coastal Bend Regional Water Planning group considered the following potential feasible water management strategies for inclusion in the 2016 Plan:

- Conservation
- Reuse
- Management of Existing Supplies
- Conjunctive Use
- Acquisition of Available Existing Water Supplies
- Development of New Water Supplies
- Development of Regional Water Supply Projects or Facilities
- Voluntary Transfer of Water Within the Region
- Emergency Transfers of Water

Region N considered a complete list of potentially feasible water management strategies based on previous plans, local on-going studies, and feedback from local sponsors as summarized in Table 11.2. These potentially feasible strategies included all water management strategy types referenced in the Texas Water Code as presented above. On February 13, 2014, Region N removed non-relevant strategies no longer actively considered by local sponsors and selected water management strategies for evaluation in the 2016 Plan. A total of 15 water management strategies were investigated during the development of the Coastal Bend Regional Water Plan. Many of these strategies include several water supply options within the main strategy. These strategies are summarized in Table 5A.1.1. The potentially feasible water management strategies selected by the CBRWPG for the 2016 Plan, are based on those identified in the 2011 Plan, in addition to new projects identified by Wholesale Water Providers and other water user groups. Results from studies since the 2011 Plan assisted in the selection process of potentially feasible water management strategies.

Table 5A.1.1.
Potentially Feasible Water Management Strategies Selected by the CBRWPG for Evaluation in the 2016 Plan

N-1	Municipal Water Conservation
N-2	Irrigation Water Conservation
N-3	Manufacturing Water Conservation and Nueces River Water Quality
N-4	Mining Water Conservation
N-5	(Reuse of) Reclaimed Wastewater Supplies
N-6	Modify Existing Reservoir Operating Policy and Safe Yield Analyses
N-7	Gulf Coast Aquifer Supplies and Voluntary Redistribution of Available Supplies
N-8	Brackish Groundwater Desalination
N-9	Seawater Desalination and Variable Salinity Program
N-10	Potential Water System Interconnections
N-11	Local Balancing Storage Reservoir
N-12	Lavaca River Diversion and Off-Channel Reservoir Project
N-13	GBRA Lower Basin Storage
N-14	SPMWD Industrial Water Treatment Plant Improvements
N-15	O.N. Stevens Water Treatment Plant Improvements

Water management strategies from previous plans considered no longer relevant for active evaluation in the 2016 Plan were summarized and are included in Chapter 11.3. All potentially feasible water management strategy evaluations in the 2016 Plan included in Chapter 5D were evaluated in accordance with 31 Texas Administrative Code 357.34 requirements.

New strategies were developed in accordance with TWDB guidelines. Water management strategies from previous plans that were identified as relevant by the Coastal Bend Regional Water Planning group for the 2016 Plan were updated to reflect new costs, redeveloped to meet current rule requirements, revised for changed physical or socioeconomic conditions, and/or updated to reflect current project configuration information based on the level of detail requested by project sponsors or Coastal Bend Regional Water Planning group members.

At their regular public meeting on January 19, 2012, the Coastal Bend Regional Water Planning Group approved their process for identifying and evaluating potentially feasible water management strategies for the Coastal Bend Region, which is provided in Figure 5A.1.1.

Identification of Potentially Feasible Water Management Strategies For Development of the 2016 Coastal Bend Regional Water Plan (adopted January 2012, minor scheduling updates indicated with tracked changes - November 2013)

The process of identifying potentially feasible water management strategies outlined below is followed for the development of the 2016 Coastal Bend Regional Water Plan (2016 Plan)[1]:

1) The Coastal Bend Regional Water Planning Group (RWPG) recognizes that regional water planning is an evolving process and draws upon results obtained from previous planning cycles. A summary of recommended and considered water management strategies from the 2001, 2006, and 2011 Plans was considered at the onset of development of the 2016 Plan. Water management strategies proposed or discussed previously are technically evaluated on a stand-alone basis and/or with coordinated operation with existing water supplies and/or reservoir operations.
2) The Texas Water Development Board (TWDB) defined a limited scope of work for Phase I 2016 Plan activities to include: re-evaluating water demands and supply availability, identifying potentially feasible water management strategies, preparing a Technical Memorandum, and administration and public participation activities. The Coastal Bend RWPG developed scope(s) of work for Phase II development of the 2016 Plan to include: necessary updates to recommended water management strategies included in the adopted 2011 Plan, technical evaluations of new water management strategies deemed to be potentially feasible for meeting needs in the region, and work necessary to comply with Texas Administrative Code Chapter 357 Regional Water Planning Guidelines.[2]
3) The Phase I scope of work was presented at a public meeting of the Coastal Bend RWPG on February 10, 2011. The Coastal Bend RWPG held a public meeting on April 14, 2011 to receive public comment on issues to address or provisions to be included in 2016 Plan development.
4) The Phase II draft scope of work was developed and presented for public inspection and revised according to comment in accordance with TWDB notice and public participation guidance and rules (§357.E). The Phase II scope of work was approved by the Coastal Bend RWPG on August 16, 2012 and submitted to the TWDB.
5) Current water planning information, including specific water management strategies of interest, was solicited from major wholesale water providers for development of the 2016 Plan. The wholesale water providers were encouraged to classify each water management strategy on their draft list as recommended, alternative, or rejected (where applicable).
6) Considering information provided by water providers, draft lists of potentially feasible water management strategies were prepared and discussed at the November 2013 Coastal Bend RWPG meeting for public comment.
7) Refined lists of potentially feasible water management strategies to meet water user group needs were compiled for Coastal Bend RWPG consideration and approval at their February 2014 meeting and included in the Technical Memorandum due to the TWDB on August 1, 2014. This list of potentially feasible water management strategies is presented in the Initially Prepared Plan and will be included in the 2016 Plan.

[1] Pursuant to Texas Administrative Code Title 31 Part 10 Chapter 357.5(e)(4) of the Regional Water Planning Guidelines which states: "Before a regional water planning group begins the process of identifying potentially feasible water management strategies, it shall document the process by which it will list all possible water management strategies and identify the water management strategies that are potentially feasible for meeting a need in the region."
[2] Final Texas Administrative Code Regional Water Planning Guideline revisions were adopted by the TWDB governing Board in November 2012.

Figure 5A.1.1.
Region N-Adopted Process for Identification of Potentially Feasible Water Management Strategies for Development of the 2016 Coastal Bend Regional Water Plan

5B.1 Water Management Strategy Evaluations and Recommended and Alternative Water Management Strategies

Table 5B.1.1 summarizes strategies that were selected for inclusion as recommended or alternative strategies in the plan for Wholesale Water Providers in Region N and Table 5B.1.2 shows potential strategies for other local service areas. The Plan does not include any retail distribution-level infrastructure or associated costs, except those associated with conservation-related strategies such as pipeline and meter replacement programs. Strategies related to water treatment plant improvements (5D.14- San Patricio Municipal Water District WTP and 5D.15- O.N. Stevens WTP Improvements) rely on development of new raw water supplies to fully deliver at treated capacity. Without new raw water supplies, the treated water available with these strategies declines as existing raw water supplies become utilized by industrial customers to meet growing water demands. There are no Region N strategies that mutually exclude another recommended strategy.

All strategies are compared with respect to four areas of interest: 1) additional water supply; 2) unit cost of treated water; 3) degree of water quality improvement; and 4) environmental issues and special concerns. A graphical comparison of how each significant strategy compares to the others with respect to unit cost and water supply quantity is shown in Figure 5B.1.1. A detailed analysis of each strategy is included in Section 5D (refer to Chapters 5D.1 through 5D.15). In these detailed descriptions, each strategy was evaluated with respect to ten impact categories, as required by TWDB rules. These categories are shown in Table 5B.1.3. An evaluation summary is included at the end of each water management strategy description, which summarizes how each strategy relates to the ten impact categories.

Each strategy includes a separate Environmental Issues discussion, which describes environmental factors including impacts to agricultural resources. In the evaluation summaries, some impacts are qualitatively discussed. Tables 5B.1.4 and 5B.1.5 include the keys to the environmental issues and impacts to agricultural resources descriptors, respectively, that are presented in the evaluation summaries.

Recommended plans to meet the specific needs of the cities and other water user groups during the planning period (2020 through 2070) are presented in the following sections. The plans are organized by county and water user group in the following sections (Chapters 5B.2 to 5B.13). Water user group and wholesale water provider water supply plans frequently include multiple recommended water management strategies, that when totaled, sum up to more than the volume needed to meet a water supply shortage to account for uncertainties in population projections, future demands, climate variability, yield of recommended water management strategies, permitting challenges, and other uncertainties. The TWDB-provided table that shows the calculated management supply factors for each decade for each water user group and wholesale water provider is unavailable at this time, but will be included in the final 2016 Plan.

Table 5B.1.1.
Potential Water Management Strategies to Meet Long-Term Needs for Wholesale Water Providers

WMS ID	Water Management Strategy	Additional Water Supply (ac-ft/yr)	Total Project Cost	Annual Cost	Unit Cost of Additional Treated Water ($ per ac-ft/yr)	Degree of Water Quality Improvement	Environmental Issues/ Special Concerns
5D.1	**Municipal Water Conservation**	up to 17,034	Variable; Regional cost up to 8,226,575[1]	Variable	$470-$510	No Change	Possible reduction in return flows to bay and estuary
5D.3	**Manufacturing Water Conservation**						
3-1	Blending of MRP Phase II	up to 1,497	Not Applicable	Not Applicable	Not Applicable[2]	Significant Improvement	None
3-2	Outlet works to remove high TDS from Calallen Pool	627-869	$3,151,000	$287,000	$699-$827[3]	Significant Improvement	None
3-3	Intake Modifications	836-1,158	$8,535,000	$832,000	$1,205-$1,364[3]	Significant Improvement	None
3-4	Pipeline from LCC to Calallen	19,600-23,100	$190,005,000	$19,541,000	$1,215-$1,366[3]	Significant Improvement	Potentially significant environmental impacts; construction and maintenance of pipeline corridors
5D.5	**Reclaimed Wastewater Supplies[4]**	Up to 20,178	$21,292,000 to $52,097,000	$1,997,000 to $11,641,000	$577 to $892	No Change	Potential reduction of freshwater inflows to estuary; construction and maintenance of pipeline corridors
5D.6	**Modify Existing Reservoir Operating Policy and Safe Yield Analysis**	None	None	None	None	No Change	None
5D.7	**Gulf Coast Aquifer Supplies (Blending)**	707 to 28,155	$4,630,000 to $110,706,000	$514,000 to $14,772,000	$525 to $1,129	Slight fluctuations and deterioration possible	Requires blending with 22,850 to 48,047 ac-ft of treated surface water for total water demand of 51,005 ac-ft for SPMWD customers in 2070. Requires blending with 2,627 ac-ft of treated surface water for total water demand of 3,334 ac-ft for STWA customers in 2070.
5D.8	**Brackish Groundwater Desalination**	12,000 to 24,000	$98,267,000 to $129,433,000	$15,028,000 to $20,470,000	$853 to $1,252	Variable. Low to significant Improvement[5]	Brine from desalt plant requires disposal; construction and maintenance of pipeline corridor
5D.9	**Seawater Desalination and Variable Salinity Program**	22,420	$248,000,000	$31,797,560 to $32,515,000	$1,418 to $1,450	Variable. Low to significant Improvement[5]	Brine from desalt plant requires disposal; construction and maintenance of pipeline corridor
5D.11	**Local Balancing Storage Reservoir**	1,583	$8,182,000	$732,000	$831[3]	No Change	Construction and maintenance of pipeline corridors and terminal storage
5D.12	**Lavaca Off-Channel Reservoir**	16,963	$177,485,000	$14,704,000	$1,236[3]	No Change	Direct impact to around 3,000 acres
5D.13	**GBRA Lower Basin Storage Project**	20,000	$72,546,000	$8,849,000	$811[3]	Slight Improvement	Interregional coordination; inter-basin transfer likely needed
5D.14	**SPMWD WTP Improvements**	18,529	$58,366,000	$14,997,000	$809	No change	None
5D.15	**O.N. Stevens WTP Improvements**	up to 28,025	$44,029,540	$5,681,000	$572	No change	None

[1] Assumes unit costs of $470 to $510/ac-ft.
[2] Cost of Manufacturing Water Conservation not determined.
[3] Cost has been adjusted to include treatment. Cost for treatment is estimated at $369 per acft.
[4] Includes Portland Reuse (2 mgd) and Greenwood WWTP reuse strategies.
[5] Depends on the amount of raw water that bypasses treatment for blending with desalinated water to stabilize and prevent corrosivity in the pipeline conveyance system. At larger ratios of bypassed water to desalinated water, the degree of water quality improvement over current supplies is diminished.

Table 5B.1.2. Potential Water Management Strategies to Meet Long-Term Needs for Local Service Areas

WMS	Water Management Strategy	Additional Water Supply (ac-ft/yr)	Total Project Cost	Annual Cost	Unit Cost of Additional Treated Water ($ per ac-ft/yr)	Degree of Water Quality Improvement	Environmental Issues/ Special Concerns
5D.1	**Municipal Water Conservation**	up to 17,034	Variable; Regional Cost up to $8,226,575[1]	Variable	$470-$510	No Change	Possible reduction in return flows to bay and estuary
	Pipeline Replacement- Alice	up to 576	$21,384,000	$2,138,400	$62,120	No Change	None
5D.2	**Irrigation Water Conservation**	up to 2,803	Variable; Regional Cost up to $642,804	Variable	$230[2]	No Change	None
5D.4	**Mining Water Conservation**	up to 357	Highly Variable	Highly Variable	Variable	No Change	None
5D.5	**Reclaimed Wastewater Supplies-City of Alice**	897	$8,661,000 to $10,838,000	$1,185,000 to $1,366,000	$1,321 to $1,523	Some Degradation	Potential reduction of freshwater inflows to San Fernando Creek and Baffin Bay; construction and maintenance of pipeline corridors
5D.7	**Gulf Coast Aquifer Supplies**						
	Drill additional well for non-municipal users	Variable, ranges from 43 to 966	Variable; up to $1,685,000[3]	Variable; up to $189,000[3]	Variable, from $159[2] to $302[2]	Some Degradation	Minor impacts
	San Diego	158	$940,000	$106,000	$671	Some Degradation	Minor impacts
	Beeville	Up to 1,797 with both projects	Variable; up to $5,038,000[4]	Variable; up to $751,000[4]	$135 to $484	Some Improvement	Minor impacts
5D.8	**Brackish Groundwater Desalination (Alice)**	3,363	$33,277,000	$4,956,000	$1,474	Variable. Low to significant Improvement[5]	Brine from desalt plant requires disposal by evaporation, deep well injection, blending, or discharging to saltwater body
5D.10	**Potential System Interconnections**						
	Duval County	1,072 to 2,708	Up to $34,786,000	Up to $5,677,000	$1,301 to $2,096	Some Negative Impact	Construction and maintenance of pipeline corridor
	Jim Wells County	494 to 929	Up to $9,398,000	Up to $1,678,000	$1,806 to $2,235	Some Negative Impact	Construction and maintenance of pipeline corridor
	Brooks County	2,844	$21,117,000	$4,340,000	$1,526	Some Negative Impact	Construction and maintenance of pipeline corridor
	STWA to Jim Wells/Brooks County	3,024	$34,899,000	$6,166,000	$2,039	Some Negative Impact	Construction and maintenance of pipeline corridor
	San Patricio County	125-1,507	$1,833,000 to $5,545,000	$259,000 to $1,630,000	$1,082 to$2,072	Some Negative Impact	Construction and maintenance of pipeline corridor
	Alice to STWA	2,800	$5,866,000	$3,746,000	$1,158	No change	Construction and maintenance of pipeline corridor

[1] Assumes unit costs of $470 to $510 per ac-ft.
[2] Unit cost for raw water supplies.
[3] Costs based on drilling 3 wells for McMullen County-Mining.
[4] Costs to implement both Chase Field and 0.3 mgd irrigation well conversion project.
[5] Depends on the amount of raw water that bypasses treatment for blending with desalinated water. At larger ratios of bypassed water to desalinated water, the degree of water quality improvement over current supplies is diminished.

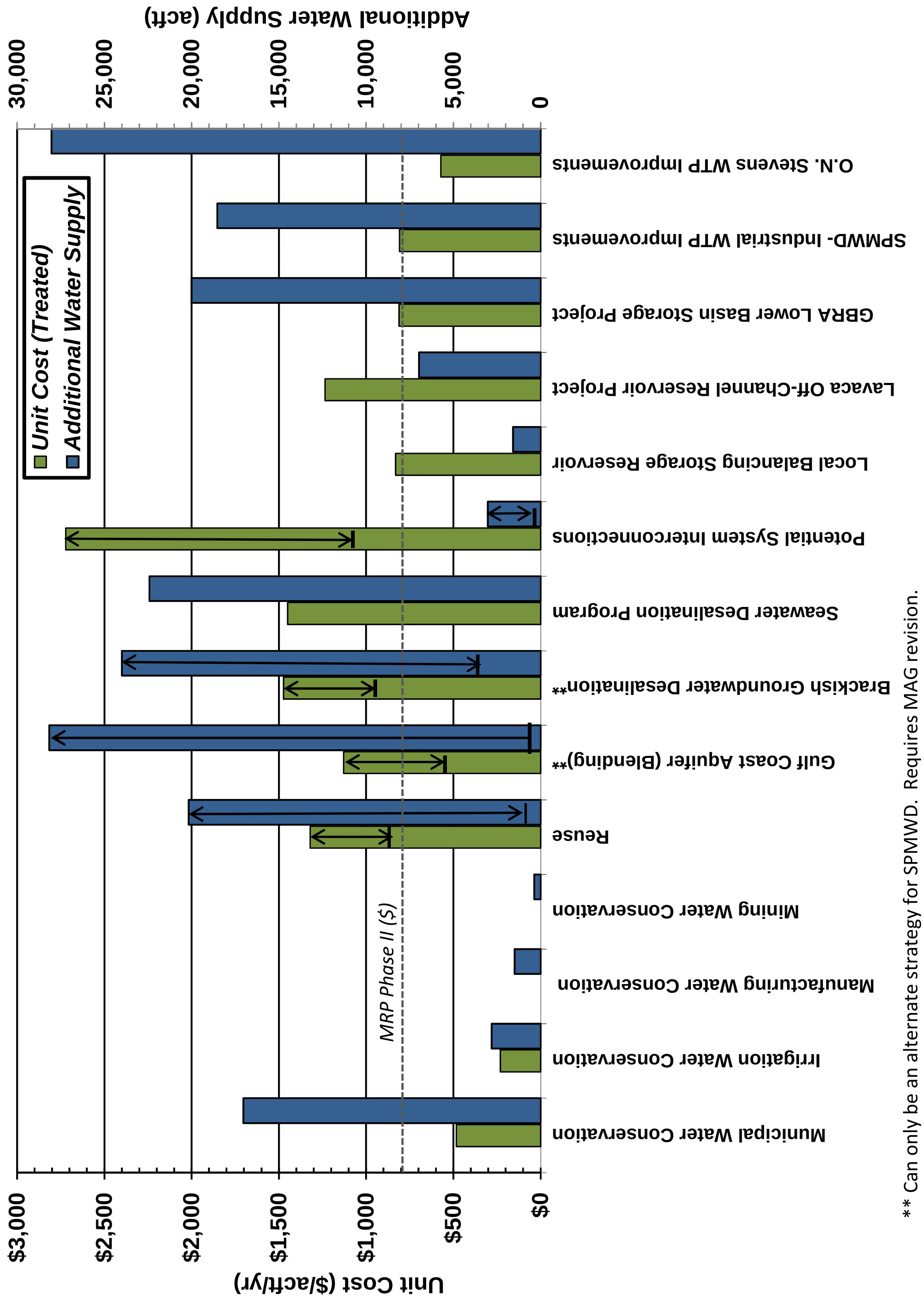

Figure 5B.1.1.
Unit Cost and Water Supply Comparison for Selected Water Management Strategies

Table 5B.1.3.
Summary of Impact Categories for Evaluation of Water Management Strategies

a.	Water Supply 1. Quantity 2. Reliability 3. Cost of Treated Water
b.	Environmental factors 1. Instream flows 2. Bay and Estuary Inflows 3. Wildlife Habitat 4. Wetlands 5. Threatened and Endangered Species 6. Cultural Resources 7. Water Quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents
c.	Impacts to State water resources
d.	Threats to agriculture and natural resources in region
e.	Recreational impacts
f.	Equitable comparison of strategies
g.	Interbasin transfers
h.	Third party social and economic impacts from voluntary redistribution of water
i.	Efficient use of existing water supplies and regional opportunities
j.	Effect on navigation

Table 5B.1.4.
Impacts to Environmental Factors Key

Impacts to Environmental Factors Key	Criteria
None or Low; Negligible	Reduction in environmental flows with implementation of the strategy is indiscernible (less than 1%) using the approved surface water availability model, as compared to flows without the project. Wildlife habitat is not expected to be altered by the project.
Moderate; Some	Reduction in environmental flows with implementation of the strategy is expected to range from 1% to 10% using the approved surface water availability model, as compared to flows without the project. Due to the nature of the strategy, localized impacts to small creeks or on-site tanks may be noticed (up to 10%). Wildlife habitat may be temporarily impacted during project construction, but long-term impacts to wildlife habitat are not expected.
High	Reduction in environmental flows with implementation of the strategy is expected to exceed 10% using the approved surface water availability model, as compared to flows without the project. Long-term wildlife habitat alteration is highly likely with project.

Table 5B.1.5.
Impacts to Agricultural Resources Key

Impacts to Agricultural Resources Key	Criteria
None or Low; Negligible	Temporary impacts to agricultural land during project construction. Occasion disturbances due to maintenance on right of way for pipelines.
Moderate; Some	Loss of up to 50 irrigated acres permanently due to repurposing of land to support the project (i.e. impoundment).
High	Loss of more than 50 irrigated acres permanently due to repurposing of land to support the project (i.e. impoundment).

According to the TWDB, regional planning is a reconnaissance-level effort and a detailed investigation of project impacts is beyond the scope and mandate of this effort. The impacts, costs, and benefit of large-scale projects such as reservoirs or major diversions would, if implemented, undergo additional and extensive evaluation during permitting under Section 404 of the Clean Water Act, the National Environmental Protection Action, and any other applicable federal, state, or local regulations.

Drought Management is not a recommended water management strategy to meet projected water needs in the Coastal Bend Region, in part because it cannot be demonstrated to be an economically feasible strategy. However, a safe yield reserve of 125,000 ac-ft (roughly equivalent to one-year demand) is included as a drought management measure when evaluating regional surface water supplies from the CCR/LCC/Texana/MRP Phase II system.

The TWDB socioeconomic impact analysis of water needs in Coastal Bend Region was provided for the Region N Plan. As part of the analysis, the TWDB developed costs to represent impacts of leaving water needs entirely unmet for each water use category and as an aggregate for the region under a repeat of the drought of record. The TWDB's socioeconomic impact analysis represents a snapshot of socioeconomic impacts that may occur during a single year during a drought of record within each of the planning decades. The TWDB's analysis for Region N is included in Appendix 2.

The estimated effect of projected water shortages upon income in the region, are $4,492 million per year in 2020, $5,487 million per year in 2040, and $1,715 million per year in 2070. If the water needs are left entirely unmet, the level of shortage in 2020 results in 24,000 fewer jobs than would be expected if the water needs of 2020 are fully met. The gap in job growth due to water shortages grows to 5,430 fewer jobs by 2040 and 1,540 few jobs by 2070.

Future projects involving authorization from either the TCEQ and/or TWDB which are not specifically addressed in the plan are considered to be consistent with the plan under the following circumstances:

1. TWDB receives applications for financial assistance for many types of water supply projects, including water conservation, and when appropriate, wastewater reuse strategies. Other projects involve repairing, replacing, or expanding treatment plants, pump stations, pipelines and water storage facilities including ASR. The RWPG considers projects that do not involve the development of or connection to a new water source to be consistent with the regional water plan even though not specifically recommended in the plan.
2. TCEQ considers water rights applications for various types of uses (e.g., recreation, navigation, irrigation, hydroelectric power, industrial, recharge, municipal and others). Many of these applications are for small amounts of water, some are temporary, and some are even non-consumptive. Because waters of the Nueces River Basin are fully appropriated to the City of Corpus Christi and others, any new water rights application for consumptive water use from this Basin will need to protect the existing water rights or provide appropriate mitigation to existing water right owners. Throughout the Coastal Bend Region the types of small projects that may arise are so unpredictable that the RWPG is of the opinion that each project should be considered by the TWDB and TCEQ on their merits, and that the Legislature foresaw this situation and provided appropriate language for each agency to deal with it.

(Note: The provision related to TCEQ is found in Texas Water Code §11.134. It provides that the Commission shall grant an application to appropriate surface water, including amendments, only if the proposed appropriator addresses a water supply need in a manner consistent with an approved regional water plan. TCEQ may waive this requirement if conditions warrant. For TWDB funding, Texas Water Code §16.053(j) states that after January 5, 2002 TWDB may provide financial assistance to a water supply project only after the Board determines that the needs to be addressed by the project will be addressed in a manner that is consistent with that appropriate regional water plan. The TWDB may waive this provision if conditions warrant.)

5B.2 Aransas County Water Supply Plan

Table 5B.2.1 lists each water user group in Aransas County and their corresponding surplus or shortage in years 2040 and 2070. For each water user group with a projected shortage, a water supply plan has been developed and is presented in the following subsections. There are no projected shortages for Aransas County water user groups.

Table 5B.2.1.
Aransas County Surplus/(Shortage)

Water User Group	Surplus/(Shortage)[1] 2040 (ac-ft/yr)	Surplus/(Shortage)[1] 2070 (ac-ft/yr)	Comment
City of Aransas Pass	0	0	Supply equals demand
City of Fulton	0	0	Supply equals demand
City of Rockport	0	0	Supply equals demand
County-Other	0	0	Supply equals demand
Manufacturing	118	93	No projected shortage
Steam-Electric	none	none	No demands projected
Mining	5	5	No projected shortage
Irrigation	none	none	No demands projected
Livestock	0	0	Supply equals demand

[1] From Tables 4.2 and 4.3, Chapter 4 – Comparison of Water Demands with Water Supplies to Determine Needs.

5B.2.1 City of Aransas Pass

The City of Aransas Pass is located in Aransas, Nueces, and San Patricio Counties; consequently, its water demand and supply values are split into the tables for each county. Aransas Pass contracts with the San Patricio Municipal Water District (SPMWD) to purchase treated water. The contract allows the City of Aransas Pass to purchase only the water that it needs. No shortages are projected for the City of Aransas Pass and no changes in water supply are recommended.

5B.2.2 City of Fulton

The City of Fulton has a contract with the SPMWD to purchase treated water. The contract allows the City to purchase only the water that it needs. No shortages are projected for the City of Fulton; however, additional water conservation is a recommended water management strategy for the City (Table 5B.2.2).

Table 5B.2.2.
Recommended Water Supply Plan for the City of Fulton

	2020 (ac-ft/yr)	***2030 (ac-ft/yr)***	***2040 (ac-ft/yr)***	***2050 (ac-ft/yr)***	***2060 (ac-ft/yr)***	***2070 (ac-ft/yr)***
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	12	33	46	44	44	44
Total New Supply	**12**	**33**	**46**	**44**	**44**	**44**

Estimated costs of the recommended plan for the City of Fulton are shown in Table 5B.2.3.

Table 5B.2.3.
Recommended Plan Costs by Decade for the City of Fulton

Plan Element	***2020***	***2030***	***2040***	***2050***	***2060***	***2070***
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$6,233	$17,055	$23,242	$22,522	$22,442	$22,442
Unit Cost ($/ac-ft)*	$510	$510	$510	$510	$510	$510

** Unit costs for this plan element are rounded.*

5B.2.3 City of Rockport

The City of Rockport has a contract with the SPMWD to purchase treated water. The contract allows the City of Rockport to purchase only the water that it needs. No shortages in annual water supplies are projected for the City of Rockport; however, additional water conservation is a recommended water management strategy for the City (Table 5B.2.4).

Table 5B.2.4.
Recommended Water Supply Plan for the City of Rockport

	2020 (ac-ft/yr)	***2030 (ac-ft/yr)***	***2040 (ac-ft/yr)***	***2050 (ac-ft/yr)***	***2060 (ac-ft/yr)***	***2070 (ac-ft/yr)***
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	66	192	172	159	156	156
Total New Supply	**66**	**192**	**172**	**159**	**156**	**156**

Estimated costs of the recommended plan for the City of Rockport are shown in Table 5B.2.5.

Table 5B.2.5.
Recommended Plan Costs by Decade for the City of Rockport

Plan Element	2020	2030	2040	2050	2060	2070
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$33,745	$97,781	$87,525	$81,036	$79,426	$79,426
Unit Cost ($/ac-ft)*	$510	$510	$510	$510	$510	$510

** Unit costs for this plan element are rounded.*

5B.2.4 County-Other

County-Other in Aransas County obtains water from groundwater sources and the SPMWD. No shortages in annual water supplies are projected for the Aransas County-Other and no changes in water supply are recommended.

5B.2.5 Manufacturing

Manufacturing in Aransas County obtains water from the Gulf Coast Aquifer. No shortages in annual water supplies are projected for the Aransas County Manufacturing and no changes in water supply are recommended.

5B.2.6 Steam-Electric

No steam-electric demand exists or is projected for the county.

5B.2.7 Mining

The mining water demands in Aransas County are met by groundwater from the Gulf Coast Aquifer. No shortages are projected for mining users and no changes in water supply are recommended.

5B.2.8 Irrigation

No irrigation demand exists or is projected for the county.

5B.2.9 Livestock

The livestock water demands in Aransas County are met by groundwater from the Gulf Coast Aquifer and surface water from local on-farm sources. No shortages are projected for livestock and no changes in water supply are recommended.

5B.3 Bee County Water Supply Plan

Table 5B.3.1 lists each water user group in Bee County and their corresponding surplus or shortage in years 2040 and 2070. There are no projected shortages for Bee County water user groups.

Table 5B.3.1.
Bee County Surplus/(Shortage)

Water User Group	Surplus/(Shortage)[1] 2040 (ac-ft/yr)	Surplus/(Shortage)[1] 2070 (ac-ft/yr)	Comment
City of Beeville	0	0	Supply equals demand
El Oso WSC			See Live Oak County
County-Other	19	49	No projected shortage
Manufacturing	0	0	Supply equals demand
Steam-Electric	none	none	No demands projected
Mining	82	192	No projected shortage
Irrigation	2,229	40	No projected shortage
Livestock	0	0	Supply equals demand

[1] From Tables 4.4 and 4.5, Chapter 4 – Comparison of Water Demands with Water Supplies to Determine Needs.

5B.3.1 City of Beeville

The City of Beeville contracts with City of Corpus Christi to purchase raw water from the CCR/LCC System. The contract allows the City of Beeville to purchase only the water that it needs. No shortages are projected for the City of Beeville; however, the following water management strategies are recommended for the City (Table 5B.3.2).

Table 5B.3.2.
Recommended Water Supply Plan for the City of Beeville

	2020 (ac-ft/yr)	2030 (ac-ft/yr)	2040 (ac-ft/yr)	2050 (ac-ft/yr)	2060 (ac-ft/yr)	2070 (ac-ft/yr)
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	117	333	542	710	706	707
Chase Field Project	1,457	1,457	1,457	1,457	1,457	1,457
Well Conversion Project	340	340	340	340	340	340
Total New Supply	**1,941**	**2,130**	**2,339**	**2,507**	**2,503**	**2,504**

Estimated costs of the recommended plan for the City of Beeville are shown in Table 5B.3.3.

Table 5B.3.3.
Recommended Plan Costs by Decade for the City of Beeville

Plan Element	2020	2030	2040	2050	2060	2070
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$58,701	$166,265	$270,929	$335,237	$353,139	$353,326
Unit Cost ($/ac-ft)*	$500	$500	$500	$500	$500	$500
Groundwater Supplies- Chase Field Project (Chapter 5D.7)						
Annual Cost ($/yr)	$705,000	$705,000	$305,000	$305,000	$305,000	$305,000
Unit Cost ($/ac-ft)	$484	$484	$209	$209	$209	$209
Groundwater Supplies- Well Conversion Project (Chapter 5D.7)						
Annual Cost ($/yr)	$46,000	$46,000	$46,000	$46,000	$46,000	$46,000
Unit Cost ($/ac-ft)	$135	$135	$135	$135	$135	$135

** Unit costs for this plan element are rounded.*

5B.3.2 El Oso WSC

See Live Oak County for the El Oso WSC plan.

5B.3.3 County-Other

Bee County-Other demands are met with groundwater from the Gulf Coast Aquifer. No shortages are projected for County-Other entities and no changes in water supply are recommended.

5B.3.4 Manufacturing

There are small manufacturing water demands in Bee County. These demands are met by groundwater from the Gulf Coast Aquifer. No shortages are projected for manufacturing and no changes in water supply are recommended.

5B.3.5 Steam-Electric

No steam-electric demand exists or is projected for the county.

5B.3.6 Mining

Mining demands in Bee County are met by groundwater from the Gulf Coast Aquifer. No shortages are projected for mining and no changes in water supply are recommended.

5B.3.7 Irrigation

Irrigation demands in Bee County are met by groundwater from the Gulf Coast Aquifer. No shortages are projected for irrigation users and no changes in water supply are recommended.

5B.3.8 Livestock

The livestock water demands in Bee County are met by groundwater from the Gulf Coast Aquifer and surface water from local on-farm sources. No shortages are projected for livestock and no changes in water supply are recommended.

5B.4 Brooks County Water Supply Plan

Table 5B.4.1 lists each water user group in Brooks County and their corresponding surplus or shortage in years 2040 and 2070. All water user groups in Brooks County have an adequate supply, as shown in Table 5B.4.1.

Table 5B.4.1.
Brooks County Surplus/(Shortage)

Water User Group	Surplus/(Shortage)[1] 2040 (ac-ft/yr)	Surplus/(Shortage)[1] 2070 (ac-ft/yr)	Comment
City of Falfurrias	942	782	No projected shortage
County-Other	80	1	No projected shortage
Manufacturing	none	none	No demands projected
Steam-Electric	none	none	No demands projected
Mining	20	62	No projected shortage
Irrigation	315	3	No projected shortage
Livestock	0	0	Supply equals demand

[1] From Tables 4.6 and 4.7, Chapter 4 – Comparison of Water Demands with Water Supplies to Determine Needs.

5B.4.1 City of Falfurrias

The City of Falfurrias receives groundwater supplies from the Gulf Coast Aquifer. No shortages are projected for the City of Falfurrias; however, additional water conservation is a recommended water management strategy for the City (Table 5B.4.2).

Table 5B.4.2.
Recommended Water Supply Plan for the City of Falfurrias

	2020 (ac-ft/yr)	2030 (ac-ft/yr)	2040 (ac-ft/yr)	2050 (ac-ft/yr)	2060 (ac-ft/yr)	2070 (ac-ft/yr)
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	91	224	360	508	649	786
Total New Supply	**91**	**224**	**360**	**508**	**649**	**786**

Estimated costs of the recommended plan for the City of Falfurrias are shown in Table 5B.4.3.

Table 5B.4.3.
Recommended Plan Costs by Decade for the City of Falfurrias

Plan Element	***2020***	***2030***	***2040***	***2050***	***2060***	***2070***
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$45,747	$111,976	$180,009	$254,008	$324,710	$392,933
Unit Cost ($/ac-ft)*	$500	$500	$500	$500	$500	$500

** Unit costs for this plan element are rounded.*

5B.4.2 County-Other

The Brooks County-Other municipal users receive groundwater supplies from the Gulf Coast Aquifer. No shortages are projected for Brooks County-Other and no changes in water supply are recommended.

5B.4.3 Manufacturing

No manufacturing demand exists or is projected for the county.

5B.4.4 Steam-Electric

No steam-electric demand exists or is projected for the county.

5B.4.5 Mining

The mining water demands in Brooks County are met by groundwater from the Gulf Coast Aquifer. No shortages are projected for mining and no changes in water supply are recommended.

5B.4.6 Irrigation

The irrigation water demands in Brooks County are met by groundwater from the Gulf Coast Aquifer. No shortages are projected for irrigation and no changes in water supply are recommended.

5B.4.7 Livestock

The livestock water demands in Brooks County are met by groundwater from the Gulf Coast Aquifer and surface water from local on-farm sources. No shortages are projected for livestock and no changes in water supply are recommended.

5B.5 Duval County Water Supply Plan

Table 5B.5.1 lists each water user group in Duval County and their corresponding surplus or shortage in years 2040 and 2070. For each water user group with a projected shortage, a water supply plan has been developed and is presented in the following subsections.

Table 5B.5.1.
Duval County Surplus/(Shortage)

Water User Group	***Surplus/(Shortage)[1]***		***Comment***
	2040 (ac-ft/yr)	***2070 (ac-ft/yr)***	
City of Benavides	118	96	No projected shortage
City of Freer	240	177	No projected shortage
City of San Diego	(56)	(158)	Projected shortage – see plan below
County-Other	82	40	No projected shortage
Manufacturing	none	none	No demands projected
Steam-Electric	none	none	No demands projected
Mining	3,304	3,552	No projected shortage
Irrigation	588	66	No projected shortage
Livestock	0	0	Supply equals demand

1 From Tables 4.8 and 4.9, Chapter 4 – Comparison of Water Demands with Water Supplies to Determine Needs.

5B.5.1 City of Benavides

The City of Benavides receives groundwater supplies from the Goliad Sands of the Gulf Coast Aquifer. No shortages are projected for the City of Benavides; however, additional water conservation is a recommended water management strategy for the City (Table 5B.5.2).

Table 5B.5.2.
Recommended Water Supply Plan for the City of Benavides

	2020 (ac-ft/yr)	***2030 (ac-ft/yr)***	***2040 (ac-ft/yr)***	***2050 (ac-ft/yr)***	***2060 (ac-ft/yr)***	***2070 (ac-ft/yr)***
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	4	0	0	0	0	0
Total New Supply	**4**	**0**	**0**	**0**	**0**	**0**

Estimated costs of the recommended plan for the City of Benavides are shown in Table 5B.5.3.

Table 5B.5.3.
Recommended Plan Costs by Decade for the City of Benavides

Plan Element	2020	2030	2040	2050	2060	2070
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$2,176	$0	$0	$0	$0	$0
Unit Cost ($/ac-ft)*	$500	N/A	N/A	N/A	N/A	N/A

** Unit costs for this plan element are rounded.*

5B.5.2 City of Freer

The City of Freer receives groundwater supplies from the Catahoula portion of the Gulf Coast Aquifer. No shortages are projected for the City of Freer; however, additional water conservation is a recommended water management strategy for the City (Table 5B.5.4).

Table 5B.5.4.
Recommended Water Supply Plan for the City of Freer

	2020 (ac-ft/yr)	2030 (ac-ft/yr)	2040 (ac-ft/yr)	2050 (ac-ft/yr)	2060 (ac-ft/yr)	2070 (ac-ft/yr)
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	24	73	124	168	171	175
Total New Supply	**24**	**73**	**124**	**168**	**171**	**175**

Estimated costs of the recommended plan for the City of Freer are shown in Table 5B.5.5.

Table 5B.5.5.
Recommended Plan Costs by Decade for the City of Freer

Plan Element	2020	2030	2040	2050	2060	2070
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$12,165	$36,336	$61,873	$83,830	$85,675	$87,510
Unit Cost ($/ac-ft)*	$500	$500	$500	$500	$500	$500

** Unit costs for this plan element are rounded.*

5B.5.3 City of San Diego

The City of San Diego is located in Duval and Jim Well Counties; however, its water supply plan is presented here. The City of San Diego obtains groundwater supplies from the Goliad Sands of the Gulf Coast Aquifer.

Shortages are projected for the City of San Diego. The recommended water supply management plan for the City is shown in Table 5B.5.6. There are sufficient Gulf Coast Aquifer supplies to drill an additional well without exceeding MAG constraints.

Table 5B.5.6.
Recommended Water Supply Plan for the City of San Diego

	2020 (ac-ft/yr)	***2030 (ac-ft/yr)***	***2040 (ac-ft/yr)***	***2050 (ac-ft/yr)***	***2060 (ac-ft/yr)***	***2070 (ac-ft/yr)***
Projected Need (Shortage)	0	28	56	94	128	158
Recommended Plan						
Municipal Water Conservation	29	94	117	117	119	122
Gulf Coast Aquifer Supplies	0	158	158	158	158	158
Total New Supply	**29**	**252**	**275**	**275**	**277**	**280**

Estimated costs of the recommended plan for the City of San Diego are shown in Table 5B.5.7.

Table 5B.5.7.
Recommended Plan Costs by Decade for the City of San Diego

Plan Element	***2020***	***2030***	***2040***	***2050***	***2060***	***2070***
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$14,428	$47,002	$58,292	$58,317	$59,557	$61,227
Unit Cost ($/ac-ft)*	$500	$500	$500	$500	$500	$500
Gulf Coast Aquifer Supplies – Drill Additional Well(s) (Chapter 5D.7)						
Annual Cost ($/yr)		$106,000	$106,000	$27,000	$27,000	$27,000
Unit Cost ($/ac-ft)		$671	$671	$171	$171	$171

** Unit costs for this plan element are rounded.*

The City of Alice has run a 16-inch water transmission line to Hwy 281 bypass, approximately 8 to 9 miles from the City of San Diego. This pipeline could be extended to provide water supply from the City of Alice to San Diego. Although this is not a recommended strategy, it could provide an alternative supply to the City of San Diego.

5B.5.4 County-Other

Duval County-Other municipal users receive groundwater supplies from the Gulf Coast Aquifer. No shortages are projected for Duval County-Other and no changes in water supply are recommended.

5B.5.5 Manufacturing

No manufacturing demand exists or is projected for the county.

5B.5.6 Steam-Electric

No steam-electric demand exists or is projected for the county.

5B.5.7 Mining

Duval County-Other mining users receive groundwater supplies from the Gulf Coast Aquifer. No shortages are projected for Duval County mining users and no changes in water supply are recommended.

5B.5.8 Irrigation

Irrigation demands are met by groundwater from the Gulf Coast Aquifer. No shortages are projected for irrigation and no changes in water supply are recommended.

5B.5.9 Livestock

The livestock water demands in Duval County are met by groundwater from the Gulf Coast Aquifer and surface water from local on-farm sources. No shortages are projected for livestock and no changes in water supply are recommended.

5B.6 Jim Wells County Water Supply Plan

Table 5B.6.1 lists each water user group in Jim Wells County and their corresponding surplus or shortage in years 2040 and 2070. For each water user group with a projected shortage, a water supply plan has been developed and is presented in the following subsections.

Table 5B.6.1.
Jim Wells County Surplus/(Shortage)

Water User Group	Surplus/(Shortage)[1]		Comment
	2040 (ac-ft/yr)	2070 (ac-ft/yr)	
City of Alice	0	0	Supply equals demand
City of Orange Grove	405	333	No projected shortage
City of Premont	1,016	879	No projected shortage
City of San Diego			See Duval County
County-Other	540	70	No projected shortage
Manufacturing	none	none	No demands projected
Steam-Electric	none	none	No demands projected
Mining	19	57	No projected shortage
Irrigation	544	109	No projected shortage
Livestock	0	0	Supply equals demand

[1] From Tables 4.10 and 4.11, Chapter 4 – Comparison of Water Demands with Water Supplies to Determine Needs.

5B.6.1 City of Alice

The City of Alice has a contract to purchase water from the City of Corpus Christi via Lake Corpus Christi. The City also maintains a small reservoir in town, Lake Findley, which serves as temporary storage of waters from Lake Corpus Christi. This reservoir is fed naturally by a small watershed and has no effective firm yield. No shortages are projected for the City of Alice; however, the following water management strategies are recommended for the City (Table 5B.6.2).

Table 5B.6.2.
Recommended Water Supply Plan for the City of Alice

	2020 (ac-ft/yr)	2030 (ac-ft/yr)	2040 (ac-ft/yr)	2050 (ac-ft/yr)	2060 (ac-ft/yr)	2070 (ac-ft/yr)
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	143	462	812	838	876	916
Brackish Groundwater	3,363	3,363	3,363	3,363	3,363	3,363
STWA Interconnections	2,800	2,800	2,800	2,800	2,800	2,800
Reuse	0	897	897	897	897	897
Pipeline Replacement Program	0	173	460	576	576	576
Total New Supply	**6,306**	**7,522**	**7,872**	**7,898**	**7,936**	**7,976**

Estimated costs of the recommended plan for the City of Alice are shown in Table 5B.6.3.

Table 5B.6.3.
Recommended Plan Costs by Decade for the City of Alice

Plan Element	2020	2030	2040	2050	2060	2070
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$73,170	$235,658	$413,944	$427,364	$446,726	$467,094
Unit Cost ($/ac-ft)*	$510	$510	$510	$510	$510	$510
Brackish Groundwater (Chapter 5D.8)						
Annual Cost ($/yr)	$4,956,000	$4,956,000	$2,171,000	$2,171,000	$2,171,000	$2,171,000
Unit Cost ($/ac-ft)	$1,474	$1,474	$646	$646	$646	$646
STWA Interconnections (Chapter 5D.10)						
Annual Cost ($/yr)	$3,242,000	$3,242,000	$2,751,000	$2,751,000	$2,751,000	$2,751,000
Unit Cost ($/ac-ft)	$1,158	$1,158	$983	$983	$983	$983
Reuse (Chapter 5D.5)						
Annual Cost ($/yr)	N/A	$1,185,000	$1,185,000	$460,000	$460,000	$460,000
Unit Cost ($/ac-ft)	N/A	$1,321	$1,321	$512	$512	$512
Pipeline Replacement Program (Chapter 5D.1, Table 5D.1.7.)						
Annual Cost ($/yr)	N/A	$2,138,400	$2,138,400	$0	$0	$0
Unit Cost ($/ac-ft)	N/A	$62,120	$62,120	N/A	N/A	N/A

** Unit costs for this plan element are rounded.*

5B.6.2 City of Orange Grove

The City of Orange Grove's water supply is from the Gulf Coast Aquifer. No shortages are projected for the City of Orange Grove; however, additional water conservation is a recommended water management strategy for the City (Table 5B.6.4).

Table 5B.6.4.
Recommended Water Supply Plan for the City of Orange Grove

	2020 (ac-ft/yr)	*2030 (ac-ft/yr)*	*2040 (ac-ft/yr)*	*2050 (ac-ft/yr)*	*2060 (ac-ft/yr)*	*2070 (ac-ft/yr)*
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	18	49	83	120	159	183
Total New Supply	**18**	**49**	**83**	**120**	**159**	**183**

Estimated costs of the recommended plan for the City of Orange Grove are shown in Table 5B.6.5.

Table 5B.6.5.
Recommended Plan Costs by Decade for the City of Orange Grove

Plan Element	*2020*	*2030*	*2040*	*2050*	*2060*	*2070*
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$8,962	$24,700	$41,570	$59,964	$79,435	$91,591
Unit Cost ($/ac-ft)*	$500	$500	$500	$500	$500	$500

** Unit costs for this plan element are rounded.*

5B.6.3 City of Premont

The City of Premont's water supply is from the Gulf Coast Aquifer. No shortages are projected for the City of Premont; however, additional water conservation is a recommended water management strategy for the City (Table 5B.6.6).

Table 5B.6.6.
Recommended Water Supply Plan for the City of Premont

	2020 (ac-ft/yr)	*2030 (ac-ft/yr)*	*2040 (ac-ft/yr)*	*2050 (ac-ft/yr)*	*2060 (ac-ft/yr)*	*2070 (ac-ft/yr)*
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	31	87	149	221	289	303
Total New Supply	**31**	**87**	**149**	**221**	**289**	**303**

Estimated costs of the recommended plan for the City of Premont are shown in Table 5B.6.7.

Table 5B.6.7.
Recommended Plan Costs by Decade for the City of Premont

Plan Element	2020	2030	2040	2050	2060	2070
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$15,519	$43,666	$74,735	$110,538	$144,493	$151,644
Unit Cost ($/ac-ft)*	$500	$500	$500	$500	$500	$500

** Unit costs for this plan element are rounded.*

5B.6.4 City of San Diego

The City of San Diego is in both Duval and Jim Wells Counties. See Duval County for the City's water management plan.

5B.6.5 County-Other

Jim Wells County-Other municipal users receive groundwater supplies from the Gulf Coast Aquifer. No shortages are projected for Jim Wells County-Other and no changes in water supply are recommended.

5B.6.6 Manufacturing

No manufacturing demand exists or is projected for the county. Although the TWDB projections do not show any future manufacturing water demands, historical water use data indicates that 79 ac-ft was used by Jim Wells- Manufacturing in 2012. For future planning cycles, this potential demand should be revisited.

5B.6.7 Steam-Electric

No steam-electric demand exists or is projected for the county.

5B.6.8 Mining

Mining demands are met by groundwater from the Gulf Coast Aquifer. No shortages are projected for mining and no changes in water supply are recommended.

5B.6.9 Irrigation

Irrigation demands are met by groundwater from the Gulf Coast Aquifer. No shortages are projected for irrigation and no changes in water supply are recommended.

5B.6.10 Livestock

The livestock water demands in Jim Wells County are met by groundwater from the Gulf Coast Aquifer and surface water from local on-farm sources. No shortages are projected for livestock and no changes in water supply are recommended.

5B.7 Kenedy County Water Supply Plan

Table 5B.7.1 lists each water user group in Kenedy County and their corresponding surplus or shortage in years 2040 and 2070. All water user groups in Kenedy County have an adequate supply, as shown in Table 5B.7.1.

Table 5B.7.1.
Kenedy County Surplus/(Shortage)

Water User Group	*Surplus/(Shortage)*[1] 2040 (ac-ft/yr)	2070 (ac-ft/yr)	*Comment*
County-Other	43	41	No projected shortage
Manufacturing	none	none	No demands projected
Steam-Electric	none	none	No demands projected
Mining	38	103	No projected shortage
Irrigation	none	none	No demands projected
Livestock	0	0	Supply equals demand

[1] From Tables 4.12 and 4.13, Chapter 4 – Comparison of Water Demands with Water Supplies to Determine Needs.

5B.7.1 County-Other

The Kenedy County-Other municipal users receive groundwater supplies from the Gulf Coast Aquifer. No shortages are projected for Kenedy County-Other entities; however, additional water conservation is a recommended water management strategy for the entity (Table 5B.7.2).

Table 5B.7.2.
Recommended Water Supply Plan for Kenedy County-Other

	2020 (ac-ft/yr)	*2030 (ac-ft/yr)*	*2040 (ac-ft/yr)*	*2050 (ac-ft/yr)*	*2060 (ac-ft/yr)*	*2070 (ac-ft/yr)*
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	17	40	60	79	97	113
Total New Supply	**17**	**40**	**60**	**79**	**97**	**113**

Estimated costs of the recommended plan for Kenedy County-Other are shown in Table 5B.7.3.

Table 5B.7.3. Recommended Plan Costs by Decade for Kenedy County-Other

Plan Element	2020	2030	2040	2050	2060	2070
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$8,294	$19,893	$29,764	$39,399	$48,541	$56,521
Unit Cost ($/ac-ft)*	$500	$500	$500	$500	$500	$500

** Unit costs for this plan element are rounded.*

5B.7.2 Manufacturing

No manufacturing demand exists or is projected for the county.

5B.7.3 Steam-Electric

No steam-electric demand exists or is projected for the county.

5B.7.4 Mining

The mining water demands in Kenedy County are met by groundwater from the Gulf Coast Aquifer. No shortages are projected for mining and no changes in water supply are recommended.

5B.7.5 Irrigation

No irrigation demand exists or is projected for the county.

5B.7.6 Livestock

The livestock water demands in Kenedy County are met by groundwater from the Gulf Coast Aquifer and surface water from local on-farm sources. No shortages are projected for livestock and no changes in water supply are recommended.

5B.8 Kleberg County Water Supply Plan

Table 5B.8.1 lists each water user group in Kleberg County and their corresponding surplus or shortage in years 2040 and 2070. For each water user group with a projected shortage, a water supply plan has been developed and is presented in the following subsections.

Table 5B.8.1.
Kleberg County Surplus/(Shortage)

Water User Group	Surplus/(Shortage)[1]		Comment
	2040 (ac-ft/yr)	2070 (ac-ft/yr)	
City of Kingsville	69	69	No projected shortage
Ricardo WSC	112	112	No projected shortage
County-Other	2,954	2,816	No projected shortage
Manufacturing	none	none	No demands projected
Steam-Electric	none	none	No demands projected
Mining	40	82	No projected shortage
Irrigation	138	34	No projected shortage
Livestock	0	0	Supply equals demand

[1] From Tables 4.14 and 4.15, Chapter 4 – Comparison of Water Demands with Water Supplies to Determine Needs.

5B.8.1 City of Kingsville

The City of Kingsville has a contract with the South Texas Water Authority (STWA) to purchase treated surface water from the CCR/LCC/Texana/MRP Phase II System. The City also has five wells with a combined capacity of 3.7 mgd (or 4,130 ac-ft/yr) that pump groundwater from the Gulf Coast Aquifer. No shortages are projected for Kingsville and no changes in water supply are recommended.

5B.8.2 Ricardo WSC

STWA provides water to the Ricardo Water Supply Corporation via a direct 12” transmission line which was put in operation in December 2013. Ricardo WSC demands are met with surface water supplies. No shortages are projected for Ricardo WSC and no changes in water supply are recommended.

5B.8.3 County-Other

Kleberg County-Other receives groundwater supplies from the Gulf Coast Aquifer. No short-ages are projected for the Kleberg County-Other; however, additional water conservation is a recommended water management strategy for this entity (Table 5B.8.2).

Table 5B.8.2.
Recommended Water Supply Plan for Kleberg County-Other

	2020 (ac-ft/yr)	***2030 (ac-ft/yr)***	***2040 (ac-ft/yr)***	***2050 (ac-ft/yr)***	***2060 (ac-ft/yr)***	***2070 (ac-ft/yr)***
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	13	24	15	15	14	15
Total New Supply	**13**	**24**	**15**	**15**	**14**	**15**

Estimated costs of the recommended plan for Kleberg County-Other are shown in Table 5B.7.3.

Table 5B.8.3.
Recommended Plan Costs by Decade for Kleberg County-Other

Plan Element	***2020***	***2030***	***2040***	***2050***	***2060***	***2070***
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$6,724	$12,315	$7,742	$7,619	$7,055	$7,581
Unit Cost ($/ac-ft)*	$510	$510	$510	$510	$510	$510

** Unit costs for this plan element are rounded.*

5B.8.4 Manufacturing

No manufacturing demand exists or is projected for the county. Although the TWDB projections do not show any future manufacturing water demands, historical water use data indicates that 951 ac-ft was used by Kleberg- Manufacturing in 2013. For future planning cycles, this potential demand should be revisited.

5B.8.5 Steam-Electric

No steam-electric demand exists or is projected for the county.

5B.8.6 Mining

Mining water demands in Kleberg County are met by groundwater from the Gulf Coast Aquifer. No shortages are projected for mining and no changes in water supply are recommended.

5B.8.7 Irrigation

Irrigation demands are met by groundwater from the Gulf Coast Aquifer. No shortages are projected for irrigation and no changes in water supply are recommended.

5B.8.8 Livestock

The livestock demands in Kleberg County are met by groundwater from the Gulf Coast Aquifer and surface water from local on-farm sources. No shortages are projected for livestock and no changes in water supply are recommended.

5B.9 Live Oak County Water Supply Plan

Table 5B.9.1 lists each water user group in Live Oak County and their corresponding surplus or shortage in years 2040 and 2070. For each water user group with a projected shortage, a water supply plan has been developed and is presented in the following subsections.

Table 5B.9.1.
Live Oak County Surplus/(Shortage)

Water User Group	***Surplus/(Shortage)[1]***		***Comment***
	2040 (ac-ft/yr)	***2070 (ac-ft/yr)***	
El Oso WSC	372	385	No projected shortage
City of George West	444	449	No projected shortage
McCoy WSC	9	10	No projected shortage
City of Three Rivers	840	844	No projected shortage
County-Other	234	244	No projected shortage
Manufacturing	2,965	2,721	No projected shortage
Steam-Electric	none	none	No demands projected
Mining	13	588	No projected shortage
Irrigation	474	92	No projected shortage
Livestock	0	0	Supply equals demand

[1] From Tables 4.16 and 4.17, Chapter 4 – Comparison of Water Demands with Water Supplies to Determine Needs.

5B.9.1 El Oso WSC

El Oso Water Supply Corporation is located in both Bee and Live Oak Counties; consequently. The El Oso Water Supply Corporation receives groundwater supplies from the Gulf Coast Aquifer. No shortages are projected for El Oso Water Supply Corporation; however, additional water conservation is a recommended water management strategy for the WSC (Table 5B.9.2).

Table 5B.9.2.
Recommended Water Supply Plan for the El Oso WSC

	2020 (ac-ft/yr)	2030 (ac-ft/yr)	2040 (ac-ft/yr)	2050 (ac-ft/yr)	2060 (ac-ft/yr)	2070 (ac-ft/yr)
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	20	35	50	51	41	41
Total New Supply	**20**	**35**	**50**	**51**	**41**	**41**

Estimated costs of the recommended plan for the El Oso WSC are shown in Table 5B.9.3.

Table 5B.9.3.
Recommended Plan Costs by Decade for the El Oso WSC

Plan Element	2020	2030	2040	2050	2060	2070
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$10,149	$17,562	$25,029	$25,523	$20,523	$20,523
Unit Cost ($/ac-ft)*	$500	$500	$500	$500	$500	$500

** Unit costs for this plan element are rounded.*

5B.9.2 City of George West

The City of George West's demands are met with groundwater from the Gulf Coast Aquifer. No shortages are projected for George West; however, additional water conservation is a recommended water management strategy for the City (Table 5B.9.4).

Table 5B.9.4.
Recommended Water Supply Plan for the City of George West

	2020 (ac-ft/yr)	2030 (ac-ft/yr)	2040 (ac-ft/yr)	2050 (ac-ft/yr)	2060 (ac-ft/yr)	2070 (ac-ft/yr)
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	15	46	44	40	39	39
Total New Supply	**15**	**46**	**44**	**40**	**39**	**39**

Estimated costs of the recommended plan for the City of George West are shown in Table 5B.9.5.

Table 5B.9.5.
Recommended Plan Costs by Decade for the City of George West

Plan Element	2020	2030	2040	2050	2060	2070
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$7,665	$23,057	$22,121	$20,121	$19,621	$19,621
Unit Cost ($/ac-ft)*	$500	$500	$500	$500	$500	$500

** Unit costs for this plan element are rounded.*

5B.9.3 McCoy WSC

McCoy WSC's demands are met with groundwater from the Carrizo-Wilcox Aquifer. No shortages are projected for McCoy WSC and no changes in water supply are recommended.

5B.9.4 City of Three Rivers

The City of Three Rivers' demands are met with surface water rights on the Nueces River. No shortages are projected for Three Rivers; however, additional water conservation is a recommended water management strategy for the City (Table 5B.9.6).

Table 5B.9.6.
Recommended Water Supply Plan for the City of Three Rivers

	2020 (ac-ft/yr)	2030 (ac-ft/yr)	2040 (ac-ft/yr)	2050 (ac-ft/yr)	2060 (ac-ft/yr)	2070 (ac-ft/yr)
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	11	22	15	11	11	11
Total New Supply	**11**	**22**	**15**	**11**	**11**	**11**

Estimated costs of the recommended plan for the City of Three Rivers are shown in Table 5B.9.7.

Table 5B.9.7.
Recommended Plan Costs by Decade for the City of Three Rivers

Plan Element	2020	2030	2040	2050	2060	2070
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$5,340	$11,060	$7,560	$5,560	$5,560	$5,560
Unit Cost ($/ac-ft)*	$500	$500	$500	$500	$500	$500

** Unit costs for this plan element are rounded.*

5B.9.5 County-Other

Live Oak County-Other municipal users receive groundwater supplies from the Gulf Coast Aquifer. No shortages are projected for Live Oak County-Other and no changes in water supply are recommended.

5B.9.6 Manufacturing

Live Oak County manufacturing users receive groundwater supplies from the Gulf Coast Aquifer and surface water supplies from run-of-river rights in the Nueces Basin. No shortages are projected for Live Oak Manufacturing and no changes in water supply are recommended.

5B.9.7 Steam-Electric

No steam-electric demand exists or is currently projected for the county.

5B.9.8 Mining

Live Oak County mining users receive groundwater supplies from the Gulf Coast Aquifer. No shortages are projected for Live Oak Mining and no changes in water supply are recommended.

5B.9.9 Irrigation

Live Oak County irrigation users receive groundwater supplies from the Gulf Coast Aquifer. No shortages are projected for Live Oak Irrigation and no changes in water supply are recommended.

5B.9.10 Livestock

The livestock demands in Live Oak County are met by groundwater from the Gulf Coast Aquifer and surface water from local on-farm sources. No shortages are projected for livestock and no changes in water supply are recommended.

5B.10 McMullen County Water Supply Plan

Table 5B.10.1 lists each water user group in McMullen County and their corresponding surplus or shortage in years 2040 and 2070. For each water user group with a projected shortage, a water supply plan has been developed and is presented in the following subsections.

Table 5B.10.1.
McMullen County Surplus/(Shortage)

Water User Group	Surplus/(Shortage)[1]		Comment
	2040 (ac-ft/yr)	2070 (ac-ft/yr)	
County-Other	455	456	No projected shortage
Manufacturing	none	none	No demands projected
Steam-Electric	none	none	No demands projected
Mining	(3,219)	230	Projected shortage
Irrigation	(44)	(51)	Projected shortage
Livestock	0	0	Supply equals demand

[1] From Tables 4.18 and 4.19, Chapter 4 – Comparison of Water Demands with Water Supplies to Determine Needs.

5B.10.1 County-Other

The McMullen County-Other municipal users receive groundwater supplies from the Carrizo-Wilcox, Queen City, and Sparta Aquifers. No shortages are projected for McMullen County-Other entities and no changes in water supply are recommended.

5B.10.2 Manufacturing

No manufacturing demand exists or is projected for the county. Although the TWDB projections do not show any future manufacturing water demands, historical water use data indicates that 218 ac-ft was used by McMullen- Manufacturing in 2013. For future planning cycles, this potential demand should be revisited.

5B.10.3 Steam-Electric

No steam-electric demand exists or is projected for the county.

5B.10.4 Mining

Mining users in McMullen County obtain water from the Carrizo and Gulf Coast Aquifers. Shortages are projected for mining users within the county. The recommended water supply management plan for these entities are shown in Table 5B.10.2. Mining water conservation and additional groundwater (up to the MAG) are only able to meet a portion of the projected shortage. After considering strategies, there is an unmet need from Year 2020 to Year 2070. The maximum unmet need during the planning period is 2,063 ac-ft/yr in Year 2030. A TWDB socio-economic impact analysis of not meeting needs is included in Appendix 2.

Table 5B.10.2.
Recommended Water Supply Plan for McMullen County Mining

	2020 (ac-ft/yr)	2030 (ac-ft/yr)	2040 (ac-ft/yr)	2050 (ac-ft/yr)	2060 (ac-ft/yr)	2070 (ac-ft/yr)
Projected Need (Shortage)	2,733	3,269	3,219	1,087	315	0
Recommended Plan						
Mining Water Conservation	106	240	357	262	231	196
Gulf Coast Aquifer Supplies	966	966	966	966	966	966
Total New Supply	**1,072**	**1,206**	**1,323**	**1,228**	**1,197**	**1,162**

Estimated costs of the recommended plan for McMullen County Mining are shown in Table 5B.10.3.

Table 5B.10.3.
Recommended Plan Costs by Decade for McMullen County Mining

Plan Element	2020	2030	2040	2050	2060	2070
Mining Water Conservation (Chapter 5D.4)						
Annual Cost ($/yr)	N/A	N/A	N/A	N/A	N/A	N/A
Unit Cost ($/ac-ft)*	N/A	N/A	N/A	N/A	N/A	N/A
Gulf Coast Aquifer Supplies- Drill Additional Well(s) (Chapter 5D.7)						
Annual Cost ($/yr)	$189,000	$189,000	$48,000	$48,000	$48,000	$48,000
Unit Cost ($/ac-ft)	$196	$196	$50	$50	$50	$50

** Unit costs for this plan element are rounded.*

5B.10.5 Irrigation

Irrigation users in McMullen County obtain water from the Carrizo Aquifer. Shortages are projected for irrigation users within the county. The recommended water supply management plan for these entities are shown in Table 5B.10.4.

Table 5B.10.4.
Recommended Water Supply Plan for McMullen County Irrigation

	2020 (ac-ft/yr)	2030 (ac-ft/yr)	2040 (ac-ft/yr)	2050 (ac-ft/yr)	2060 (ac-ft/yr)	2070 (ac-ft/yr)
Projected Need (Shortage)	40	42	44	46	49	51
Recommended Plan						
Irrigation Water Conservation	1	2	3	5	6	8
Gulf Coast Aquifer Supplies	43	43	43	43	43	43
Total New Supply	**44**	**45**	**46**	**48**	**49**	**51**

Estimated costs of the recommended plan for McMullen County Irrigation are shown in Table 5B.10.5.

Table 5B.10.5.
Recommended Plan Costs by Decade for McMullen County Irrigation

Plan Element	2020	2030	2040	2050	2060	2070
Irrigation Water Conservation (Chapter 5D.2)						
Annual Cost ($/yr)	$230	$483	$759	$1,058	$1,409	$1,760
Unit Cost ($/ac-ft)*	$230	$230	$230	$230	$230	$230
Gulf Coast Aquifer Supplies- Drill Additional Well(s) (Chapter 5D.7)						
Annual Cost ($/yr)	$13,000	$13,000	$2,000	$2,000	$2,000	$2,000
Unit Cost ($/ac-ft)	$302	$302	$47	$47	$47	$47

** Unit costs for this plan element are rounded.*

5B.10.6 Livestock

The livestock water demands in McMullen County are met by groundwater from the Gulf Coast Aquifer and surface water from local on-farm sources. No shortages are projected for livestock and no changes in water supply are recommended.

5B.11 Nueces County Water Supply Plan

Table 5B.11.1 lists each water user group in Nueces County and their corresponding surplus or shortage in years 2040 and 2070. For each water user group with a projected shortage, a water supply plan has been developed and is presented in the following subsections.

Table 5B.11.1.
Nueces County Surplus/(Shortage)

Water User Group	Surplus/(Shortage)[1] 2040 (ac-ft/yr)	Surplus/(Shortage)[1] 2070 (ac-ft/yr)	Comment
City of Agua Dulce	0	0	Supply equals demand
City of Aransas Pass			See Aransas County
City of Bishop	0	0	Supply equals demand
City of Corpus Christi	0	0	Supply equals demand
City of Driscoll	0	0	Supply equals demand
Nueces WSC	0	0	Supply equals demand
City of Port Aransas	0	0	Supply equals demand
River Acres WSC	0	0	Supply equals demand
City of Robstown	(1,511)	(1,525)	Projected shortage – see plan below
County-Other	176	3	No projected shortage
Manufacturing	7,643	(19,603)	Projected shortage – see plan below
Steam-Electric	0	(6,893)	Projected shortage – see plan below
Mining	0	0	Supply equals demand
Irrigation	217	141	No projected shortage
Livestock	0	0	Supply equals demand

[1] From Tables 4.20 and 4.21, Chapter 4 – Comparison of Water Demands with Water Supplies to Determine Needs.

5B.11.1 City of Agua Dulce

The City of Agua Dulce has a contract with the South Texas Water Authority (STWA) to purchase treated surface water from the CCR/LCC/Texana/MRP Phase II System. No shortages are projected for the City of Agua Dulce and no changes in water supply are recommended.

5B.11.2 City of Aransas Pass

See Aransas County for the City of Aransas Pass water supply plan.

5B.11.3 City of Bishop

The City of Bishop has a contract with STWA to purchase treated surface water. Additionally, the City pumps groundwater from the Gulf Coast Aquifer. No shortages are projected for the City of Bishop; however, additional water conservation is a recommended water management strategy for the City (Table 5B.11.2).

Table 5B.11.2.
Recommended Water Supply Plan for the City of Bishop

	2020 (ac-ft/yr)	2030 (ac-ft/yr)	2040 (ac-ft/yr)	2050 (ac-ft/yr)	2060 (ac-ft/yr)	2070 (ac-ft/yr)
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	16	39	27	23	23	23
Total New Supply	**16**	**39**	**27**	**23**	**23**	**23**

Estimated costs of the recommended plan for the City of Bishop are shown in Table 5B.11.3.

Table 5B.11.3.
Recommended Plan Costs by Decade for the City of Bishop

Plan Element	2020	2030	2040	2050	2060	2070
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$8,009	$20,042	$13,786	$11,888	$11,800	$11,830
Unit Cost ($/ac-ft)*	$510	$510	$510	$510	$510	$510

** Unit costs for this plan element are rounded.*

5B.11.4 City of Corpus Christi

The City of Corpus Christi meets its demands with its own water rights in the CCR/LCC System, through a contract with the Lavaca-Navidad River Authority (LNRA) that provides water from Lake Texana, and supplies associated with water rights in the Colorado River Basin delivered through the Mary Rhodes Pipeline- Phase II project. Although no shortages are projected for the City's own municipal needs, the City also provides surface water to SPMWD, STWA, and manufacturing and steam-electric water user groups in Nueces and San Patricio Counties. Shortages are assigned to manufacturing and steam-electric water user groups in Nueces and San Patricio Counties. Additional water conservation is a recommended water management strategy for the City (Table 5B.11.4).

Table 5B.11.4.
Recommended Water Supply Plan for the City of Corpus Christi

	2020 (ac-ft/yr)	2030 (ac-ft/yr)	2040 (ac-ft/yr)	2050 (ac-ft/yr)	2060 (ac-ft/yr)	2070 (ac-ft/yr)
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	2,305	7,354	10,985	10,667	10,765	10,898
Total New Supply	**2,305**	**7,354**	**10,985**	**10,667**	**10,765**	**10,898**

Estimated costs of the recommended plan for the City of Corpus Christi are shown in Table 5B.11.5.

Table 5B.11.5.
Recommended Plan Costs by Decade for the City of Corpus Christi

Plan Element	2020	2030	2040	2050	2060	2070
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$1,083,268	$3,456,356	$5,163,045	$5,013,510	$5,059,753	$5,122,216
Unit Cost ($/ac-ft)*	$470	$470	$470	$470	$470	$470

** Unit costs for this plan element are rounded.*

5B.11.5 City of Driscoll

The City of Driscoll has a contract with STWA to purchase treated surface water from the CCR/LCC/Texana/MRP Phase II System. No shortages are projected for the City of Driscoll and no changes in water supply are recommended.

5B.11.6 Nueces WSC

Nueces WSC has a contract with the South Texas Water Authority (STWA) to purchase treated surface water from the CCR/LCC/Texana/MRP Phase II System. The Nueces WSC provides water supplies to a number of small rural entities in Nueces County as shown in Figure 3.3. No shortages are projected for Nueces WSC and no changes in water supply are recommended.

5B.11.7 City of Port Aransas

The City of Port Aransas (Nueces County Water Control & Improvement District #4) has contracts with the City of Corpus Christi and SPMWD to purchase treated surface water from the CCR/LCC/Texana/MRP Phase II System. No shortages are projected for Port Aransas; however, additional water conservation is a recommended water management strategy for the City of Port Aransas (Table 5B.11.6).

Table 5B.11.6.
Recommended Water Supply Plan for the City of Port Aransas

	2020 (ac-ft/yr)	2030 (ac-ft/yr)	2040 (ac-ft/yr)	2050 (ac-ft/yr)	2060 (ac-ft/yr)	2070 (ac-ft/yr)
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	160	374	589	792	985	1,161
Total New Supply	**160**	**374**	**589**	**792**	**985**	**1,161**

Estimated costs of the recommended plan for the City of Port Aransas are shown in Table 5B.11.7.

Table 5B.11.7.
Recommended Plan Costs by Decade for the City of Port Aransas

Plan Element	2020	2030	2040	2050	2060	2070
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$81,511	$190,875	$300,453	$403,870	$502,231	$592,172
Unit Cost ($/ac-ft)*	$510	$510	$510	$510	$510	$510

** Unit costs for this plan element are rounded.*

5B.11.8 River Acres WSC

River Acres WSC obtains its water from Nueces County WCID #3. No shortages are projected for River Acres WSC; however, additional water conservation is a recommended water management strategy for the WSC (Table 5B.11.8).

Table 5B.11.8.
Recommended Water Supply Plan for River Acres WSC

	2020 (ac-ft/yr)	2030 (ac-ft/yr)	2040 (ac-ft/yr)	2050 (ac-ft/yr)	2060 (ac-ft/yr)	2070 (ac-ft/yr)
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	9	0	0	0	0	0
Total New Supply	**9**	**0**	**0**	**0**	**0**	**0**

Estimated costs of the recommended plan for River Acres WSC are shown in Table 5B.11.9.

Table 5B.11.9.
Recommended Plan Costs by Decade for River Acres WSC

Plan Element	2020	2030	2040	2050	2060	2070
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$4,358	$0	$0	$0	$0	$0
Unit Cost ($/ac-ft)*	$510	N/A	N/A	N/A	N/A	N/A

** Unit costs for this plan element are rounded.*

5B.11.9 City of Robstown

The City of Robstown has a contract with the Nueces County WCID #3 to purchase treated surface water from the Nueces River. Due to shortages of the Nueces County WCID #3, the City of Robstown also shows a water shortage during the planning period. The following water supply plan is recommended for the City (Table 5B.11.10). It should be noted that the local balancing storage would be constructed by the Nueces County WCID #3.

Table 5B.11.10.
Recommended Water Supply Plan for the City of Robstown

	2020 (ac-ft/yr)	*2030 (ac-ft/yr)*	*2040 (ac-ft/yr)*	*2050 (ac-ft/yr)*	*2060 (ac-ft/yr)*	*2070 (ac-ft/yr)*
Projected Need (Shortage)	1,583	1,547	1,511	1,513	1,518	1,525
Recommended Plan						
Municipal Water Conservation	125	336	532	748	884	884
Local Balancing Storage	1,583	1,583	1,583	1,583	1,583	1,583
Total New Supply	**1,708**	**1,919**	**2,115**	**2,331**	**2,467**	**2,467**

Estimated costs of the recommended plan for the City of Robstown are shown in Table 5B.11.11.

Table 5B.11.11.
Recommended Plan Costs by Decade for the City of Robstown

Plan Element	*2020*	*2030*	*2040*	*2050*	*2060*	*2070*
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$63,709	$171,216	$271,127	$381,536	$450,801	$450,801
Unit Cost ($/ac-ft)*	$510	$510	$510	$510	$510	$510
Local Balancing Storage (Chapter 5D.11)						
Annual Cost ($/yr)	$1,316,000	$1,316,000	$1,052,000	$1,052,000	$739,000	$739,000
Unit Cost ($/ac-ft)	$831	$831	$665	$665	$467	$67

** Unit costs for this plan element are rounded.*

5B.11.10 County-Other

Nueces County-Other obtains water from the CCR/LCC/Texana/MRP Phase II System via the City of Corpus Christi and the STWA. Some entities also obtain water from the Nueces River through the Nueces County WCID #3. There are also some entities that obtain water from the Gulf Coast Aquifer. No shortages are projected for Nueces County-Other and no changes in water supply are recommended.

5B.11.11 Manufacturing

The City of Corpus Christi provides treated and raw surface water for manufacturing in Nueces County from the CCR/LCC/Texana/MRP Phase II System. Additional manufacturing supplies are from the Gulf Coast Aquifer and reuse supplies. The City also provides surface water for manufacturing in San Patricio County. A shortage in manufacturing supply occurs beginning in 2050. The recommended water supply plan for Nueces County Manufacturing is shown below (Table 5B.11.12). ***The recommended strategies shown (except for the 18 mgd reuse project) would likely be jointly developed by the City of Corpus Christi and the SPMWD. Note: The total project yield for manufacturing water conservation, seawater desalination, and GBRA Lower Basin projects are larger than shown in the table below.*** The manufacturing conservation yield is 1,081 ac-ft/yr in 2020 and increases to 1,497 ac-ft/yr by 2070. The seawater desalination project yield is 22,420 ac-ft/yr and the GBRA Lower Basin project supply based on Region N's prorata share by participating in the project is 20,000 ac-ft/yr. Supplies were assigned amongst Nueces County-Manufacturing, Nueces County- Steam and Electric, and San Patricio County- Manufacturing based on shortage. The sum of the yield shown in Tables 5B.11.12, 5B.11.14, and 5B.12.8 for the three water user groups, when combined, sums up to the total project yield for each of the three jointly developed projects.

Table 5B.11.12.
Recommended Water Supply Plan for Nueces County Manufacturing

	2020 (ac-ft/yr)	*2030 (ac-ft/yr)*	*2040 (ac-ft/yr)*	*2050 (ac-ft/yr)*	*2060 (ac-ft/yr)*	*2070 (ac-ft/yr)*
Projected Need (Shortage)	0	0	0	1,905	10,981	19,603
Recommended Plan						
Manufacturing Water Conservation	501	542	583	626	668	709
O.N. Stevens WTP Improvements	20,739	13,095	5,656	356	0	0
Additional Reuse	0	20,178	20,178	20,178	20,178	20,178
Seawater Desalination	0	9,000	9,000	9,000	9,000	9,000
GBRA Lower Basin Project	0	8,000	8,000	8,000	8,000	8,000
Total New Supply	**21,240**	**50,815**	**43,417**	**38,160**	**37,846**	**37,887**

In addition to these projects, brackish groundwater desalination is also considered to be an alternative water supply strategy for this water user group.

Estimated costs of the recommended plan for Nueces County Manufacturing are shown in Table 5B.11.13.

Table 5B.11.13.
Recommended Plan Costs by Decade for Nueces County Manufacturing

Plan Element	2020	2030	2040	2050	2060	2070
Manufacturing Water Conservation (Chapter 5D.3)						
Annual Cost ($/yr)	N/A	N/A	N/A	N/A	N/A	N/A
Unit Cost ($/ac-ft)*	N/A	N/A	N/A	N/A	N/A	N/A
O.N. Stevens WTP Improvements (Chapter 5D.15)						
Annual Cost ($/yr)	$11,862,708	$9,035,550	$3,563,000	$224,000	N/A	N/A
Unit Cost ($/ac-ft)	$572	$690	$630	$630	N/A	N/A
Additional Reuse (Chapter 5D.5)						
Annual Cost ($/yr)	$0	$11,641,000	$11,641,000	$7,281,000	$7,281,000	$7,281,000
Unit Cost ($/ac-ft)	N/A	$577	$577	$361	$361	$361
Seawater Desalination** (Chapter 5D.9)						
Annual Cost ($/yr)	$0	$13,052,000	$13,052,000	$4,947,000	$4,947,000	$4,947,000
Unit Cost ($/ac-ft)	N/A	$1,450	$1,450	$550	$550	$550
GBRA Lower Basin Project (Chapter 5D.13)						
Annual Cost ($/yr)	$0	$6,491,600	$6,491,600	$4,818,000	$4,818,000	$4,256,000
Unit Cost ($/ac-ft)	N/A	$811	$811	$602	$602	$532

** Unit costs for this plan element are rounded.*

*** Note: Seawater Desalination costs are at the fence and do not include transmission pipelines for delivery to point of use.*

5B.11.12 Steam-Electric

The steam-electric users in Nueces County are provided water by City of Corpus Christi. Steam-electric users in Nueces County are projected to have shortages beginning in 2060. Since water management strategies for this water user will likely be developed by Wholesale Water Providers, the total project costs and supplies are shown in the water supply plan below (Table 5B.11.14). ***The recommended strategies shown (except for the 18 mgd reuse project) would likely be jointly developed by the City of Corpus Christi and the SPMWD. Note: The total project yield for manufacturing water conservation, seawater desalination, and GBRA Lower Basin projects are larger than shown in the table below.*** The manufacturing conservation yield is 1,081 ac-ft/yr in 2020 and increases to 1,497 ac-ft/yr by 2070. The seawater desalination project yield is 22,420 ac-ft/yr and the GBRA Lower Basin project supply based on Region N's prorata share by participating in the project is 20,000 ac-ft/yr. Supplies were assigned amongst Nueces County-Manufacturing, Nueces County- Steam and Electric, and San Patricio County- Manufacturing based on shortage. The sum of the yield shown in Tables 5B.11.12, 5B.11.14, and 5B.12.8 for the three water user groups, when combined, sums up to the total project yield for each of the three jointly developed projects.

Table 5B.11.14.
Recommended Water Supply Plan for Nueces County Steam-Electric

	2020 (ac-ft/yr)	***2030 (ac-ft/yr)***	***2040 (ac-ft/yr)***	***2050 (ac-ft/yr)***	***2060 (ac-ft/yr)***	***2070 (ac-ft/yr)***
Projected Need (Shortage)	0	0	0	0	2,846	6,893
Recommended Plan						
Manufacturing Water Conservation	40	40	40	40	40	40
O.N. Stevens WTP Improvements	7,286	4,601	1,987	125	0	0
Seawater Desalination	0	4,420	4,420	4,420	4,420	4,420
GBRA Lower Basin Project	0	4,000	4,000	4,000	4,000	4,000
Total New Supply	**7,326**	**13,061**	**10,447**	**8,585**	**8,460**	**8,460**

In addition to these projects, brackish groundwater desalination is also considered to be an alternative water supply strategy for this water user group.

Estimated costs of the recommended plan for Nueces County Manufacturing are shown in Table 5B.11.15.

Table 5B.11.15.
Recommended Plan Costs by Decade for Nueces County Steam-Electric

Plan Element	***2020***	***2030***	***2040***	***2050***	***2060***	***2070***
Manufacturing Water Conservation (Chapter 5D.3)						
Annual Cost ($/yr)	N/A	N/A	N/A	N/A	N/A	N/A
Unit Cost ($/ac-ft)*	N/A	N/A	N/A	N/A	N/A	N/A
O.N. Stevens WTP Improvements (Chapter 5D.15)						
Annual Cost ($/yr)	$4,168,000	$3,175,000	$1,252,000	$79,000	N/A	N/A
Unit Cost ($/ac-ft)	$572	$690	$630	$630	N/A	N/A
Additional Reuse (Chapter 5D.5)						
Annual Cost ($/yr)	$0	$2,622,000	$2,622,000	$1,640,000	$1,640,000	$1,640,000
Unit Cost ($/ac-ft)	N/A	$577	$577	$361	$361	$361
Seawater Desalination** (Chapter 5D.9)						
Annual Cost ($/yr)	$0	$6,410,000	$6,410,000	$2,430,000	$2,430,000	$2,430,000
Unit Cost ($/ac-ft)	N/A	$1,450	$1,450	$550	$550	$550
GBRA Lower Basin Project (Chapter 5D.13)						
Annual Cost ($/yr)	$0	$3,245,800	$3,245,800	$2,409,000	$2,409,000	$2,128,000
Unit Cost ($/ac-ft)	N/A	$811	$811	$602	$602	$532

** Unit costs for this plan element are rounded.*

*** Note: Seawater Desalination costs are at the fence and do not include transmission pipelines for delivery to point of use.*

5B.11.13 Mining

Nueces County Mining users obtain their water supplies from the Corpus Christi System via the City of Corpus Christi and groundwater from the Gulf Coast Aquifer. There are no projected shortages for mining users in Nueces County and no changes in water supply are recommended.

5B.11.14 Irrigation

Irrigation demands in Nueces County are met with groundwater from the Gulf Coast Aquifer. There are no shortages in irrigation use in Nueces County and no changes in water supply are recommended.

5B.11.15 Livestock

The livestock demands in Nueces County are met by groundwater from the Gulf Coast Aquifer and surface water from local on-farm sources. No shortages are projected for livestock and no changes in water supply are recommended.

5B.12 San Patricio County Water Supply Plan

Table 5B.12.1 lists each water user group in San Patricio County and their corresponding surplus or shortage in years 2040 and 2070. For each water user group with a projected shortage, a water supply plan has been developed and is presented in the following subsections.

Table 5B.12.1.
San Patricio County Surplus/(Shortage)

Water User Group	Surplus/(Shortage)[1]		Comment
	2040 (ac-ft/yr)	2070 (ac-ft/yr)	
City of Aransas Pass			See Aransas County
City of Gregory	0	0	Supply equals demand
City of Ingleside	0	0	Supply equals demand
City of Ingleside on the Bay	0	0	Supply equals demand
Lake City	6	4	No projected shortage
City of Mathis	0	0	Supply equals demand
City of Odem	0	0	Supply equals demand
City of Portland	0	0	Supply equals demand
Rincon WSC	0	0	Supply equals demand
City of Sinton	506	462	No projected shortage
City of Taft	0	0	Supply equals demand
County-Other	0	0	Supply equals demand
Manufacturing	(11,126)	(18,529)	Projected shortage – see plan below
Steam-Electric	none	none	No demands projected
Mining	125	32	No projected shortage
Irrigation	916	(4,191)	Projected shortage – see plan below
Livestock	0	0	Supply equals demand

[1] From Tables 4.22 and 4.23, Chapter 4 – Comparison of Water Demands with Water Supplies to Determine Needs.

5B.12.1 City of Aransas Pass

See Aransas County for the City of Aransas Pass water supply plan.

5B.12.2 City of Gregory

The City of Gregory has a contract with the SPMWD to purchase treated water. The contract allows the City to purchase only the water that it needs. No shortages are projected for the City of Gregory; however, additional water conservation is a recommended water management strategy for the City (Table 5B.12.2).

Table 5B.12.2.
Recommended Water Supply Plan for the City of Gregory

	2020 (ac-ft/yr)	***2030 (ac-ft/yr)***	***2040 (ac-ft/yr)***	***2050 (ac-ft/yr)***	***2060 (ac-ft/yr)***	***2070 (ac-ft/yr)***
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	8	11	6	6	5	5
Total New Supply	**8**	**11**	**6**	**6**	**5**	**5**

Estimated costs of the recommended plan for the City of Gregory are shown in Table 5B.12.3.

Table 5B.12.3.
Recommended Plan Costs by Decade for the City of Gregory

Plan Element	***2020***	***2030***	***2040***	***2050***	***2060***	***2070***
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$3,888	$5,646	$3,207	$2,908	$2,709	$2,719
Unit Cost ($/ac-ft)*	$510	$510	$510	$510	$510	$510

** Unit costs for this plan element are rounded.*

5B.12.3 City of Ingleside

The City of Ingleside has a contract with the SPMWD to purchase treated water. The contract allows the City to purchase only the water that it needs. No shortages are projected for the City of Ingleside and no changes in water supply are recommended.

5B.12.4 City of Ingleside on the Bay

The City of Ingleside on the Bay has a contract with the SPMWD to purchase treated water. The contract allows the City to purchase only the water that it needs. No shortages are projected for the City of Ingleside on the Bay and no changes in water supply are recommended.

5B.12.5 Lake City

The City of Lake City obtains its water supply from the Gulf Coast Aquifer. No shortages are projected for the City of Lake City and no changes in water supply are recommended.

5B.12.6 City of Mathis

The City of Mathis has a contract with the City of Corpus Christi to purchase raw water from the CCR/LCC/Texana/MRP Phase II System. The contract allows the City to purchase only the water that it needs. No shortages are projected for the City of Mathis and no changes in water supply are recommended.

5B.12.7 City of Odem

The City of Odem has a contract with the SPMWD to purchase treated water. The contract allows the City to purchase only the water that it needs. No shortages are projected for the City of Odem and no changes in water supply are recommended.

5B.12.8 City of Portland

The City of Portland has a contract with the SPMWD to purchase treated water. The contract allows the City to purchase only the water that it needs. No shortages are projected for the City of Portland; however, additional water conservation is a recommended water management strategy for the City (Table 5B.12.4).

Table 5B.12.4.
Recommended Water Supply Plan for the City of Portland

	2020 (ac-ft/yr)	2030 (ac-ft/yr)	2040 (ac-ft/yr)	2050 (ac-ft/yr)	2060 (ac-ft/yr)	2070 (ac-ft/yr)
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	74	49	0	0	0	0
Total New Supply	**74**	**49**	**0**	**0**	**0**	**0**

Estimated costs of the recommended plan for the City of Portland are shown in Table 5B.12.5.

Table 5B.12.5.
Recommended Plan Costs by Decade for the City of Portland

Plan Element	2020	2030	2040	2050	2060	2070
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$37,518	$24,965	$0	$0	$0	$0
Unit Cost ($/ac-ft)*	$510	$510	N/A	N/A	N/A	N/A

** Unit costs for this plan element are rounded.*

5B.12.9 Rincon WSC

Rincon WSC has a contract with the SPMWD to purchase treated water. The contract allows the WSC to purchase only the water that it needs. No shortages are projected for Rincon WSC and no changes in water supply are recommended.

5B.12.10 City of Sinton

The City of Sinton meets its demands with groundwater pumped from the Gulf Coast Aquifer. No shortages are projected for the City of Sinton; however, additional water conservation is a recommended water management strategy for the City (Table 5B.12.6).

Table 5B.12.6.
Recommended Water Supply Plan for the City of Sinton

	2020 (ac-ft/yr)	2030 (ac-ft/yr)	2040 (ac-ft/yr)	2050 (ac-ft/yr)	2060 (ac-ft/yr)	2070 (ac-ft/yr)
Projected Need (Shortage)	0	0	0	0	0	0
Recommended Plan						
Municipal Water Conservation	62	170	277	385	447	451
Total New Supply	**62**	**170**	**277**	**385**	**447**	**451**

Estimated costs of the recommended plan for the City of Sinton are shown in Table 5B.12.7.

Table 5B.12.7.
Recommended Plan Costs by Decade for the City of Sinton

Plan Element	2020	2030	2040	2050	2060	2070
Municipal Water Conservation (Chapter 5D.1)						
Annual Cost ($/yr)	$31,598	$86,789	$141,048	$196,156	$228,195	$229,836
Unit Cost ($/ac-ft)*	$510	$510	$510	$510	$510	$510

** Unit costs for this plan element are rounded.*

5B.12.11 City of Taft

The City of Taft has a contract with the SPMWD to purchase treated water. The contract allows the City to purchase only the water that it needs. No shortages are projected for the City of Taft and no changes in water supply are recommended.

5B.12.12 County-Other

County-Other demands are met with surface water from the CCR/LCC/Texana/MRP Phase II System provided by the SPMWD and groundwater from the Gulf Coast Aquifer. No shortages are projected for County-Other entities and no changes in water supply are recommended.

5B.12.13 Manufacturing

The City of Corpus Christi provides the surface water for manufacturing in San Patricio County through the SPMWD from the CCR/LCC/Texana/MRP Phase II System. Additional manufacturing supplies are from the Gulf Coast Aquifer and reuse supplies. The City also provides surface water for manufacturing in Nueces County. A shortage in manufacturing supply occurs beginning in 2020. The recommended water supply plan for San Patricio County Manufacturing is shown below (Table 5B.12.8). ***The recommended strategies shown (except for the 18 mgd reuse project and Portland Reuse project) would likely be jointly developed by the City of Corpus Christi and the SPMWD. Note: The total project yield for manufacturing water conservation, seawater desalination, and GBRA Lower Basin projects are larger than shown in the table below.*** The manufacturing water conservation yield for both

San Patricio and Nueces Counties is 1,081 ac-ft/yr in 2020 and increases to 1,497 ac-ft/yr by 2070. The seawater desalination project yield is 22,420 ac-ft/yr and the GBRA Lower Basin project supply based on Region N's prorata share by participating in the project is 20,000 ac-ft/yr. Supplies were assigned amongst Nueces County-Manufacturing, Nueces County- Steam and Electric, and San Patricio County- Manufacturing based on shortage. The sum of the yield shown in Tables 5B.11.12, 5B.11.14, and 5B.12.8 for the three water user groups, when combined, sums up to the total project yield for each of the three jointly developed projects.

Table 5B.12.8.
Recommended Water Supply Plan for San Patricio County Manufacturing

	2020 (ac-ft/yr)	***2030 (ac-ft/yr)***	***2040 (ac-ft/yr)***	***2050 (ac-ft/yr)***	***2060 (ac-ft/yr)***	***2070 (ac-ft/yr)***
Projected Need (Shortage)	6,451	8,804	11,126	13,172	15,754	18,529
Recommended Plan						
Manufacturing Water Conservation	540	582	624	665	706	748
SPMWD Industrial WTP Improvements	18,529	18,529	18,529	18,529	18,529	18,529
Portland Reuse Pipeline	2,240	2,240	2,240	2,240	2,240	2,240
Seawater Desalination	0	9,000	9,000	9,000	9,000	9,000
GBRA Lower Basin Project	0	8,000	8,000	8,000	8,000	8,000
Total New Supply	**19,069**	**36,111**	**36,153**	**36,194**	**36,235**	**36,277**

In addition to these projects, brackish groundwater desalination is also considered to be an alternative water supply strategy for this water user group.

Estimated costs of the recommended plan for San Patricio County Manufacturing are shown in Table 5B.12.9.

Table 5B.12.9.
Recommended Plan Costs by Decade for San Patricio County Manufacturing

Plan Element	2020	2030	2040	2050	2060	2070
Manufacturing Water Conservation (Chapter 5D.3)						
Annual Cost ($/yr)	N/A	N/A	N/A	N/A	N/A	N/A
Unit Cost ($/ac-ft)*	N/A	N/A	N/A	N/A	N/A	N/A
SPMWD Industrial WTP Improvements (Chapter 5D.14)						
Annual Cost ($/yr)	$14,997,000	$14,997,000	$10,113,000	$10,113,000	$10,113,000	$10,113,000
Unit Cost ($/ac-ft)	$809	$809	$546	$546	$546	$546
Portland Reuse Pipeline (Chapter 5D.5)						
Annual Cost ($/yr)	$1,997,000	$1,997,000	$1,997,000	$1,997,000	$1,997,000	$1,997,000
Unit Cost ($/ac-ft)	$892	$892	$96	$96	$96	$96
Seawater Desalination (Chapter 5D.9)						
Annual Cost ($/yr)	$0	$13,052,000	$13,052,000	$4,947,000	$4,947,000	$4,947,000
Unit Cost ($/ac-ft)	N/A	$1,450	$1,450	$550	$550	$550
GBRA Lower Basin Project (Chapter 5D.13)						
Annual Cost ($/yr)	$0	$6,491,600	$6,491,600	$4,818,000	$4,818,000	$4,256,000
Unit Cost ($/ac-ft)	N/A	$811	$811	$602	$602	$532

** Unit costs for this plan element are rounded.*

*** Note: Seawater Desalination costs are at the fence and do not include transmission pipelines for delivery to point of use.*

5B.12.14 Steam-Electric

No steam-electric demand exists or is projected for the county.

5B.12.15 Mining

The mining demands in San Patricio County are met by groundwater from Gulf Coast Aquifer. No shortages are projected for mining and no changes in water supply are recommended.

5B.12.16 Irrigation

Irrigation users in San Patricio County obtain water from the Gulf Coast Aquifer. Shortages are projected for irrigation users within the county. The recommended water supply management plan for these entities is shown in Table 5B.12.10. Irrigation water conservation and additional groundwater (up to the MAG) are only able to meet a portion of the projected shortage. After considering strategies, there is an unmet need of 693 ac-ft/yr in Year 2070. A TWDB socio-economic impact analysis of not meeting needs is included in Appendix 2.

Table 5B.12.10.
Recommended Water Supply Plan for San Patricio County Irrigation

	2020 (ac-ft/yr)	2030 (ac-ft/yr)	2040 (ac-ft/yr)	2050 (ac-ft/yr)	2060 (ac-ft/yr)	2070 (ac-ft/yr)
Projected Need (Shortage)	0	0	0	499	2,063	4,191
Recommended Plan						
Irrigation Water Conservation	0	0	0	1,494	2,063	2,795
Gulf Coast Aquifer Supplies	0	0	0	703	703	703
Total New Supply	**0**	**0**	**0**	**2,197**	**2,766**	**3,498**

Estimated costs of the recommended plan for San Patricio County Irrigation are shown in Table 5B.12.11.

Table 5B.12.11.
Recommended Plan Costs by Decade for San Patricio County Irrigation

Plan Element	2020	2030	2040	2050	2060	2070
Irrigation Water Conservation (Chapter 5D.2)						
Annual Cost ($/yr)	$0	$0	$0	$343,620	$474,490	$642,804
Unit Cost ($/ac-ft)*	N/A	N/A	N/A	$230	$230	$230
Gulf Coast Aquifer Supplies- Drill Additional Well(s) (Chapter 5D.7)						
Annual Cost ($/yr)	$0	$0	$0	$112,000	$112,000	$15,000
Unit Cost ($/ac-ft)	N/A	N/A	N/A	$159	$159	$21

** Unit costs for this plan element are rounded.*

5B.12.17 Livestock

The livestock water demands in San Patricio County are met by groundwater from the Gulf Coast Aquifer and surface water from local on-farm sources. No shortages are projected for livestock and no changes in water supply are recommended.

5B.13 Wholesale Water Provider Water Supply Plans

Table 5B.13.1 lists each Wholesale Water Provider and their corresponding surplus or shortage in years 2040 and 2070. For each Wholesale Water Provider with a projected shortage, a water supply plan has been developed.

Table 5B.13.1. Wholesale Water Provider Surplus/(Shortage)

Water User Group	Surplus/(Shortage)[1] 2040 (ac-ft/yr)	Surplus/(Shortage)[1] 2070 (ac-ft/yr)	Comment
City of Corpus Christi	7,643	(26,496)	Projected shortage – see plan below
San Patricio MWD	(11,126)	(18,529)	Projected shortage – see plan below
South Texas Water Authority	0	0	Supply equals demand
Nueces County WCID #3	(1,511)	(1,525)	Projected shortage – see plan below

[1] Surplus/(Shortage) for each Wholesale Water Provider calculated by taking total surface water availability (constrained by water treatment plant capacity) less municipal retail and wholesale demands, steam-electric demands, manufacturing demands, and/or mining demands (Table 4.24).

5B.13.1 City of Corpus Christi

As the primary provider of surface water to the Coastal Bend Region, the City of Corpus Christi is the major Wholesale Water Provider in the region. Corpus Christi has 214,000 ac-ft in available safe yield supply in 2070 through its own water right in the CCR/LCC System and a contract with LNRA from Lake Texana. This also includes the firm portion of the City owned 35,000 ac-ft/yr permit for the Garwood water rights located on the Colorado River.

The City provides treated and raw water from the CCR/LCC/Texana/MRP Phase II System to the water user groups and other entities shown in Table 5B.13.2.

Table 5B.13.2. Purchasers of Water from the City of Corpus Christi

Water User Group / Entity	***County***
San Patricio MWD	San Patricio
South Texas Water Authority	Kleberg, Nueces
City of Alice	Jim Wells
City of Beeville	Bee
City of Mathis	San Patricio
City of Three Rivers	Live Oak
Nueces County WCID #4 (Port Aransas)	Nueces
Nueces County-Other	Nueces
Steam-Electric	Nueces
Manufacturing	Nueces
Mining	Nueces

The shortage listed in Table 5B.13.1 reflects the entire City's demands — both municipal retail and wholesale, as well as steam-electric, manufacturing and mining demands, as well as taking water treatment plant constraints into consideration. The shortage begins in 2050 and is due to large manufacturing and steam-electric demands in Nueces County. For a list of the water management strategies available to meet these shortages, refer to the water supply plan for manufacturing and steam-electric in Nueces County in Chapter 5B.11.11 and Chapter 5B.11.12.

5B.13.2 San Patricio Municipal Water District

The San Patricio Municipal Water District (SPMWD) is the second largest Wholesale Water Provider in the region. SPMWD has a contract with the City of Corpus Christi to purchase water from the CCR/LCC/Texana/MRP Phase II System. SPMWD treats this water and provides it to the water user groups and other entities shown in Table 5B.13.3.

Table 5B.13.3.
Purchasers of Water from San Patricio MWD

Water User Group / Entity	County
City of Aransas Pass	Aransas, Nueces, San Patricio
City of Gregory	San Patricio
City of Ingleside	San Patricio
City of Ingleside by the Bay	San Patricio
City of Odem	San Patricio
City of Portland	San Patricio
City of Rockport	Aransas
City of Taft	San Patricio
Port Aransas	Nueces
County-Other	Aransas, San Patricio
City of Fulton	Aransas
Manufacturing	San Patricio

The shortage listed in Table 5B.13.1 reflects all of SPMWD's demands — both municipal retail and wholesale, as well as manufacturing demands. The shortage also takes into account water treatment plant constraints. The shortage begins in 2020 due to treatment plant constraints and is due to large manufacturing demands in San Patricio County. Raw water shortage begins in 2030, but can be postponed to 2050 by increasing contracted supplies from the City of Corpus Christi up to unused CCR/LCC/Texana/MRP Phase II safe yield. For the water management strategies available to meet these shortages, refer to the water supply plan for manufacturing in San Patricio County in Chapter 5B.12.13.

5B.13.3 South Texas Water Authority

The South Texas Water Authority (STWA) is the third largest Wholesale Water Provider in the region. STWA has a contract with the City of Corpus Christi to purchase treated water from the CCR/LCC/Texana/MRP Phase II System. STWA provides this water to the water user groups and other entities shown in Table 5B.13.4.

Table 5B.13.4.
Purchasers of Water from South Texas Water Authority

Water User Group / Entity	County
City of Agua Dulce	Nueces
City of Bishop	Nueces
City of Driscoll	Nueces
Nueces County-Other[1]	Nueces
Nueces WSC	Nueces
City of Kingsville	Kleberg
Ricardo WSC	Kleberg
[1] Includes Nueces County WCID #5.	

There are no shortages listed in Table 5B.13.1 for South Texas Water Authority.

5B.13.4 Nueces County WCID #3

The Nueces County WCID #3 is the smallest Wholesale Water Provider in the region. Nueces County WCID #3 receives a firm yield of 1,955 ac-ft/yr from its Nueces Basin run-of-river rights. Nueces County WCID #3 provides this water to the water user groups and other entities shown in Table 5B.13.5.

Table 5B.13.5.
Purchasers of Water from Nueces County WCID #3

Water User Group / Entity	*County*
City of Robstown	Nueces
River Acres WSC	Nueces
Nueces County-Other	Nueces

Nueces County WCID #3 is projected to have a water shortage throughout the planning period. The plan for Nueces County WCID #3 is shown in the City of Robstown water management plan (Chapter 5B.11.9).

5B.14 Summary of Recommended Water Management Strategies by Wholesale Water Provider and Water User Group

A summary of recommended water management strategies to be implemented by each wholesale water provider is presented in Table 5B.14.1. A table showing recommended water management strategies for each water user group is shown in Table 5B.14.2.

Table 5B.14.1
Summary of Recommended Water Management Strategies by Wholesale Water Provider

ID	Recommended Water Management Strategy	Total Capital Costs	First Decade Estimated Unit Cost ($/ac-ft/yr)	Last Decade Estimated Unit Cost ($/ac-ft/yr)	Water Yield (ac-ft/yr) 2020	2030	2040	2050	2060	2070	First Decade of Imple-mentation
City of Corpus Christi and San Patricio Municipal Water District											
5D.3	**Manufacturing Conservation** Manufacturing (San Patricio and Nueces), S&E (Nueces)	N/A	N/A	N/A	1,081	1,164	1,247	1,331	1,414	1,497	2020
5D.5	**Reclaimed Wastewater Supplies and Reuse** Manufacturing (Nueces), S&E (Nueces)	$52,097,000	$577	$361	0	20,178	20,178	20,178	20,178	20,178	2030
5D.9	**Seawater Desalination and Variable Salinity Program**	$248,000,000	$1,418 - $1,450	$550	0	22,420	22,420	22,420	22,420	22,420	2030
5D.13	**GBRA Lower Basin Storage Project**	$72,546,000 (Region N prorate share)	$811	$532	0	20,000	20,000	20,000	20,000	20,000	2030
5D.15	**O.N. Stevens Water Treatment Plant Improvements**	$31,324,000	$572	$0	28,025	17.696	7,643	N/A	N/A	N/A	2020
San Patricio Municipal Water District											
5D.5	**Portland Reuse Pipeline** Manufacturing (San Patricio)	$21,292,000	$892	$96	2,240	2,240	2,240	2,240	2,240	2,240	2020
5D.14	**SPMWD-Industrial Water Treatment Plant Improvements**	$58,366,000	$809	$546	18,529	18,529	18,529	18,529	18,529	18,529	2020
Nueces County WCID # 3											
5D.11	**Local Balancing Storage Reservoir** City of Robstown (project by Nueces County WCID #3)	$8,182,000	$831	$67	1,583	1,583	1,583	1,583	1,583	1,583	2020

N/A = Not Applicable

Table 5B.14.2
Summary of Recommended Water Management Strategies in the Coastal Bend Region

ID	Recommended Water Management Strategy	Total Capital Costs	First Decade Estimated Unit Cost ($/ac-ft/yr)	Last Decade Estimated Unit Cost ($/ac-ft/yr)	Water Yield (ac-ft/yr) 2020	2030	2040	2050	2060	2070	First Decade of Imple-mentation
5D.1	**Municipal Water Conservation**										
	Alice	N/A	$510	$510	143	462	812	838	876	916	2020
	Alice- Pipeline Replacement Program	$21,384,000	$62,120	$0	0	173	460	576	576	576	2030
	Beeville	N/A	$500	$500	117	333	542	710	706	707	2020
	Benavides	N/A	$500	$0	4	0	0	0	0	0	2020
	Bishop	N/A	$510	$510	16	39	27	23	23	23	2020
	Corpus Christi	N/A	$470	$470	2,305	7,354	10,985	10,667	10,765	10,898	2020
	County-Other, Kleberg	N/A	$510	$510	13	24	15	15	14	15	2020
	County-Other, Kenedy	N/A	$500	$500	17	40	60	79	97	113	2020
	El Oso WSC	N/A	$500	$500	20	35	50	51	41	41	2020
	Falfurrias	N/A	$500	$500	91	224	360	508	649	786	2020
	Freer	N/A	$510	$500	24	73	124	168	171	175	2020
	Fulton	N/A	$510	$510	12	33	46	44	44	44	2020
	George West	N/A	$500	$500	15	46	44	40	39	39	2020
	Gregory	N/A	$510	$510	8	11	6	6	5	5	2020
	Orange Grove	N/A	$500	$500	18	49	83	120	159	183	2020
	Port Aransas	N/A	$510	$510	160	374	589	792	985	1,161	2020
	Portland	N/A	$510	$0	74	49	0	0	0	0	2020
	Premont	N/A	$500	$500	31	87	149	221	289	303	2020
	River Acres WSC	N/A	$510	$510	9	0	0	0	0	0	2020
	Robstown	N/A	$510	$510	125	336	532	748	884	884	2020
	Rockport	N/A	$510	$510	66	192	172	159	156	156	2020
	San Diego	N/A	$500	$500	29	94	117	117	119	122	2020
	Sinton	N/A	$510	$510	62	170	277	385	447	451	2020
	Three Rivers	N/A	$500	$500	11	22	15	11	11	11	2020
5D.2	**Irrigation Conservation**										
	McMullen County	N/A	$230	$230	1	2	3	5	6	8	2020
	San Patricio County	N/A	$230	$230	0	0	0	1,494	2,063	2,795	2050
5D.3	**Manufacturing Conservation** Manufacturing (San Patricio and Nueces), S&E (Nueces)	N/A	N/A	N/A	1,081	1,164	1,247	1,331	1,414	1,497	2020
5D.4	**Mining Water Conservation** McMullen County	N/A	N/A	N/A	106	240	357	262	231	196	2020
5D.5	**Reclaimed Wastewater Supplies and Reuse**										
	Manufacturing (San Patricio and Nueces), S&E (Nueces)	$52,097,000	$577	$361	0	20,178	20,178	20,178	20,178	20,178	2030
	Manufacturing- San Patricio	$21,292,000	$892	$96	$892	$892	$96	$96	$96	$96	2020
	City of Alice-nonpotable	$8,661,000	$1,321	$512	0	897	897	897	897	897	2030
5D.6	**Modify Existing Reservoir Operating Policy and Safe Yield Analyses**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	—
5D.7	**Gulf Coast Aquifer Groundwater Supplies (Local)**										
	McMullen County-Irrigation	$129,000	$302	$47	43	43	43	43	43	43	2020
	McMullen County-Mining	$1,685,000	$196	$50	966	966	966	966	966	966	2020
	San Patricio County-Irrigation	$1,156,000	$159	$21	0	0	0	703	703	703	2050
	City of San Diego	$940,000	$671	$171	0	158	158	158	158	158	2030
	City of Beeville-Chase Field	$4,777,000	$484	$209	1,457	1,457	1,457	1,457	1,457	1,457	2020
	City of Beeville-Irrigation Well to Municipal Conversion	$261,000	$135	$135	340	340	340	340	340	340	2020
5D.8	**Brackish Groundwater Desalination** City of Alice	$33,277,000	$1,474	$646	3,363	3,363	3,363	3,363	3,363	3,363	2020
5D.9	**Seawater Desalination and Variable Salinity Program**	$248,000,000	$1,418 - $1,450	$550	0	22,420	22,420	22,420	22,420	22,420	2030
5D.10	**Potential Water System Interconnections** STWA to City of Alice	$5,866,000	$1,158	$983	2,800	2,800	2,800	2,800	2,800	2,800	2020
5D.11	**Local Balancing Storage Reservoir** City of Robstown (project by Nueces County WCID #3)	$8,182,000	$831	$67	1,583	1,583	1,583	1,583	1,583	1,583	2020
5D.13	**GBRA Lower Basin Storage Project**	$72,546,000 (Region N share)	$811	$532	0	20,000	20,000	20,000	20,000	20,000	2030
5D.14	**SPMWD-Industrial Water Treatment Plant Improvements**	$58,366,000	$809	$546	18,529	18,529	18,529	18,529	18,529	18,529	2020
5D.15	**O.N. Stevens Water Treatment Plant Improvements**	$44,029,540	$572	$0	28,025	17.696	7,643	N/A	N/A	N/A	2020

N/A = Not Applicable

5C.1 Conservation Recommendations

Regional water planning guidelines require each region to consider water conservation to meet projected shortages, although funding to implement such water conservation programs is limited. Conservation is shown as a recommended strategy for all water user groups with needs identified for the planning period. The Coastal Bend Regional Water Planning Group adopted the following conservation recommendations for the 2016 Plan.

- Municipal water user groups with per capita rates exceeding 140 gallons per person per day (gpcd) were recommended to reduce per capita consumption by 1% annually through 2070 until a 140 gpcd rate is attained. This recommendation applies to all municipal water user groups with and without projected water supply needs (or shortage).
- Irrigation and mining water user groups with identified needs were recommended to reduce water use by 15% by 2070.
- Manufacturing water user groups with identified needs were recommended to continue to pursue best management practices to reduce water consumption. Industries in the Coastal Bend Region have a good history of implementing water conservation practices, and report some of the lowest water use in the state per barrel of crude produced. The City of Corpus Christi directly, and indirectly through San Patricio Municipal Water District, provides the majority of water for manufacturing water user groups with identified needs during the projection period. The addition of Mary Rhodes Pipeline Phase II in 2015 enhances the water quality of supplies available to industries through the regional water supply system, which allows the facilities to more efficiently use water for cooling and thus promotes conservation.
- Conservation recommendations were not made for livestock water user groups.

A summary was prepared of common water conservation best management practices appropriate for the region (Table 5C.1.1) and recommended 5- and 10-year water conservation targets (Table 5C.1.2). The Coastal Bend Regional Water Planning Group recommends that water user groups in the region review the list and look to identify water user groups at a relevant size with similar water supply type and consider voluntary implementation of those best management practices, if applicable.

Based on the results from a survey conducted by the CBRWPG, water conservation grants or low-interest loans to implement the following BMPs in the Coastal Bend Region would be most beneficial in promoting efficient water use: 1) water conservation pricing; 2) prohibition on wasting water; 3) school education; 4) landscape irrigation conservation; 5) metering connections and retrofits; 6) plumbing retrofits and replacements; and 7) other BMPs identified by water user groups.

A Region N-specific model water conservation plan for municipal water users is included, electronically, in an electronic Appendix on compact disk (Appendix A). These model plans include a list of best management practices in the region, to supplement TCEQ model water conservation plans found on TCEQ's website: http://www.tceq.state.tx.us/permitting/water_rights/wr_technical-resources/conserve.html

Table 5C.1.1.
Summary of Water Conservation BMPs in the Coastal Bend Region

Wholesale Water Provider	WCP Available	Date	Best Management Practices: Reduce Water Losses/ Unaccounted for Water/Leak Detection	Water Conservation Pricing/Seasonal or Inverted Block Rates	Reuse	Improve Meter Accuracy	Toilet Replacement/ Retrofit Programs	Public/School Education	Landscape Conservation/ Xeriscape	Others
City of Corpus Christi[1]	Y	2013	√	√	√	√	√	√	√	
San Patricio Municipal Water District[1]	Y	2011	√	√	√	√		√	√	√
South Texas Water Authority[1]	Y	2013	√	√		√		√	√	√
Nueces County WCID #3[1,2]	Y	2009	√			√	√	√		
Water User Group										
Alice[1]	Y	2008	√	√	√	√		√	√	
Aransas Pass[2]	Y	2008	√	√		√	√	√	√	
Corpus Christi[1]	Y	2013	√	√	√	√	√	√	√	
El Oso WSC	Y	2009	√	√		√		√		√
Kingsville[2]	Y	2010	√	√	√	√		√	√	
McCoy WSC[1]	Y	2009	√	√		√		√		
Nueces WSC[1]	Y	2013	√	√		√		√		
Portland[1]	Y	2009	√	√	√	√	√	√	√	
Ricardo WSC[1]	Y	2013	√	√		√		√		
Robstown[2]	Y	2011						√		
Taft[1]	Y	2013	√	√	√	√	√	√	√	
Odem[1]	Y	2013	√	√		√		√	√	√
Three Rivers[2]	Y	2009	√			√	√	√	√	

[1] Water Conservation Plan on-file with the Nueces River Authority.
[2] Water Conservation Plan provided by the TWDB.

Table 5C.1.2.
Summary of 5 and 10 Year Water Conservation Goals in the Coastal Bend Region

Wholesale Water Provider	5-Year Goal		10-Year Goal	
	GPCD Target	General	GPCD Target	General
City of Corpus Christi[1]	195[2]	1% annual reduction over next decade	184[2]	1% annual reduction over next decade
San Patricio Municipal Water District[1]	N/A	10% below 5-yr State avg. Limit unaccounted for water to no more than 3% amount diverted.	N/A	10% below 5-yr State avg. Limit unaccounted for water to no more than 3% amount diverted.
South Texas Water Authority[1]	140-145	Not Available	140-145	Not Available
Nueces County WCID #3[1,3]	140	Not Available	133	Not Available
Water User Group				
Alice[1]	N/A	Reduce per capita use by 3%	N/A	Reduce per capita use by 3%
Aransas Pass[3]	N/A	2.5% per capita	N/A	5% per capita
Corpus Christi[1]	195	1% annual reduction over next decade	184	1% annual reduction over next decade
El Oso WSC	N/A	Reduce water loss	N/A	Reduce water loss
Kingsville[3]	144	1% annual reduction	135	1% annual reduction
McCoy WSC[1]	115	Maintain current per capita usage; Reduce water loss to 4% of water pumped, not including line flushing and fire fighting	110	Reduce usage by 4.5%; Reduce water loss to 2% of water pumped, not including line flushing and fire fighting
Nueces WSC[1]	118	Maintain current per capita usage	118	Maintain current per capita usage
Portland[1]	272	5% reduction	258	10% reduction
Ricardo WSC[1]	95	Maintain current per capita usage	95	Maintain current per capita usage
Robstown[3]	N/A	Not Available	N/A	Not Available
Taft[1]	147	Reduce per capita use by 3%	140	Reduce per capita use by 3%
Odem[1]	N/A	Reduce seasonal demands by 2%	N/A	Reduce per capita use by 5%; reduce unaccounted for water by 7%
Three Rivers[3]	N/A	200 gallons/person/day by 2015	N/A	Not Available

N/A = Not Available
[1] Water Conservation Plan on-file with the Nueces River Authority.
[2] Calculated by taking volume of treated water, excluding water sold to wholesale customers, and dividing by permanent population, divided by 365. Because industrial use is close to 40% of treated water, the per capita rate is higher. Target goal for residential use is 73 gpcd (2018) and 69 gpcd (Year 2023).
[3] Water Conservation Plan provided by the TWDB.

5D Water Management Strategy Evaluations

A detailed evaluation of the 15 water management strategies for the 2016 Plan is provided in 5D.1 through 5D.15.

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5D.1

Municipal Water Conservation (N-1)

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5D.1 Municipal Water Conservation (N-1)

5D.1.1 Description of Strategy

Water conservation refers to those methods and practices that either reduce the demand for water supply or increase the efficiency of the supply or use facilities so that existing supply is conserved and made available for future use. Water conservation is typically a low-capital intensive alternative that water supply entities can pursue. Water supply entities and some major water right holders are required by Senate Bill 1 regulations to submit a Drought Contingency and Water Conservation Plan to the TCEQ for approval. These plans must detail the water supply entities' plans to reduce water demand at times when the demand threatens the total capacity of the water supply delivery system or overall supplies are low. Information regarding water supply entities that have provided Water Conservation Plans to TCEQ is summarized in Chapter 1.

In 2001, the Texas Legislature amended the Texas Water Code to require Regional Water Planning Groups to consider water conservation and drought management measures for each water user group with a need (projected water shortage). The Water Conservation Implementation Task Force (Task Force) was created by Senate Bill 1094 to identify and describe Water Conservation Best Management Practices (BMPs) and provide a BMP Guide for use by Regional Water Planning groups in the development of the 2006 Regional Water Plans. The Task Force recommended that a standardized methodology be used for determining per capita per day (gpcd) municipal water use so as to allow consistent evaluations of effectiveness of water conservation measures among Texas cities that are located in the different climates and parts of Texas. The Task Force further recommended gpcd targets and goals that should be considered by retail public water suppliers when developing water conservation plans required by the state, as follows:

- All public water suppliers that are required to prepare and submit water conservation plans should establish targets for water conservation, including specific goals for per capita water use and for water loss programs using appropriate water conservation BMPs.
- Municipal Water Conservation Plans required by the state shall include per capita water-use goals, with targets and goals established by an entity giving consideration to a minimum annual reduction of 1 percent in total gpcd, until such time as the entity achieves a total gpcd of 140 gpcd or less, or
- Municipal water use (gpcd) goals approved by regional water planning groups.

Additional water conservation guidance reports include a TWDB report entitled, "Quantifying Effectiveness of Various Water Conservation Techniques in Texas," and a document entitled, "Strategies to Enhance Water Conservation in the Coastal Bend," specifically prepared to assist communities with water conservation in the Coastal Bend Area.

For regional water planning purposes, municipal water use is defined as residential and commercial water use. Municipal water is primarily for drinking, sanitation, cleaning, cooling, fire protection, and landscape watering for residential, commercial, and institutional establishments. A key parameter of municipal water use within a typical city or water service area is the number of gallons used per person per day (per capita water use). The objective of water conservation is to decrease the amount of water — measured in gallons per person per day (gpcd) — that a typical person uses.

Per capita water use was calculated using TWDB-approved population and water demand estimates based on water user surveys for each decade from 2011 to 2070. For this round of regional water planning the population and municipal water demand projections for the Coastal Bend Region were provided by TWDB. The per capita water use in 2011 and projected per capita water use in 2020, 2030, 2040, 2050, 2060, and 2070 include expected effects of low flow plumbing fixtures upon per capita water use and are shown for each municipal entity located in the Coastal Bend Region in Table 5D.1.1. The 46 municipal entities of Region N are listed in Table 5D.1.1, in the order of low to high per capita water use, in year 2011. The projected savings attributed to plumbing fixture requirements are shown in Table 5D.1.2 and these savings are included in the per capita rates shown in Table 5D.1.1.

The purpose of the municipal water conservation water management strategy is to evaluate the potential of additional municipal water conservation for inclusion in the Regional Water Plan to meet a part of the projected water needs (shortages) of each municipal entity.

The City of Corpus Christi, the largest water user in the Coastal Bend Region, has demonstrated significant water savings attributable to conservation efforts over the last decade. The City's municipal water use was nearly 220 gpcd in 1990[1] and was reduced to 177 gpcd by 2000, a decrease of 43 gpcd (or 19.5 percent). According to TWDB water use projections, the City of Corpus Christi water use is anticipated to decline to 164 gpcd by 2070 (Table 5D.1.1).

As part of this round of regional water planning, the Coastal Bend Regional Water Planning Group (CBRWPG) gathered and reviewed water conservation plans from municipal water user groups in the Coastal Bend Region. The purpose of reviewing these plans was to gather information regarding preferred voluntary water conservation BMPs in the Coastal Bend Region and success of their ongoing programs identified previously by the CBRWPG.[2] The survey was also intended to gather information about the goals that water user groups in the region have in the next five and ten years. Based on plans gathered from 2005 to 2013, local water conservation programs in the Coastal Bend Region have utilized leak detection, water conservation pricing measures, reuse, retrofit programs, xeriscaping and other BMPs as shown in Table 5D.1.3. According to the plans, there are a range of goals in the region. Some user groups want to maintain their current per capita use, some have identified 1%, 2.5%, 3% or 5% reductions over various time periods, and one plans to have a gpcd 10% below the state average as shown in Table 5D.1.4. This information was used by the Coastal Bend Regional Water Planning Group to develop municipal water conservation goals and prepare a list of BMPs for the region.

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[1] City of Corpus Christi Water Conservation Plan, 1999.
[2] Coastal Bend Regional Water Planning Group, 2011 Regional Water Plan, Study 1 – Region-Specific Water Conservation Best Management Practices (BMPs), April 2009.

Table 5D.1.1.
Municipal Water User Groups Projected Per Capital Water Use (TWDB Projections)

No.	County	Water User	Year 2011 gpcd	Projected Per Capita Water Use with Low Flow Plumbing Fixtures(gpcd)					
				2020	2030	2040	2050	2060	2070
1	SAN PATRICIO	RINCON WSC	97	90	88	86	86	85	85
2	SAN PATRICIO	INGLESIDE	103	94	91	88	87	87	87
3	ARANSAS	COUNTY-OTHER	109	99	95	92	90	90	90
4	KLEBERG	RICARDO WSC	113	104	101	98	97	97	97
5	SAN PATRICIO	INGLESIDE ON THE BAY	114	105	102	99	97	97	96
6	SAN PATRICIO	LAKE CITY	115	106	102	98	96	97	97
7	LIVE OAK	COUNTY-OTHER	118	110	107	105	104	104	104
8	LIVE OAK	MCCOY WSC	120	114	109	109	104	104	104
9	DUVAL	COUNTY-OTHER	123	113	109	106	104	104	104
10	BROOKS	COUNTY-OTHER	124	113	109	106	105	105	104
11	NUECES	NUECES WSC	124	116	114	112	112	111	111
12	SAN PATRICIO	MATHIS	124	114	110	106	105	105	105
13	NUECES	DRISCOLL	125	115	111	108	106	106	106
14	MCMULLEN	COUNTY-OTHER	127	118	114	111	109	109	109
15	NUECES	COUNTY-OTHER	127	117	113	111	109	109	109
16	BEE	COUNTY-OTHER	133	124	121	118	117	117	117
17	JIM WELLS	COUNTY-OTHER	136	127	123	120	119	118	118
18	SAN PATRICIO	ARANSAS PASS	137	128	123	120	119	118	118
19	SAN PATRICIO	COUNTY-OTHER	138	127	123	122	122	122	122
20	SAN PATRICIO	TAFT	138	128	124	120	119	119	119
21	KLEBERG	KINGSVILLE	140	130	126	123	121	121	121
22	NUECES	AGUA DULCE	141	132	128	125	123	123	123
23	SAN PATRICIO	ODEM	143	133	129	126	124	124	124
24	NUECES	RIVER ACRES WSC	153	143	139	136	134	134	134
25	DUVAL	BENAVIDES	154	143	139	137	137	136	136
26	SAN PATRICIO	PORTLAND	156	147	143	140	138	138	138
27	SAN PATRICIO	GREGORY	160	150	145	143	142	142	142
28	KLEBERG	COUNTY-OTHER	161	150	146	143	143	143	143
29	LIVE OAK	THREE RIVERS	164	155	151	147	145	145	145
30	NUECES	BISHOP	164	154	149	146	145	145	145
31	ARANSAS	ROCKPORT	170	162	159	156	155	155	155
32	LIVE OAK	GEORGE WEST	173	164	160	156	154	154	154
33	DUVAL	SAN DIEGO	177	167	162	159	158	158	158
34	ARANSAS	FULTON	181	173	170	168	167	167	167
35	NUECES	CORPUS CHRISTI	182	172	168	166	164	164	164
36	JIM WELLS	ALICE	188	178	173	170	169	169	168
37	LIVE OAK	EL OSO WSC	192	193	188	185	183	174	174
38	DUVAL	FREER	201	191	186	183	183	182	182
39	BEE	BEEVILLE	203	193	189	185	184	184	184
40	SAN PATRICIO	SINTON	219	209	205	202	200	200	200
41	NUECES	ROBSTOWN	222	212	207	204	204	203	203
42	JIM WELLS	PREMONT	227	217	212	209	208	208	208
43	JIM WELLS	ORANGE GROVE	241	231	227	224	223	222	223
44	BROOKS	FALFURRIAS	297	287	282	279	279	278	278
45	KENEDY	COUNTY-OTHER	480	470	468	464	463	464	464
46	NUECES	PORT ARANSAS	534	525	521	519	518	517	517

Table 5D.1.2.
Projected Municipal Demand Savings Due to Plumbing Fixture Code Requirements

No.	County	Water User	Projected Municipal Demand Savings (ac-ft/yr) Due to Plumbing Fixture Code Requirements					
			2020	2030	2040	2050	2060	2070
1	SAN PATRICIO	RINCON WSC	28	38	44	48	50	50
2	SAN PATRICIO	INGLESIDE	99	144	178	197	204	206
3	ARANSAS	COUNTY-OTHER	143	208	256	283	288	288
4	KLEBERG	RICARDO WSC	29	44	57	66	72	76
5	SAN PATRICIO	INGLESIDE ON THE BAY	7	10	13	14	15	15
6	SAN PATRICIO	LAKE CITY	6	9	11	13	13	13
7	LIVE OAK	COUNTY-OTHER	57	77	92	100	103	103
8	LIVE OAK	MCCOY WSC	2	3	3	3	3	3
9	DUVAL	COUNTY-OTHER	48	73	94	107	112	115
10	BROOKS	COUNTY-OTHER	30	48	63	73	79	84
11	NUECES	NUECES WSC	22	32	38	42	44	45
12	SAN PATRICIO	MATHIS	59	89	113	121	125	126
13	NUECES	DRISCOLL	9	14	18	20	21	21
14	MCMULLEN	COUNTY-OTHER	8	11	14	15	15	15
15	NUECES	COUNTY-OTHER	128	219	284	321	337	346
16	BEE	COUNTY-OTHER	192	278	341	373	380	380
17	JIM WELLS	COUNTY-OTHER	196	299	385	446	479	503
18	ARANSAS, SAN PATRICIO, NUECES	ARANSAS PASS	94	140	176	196	202	204
19	SAN PATRICIO	COUNTY-OTHER	144	203	213	221	228	230
20	SAN PATRICIO	TAFT	36	55	70	74	76	77
21	KLEBERG	KINGSVILLE	328	514	674	787	851	902
22	NUECES	AGUA DULCE	10	15	19	22	22	23
23	SAN PATRICIO	ODEM	28	42	54	59	61	61
24	NUECES	RIVER ACRES WSC	30	47	60	68	70	71
25	DUVAL	BENAVIDES	18	27	32	34	35	36
26	SAN PATRICIO	PORTLAND	169	253	317	354	365	368
27	SAN PATRICIO	GREGORY	24	37	43	44	46	46
28	KLEBERG	COUNTY-OTHER	43	69	85	93	100	106
29	LIVE OAK	THREE RIVERS	20	29	36	39	40	40
30	NUECES	BISHOP	40	62	80	86	89	91
31	ARANSAS	ROCKPORT	87	122	146	161	164	164
32	LIVE OAK	GEORGE WEST	26	38	48	52	53	53
33	DUVAL, JIM WELLS	SAN DIEGO	56	86	111	120	126	130
34	ARANSAS	FULTON	13	18	22	24	24	24
35	NUECES	CORPUS CHRISTI	3,613	5,602	7,101	7,938	8,224	8,350
36	JIM WELLS	ALICE	240	373	485	559	599	629

No.	County	Water User	Projected Municipal Demand Savings (ac-ft/yr) Due to Plumbing Fixture Code Requirements					
			2020	**2030**	**2040**	**2050**	**2060**	**2070**
37	LIVE OAK, BEE	EL OSO WSC	0	6	9	12	23	23
38	DUVAL	FREER	35	54	68	72	76	78
39	BEE	BEEVILLE	149	224	282	303	308	308
40	SAN PATRICIO	SINTON	66	99	125	140	144	146
41	NUECES	ROBSTOWN	144	203	253	257	261	262
42	JIM WELLS	PREMONT	34	53	69	77	82	86
43	JIM WELLS	ORANGE GROVE	16	25	32	37	40	42
44	BROOKS	FALFURRIAS	59	90	113	119	125	128
45	KENEDY	COUNTY-OTHER	5	7	9	10	10	10
46	NUECES	PORT ARANSAS	39	59	74	83	86	87
	Total for Region N		**6,629**	**10,146**	**12,809**	**14,283**	**14,867**	**15,163**

Table 5D.1.3.
Summary of Water Conservation BMPs in the Coastal Bend Region

Wholesale Water Provider	WCP Available	Date	Best Management Practices: Reduce Water Losses/Unaccounted for Water/Leak Detection	Water Conservation Pricing/Seasonal or Inverted Block Rates	Reuse	Improve Meter Accuracy	Toilet Replacement/ Retrofit Programs	Public/School Education	Landscape Conservation/ Xeriscape	Others
City of Corpus Christi[1]	Y	2013	√	√	√	√	√	√	√	
San Patricio Municipal Water District[1]	Y	2011	√	√	√	√		√	√	√
South Texas Water Authority[1]	Y	2013	√	√		√		√	√	√
Nueces County WCID # 3[1,2]	Y	2009	√			√	√	√		
Water User Group										
Alice[1]	Y	2008	√	√	√	√		√	√	
Aransas Pass[2]	Y	2008	√	√		√	√	√	√	
Corpus Christi[1]	Y	2013	√	√	√	√	√	√	√	
El Oso WSC	Y	2009	√	√		√		√		√
Kingsville[2]	Y	2010	√	√	√	√		√	√	
McCoy WSC[1]	Y	2009	√	√		√		√		
Nueces WSC[1]	Y	2013	√	√		√		√		
Portland[1]	Y	2009	√	√	√	√	√	√	√	
Ricardo WSC[1]	Y	2013	√	√		√		√		
Robstown[2]	Y	2011						√		
Taft[1]	Y	2013	√	√	√	√	√	√	√	
Odem[1]	Y	2013	√	√		√		√	√	√
Three Rivers[2]	Y	2009	√			√	√	√	√	

[1]Water Conservation Plan on-file with the Nueces River Authority.

[2]Water Conservation Plan provided by the TWDB.

Table 5D.1.4.
Summary of 5- and 10-Year Goals for Water Conservation in the Coastal Bend Region

Wholesale Water Provider	5 year goal		10 year goal	
	GPCD Target	General	GPCD Target	General
City of Corpus Christi[1]	195 [2]	1% annual reduction over next decade	184 [2]	1% annual reduction over next decade
San Patricio Municipal Water District[1]	N/A	10% below 5-yr State avg. Limit unaccounted for water to no more than 3% amount diverted.	N/A	10% below 5-yr State avg. Limit unaccounted for water to no more than 3% amount diverted.
South Texas Water Authority[1]	140-145	Not Available	140-145	Not Available
Nueces County WCID # 3[1,3]	140	Not Available	133	Not Available
Water User Group				
Alice[1]	N/A	Reduce per capita use by 3%	N/A	Reduce per capita use by 3%
Aransas Pass[3]	N/A	2.5% per capita	N/A	5% per capita
Corpus Christi[1]	195 2	1% annual reduction over next decade	184 2	1% annual reduction over next decade
El Oso WSC	N/A	Reduce water loss.	N/A	Reduce water loss.
Kingsville[3]	144	1% annual reduction	135	1% annual reduction
McCoy WSC[1]	115	Maintain current per capita usage; Reduce water loss to 4% of water pumped, not including line flushing and fire fighting	110	Reduce usage by 4.5%. Reduce water loss to 2% of water pumped, not including line flushing and fire fighting.
Nueces WSC[1]	118	Maintain current per capita usage	118	Maintain current per capita usage
Portland[1]	272	5% reduction	258	10% reduction
Ricardo WSC[1]	95	Maintain current per capita usage	95	Maintain current per capita usage
Robstown[3]	N/A	Not Available	N/A	Not Available
Taft[1]	147	Reduce per capita use by 3%	140	Reduce per capita use by 3%
Odem[1]	N/A	Reduce seasonal demands by 2%	N/A	Reduce per capita use by 5%; reduce unaccounted for water by 7%
Three Rivers[3]	N/A	200 gallons/person/day by 2015	N/A	Not Available

N/A = Not Available

[1] Water Conservation Plan on-file with the Nueces River Authority.

[2] Calculated by taking volume of treated water, excluding water sold to wholesale customers, and dividing by permanent population, divided by 365. Because industrial use is close to 40% of treated water, the per capita rate is higher. Target goal for residential use is 73 gpcd (2018) and 69 gpcd (Year 2023).

[3] Water Conservation Plan provided by the TWDB.

The Coastal Bend Regional Water Planning Group recommends that water user groups, with and without shortages, exceeding 140 gallons per capita per day (gpcd) reduce consumption by 1 percent each year until reaching a per capita rate of 140 gpcd. For entities with projected water use equal or less than 140 gpcd in 2070, TWDB projections are recommended. All water user groups in the region are encouraged to voluntarily conserve water.

In 2011, 20 municipal water users in the Coastal Bend Water Planning Region had per capita water use of less than 140 gpcd (Table 5D.1.1). Water users with 140 gpcd or less represented 26.6 percent of the population of the Region in 2011, and used 19.8 percent of the quantity of municipal water used in the Region (Table 5D.1.5). In 2011, in the Region, 54.3 percent of the municipal entities had per capita water use greater than 140 gpcd. This group represented 73.4 percent of the region's population in 2011, and accounted for 80.2 percent of the municipal water used in the Region (Table 5D.1.5).

Table 5D.1.5.
Municipal Water User Groups Number, Population, and Water Use by Per Capita Water Use Levels Coastal Bend Water Planning Region

Per Capita Water Use in 2011 (gpcd)	***Number of WUGs***	***Percent of WUGs***	***Population***		***Water Use***	
			2011 (number)	***Percent of Total***	***2011 (ac-ft)***	***Percent of Total***
140 and less	21	45.7%	155,888	26.6%	22,301	19.8%
Greater than 140	25	54.3%	430,468	73.4%	90,374	80.2%
Totals	46	100.0%	586,356	100.0%	112,675	100.0%

5D.1.2 Available Yield

Of the 46 municipal entities in Region N, 25 had per capita water use rates in year 2011 equal to or higher than 140 gpcd, the goal established by the CBRWPG. All municipal entities in the Coastal Bend Region are encouraged to conserve water, regardless of per capita consumption. The CBRWPG recommends a 1 percent reduction per year in water use for those municipal entities with per capita use greater than 140 gpcd until a gpcd of 140 is reached. This conservation can be achieved in a variety of ways, including using these BMPs identified by the Task Force:

1. System Water Audit and Water Loss,
2. Water Conservation Pricing,
3. Prohibition on Wasting Water,
4. Showerhead, Aerator, and Toilet Flapper Retrofit,
5. Residential Toilet Replacement Programs with Ultra-Low-Flow toilets,
6. Residential Clothes Washer Incentive Program,
7. School Education,
8. Water Survey for Single-Family and Multi-Family Customers,
9. Landscape Irrigation Conservation and Incentives,

10. Water-Wise Landscape Design and Conversion Programs,
11. Athletic Field Conservation,
12. Golf Course Conservation,
13. Metering of all New Connections and Retrofitting of Existing Connections,
14. Wholesale Agency Assistance Programs,
15. Conservation Coordinator,
16. Reuse of Reclaimed Water[3],
17. Public Information,
18. Rainwater Harvesting and Condensate Reuse,
19. New Construction Greywater,
20. Park Conservation, and
21. Conservation Programs for Industrial, Commercial, and Institutional Accounts.

The water conservation water management strategy for municipal entities of the Coastal Bend Region is based upon BMPs listed above, quantities and costs of water conservation measures as reported in TWDB and TCEQ guidance documents[4,5], and the Task Force guidelines for water-use targets and goals listed previously. Costs and savings presented in the Task Force Draft Report are general and have limited applicability. Specific conservation measures are not assigned to each municipal entity to provide flexibility for entities to identify practical conservation strategies that fit their individual situation the best.

A description of water conservation BMPs is listed below to assist municipal entities exceeding 140 gpcd achieve a 1 percent reduction in water use each year until a 140 gpcd is reached. Indoor, landscape irrigation, and general water conservation methods are discussed below. The TWDB water demand and per capita projections already includes water savings through mandated plumbing fixture replacement programs. The target water conservation goals recommended by the Coastal Bend Region are to be achieved with additional BMPs to achieve the desired water savings above the amount already included in TWDB projections.

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[3] Reuse of Reclaimed Water to read "It is assumed that any savings associated with reuse is a small contribution to the savings identified on Table 5D.1.8 and does not duplicate reuse projects identified in Section 5D.5
[4] TWDB, GDS Associates, "Quantifying the Effectiveness of Various Water Conservation Techniques in Texas," July 2003.
[5] TCEQ Water Audit, August 26, 2002.

5D.1.2.1 Indoor Water Conservation

With respect to plumbing fixtures, in 1991 the Texas Legislature enacted Senate Bill 587, which established minimum standards for plumbing fixtures sold in Texas.[6] The bill became effective on January 1, 1992, and allowed for wholesalers and retailers to clear existing inventories of pre-standards plumbing fixtures by January 1, 1993. The standards for new plumbing fixtures, as specified by Senate Bill 587, are shown in Table 5D.1.6. The TCEQ has promulgated rules requiring the labeling of both plumbing fixtures and water-using appliances sold in Texas. The labels must specify the rates of flow for plumbing fixtures and lawn sprinklers, and the amounts of water used per cycle for clothes washers and dishwashers.[7]

Table 5D.1.6.
Standards for Plumbing Fixtures

Fixture	*Standard*
Toilets*	1.28 gallons per flush
Shower Heads	2.75 gallons per minute at 80 psi
Urinals	0.5 gallon per flush
Faucet Aerators	2.20 gallons per minute at 60 psi
Drinking Water Fountains	Shall be self-closing

* House Bill 2667 of the 81st Texas Legislature, 2009

In 2009, the Texas Legislature enacted House Bill (HB) 2667 establishing new minimum standards for plumbing fixtures sold in Texas beginning in 2014. HB 2667 clarifies and sets out the national standards of the American Society of Mechanical Engineers and American National Standards Institute by which plumbing fixtures will be produced and tested. This bill establishes a phase-in of high efficiency plumbing fixtures brought into Texas, which will allow manufacturers the time to change their production, at the same time allowing retailers the opportunity to turn over their inventory. HB 2667 creates an exemption for those manufacturers that volunteer to register their products with the United States Environmental Protection Agency's WaterSense Program, which should result in additional water savings. This bill also repeals the TCEQ certification process for plumbing fixtures since the plumbing fixtures must meet national certification and testing procedures.

The TCEQ has promulgated rules to reflect this new change in law. The 2009 law requires that by January 2014, all toilets use no more than 1.28 gallons per flush (20% savings from the 1991 1.6 gallons per flush standard). Based upon an average frequency of per-person toilet use in households of 5.1 and a per-use savings of 0.32 gallons per use the supplementary savings of adopting high-efficiency toilets is 1.63 gpcd. The savings associated with this new toilet efficiency program is also reflected in Table 5D.1.7.

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[6] Senate Bill 587, Texas Legislature, Regular Session, 1991, Austin, Texas.
[7] Chapter 290, 30 TAC Sections 290.251, 290.253 - 290.256, 290.260, 290.265, 290.266, Water Hygiene, Texas Register, Page 9935, December 24, 1993.

Table 5D.1.7.
Water Conservation Potentials of Low Flow Plumbing Fixtures

Plumbing Fixture	***Water Savings (gpcd)***
Toilets and Showerheads	16.0
Additional Savings (High Efficiency Toilet)*	1.63
Faucet Aerators – 2.2 gallons per minute	2.0
Urinals – 1.0 gallon per minute	0.3
Drinking Fountains (self-closing)	0.1
Total	20.03 (~20 gpcd)

* TWDB, 2013

The TWDB has estimated that the effect of the new plumbing fixtures in dwellings, offices, and public places will be a reduction in per capita water use of approximately 20 gallons per capita per day (gpcd), in comparison to what would have occurred with previous generations of plumbing fixtures.[8] The estimated water conservation effect of 20 gpcd was obtained using the data found in Table 5D.1.7. The low flow plumbing fixtures effects that are already included in the water demand projections are deducted from the 20 gpcd plumbing fixtures potentials to avoid double counting and isolate advanced water conservation savings beyond the plumbing fixture replacement programs.

5D.1.2.2 Outdoor Water Conservation

In addition to the indoor water conservation measures described above, the water conservation water management strategy for municipal entities for the Coastal Bend Region includes landscape irrigation and lawn watering. Unlike indoor water conservation, no limit was assumed for the savings potentials associated with outdoor conservation. Instead, outdoor water conservation is used to meet the projected water savings that is needed to meet the Region N municipal water goals, as stated above.

5D.1.2.3 General Water Conservation

A municipality can determine unaccounted for water losses by performing a water audit, which includes collecting information that can then be used to calculate unaccounted for water loss using the following equation:

Unaccounted for water = Water production/purchased (gallons) – Water sales (gallons)

To maximize the benefits of this conservation strategy, the utility uses this audit information to revise meter testing and repairs, reduce unmetered use, improve accuracy of the utility's metering system, and implement effective water loss management strategies. Factors that affect the

[8] "Water Conservation Impacts on Per Capita Water Use," Water Planning Information, Texas Water Development Board, Austin, Texas, 1992.

amount of unaccounted for water include density of the system, age of the system, construction quality of the system, and accuracy of the water metering.[9]

In December 2004, in response to House Bill 3338, the TWDB adopted rules to require retail public utilities, as defined by Texas Water Code §13.002, to perform a water loss audit and submit water loss audit forms to the TWDB every five years.[10] Pursuant to TWDB Rules[11] for regional water planning, regional water planning groups are required to include information compiled by the TWDB from water loss audits performed by retail public utilities and consider strategies to address any issues identified in the water loss audit information compiled by the TWDB. A discussion of the water loss audit information provided by the TWDB for Coastal Bend Retail Public Utilities is included in Section 1. To assist communities and water supply entities with their conservation planning, the TWDB prepared two publications: the first in January 2007 entitled *An Analysis of Water Loss as Reported by Public Water Suppliers in Texas (Final Report)* and one in March 2008 entitled *Water Loss Audit Manual for Texas Utilities*. Additionally a document entitled *Strategies to Enhance Water Conservation in the Coastal Bend* was specifically prepared to assist communities in the Coastal Bend Area with water conservation. Both the TWDB and Coastal Bend Area documents include a water audit to assist each community in assessing their system. It is anticipated that efforts to assess water losses will improve with future water audits filed on a five year basis, as retail public utilities become more familiar with reporting methodologies and the TWDB provides additional guidance and support.

The TCEQ reports that unaccounted for water losses of 15 percent or less are acceptable for communities greater than 5,000 people. Losses above 15 percent may be an area of concern and provide conservation potentials. Of the 26 entities in the Coastal Bend that responded to the 2010 Water Loss Survey, 6 reported water losses exceeding 15%. Based on this information, these utilities may want to consider pipeline replacement programs.[12] Pipeline replacement programs are intended to address real losses, that is, those losses primarily associated with breaks, leaks, and unreported losses. Estimated costs for a 10-year pipeline replacement program was prepared for these 6 entities as shown in Table 5D.1.8. Pipeline cost was based on the Unified Costing Model cost and following assumptions:

- Entities with < 32 connections: pipeline costs based on 12" rural, soil environment of $35 per ft ($184,800 per mile)
- Entities with > 32 connections: pipeline costs based on 16" urban, soil environment of $81 per ft ($427,680 per mile)
- Pipeline replacement of 10% each year. Full replacement after 10 years.

[9] Naismith Engineering, Inc., "Strategies to Enhance Water Conservation in the Coastal Bend," April 1999.
[10] In accordance with Texas Administrative Code §358.6.
[11] In accordance with Texas Administrative Code §357.7(a)(1)(M) and Texas Administrative Code §357.7(a)(7)(a)(iv)
[12] Meter retrofits can also achieve water savings, but due to high cost variability based on individual systems this best practice was not explored in detail.

Table 5D.1.8.
Summary of Estimated Pipeline Replacement Costs for Entities Reporting Losses Greater than 15%

Utility Name	Retail Pop Served	Main Line Miles	Real Loss/Input Volume*	Total 20 Year Water Savings Needed to Achieve 5% Real Loss (gallons)	Annual Water Savings Needed to Achieve 5% Real Loss in 20 years (gallons)	Amount of Pipe (mi) to Be Replaced Annually to Achieve 100% Replacement in 20 years	Annual Cost ($)	Cost 10 Year Program ($)	Amortized Annual Cost of 10-Year Program ($)	Unit Cost ($ per acft saved)
CITY OF ALICE	19,010	100	21%	187,725,113	9,386,256	5	$2,138,400	$21,384,000	$1,789,399	$62,120
TYNAN WSC	93	8	21%	1,054,479	52,724	0.4	$171,072	$1,710,720	$143,152	$884,725
CITY OF BISHOP	3,300	6	30%	45,538,743	2,276,937	0.3	$128,304	$1,283,040	$107,364	$15,365
HOLIDAY BEACH WSC	2,040	18	32%	67,575,423	3,378,771	0.9	$384,912	$3,849,120	$322,092	$31,063
CITY OF PREMONT	200	18	34%	4,300,642	215,032	0.9	$166,320	$1,663,200	$139,175	$210,901
BAFFIN BAY WSC	1,099	45	67%	24,978,500	1,248,925	2.25	$415,800	$4,158,000	$347,939	$90,779

* Note: The percentage shown is attributable to real losses, which can be addressed with pipeline replacement programs. These percentages will differ from water loss survey information presented on Table 1.4 which reports total water loss (apparent and real loss).

In addition to unaccounted for water losses, public information programs can be an important and key element to having water users save water inside homes and commercial structures, in landscaping and lawn watering, and in recreation uses. Public information and education can work in two ways to accomplish water conservation. One way is to inform and convince water users to obtain and use water-efficient plumbing fixtures and appliances, to adopt low water use landscaping plans and plants, to find and repair plumbing leaks, to use gray water for permissible uses (e.g., lawn and shrubbery watering where regulations allow), and to take advantage of water conservation incentives where available.

The accurate metering of consumed water encourages personal accountability, water conservation and equity in billing rates. Meter replacement programs can be an effective measure for reducing apparent loss, or water that has been consumed but not properly measured or billed. The 2010 Water Loss Survey reported an overall customer meter accuracy of 98% and apparent loss in the Coastal Bend of 1.9% based on responses from 26 entities. However, 10 of the 26 entities in the Coastal Bend that responded to the survey reported apparent losses greater than 5%. Based on this information, these utilities may want to consider meter replacement programs. The majority of meters used in residential systems are between 5/8 and 1-inch with ± 1.5% accuracy and the cost averages about $120 per meter[13]. Estimated costs for meter replacement program for entities reporting apparent losses greater than 5% is shown in Table 5D.1.9.

A second way public information and education can work to conserve water is to inform water users of ways to manage and operate existing and new fixtures and appliances so that less water is used. This includes ideas and practices such as washing full loads of clothes and dishes; using a pail of water instead of a flowing hose to wash automobiles; turning the water off while brushing one's teeth, washing one's hands, or shaving; and watering lawns, gardens, and shrubs during evening — as opposed to daytime — hours.

After subtracting demand reductions already incorporated into the TWDB demand projections, a 1 percent reduction in per capita water use per year for those cities and county-others using greater than 140 gpcd in 2011 would result in savings — less water used — of 15,004 ac-ft in 2040 and 17,034 ac-ft in 2070, as seen in Table 5D.1.10. Note: Water savings are only included for 25 of the 46 municipal entities, since 21 of the entities had a water use equal or less than 140 gpcd in 2011. As can be seen in Table 5D.1.11, the average per capita water use for cities exceeding 140 gpcd in 2011 with additional conservation is approximately 13 and 20 percent lower than without additional conservation in 2040 and 2070 respectively.

[13] Seametrics MJN Pulse Water Meter ¾” $116/each and Assured Automation inline, multi-jet ½” $117/each, internet October 2015.

Table 5D.1.9.
Summary of Estimated Meter Replacement Costs for Entities Reporting Apparent Losses Greater than 5%

UtilityName	# of Retail Service Connections	System Input Volume (gallons)	Total Apparent Loss (gallons)	Apparent Loss (%)	Number of Meters to be Replaced Annually to Achieve 100% of replacement in 10 years	Annual Cost ($120 per meter; 10 year program)	Total 10 Year Program Meter Replacement Cost	Amortized Annual Cost of 10-Year Program ($)
CITY OF PORTLAND	7,544	666,548,000	51,329,240	8%	755	$90,600	$905,280	$75,753
NUECES COUNTY WCID 3	4,250	494,360,000	38,945,580	8%	425	$51,000	$510,000	$42,676
FALFURRIAS UTILITY BOARD	2,398	428,360,727	58,967,027	14%	240	$28,800	$287,760	$24,080
CITY OF THREE RIVERS	1,052	692,444,444	90,723,094	13%	106	$12,720	$126,240	$10,564
RICARDO WSC	877	82,575,000	8,352,695	10%	88	$10,560	$105,240	$8,806
CITY OF ODEM	1,153	98,221,000	8,551,710	9%	116	$13,920	$138,360	$11,578
CITY OF GREGORY	685	101,053,060	5,464,840	5%	69	$8,280	$82,200	$6,878
CITY OF ORANGE GROVE	697	96,284,848	13,226,855	14%	70	$8,400	$83,640	$6,999
BAFFIN BAY WSC	366	40,430,000	2,920,000	7%	37	$4,440	$43,920	$3,675
NUECES COUNTY WCID 5	270	31,042,424	1,561,826	5%	27	$3,240	$32,400	$2,711

Table 5D.1.10.
Potential Additional Water Conservation Savings for Water User Groups Having 2011 per Capita Water Use Greater than 140 gpcd

Water User	County	Housing Area	Water Demand Reductions via Additional Water Conservation											
			2020		2030		2040		2050		2060		2070	
			gpcd	acft/yr	gpcd	acft/yr	gpcd	acft/yr	gpcd	acft/yr	gpcd	acft/yr	gpcd	acft/yr
RIVER ACRES WSC	NUECES	Suburban	3	9	0	0	0	0	0	0	0	0	0	0
BENAVIDES	DUVAL	Rural	3	4	0	0	0	0	0	0	0	0	0	0
PORTLAND	SAN PATRICIO	Suburban	4	74	3	49	0	0	0	0	0	0	0	0
GREGORY	SAN PATRICIO	Suburban	3	8	5	11	3	6	2	6	2	5	2	5
COUNTY-OTHER	KLEBERG	Suburban	3	13	6	24	3	15	3	15	3	14	3	15
THREE RIVERS	LIVE OAK	Rural	5	11	11	22	7	15	5	11	5	11	5	11
BISHOP	NUECES	Suburban	4	16	9	39	6	27	5	23	5	23	5	23
ROCKPORT	ARANSAS	Suburban	6	66	18	192	16	172	15	159	15	156	15	156
GEORGE WEST	LIVE OAK	Rural	6	15	17	46	16	44	14	40	14	39	14	39
SAN DIEGO	DUVAL	Rural	5	29	16	94	19	117	18	117	18	119	18	122
FULTON	ARANSAS	Suburban	8	12	20	33	28	46	27	44	27	44	27	44
CORPUS CHRISTI	NUECES	Urban	6	2,305	18	7,354	26	10,985	24	10,667	24	10,765	24	10,898
ALICE	JIM WELLS	Suburban	6	143	18	462	30	812	29	838	29	876	28	916
EL OSO WSC	LIVE OAK	Rural	17	20	29	35	42	50	43	51	34	41	34	41
FREER	DUVAL	Rural	7	24	20	73	33	124	43	168	42	171	42	175
BEEVILLE	BEE	Rural	8	117	21	333	34	542	44	710	44	706	44	707
SINTON	SAN PATRICIO	Suburban	9	62	24	170	38	277	52	385	60	447	60	451
ROBSTOWN	NUECES	Suburban	9	125	24	336	38	532	54	748	63	884	63	884
PREMONT	JIM WELLS	Rural	9	31	25	87	39	149	55	221	68	289	68	303
ORANGE GROVE	JIM WELLS	Rural	11	18	28	49	44	83	60	120	75	159	83	183
FALFURRIAS	BROOKS	Rural	16	91	37	224	57	360	78	508	97	649	114	786
COUNTY-OTHER	KENEDY	Rural	32	17	71	40	105	60	139	79	171	97	199	113
PORT ARANSAS	NUECES	Suburban	37	160	80	374	120	589	157	792	191	985	222	1,161
Total				**3,370**		**10,048**		**15,004**		**15,702**		**16,482**		**17,034**

Table 5D.1.11.
Coastal Bend Region Average Per Capita Water Use for Expected and Advanced Conservation (gpcd)

Type of Conservation	Region Average		Average for Water Users >140 gpcd in 2000	
	2040	2070	2040	2070
TWDB projections	155	153	195	193
TWDB plus additional conservation	149	140	169	153

5D.1.3 Environmental Issues

Environmental impacts from water conservation measures in the Coastal Bend Region are not associated with direct physical impacts to the natural environment. Some of the indoor conservation measures recommended could reduce the amount of treated wastewater available to send to the Nueces Bay and Estuary during low flow times, which could be offset by possible positive impact resulting from higher reservoir levels.

Under a 2001 Agreed Order from the TCEQ[14], the City is required to pass specified volumes of inflows to the reservoirs in accordance with a monthly schedule to mitigate the impacts of Choke Canyon Reservoir and maintain the health of the Nueces Estuary. In any month when the System storage is less than 40 percent but greater than 30 percent, the target Nueces Bay inflow requirement may be reduced to 1,200 ac-ft/mo when the City and its customers implement Condition II of the City's Water Conservation and Drought Contingency Plan (Plan). If System storage drops below 30 percent, bay and estuary releases (except for return flows) may be suspended when the City and its customers implement Condition III of the Plan. The City's water conservation and drought contingency plan is summarized in Chapters 5C and 7.

5D.1.4 Engineering and Costing

Municipal water conservation costs were based on a TWDB study[15] performed by GDS Associates quantifying the effectiveness of various water conservation techniques. Of all the indoor water conservation activities, clothes washer rebates are the most costly, ranging in cost from $735/ac-ft to $828/ac-ft, as seen in Table 5D.1.12. For outdoor conservation activities, rain barrels are the most costly program. Costs varied significantly for reducing seasonal water use, unaccounted for loss, and public education programs, and therefore were not presented. For example, a city's cost of a meter replacement and leak detection program, generally part of the utilities' operation and maintenance budget, would vary based on size and age of utility operation and will increase the cost per ac-ft of water conservation activities.

[14] Texas Commission on Environmental Quality (TCEQ), Agreed Order Establishing Operational Procedures Pertaining to Special Condition B, Certificate of Adjudication No. 21-3214, Held by City of Corpus Christ, et al., April 28, 1995.
[15] "Quantifying the Effectiveness of Various Water Conservation Techniques in Texas," Texas Water Development Board, GDS Associates, Austin, Texas, July 2003.

Table 5D.1.12.
Costs of Possible Water Conservation Techniques (BMPs)

Water Conservation Techniques*	Potential Savings for Region N (ac-ft)	Number of People Affected	Potential Savings (ac-ft per person per year)	Total Costs (dollars)	Cost per ac-ft of Water Saved Amortized at 6%*
Rural Areas					
SF Toilet Retrofit	468	99,414	0.004704614	2,739,452	416
SF Showerheads and Aerators	245	99,414	0.002464322	225,602	119
SF Clothes Washer Rebate	561	99,414	0.005645537	4,350,895	825
SF Irrigation Audit-High User	90	99,414	0.00090782	112,801	459
SF Rainwater Harvesting	69	99,414	0.000694268	503,576	703
SF Rain Barrels	45	99,414	0.000450943	443,862	1,169
MF Toilet Retrofit	28	4,695	0.005880856	113,396	291
MF Showerheads and Aerators	14	4,695	0.003080449	6,048	54
MF Clothes Washer Rebate	4	4,695	0.000781569	13,104	553
MF Irrigation Audit	4	4,695	0.000751864	3,780	393
MF Rainwater Harvesting	1	4,695	0.000212993	5,166	496
Totals	1,528	104,109	**0.025575234**	8,517,681	**$500****
Suburban Areas					
SF Toilet Retrofit	686	158,226	0.0043332	4,028,677	417
SF Showerheads and Aerators	359	158,226	0.0022698	331,773	120
SF Clothes Washer Rebate	823	158,226	0.0051999	6,398,487	828
SF Irrigation Audit-High User	133	158,226	0.000838863	165,887	459
SF Rainwater Harvesting	102	158,226	0.000641487	740,566	703
SF Rain Barrels	66	158,226	0.000416682	799,811	1,169
MF Toilet Retrofit	58	9,939	0.005881034	340,089	413
MF Showerheads and Aerators	31	9,939	0.003080542	18,138	77
MF Clothes Washer Rebate	11	9,939	0.001107273	39,299	553
MF Irrigation Audit	11	9,939	0.001064493	11,336	393
MF Rainwater Harvesting	3	9,939	0.000302847	15,493	496
Totals	2,281	168,165	**0.020546**	12,889,556	**$510****
Urban Areas					
SF Toilet Retrofit	1,042	221,401	0.00470461	5,430,181	370
SF Showerheads and Aerators	546	221,401	0.00246432	447,191	106
SF Clothes Washer Rebate	1,250	221,401	0.005645533	8,624,405	735
SF Irrigation Audit-High User	179	221,401	0.000808036	223,596	459
SF Rainwater Harvesting	148	221,401	0.000669058	998,195	649
SF Rain Barrels	96	221,401	0.000434596	1,078,051	1,079
MF Toilet Retrofit	303	51,481	0.005880773	1,266,035	297
MF Showerheads and Aerators	159	51,481	0.003080405	67,522	55
MF Clothes Washer Rebate	41	51,481	0.000795799	146,297	553
MF Irrigation Audit	39	51,481	0.000765137	42,201	393
MF Rainwater Harvesting	12	51,481	0.000235621	57,675	458
Totals **	3,814	272,882	**0.02448313**	18,381,350	**$470****

* SF is Single Family and MF is Multi-family residential housing.
** Average of Measures included. Used for municipal conservation costs
Source: "Quantifying the Effectiveness of Various Water Conservation Techniques in Texas," Texas Water Development Board, GDS Associates, Austin, Texas, July 2003.

The costs for various water conservation strategies are presented in Table 5D.1.12. Eleven of the twenty-one possible BMPs suggested by the task force and listed above were averaged to calculate program costs. The average cost of municipal water conservation for rural entities is $500/ac-ft of water saved, $510/ac-ft of water saved for suburban entities, and $470/ac-ft for urban entities. These values include both indoor BMPs such as toilet retrofits, and outdoor conservation measures such as landscape incentives. The total program costs for municipal entities having per capita use greater than 140 gpcd in 2011 are presented in Table 5D.1.13. Total conservation potential costs for Region N are estimated at $1,621,610 in 2020 and increasing to $8,218,547 by 2070. The CBRWPG has expressed a desire to offer BMPs to encourage conservation while maintaining flexibility for municipal users to adopt strategies that suit them the best.

5D.1.5 Implementation Issues

There are several issues that may slow down the efforts of water conservation activities. The most crucial is to get water customers to change their water use habits. Effective public out-reach and education can go a long way to reducing water use, but in the end the effectiveness of any program is dependent upon the individual. A key element to the Drought Contingency and Water Conservation Plan that each city has been required to submit to the TCEQ is the curtailment of water use during drought. Enforcement of these restrictions — usually ones that limit lawn watering — is often difficult. Lastly, capital costs for retrofit programs can be large depending on the system, and may be difficult for cities or rural entities to initially finance.

5D.1.6 Evaluation Summary

An evaluation summary of this water management option is provided in Table 5D.1.14.

Table 5D.1.13.
Cost of Water Conservation for Selected Water Conservation Techniques for Water User Groups Having 2011 per Capita Water Use Greater than 140 gpcd

Water User	County	Housing Area	Cost per acft	Cost of Water Savings via Additional Water Conservation					
				2020 (dollars)	2030 (dollars)	2040 (dollars)	2050 (dollars)	2060 (dollars)	2070 (dollars)
RIVER ACRES WSC	NUECES	Suburban	510	$4,358	$0	$0	$0	$0	$0
BENAVIDES	DUVAL	Rural	500	$2,176	$0	$0	$0	$0	$0
PORTLAND	SAN PATRICIO	Suburban	510	$37,518	$24,965	$0	$0	$0	$0
GREGORY	SAN PATRICIO	Suburban	510	$3,888	$5,646	$3,207	$2,908	$2,709	$2,719
COUNTY-OTHER	KLEBERG	Suburban	510	$6,724	$12,315	$7,742	$7,619	$7,055	$7,581
THREE RIVERS	LIVE OAK	Rural	500	$5,340	$11,060	$7,560	$5,560	$5,560	$5,560
BISHOP	NUECES	Suburban	510	$8,009	$20,042	$13,786	$11,888	$11,800	$11,831
ROCKPORT	ARANSAS	Suburban	510	$33,745	$97,781	$87,525	$81,036	$79,426	$79,426
GEORGE WEST	LIVE OAK	Rural	500	$7,665	$23,057	$22,121	$20,121	$19,621	$19,621
SAN DIEGO	DUVAL	Rural	500	$14,428	$47,002	$58,292	$58,317	$59,557	$61,227
FULTON	ARANSAS	Suburban	510	$6,233	$17,055	$23,242	$22,522	$22,442	$22,442
CORPUS CHRISTI	NUECES	Urban	470	$1,083,268	$3,456,356	$5,163,045	$5,013,510	$5,059,753	$5,122,216
ALICE	JIM WELLS	Suburban	510	$73,170	$235,658	$413,944	$427,364	$446,726	$467,094
EL OSO WSC	LIVE OAK	Rural	500	$10,149	$17,562	$25,029	$25,523	$20,523	$20,523
FREER	DUVAL	Rural	500	$12,165	$36,336	$61,873	$83,830	$85,675	$87,510
BEEVILLE	BEE	Rural	500	$58,701	$166,265	$270,929	$355,237	$353,139	$353,326
SINTON	SAN PATRICIO	Suburban	510	$31,598	$86,789	$141,048	$196,156	$228,195	$229,836
ROBSTOWN	NUECES	Suburban	510	$63,709	$171,216	$271,127	$381,536	$450,801	$450,801
PREMONT	JIM WELLS	Rural	500	$15,519	$43,666	$74,735	$110,538	$144,493	$151,644
ORANGE GROVE	JIM WELLS	Rural	500	$8,962	$24,700	$41,570	$59,964	$79,435	$91,591
FALFURRIAS	BROOKS	Rural	500	$45,747	$111,976	$180,009	$254,008	$324,710	$392,933
COUNTY-OTHER	KENEDY	Rural	500	$8,294	$19,893	$29,764	$39,399	$48,541	$56,521
PORT ARANSAS	NUECES	Suburban	510	$81,511	$190,875	$300,453	$403,870	$502,231	$592,172
Total				**1,622,879**	**4,820,213**	**7,197,001**	**7,560,907**	**7,952,392**	**8,226,575**

Table 5D.1.14.
Evaluation Summary of Municipal Water Conservation

Impact Category	*Comment(s)*
a. Water Supply 1 Quantity 2. Reliability	1. Firm Yield: 17,034 ac-ft/yr in Year 2070 2. Cost: Ranges from $55 to $1,169 per ac-ft water saved (based on BMP selected.)
b. Environmental factors	
1. Instream flows	1. Some impact due to decreased return flows, which could be offset by possible positive impact resulting from higher reservoir levels.
2. Bay and Estuary Inflows	2. Some impact due to decreased return flows, which could be offset by possible positive impact resulting from higher reservoir levels.
3. Wildlife Habitat	3. Some impact due to decreased return flows, which could be offset by possible positive impact resulting from higher reservoir levels.
4. Wetlands	4. Some impact due to decreased return flows, which could be offset by possible positive impact resulting from higher reservoir levels.
5. Threatened and Endangered Species	5. None.
6. Cultural Resources	6. No cultural resources affected.
7. Water Quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	7. None or low impact.
c. Impacts to State water resources	• No apparent negative impacts on water resources
d. Threats to agriculture and natural resources in region	• None
e. Recreational impacts	• None
f. Equitable Comparison of Strategies	• Standard analyses and methods used
g. Interbasin transfers	• None
h. Third party social and economic impacts from voluntary redistribution of water	• None
i. Efficient use of existing water supplies and regional opportunities	• Improvement over current conditions
j. Effect on navigation	• None
k. Consideration of water pipelines and other facilities used for water conveyance	• May be some impact to disinfectant chlorine residuals.

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5D.2

Irrigation Water Conservation (N-2)

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5D.2 Irrigation Water Conservation (N-2)

5D.2.1 Description of Strategy

Irrigation water use is the use of freshwater that is pumped from aquifers and/or diverted from streams and reservoirs and applied directly to grow cotton, corn, sorghum, and other crops in the study area. The amount of water supplied to irrigate agriculture accounted for around 55 percent of approximately 13.8 million ac-ft of water used in the state in 2010.[1] Approximately 7.6 million ac-ft of water were used in Texas to grow a variety of crops ranging from food and feed grains to fruits and vegetables to cotton. Of these 7.6 million ac-ft, groundwater resources provide approximately 75 percent of the water used for irrigation purposes, with surface water supplies accounting for the remaining 25 percent. Although irrigated agriculture accounts for only 27 percent of all harvested cropland acres in Texas, the value of irrigated crops account for about 53 percent of the total value of crop production in the State.[2]

In Texas, irrigated acreage development peaked in 1974 with 8.6 million acres of irrigated cropland. By 2012, irrigated acreage had declined statewide by approximately 4.1 million acres, with a corresponding decline in on-farm water use of more than 3.6 million ac-ft, a reduction of 27 percent.[3,4] There are a number of factors associated with this declining trend, including more acreage being set aside for compliance with federal farm programs, poor economic conditions in the agricultural sector, a decline in the number and size of farms, technological advancements in crop production, advancement and implementation of more water efficient irrigation systems, and better irrigation management practices.

Irrigation water is supplied by groundwater and surface water and is typically applied to land by: 1) flowing or flooding water down the furrows; and 2) with the use of sprinklers. When groundwater is used, irrigation wells are usually located within the fields to be irrigated. For surface water supplies, typically water is diverted from the source and conveyed by canals and pipelines to the fields. In both the use of groundwater and surface water, the conservation objective is to reduce the quantity of water that is lost to deep percolation and evaporation between the originating points (wells in the case of groundwater, and stream diversion points in the case of surface water), and the irrigated crops in the fields. Thus, the focus is upon investments in irrigation application equipment, instruments, and conveyance facility improvements (canal lining and pipelines) to reduce seepage losses, deep percolation, and evaporation of water between the originating points of the water and the destination locations within the irrigated fields, and management of the irrigation processes to improve efficiencies of irrigation water use and reduce the quantities of water needed to accomplish irrigation.

Although the statewide trend in irrigated acreage is downward, irrigated acreage in the Coastal Bend Region does not reflect this trend. Crops grown on irrigated acres in the Coastal Bend

[1] Texas Water Development Board (TWDB) Historical Water Use Database, 2010.
[2] 2012 Census of Agriculture.
[3] 2012 Census of Agriculture.
[4] TWDB, Historical Water Use Database, 2012.

Region included cotton, grain sorghum, corn, forage crops, peanuts, pecans, hay-pasture, Irish potatoes, vegetables, and other crops. The 2012 agricultural census indicates that irrigated acreage in the 11-county Coastal Bend area totaled about 18,551 acres, with nearly 84 percent of the regional total occurring in Bee, Jim Wells, and San Patricio counties. Table 5D.2.1 summarizes the variety of crops grown in the Coastal Bend Region and number of irrigated crops for each county in 2007.

Table 5D.2.1.
Irrigated Acres by Crop (2012) Coastal Bend Region

	Corn	***Cotton***	***Sorghum***	***Vegetables***	***Hay***	***Other[1]***	***Total***
Aransas	0	0	0	0	0	10	10
Bee	1,539	0	2,985	0	0	607	5,131
Brooks	0	0	0	0	100	970	1,070
Duval	0	0	0	0	0	0	-
Jim Wells	0	0	0	1,601	1,193	2,001	4,795
Kenedy	0	0	0	0	0	660	660
Kleberg	0	0	0	0	0	112	112
Live Oak	0	0	0	0	292	442	734
McMullen	0	0	0	0	0	0	-
Nueces	0	0	0	0	12	420	432
San Patricio	1,440	2,532	1,307	0	98	230	5,607
Total	**2,979**	**2,532**	**4,292**	**1,601**	**1,695**	**5,452**	**18,551**
Percent	**16.05%**	**13.65%**	**23.14%**	**8.63%**	**9.14%**	**29.39%**	**100%**

Source: USDA National Agricultural Statistics Service 2012 Census (http://quickstats.nass.usda.gov/?source_desc=CENSUS)

In 2010, the irrigators in the Coastal Bend Region used 18,398 ac-ft of water, of which nearly 99 percent was from groundwater sources. In 2012, the TWDB estimated that the irrigators in the 11- county Coastal Bend used 25,015 ac-ft. About 4,500 ac-ft of the 6,617 ac-ft increase in regional water use was attributed to San Patricio County which reported a 62% increase in 2012 water use as compared to 2010.

In the Coastal Bend Region, all of the 11 counties receive a majority of their irrigation water supply from groundwater sources. Nueces County irrigators receive some of their water supply from run-of-river water rights from the Nueces River and Jim Wells receives some water from creeks and stock ponds.

For this round of regional water planning, irrigation water demands are based on data provided by TWDB for Aransas, Bee, Kenedy, and San Patricio Counties and updated water demand projections developed by the Coastal Bend Regional Water Planning Group and subsequently adopted by the TWDB for Brooks, Duval, Jim Wells, Kleberg, Live Oak, McMullen, and Nueces Counties. The irrigation water demand projections prepared by the Coastal Bend Regional Water Planning Group were based on groundwater conservation district information and FSA-provided irrigation acreage estimates. The final TWDB-adopted projections based on the feedback from the Coastal Bend Regional Water Planning Group resulted in a region-wide irrigation water demand increase of 9 to 22% (or 2,140 to 7,300 ac-ft more) as compared to initial, TWDB draft projections. The irrigation water demand projections for the Coastal Bend Region show significant increases in irrigation usage in the future, primarily attributable to projected increases in irrigation water demands in Bee and San Patricio Counties. For example, San Patricio County irrigation water demand is estimated to increase from 11,085 ac-ft/yr in 2020 to 18,632 ac-ft/yr in 2070 (an increase of 68%). Similarly, Bee County irrigation water demand is also estimated to increase by 68% during the planning period from 4,751 ac-ft/yr in 2020 to 7,985 ac-ft/yr in 2070. For the Coastal Bend Region, the TWDB estimate of irrigation water use is projected to increase from 26,419 ac-ft in 2010 to 40,124 ac-ft by 2070, representing an increase of approximately 52 percent over the planning period.

In the Coastal Bend Region, McMullen and San Patricio Counties are projected to have irrigation needs (shortages) during the 2020 to 2070 planning period, as shown in Table 5D.2.2. McMullen County currently has no water reported for irrigation uses. Due to poor quality water in shallower aquifer systems, if irrigation does occur in McMullen County in the future then groundwater supplies from the Carrizo aquifer as deep as 3,300 to 5,000 ft below land surface may be the best candidates.[5] San Patricio County's groundwater use for irrigators is constrained by modeled available groundwater (MAG) estimates. If MAGs are revised by Groundwater Management Area 16 and San Patricio County Groundwater Conservation District's Management Plan, then drilling additional wells could help fully address future water shortages in conjunction with conservation practices.

The projected need increases over the planning period from 40 ac-ft in 2020 to 51 ac-ft in 2070. At the time of the 2007 Agricultural Census, McMullen County had 0 irrigated acres (Table 5D.2.1). Recently, the TWDB adopted projections listing a small irrigation demand for the county.

TWDB Rules for regional water planning require Regional Water Planning Groups to consider water conservation and drought management measures for each water user group with a need (projected water shortage). In addition, the Rules direct water conservation BMPs, as identified by the Water Conservation Implementation Task Force (Task Force), be considered in the development of the water conservation water management strategy.

[5] Correspondence between HDR and Lonnie Stewart (McMullen Groundwater Conservation District), February 7, 2015.

Table 5D.2.2.
Projected Water Demands, Supplies, and Water Needs (Shortages) for Irrigation Users in McMullen and San Patricio Counties

	Projections (ac-ft/yr)					
	2020	**2030**	**2040**	**2050**	**2060**	**2070**
McMullen County						
Irrigation Demand	40	42	44	46	49	51
Irrigation Existing Supply						
Groundwater	0	0	0	0	0	0
Surface Water	0	0	0	0	0	0
Total Irrigation Supply	0	0	0	0	0	0
Surplus (Shortage)	(40)	(42)	(44)	(46)	(49)	(51)
San Patricio County						
Irrigation Demand	11,085	12,244	13,525	14,940	16,504	18,632
Irrigation Existing Supply						
Groundwater	14,441	14,441	14,441	14,441	14,441	14,441
Surface Water	0	0	0	0	0	0
Total Irrigation Supply	14,441	14,441	14,441	14,441	14,441	14,441
Surplus (Shortage)	3,356	2,197	916	(499)	(2,063)	(4,191)

5D.2.2 Available Yield

As part of the 2016 regional water planning process, the CBRWPG recommended that counties with projected irrigation needs (shortages) reduce their irrigation water demands by 15 percent by 2020 using BMPs identified by the Task Force. A 15 percent reduction in irrigation water demand by 2070, results in a water savings of up to 8 ac-ft/yr for McMullen County and up to 2,795 ac-ft/yr for San Patricio County. This results in a new need after conservation of 43 ac-ft for McMullen County in 2070 and 1,396 ac-ft for San Patricio County in 2070 as shown in Table 5D.2.3.

Table 5D.2.3.
Projected Water Demands and Needs (Shortages) for Irrigation Users after Recommended Irrigation Water Conservation in McMullen and San Patricio Counties

	Projections (ac-ft/yr)					
	2020	**2030**	**2040**	**2050**	**2060**	**2070**
McMullen County						
New Demand	39	40	41	41	43	43
Expected Savings	1	2	3	5	6	8
Shortage After Conservation (ac-ft/yr)	(39)	(40)	(41)	(41)	(43)	(43)
Shortage Reduction (ac-ft/yr)	3%	5%	7%	10%	13%	15%
San Patricio County						
New Demand	11,085	12,244	13,525	13,446	14,441	15,837
Expected Savings	0	0	0	1,494	2,063	2,795
Shortage After Conservation (ac-ft/yr)	0	0	0	0	0	(1,396)
Shortage Reduction (ac-ft/yr)	N/A	N/A	N/A	100%	100%	67%

The Task Force report lists the following irrigation BMPs that may be used to achieve the recommended water savings:[6]

1. Irrigation Scheduling;
2. Volumetric Measurement of Irrigation Water Use;
3. Crop Residue Management and Conservation Tillage;
4. On-farm Irrigation audit;
5. Furrow Dikes;
6. Land Leveling;
7. Contour Farming;
8. Conservation of Supplemental Irrigated Farmland to Dry-Land Farmland;
9. Brush Control/Management;
10. Lining of On-Farm Irrigation ditches;
11. Replacement of On-/farm Irrigation Ditches with Pipelines;
12. Low Pressure Center Pivot Sprinkler Irrigation Systems;
13. Drip/Micro-Irrigation System;
14. Gated and Flexible Pipe for Field Water Distribution Systems;
15. Surge Flow Irrigation for Field Water Distribution Systems;
16. Linear Move Sprinkler Irrigation Systems;

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

17. Lining of District Irrigation Canals;
18. Replacement of District Irrigation canals and Lateral canals with Pipelines;
19. Tailwater Recovery and Use System; and
20. Nursery Production Systems.

The Task Force report describes the above BMP methods and how they reduce irrigation water use, however information regarding specific water savings and costs to install irrigation water saving systems is generally unavailable. The Task Force report does include water savings and costs for three irrigation water conservation BMPs: 1) furrow dikes; 2) low-pressure sprinklers (LESA); and 3) low-energy precision application systems (LEPA). These major irrigation water conservation techniques applicable in the Coastal Bend Region are described briefly below.

Furrow dikes are small mounds of soil mechanically installed a few feet apart in the furrow. These mounds of soil create small reservoirs that capture precipitation and hold it until it soaks into the soil instead of running down the furrow and out the end of the field. This practice can conserve (capture) as much as 100 percent of rainfall runoff, and furrow dikes are used to prevent irrigation runoff under sprinkler systems. This maintains high irrigation uniformity and increases irrigation application efficiencies. Capturing and holding precipitation that would have drained from the fields replaces required irrigation water on irrigated fields; and furrow dikes have been demonstrated to be useful management tools on both irrigated and non-irrigated cropland.

Use of furrow dikes can have water savings up to 12 percent gross quantity of water applied using sprinkler irrigation. Furrow dikes require special tillage equipment and costs $7 to $39 per acre to install (for September 2008 dollars). Low-pressure sprinklers (LESA) with 75 percent application efficiency improve irrigation application efficiency in comparison to conventional furrow irrigation by reducing water requirements per acre by 15 percent. LEPA systems involve a sprinkler system that has been modified to discharge water directly into furrows at low pressure, thus reducing evaporation losses. When used in conjunction with furrow dikes, which hold both precipitation and sprinkler applied water behind small mounds of earth within the furrows, LEPA systems can accomplish the irrigation objective with less water than is required for the furrow irrigation and pressurized sprinkler methods.

If LEPA is used with furrow dike systems the expected water savings would be approximately 0.62 ac-ft/acre. Use of LEPA and furrow dikes allows irrigation farmers to produce equivalent yields per acre at lower energy and labor costs of irrigation. It has been demonstrated that LEPA systems improve production and profitability of irrigation farming. The barriers to installation are high capital costs; with no assurance (at the present time) that the water saved would be available to the irrigation farmer who incurred the costs.

5D.2.3 Environmental Issues

The irrigation water conservation methods described above have been developed and tested through public and private sector research, and have been adopted and applied within the Region. Hundreds of LEPA systems have been installed, and are in operation today, and experience has shown that there are not any significant environmental issues associated with this water management strategy. For example, this method improves water use efficiency without making changes to wildlife habitat. This method of application, when coupled with furrow dikes reduces runoff of both applied irrigation water and rainfall. The results are reduced transport of sediment and any fertilizers or other chemicals that have been applied to the crops. Thus, the proposed conservation practices do not have potential adverse effects, and in fact have potentially beneficial environmental effects.

5D.2.4 Engineering and Costing

The CBRWPG recommended irrigation water conservation (15 percent reduction in demands by 2070) as a water management strategy for irrigation needs, resulting in a maximum water savings of 2,803 ac-ft/yr in 2070 for San Patricio and McMullen Counties. Region N recommends that irrigators in these counties consider use of furrow dikes, LESA, or LEPA programs to achieve the recommended water savings targets. Irrigators are to decide which of these or other options would serve them best. Installing LESA or LEPA systems would incur a greater capital cost, and therefore higher annual costs, however both achieve a substantially higher water savings potential and therefore have more economical unit cost ($/ac-ft) when compared to furrow dikes.

An average cost of implementing furrow dikes, LESA, and LEPA programs of $230 per ac-ft/yr was used for water saved with the exact technology to implement left to the WUG's discretion to choose the program that works best for them. The estimated costs for McMullen and San Patricio Counties are shown in Table 5D.2.4. Each of the three irrigation water conservation strategies described (furrow dikes, LESA, and LEPA) have the potential to increase water savings beyond the recommendations of the CBRWPG. For example, installing LEPA or LESA for acreage currently equipped with sprinkler systems could potentially eliminate all shortages.

***Table 5D.2.4.*[7]**
Potential Water Savings and Costs (Total Project, Annual Average, and Unit Costs) to Implement Irrigation Water Conservation BMPs in McMullen and San Patricio Counties

	Projections (ac-ft/yr)					
	2020	**2030**	**2040**	**2050**	**2060**	**2070**
McMullen County						
Expected Savings (ac-ft)	1	2	3	5	6	8
Costs ($	$230	$483	$759	$1,058	$1,409	$1,760
San Patricio County						
Expected Savings (ac-ft)	0	0	0	1,494	2,063	2,795
Costs ($)	$0	$0	$0	$343,620	$474,490	$642,804

[7] The cost of implementing irrigation water conservation practices was calculated based on estimated water savings and application efficiencies from TWDB Report 347, Surveys of Irrigation in Texas (2001) and costs to implement furrow dikes, LESA, and LEPA programs by acre from TWDB Report 362- Water Conservation Best Management Practices Guide (2004).

It may not be economically feasible for some agricultural producers to pay for additional water supplies to meet projected irrigation water needs (shortages), even if such supplies were available. For example, in 2004, for irrigated cotton, the estimated income remaining after other production expenses had been paid was about $158 per acre. For cotton farming, which is most prevalent in San Patricio County, it may be practical to install furrow, LESA, or LEPA systems. For other crops, if the cost of water exceeds the estimated income, then it would not be practical to pay for additional water.

5D.2.5 Implementation Issues

The rate of adoption of efficient water-using practices is dependent upon public knowledge of the benefits, information about how to implement water conservation measures, and financing. There is widespread public support for irrigation water conservation and it is being implemented at a steady pace, and as water markets for conserved water expand, this practice will likely reach its maximum potential. A major barrier to implementation of water conservation is financing. The TWDB has irrigation conservation programs that may provide funding to irrigators to implement irrigation BMPs that increase water use efficiency. Future planning efforts should consider the use of detailed studies to fully determine the maximum potential benefits of additional irrigation conservation.

5D.2.6 Evaluation Summary

An evaluation summary of this water management option is provided in Table 5D.2.5.

Table 5D.2.5.
Evaluation Summary of Irrigation Water Conservation

Impact Category	***Comment(s)***
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	 1. Firm yield: Variable according to BMP selected and extent of participation. Max Projected for 15% goal is 8 ac-ft/yr for McMullen County and 2,795 ac-ft/yr for San Patricio County (or 2,803 ac-ft total). 2. Highly reliable quantity. 3. Cost: Average of $230 per ac-ft water saved based on BMP selected.
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. None or low impact. 2. None or low impact. 3. No apparent negative impact. 4. None. 5. None. 6. No cultural resources affected. 7. None or low impact.
c. Impacts to State water resources	• No apparent negative impacts on water resources
d. Threats to agriculture and natural resources in region	• None
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Standard analyses and methods used
g. Interbasin transfers	• None
h. Third party social and economic impacts from voluntary redistribution of water	• None
i. Efficient use of existing water supplies and regional opportunities	• Improvement over current conditions by reducing rate of decline of local groundwater levels
j. Effect on navigation	• None

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5D.3

Manufacturing Water Conservation and Nueces River Water Quality Issues (N-3)

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5D.3 Manufacturing Water Conservation and Nueces River Water Quality Issues (N-3)

5D.3.1 Description of Strategy

Manufacturing is an integral part of the Texas economy, and for many industries, water plays a key role in the manufacturing process. Some of these processes require direct consumption of water as part of the products; others consume very little water but use a large quantity for cleaning and cooling. In 2010, Nueces and San Patricio Counties accounted for 92 percent of the total self reported manufacturing water use in Coastal Bend Region of 44,824 ac-ft. Manufacturing use for the entire planning region is projected to increase to 98,724 ac-ft in 2030 and 127,266 ac-ft by 2070. In 2070, Nueces and San Patricio Counties will account for 98 percent of the total manufacturing water use in the region.

In the manufacturing sector, water quality impacts the quantity of water needed for cooling purposes. Cooling water accounts for 60 to 75 percent of the industrial demand in the region.[1] Assuming 60 percent demand, the industrial demand for cooling water in Nueces and San Patricio Counties is expected to grow from about 26,892 ac-ft/yr in 2010 to 74,856 ac-ft/yr in 2070. The quantity of water needed by industry for cooling is substantial and could potentially be reduced by providing water with lower mineral content. High levels of dissolved minerals result in an increase in manufacturing water demands, due to accelerated build-up of mineral deposits in industrial cooling facilities. Additional water savings can also be achieved by stabilizing the water quality and thereby minimizing the variation in water quality. Manufacturing water conservation would benefit the entire Coastal Bend Region by preventing the need to obtain, treat, and distribute the amount of water that is conserved. Alternatively, the amount of water that is conserved could be used for other beneficial purposes.

Devising water management strategies using water from the Lower Nueces River Basin has been a challenge, especially with regard to water losses and water quality. Figure 5D.3.1 shows that median chloride concentrations at the Calallen Pool near the City of Corpus Christi's O.N. Stevens Water Treatment Plant (WTP) intake (155 mg/L) are 2 times the level of chlorides in water released from Lake Corpus Christi (80 mg/L). Previous studies by the U.S. Geological Survey (USGS) and others have also indicated a significant increase in the concentration of dissolved minerals in the Lower Nueces River between Mathis and the Calallen Saltwater Barrier Dam.[2]

Figure 5D.3.1 also shows the change in chloride concentrations occurring between Lake Corpus Christi (Hwy 359 site) and the Calallen Dam. The results indicate that on average about 60 percent of the increase in chlorides occurs upstream of the Calallen Pool and about 40 percent of the increase within the pool. Despite similar conclusions from the various previous studies, the source(s) of this increase in mineral concentrations has not previously been conclusively

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[1] City of Corpus Christi, "Effluent Reuse Study," February 2002.
[2] USGS studies report average chloride concentrations in the Calallen Pool are 2.5 times the level of chlorides in water released from Lake Corpus Christi.

established. Potential sources of minerals to the Calallen Pool include saltwater intrusion, groundwater seepage, and upstream sources of contamination from abandoned wells in adjacent oil fields and gravel washing operations.

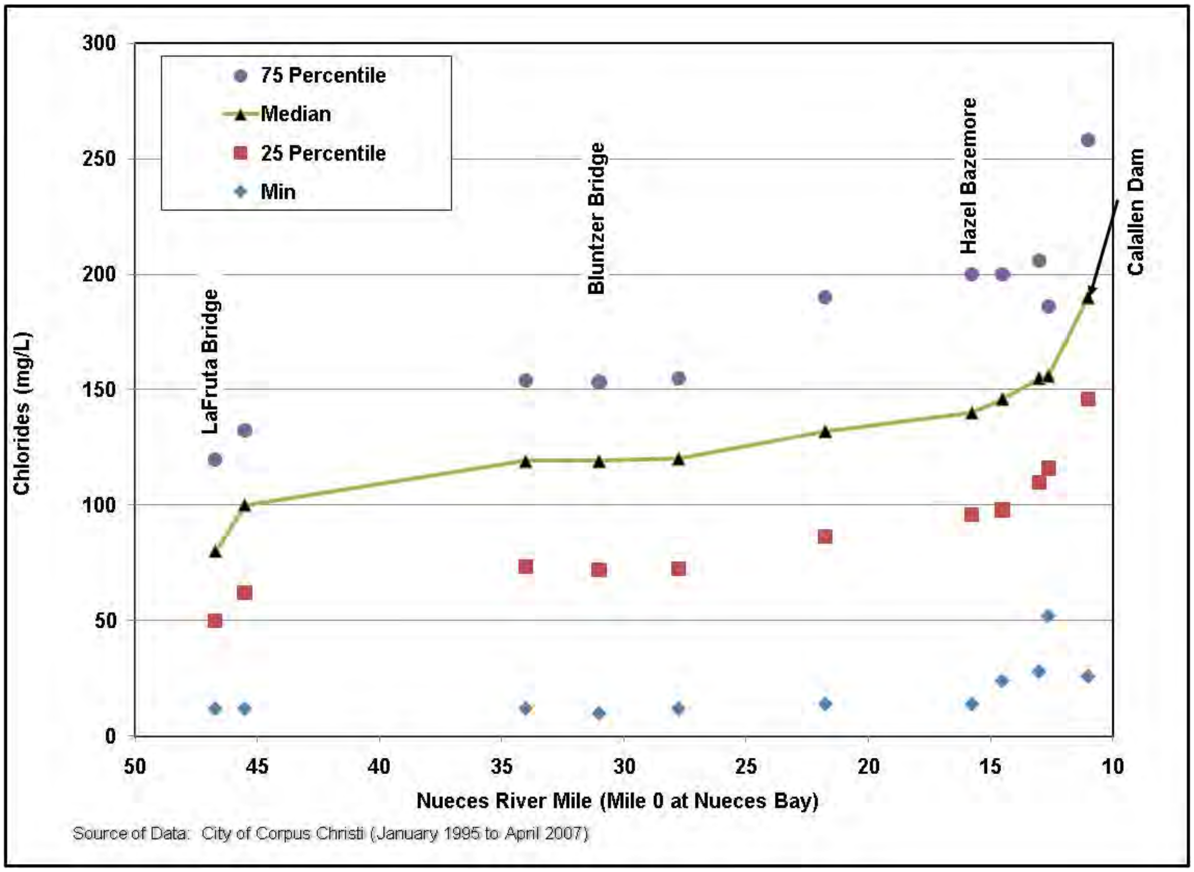

Figure 5D.3.1.
Summary of Historical Data — Chloride Content of the Lower Nueces River, Segment 2102

This strategy includes discussion of previous studies and recent Lower Nueces River water quality assessment conducted by the Coastal Bend Regional Water Planning Group (CBRWPG). For the 2011 Plan, the CBRWPG conducted assessments of a water budget of LCC and water quality of the Lower Nueces River from Lake Corpus Christi to the Calallen Pool. Following results from the water quality study, the report discusses manufacturing water demands and specific water management strategies that may address water supply issues to promote manufacturing water conservation.

5D.3.2 Previous Water Quality Analyses

For the 2001 Regional Water Plan, a surface water and groundwater evaluation was conducted for the Nueces River downstream of Lake Corpus Christi. The study showed the most significant concentration increase in chlorides (and dissolved minerals in general) occurs with increasing depth within the channel. Sampling results showed stratification within the Calallen Pool, with large mineral concentration increases occurring within the bottom two feet near the water intake locations. The stratification of the channel was found to be the most significant when no water was spilling over Calallen Dam and the least detectable during periods of high flow. The largest increase in dissolved mineral concentrations was found 100 yards downstream of the O.N. Stevens intake. The study also showed that the surface water sample taken at the Stevens intake is geochemically more similar to the groundwater sample taken at Hazel Bazemore Park, than to any of the other surface water samples (including samples taken at the same location, just three feet higher in the water column). This suggests that groundwater intrusion is taking place in the Calallen Pool.

A second phase of this investigation was initiated as part of the 2001 Regional Water Plan in an effort to identify the possible sources of elevated levels of dissolved solids in the Nueces River water in addition to the surface water sampling effort just described. This effort included monitor well installation, groundwater and surface water sampling, obtaining and interpreting aerial/ satellite imagery of the area between Wesley Seale Dam and Calallen Pool, to identify possible point source contributions (specifically, abandoned oil and gas wells and sand/gravel washing operations), and groundwater intrusion. The results of the surface water and groundwater interaction study are included in the 2001 Plan.

The opportunity exists with permanent monitor wells in place around the Calallen Pool to conduct a comprehensive sampling program to evaluate the gaining and losing nature of the surface/groundwater system and then relate this information to surface water and groundwater sample results acquired within a time period during which the Calallen Pool experiences low and high flow conditions. Based upon the results of the sampling program, best management practices and mitigation can then be suggested.

The Nueces River Partnership is working to develop a watershed protection plan for the Lower Nueces River for the 182.6 square miles contributing to the Nueces between Lake Corpus Christi and the saltwater barrier dam. The Texas Clean Rivers Program developed a watershed management approach to conducting basin wide water quality assessments required by Senate Bill 818. Water quality data from this effort is available for Lake Corpus Christi and the 39 river miles downstream to the saltwater barrier. The Nueces BBASC Study #3, currently being conducted by HDR, will develop nutrient budgets based on quantitative understanding of natural supply of all nutrient forms and anthropogenic changes in these supplies over time for the Nueces Bay watershed and determine annual loads for pre-development and current conditions.

5D.3.3 Assessment of Water Budget and Salinity in the Lower Nueces River Basin

5D.3.3.1 Introduction

The major purpose of this assessment for the 2016 Plan is to improve our understanding of: 1) surface water/groundwater interactions; and 2) influences on water quality conditions. The areas of interest are Lake Corpus Christi (LCC) and the Nueces River between LCC and Calallen.

For purposes of this report, the Lower Nueces River Basin is considered to be between the USGS station 08210000 Nueces River near Three Rivers, TX and station 08211500 Nueces River at Calallen.

The location of the study area and the stream gaging stations is shown in Figure 5D.3.2. Data used for the study included:

- Streamflow – USGS;
- Groundwater levels, groundwater quality, precipitation and lake evaporation – Texas Water Development Board (TWDB);
- LCC stage and volume and direct lake diversions – Nueces River Authority (NRA); and
- Stream water quality and Calallen diversions – City of Corpus Christi.

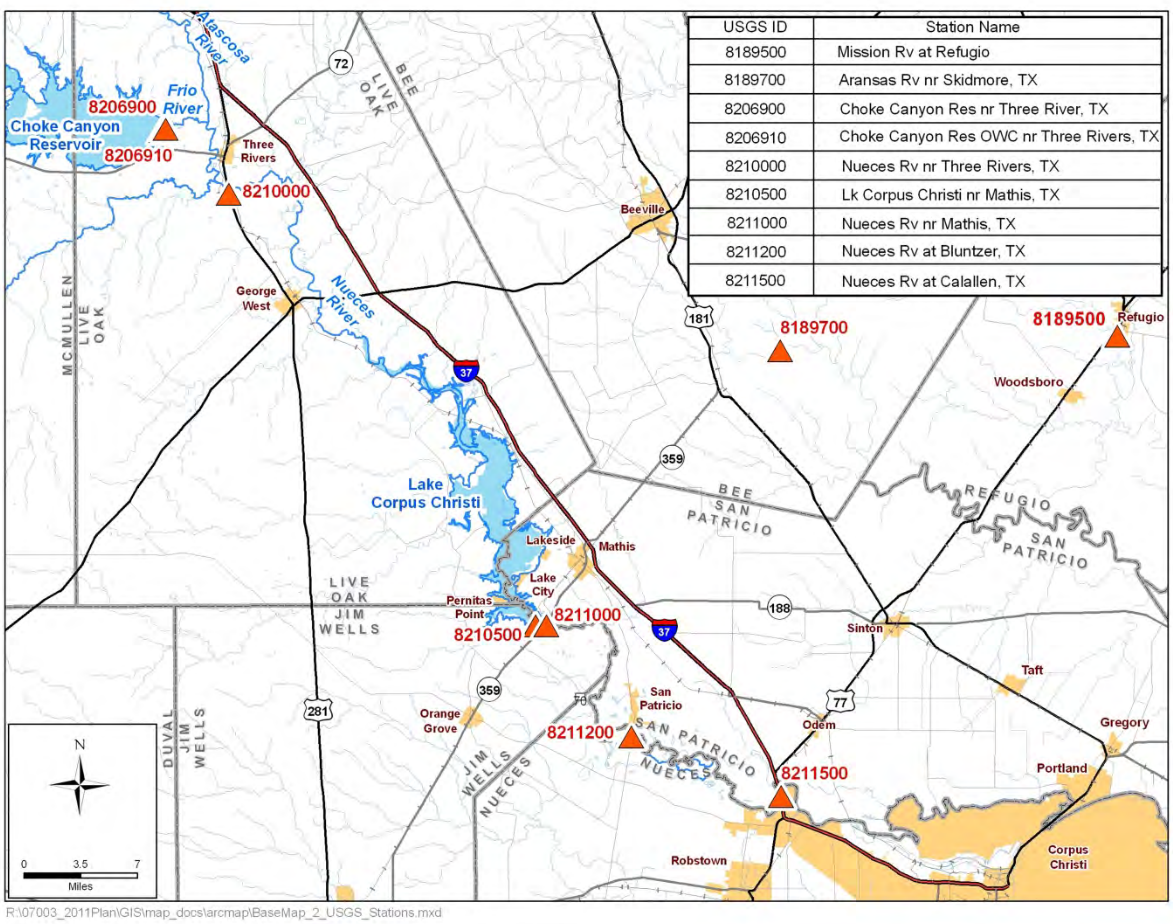

Figure 5D.3.2.
Location of Study Area and Streamflow Gaging Stations

5D.3.3.2 Surface Water/Groundwater Interactions

The interaction (movement) of water between the Nueces River and LCC (surface water) and major aquifers (groundwater) is studied for LCC and in the Nueces River reach between Mathis and Calallen. For LCC, the interaction is studied by calculating the seepage into and out of the lake from a water budget model. For the Lower Nueces River, the interaction is studied by calculating the streamflow gains and losses between streamflow USGS gaging stations.

Seepage Into and Out of Lake Corpus Christi

The selected approach in calculating the seepage into and out of LCC is to develop a water balance model that accounts for all the major inflows and outflows and estimates seepage from the lake as the amount of water needed to balance the other inflow and outflow components. The hydrologic connection of LCC with the Gulf Coast Aquifer, primarily the Goliad Sands (Evangeline Aquifer), is assessed by compiling, plotting and studying groundwater level data in the vicinity of the lake.

Water Balance Model

A schematic of the water balance model is shown in Figure 5D.3.3. As shown, the major components of inflow to LCC are the Nueces River, runoff from intervening drainage area around the lake, precipitation and seepage; and, the major components of outflow are reservoir releases, lake diversions, evaporation and seepage. The period of study is from January 1959, which is shortly after the enlargement of the current reservoir was completed, to 2008. Because of the length of the study period, data constraints, and 'noise' in the daily data, the selected time interval for the water balance model is a month. This minimizes, not eliminates, the potential for outliers in trying to balance the inflow and outflow components.

Inflow from the Nueces River is estimated from the USGS station 08210000 Nueces River near Three Rivers. The intervening area between the Nueces River below the Three Rivers gage and above the LCC Wesley Seale Dam is paired with the USGS station 08189700 Aransas River near Skidmore which is about 20 miles northeast of the lake (Figure 5D.3.3). The streamflow records for the Aransas station were adjusted to the intervening area by: 1) subtracting an estimate of the City of Beeville's wastewater from data; 2) calculating the unit runoff of the gaged watershed; 3) assuming the unit runoff in the intervening area is the same as for the Aransas River near Skidmore watershed; and 4) multiplying the intervening area times the unit runoff of the Aransas River. The USGS station 08189700 Aransas River near Skidmore station was started in 1964. From 1959-1964, the Aransas River near Skidmore streamflow was estimated by using the USGS station 08189500 Mission River at Refugio streamflow and making an adjustment based on watershed size. The precipitation on the lake was obtained from the TWDB data base. An average of precipitation for grids 909 and 910 was considered to be representative.

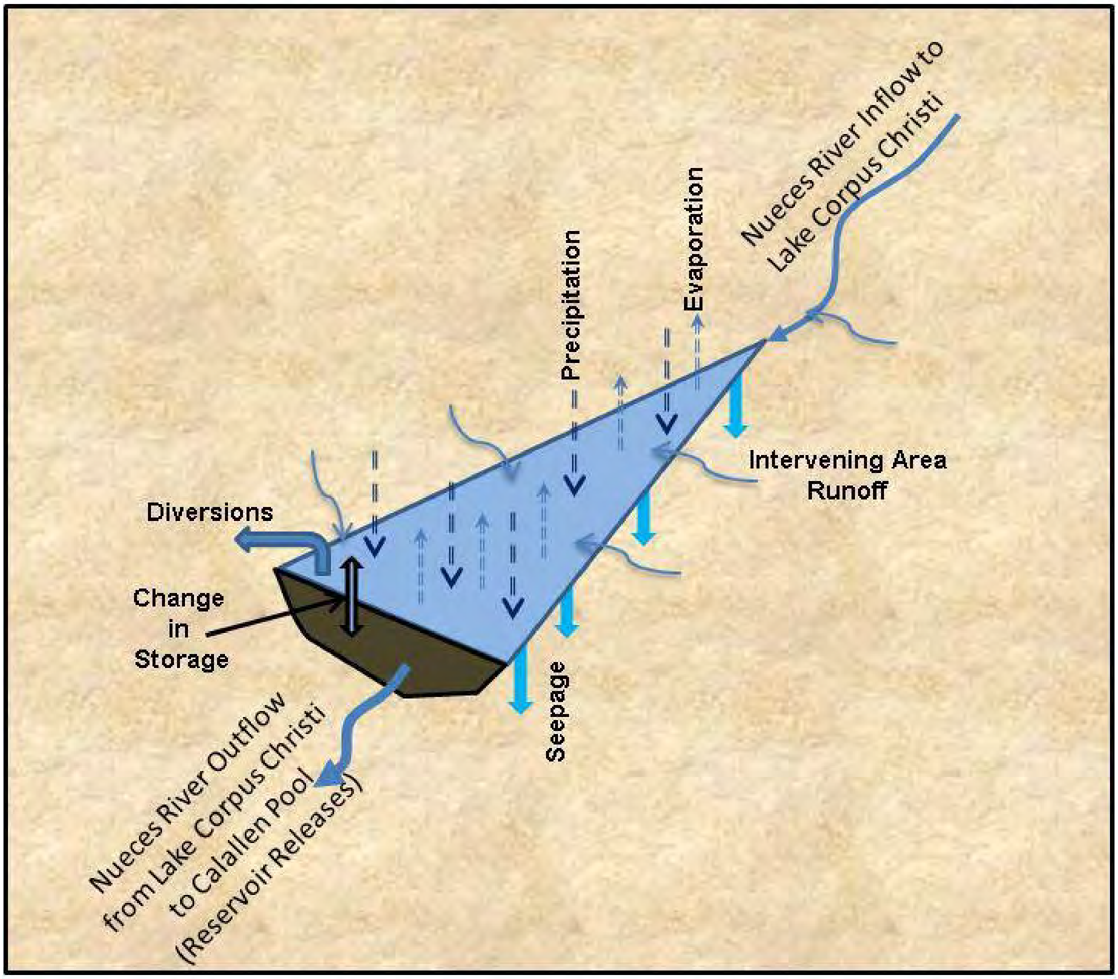

Figure 5D.3.3.
Schematic of Lake Corpus Christi Water Balance Components

Outflow from LCC releases is estimated from the USGS station 08211000 Nueces River near Mathis. Major direct diversions from LCC are made by the Cities of Alice, Beeville and Mathis. Diversion data were provided by the NRA. The evaporation from the lake was obtained from the TWDB data base. An average of evaporation for grids 909 and 910 was considered to be representative. LCC records on stage and volume were obtained from the NRA.

Charts showing the annual water budget components are shown in:

- Figure 5D.3.4: Amount of inflow and outflow from precipitation and evaporation, respectively;
- Figure 5D.3.5: Inflow and outflow for LCC;
- Figure 5D.3.6: Inflow to LCC from intervening area and Outflow from direct lake diversions;
- Figure 5D.3.7: Net change in lake storage; and
- Figure 5D.3.8: Seepage into and out of lake.

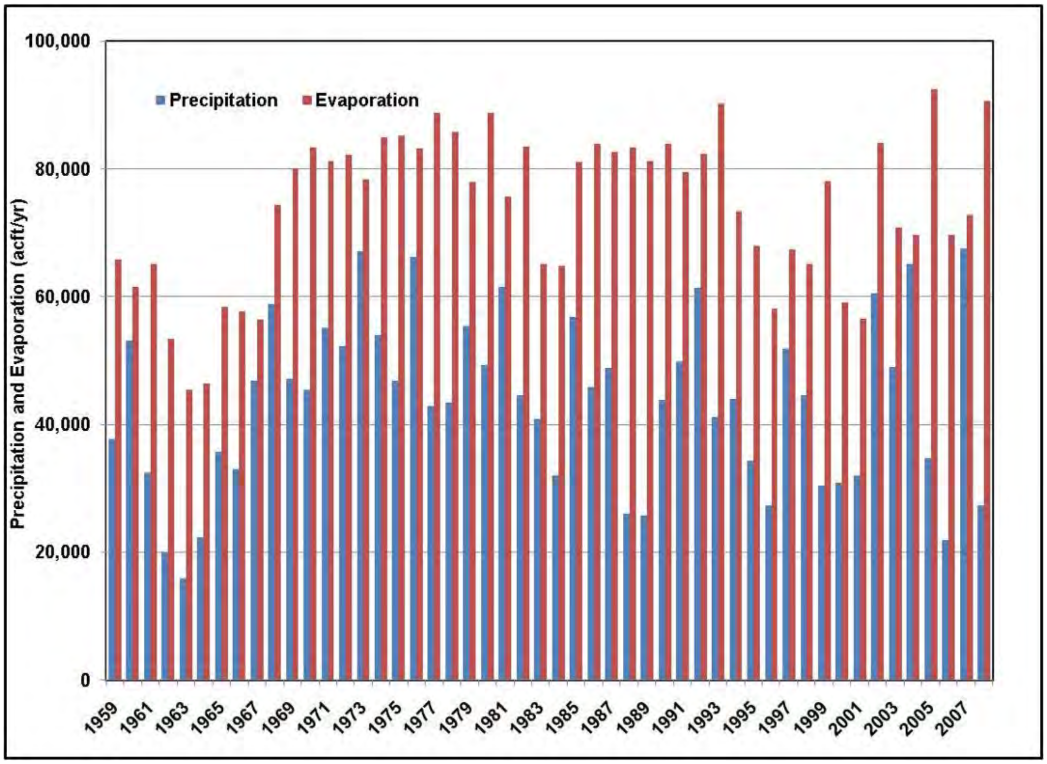

Figure 5D.3.4.
Precipitation and Evaporation

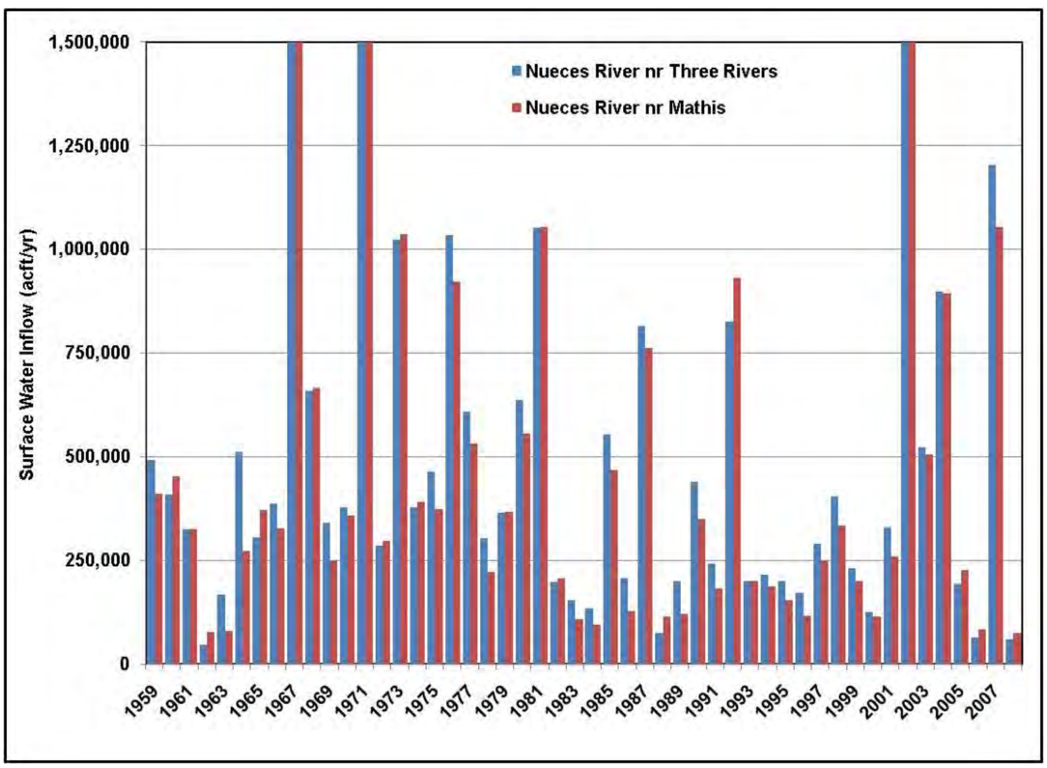

Figure 5D.3.5.
Streamflow at Nueces River Inflow and Outflow Stations

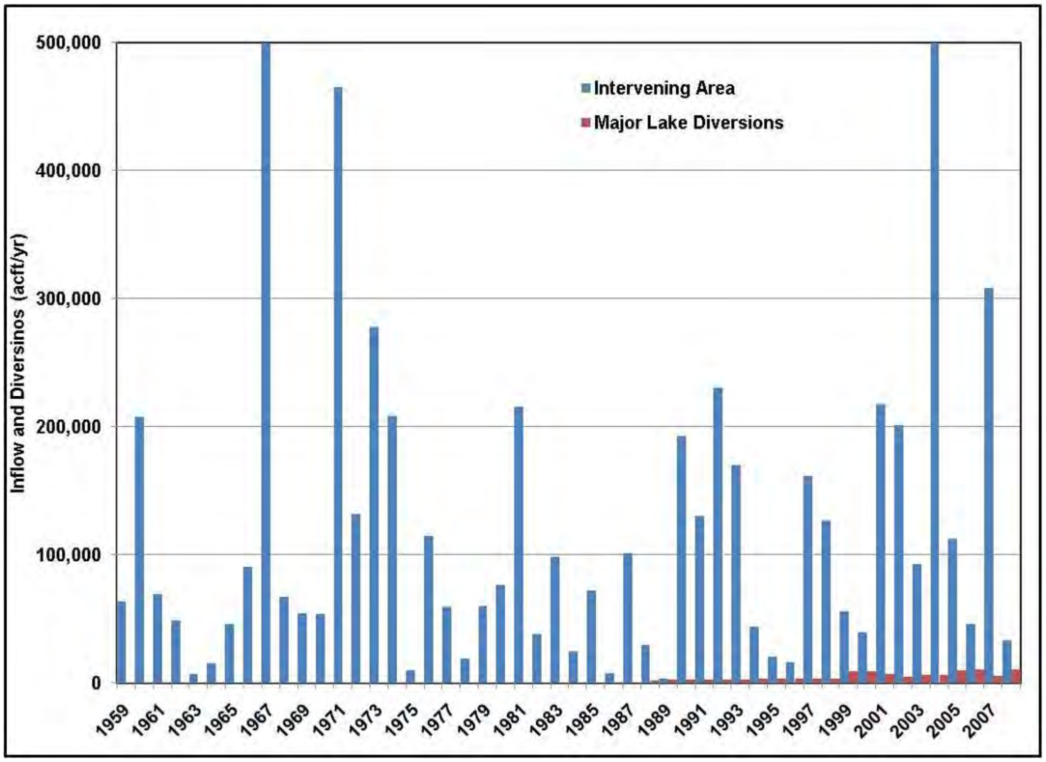

Figure 5D.3.6.
Intervening Area Inflow and Major Water Supply from Lake Corpus Christi

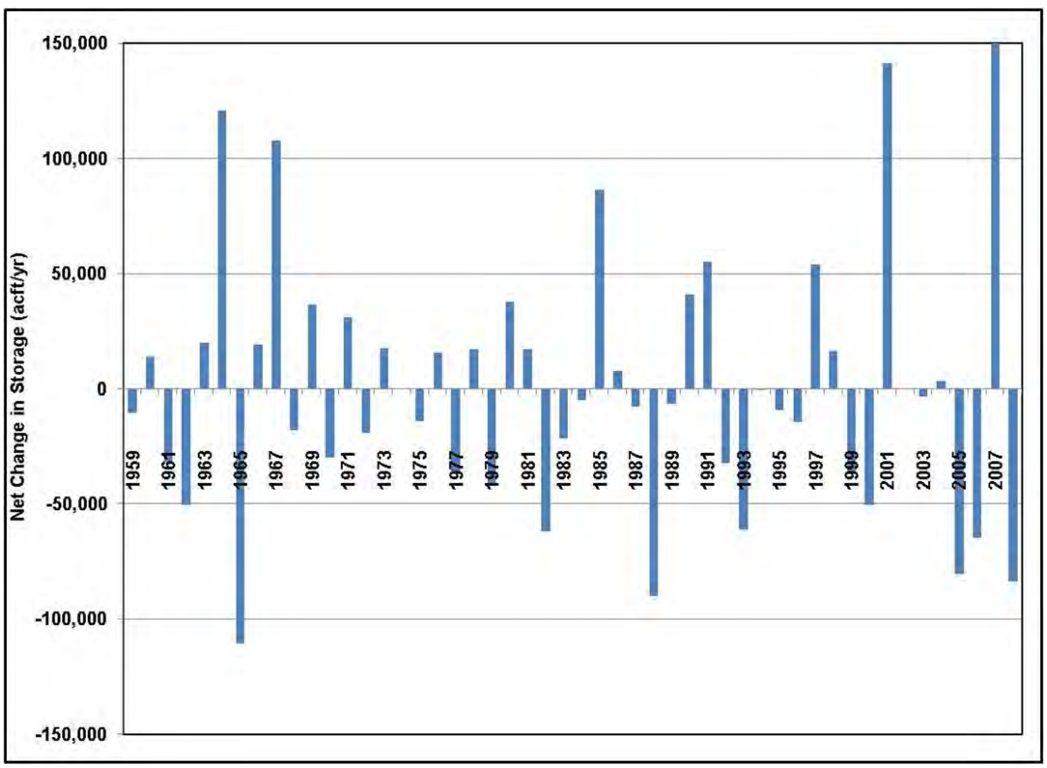

Figure 5D.3.7.
Net Change in Lake Storage

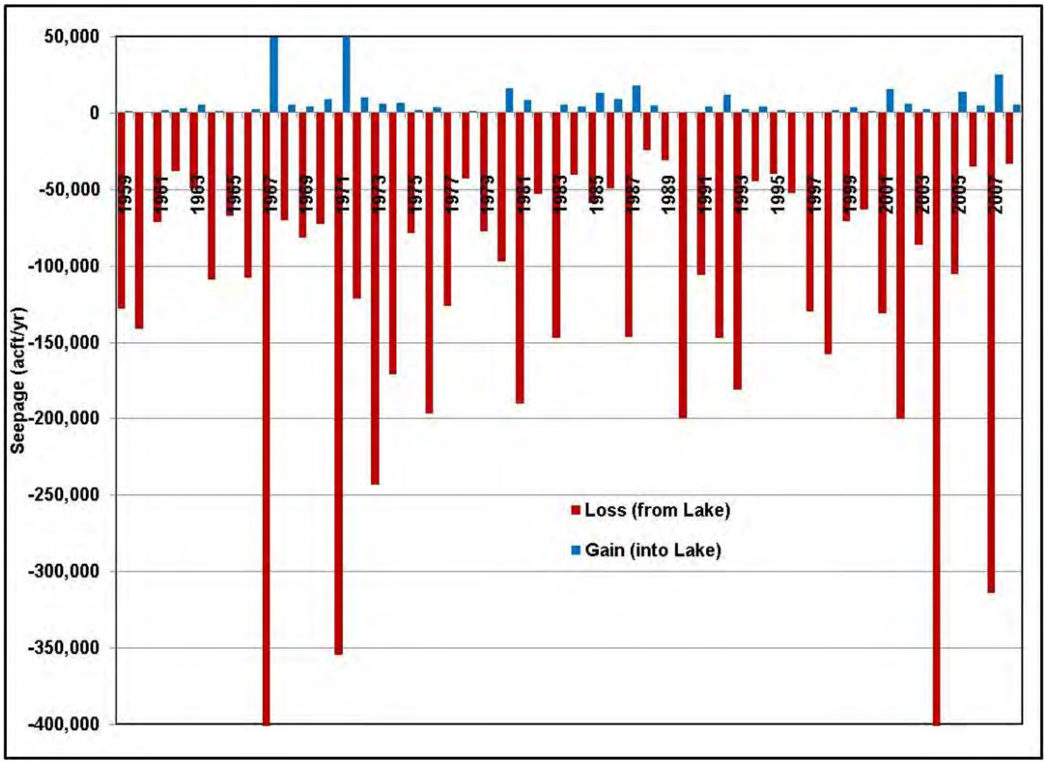

Figure 5D.3.8.
Seepage Into and Out of Lake

The seepage in the water balance model is considered to be an unknown and is the amount of water needed each month for the water budget to balance.

A water budget summary of the lake's water budget is presented in Table 5D.3.1. The results of this analysis shows seepage out of the lake represents about 17 percent of the outflow and about 1 percent of the inflow. The largest component of inflow is from the Nueces River near Three Rivers, which is about 68 percent. Releases from LCC's Wesley Seale Dam are about 64 percent of the outflow. Evaporation accounts for about 10 percent of the outflow.

Table 5D.3.1.
Annual Average of Lake Corpus Christi's Major Water Budget Components

	Units (ac-ft/yr)		*Percentage*	
Component	***Inflow***	***Outflow***	***Inflow***	***Outflow***
Nueces River-Three Rivers	509,100		68	
Nueces River-Mathis		480,500		64
Precipitation	43,600		6	
Evaporation		73,900		10
Intervening Runoff	125,300		17	
Lake Diversions		2,300		0
Net Change in Storage	64,100	64,600	8	9
Seepage	6,700	127,500	1	17
TOTAL	**748,800**	**748,800**	**100**	**100**

A detailed chart that illustrates the seepage and lake stage is provided in Figure 5D.3.9. As shown, there is considerable 'noise' in the seepage calculation, which is attributed to the accuracy of the records, especially streamflow during high flow conditions, precipitation, evaporation, lake's stage record as being representative the lake volume during flooding conditions, and the method used to estimate intervening runoff. Included on this chart is a curve that is intended to represent a smoothed and more realistic pattern of the seepage. It is the median value of 12-month period. A median statistic was selected to omit outliers.

A study of Figure 5D.3.9 suggests that 50% of the time the seepage tends to be between 15 and 115 cfs (900 to 5,600 ac-ft/yr) out of the lake. A trendline suggests slightly increasing trend in seepage out of the lake (about 0.4 cfs (300 ac-ft/yr) over the 50-year period).

There is also an interest in estimating the seepage during several lake conditions, including low conditions (stage less than 90 ft-msl), high conditions (stage greater than 90 ft-msl), falling stage over extended periods and rising stage over extended periods.

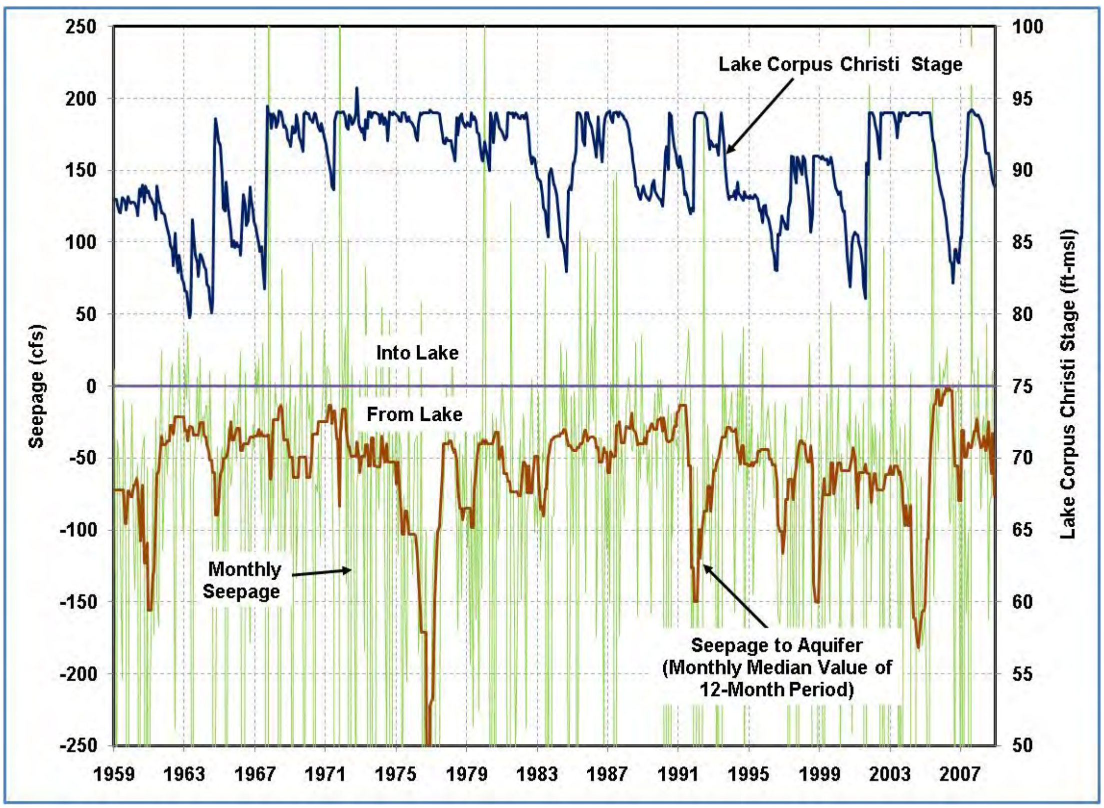

Figure 5D.3.9.
Seepage and Lake Stages

Table 5D.3.2 provides a summary of these results for the smoothed seepage values. These results suggest that the lowest seepage rate occurs when the lake stage is in a prolonged decline. The greatest seepage rate occurs at high stages. Seepage during rising stage conditions is slightly greater than low seepage rates. These results support the conceptual understanding that: 1) higher lake stages increases the hydraulic gradient between the lake and the aquifer, which would cause higher seepage rates; 2) higher seepage rates during a rising stage are greater than during a falling stage because of filling and emptying of pore space as well as flow into the aquifer; and 3) seepage rates during low conditions are relatively small because of a lower hydraulic gradient between the lake and the aquifer. The overall average seepage is closer to the seepage during high conditions than low conditions because the lake's stage is much longer for high conditions than low conditions.

Table 5D.3.2.
Estimated Seepage from Lake Corpus Christi for Various Lake Conditions

Lake Condition	Seepage Rate from Lake, Smoothed Graph (ac-ft/yr)	
	Average	Median
Low (Stage lower than 90 ft-msl)	35,200	30,200
High (Stage higher than 90 ft-msl)	44,900	35,800
Falling (Stage Declining over Extended Period)	31,800	29,100
Rising (Stage Rising over Extended Period)	36,700	30,900
All	41,100	35,200

A USGS study[3] for the period since filling of the lake (1958 thru 1965 estimated an average seepage loss of about 62,000 ac-ft/yr, or 86 cfs. These higher losses than the ones calculated from this study may be partly attributed to the initial filling of the lake.

Hydrogeology

LCC is formed in the Nueces River valley and is underlain almost entirely by the Goliad Sand, which is the main water-bearing zone of the Evangeline Aquifer. Figure 5D.3.10 is a generalized map of the surface geology in the study area. In the vicinity of the lake, these formations dip toward the Gulf of Mexico about 40-50 ft per mile. Thus, as one moves toward the coast the Evangeline Aquifer becomes deeper and deeper and is eventually overlain by younger sediments, which become thicker and thicker toward the coast. The geologic units and a general description of the lithology are listed in Table 5D.3.3.

[3] Gilbert, C.R., 1975, Water-Loss studies of Lake Corpus Christi Nueces River Basin, Texas, 1949-1965: Texas Water Development Board Report 104.

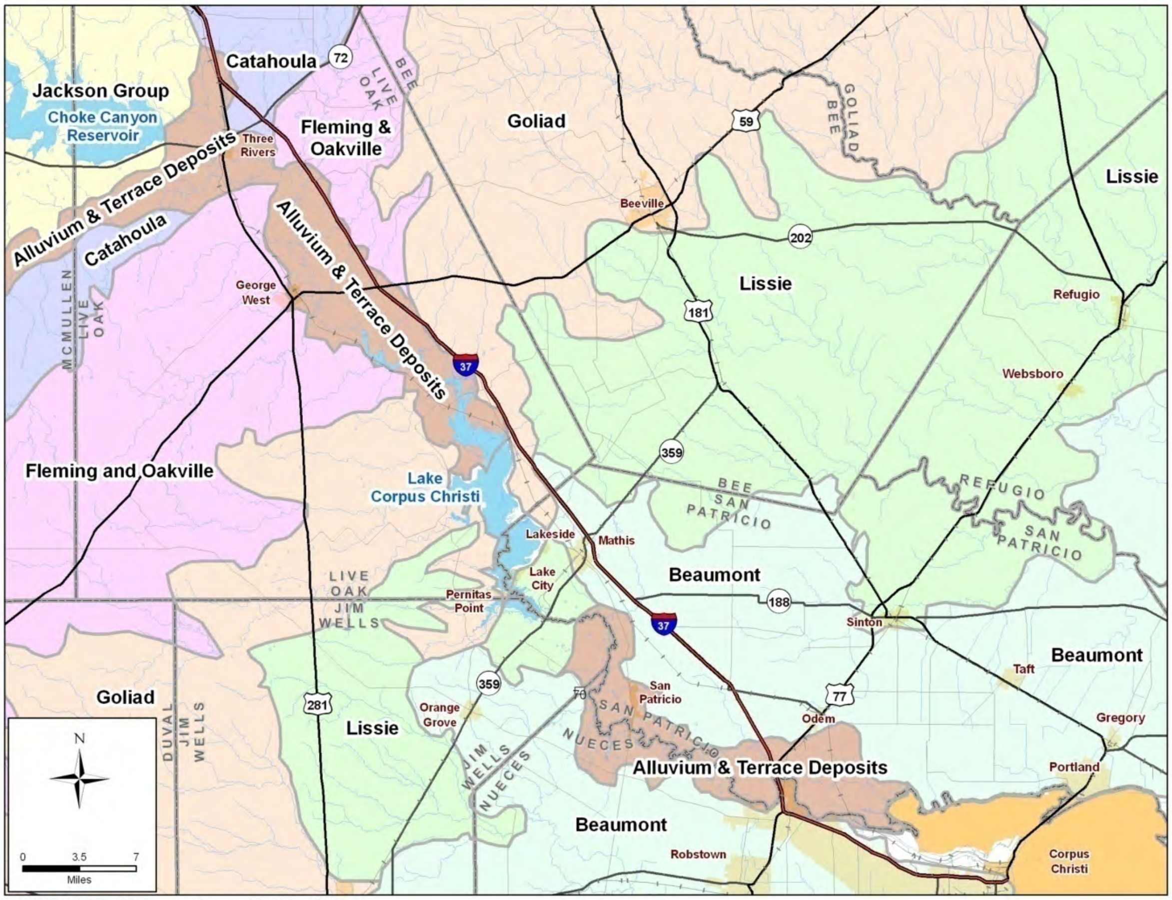

Figure 5D.3.10.
Generalized Land Surface Geology

Table 5D.3.3.
Stratigraphic Units and Lithology of Gulf Coast Sediments
(Units are from Youngest to Oldest)

Stratigraphic Unit	***Lithology***
Alluvium and Terrace Deposits	Clay, silt, sand and gravel
Beaumont Clay	Clay interbedded with sand
Lissie	Clay, sandy clay, sand, and gravel
Goliad Sand	Sand or sandstone interbedded with clay and gravel
Fleming and Oakville	Clay and sandstone
Catahoula	Clay, mudstone and sandstone
Jackson Group	Clay, shale and sandstone

The hydraulic potential for the movement of water between LCC and the Evangeline Aquifer is assessed by studying maps of the outcrop of the Goliad Sand and mapping groundwater levels of the Evangeline Aquifer in the vicinity of the lake. The approach in mapping the general direction of groundwater movement as they relate to LCC was to plot the water levels of Evangeline wells for a period prior to the enlargement of the lake and a relatively recent period. These data are intended to show the groundwater conditions before and after the lake was enlarged. Figure 5D.3.11 is a posting of water level data collected at wells screened in the Evangeline Aquifer that were collected thru 1958. If multiple data values were available, the most recent one was selected. As expected, the data show considerable scatter and irregularities in some local areas, which is attributed to data collected over a long period of time and wells with widely varying depths and construction. A mapping of the generalized groundwater flow pattern, as illustrated in Figure 5D.3.11, is generally toward the Nueces River and the coast. Figure 5D.3.12 is a posting of water level data collected at wells screened in the Evangeline Aquifer collected after 1970. If multiple data values were available, the earliest one was selected. As with the other water level map, the data also show considerable scatter and irregularities in some local areas. For a lake stage of about 90 ft, a mapping of the generalized groundwater flow pattern (illustrated in Figure 5D.3.12) is generally away from the lake and toward the coast. A line is shown on the map to generally indicate a divide along the lake that separates the gaining and losing sections for average lake conditions, which is considered to be 90 ft-msl. The flow pattern is generally in a southeast direction towards the coast. The data suggest that the seepage fans out over a large area rather than largely being returned to the Nueces River downstream of the lake. Inspection of the generalized land surface geology map (Figure 5D.3.10) shows the Beaumont Clay occurs along or underneath the lower Nueces River valley. This formation is above the Goliad Sands (Evangeline Aquifer) and below the alluvium and appears to greatly retard the migration of water from the Evangeline Aquifer to the Nueces River downstream of the lake. Of great significance, this map suggests that water from the lake does not generally go into bank storage during a rise in the stage for return to the lake during a lowering of the lake's stage. The concept of bank storage applies in many cases where a stream is incised in an alluvial fill valley. However, this concept does not appear to be applicable for LCC, which is supported by the seepage analysis in the previous section.

To better understand the impact of the filling of LCC and the periodic lowering and rising of the lake stage on groundwater levels, water level hydrographs were drawn for several wells in the surrounding area (Figure 5D.3.13). All of these water level hydrographs except for the well 7933501, which is about 10 miles west of Beeville and 15 miles north of the lake and considered to be upgradient of the lake, show some rise in water levels since 1958. In many of the wells, the water levels have risen 25-40 ft from about 1958 to the mid-1980s. Some of the rise, especially at the well 7958201 at Mathis, probably is attributed to a reduction in groundwater pumping. The rise in groundwater levels in the upper watershed areas suggest a partial hydrologic blockage of groundwater flow by the lake's relatively high water level, which has caused the historic flow pattern to be diverted toward the coast instead of toward the Nueces River where the lake now exists. It is of interest that wells (8408301, 8301605, 8301901, and 8309204, which are 10-20 miles south of the lake, show a strong recovery that appears to be attributed to the filling of LCC. The influences of other factors, such as increases in recharge and reduction in historic pumpage, are not known. Thus, one can't conclusively attribute the rise of these water levels to the filling of LCC.

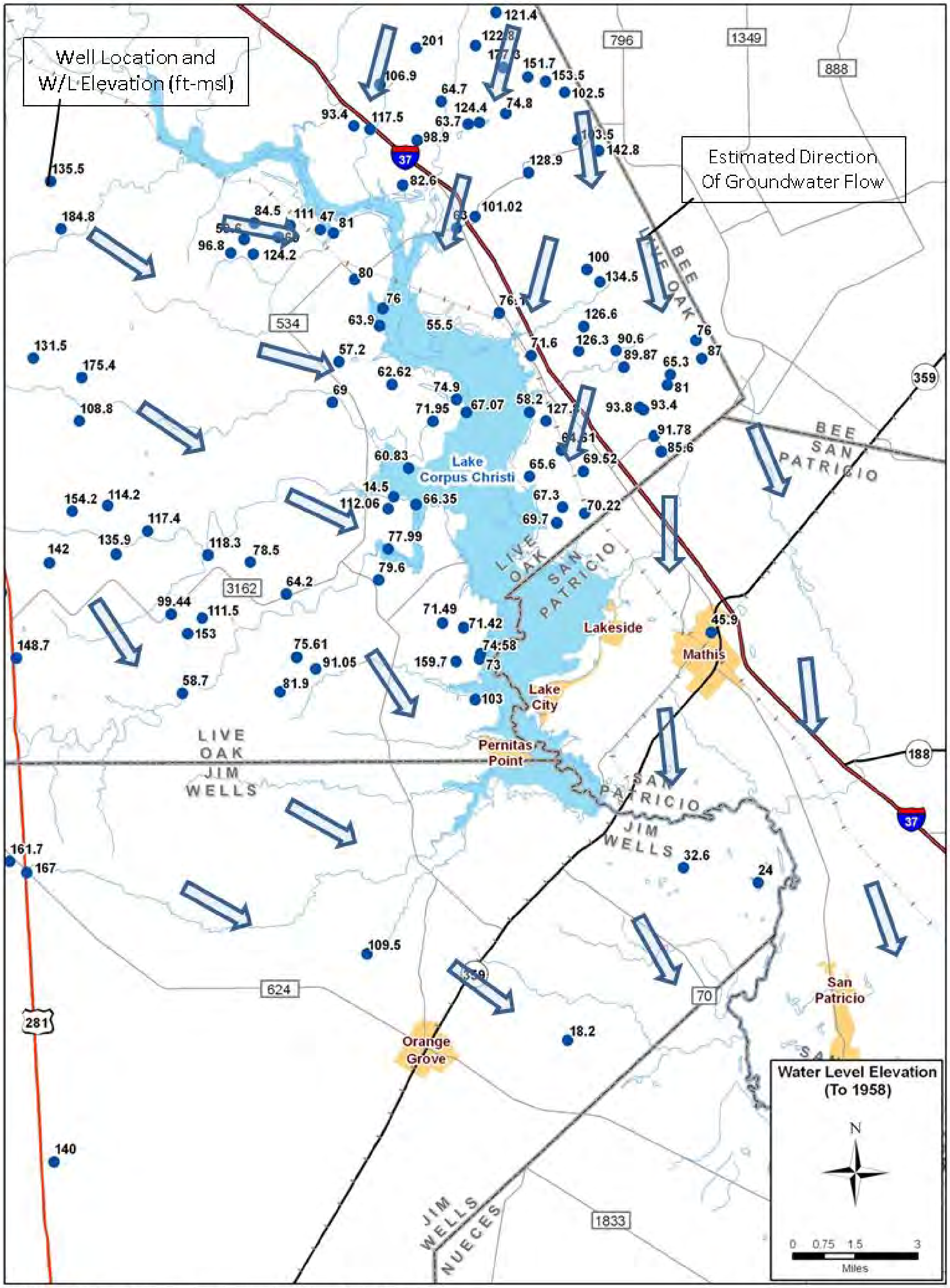

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Figure 5D.3.11.
Groundwater Levels in the Evangeline Aquifer Prior to 1958 with Generalized Groundwater Flow Patterns

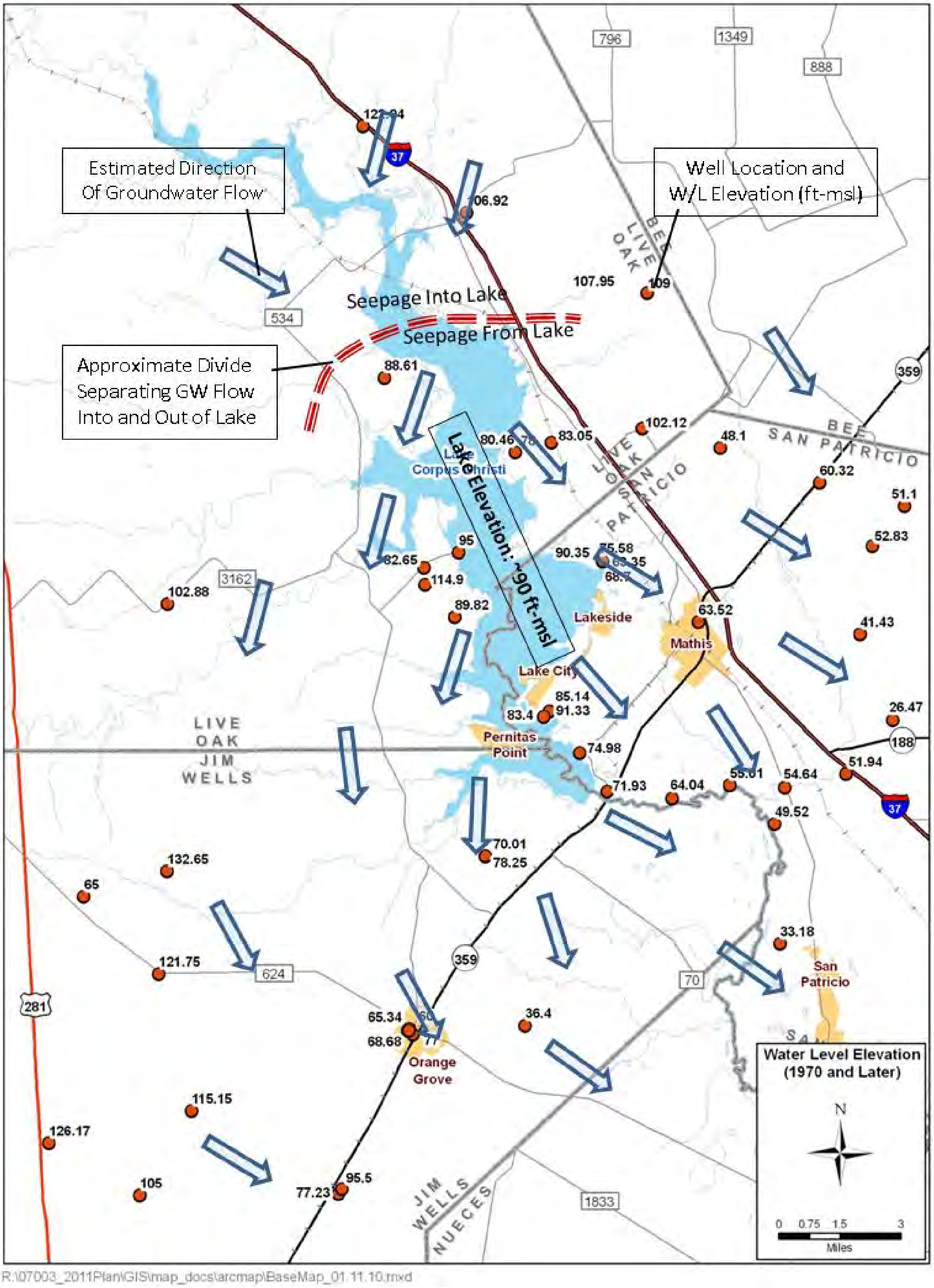

Figure 5D.3.12.
Groundwater Levels in the Evangeline Aquifer Since 1970 with Generalized Groundwater Flow Patterns

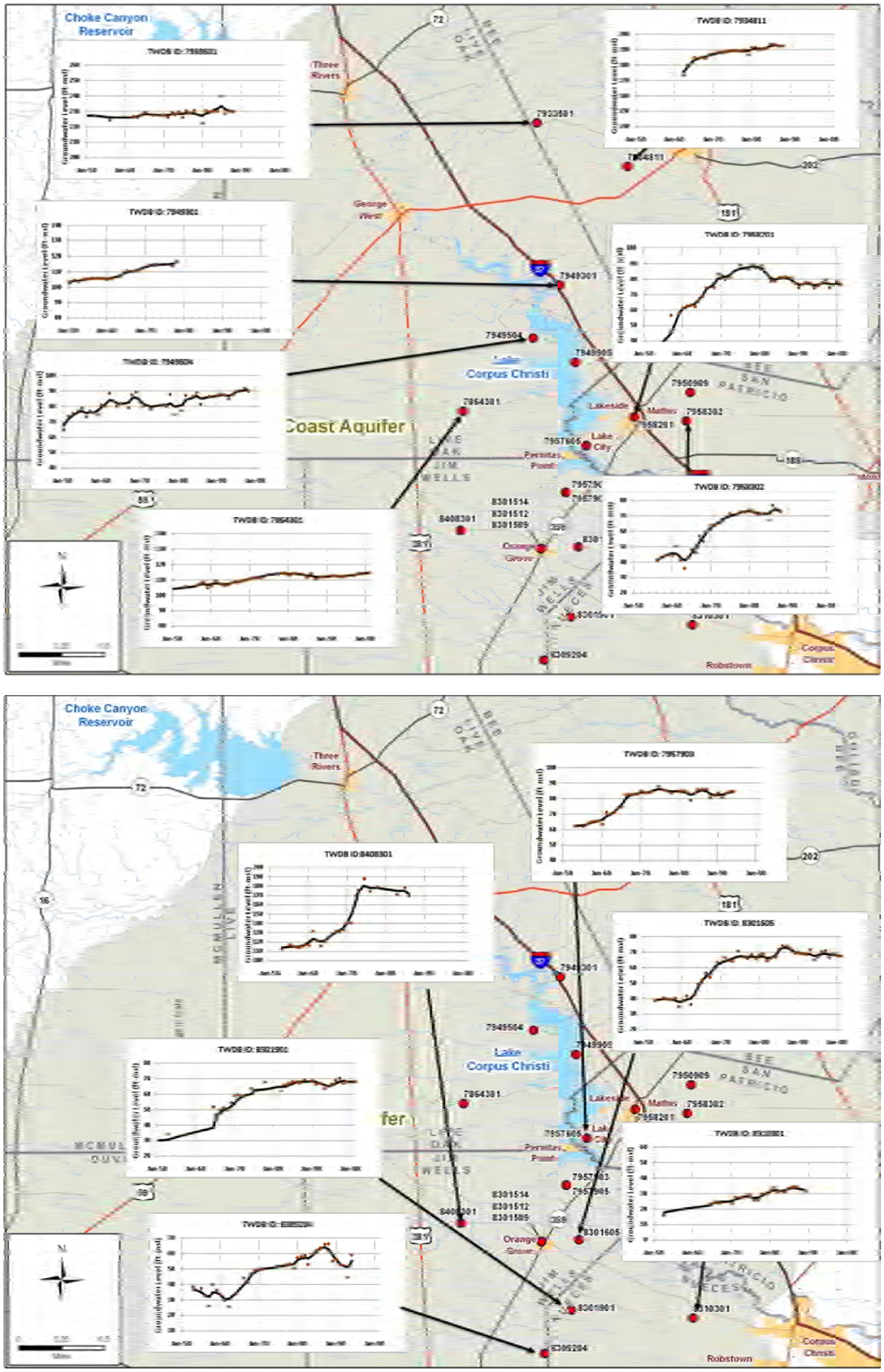

Figure 5D.3.13.
Groundwater Hydrographs for Selected Wells

Streamflow Gains and Losses in the Nueces River Downstream of Lake Corpus Christi

A study of the steamflow gains and losses was conducted between the USGS gages 08211000 Nueces River near Mathis and 08211200 Nueces River at Bluntzer and between the Bluntzer station and 08211500 Nueces River at Calallen (Figure 5D.3.2). A summary of streamflow and water quality data compiled during this study is presented in Table 5D.3.4. Water supply intakes are located in the Calallen Pool area, just upstream of the 08211500 Nueces River at Calallen gage as shown in Figure 5D.3.14. Although continuous water quality data from the Calallen Pool was provided from December 2003 to June 2009, daily water supply diversion data was provided for the period from January 2005 to July 2009. Suitable data for analysis for the upper subreach was from June 1992 through July 2009. For the lower subreach, the period was from January 2005 through July 2009. For this analysis, water supply diversions from the Calallen Pool were added to the USGS gaged record at the Calallen station. Other diversions, return flows and tributary inflows are assumed to be small and are not account for in the analysis.

The approach in calculating the streamflow gains and losses included: 1) advancing the flow record at the downstream station by one day to better match the timing of changes in streamflow between the two stations; 2) subtracting the upstream station's discharge from the downstream station's discharge (a positive values is a gain to the stream and a negative value is a loss from the stream); 3) filtering the outliers in the gain/loss results by removing the bottom and top ten percent; and 4) preparing a hydrograph of the gain/loss values and a scatter plot of the upstream station's discharge and the gains/losses.

Subreach from Mathis to Bluntzer

Hydrographs illustrating results of the streamflow gains and losses analysis are presented in Figure 5D.3.15. Overall, the chart shows the reach is occasionally gaining as much of 55 cfs and losing as much as 15 cfs. A statistical trendline analysis did not indicate any time trends during this period. A frequency distribution shows the subreach is gaining water slightly less than 80 percent of the time, with median gains of about 10 cfs. The average of the daily gains and losses show the average about a 11 cfs gain.

A scatter plot of the daily gain/loss results and the daily streamflow at the Mathis gage is presented in Figure 5D.3.16. From the major cluster of points, the chart indicates a greater gain at lower flows, and losses tending to occur at higher flows. This is conceptually consistent with the stream having a baseflow component during low flows (stream stage is low) and discharging water to the alluvial when the streamflows are high (stream stage is high).

Table 5D.3.4.
Summary of Available, Historical Water Quality Data from Lake Corpus Christi to Calallen

Data Collection Program	Measurement Frequency	Period of Record	Constituents Measured							Comments
			Flow	Cond.	Turbidity	Ca	Cl-	Hardness	Others	
City of Corpus Christi										
O.N. Stevens Intake	Monthly	1/1998- 10/2006; 8/2008- 3/2009		✓	✓	✓	✓	✓	✓	Fluoride & others
La Fruta to Calallen Dam (11 locations)	Bi-weekly	1/1995- 4/2007					✓		✓	Rainfall, DO
Lake Texana	Monthly	1/1999- 3/2009		✓	✓	✓	✓	✓	✓	
San Patricio Municipal Water District	Generally Bi-monthly; Weekly from 1/2007-3/2009	1/2001- 3/2009		✓		✓	✓	✓		Magnesium & others. Limited data in 2003-2005.
Celanese- Bishop Facility	Weekly	1/2006- 12/2008		✓	✓	✓	✓		✓	pH
Flint Hills Resources	Daily	12/2003- 6/2009		✓	✓			✓	✓	Alkalinity
TCEQ/ NRA Clean Rivers Program (Lower Nueces Basin)										
Nueces River at La Fruta Bridge (12965)	Quarterly	9/1977-Current		✓	✓		✓	✓	✓	
Nueces River at Bluntzer Bridge (12964)	Quarterly	9/1977-Current		✓	✓		✓	✓	✓	
Nueces River at Corpus Christi WTP (12963)	Quarterly	5/1977-12/1992		✓	✓		✓	✓	✓	
USGS/ City of Corpus Christi Gages (Lower Nueces Basin)										
Nueces River nr Mathis (8211000)	Real-time	9/1938- Current	✓							
Nueces River at Bluntzer (8211200)	Real-time	1/1966- Current (flow) 11/2008-Current (WQ)	✓	✓					✓	temp, pH, DO
Nueces River bl Hazel Bazemore Pk (08211450)	Real-time	11/2008- Current		✓					✓	temp, pH, DO
Nueces River at Calallen (8211500)	Real-time	10/1989- Current	✓							

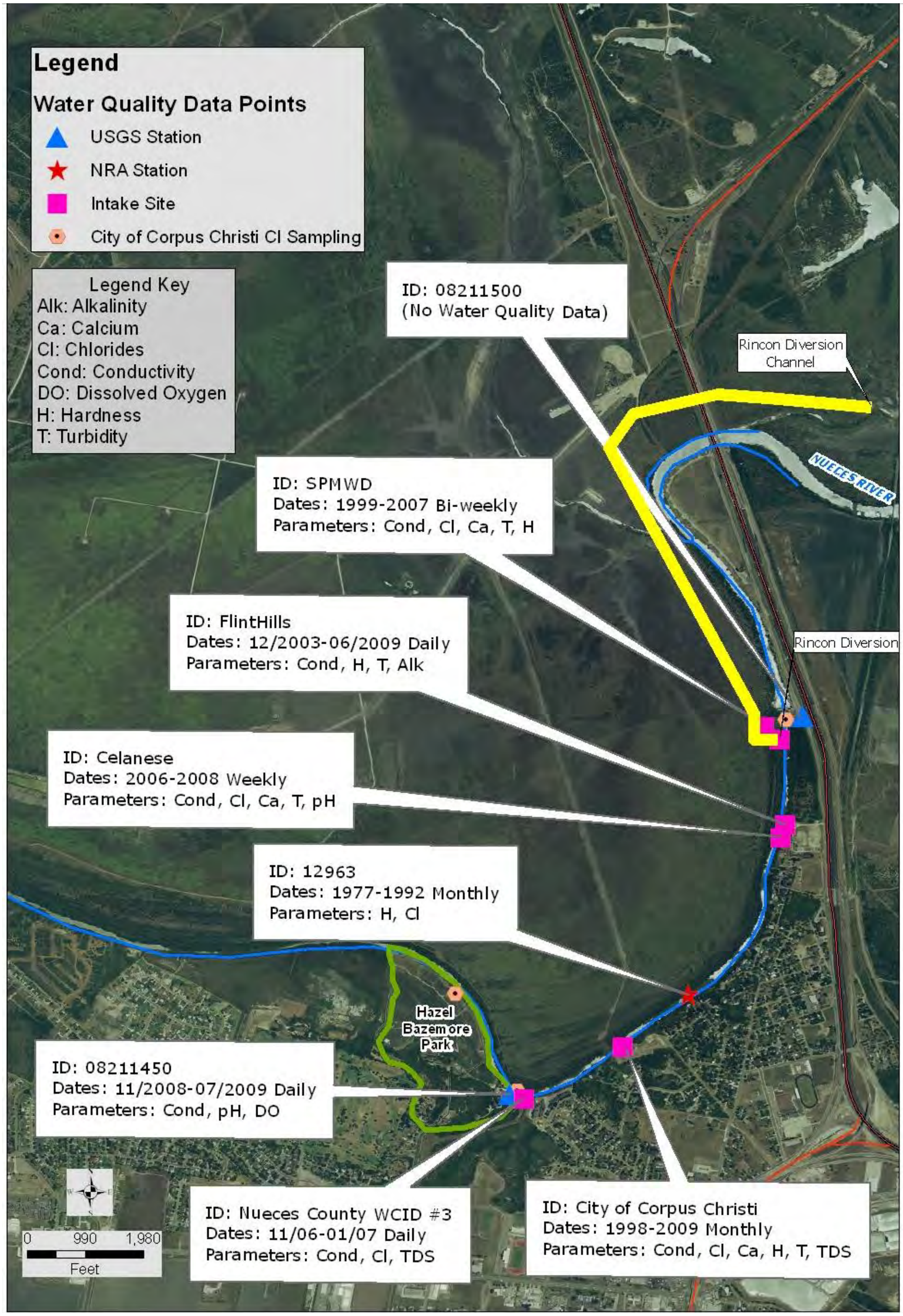

Figure 5D.3.14.
Water Quality Locations near Calallen Pool

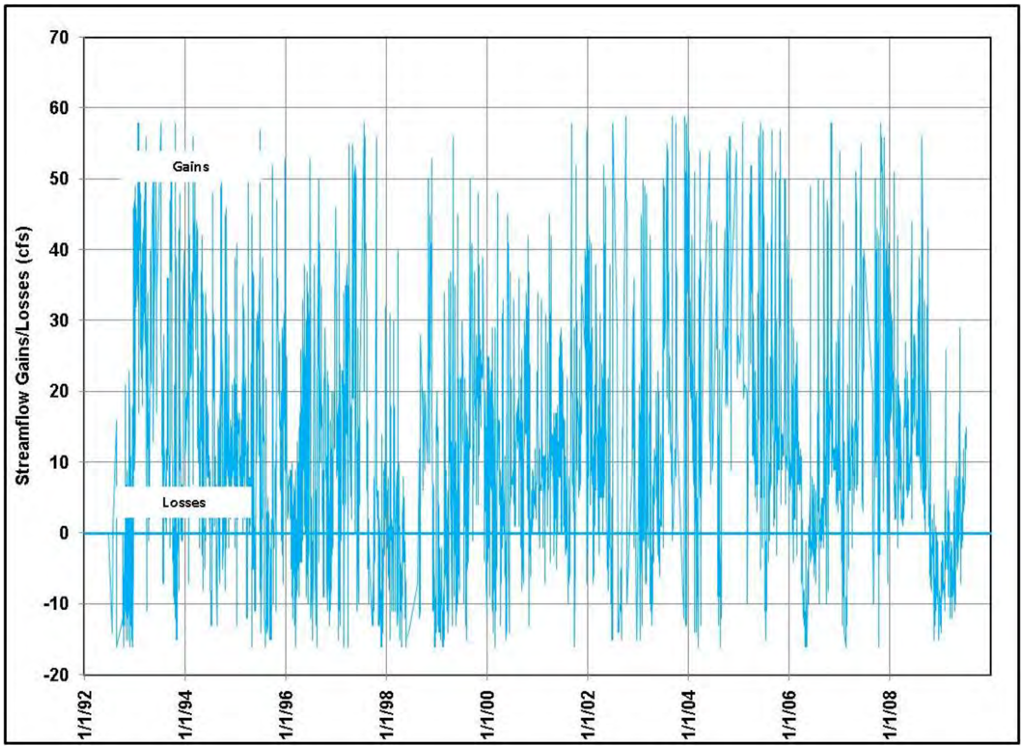

Figure 5D.3.15.
Streamflow Gains/Losses along Nueces River: Mathis to Bluntzer

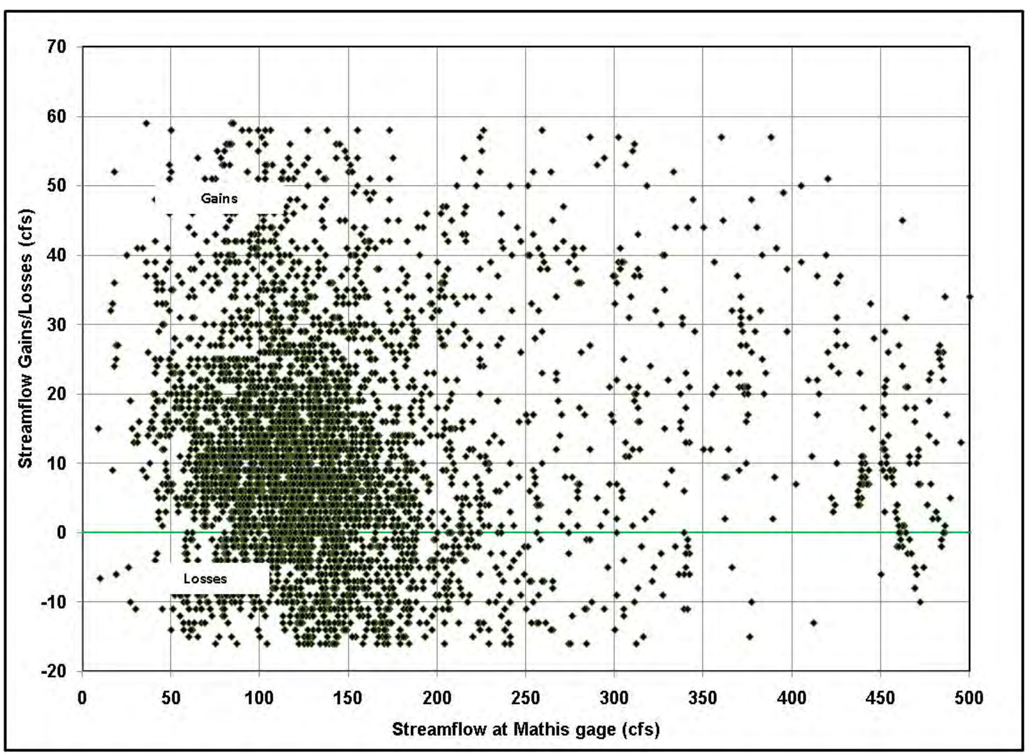

Figure 5D.3.16.
Correlation of Streamflow Gains/Losses along Nueces River between Mathis and Bluntzer with Streamflow at Mathis

Subreach from Bluntzer to Calallen

Hydrographs illustrating results of the streamflow gains and losses analysis for the subreach between Bluntzer and Calallen are presented in Figure 5D.3.17. Overall, the chart shows the reach is occasionally gaining as much of 40 cfs and losing as much as 75 cfs. A statistical trendline analysis indicated a slight trend of decreasing losses, however, results in 2009 suggest otherwise. This is a very short period for a trend analysis and probably is indicative of short-term rather than long-term hydrologic conditions. A frequency distribution shows the reach is losing water about 60 percent of the time, with the median being about a 5 cfs loss. The average of the gains and losses show the average to be about a 10 cfs loss.

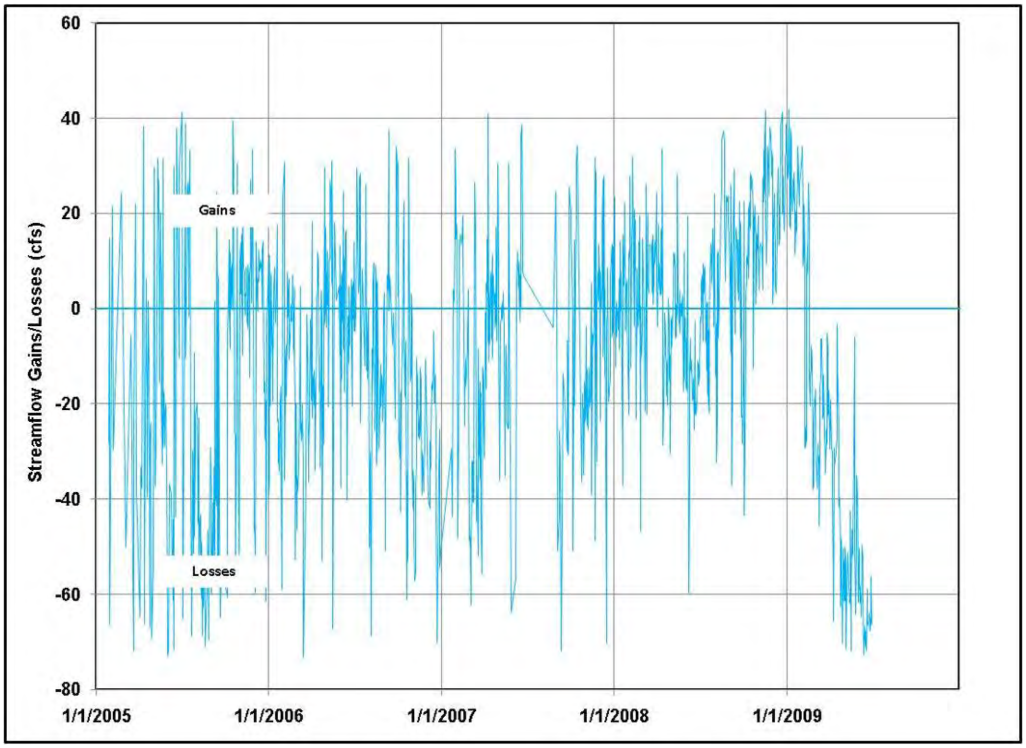

Figure 5D.3.17.
Streamflow Gains/Losses along Nueces River: Bluntzer to Calallen

A scatter plot showing the correlation of the daily gain/loss results and the daily streamflow at the Bluntzer gage is presented in Figure 5D.3.18. From the major cluster of points, the chart indicates a noticeable gain at lower flows and losses at higher flows. Again, this is conceptually consistent with the stream having a baseflow component during low flows (stream stage is low) and discharging water to the alluvial when the streamflows are high (stream stage is high). The greater losses in this reach than in the Mathis to Bluntzer reach may be partly attributed to Calallen Dam, which causes the stage of the Nueces River in the lower reach to be higher than native conditions. The cluster of points indicates stream gains tend to be about 30 cfs when the streamflow at Bluntzer is about 60 cfs. Thus, a substantial portion of the streamflow at Calallen is from the alluvium during low flow conditions.

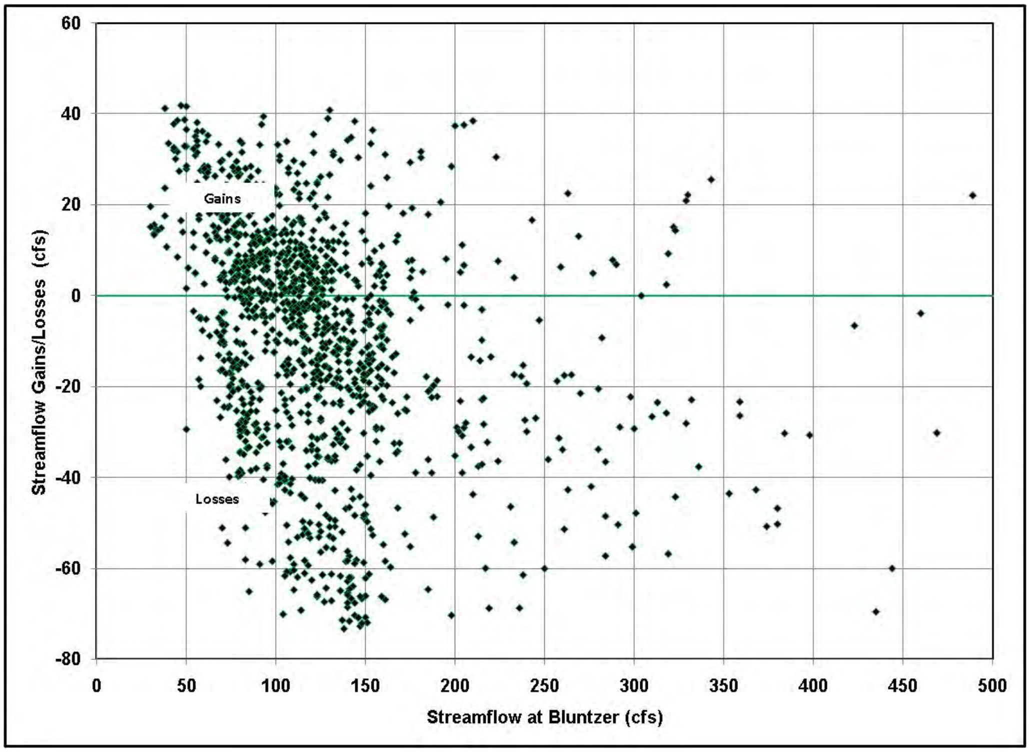

Figure 5D.3.18.
Correlation of Streamflow Gains/Losses along Nueces River between Bluntzer and Calallen with Streamflow at Bluntzer

Caution is warranted in considering the reliability and accuracy of these findings. USGS rates the accuracy of the stream discharge at Calallen to be 'poor' and records at Bluntzer as being 'good'. For this analysis, the multiple diversions from the Calallen Pool are added to the discharge at the Calallen station. This amplifies the question of overall accuracy of the streamflow data used in this analysis. The overall results are believed to be suitable for generalized analyses; however, individual values and conditions are questionable.

5D.3.3.3 Hydrologic Influences on Water Quality

A major use of the water from LCC and the Lower Nueces River is for municipal and industrial purposes. As a result, there is a great interest in not only having a sufficient supply during all times but to have water quality meet drinking water standards and be consistent over time. One of the long-term issues with water from the Calallen Pool is variable water quality, especially with regard to salinity (chloride concentrations) during the summer and periods of drought.

For LCC, the hydrologic influences on water quality are studied with regard to the inflow from the Nueces River and surface water/groundwater interaction. Other potential significant influences are stratification of the lake, especially in the deep section near the dam, and evaporation.

For the Nueces River downstream of LCC, the influences are a study of increasing and decreasing salinity between streamflow gaging stations. For purposes of this study, chloride concentrations are considered to be an index to other water quality parameters such as total dissolved solids.

Hydrologic Influences on Lake Corpus Christi

Inflow from the Nueces River

The approach used to study the influences of the Nueces River on the water quality in LCC is to prepare charts showing streamflow and chloride concentrations at the USGS Nueces River near Three River station (Figure 5D.3.19) over time. A study of the chloride data shows a major decrease in chloride concentrations in about 1988, which coincided with the filling of Choke Canyon Reservoir. An inspection of the Nueces River near Three Rivers hydrograph seems to suggest a reduction in the streamflow; however, a cumulative flow analysis did not indicate a noticeable shift in the long-term trends. A study of the correlation between chloride concentration and streamflow for the periods before the filling of Choke Canyon Reservoir showed a very large percentage of the high chloride concentrations occurred during low flow conditions (about 100 cfs), sometimes ranging up to over 800 mg/L. Overall, the average chloride concentration for all the samples between 1968 and 1987 was about 265 mg/L. Since the filling of the lake, the chloride concentrations during the low flow conditions were much lower and seldom greater than 200 mg/L, and having an average of about 65 mg/L for all samples.

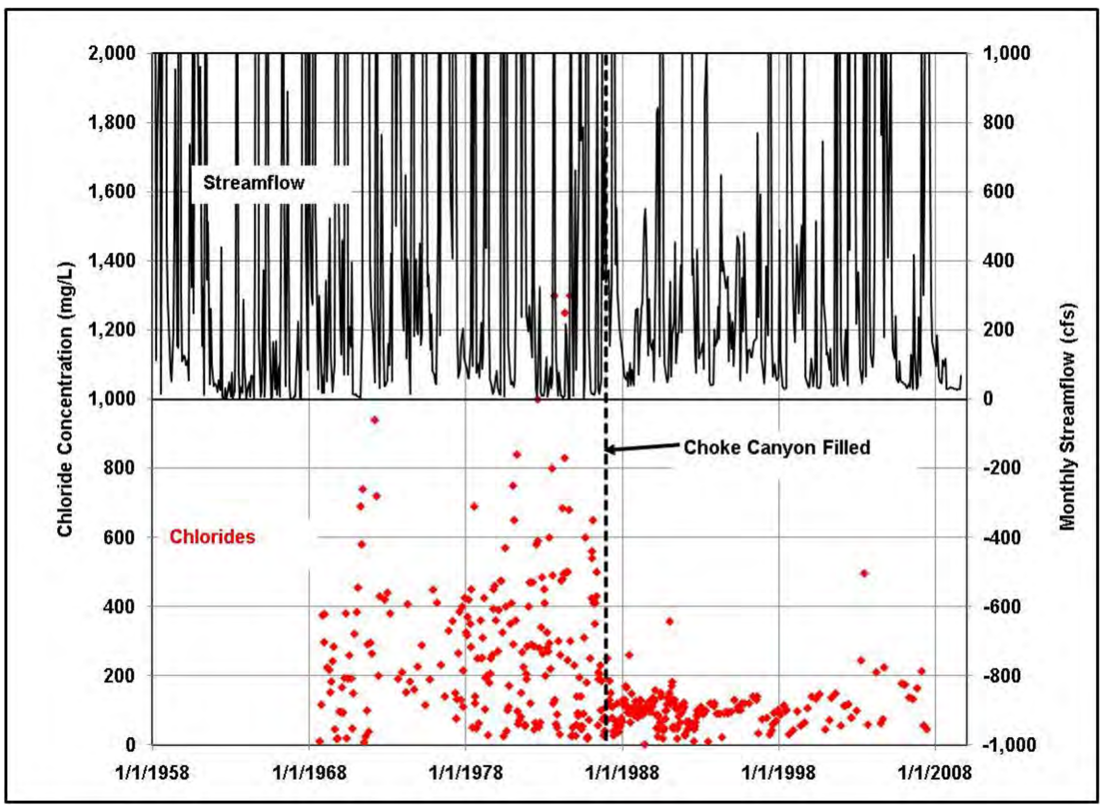

Figure 5D.3.19.
Streamflow and Chloride Concentrations at Nueces River near Three Rivers Station

During this time period, chloride and stage data from LCC were compiled and plotted in a manner similar to the Nueces River near Three River gage (Figure 5D.3.20). It is important to note that the chloride data used in this study was from samples that were collected at a TCEQ and Nueces River Authority sampling site near mid-dam (Station 12967).[4] This chart shows a tendency for chloride concentrations to be higher prior to the filling of Canyon Creek Reservoir than afterward, except for the 2005-2007 drought. This is mostly attributed to: 1) most all the inflow to Choke Canyon Lake is with flood waters having a very low chloride concentration; and 2) most all the samples prior to filling the lake were low to medium flow conditions. As a result, the samples from the Nueces River-Three Rivers station is mostly a blending of all flows, instead of the low and medium flows. Overall, these data and analyses show a pattern of gradually increasing chlorides during declining and low lake stages, and an abrupt lowering when the lake rapidly fills.

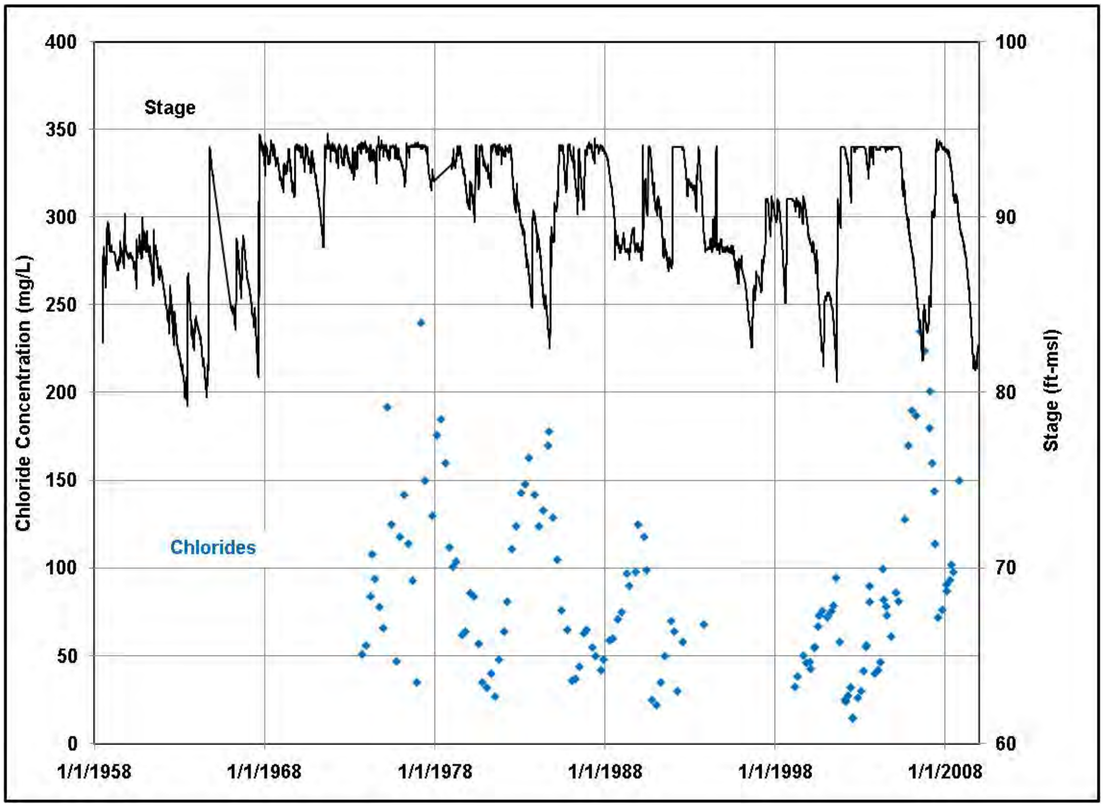

Figure 5D.3.20.
Lake Corpus Christi Stage and Chloride Concentrations near Water Surface at a Sampling Site near Dam

[4] Most of the water data is representative of water within the top 10 feet of LCC water level.

A comparison of the chloride concentrations and temporal patterns at the two sampling stations (Nueces River near Three Rivers Gage and TCEQ/NRA LCC near mid-dam station) is shown in Figure 5D.3.21. These data show and as stated earlier, especially since the filling of Choke Canyon Reservoir, that the chloride concentrations in LCC tend to follow the chloride concentrations at the Three Rivers station. This is especially noticeable during the droughts when the chloride concentrations are rising at both sampling stations and following flood conditions when the chloride concentrations are abruptly reduced. These chloride data suggest that the chlorides in the lake stay at or below the concentrations at the Three Rivers station.

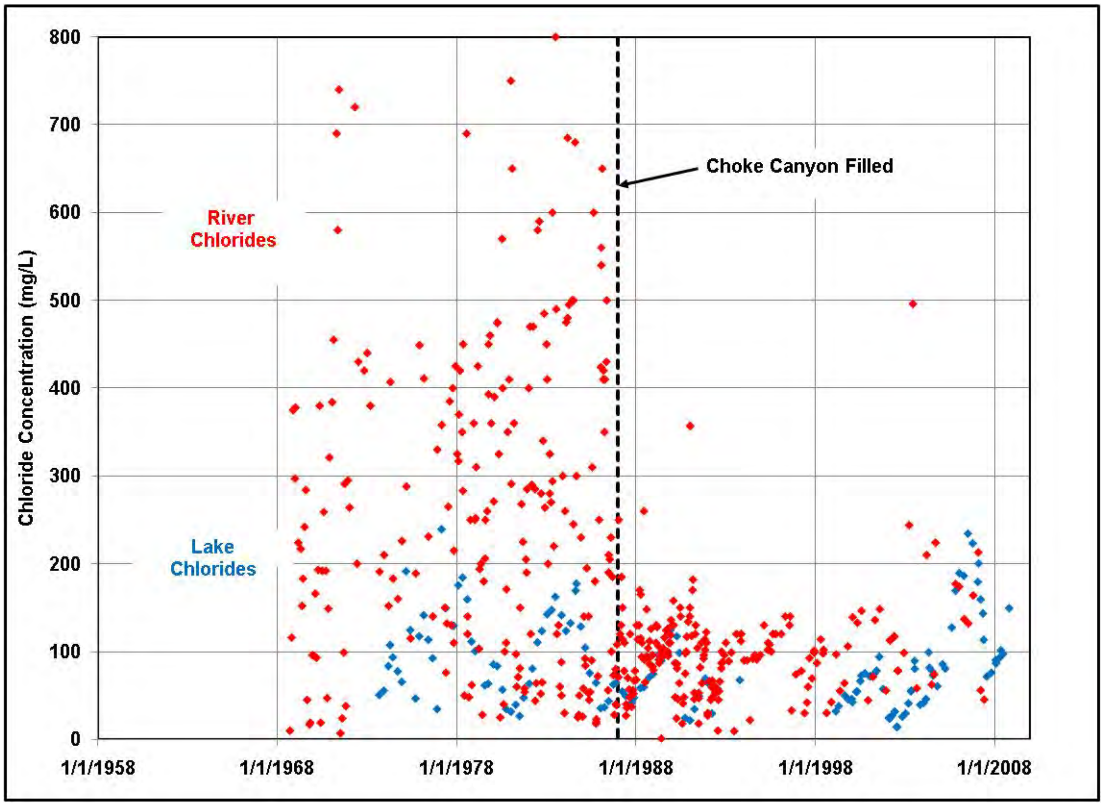

Figure 5D.3.21.
Chloride Concentrations at Nueces River: Three Rivers and Lake Corpus Christi

A comparison of chloride concentrations at TCEQ/NRA LCC mid-dam station and USGS Station 08211000 Nueces River at Mathis gage for water quality data collected from 1996 to 2006 shows an increase of chlorides for released water from LCC. As shown in Figure 5D.3.22, based on water quality data from 1996 to 2006, the median chloride levels at USGS Nueces River at Mathis Gage 08211000 during the period was 76 mg/L as compared to median chloride levels of 55 mg/L at the TCEQ/NRA Lake Corpus Christi station near the dam (or 40% increase). This is likely due to stratification of water in LCC, described in further detail in Chapter 5D.3.3.4.

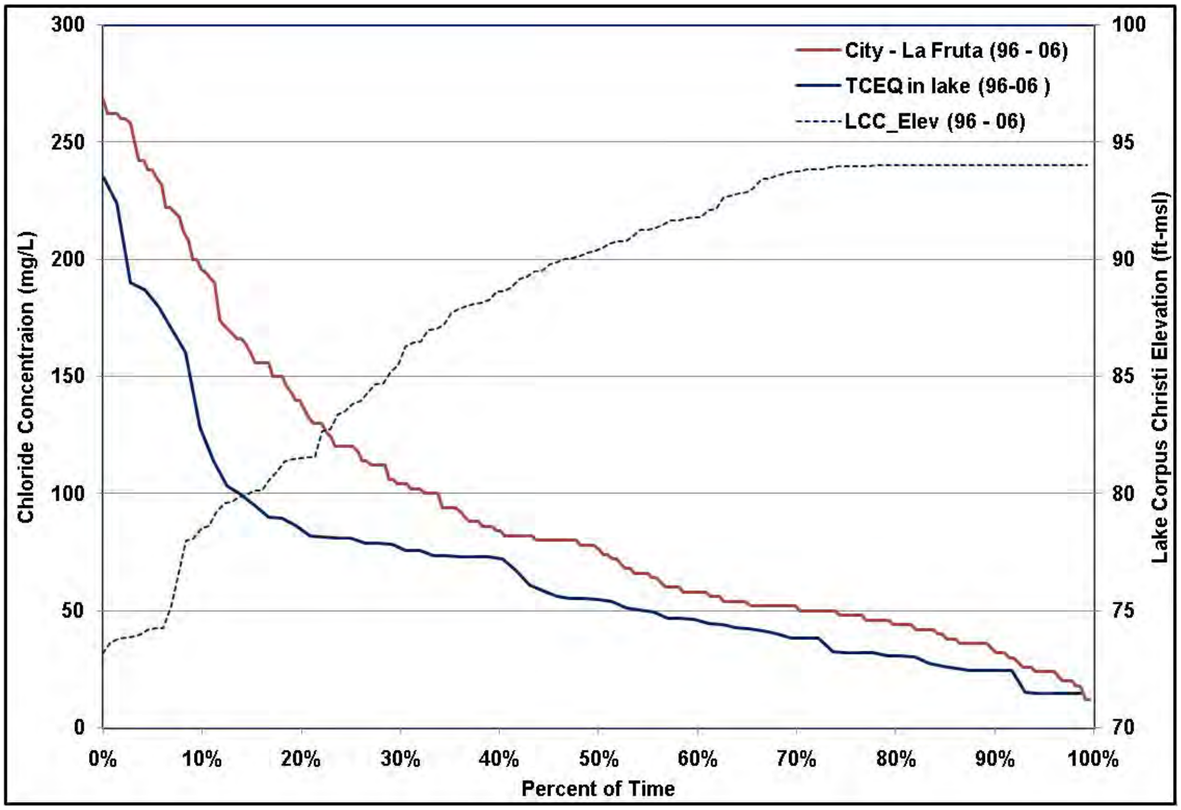

Figure 5D.3.22.
Comparison of Chloride Levels in LCC to Lower Nueces River near Mathis Gage Less than ½ Mile Downstream of LCC

Groundwater in the Evangeline Aquifer

A map showing the chloride concentrations of water samples from Evangeline Aquifer wells in the area surrounding LCC is presented in Figure 5D.3.23. In the vicinity of the lake, these data show substantial variations in the water quality. Some of this variation can be attributed to local variations in aquifer characteristics and well depths, and some possibly can be attributed to well construction and leakage from formations with poor quality of water. Overall, the chloride concentrations tend to range between 150 to 300 mg/L. These chloride concentrations are somewhat greater than the typical 25 to 100 mg/L concentrations in the lake since the filling of Choke Canyon Reservoir, except for the 2005-2007 drought. Of great importance, aquifer characteristics and groundwater hydraulics do not appear to be sufficient to cause substantial quantities of groundwater into the lake to substantially change the water quality of LCC.

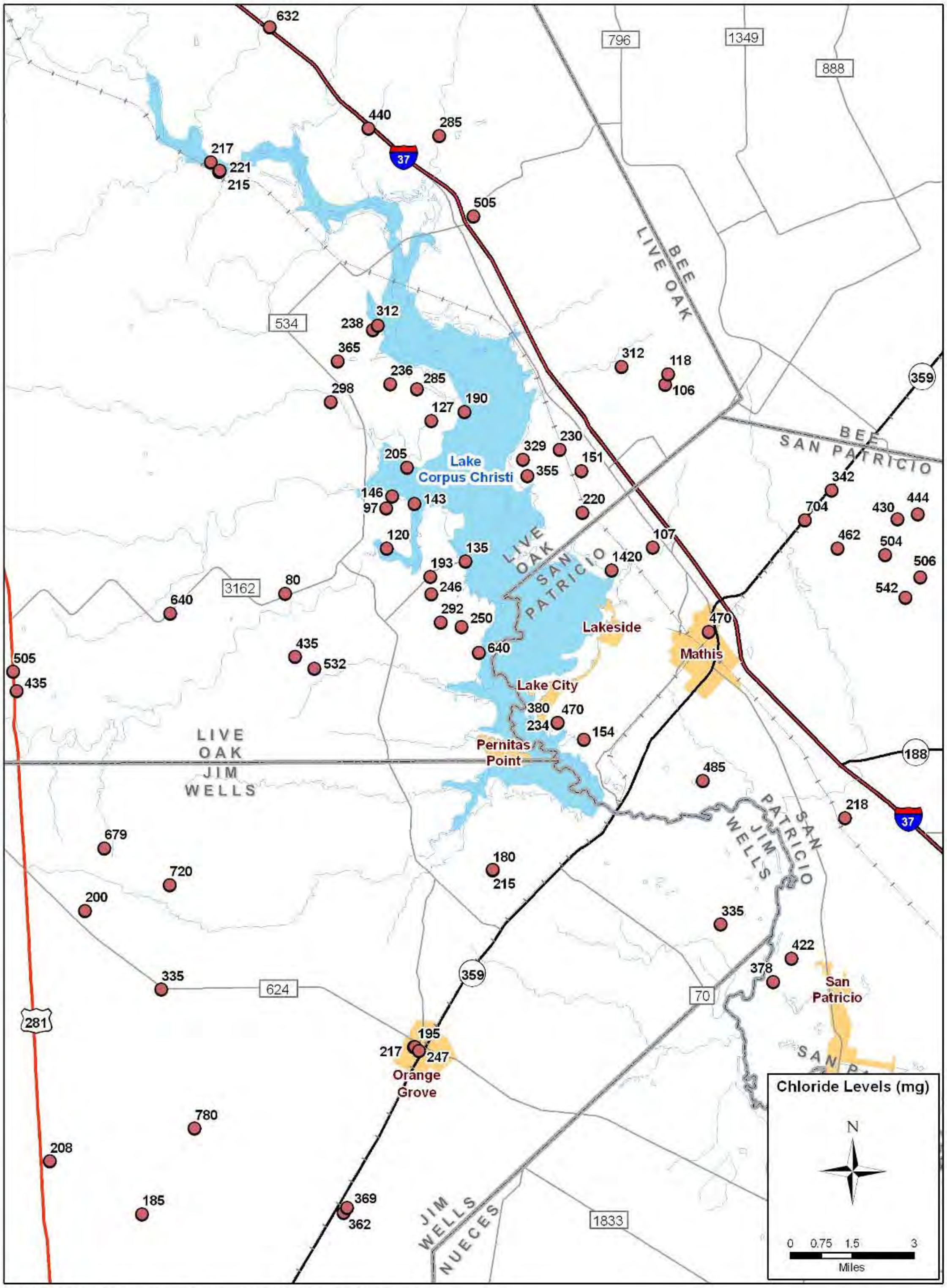

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Figure 5D.3.23.
Chloride Concentrations for Evangeline Aquifer Wells

Hydrologic Influences in Nueces River downstream of Lake Corpus Christi

The approach used to study the influences contributing to poor water quality water of the Nueces River includes calculating the change in the chloride concentrations for samples collected on the same day (a positive value is a stream gain in chlorides and a negative value is a loss of chlorides from the stream and: 1) plotting a timeline of chloride *gains/losses along with the streamflow*; 2) preparing a scatter plot of the correlation of chloride gains/losses against streamflow; 3) plotting a timeline of *chloride gains/losses and streamflow gains/losses*; and 4) preparing a scatter plot of the correlation of *chloride gains/losses against streamflow gains/losses*. The scatter plots are particularly useful to attempting to correlate trends in chloride gains/losses with streamflow and streamflow gains/losses.

The data set for the Mathis to Bluntzer and Bluntzer to Calallen Pool reaches are from January 1996 to April 2007 and January 2005 to December 2007, respectively, based on readily available water quality data. The USGS Station 08211200 Nueces River at Bluntzer began recording real-time water quality data in November 2008. This analysis uses water sampling data collected by the City of Corpus Christi at Mathis and Bluntzer. Typically, water samples were collected twice a month. The selected sampling site for the Calallen Pool station is Hazel-Bazemore based on data provided by the City of Corpus Christi.

Subreach from Mathis to Bluntzer

The first analysis considered the relation of gain/losses of chlorides and streamflow in the subreach. A timeline of this relation is shown in Figure 5D.3.24. A correlation of the two parameters is shown in Figure 5D.3.25.

The timeline chart indicates a little or no trends over time, however, it does illustrate relatively higher gains in chlorides (greater than 50 mg/L) from 2002-2004. During this period, the streamflow generally appears to be slightly lower than earlier and later periods. Intermediate high flow event during the 2002-2004 period only temporarily lower the gains in chlorides.

The correlation chart shows most of the streamflow is between 50 and 160 cfs and gains in chlorides mostly range from 0 to 100 mg/L. Inspection of the scatter plot suggests that chlorides slightly decrease with higher flow; however, this relationship is weak.

The second analysis considered the relation of *gain/losses of chlorides and streamflow gains/losses* in the reach, which were calculated in a previous section. A timeline of this relation is shown in Figure 5D.3.26. A correlation of the two parameters is shown in Figure 5D.3.27.

As previously noted, the timeline chart of gains/losses of chlorides and gains/losses of stream-flow shows an irregular pattern from 2002-2004, when the chloride gains tend to be elevated. During this period, the streamflow gains also seem to be slightly higher than earlier and later periods. Overall from 1996-2007, there does not seem to be a time trend of gaining or losing chlorides or streamflow.

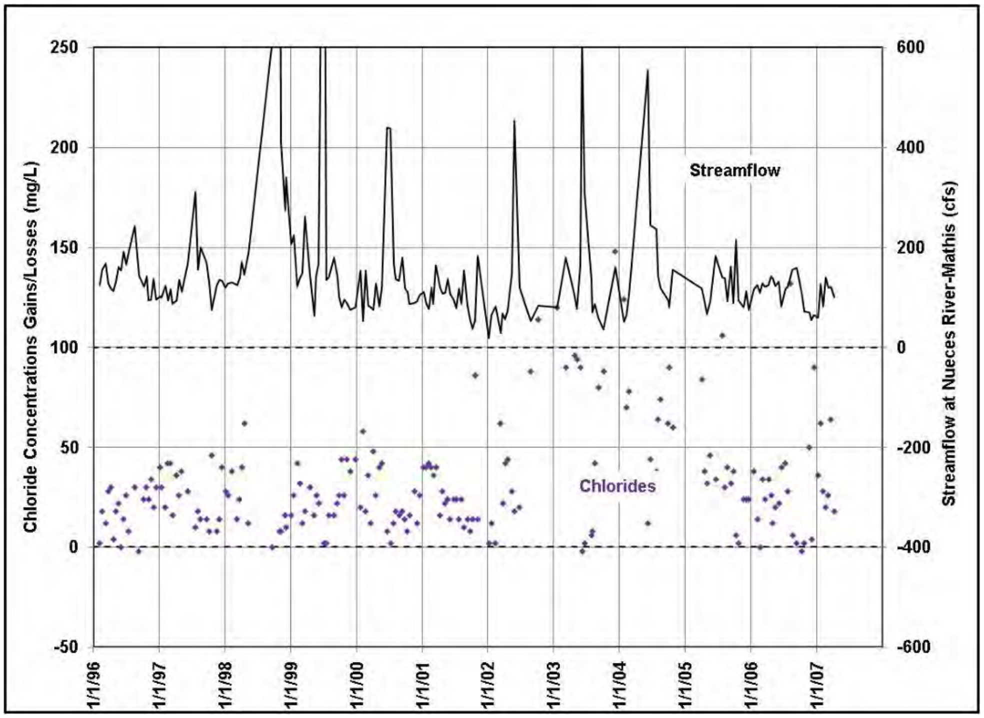

Figure 5D.3.24.
Chlorides Gains/Losses and Streamflow along Nueces River: Mathis to Bluntzer

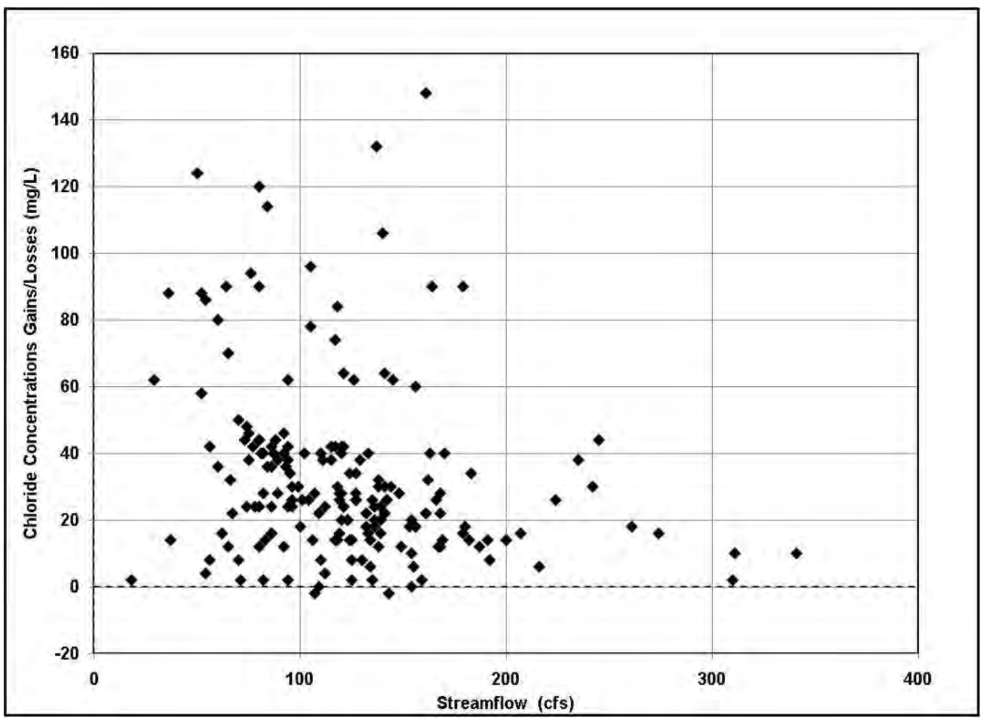

Figure 5D.3.25.
Correlation of Gains/Losses of Chlorides and Streamflow along Nueces River: Mathis to Bluntzer

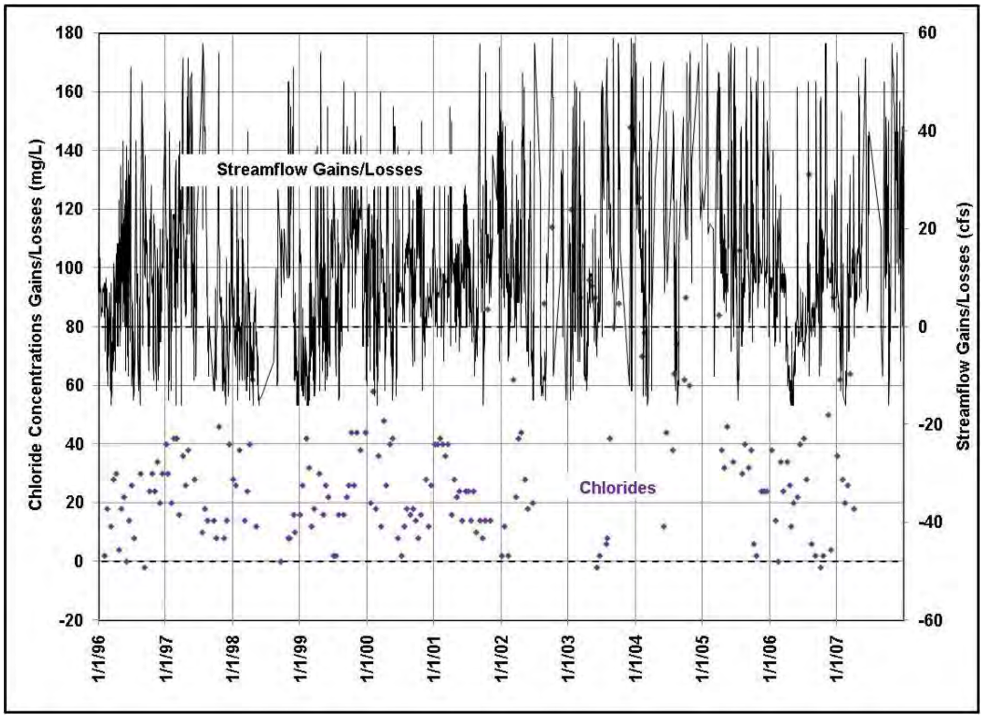

Figure 5D.3.26.
Chlorides Gains/Losses and Streamflow Gains/Losses along Nueces River: Mathis to Bluntzer

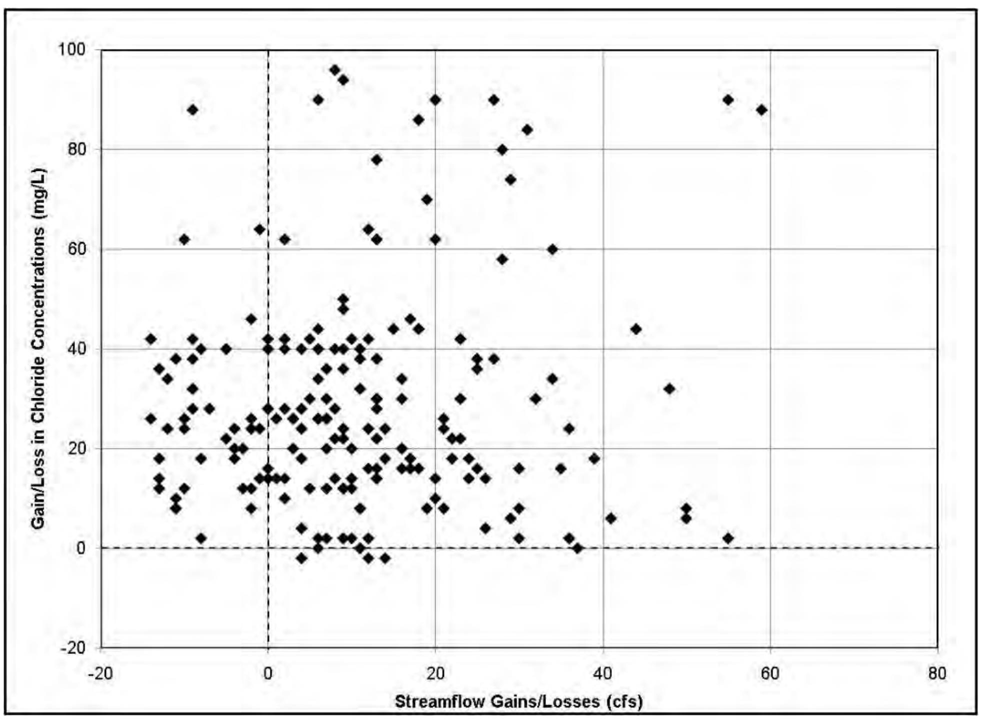

Figure 5D.3.27.
Correlation of Chloride Gains/Losses and Streamflow Gains/Losses along Nueces River: Mathis to Bluntzer

The correlation chart shows most of the streamflow gains/losses from Mathis to Bluntzer tends to range between a 5 cfs loss to a 30 cfs gain and chlorides tend to gain in concentrations up to 50 mg/L. Further study of these results show the stream is gaining about 80 percent of the time. Overall, an inspection of the chart suggests that the gains in chlorides slightly increases with higher streamflow gains; however, the confidence in this relationship is weak. These results support a concept of increasing chlorides in this reach is related to an increase in groundwater inflow into the reach. However, there are some occurrences where there is a gain in chlorides yet the stream is showing a loss of water. A possible explanation is that one subreach is gaining streamflow from groundwater and another subreach is losing streamflow to groundwater at a rate greater than the gains. Another possible explanation is that a tributary is discharging saline water into the river.

Subreach from Bluntzer to Calallen

The analysis for this reach uses the same approach as the Mathis to Bluntzer reach. The first analysis considered the relation of in the subreach. A timeline of gain/losses of chlorides and streamflow is shown in Figure 5D.3.28. A correlation of the two parameters is shown in Figure 5D.3.29.

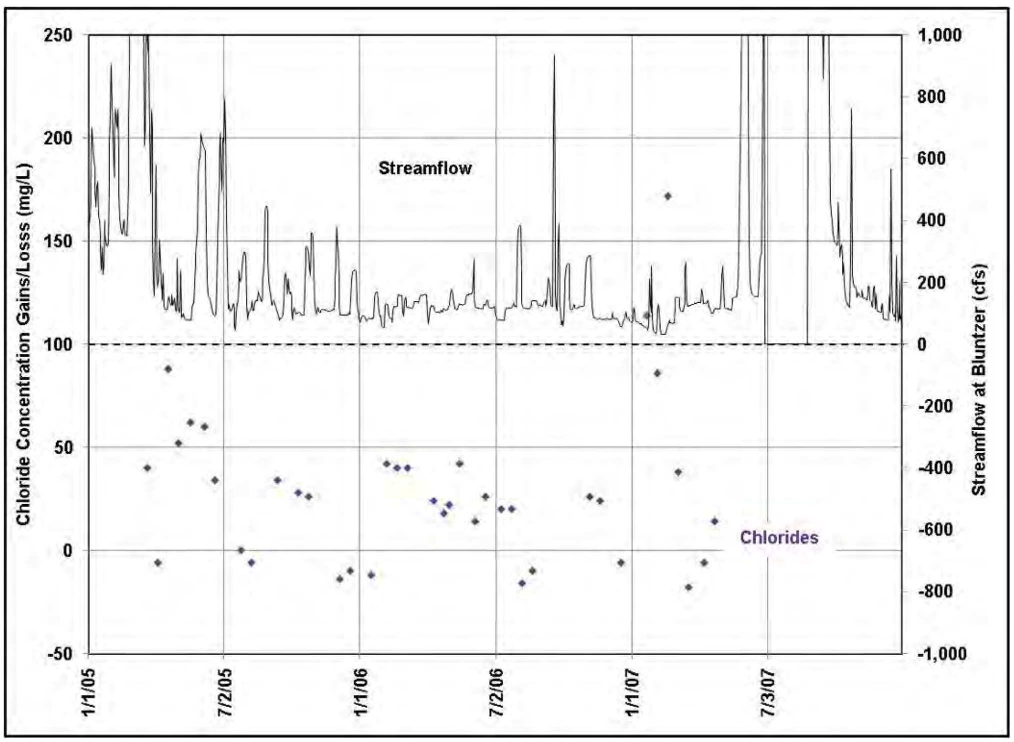

Figure 5D.3.28.
Chlorides Gains/Losses and Streamflow along Nueces River: Bluntzer to Calallen

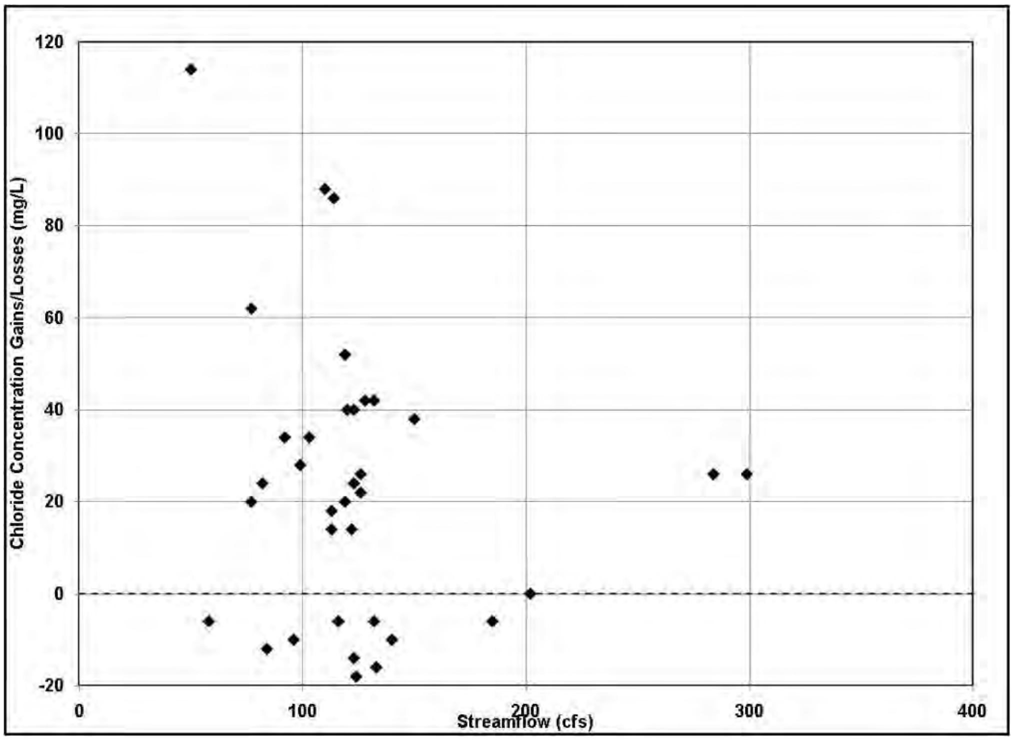

Figure 5D.3.29.
Correlation of Gains/Losses of Chlorides and Streamflow along Nueces River: Bluntzer to Calallen

The timeline chart of *gains/losses of chlorides and of streamflow* shows an irregular pattern of chlorides during the spring and early summer of 2005 and another one in the winter of 2007. During the period of available chloride data, the streamflow at the Bluntzer station was relatively uniform, but included two high flow events in late 2005, which noticeably lowered the gains in chlorides. Overall, the chloride gains/losses are relatively uniform and do not show a time trend for this relatively short period.

The correlation chart of chloride gains/losses and streamflow shows that most of the water samples were collected when streamflow ranged between 50 and 150 cfs at Bluntzer. During this time the concentration of chlorides tended to range from a loss of 5 mg/L to a gain of about 50 mg/L. This limited data set did not show a noticeable chloride gains/losses relation with streamflow. This correlation may not hold when more data become available with high flow conditions.

The second analysis is the relation between *chloride gains/losses and streamflow gains/losses*. A timeline of gain/losses of chlorides and streamflow is shown in Figure 5D.3.30. A correlation of the two parameters is shown in Figure 5D.3.31.

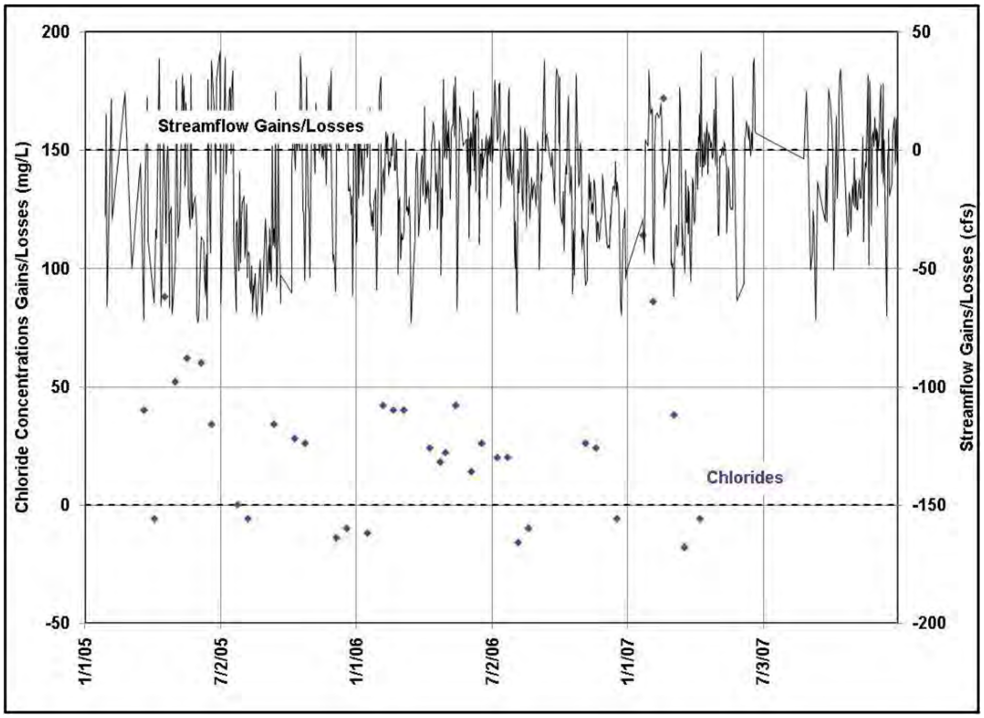

Figure 5D.3.30.
Chlorides Gains/Losses and Streamflow Gains/Losses along Nueces River: Bluntzer to Calallen

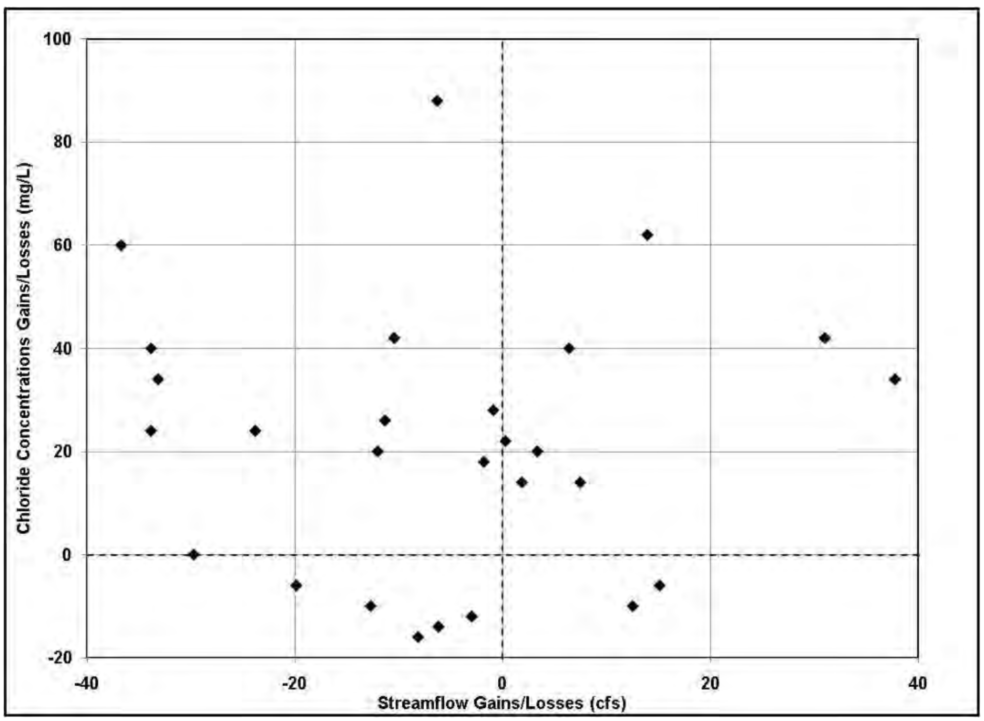

Figure 5D.3.31.
Correlation of Chloride Gains/Losses and Streamflow Gains/Losses along Nueces River: Bluntzer to Calallen

The timeline chart of gains/losses of chlorides and gains/losses of streamflow shows essentially no trend, but has a somewhat irregular pattern of chlorides during the spring and early summer of 2005 and another one in the winter of 2007 and a period of unusually high streamflow losses during the late summer of 2005. This was previously noted.

The correlation chart of chloride gains/losses and streamflow gains/losses shows that most of the water samples were collected when streamflow gains/losses usually ranged between losing about 35 cfs to gaining about 18 cfs. The analysis does not show a relationship that would suggest a change in chloride gains/losses in response to changes in streamflow gains/losses. The reasons for the occurrence of increases in chlorides while the stream is losing water are not clear. A possibly explanation is that a subreach is gaining streamflow from groundwater or tributary and another subreach is losing streamflow to groundwater at a rate greater than the gains. Another is the potential inaccuracies of the streamflow data. As stated earlier, the USGS rates the accuracy of the stream discharge at Calallen to be 'poor' and records at Bluntzer as being 'good'. For this analysis, the multiple diversions from the Calallen Pool are added to the discharge at the Calallen station. This amplifies the lack of overall confidence in the accuracy of the streamflow data used in this analysis. The overall results are believed to be suitable for analyses; however, individual values may be questionable. Finally, the analysis did not consider a travel time for the chloride concentrations, which may be several days between the Bluntzer and Calallen stations during low flow conditions.

5D.3.3.4 Suggested Studies to Refine Water Management Models in the Lower Nueces River Basin

During Phase I development of the 2011 Plan, the Corpus Christi Water Supply Model was updated to include a water quality component as summarized in Chapter 11. The calibrated model closely approximated water quality statistics derived from measured values for 25th to 75th percentile conditions, but deviated for less frequent and likely extreme hydrologic conditions (that occurred 10 to 20% of the time). One potential explanation for deviations of calculated salinity in the Lower Nueces River Basin Bay and Estuary Model and the Corpus Christi Water Supply Model from measured results is an assumption of water in LCC being fully blended. In reality, there is a great possibility of water in the lake becoming stratified during certain times. Potential stratification could cause water released from LCC's Wesley Seale Dam to have different chloride levels than measured chloride levels in stored water in LCC near the water level surface (Figure 5D.3.22).

The most likely times are when the more saline would develop on the surface from evaporation would settle to the bottom of the lake because it is more dense. This is most likely to occur near the dam where the lake is the deepest. A temperature inversion commonly occurs in the fall and winter when the shallow water is cooled and migrates to the bottom due to differences in water density. Possibly the condensing of the shallow water during the summer from evaporation and the cooling of the water could enhance the inversion of shallow water and deep water, which would cause the salinity of water near the bottom of the lake to be higher than the average for the lake. A data collection program is planned for the winter, spring and summer of 2010 to document if does or does not occur. Plans are use a portable water quality monitoring probe (temperature and specific conductivity) to measure these parameters at about 3-foot intervals. The sampling site is near the lake's discharge outlet. Of great interest, the opening for the discharge structure is within a few feet of the bottom of the lake.

Other suggested studies to improve the understanding of the variations in salinity in the Lower Nueces River Basin include:

- Assessment of the influence of evaporation on increasing the salinity in LCC, especially during drought conditions.
- Preparation of a mass balance model (water and salinity) of Lake Corpus for the flux of water and salt. The suggested time periods for the mass balance study are when the lake and hydrologic conditions area rather stable and would include high and low conditions.
- Preparation of a water balance model for the Nueces River downstream of LCC. This would be for the period stable conditions and when suitable streamflow and water quality records are available.
- After the completion of the water balance model for the Nueces River downstream of LCC, prepare a mass balance model to account for the salinity conditions.
- Hydrogeologic studies in the vicinity of the Nueces River downstream of LCC to define the hydraulics for surface water/groundwater interaction and the quality of groundwater near the river.
- Development of a groundwater model in the region from Three Rivers to Calallen and centered along the Nueces River. Its initial application would be to better define the factors that control surface water/groundwater interaction and the movement of seepage from LCC during various lake stages.

5D.3.4 Projected Water Needs (Shortages) for Manufacturing Users During 2020 to 2070 Planning Period

There are two counties in the Coastal Bend Region with projected manufacturing water needs: Nueces, and San Patricio Counties. Nueces and San Patricio County manufacturers receive a small supply of groundwater, both the majority is surface water provided from the CCR/LCC System. Since CCR/LCC System demands exceed supply, non-municipal water users have projected shortages. Nueces County manufacturers see projected shortages beginning in 2050 (1,905 ac-ft) and continuing to 2070 (19,603 ac-ft). San Patricio County manufacturers see projected shortages beginning in 2030 (2,553 ac-ft) and continuing to 2070 (19,764 ac-ft). A maximum shortage of 36,367 ac-ft for manufacturing water users is projected for the entire Coastal Bend Region in 2070.

TWDB Rules for regional water planning require RWPGs to consider water conservation and drought management measures for each water user group with a need (projected water shortage). The Task Force report lists the following industrial BMPs that may be used to achieve water savings[5]:

[5] Water Conservation Implementation Task Force, Report to the 79th Legislature, Texas Water Development Board,

1. Industrial Water Audit
2. Industrial Water Waste Reduction
3. Industrial Submetering
4. Cooling Towers
5. Cooling Systems (other than Cooling Towers)
6. Industrial Alternative Sources and Reuse and Recirculation of Process Water
7. Rinsing/Cleaning
8. Water Treatment
9. Boiler and Steam Systems
10. Refrigeration (including Chilled Water)
11. Once-Through Cooling
12. Management and Employee Programs
13. Industrial Landscape
14. Industrial Site Specific Conservation

The Task Force report describes the above BMP methods and how they reduce water use; however, information regarding specific water savings and costs to implement conservation programs is generally unavailable. Conservation savings and costs are by nature facility specific. Since manufacturing entities are presented on a county basis and are not individually identified, identification of specific water management strategies are not a reasonable expectation.

The CBRWPG recommends enhancing water quality to reduce manufacturing water use.

5D.3.5 Summary of Manufacturing Water Use Savings Alternatives

Water supply intakes in the Calallen Pool receive Lake Corpus Christi water via the ‘bed and banks’ of the Nueces River. The purpose of this section is to evaluate options to improve the quality of the water entering the water supply intakes. The following control strategies are considered:

- Blending of Lake Texana Water with Nueces River Water
- Outlet Works to Remove High TDS Water from the Calallen Pool
- Modification of Existing Intakes
- Pipeline from Lake Corpus Christi to the O.N. Stevens WTP
- Plugging Leaky and Abandoned Oil Wells

The potential for manufacturing water use savings is based on the reduction in chloride concentration of the water supply achieved by each option. Figure 5D.3.32 shows the estimated industrial cooling water usage savings for various levels of water quality improvement. These estimates are based on correspondence with local industries and other sources.

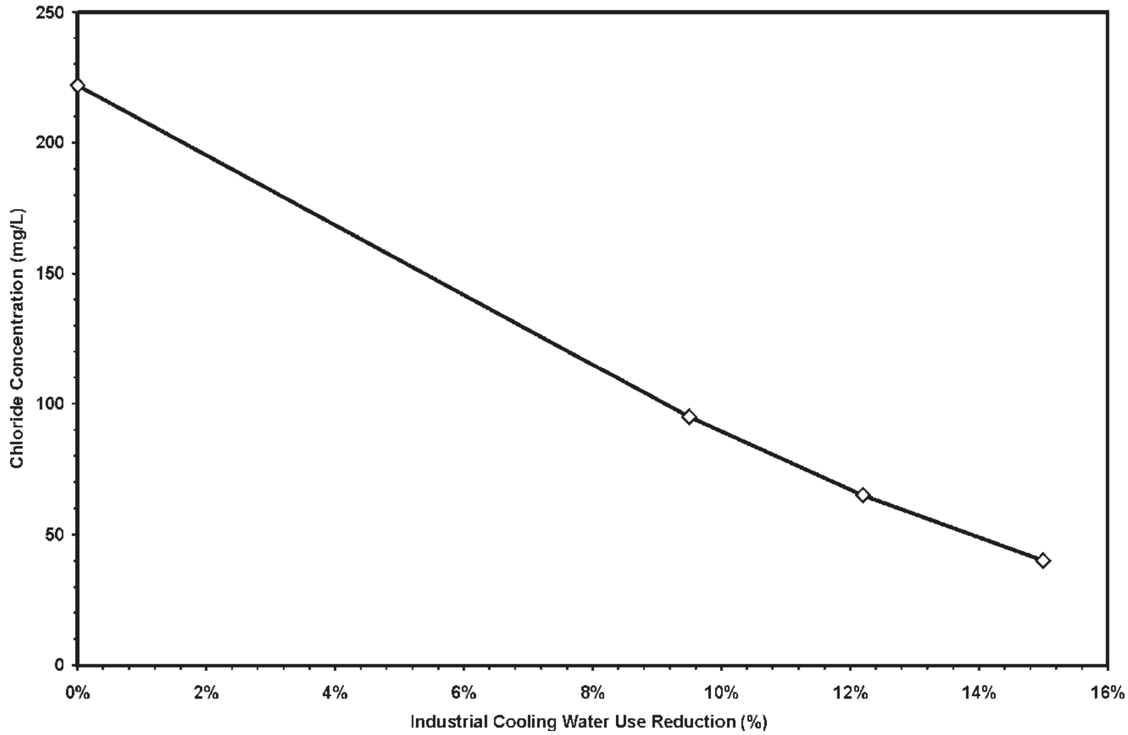

Figure 5D.3.32.
Potential for Manufacturing Water Use Savings Based on Reduction in Chlorides

5D.3.6 Available Yield and Water Quality

Cooling towers permit the reuse of cooling water by industry. However, the extent of reuse is limited by water chemistry. Changes in chemistry during cycling of cooling water impact corrosion, scale deposition, and biological fouling of industrial facilities. To control the chemical character of recycled cooling water and prevent these adverse effects, industries discharge (blow down) water from the system. The quantity of makeup water needed is the amount evaporated plus the amount of blow down. Improving makeup water quality would allow industry to reduce their blow down quantity. Other savings include reduced cooling tower chemical costs, and reduced treated water chemical usage and costs. The amount of industrial conservation achieved by improving water quality depends on the current water quality, industrial operations, and amount of water quality improvement effected.

Chloride is an effective indicator of total dissolved solids and is used as an illustrative example of the savings potential as a result of improving the quality of water entering the manufacturing industry's systems. Another important constituent to cooling water quality is hardness. The concentration of hardness is a critical limitation in the quality of the cooling tower water supply.

The presence of bromide in drinking water supplies affects the formation of disinfection byproducts (DBPs) such as brominated trihalomethane (THM) and haloacetic acid (HAA) species during treatment. THMs and HAAs have been linked to a number of serious health risks and are regulated by the U.S. Environmental Protection Agency. Reducing the level of bromide in drinking water sources, such as the Nueces River, will reduce the amount of DBPs in the finished drinking water and decrease the cost associated with treatment. The following options were evaluated with respect to the concentration ranges of chloride, hardness and bromide. The potential water savings as a result of each option were based on both the maximum and minimum reductions in chloride levels as indicated in Figure 5D.3.32.

5D.3.6.1 Blending of Texana Water and Mary Rhodes Pipeline Phase II

Corpus Christi currently contracts for a firm amount of 41,840 ac-ft/yr and an interruptible amount of 12,000 ac-ft/yr of water from Lake Texana; and holds a water right on the Colorado River to divert up to 35,000 ac-ft/yr near Bay City. Lake Texana and Colorado River supplies constitute about 35 percent of the safe yield supply of 219,000 ac-ft in 2020. The addition of Lake Texana and Colorado River water to the region's water supply lowers total dissolved solids and improved water quality for most industrial users. The median chloride concentration of Nueces River water at Calallen Pool is 253 mg/L and the 90th percentile is 314 mg/L. Blending 40 percent Nueces River water with 35 percent Lake Texana water, and 25 percent Colorado River water[6] reduces the median chloride concentration to 119 mg/L and the 90th percentile to about 153 mg/L. Figure 5D.3.33 presents the maximum, median, and minimum chloride, hardness and bromide concentrations for the Nueces River at O.N. Stevens WTP, Lake Texana, and the blended supplies. The average hardness concentration is reduced by 31 percent to 194 mg/L from 282 mg/L. The median bromide concentration is reduced by 20 percent as a result of blending.

In order to obtain the maximum potential savings in manufacturing water use this blended water would need to be made available to as many industries as possible. Two significant industries that withdraw raw water from the Calallen Pool that currently do not have access to the Texana water include Flint Hills Resources and Celanese-Bishop. These industries have seen a decline in water quality due to reduced water supply releases from Lake Corpus Christi resulting in higher dissolved solids and mineral concentrations in the Calallen Pool.[7] In the previous 2011 Plan, a study was conducted to evaluate potential pipeline interconnections to the Mary Rhodes Pipeline to provide water supplies to two industries[8] that have intakes in the Calallen Pool. The results of this study are included in Chapter 5D.3.6.6, with minor updates to cost for the 2016 Plan.

Reductions in chloride levels attributed to adding Lake Texana and Colorado River supplies to the regional water supply system are expected to result in a 5 to 8 percent savings in cooling water use in the region. Industrial water conservation savings associated with reducing the chloride concentration by about 56-59 percent are as follows:

- Year 2020 – 2,700 to 4,321 ac-ft/yr
- Year 2070 – 3,743 to 5,988 ac-ft/yr

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[6] Percentages developed based on full utilization of imported water from adjoining basins up to water right limits (maximum diversion from the Colorado) and contracted supplies from Lake Texana with remaining supply up to current demand being met with CCR/LCC supplies in the Nueces Basin.
[7] HDR Engineering, Inc., "Effluent Reuse Study," February 2002.
[8] Flint Hills Resources also receives treated water supplies from the City of Corpus Christi.

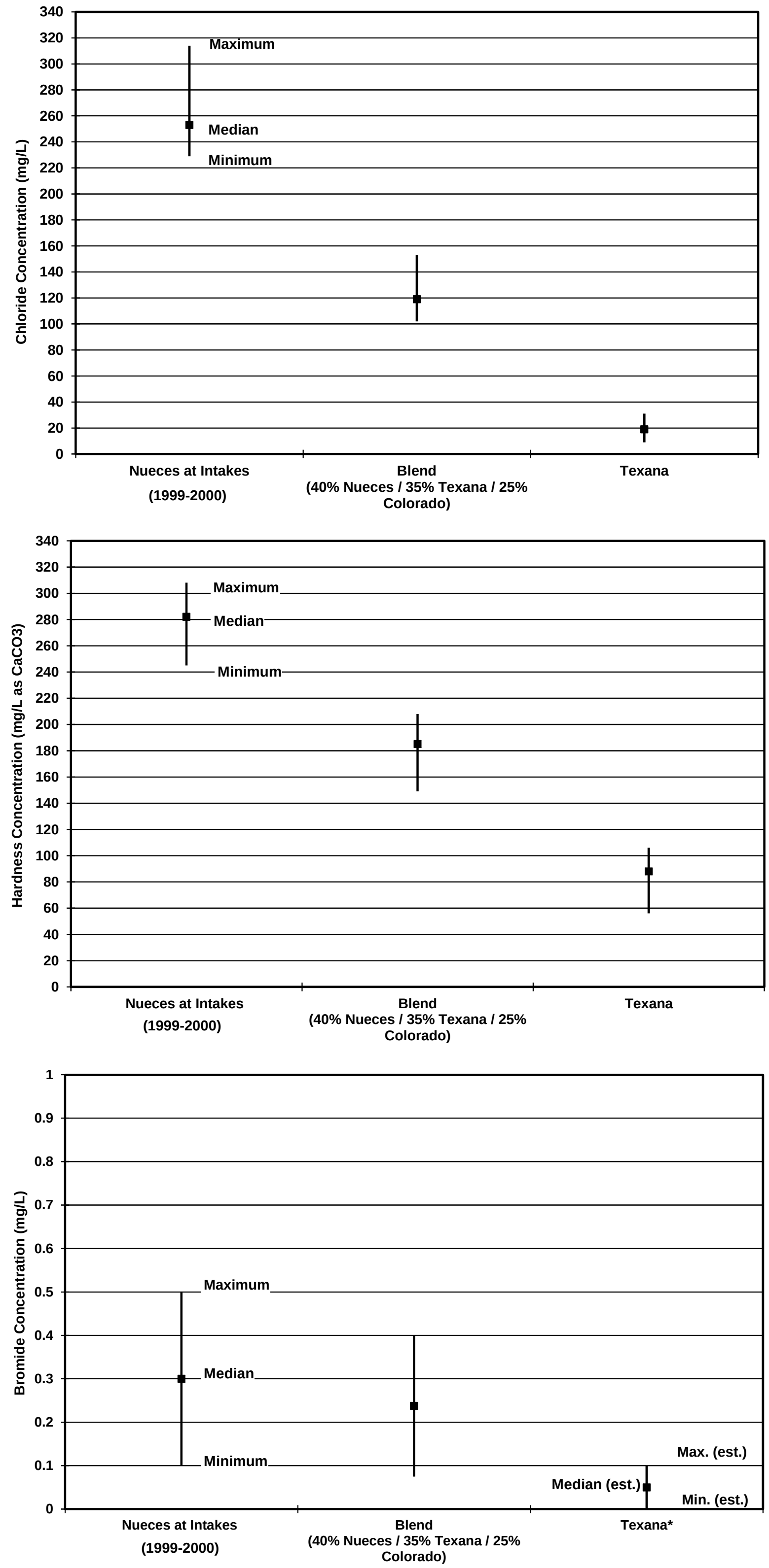


Figure 5D.3.33.
Blending Nueces River and Lake Texana Water Decreases Selected Dissolved Mineral Concentration and Variability

Of this industrial water conservation savings, adding Colorado River supplies through the MRP Phase II project is expected to increase water savings for cooling water use by 1 to 2 percent as compared to savings from Lake Texana supplies alone. Industrial water conservation savings solely associated with the addition of MRP Phase II are as follows:

- Year 2020 – 540 to 1,080 ac-ft/yr
- Year 2070 – 749 to 1,497 ac-ft/yr

5D.3.6.2 Outlet Works to Remove High TDS from Calallen Pool

The sampling data has shown that within the Calallen Pool there are sites where saline groundwater entering the system remains at the bottom of the deepest parts of the pool. Removal of the groundwater before the dissolved minerals diffuse into the entire channel could significantly improve the overall quality of the water remaining. This option includes a gravity line to siphon a maximum of 6 mgd from the bottom of the channel at up to eight locations. The alignment of the pipe system is shown in Figure 5D.3.34. The pipe system discharges into an inlet/outlet structure that bypasses the Calallen Dam that will allow for accurate measurement. The line is designed to be flushed by either connecting to San Patricio Municipal Water District's raw water discharge line to backwash the pipeline to remove any buildup of debris or use compressed air to flush the system. Removing the saline groundwater from the channel is estimated to reduce chloride concentrations of the Nueces River water by 15 to 20 percent to 215 mg/L based on the median levels, and to 267 mg/L based on the 90th percentile levels. The outlet works are estimated to reduce hardness levels by 3.8 percent to an average concentration of 272 mg/L. Figure 5D.3.35 also shows a 39.7 percent reduction in bromide from an average concentration of 0.3 mg/L to 0.18 mg/L.

For determining the estimated benefit of this option, it is assumed that the outlet works are implemented in conjunction with blending Texana and Colorado River (MRP Phase II) water with Nueces River water. After blending with the Texana water, the final median chloride concentration is reduced by 13 percent to 103 mg/L and 135 mg/L based on the 90th percentile levels as compared to blended supplies without outlet works. The additional reductions in hardness and bromide concentrations are 2 percent and 37 percent, respectively. This option results in an additional savings of manufacturing water consumption by the following amounts:

- Year 2020 – 627 ac-ft/yr; and
- Year 2070 – 869 ac-ft/yr.

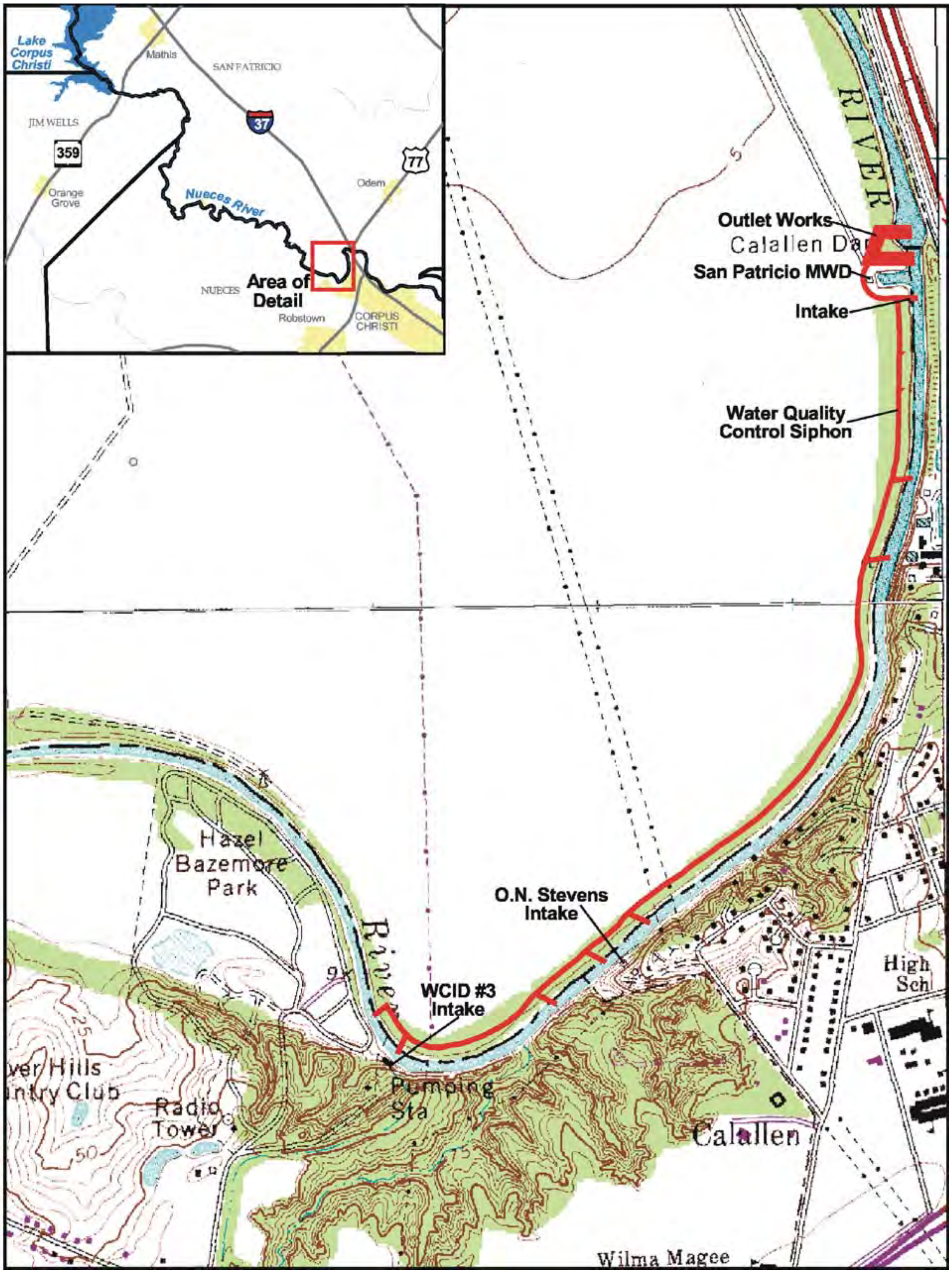
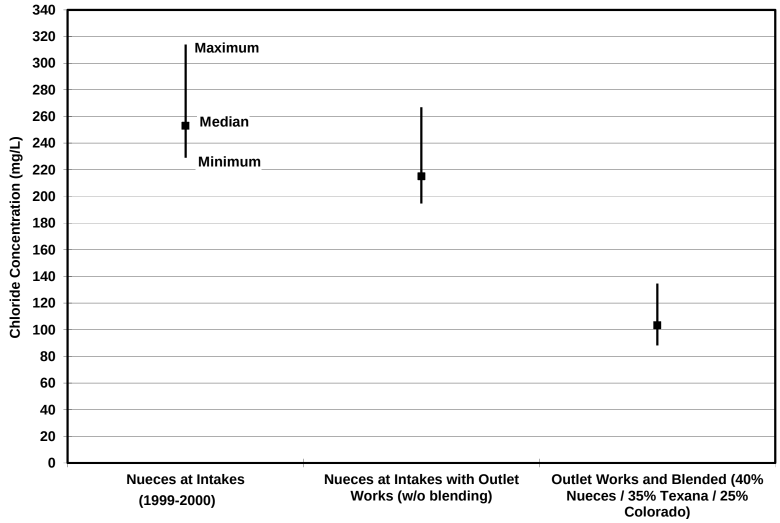
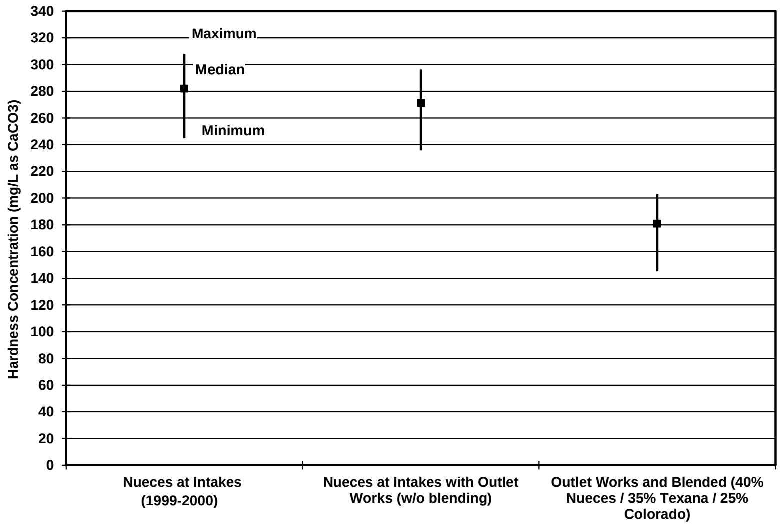


Figure 5D.3.34.
Location of Water Quality Control Siphon and Outlet Works





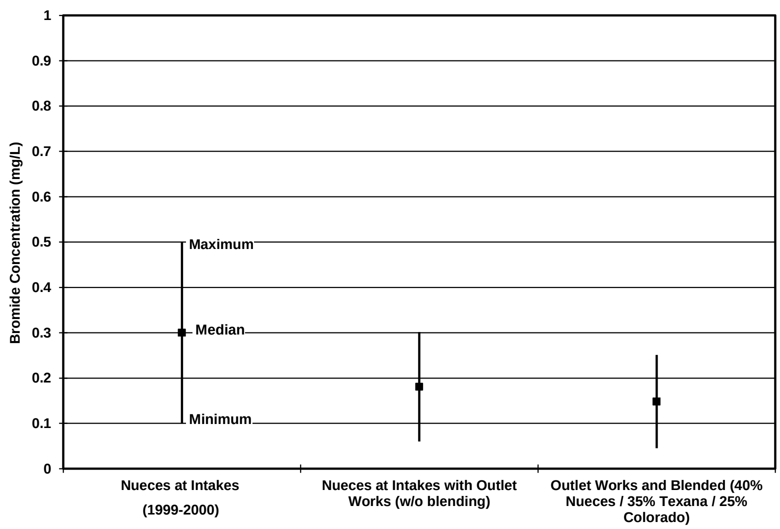


Figure 5D.3.35.
Decrease in Selected Dissolved Minerals with Outlet Works and Blending with Lake Texana Water

5D.3.6.3 Intake Modifications

The results of the sampling program show stratification within the Calallen Pool, with large mineral concentration increases occurring within the bottom two feet near the water intake locations. A potential option for increasing manufacturing water conservation is modification of the industrial intake structures to prevent withdrawal of water from the deepest part of the channel. Modifications to existing surface water intakes to allow only water from the uppermost portion of the water column to enter the system will differ depending upon the design of the intake. There are two major types of intakes within the channel. The first is a screened pipeline intake and the second is a side stream intake.

The first intake system would require the installation of a pipe with variable level intake screens, which can be opened and closed to allow the optimum quality of water to be withdrawn from the channel. There are multiple modifications possible for the side stream intake. These include the addition of framing, which will allow stop logs to be placed in front of the intake and allow water from selected depths to enter the system. The second is the installation of an exterior sill wall outside of the intake structure. The third option is the construction of an interior baffle wall within the intake structure. The four intakes that would result in the most benefit from modifications include the two side stream intakes operated by the City of Corpus Christi, a single side stream intake operated by the Celanese Corporation Bishop Facility, and a screened pipeline intake operated by Nueces County WCID #3.

The benefit of intake modifications is considered only in conjunction with the outlet works and siphon pipeline, as the siphon would be necessary to prevent the build-up of poor quality groundwater in the bottom of the Calallen Pool. Allowing only water from the uppermost portion of the Nueces River water column to enter the intakes after the most of the saline groundwater has been removed from the channel by the outlet works results in an additional reduction in median and maximum chloride of about 4 percent over the reductions achieved by the outlet works alone. An additional 12 percent reduction in bromide is achieved and hardness is further reduced by 1 percent, as shown in Figure 5D.3.36. It is estimated that the additional water savings due to intake modifications with outlet works are 836 ac-ft/yr for year 2020 and 1,158 ac-ft/yr for 2070.

5D.3.6.4 Pipeline from Lake Corpus Christi to the O.N. Stevens WTP

A pipeline to deliver 150,000 ac-ft/yr[9] from Lake Corpus Christi to the O.N. Stevens WTP would significantly reduce the chloride concentration of the raw water. Delivering just a portion of the total system yield from the Nueces River system to some users would increase the concentration of dissolved solids of the water remaining within the channel that would be diverted by other industrial and municipal users. Delivering the entire system yield eliminates this problem by supplying water with improved quality to all industrial and municipal users.

[9] Safe yield for CCR/LCC System in 2020 is approximately 150,000 ac-ft/yr without Lake Texana and MRP Phase II supplies.

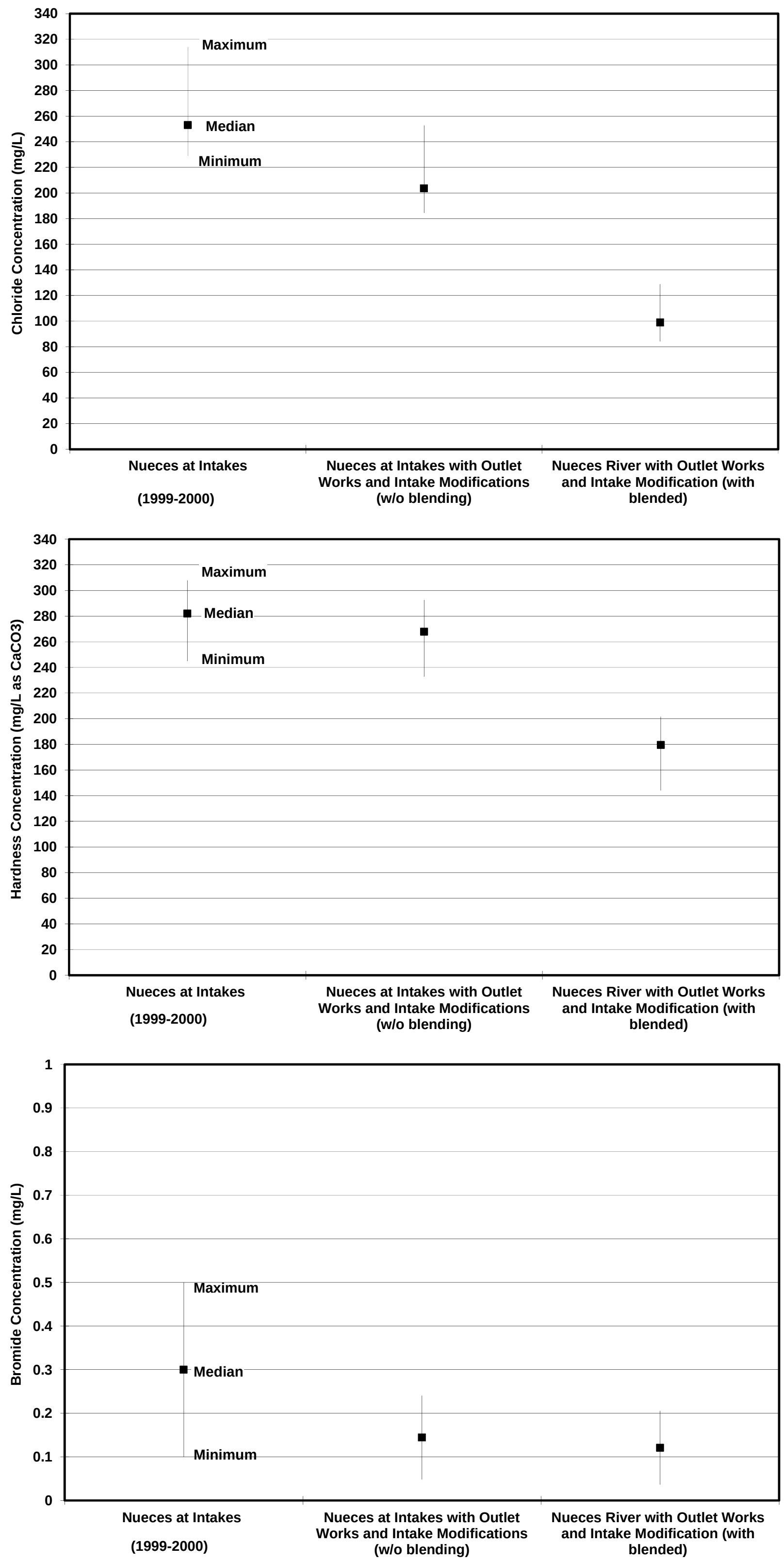


Figure 5D.3.36.
Decrease in Selected Dissolved Mineral Concentrations with Intake Modifications, Outlet Works, and Blending with Lake Texana Water

The quality of the water would improve from a median chloride concentration of 253 mg/L to a median chloride concentration of 39 mg/L as shown in Figure 5D.3.37. The hardness levels of Lake Corpus Christi are 27 percent lower than the Nueces River. The average improvement in hardness is from 282 mg/L to 206 mg/L. It is estimated that the manufacturing industry would save about 10 percent to 13 percent of water consumption as a result of the decrease in chloride concentration. This results in a 3,100 ac-ft/yr to 4,000 ac-ft/yr savings in 2020 and 5,100 ac-ft/yr to 6,600 ac-ft/yr savings in 2070. Other benefits to industry include:

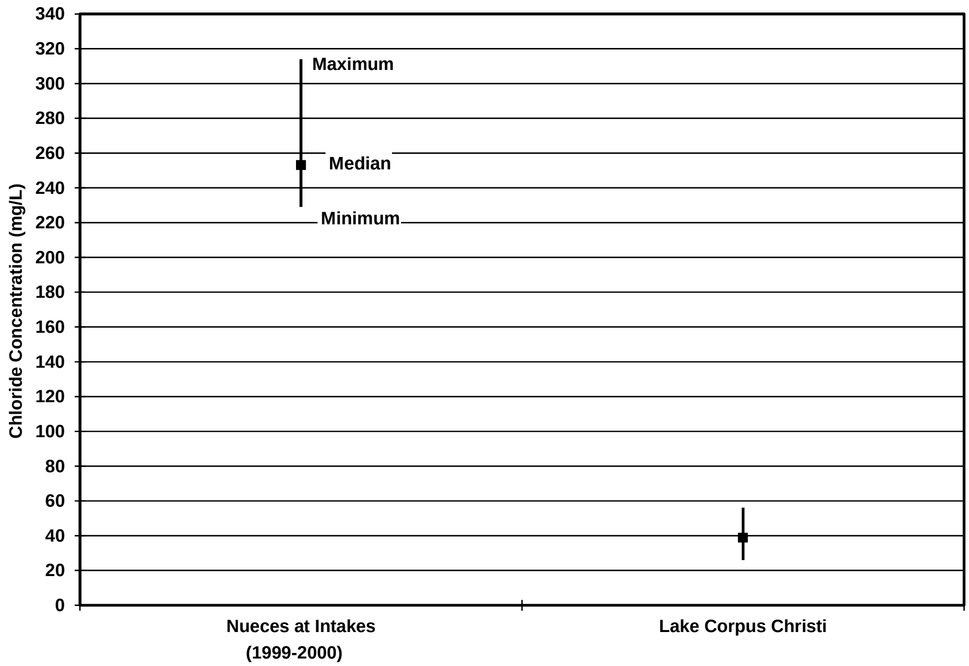
- Reduced cooling tower chemical costs
- Reduced demineralized water chemical usage and costs
- Reduced salt loading in the final plant effluent (environmental benefit).

The major facilities needed to deliver raw water from Lake Corpus Christi to the O.N. Stevens WTP include an intake pump station at the lake and a 21-mile transmission pipeline to Calallen. The river habitat downstream of Lake Corpus Christi would be supplied with water from natural inflows and pass-throughs to the Nueces Estuary from Lake Corpus Christi. The total yield for this option includes reduced channel losses and increased manufacturing water conservation. Recent studies indicate channel losses average 11 percent between Lake Corpus Christi and the Calallen Pool (or about 16,500 ac-ft/yr on water supply releases of 150,000 ac-ft), depending on flow and seasonal conditions.[10] This project would result in total savings of between 19,600 to 23,100 ac-ft/yr.

5D.3.6.5 Plugging Leaky and Abandoned Oil Wells

Unplugged and leaking plugged wellbores pose a threat of pollution to the surface and subsurface waters by providing a pathway for the migration of fluids (in particular oil and saltwater) from hydrocarbon bearing zones into formations containing usable quality water and into surface waters. As long as a well remains unplugged, the potential threat remains until it is eliminated by properly plugging the wellbore.

[10] CRR/LCC updates, 2005.



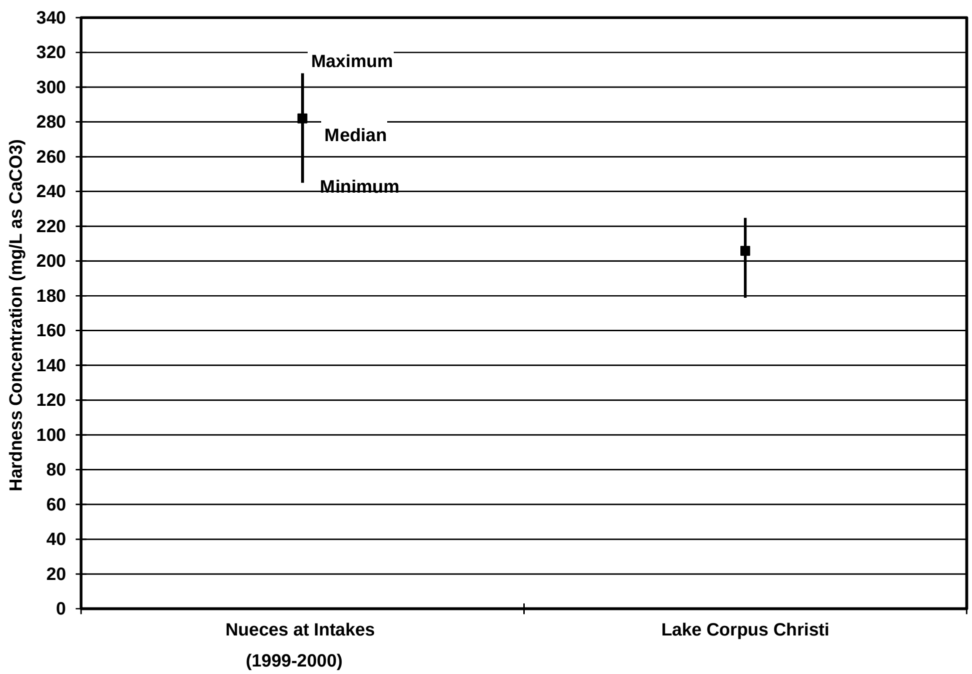


Figure 5D.3.37.
Comparison of Chloride and Hardness Concentrations

The State of Texas has maintained a well plugging fund since 1965 to plug abandoned wells that pose a pollution hazard when: the responsible owner/operator cannot be located; is insolvent; or the responsible owner/operator is unwilling to plug the well. Wells are considered in the Nueces River and Lake Corpus Christi for plugging when they become non-compliant or inactive for at least 12 months and have not received an approved permit extension. A priority system is used to rate the need for plugging non-compliant wells based upon 20 human health, safety, environmental, and wildlife factors. Leaking wells receive the highest priority (Level 1) and all other wells receive a priority between 2 and 4 depending on the level of threat to the environment. Wells with a priority of 1, 2, or 3 are recommended for plugging with Oil Field Cleanup (OFCU) Funds. The Texas Railroad Commission has utilized the OFCU Fund to plug more that 15,000 wells within the State of Texas. Of those, 139 wells have been in San Patricio County and 96 were in Nueces County. However, thousands of additional abandoned wells remain in Texas. There are currently 193 and 184 non-compliant wells in San Patricio and Nueces Counties, respectively. Of these non-compliant wells, only 31 have a Level 4 priority. It is unknown how many improperly plugged wells are leaking and are in need of repair. Within San Patricio and Nueces Counties, there were 16 total wells scheduled to be plugged in 2000 at an average estimated cost of $21,000 per well. Additional study is needed to determine the impact of the leaking wells on the lower Nueces River.

5D.3.6.6 Potential Interconnections to the Mary Rhodes Pipeline

In the previous 2011 Plan, a study was conducted to evaluate potential pipeline interconnections to the Mary Rhodes Pipeline to provide water supplies to two industries[11] that have intakes in the Calallen Pool.

Water Quality Constituents of Interest

Discussions with industries that have intakes in the Calallen Pool area to provide Nueces River water and that do not currently have access to MRP supplies resulted in identification of the several specific water quality concerns. One primary concern is fluctuations in the total dissolved solids (TDS) of the Lower Nueces River water that causes treatment difficulties and additional costs for desalination when TDS concentrations are elevated. A related concern is the relatively high chlorides and other dissolved ions that increase corrosion potential. Other concerns included elevated hardness which increases the scaling potential and requires additional softening for removal. Additional softening treatment to remove hardness increases treatment costs and increases the quantity of treatment sludge requiring disposal. Based on these water quality concerns, the primary water quality constituents of interest for blended water qualities and treatment requirements at the industrial facilities are shown in Table 5D.3.5.

[11] Flint Hills Resources also receives treated water supplies from the City of Corpus Christi.

Table 5D.3.5.
Water Quality Constituents and General Impacts on Water Treatment

Water Quality Constituent	*General Impact on Treatment*
Turbidity	Sludge production
Total Hardness	Required lime dose and sludge production, corrosion chemistry
Total Dissolved Solids (TDS)	Desalination and softening requirements, corrosion chemistry
Chloride	Desalination and softening requirements, corrosion chemistry

Blending Scenarios

The composition of raw water supplies treated at these industrial facilities has historically been 100% Nueces River water. Water delivered directly from MRP previously consisted of 100% Lake Texana water; but after MRP Phase II is implemented in 2015 will consist of about 45% Colorado River water and 55% Lake Texana water depending on water available for diversion. The City has a contract with the Lavaca-Navidad River Authority to divert 41,840 ac-ft/yr on a firm basis and up to 12,000 ac-ft/yr on an interruptible basis from Lake Texana (up to 53,840 ac-ft/yr) and Colorado River water rights up to 35,000 ac-ft/yr. Actual diverted interruptible supplies from 2010 to 2014 varied from 0 to 8,485 ac-ft/yr based on need and water availability.[12] For the blending scenario, the current supply of Lake Texana water was assumed to continue while MRP Phase II supplies are added.

Water Quality for Blending Scenarios

The median raw water quality for the blends considered is shown in Table 5D.3.6. The blended water scenario with both Lake Texana and Colorado River water supply sources is based on the contract maximums delivered through MRP for an estimated total supply up to 88,840 ac-ft/yr, or 82% of the pipeline capacity. The water quality variability of each constituent for each of the four water sources is summarized in Figures 5D.3.38 through 5D.3.41. These figures show the low concentration (only 35% of samples lower than this value), median concentration (50% of samples lower than this value), and high concentration (65% of samples lower than this value).

[12] In Year 2011, only 40,908 ac-ft total was delivered from Lake Texana, which was less than the base permit of 41,840 ac-ft/yr.

Table 5D.3.6.
Median Raw Water Quality of Blends

Label	***Existing 100% Nueces***	***100% Texana***	***Texana with 45% Colorado***
Nueces River	100.0%	0.0%	0.0%
Lake Texana	0.0%	100.0%	55.0%
Colorado River	0.0%	0.0%	45.0%
Groundwater	0.0%	0.0%	0.0%
Water Quality			
Turbidity, NTU	23	57	45
Total Dissolved Solids, mg/L	758	133	207
Chloride, mg/L	253	19	30
Total Hardness, mg/L as $CaCO_3$	282	88	138

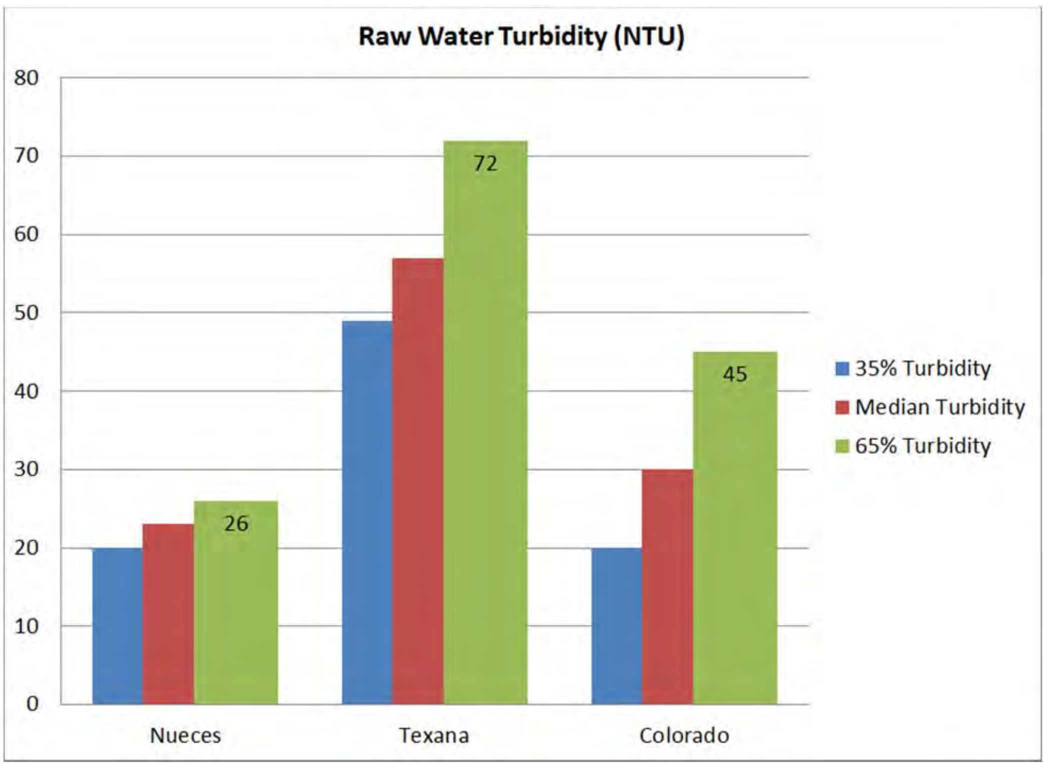


Figure 5D.3.38.
Raw Water Turbidity for Each Water Source

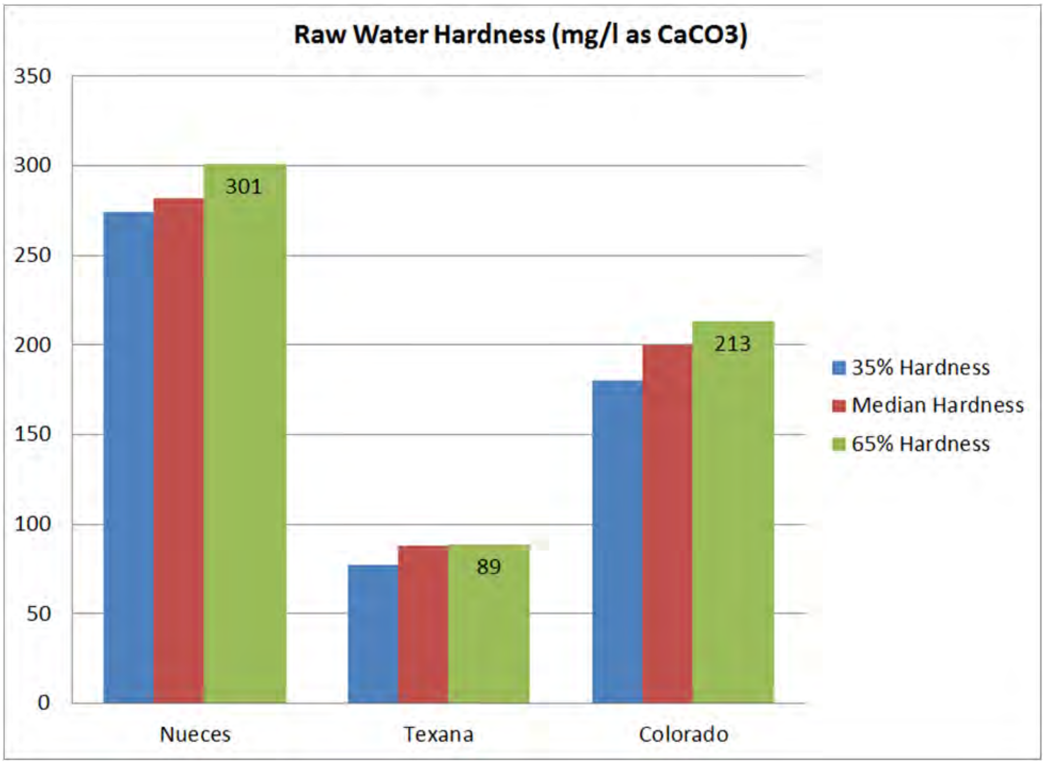


Figure 5D.3.39.
Raw Water Hardness for Each Water Source

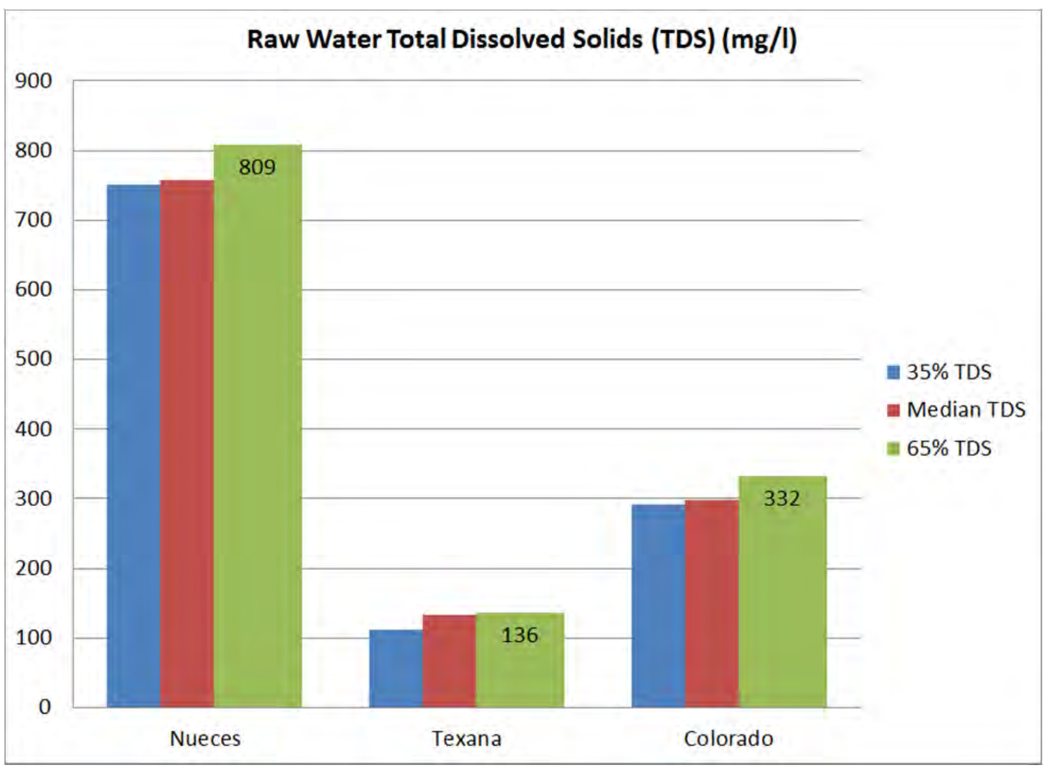


Figure 5D.3.40.
Raw Water TDS for Each Water Source

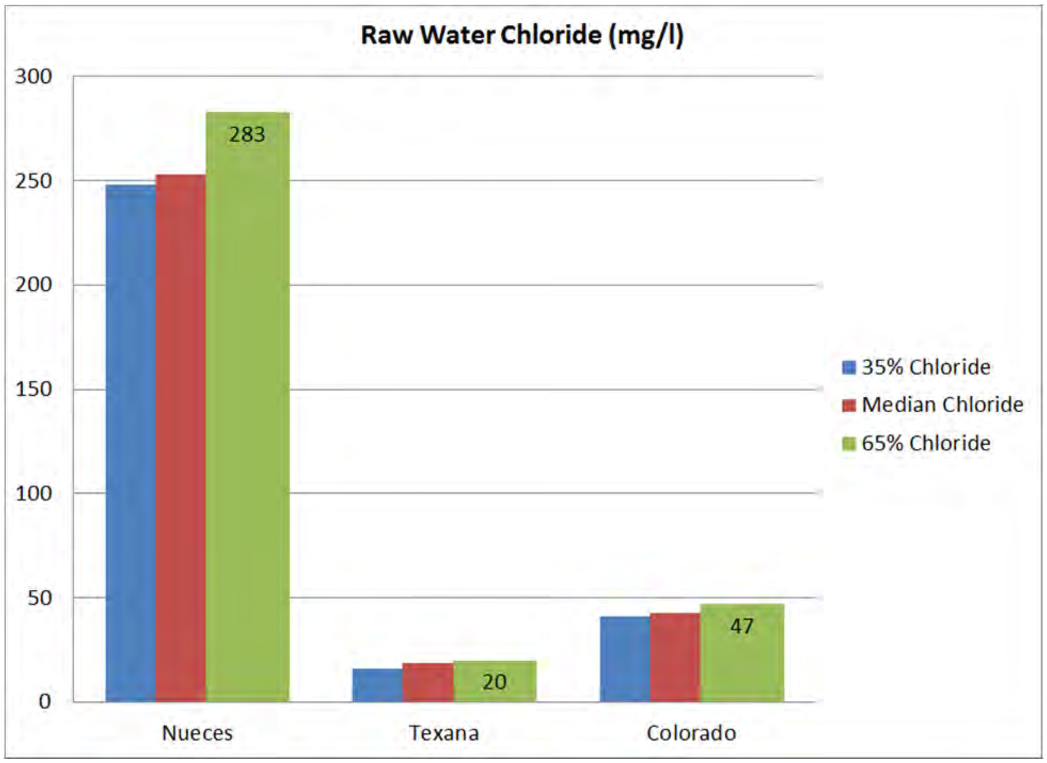


Figure 5D.3.41.
Raw Water Chloride for Each Water Source

Summary of Water Quality and Blending Analysis

The blending analysis and resulting water treatment estimates are based on the median water quality for each water supply. The quantity of sludge produced, level of desalination required, and quantity of water required to meet industrial needs will vary if water quality of any of the raw water sources changes considerably throughout the year or from year to year. However, based on the range of historical water quality for each water source, the water quality of all the evaluated water sources vary within ranges that can successfully be treated by industrial users with existing treatment methods.

The analysis is based on a total average water use for industrial users supplied directly from MRP of 5 mgd (5,600 ac-ft/yr). The treatment impacts assume that there is not an off-channel reservoir prior to the industrial treatment systems, and therefore, the quantity of sludge produced by lime treatment is impacted by the turbidity of the raw water. Higher turbidity is removed in treatment producing more sludge that must be disposed. Table 5D.3.7 shows the assumed quantity of 100% Nueces water that is currently being used in cooling towers and boiler feed and the associated treatment required for each use.

Table 5D.3.7.
Quantity of Water for Each Industrial Use

Water Use (Treatment Required)	%	Quantity (mgd)
Cooling Tower (Lime Softening)	85.0%	4.25
Boiler (Lime Softening + Desalination)	15.0%	0.75

All the water currently supplied to industrial users is treated by lime softening to remove suspended solids, reduce hardness, and remove other impurities. A simplified estimate of lime softening treatment cost differences for different blended water qualities was developed based on an estimate of the quantity of sludge produced. The quantity of sludge produced from lime softening is primarily dependent on the hardness and alkalinity of the raw water. During lime softening treatment, lime (calcium hydroxide) is added to the raw water to raise the pH and, therefore, precipitate hardness and other impurities that are more soluble at lower pH's. The higher the hardness concentration in the raw water, the larger the quantity of hardness that will be removed by lime softening treatment creating more sludge for disposal. Similarly, higher concentrations of alkalinity buffer the water requiring higher doses of lime to raise pH. The higher dose of lime adds more calcium hardness that is subsequently precipitated at the higher pH resulting in higher quantities of treatment sludge. To develop the relative cost differences for lime treatment, a unit cost for sludge disposal of $0.10/pound was assumed. There are other treatment processes such as filtration and disinfection utilized for the water supplied to the cooling towers. However, for this cost analysis those treatment processes are not considered because the potential changes in treatment costs for those processes are relatively insignificant when compared to potential cost differences in the lime softening process due to water quality changes.

In addition to lime softening treatment, the portion of water used for boiler feed at industrial facilities is treated with reverse osmosis for desalination and ion exchange softening to reduce the level of hardness and impurities to low levels. This ultrapure water can more efficiently be used in boilers for steam generation. The lime softening treatment step does not remove all total dissolved solids and removes very little or none of some constituents such as single-valent ions like chloride. Therefore, water with higher concentrations of total dissolved solids and especially higher concentrations of chlorides will require more extensive desalination prior to being utilized for boiler feed. For this simplified estimate of desalination treatment costs the relative concentration of dissolved solids was utilized to estimate the relative desalination costs for the different blended water qualities. The cost to treat 0.75 mgd of boiler feed water with desalination treatment steps for the existing supply of 100% Nueces water was assumed to be $300,000 per year. Water supplied from MRP with lower dissolved solids will have lower desalination treatment costs due to better desalination treatment performance, including lower pressure required and better recovery rates for reverse osmosis systems. A summary of estimated differences in treatment costs for each blended water scenario is shown in Table 5D.3.8.

Table 5D.3.8.
Industrial Water Treatment Cost Differences for Blends

		Existing 100% Nueces	*100% Texana*	*Texana with 45% Colorado*
Lime Sludge Produced and Cost of Disposal (Cooling Tower & Boiler Water Treated = 100% of Total = 5.0 mgd)				
Quantity of Lime Sludge	PPD	18,800	5,900	9,200
Cost of Lime Sludge Disposal	$/year	$533,000	$193,000	$350,000
Suspended Solids Sludge Produced and Cost of Disposal (All Water Treated Total = 5.0 mgd)				
Turbidity	mg/L	23	57	45
Sludge from Suspended Solids	PPD	1,000	2,400	1,900
Cost of Solids Sludge Disposal	$/year	$44,000	$105,000	$83,000
Desalination Costs (Boiler Water Treated = 15% of Total = 0.75 mgd)				
Desalination Costs	$/year	$400,000	$70,000	$109,000
Total Sludge and Desalination Costs				
Total Sludge and Desalination Cost	$/year	$1,267,000	$433,000	$595,000
% Decrease from 100% Nueces	%	0.0%	65.8%	53.0%

Note: PPD = Pounds per Day

Improved water quality can result in decreased total water supply required to meet industrial demands. There will be a decrease in water demand if cooling tower cycles are increased. When water can be concentrated more by recycling through the cooling tower more times then less water is lost as blowdown. Scaling due to elevated concentrations of constituents such as hardness will limit the number of cooling tower cycles. Similarly, corrosion due to elevated concentrations of constituents such as chloride will also limit the number of cooling tower cycles. Industrial users indicated that with the existing raw water supply of 100% Nueces it was generally possible to utilize five cooling tower cycles. For this analysis, the number of cooling tower cycles that may be utilized for each of the blended water scenarios was estimated based on the relative concentration of hardness and chloride in the raw water with higher concentrations of hardness and chloride resulting in a lower number of cooling tower cycles.

A decrease in total dissolved solids concentration in the industrial water supply can also result in decreased water demand due to less water requiring desalination and improvement in the recovery rate from reverse osmosis treatment. For this estimate, the quantity of water lost as concentrate during desalination treatment was assumed to be 10% for the current supply of 100% Nueces water. Water lost from desalination for the blend scenarios was estimated to be proportional to the total dissolved solids concentration with lower concentrations resulting in less desalination water lost. Table 5D.3.9 shows the estimated differences in the quantity of raw water necessary to meet industrial demands for each of the blend scenarios.

A potential pipe route to connect the MRP to the existing industrial raw water intake pump stations that are currently drawing water from the Nueces River is shown in Figure 5D.3.42. Costs are presented in Table 5D.3.13.

Table 5D.3.9.
Industrial Water Treatment Cost Differences for Blends

		Existing 100% Nueces	*100% Texana*	*Texana with 45% Colorado*
Cooling Tower Water Blowdown Quantity of Water				
Cooling Tower Cycles		5	10	8
Cooling Tower Blowdown Quantity	mgd	0.85	0.38	0.49
Evaporative Loss	mgd	3.40	3.40	3.40
Total Cooling Tower Water	mgd	4.25	3.78	3.89
Desalination Quantity of Water Due to Recovery Rate and Quantity of Water Desalinated				
Desalination % of Water Lost	% of Total	10.0	1.8	2.7
Quantity of Desalinated Product Water	mgd	0.68	0.68	0.68
Desalination Water Lost	mgd	0.07	0.01	0.03
Total Desalination Water	mgd	0.75	0.69	0.71
Total Water Use Change				
Total Water Use	mgd	5.00	4.47	4.59
Quantity Decrease from 100% Nueces	mgd	0.00	0.53	0.41
Quantity Decrease from 100% Nueces	ac-ft/yr	0	593	464
% Decrease from 100% Nueces	%	0.0%	10.6%	8.3%

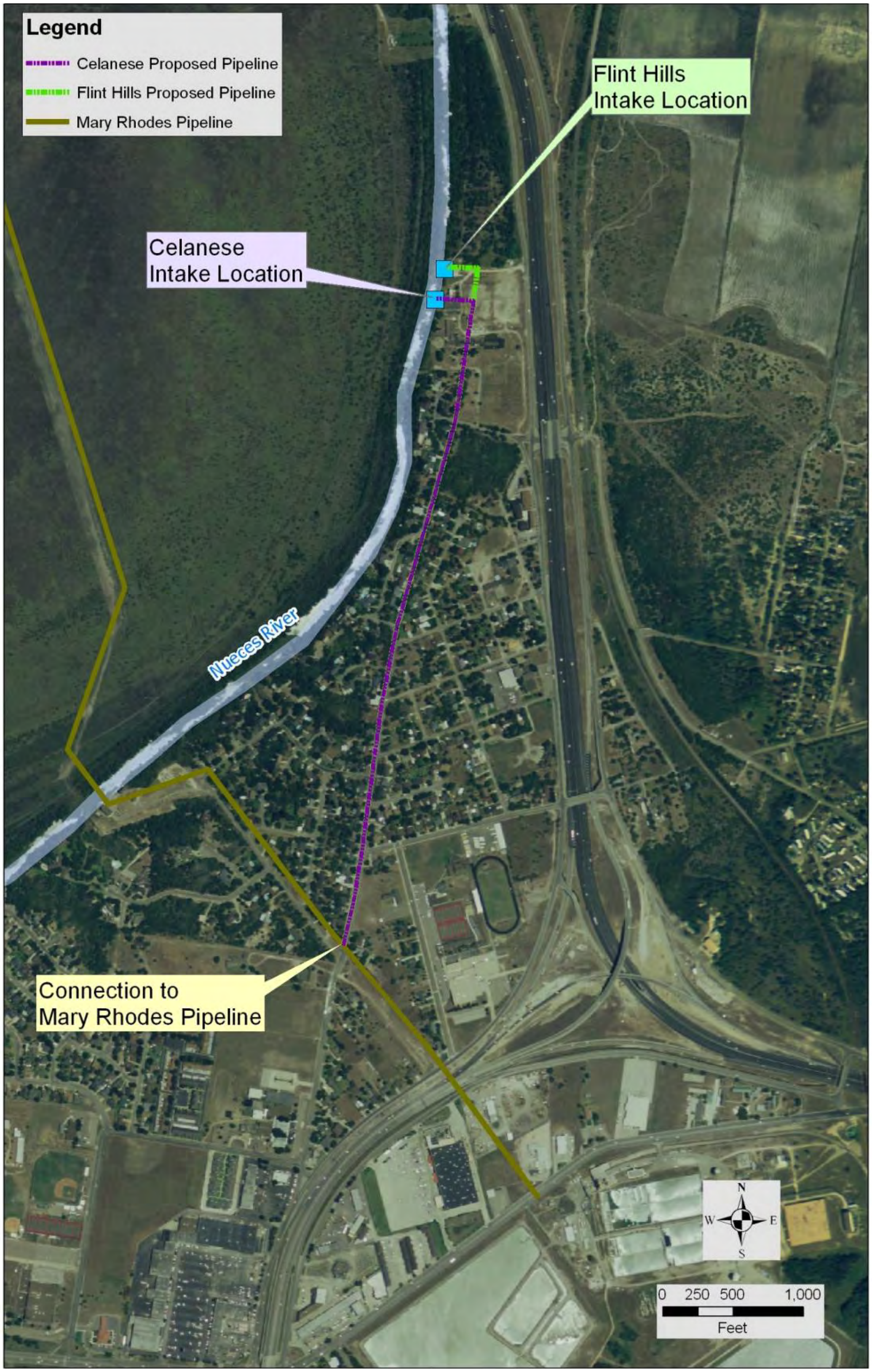


Figure 5D.3.42.
MRP Interconnect Pipeline Route

5D.3.7 Environmental Issues

Any major construction undertaken within the Nueces River channel or along the riparian corridor such as intake modifications, building a siphon system to remove high TDS or a pipeline, will have some, though minor, environmental impacts.

Construction of the siphon system will include up to eight intake structures placed in the Nueces River. As the water volumes to be moved by this system will be relatively small (6 mgd, an intake stream of about 1.2 cfs at each of the eight intakes), the intake structures will be small. Disturbance of riparian and riverine habitats due to construction of eight intake structures is expected to total substantially less than one acre. Construction of the approximately 1.7 mile long pipeline to the upper end of Segment 2101 (Nueces River Tidal) will disturb about 6.7 acres of ground cover within a 30-foot wide construction easement. Impacts to riparian areas can be minimized by locating the pipeline outside of the very narrow wooded corridor that lines the left bank of the Nueces River in this reach.

Operation of the siphon system will result in changes in the ambient Nueces River TDS concentrations that are within the tolerance limits of the freshwater fish and invertebrate species of the lower Nueces River. Likewise, the relatively small discharge of Nueces River bottom water into the tidal segment will still be well within the generally accepted freshwater range (i.e. <2,500 mg/L), and will mix with brackish bay waters through tidal action, as is the case with existing Nueces River flows over Calallen Dam.

The operation of the siphon is expected to have a negligible effect on the estuary, as water quality of the releases will be fresh relative to the estuary salinity.

Additional studies should be conducted prior to implementing a siphon system at Calallen Pool to evaluate water quality constituents (other than salinity and TDS) and impacts associated with leaky and abandoned oil wells.

The proposed Lake Corpus Christi to Calallen pipeline corridor would be within Jim Wells and San Patricio Counties. The pipeline is intended to transfer water without using the bed and banks of the Nueces River. The construction of a 21-mile pipeline from LCC to the Calallen Dam would result in soil and vegetation disturbance within the approximately 245-acre pipeline construction corridor. Longer-term terrestrial impacts would be confined to the 105-acre maintained right-of-way. Prior to implementation of this strategy, further studies to evaluate environmental impacts of the project will be required. The major environmental issues related to pumping water via a pipeline from Lake Corpus Christi to Calallen include the effects of changes in Nueces River flows. The remaining flows in the river would include pass throughs to the estuary from Lake Corpus Christi and natural inflows. Further studies would be needed to assess the required flows within the channel to maintain stream habitat and the project's impact on these flows.

All of the options result in conservation of manufacturing water use by improving water quality and thereby increasing the amount of water available for other users. Also, reducing the dissolved solids content of the water entering the manufacturing industries' cooling systems reduces the mineral loading content of the final plant effluent. Plugging leaky and abandoned oil wells reduces hydrocarbon pollution and contamination by saline water to surface and subsurface water.

5D.3.8 Engineering and Costing

5D.3.8.1 Blending of Lake Texana Water and Mary Rhodes Pipeline Phase II with Nueces River Water

The blend ratio considered for this option includes 40 percent Nueces River water, 35 percent Texana water, and 25 percent Colorado River water based on anticipated system operation considering contracts and TCEQ-authorized water rights.

5D.3.8.2 Outlet Works to Remove High TDS from Calallen Pool

The cost estimate for the pipe system facilities to remove water with high TDS from the bottom of the Calallen Pool is shown in Table 5D.3.10. The total capital cost is estimated at $2,308,000. The project cost is 3,151,000. The total annual cost is estimated to be $287,000. Assuming that the outlet works are implemented in conjunction with blending Texana and Nueces River water for the industries, the additional system yield savings of 627 to 869 ac-ft/yr results in a unit cost of $330-$458 per ac-ft/yr.

5D.3.8.3 Intake Modifications

The benefit of intake modifications is considered in conjunction with the outlet works and siphon pipeline. The approximate capital cost of all intake structures is estimated to be about $3,809,000. The four intakes include one operated by the Celanese Bishop Plant Facility, two by the City of Corpus Christi and one operated by Nueces County WCID #3. Intake modification with the outlet works is estimated to save an approximately 836 to 1,158 ac-ft/yr for 2020 and 2070. The cost estimate for this control strategy is shown in Table 5D.3.11. The total capital cost is estimated at $6,117,000. The project cost is $8,535,000. The total annual cost is estimated to be $832,000. Therefore, the unit cost of water saved is estimated to be about $718 to $995 per ac-ft per year.

Table 5D.3.10.
Cost Estimate Summary for Outlet Works and Siphon to Remove High TDS from Calallen Pool (September 2013 Prices)

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Siphons, Control Valves, and Vaults (8 siphons)	$252,000
Intake at Dam, Valves and Vaults at Intake	$1,056,000
Gravity Pipeline (12-, 14-, 18- and 24-inch telescopic line)	$1,000,000
TOTAL COST OF FACILITIES	**$2,308,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$693,000
Environmental & Archaeology Studies and Mitigation	$43,000
Interest During Construction (4% for 1 year with a 1% ROI)	$107,000
TOTAL COST OF PROJECT	**$3,151,000**
ANNUAL COST	
Debt Service (6 percent, 20 years)	$264,000
Operation and Maintenance	$23,000
TOTAL ANNUAL COST	**$287,000**
Available Project Yield (ac-ft/yr)	627 - 869
Annual Cost of Water ($ per ac-ft)	$330 - $458
Annual Cost of Water ($ per 1,000 gallons)	$1.40 - $1.01

Table 5D.3.11.
Cost Estimate Summary for Intake Modifications and Outlet Works to Remove High TDS from Calallen Pool (September 2013 Prices)

Item	Estimated Costs for Facilities
CAPITAL COST	
Intake Modifications	$3,809,000
Siphons, Control Valves, and Vaults (8 siphons)	$252,000
Intake at Dam, Valves and Vaults at Intake	$1,056,000
Gravity Pipeline (12-, 14-, 18- and 24-inch telescopic line)	$1,000,000
TOTAL COST OF FACILITIES	**$6,117,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$2,027,000
Environmental & Archaeology Studies and Mitigation	$43,000
Land Acquisition and Surveying (6.2 acres)	$59,000
Interest During Construction (4% for 1 year with a 1% ROI)	$289,000
TOTAL COST OF PROJECT	**$8,535,000**
ANNUAL COST	
Debt Service (6 percent, 20 years)	$714,000
Operation and Maintenance	$118,000
TOTAL ANNUAL COST	**$832,000**
Available Project Yield (ac-ft/yr)	836 - 1,158
Annual Cost of Water ($ per ac-ft)	$718 - $995
Annual Cost of Water ($ per 1,000 gallons)	$2.21 - $3.05

5D.3.8.4 Pipeline from Lake Corpus Christi to O.N. Stevens Water Treatment Plant

The major facilities needed to deliver 150,000 ac-ft/yr of raw water from Lake Corpus Christi to the Calallen Dam include an intake pump station and 21-mile transmission pipeline. The pipeline capacity was calculated based upon a peak day to average day ratio of 1.75 and is capable of transferring up to 234 mgd. The cost for the facilities is shown in Table 5D.3.12. The total capital cost is estimated at $139,469,000. The total project cost is $190,005,000. The total annual cost is estimated to be $19,541,000. Increases in yield include reduced channel losses (16,500 ac-ft/yr) and increased manufacturing water conservation (3,100 to 6,600 ac-ft/yr), resulting in total savings of between 19,600 and 23,100 ac-ft/yr and a unit cost of $846 to $997 per ac-ft/yr. After adding estimated treated water costs of $369 per ac-ft, the treated water unit cost is expected to range from $1,215 to $1,366 per ac-ft.

Table 5D.3.12.
Cost Estimate Summary for Pipeline from Lake Corpus Christi to Calallen Dam (September 2008 Prices)

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Intake Pump Stations (234.3 mgd)	$15,368,000
Pipeline (Transmission: 114-inch, 21 miles) & (Concentrate)	$124,101,000
TOTAL COST OF FACILITIES	**$139,469,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$42,609,000
Environmental & Archaeology Studies and Mitigation	$575,000
Land Acquisition and Surveying (97 acres)	$926,000
Interest During Construction (4% for 1 year with a 1% ROI)	$6,426,000
TOTAL COST OF PROJECT	**$190,005,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$15,900,000
Operation and Maintenance	
Pipeline, Wells and Storage Tanks (1% of Cost of Facilities)	$1,241,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$384,000
Purchase of Water (5,600 ac-ft/yr @ 360 $/ac-ft)	$2,016,000
TOTAL ANNUAL COST	**$19,541,000**
Available Project Yield (ac-ft/yr)	19,600 – 23,100
Annual Cost of Water ($ per ac-ft)	$846 - $997
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1.75	$2.60 - $3.06

5D.3.8.5 Plugging Leaky and Abandoned Oil Wells

Within San Patricio and Nueces Counties, there were 16 wells scheduled to be plugged by the Texas Railroad Commission in 2000 at an average estimated cost of $21,000 per well. It is unknown how many old plugged wells continue to leak and are in need of repair. Additional study is needed to determine the impact of the leaking wells on the lower Nueces River.

5D.3.8.6 Potential Interconnections to the Mary Rhodes Pipeline

Pipeline Cost Estimate

The cost estimate shown in Table 5D.3.13 assumes there is adequate residual pressure in the MRP at the point of connection to transfer 5 mgd of water from MRP to a new ground storage tank located adjacent to the existing Celanese and Flint Hills pump stations. These existing raw water pump stations will be used to draw MRP water from the new ground storage tank and pump to Celanese and Flint Hills through existing pipelines that are currently transmitting raw Nueces water to the respective industrial facilities. The estimate includes a new 1-mile long, 16-inch pipeline to connect MRP to a new ground storage tank that is sized at 5% of total flow (250,000 gallons).

Table 5D.3.13.
MRP Interconnect Pipeline and Tank Cost Estimate – 5 mgd Supply (September 2008 Prices)

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Pipeline (Transmission: 16-inch, 1 mile)	$603,000
Storage Tanks (Other than at Booster Pump Stations)	$275,000
TOTAL COST OF FACILITIES	**$878,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$277,000
Environmental & Archaeology Studies and Mitigation	$50,000
Land Acquisition and Surveying (12 acres)	$39,000
Interest During Construction (4% for 1 year with a 1% ROI)	$44,000
TOTAL COST OF PROJECT	**$1,288,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$108,000
Operation and Maintenance	
Pipeline, Wells and Storage Tanks (1% of Cost of Facilities)	$9,000
Purchase of Water (5,600 ac-ft/yr @ 360 $/ac-ft)	$2,016,000
TOTAL ANNUAL COST	**$2,133,000**
Available Project Yield (ac-ft/yr)	5,600
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1	$381
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	$1.17

Summary Cost Differences for Implementation of MRP Interconnect

Table 5D.3.14 contains a summary of the overall cost differences estimated between the current water supply consisting of 100% Nueces water versus the construction costs of a new interconnect to MRP and the associated potential water treatment cost savings for the blended water supplies from MRP. The "Net Cost Savings at Same Quantity" is determined by subtracting the new costs associated with constructing the MRP interconnect pipeline and tank shown in Table 5D.3.14 ($132,000/yr) from the cost savings associated with improvements in water quality for each blend scenario that will lower treatment costs. The unit cost savings per ac-ft assuming the full 5 mgd (5,600 ac-ft/yr) of water continues to be used by industries after changing the water supply to a blend delivered directly from MRP is calculated by dividing the annual cost savings by 5,600 ac-ft/yr to determine the cost savings per ac-ft. To capture some of the additional cost savings associated with a lower quantity of water necessary when utilizing blend water from MRP, a current water supply cost of $400/ac-ft was assumed for the water supply currently consisting of 100% Nueces water. This current assumed Nueces water supply cost includes the treatment and delivery costs. A revised unit water cost with MRP blends is calculated by subtracting the "Net Cost Savings per ac-ft" associated with lowered treatment costs for the MRP blends. The "Total Cost Savings with MRP" in $/year is the difference between the current water costs with 100% Nueces minus the estimated water costs determined from the lowered treatment costs and lowered quantity of water required.

Table 5D.3.14.
Summary Cost Differences for Implementation of MRP Interconnect

		Existing 100% Nueces	*100% Texana*	*Texana with 45% Colorado*
Total Sludge and Desalination Cost Savings (Addition)				
Total Sludge and Desalination Cost	$/year	$1,267,000	$433,000	$595,000
Cost Difference from 100% Nueces	$/year	$0	$834,000	$672,000
Pipeline and Tank Capital Debt Service and O&M Total Annual Cost (Subtraction)				
Total Annual Cost	$/year	$0	$150,000	$150,000
Net Cost Savings at Same Quantity = Total Sludge and Desalination Cost Savings - Pipe and Tank Cost				
Net Cost Savings	$/year	$0	$684,000	$522,000
Current Water Use	ac-ft/yr	5,600	5,600	5,600
Cost Savings per ac-ft	$/ac-ft	$0	$122	$93
Total Cost Savings, including Water Use Quantity Change				
Current Assumed Unit Water Cost	$/ac-ft	$400	$400	$400
Current Water Use	ac-ft/yr	5,600	5,600	5,600
Total Current Water Cost	$/year	$2,240,000	$2,240,000	$2,240,000
Quantity Decrease from 100% Nueces	ac-ft/yr	0	593	464
Revised Water Use with MRP Blend	ac-ft/yr	5,600	5,007	5,136
Revised Unit Water Cost with MRP	$/ac-ft	$400	$278	$307
Revised Total Water Cost with MRP	$/year	$2,240,000	$1,390,000	$1,580,000
Total Cost Savings with MRP Blend	$/year	$0	$850,000	$660,000

The total yearly estimated cost savings for industrial users currently treating 100% Nueces changing to a water supply from MRP was highest at $850,000/year if the water delivered from MRP is 100% Texana water as is currently delivered in MRP. The estimated cost savings decrease if water supplies from the Colorado River water are blended in the future. The cost savings decrease as the proportion of Texana water decreases because the other water sources have relatively high concentrations of hardness, TDS, and chloride relative to Texana. The lowest estimated cost savings is for the blending scenario with both Texana and Colorado water sources at $660,000/year because this scenario has the lowest proportion of Texana water delivered in MRP. The project costs to implement future water supply projects for delivery through the MRP such as Garwood (Colorado River water) and Gulf Coast groundwater projects was not included in the cost estimate. It is assumed that such projects would be funded by wholesale water providers and included in customer water rates.

5D.3.9 Implementation Issues

5D.3.9.1 Blending of Lake Texana Water and Mary Rhodes Pipeline Phase II with Nueces River Water

With current contracts, the water supply from Lake Texana is approximately 25% of the safe yield supply. Blending of Lake Texana water with Nueces River water is already occurring and local industries that currently do not benefit from these water quality improvements should consider water pumping facilities to allow for blending.

5D.3.9.2 Outlet Works to Remove High TDS from Calallen Pool

Releases of water from the Calallen Pool through the siphon line should contribute towards Lake Corpus Christi's Bay and Estuary release credits. Permits and potential mitigation requirements would be needed for construction of the pipeline and Calallen Dam bypass. The construction of the outlet works may require an USACE Section 404 Permit and would require cultural resource studies along the pipeline route.

5D.3.9.3 Intake Modifications

Intake modifications within the Nueces River channel may require an USACE Section 404 permit. Also, major modifications may require the intake pump station to be out of service for a portion of the construction period. However, it is possible to complete the construction in phases in order to minimize or eliminate down time.

5D.3.9.4 Pipeline from Lake Corpus Christi to the O.N. Stevens WTP

The primary implementation issue that would need to be addressed would be the impact of the reduced flows in the Nueces River downstream of Lake Corpus Christi. An evaluation of the impacts of reduced flows on the river and riparian water rights would have to be undertaken to fully investigate the consequences of implementing this alternative. In addition, the TCEQ permits may need to be amended depending on changes in locations of diversions. Also, before a significant expenditure of funds would be considered for this alternative, a detailed long-term investigation of channel losses should be undertaken to fully understand the seasonality and variability of channel losses that occur within the river reach. Additional implementation issues for the development of a water supply from Lake Corpus Christi to Calallen include:

- USACE Section 10 and Section 404 dredge and fill permits for the pipelines.
- GLO Sand and Gravel Removal permit for pipeline stream crossings.
- GLO Easement for use of State-owned land (if any).
- TPWD Sand, Gravel, and Marl permit.
- Mitigation requirements would vary depending on impacts, but could include vegetation restoration, wetland creation or enhancement, or additional land acquisition.
- Cultural resource studies would need to be performed along the pipeline route.

5D.3.9.5 Plugging Leaky and Abandoned Oil Wells

Although the Texas Railroad Commission conducts an active well plugging program, the extent of contamination from these wells to surface waters prior to plugging is unknown. Also, it is possible that there are many undetected leaking wells that were plugged decades ago, but have since degraded. It is an important issue to investigate this possible contamination source.

5D.3.9.6 Potential Interconnections to the Mary Rhodes Pipeline

Although this strategy would reduce water quality fluctuations that industries with intakes in the Calallen Pool have been experiencing, implementation of this strategy would reduce the amount of Mary Rhodes Pipeline supplies currently delivered to the City of Corpus Christi O.N. Stevens WTP and could impact water quality for wholesale water providers and their customers.

5D.3.10 Evaluation Summary

Evaluation summaries of this regional water management strategy are provided in Tables 5D.3.15 and 5D.3.16.

Table 5D.3.15. Evaluation Summary of Manufacturing Water Conservation Strategies

Impact Category	***Comment(s)***
a. Water supply:	
1. Quantity	1. Estimated savings are shown in Table 5D.3.16.
2. Reliability	2. Unknown – additional studies needed.
3. Cost of treated water	3. Unit costs are shown in Table 5D.3.16.
b. Environmental factors:	
1. Instream flows	1. Some impact since pipeline to Lake Corpus Christi would reduce flows in Lower Nueces River.
2. Bay and estuary inflows	2. Return flows of about 10,000 to 12,000 ac-ft/yr would increase flows to the Nueces Estuary.
3. Wildlife habitat	3. Possible minor impacts to wildlife habitat from construction of facilities.
4. Wetlands	4. Possible benefit to wetlands due to enhanced water quality.
5. Threatened and endangered species	5. Pipeline to Lake Corpus Christi would require detailed studies of Lower Nueces River to determine impacts to threatened and endangered species.
6. Cultural resources	6. Cultural resource investigations should be conducted along pipeline route to evaluate impacts. Cultural resources will need to be avoided when facilities are constructed.
7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	7. During drought conditions sampling indicates worsening of water quality. Water quality improvements benefit manufacturing and municipal entities, and Nueces Bay and Estuary. The CBRWPG identified six water quality concerns associated with manufacturing water conservation strategy, as described below. a. Water quality improvement projects will reduce total dissolved solids. b. None or low impact. c. None or low impact. d. Water quality improvement projects will reduce chloride levels in Lower Nueces River. e. Water quality improvement projects will reduce bromide levels in Lower Nueces River. f. Further studies should be conducted to determine impacts of water quality improvement projects on sulfate levels in Lower Nueces River. g. None or low impact. h. None or low impact. i. CBRWPG also identified dissolved oxygen and hardness as water quality concerns related to this water management strategy. Dissolved oxygen decreases with depth within the channel. The Nueces River Dissolved Minerals Study addresses this concern. Hardness can be reduced by implementation of water quality improvement projects.

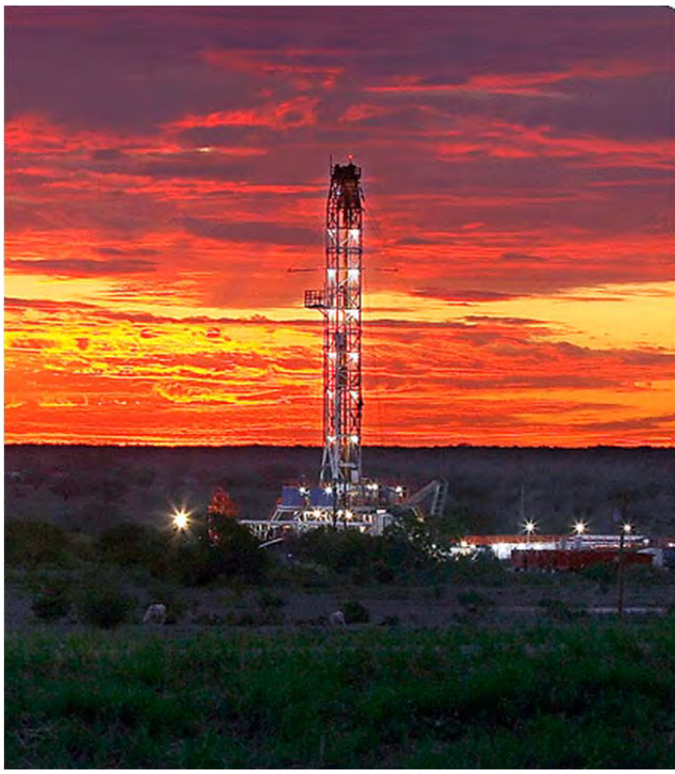
Impact Category	Comment(s)
c. Impacts to State water resources	• No significant impacts
d. Threats to agriculture and natural resources in region	• None
e. Recreational impacts	• None, except pipeline to Lake Corpus Christi would reduce flows in Lower Nueces River
f. Equitable comparison of strategies	• Water quality improvements benefit both manufacturing and municipal entities
g. Interbasin transfers	• None
h. Third party social and economic impacts from voluntary redistribution of water	• None
i. Efficient use of existing water supplies and regional opportunities	• Increases existing system efficiency
j. Effect on navigation	• None

Table 5D. 3.16.
Summary of Water Quality Control Strategies

Water Options	Amount of Water Conserved (ac-ft/yr)	Total Annual Cost of Water ($ per ac-ft)
1. Blending of Lake Texana and Mary Rhodes Phase II Water with Nueces River Water	540 to 1,497*	None**
2. Outlet Works to Remove High TDS from the Calallen Pool	627 to 869	$330 to $458
3. Modification to Existing Intakes	836 to 1,158	$718 to $995
4. Pipeline from Lake Corpus Christi to Calallen	19,600 to 23,100	$846 to $997
5. Potential Interconnections to MRP	5,600	$381

*Savings associated with MRP Phase II being added to the system. Additional savings have been realized by integrating Lake Texana supplies.

**No additional costs to be incurred unless additional water is purchased from LNRA from Lake Texana.



5D.4

Mining Water Conservation (N-4)

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5D.4 Mining Water Conservation (N-4)

5D.4.1 Description of Strategy

Water for mining uses is primarily associated with oil and gas extraction, coal mining, metal mining, and nonmetallic mineral operations. Gross state domestic product data released from the U.S. Department of Commerce showed mining economic outputs of $138.4 billion for 2008 and $1,257.7 for 2012.[1] Individual county data is not readily available. The TWDB water demand projections for mining users is generally based on projected economic output, assuming that past and current water use trends remain constant over time.

The mining water demand projections used in this plan for the Coastal Bend Region were provided by the TWDB, after increases from the Coastal Bend Regional Water Planning Group in mining water demands in Live Oak and McMullen Counties attributable to Eagleford shale activities were adopted. In the Coastal Bend Region, the trends for mining water demands are projected to increase from 2020 to 2030 with a maximum demand of 9,821 ac-ft and then decrease after 2030 to a minimum of 5,497 ac-ft/yr in 2070 as shown in Figure 5D.4.1. The decrease in water demand is due to anticipated slowdown of Eagleford Shale mining activities in the Coastal Bend Region. McMullen County has the largest projected mining water demands, constituting about half of the regional mining water demand in 2030 (Figure 5D.4.2).

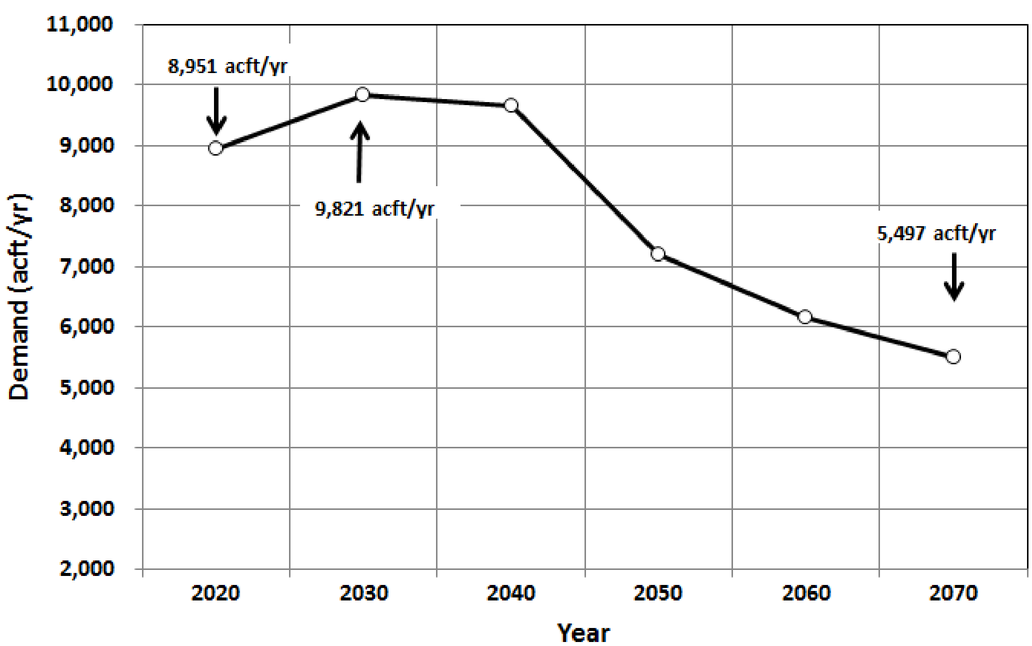

Figure 5D.4.1.
Coastal Bend Region Mining Water Demand Projections

[1] Bureau of Economic Analysis, U.S. Department of Commerce.

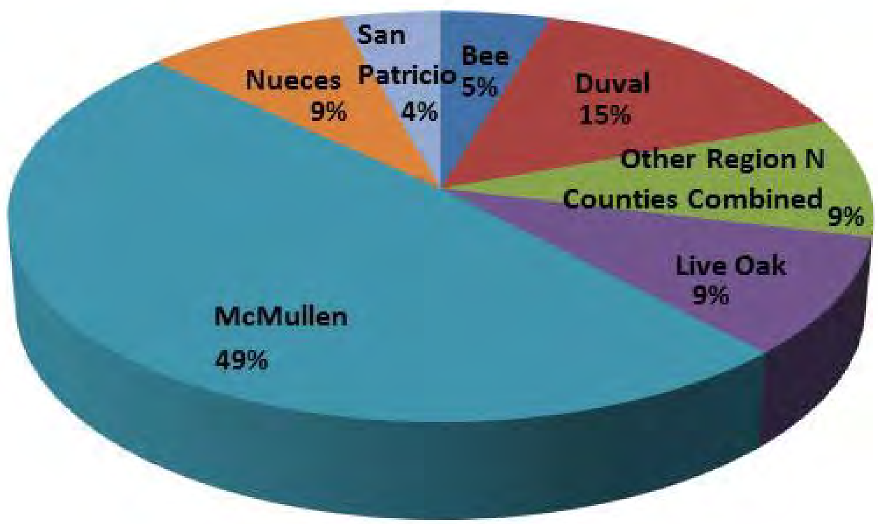

Figure 5D.4.2.
2030 Percentages of Mining Water Demand by County
Total Demand for Coastal Bend Region – 9,821 ac-ft

In the Coastal Bend Region, 10 of the 11 counties (except Nueces County) receive their full mining water supply from groundwater sources. Nueces County mining users receive one-third of their supply from surface water.

In the Coastal Bend Region, McMullen County is limited by modeled available groundwater and projected to have mining needs (shortages) from 2020 to 2060, as shown in Table 5D.4.1. Shortages decline from 2040 to 2060 due to the reduction in mining water demands expected with reductions in Eagleford shale activities assumed after 2030. McMullen Mining can receive 32 percent of their projected groundwater demands during the peak decade of 2030, resulting in a shortage of 3,269 ac-ft in 2030 and reducing to 315 ac-ft by 2060.

Table 5D.4.1.
Projected Water Demands, Supplies, and Water Needs (Shortages)
for Mining Users in McMullen County

	Mining Projections (ac-ft/yr)					
	2020 (ac-ft)	***2030 (ac-ft)***	***2040 (ac-ft)***	***2050 (ac-ft)***	***2060 (ac-ft)***	***2070 (ac-ft)***
McMullen						
Mining Demand	4,268	4,804	4,754	2,622	1,850	1,305
Mining Existing Supply						
Groundwater	1,535	1,535	1,535	1,535	1,535	1,535
Surface water	0	0	0	0	0	0
Total Mining Supply	1,535	1,535	1,535	1,535	1,535	1,535
Surplus (Shortage)	(2,733)	(3,269)	(3,219)	(1,087)	(315)	230

TWDB Rules for regional water planning require Regional Water Planning Groups to consider water conservation and drought management measures for each water user group with a need (projected water shortage). In addition, the Rules direct water conservation BMPs, as identified by the Water Conservation Implementation Task Force (Task Force), be considered in the development of the water conservation water management strategy.

5D.4.2 Available Yield

As part of the 2012 regional water planning process, the CBRWPG recommended that counties with projected mining needs (shortages) reduce their mining water demands by 15 percent by 2070 using BMPs identified by the Task Force. This method was also used previously in the 2011 plan. A 15 percent reduction in mining water demand by 2060, results in a maximum savings of 357 ac-ft, as shown in Table 5D.4.2. The CBRWPG-recommended water conservation goal alone is insufficient to fully address McMullen County Mining shortages and additional strategies are considered to address this projected supply deficit (See Chapter 5B).

Table 5D.4.2.
Projected Water Demands and Needs (Shortages) for Mining Users Considering a 15 Percent Demand Reduction for McMullen County

	Projections (ac-ft/yr)					
	2020	***2030***	***2040***	***2050***	***2060***	***2070***
McMullen						
New Demand (after conservation)	4,162	4,564	4,397	2,360	1,619	1,109
Expected Savings	106	240	357	262	231	196
New Mining Shortage (after recommended conservation)	(2,627)	(3,029)	(2,862)	(825)	(84)	426
Shortage Reduction (ac-ft/yr)	4%	7%	11%	24%	73%	N/A
Total Mining Savings (Region N)	**106**	**240**	**357**	**262**	**231**	**196**

The Task Force report lists the following industrial BMPs that may be used to achieve the recommended water savings[2]:

1. Industrial Water Audit
2. Industrial Water Waste Reduction
3. Industrial Submetering
4. Cooling Towers
5. Cooling Systems (other than Cooling Towers)
6. Industrial Alternative Sources and Reuse and Recirculation of Process Water
7. Rinsing/Cleaning
8. Water Treatment
9. Boiler and Steam Systems
10. Refrigeration (including Chilled Water)
11. Once-Through Cooling

[2] Water Conservation Implementation Task Force, Report to the 79th Legislature, Texas Water Development Board,

12. Management and Employee Programs
13. Industrial Landscape
14. Industrial Site Specific Conservation

The Task Force report describes the above BMP methods and how they reduce water use, however information regarding specific water savings and costs to implement conservation programs is generally unavailable. Conservation savings and costs are by nature facility specific. Since mining entities are presented on a county basis and are not individually identified, identification of specific water management strategies are not a reasonable expectation.

5D.4.3 Environmental Issues

The Task Force BMPs have been developed and tested through public and private sector research, and have been applied within the region. Such programs have been installed, and are in operation today, and are not expected to have significant environmental issues associated with implementation. For example, most BMPs improve water use efficiency without making changes to wildlife habitat. Thus, the proposed conservation practices do not have anticipated potential adverse effects, and in fact have potentially beneficial environmental effects.

5D.4.4 Engineering and Costing

Consistent with the approach used in the 2011 Plan, the CBRWPG recommends implementing water conservation for mining users with shortages to reduce their water demand by 15 percent by 2070. McMullen County can save up to 357 ac-ft. Costs to implement BMPs vary from site to site and the Coastal Bend Region recognizes that mining industries will pursue conservation strategies that are economically feasible with water savings benefits. For this reason, it is impractical to evaluate the costs of implementing mining water conservation strategies.

5D.4.5 Implementation Issues

Demand reduction through water conservation is being implemented throughout the Coastal Bend Region. The rate of adoption of efficient water-using practices is dependent upon public knowledge of the benefits, information about how to implement water conservation measures, and financing.

There is public support for mining water conservation and it is being implemented at a steady pace, and as water markets for conserved water expand, this practice will likely reach greater potentials. The TWDB has industrial water conservation programs including presentations and workshops for utilities who wish to train staff to develop local programs including water use site surveys, publications on industrial water reuse potential, and information on tax incentives for industries that conserve or reuse water. Future planning efforts should consider the use of detailed studies to fully determine the maximum potential benefits of mining conservation.

5D.4.6 Evaluation Summary

An evaluation summary of this water management option is provided in Table 5D.4.3.

Table 5D.4.3.
Evaluation Summary of Mining Water Conservation

Impact Category	***Comment(s)***
a. Water Supply 1 Quantity 2. Reliability	 1. Firm Yield: Variable, Max of 357 ac-ft/yr (2040) 2. Cost: Highly variable based on BMP selected and facility specifics.
b. Environmental factors 1. Instream flows 2. Bay and Estuary Inflows 3. Wildlife Habitat 4. Wetlands 5. Threatened and Endangered Species 6. Cultural Resources 7. Water Quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. None or low impact. 2. None or low impact. 3. None or low impact. 4. None or low impact. 5. None. 6. No cultural resources affected. 7. None or low impact.
c. Impacts to State water resources	• No apparent negative impacts on water resources
d. Threats to agriculture and natural resources in region	• None
e. Recreational impacts	• None
f. Equitable Comparison of Strategies	• Standard analyses and methods used
g. Interbasin transfers	• None
h. Third party social and economic impacts from voluntary redistribution of water	• None
i. Efficient use of existing water supplies and regional opportunities	• Improvement over current conditions by reducing the rate of decline of local groundwater levels.
j. Effect on navigation	• None
k. Consideration of water pipelines and other facilities used for water conveyance	• None

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5D.5

Reclaimed Wastewater Supplies and Reuse (N-5)

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5D.5 Reclaimed Wastewater Supplies and Reuse (N-5)

5D.5.1 Description of Strategy

A part of the quantity of water that is used for municipal and industrial purposes is consumed and a part is used for sanitary waste removal from homes, and for sanitary and process-related water use in commercial and industrial establishments. In the Coastal Bend Area, wastewater is collected, treated to acceptable standards as specified by regulatory agencies — Texas Commission on Environmental Quality (TCEQ) and U.S. Environmental Protection Agency (EPA) — and is either reused for non-potable purposes such as industrial uses or golf course irrigation or discharged to some receiving water. In the Corpus Christi area, significant treated effluent quantities are discharged into streams that flow into the bays and meet a part of the freshwater needs of the Nueces Estuary. The purpose of this section is to describe reclaimed wastewater reuse options and present estimates of the quantities of water supply that may be made available through: 1) wastewater reuse for municipal and industrial non-potable purposes; 2) wastewater diversions to the Nueces Delta to enhance biological productivity of estuarine marshes (in comparison to the present practice of direct discharge of wastewater into the bays and into streams that flow into the bays); and 3) discussions of wastewater reuse and water conservation effects upon estuarine inflows.

Both reuse and diversion to the Nueces Delta present opportunities to increase the Corpus Christi area water supply. In the Interim Order[1] of March 9, 1992, the TCEQ established temporary operational procedures for the City's reservoirs that included a monthly schedule of minimum desired inflows to Nueces Bay. The 1992 Interim Order directed studies of the effects of freshwater releases upon the estuary and the feasibility of relocating wastewater discharges to the upper estuary locations where increased biological productivity could justify an inflow credit computed by multiplying the amount of discharge by a number greater than one. These studies included the Allison Wastewater Treatment Plant (WWTP) Demonstration Project.

On April 28, 1995, the TCEQ replaced the 1992 Interim Order with an Agreed Order[2] (1995 Agreed Order) amending the Choke Canyon Reservoir/Lake Corpus Christi (CCR/LCC) System operational procedures. The 1995 Agreed Order directed the Nueces Estuary Advisory Council (NEAC) to continue studying the development of a methodology using a multiplier system for granting credits for specific return flows that increase biological productivity.

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[1] Interim Order Establishing Operational Procedures Pertaining to Special Condition 5.B, Certificate of Adjudication No. 21-3214, held by the City of Corpus Christi, Nueces River Authority, and the City of Three Rivers, Texas Water Commission (now TCEQ), Austin, Texas, March 9, 1992.

[2] Agreed Order Establishing Operational Procedures Pertaining to Special Condition 5.B., Certificate of Adjudication No. 21-3214, held by the City of Corpus Christi, Nueces River Authority, and the City of Three Rivers, Texas Natural Resource Conservation Commission, Austin, Texas, April 26, 1995.

On April 17, 2001, the TCEQ issued an amendment to the 1995 Agreed Order to revise operational procedures in accordance with revisions requested by the City of Corpus Christi. Changes included: 1) reductions in the passage of inflows to Nueces Bay and Estuary at 40 percent and 30 percent reservoir system capacity upon institution of mandatory outdoor watering restrictions; 2) calculating reservoir system storage capacity based on most recently completed bathymetric surveys; and 3) provisions for operating Rincon Bayou diversions and conveyance facility from Calallen Pool to deliver up to the first 3,000 ac-ft of target pass through to the upper Rincon Bayou in the Nueces Delta to enhance the amount of freshwater to Delta. Nueces Delta projects, such as Rincon Bayou and Allison WWTP Demonstration Projects, include the following potential benefits: increased water supply, increase positive flow events for Nueces Delta, and increased sources of nitrogen and lower salinity levels for the upper delta. A study completed in 2006[3] outlined the positive benefits of the Allison WWTP Demonstration Project. This report concluded that there was an increase in vegetation and creation of additional areas of salt marsh which was accompanied by more shorebirds being attracted to the area. The report also noted that with the additional water diverted to the marsh area, there was an approximately 50 percent removal of wastewater discharge into the Nueces River, reducing the potential for nutrient driven algal blooms. To evaluate the potential benefits, the 2001 Agreed Order included implementation of an ongoing monitoring program to facilitate an adaptive management program for freshwater inflows to the Nueces Estuary. NEAC prepared a recommended monitoring plan in July 2002, which was initiated in 2003.[4] Modifications to the Allison WWTP discharge permit include limitations on ammonia concentrations in the flows to the demonstration project. As a result, the City has curtailed these flows.

The Rincon Bayou Diversion Pipeline and Pump Station (Rincon pipeline) was constructed by the City of Corpus Christi pursuant to the 2001 Agreed Order and became operational in November 2007. Pursuant to the Agreed Order, the City also reopened the Nueces River Overflow Channel which has become the primary method of delivering flow to the Nueces Delta. The Rincon pipeline pump station includes three 350 horsepower mixed flow submersible pumps capable of delivering up to 60,000 gallons per minute (or 265 ac-ft/day) with all pumps operating. The Rincon pipeline and pump station does not operated continuously, however the City has operated the Rincon pipeline to provide inflow to the Upper Rincon Bayou and participated in studies with the Coastal Bend Bays and Estuaries Program to study the impacts of freshwater pumped through the Rincon pipeline on reducing salinity levels in the Nueces Delta.[5] According to USACE studies, pulsed flow at certain times of the year are more beneficial than small pass-throughs in dry months. Salinity monitors have been positioned throughout the estuary to track flow rate and retention time of water diverted through the Rincon Pipeline. The City continues to support programs to monitor salinity and gages.[6]

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[3] Concluding Report: Allison Wastewater Treatment Plant Effluent Diversion Demonstration Project, Volume I: Executive Summary. The University of Austin, Marine Science Institute, Port Aransas, Texas and Texas A&M University-Corpus Christi, Center for Coastal Studies, Corpus Christi, Texas, 2006.
[4] City of Corpus Christi, Final Integrated Monitoring Plan Fiscal Year 2005, January 2005.
[5] Coastal Bend Bays and Estuaries Program, "Nueces Delta Salinity Effects from Pumping Freshwater into the Rincon Bayou: 2009 to 2013," August 2013.
[6] City of Corpus Christi staff, April 3, 2015.

These agreements and their history are very important and must be considered in water supply planning, water reuse options, and water management programs for the Corpus Christi area. In the following subsections of this report, estimates of the quantities of municipal and industrial wastewater currently discharged are presented, and wastewater reuse practices and plans by cities and industries, and potential wastewater diversion to the Nueces Delta are described.

5D.5.2 Inventory and Location of Existing Wastewater Sources

There are about 62 active, permitted domestic and industrial WWTP discharges that discharge to the Corpus Christi Bay System in the 11-county Coastal Bend Region. These domestic and industrial discharges totaled about 81,728 ac-ft in 2013 and 87,060 ac-ft in 2014 based on annual discharges summarized in the TCEQ and Nueces River Authority's 2014 Effluent Monitoring Report (Table 5D.5.1).

The 2001 Agreed Order assumes return flows of 54,000 ac-ft/yr to the Corpus Christi Bay to alleviate hypersaline conditions in the Nueces Bay and Delta. A credit of 6,000 ac-ft/yr is provided for return flows delivered to the Nueces Delta system. Treated wastewater effluent volume exceeding this amount is potentially eligible for recovery and reuse, prior to releasing as return flow.

Figure 5D.5.1 shows the location of the City of Corpus Christi WWTPs, which are the major municipal discharges into the system. In 2014, of the 87,060 ac-ft, major municipal/domestic discharges generated about 54,858 ac-ft/yr and are italicized in Table 5D.5.1 (63 percent), while industrial discharges generated about 32,202 ac-ft/yr (37 percent).

5D.5.3 Local Wastewater Treatment Plant Considerations

Since the 1995 Trans-Texas Water Program Study, the City of Corpus Christi has initiated some programs related to their wastewater facilities plan that may impact analyses of alternatives for diversions of effluent to the Nueces Delta. The changes include the construction and operation of the Allison WWTP Nueces Delta Demonstration Project, and considering wastewater treatment plant consolidation at Greenwood WWTP.

In mid-1997, the City began preparing a plan to work with State and Federal agencies involved with the Agreed Order that would provide the freshwater flow needs of the Nueces Bay System during drought conditions through diversions of treated wastewater effluent, rather than the passage of CCR/LCC System inflows. The strategy involved constructing and operating facilities to divert both industrial and municipal wastewater effluents to locations in the Nueces Delta based on the productivity benefits determined by the preliminary findings from the Allison WWTP Project.

Table 5D.5.1.
Summary of Annual Permitted Wastewater Discharges for 2013 and 2014 into the Corpus Christi Bay and Nueces Bay System[1,2]

Facility	***2013 Discharge (ac-ft/yr)***	***2014 Discharge (ac-ft/yr)***
Town of Woodsboro	*139.24*	*136.81*
City of Sinton	*391.74*	*473.35*
Texas Department of Transportation	N/A	0.18
Rob & Bessie Welder Park	*4.73*	*4.73*
St. Paul WSC	*23.32*	*21.47*
City of Beeville-Chase Field	*N/A*	*1,337.85*
City of Beeville-Moore St.	*N/A*	*2,433.34*
Flint Hills Resources	1,891.69	1342.43
City of Corpus Christi - Allison	*3,006.28*	*2967.61*
San Patricio County MUD #1	*17.77*	*20.36*
City of Agua Dulce	*24.31*	*57.06*
City of Orange Grove	*148.44*	*158.36*
City of Driscoll	*54.91*	*48.23*
Nueces County WCID #5	*16.94*	*61.99*
Bishop CISD	*0.95*	*1.29*
LCS Nueces Detention Facility	*82.15*	*52.8*
City of Rockport	*859.84*	*1005.01*
Holiday Beach WSC	*40.29*	*30.05*
City of Taft	*295.26*	*319.86*
Town of Bayside	*2.73*	*7.18*
E.I. Du Pont De Nemours and Co.	9,758.11	10,015.08
U.S. Department of the Navy - Corpus Christi NAS	369.31	363.9
Occidental Chemical Corp.	1,395.45	1343.65
Texas A&M University System Shrimp Mariculture Research	*164.70*	*81.25*
City of Gregory	*99.55*	*113.45*
City of Ingleside	*746.69*	*711.01*
Nueces County WCID #4 Mustang Island North Plant	*1,109.56*	*1,106.20*
City of Odem	*172.87*	*158.5*
City of Portland	*1,632.92*	*1666.13*
Sublight Enterprises, Inc.	N/A	1.96
City of Aransas Pass	*234.19*	*484.73*
Gulf Marine Fabricators	7.43	3.71
Martin Operating Partnership LP	*N/A*	*0.80*
American Chrome and Chemicals	*5,802.44*	*6,967.91*
Flint Hills Resources	*1,098.29*	*1,140.39*
Valero Refining, East Plant	*1,638.48*	*1,753.93*
Citgo Refining and Chemicals	2,835.28	8,788.97
Flint Hills	9,187.91	4,372.69
Valero Refining, Texas LP	3,770.66	3,090.48
Equistar Chemicals, LP	915.76	990.33
BTB Refining (Trigeant Ltd.)	24.24	3.54

Facility	***2013 Discharge (ac-ft/yr)***	***2014 Discharge (ac-ft/yr)***
Markwest Company	0.00	N/A
John Bludworth Shipward	*640.39*	*782.04*
City of Corpus Christi - Broadway	*4,433.62*	*4,341.86*
City of Corpus Christi - Oso	*12,552.36*	*12,359.94*
City of Robstown	*1,344.17*	*1,287.71*
City of Corpus Christi - Greenwood	*5,770.12*	*5,953.64*
Corpus Christi Peoples Baptist Church	*8.38*	*3.80*
Tennessee Pipeline Construction Company	*17.80*	3.41
City of Corpus Christi - Laguna Madre	*1,464.47*	*1,477.36*
City of Corpus Christi - Whitecap	*9,002.16*	*1,032.99*
Duval County CRD	*9.42*	*7.69*
Kleberg County Kaufer-Hubert Memorial Park	*N/A*	*5.01*
Kleberg County	*28.91*	*26.69*
Tocona Polymers	*1,808.06*	1,827.75
San Diego MUD #1	*383.61*	*354.65*
City of Bishop	*155.10*	*142.97*
City of Alice-South Plant	*1,335.03*	*1,386.11*
City of Alice- North Plant	*767.25*	*745.10*
City of Kingsville	*1,631.79*	*1,327.39*
City of Kingsville	*431.03*	*302.96*
U.S. Department of the Navy - Kingsville NAS	*80.07*	52.78
Total Discharges	***81,728***	***87,060***

[1] These wastewater dischargers are recognized by the Nueces River Authority and the TCEQ as contributors to freshwater inflows to the Nueces Estuary System.

[2] Annual wastewater discharged, in ac-ft, for 2013 and 2014. Total Municipal/Domestic discharges in 2013 – 49,666 ac-ft. Total Industrial Discharges in 2013 – 32,062 ac-ft.
Total Municipal/Domestic discharges in 2014 – 54,858 ac-ft. Total Industrial Discharges in 2014– 32,202 ac-ft. *Italicized facilities were included in total municipal/domestic discharge calculation.*

Source: TCEQ and Nueces River Authority's 2014 Effluent Monitoring Report.

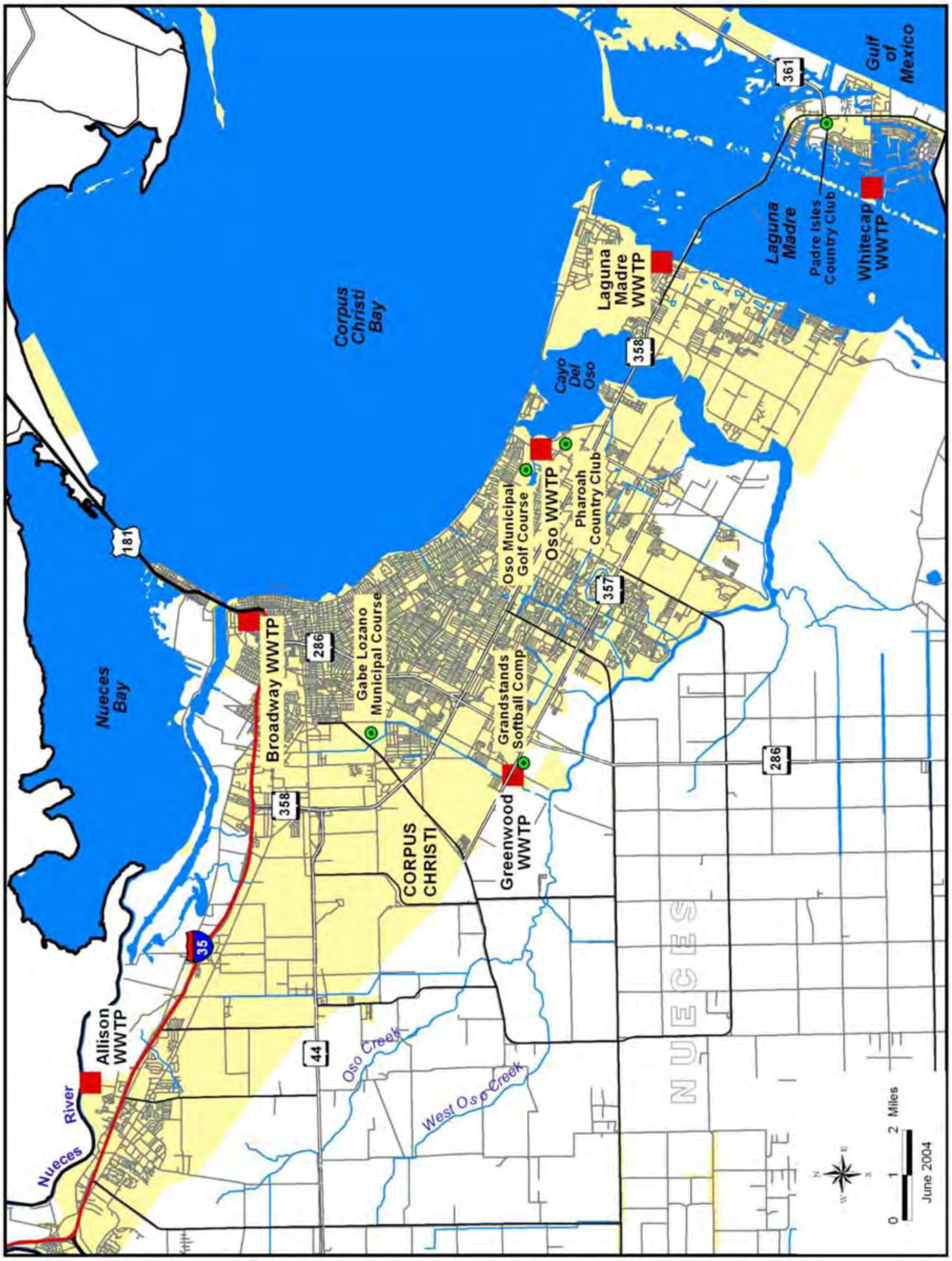

Figure 5D.5.1.
City of Corpus Christi Wastewater Treatment Plants

In 1997 to 1998, the City constructed a pipeline from the Allison WWTP to the Nueces Delta as part of a demonstration project to assess the impact of the WWTP effluent on the estuary. The Allison WWTP Demonstration Project was completed and in October 1998, the City began diverting approximately 2 million gallons per day (or 2,240 ac-ft/yr) of effluent from Allison WWTP to the Nueces Delta. Intensive data collection programs were conducted for 5 years (from 1999 to 2003) and the final summary report was issued in 2006 summarizing study results.[7] At this time, Allison WWTP effluent delivery to the Nueces Delta has been discontinued since effluent quality does not meet current TCEQ water quality standards for receiving bodies.[8]

The 2001 Agreed Order allows the City relief from inflow requirements when the reservoir system is below 30 percent and Drought Condition III has been implemented, however return flows directed at the Nueces Bay and/or Nueces Delta shall continue. The changes in the operating plan maintain the freshwater availability for Nueces Bay through return flows during drought conditions and increase the amount of dependable water supply available from the CCR/LCC System for municipal and industrial use.

An important issue associated with any diversion of domestic wastewater to the Nueces Delta is the level of wastewater treatment necessary for the wastewater diverted. Studies to date have shown that the enhancement of productivity in the Delta is dependent upon the volume of freshwater flow and concentration of nutrients in the wastewater; therefore, effluent treated to a higher quality may prove to be less effective for primary production in the Delta. Thus, the cost savings in wastewater treatment to remove more nutrients would lower the overall costs of implementing projects to divert wastewater to the Nueces Delta and thereby further reduce the costs of yield recovered from the CCR/LCC System.

In January 2004, a study[9] was conducted to evaluate groundwater discharge to the Nueces Bay and quantify the potential nutrient flow to the Bay from groundwater. Nitrate concentrations were used to measure nutrients. The results indicated between 15,000 to 40,000 kg of nitrate are released to the Nueces Bay through groundwater discharge. This estimate is only exceeded as a source of nitrogen by treated wastewater return flows.

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[7] City of Corpus Christi, "Concluding Report: Allison Wastewater Treatment Plant Effluent Diversion Demonstration Project, Volume I: Executive Summary and Volume II: Monitoring Results 1997-2003," October 2006.
[8] City of Corpus Christi staff, February 2015.
[9] Breier, Edmonds, and Villareal, "Submarine Groundwater Discharge and Associated Nutrient Fluxes to the Corpus Christi Bay System," January 2004.

5D.5.4 Choke Canyon/Lake Corpus Christi Yield Recovery through Diversion of the City of Corpus Christi WWTP Effluent and/or Freshwater River Diversions through the Rincon Pipeline to the Nueces Delta

5D.5.4.1 Description of Project

The 1992 Interim Order established operational procedures and included a monthly schedule of desired inflows to Nueces Bay to be comprised of releases, spills, and return flows from the CCR/LCC System. The 1992 Interim Order directed studies of several topics including effects of releases upon the reservoir system and the feasibility of relocating wastewater discharges to locations where increased biological productivity could justify an inflow credit computed by multiplying the amount of discharge by a number greater than one.[10] Studies have been conducted to evaluate increased productivity from diverting a combination of Nueces River water and wastewater through the Nueces Delta to Nueces Bay instead of releasing river and wastewater flows directly into the Nueces River. Prior to reopening the Rincon Bayou Demonstration Project in 2001, the Nueces River bypassed the Nueces Delta and flowed directly into Nueces Bay except during periods of high flow (Figure 5D.5.2). Previous studies have shown that diversions of both river water and treated wastewater to the Nueces Delta can be expected to increase primary production by factors of about three to five, respectively, when compared to allowing these waters to enter Nueces Bay via the Nueces River.[11]

In a study[12] performed in 1993, estimates were made of the increase in yield of the CCR/LCC System for alternative river and wastewater diversions under the 1992 Interim Order, considering a productivity increase factor of three for freshwater river diversions and five for wastewater effluent diversions to the Nueces Delta. The 1993 study showed that of diversion alternatives evaluated, the highest yield recovery and lowest cost per acre-foot of yield recovered for treated wastewater alternatives was the alternative which uses 8.8 mgd (or 820 ac-ft/mo) of wastewater from the Allison and Broadway WWTPs. This alternative was reevaluated under the 1995 Agreed Order with and without biological productivity factors for wastewater diversions to the delta.[13] As shown previously in the 2011 Plan, the average annual yield recovered for 8.8 mgd treated wastewater from the Allison and Broadway WWTPs is 1,100 ac-ft/yr without biological productivity multipliers.

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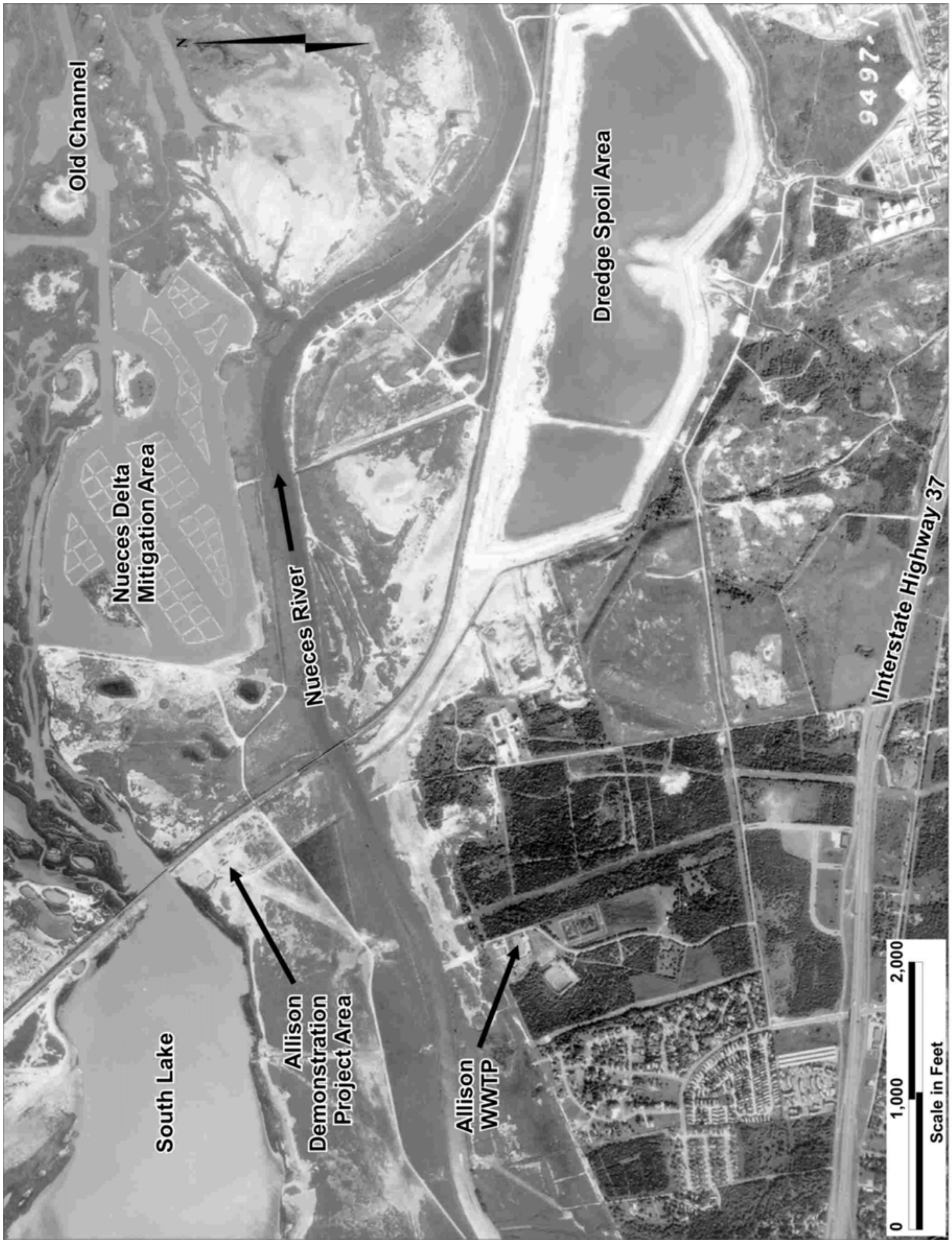
[10] Interim Order Establishing operational Procedures Pertaining to Special Condition 5.b., Certificate of Adjudication No. 21-3214, held by the City of Corpus Christi, Nueces River Authority, and the City of Three Rivers, Texas Water Commission, Austin, Texas March 9, 1992.
[11] HDR Engineering, Inc. (HDR), et al., "Regional Wastewater Planning Study – Phase II, Nueces Estuary," prepared for the City of Corpus Christi, et al., Austin, Texas, June 1993.
[12] Ibid.
[13] HDR et al., "Trans-Texas Water Program – Corpus Christi Study Area – Phase II Report," City of Corpus Christi, et al., September 1995.



Source: Naismith Engineering, Inc.

Figure 5D.5.2.
Diversion of Corpus Christi WWTP Effluent to the Nueces Delta

The 2001 Agreed Order maintains the same monthly inflow requirements based on CCR/LCC storage capacities as the 1995 Agreed Order, with an added requirement to operate a conveyance facility to deliver up to 3,000 ac-ft/mo from Calallen Pool to Upper Rincon Bayou. As mentioned previously, the conveyance facility has been constructed and is being operated by the City of Corpus Christi.

5D.5.4.2 Available Yield

This strategy is updated for the Coastal Bend 2016 Regional Water Plan and assumes that 2 mgd of wastewater from Allison WWTP and up to 32 mgd (or up to 3,000 ac-ft/mo) of river water from Calallen Pool through the Rincon Pipeline could be discharged into the Nueces Estuary with minimal or no infrastructure improvements. *For this strategy to be considered feasible with or without biological productivity multipliers, Allison WWTP effluent will need to meet TCEQ's water quality standards for delivery to the Nueces Estuary.*

Based on the yield recovery discussed above for a 8.8 mgd treated wastewater project, 2 mgd of wastewater from the Allison WWTP would be expected to yield 250 ac-ft/yr without biological productivity multipliers. A series of model runs were performed using the updated Corpus Christi Water Supply Model [formerly known as the Lower Nueces Basin and Estuary Model (NUBAY) in the previous Coastal Bend Regional Water Plans] to evaluate these scenarios for increased system yield. A series of runs were performed to determine and quantify water supply benefits associated with different quantities of water being delivered to the Nueces Estuary for a range of biological multipliers.

Two different diversion rates of 11 and 32 mgd (1,000 and 3,000 ac-ft/mo, respectively) were evaluated for the Rincon Pipeline using multipliers of 2–5. Recent discharges into the Nueces Bay were summarized using the latest information available from the EPA website and confirmed that about 5.35 mgd of treated effluent is currently being discharged into the Nueces Bay area. However, of this 5.35 mgd only 2 mgd of effluent, proposed from the Allison WWTP owned by the City of Corpus Christi, was evaluated with the 2–5 multipliers for this water management strategy. This is the only readily accessible supply that has been and could easily be discharged directly into the Nueces Estuary. Another set of scenarios were developed that combined a 2 mgd treated wastewater diversion with that of the 11 mgd (or 1,000 ac-ft/mo) river water diverted through the Rincon Pipeline.

Table 5D.5.2 summarizes the model simulation results. The yield increase ranges from just under 1,000 ac-ft for diverting 2 mgd of treated wastewater to the Nueces Estuary with a multiplier of 2 to over 17,000 ac-ft with a river diversion of 32 mgd and a multiplier of 5. A 2 mgd treated effluent diversion project with a multiplier of 5 is roughly equivalent in terms of increased yield to a combination project of 13 mgd diverted to the Nueces Estuary (11 mgd of river water and 2 mgd of treated effluent) with a multiplier of 2. The 32 mgd scenarios produce the highest yield increases compared to the other scenarios. By changing a biological multiplier of 2 to 5, at least for the volumes evaluated herein, an increase of about 2.4 to 2.5 times in firm yield would be expected.

Table 5D.5.2.
Summary of Average Annual Yield Recovered for Various Wastewater Transfer and River Diversion Alternatives

Diversion or Transfer Capability		*Biological Productivity Factors*		*Average Annual Yield Recovered (ac-ft)*
River Diversion (mgd)	*Allison WWTP (mgd)*	*River Water*	*Wastewater*	
11 mgd (1,000 ac-ft/mo) River Water Diversion from Rincon Pipeline				
11	0	2	—	4,254
11	0	3	—	7,062
11	0	4	—	8,843
11	0	5	—	10,298
2 mgd (186 ac-ft/mo) Effluent Discharge from Allison WWTP				
0	2	—	2	935
0	2	—	3	1,972
0	2	—	4	2,964
0	2	—	5	4,894
11 mgd River Water Diversion + 2 mgd Effluent Discharge (1,186 ac-ft/mo)				
11	2	2	2	4,713
11	2	3	3	8,119
11	2	4	4	10,254
11	2	5	5	11,961
32 mgd (3,000 ac-ft/mo) River Water Diversion from Rincon Pipeline				
32	0	2	—	7,019
32	0	3	—	10,365
32	0	4	—	12,936
32	0	5	—	17,060[1]

[1] This value was estimated using the ratio of the increased yield associated with the 4 to 5 multiplier for the 11 mgd runs and the combined 11 mgd plus 2 mgd runs.

5D.5.4.3 Engineering and Costs

Much of the infrastructure is already in place for this water management strategy. The Rincon Pipeline was built by the City of Corpus Christi and became operational in November 2007. The City has used the facility to deliver some of the fresh water inflow targets from the Calallen pool over to the Rincon Bayou area of the Nueces Estuary. The Allison WWTP owned and operated by the City of Corpus Christi also has some infrastructure still in place from the Allison demonstration project. These facilities can deliver about 2 mgd from the plant.

The estimated operating costs to deliver 2 mgd from the Allison WWTP are approximately $84,000 per year. This annual costs produces a unit cost ranging from $90.23 per ac-ft for a multiplier of 2 down to $17.25 per ac-ft for a multiplier of 5.

The estimated annual operating costs for the Rincon Pipeline are $150,000[14] for delivering 11 mgd, which results in unit costs ranging from $109.07 per ac-ft for a multiplier of 2 down to $45.08 per ac-ft for a multiplier of 5.

If the options were combined with both the 11 mgd of river water and 2 mgd of effluent the annual operating costs are estimated to be $548,000. This annual costs produces a unit cost ranging from $116.35 per ac-ft for a multiplier of 2 down to $45.85 per ac-ft for a multiplier of 5.

5D.5.5 Environmental

A key concern regarding use of biological multipliers applied to water that goes to meet the Agreed Order freshwater inflow targets for the Bay and Estuary is that it reduces the volume of that target for a specifically placed lesser quantity of freshwater-quality water. For example, if the B&E target were 2,000 ac-ft for a month, and 1,000 ac-ft were being diverted from the Calallen pool and being discharged into the estuary at a 2 multiplier, the target would be satisfied, and the environment in the estuary would likely benefit at least twice as much from the discharge, but only 1,000 ac-ft of water was physically passed into the bay and estuary. So while there is certainly some benefit, there are also impacts that would need to be considered prior to implementation of biological productivity multipliers. The analysis performed for this strategy showed a range of median estuary inflow reduction of a minimum of 200 ac-ft/yr to a maximum of 2,900 ac-ft/yr depending on size of project and multiplier.

The City of Corpus Christi has evaluated benefits that may be achieved by aggregating freshwater inflow targets for multiple months. The analyses include consideration of holding target inflows for months that have smaller targets and combining with larger target months to provide larger pass-through during critical months for biological productivity. This practice is not active being implemented at this time.

[14] Estimate provided by the City of Corpus Christi, March 26, 2015.

5D.5.6 Wastewater Reuse Considerations for Municipal and Industrial Purposes

5D.5.6.1 Texas Administrative Code, Chapter 210 – Use of Reclaimed Water

There are two general qualities of treated wastewater allowed for reclaimed water use under TCEQ rules, Chapter 210. These are grouped and defined as Type I and Type II uses.

Broadly defined, Type I reclaimed water quality is required where contact between humans and the reclaimed water is likely. The types of water uses for which Type I reclaimed water could be generally used are:

- Residential irrigation;
- Urban irrigation for public parks, golf courses with unrestricted public access, school yards or athletic fields;
- Fire protection;
- Irrigation of food crops where the reclaimed water may have direct contact with the edible part of the crop;
- Irrigation of pastures for milking animals;
- Maintenance of water bodies where recreation may occur;
- Toilet or urinal flushing; and
- Other similar activities where unintentional human exposure may occur.

Type I water can also be used for all Type II uses listed below.

Type II water quality is where such human contact is unlikely. The types of water uses that would generally be considered as eligible for Type II reclaimed water are:

- Irrigation of sod farms, silviculture, limited access highway rights-of-way, and other areas where human access is restricted (restricted access can include remote sites, fenced or walled borders with controlled access, or the site not being used by the public when normal irrigation operations are in process);
- Irrigation of food crops where the reclaimed water is not likely to have direct contact with the edible part of the crop;
- Irrigation of animal feed crops, other than pasture for milking animals;
- Maintenance of water bodies where direct human contact is unlikely;
- Certain soil compaction or dust control uses;
- Cooling tower makeup water;
- Hydraulic fracking;
- Irrigation or other non-potable uses of reclaimed water at a wastewater treatment facility; and
- Any eligible Type I water uses.

At a minimum, the TCEQ requires that the reclaimed water will be of the quality specified in the rules (Table 5D.5.3).

Table 5D.5.3.
Quality Standards for Using Reclaimed Water (30-day Average)

Type I	
BOD_5 or $CBOD_5$	5 mg/L
Turbidity	3 NTU
Fecal Coliform	20 CFU/100 mL (geometric mean)
Fecal Coliform (not to exceed)	75 CFU/100 mL (single grab sample)
Enterococci	4 CFU/100 mL (geometric mean)
Enterococci (not to exceed)	9 CFU/100 mL (single grab sample)
Type II Other than Pond Systems	
BOD_5	20 mg/L
or $CBOD_5$	15 mg/L
Fecal Coliform	200 CFU/100 mL (geometric mean)
Fecal Coliform (not to exceed)	800 CFU/100 mL (single grab sample)
Enterococci	35 CFU/100 mL (geometric mean)
Enterococci (not to exceed)	89 CFU/100 mL (single grab sample)
Type II Pond Systems	
BOD_5	30 mg/L
Fecal Coliform	200 CFU/100 mL (geometric mean)
Fecal Coliform (not to exceed)	800 CFU/100 mL (single grab sample)
Enterococci	35 CFU/100 mL (geometric mean)
Enterococci (not to exceed)	89 CFU/100 mL (single grab sample)

mg/L = milligrams per liter
BOD_5 = Biochemical Oxygen Demand (5-day)
C/BOD_5 = Carbonaceous Biochemical Oxygen Demand (5-day)
CFU/100 ml = Colony Forming Units per 100 milliliter

Source: TAC §210.33 - accessed March 2015

5D.5.6.2 Industrial Wastewater Reuse

In general, primary industrial customers utilize similar facility processes that are mainly responsible for water consumption, such as cooling towers and boilers. In addition, industry also uses freshwater for drinking water, sanitary use, and equipment washdown and fire protection. The primary differences in water usage, however, are product related. Process requirements influence the size and type of cooling systems and boilers needed for steam production. Process and product differences affect water quantity and quality needs. Depending on the industrial facility's plant size, age, and market conditions, different plants in the same industry category can have different water needs and water use efficiencies.

The petroleum refinery and petrochemical industries produce numerous products such as fuel oil, gasoline, petrochemicals and kerosene. The diverse chemical manufacturing industry served by the City of Corpus Christi water system produces various products such as high quality plastics, weather resistant paints, alumina, chromium compounds, Freon, adhesives, formaldehyde, synthetic resins, and pharmaceuticals. In general, the chemical manufacturing industry requires more water per unit production due to the nature of the chemical manufacturing process and the water content of certain produced chemicals.

In most area industries, heat dissipation is the single largest demand for water within a plant. Typically, water is used to remove heat from process streams. The heated water is cooled by a cooling water system. Cooling water systems in the study area are either recirculating freshwater cooling systems, which use cooling towers, or are once-through cooling systems. Once-through cooling systems in the study area are primarily steam-electric power plants that use very large volumes of seawater to cool the steam (for reuse) required to turn turbines for electric power generation. In order to prevent unacceptable build-up of minerals and salts, a portion of the cooling water from the cooling tower is discharged or blown down. Thus a continuous supply of new water (make-up) is required to supplement the freshwater lost due to evaporation and blow down.

Boiler-feed water is the second largest use of freshwater. This involves heating water to produce steam for process use. Steam is used to add heat to process streams and to power turbines for generating electricity. Steam is also used to drive pumps, compressors and fans, as well as in the process to facilitate fractionation in petroleum refineries and chemical plants. This steam is condensed and returned to the boiler feed water system to be reused.

The third largest industrial use of City water is in the process stream, where water is used as a feedstock, for example, in the reforming process to produce hydrogen in refineries and to scrub air contaminants (cleaning a contaminated airstream with a liquid), in digesters, or for chemical and product separation. The remaining use of freshwater within industry is primarily for drinking water, sanitary use, equipment washdown, and fire protection.

For most chemical and refining plants, cooling accounts for 60 to 75 percent of the water use, boiler water use accounts for 20 to 30 percent, process water accounts for 5 to 9 percent, and potable or sanitary use accounts for 1 percent. Chemical plants typically utilize more water in their process streams and in their products, while refineries, which produce steam for electrical generation, utilize more water for boiler use.

The following factors influence and control current water use, the potential for industrial water conservation, and the potential for area industries to use alternative sources of water, including treated municipal wastewater, brackish groundwater, and seawater. The list of important factors includes:

- The location of each water-using industrial plant in relation to a source or sources of water;
- The location of each water-using industrial plant in relation to streams or other features into which wastewater can be discharged;

- The type of industry, which determines the type of water use (i.e. refineries which use varying and/or different grades of crude petroleum, refineries which are producing reformulated gas, chemical plants which produce a range of chemicals and pharmaceuticals, and plants which extract compounds from ores to produce metals and other products); and
- The metallurgy of equipment in the cooling system that would come in contact with the cooling water.

5D.5.7 Current Reuse Projects in the Coastal Bend Region

5D.5.7.1 Municipal and Irrigation Reuse Projects in the Coastal Bend Region

A summary of the existing municipal wastewater reuse projects currently in operation in the Coastal Bend Region is presented in Table 5D.5.4. Many of these projects are discussed in more detail in the subsequent sections.

Table 5D.5.4.
Existing Municipal Wastewater Reuse for the City of Corpus Christi in 2012

Facility	*Use*	*Flow (mgd)*
Allison WWTP	Texas Veterans Cemetery (Start Date - Sept 2012)	0.04
Whitecap WWTP	Padre Island Golf Course	0.60
Laguna WWTP	Naval Air Station Golf Course (Start Date - May 2012)	0.26
Greenwood WWTP	Gabe Lozano Golf Course	0.32
Greenwood WWTP	Grandstand-Champions Park (Seasonal)	0.003
Oso WWTP	Southside Corpus Christi Country Club*	0.00
Oso WWTP	Oso Golf Course	0.20

* Operation started in 2013.
Source: E-mail. Diana Zertuche Garza. March 30, 2015.

The City of Corpus Christi's present water conservation and reuse plans emphasize education and changes to the water rate structure to promote conservation and reuse. Water customers have been requested to reduce water usage wherever possible through the installation of more efficient plumbing fixtures and through landscape watering schedules. The City adopted plans to reduce water use by diverting a portion of its WWTP effluent to some public facilities for irrigation purpose (i.e. for golf course and park irrigation). Currently, the City has reuse facilities at five of their WWTPs, which serve three golf courses, the Veterans cemetery, Corpus Christi Country Club, and the Naval Air Station.[15] The City completed Oso Plant Effluent Reuse Improvements to include two new golf courses and one sports complex that currently irrigate with potable (municipal) water supplies. The following improvements that were completed by

[15] Information regarding existing Reuse was provided by the City of Corpus Christi, February, 21013.

the City included: 1) Oso WWTP Effluent Diversion Pump Station; 2) 18,276 LF of 16" Effluent Distribution Main; 3) 9,905 LF of 16" Effluent Force Main for King's Crossing Lateral; and 4) 3,000 LF of 16" Effluent Force Main for Bill Witt Park Lateral. In addition to the existing reuse projects at Allison WWTP, Greenwood WWTP, Oso WWTP, Laguna Madre WWTP, and Whitecap WWTP, potential effluent to refineries along ship channel from Greenwood WWTP or Regional WWTP site may be established.

Although an Agreed Order with the TCEQ is in place that requires the City to release a portion of their WWTP effluent into local bay systems as freshwater inflows, it is estimated that from the Oso WWTP alone, there is still an available supply of approximately 7.0 mgd (7,848 ac-ft/yr) that could be used for irrigation while still meeting the pass-through requirements of the TCEQ Agreed Order. In 2012, about 220 ac-ft of Oso WWTP effluent was used by the Oso Golf Course. Oso WWTP effluent is also used by Hans Sutter Park, Texas A&M University, Youth Sports Complex, and Southside- Corpus Christi Country Club. If additional reuse of 550 ac-ft is made available for the City's proposed Oso Plant Effluent Reuse Improvement projects, the amount of supply captured by these additional proposed projects would be, less than 10% of the available effluent supply from Oso WWTP. It is possible that the infrastructure that will be put in place by this strategy would yield more supply, however, additional customers beyond these two golf courses and the Bill Witt Park sports complex have not been identified or quantified at this time.

In the year 2012, the City provided a total of 1,450 ac-ft of effluent to four golf courses, one cemetery, and one sports complex. This practice has some limitations, as the need for waste-water for irrigation is not continuous and is often highly variable. Thus, the wastewater is not reused in the same amount every month. For example, it is not used after heavy rains and it is not used during winter months when the grass is not growing and will not consume the wastewater. For example, in 2001, wastewater reuse from the City's WWTPs for golf course and baseball park irrigation was about 394 million gallons (or 1,210 ac-ft/yr). In 2002, the wastewater reuse was reduced to 333 million gallons (or 1,020 ac-ft).

5D.5.7.2 Industrial Reuse Projects in the Coastal Bend Region

The water quality requirements of industry in the area are determined by the water quality constraints for cooling tower make-up, boiler make-up, process water, and potable water. Since water used for cooling tower make-up and boiler make-up are the predominant industrial uses of water, the opportunities to substitute alternative water sources for cooling towers, and boiler make-up present the greatest potential opportunities to conserve existing freshwater supplies which is discussed in detail in Chapter 5D.3. Because cooling tower make-up can utilize water of poorer quality as compared to the high quality water required in a boiler, the reuse of waste-water effluent in cooling towers provides the best opportunity for this alternative water supply.

The quality of water used by an industry can have numerous impacts on their facilities. Industrial process equipment can degrade, cooling efficiency can be reduced, health and safety problems can develop, and permitted wastewater discharge limits can be exceeded if the water has undesirable qualities. The most frequent water quality problems within industrial water systems are scaling, corrosion, biological growth, fouling, and foaming. In addition, permitted wastewater discharge parameters, as well as cooling tower solid waste characteristics, are influenced by cooling tower water quality. Solid wastes generated from water treatment and control facilities such as cooling tower basin sludge, have characteristics that affect the costs of handling and disposal, triggering new regulatory requirements, and may affect waste minimization programs.

The high degree of purity required for boiler water is critical because it is used to make steam. If water quality is not properly controlled, contamination from minerals such as calcium and magnesium will be deposited on boilers, restricting the transfer of heat to the boiler water. In addition, boiler metal will corrode and deposits in the steam system will adversely affect the other equipment. Water sources, which have higher concentrations of minerals, create a greater potential for requiring costly pretreatment. During the drought of 1984, the City considered diverting treated wastewater to local industrial facilities for cooling tower make-up water in an attempt to reduce the quantity of CCR/LCC System water needed for these purposes. However, this plan was severely limited as the WWTPs are not conveniently located and the discharge is not readily available to industrial plants, requiring the construction of extensive force mains to deliver the wastewater to these facilities. In addition, high chloride concentrations existed in the wastewater effluent, particularly from the Broadway WWTP, making this source unattractive since high chloride concentrations require costly treatment before industries can use the water.[16] The City then requested that its industrial water customers minimize water use from the CCR/LCC System without seriously jeopardizing production. Industry representatives responded by carefully studying ways to reduce water demands through increased efficiency in the use of existing supplies, reuse of available supplies, and development and use of alternative water supplies. In response to water shortages during the drought of 1984, concerns about rising costs of water, increased regulation and rising costs of wastewater treatment and disposal, and public interest in water conservation, Corpus Christi area industries implemented water conservation and water reuse measures that have significantly reduced quantities of water needed per unit of production. For example, Corpus Christi area petroleum refineries use between 35 and 46 gallons of water per barrel of crude oil refined, while refineries in Houston use 91 gallons, and refineries in Beaumont use 96 gallons.

As a result of these events, the major Corpus Christi area industrial customers have implemented various water conservation measures since the 1984 drought period, particularly during periods of plant expansion. Since 1984 there has been increasing quantities of water conserved by local industry. Nueces County Manufacturing and San Patricio Manufacturing are currently utilizing 1,140 ac-ft/yr and 448 ac-ft/yr of direct recycled reuse respectively. Provided in Table 5D.5.5 is a list of water conservation measures, which have been implemented by industry as well as future water conservation strategies, including wastewater reuse. In comparison to other Texas industry, the industries in Corpus Christi have one of the best records of water use efficiency based on results of the TWDB's "Pequod Survey".[17]

[16] During the 1984 drought, one refinery used some wastewater from the City's Broadway Wastewater Treatment Plant. The treated wastewater was mixed with the treated water and the refinery's industrial wastewater but required 8 hours of chlorination to control viruses and lime softening to control hardness.
[17] Texas Industrial Water Usage Survey, Pequod Associates, Inc. and TWDB, Austin, Texas, August 1993.

Table 5D.5.5.
Water Conservation Measures - Corpus Christi Area Industry

Current Measures
• Recycling Cooling Tower and Boiler Blowdown • Improved Control Systems • Dry Cooling, Air Cooled Heat Exchangers • More Efficient Drift Eliminators • Changed Washdown Procedures • Automatic Cooling Tower Blowdown • Leak Detection/Repair • Steam Condensate Recovery • Reuse Wastewater Treatment Effluent for Firewater, Cooling Tower Make-up • Cycling-Up Cooling Towers • Stormwater Reuse • Salt Water for Area Washdown • Salt Water Lubrication of Circulating Water Feed Pumps • Reverse Osmosis with Demineralization • Voluntary Water Conservation Planning • Regulatory Requirement to Consider Reuse • Saltwater for Cooling
Future Measures
• Uniform blending of Lake Texana/Nueces River waters to provide consistently better water quality with less variation in dissolved minerals. • Increased Evaluation of Alternative Water Sources to Replace Treated City Water • Additional Application of Reverse Osmosis Treatment • Increased Wastewater Treatment Plant Effluent Reuse • Possible Side-Stream Softening • New Process Changes • Additional Steam Leak Repair • New Chemical Treatment Technology • Increased Water Audit by Industry • Possible Water Conservation Incentives • Possible Regulatory or Local Government Water Conservation Planning Goals • Increasing Water Conservation Research and Education • Additional Industry Pursuing Water Conservation Measures

5D.5.8 Identified Potential Future Reuse Projects in the Coastal Bend Region

Water conservation can impact the quantity of wastewater generated, and thus available for reuse and/or for credit to meet freshwater needs of the Nueces Estuary. Figure 5D.5.3 shows that while the general population of the City of Corpus Christi is growing, the total quantity of wastewater treated and discharged has remained relatively constant. The increase in population from 2009 to 2010 is likely attributed to a “calibration” of population data associated with the 2010 census collection efforts. The reduction of wastewater return flows from 2011 to 2013, a reduction of about 18% from 2010, is likely attributed to effective water conservation practices during drought years.

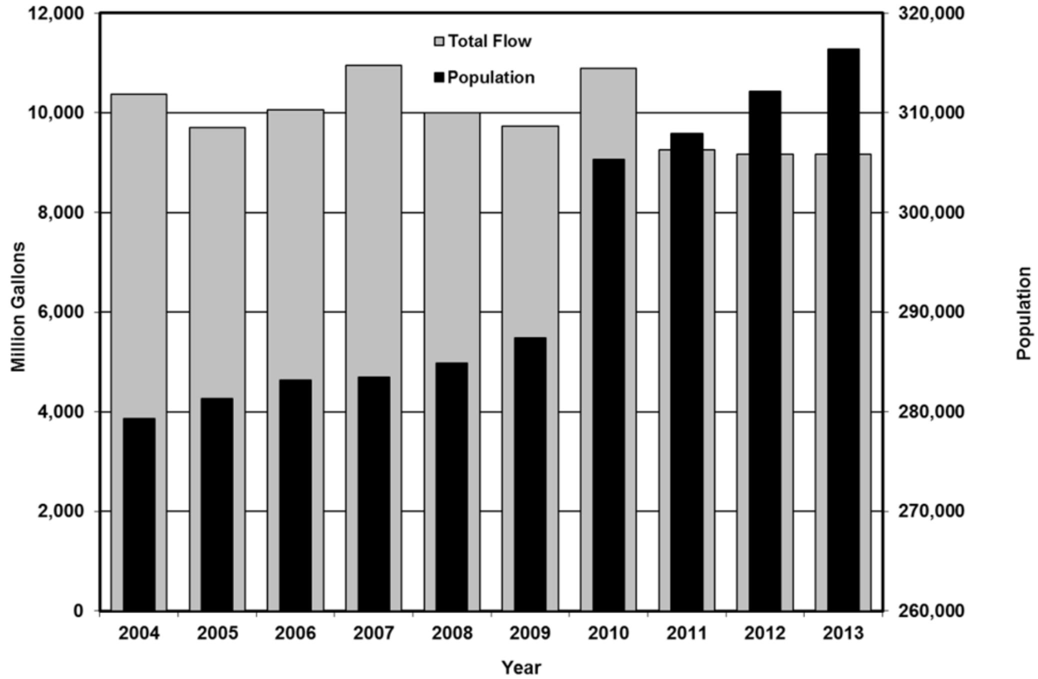


Figure 5D.5.3.
City of Corpus Christi Wastewater Flows versus Population

5D.5.8.1 City of Corpus Christi Wastewater Effluent to Nueces Industries

The City of Corpus Christi views water reuse as an important component of the region's future water supply and has received authorization from TCEQ to use and deliver recycled water. The city included water reuse as a best management practice in their water conservation plan and adopted a recycled water Ordinance in July 2013. The City is also considering a centralized wastewater treatment facility which may be desirable for providing reuse supplies to Nueces County-industries in hopes of improving the drought resiliency of their operations and increasing the sustainability of their company. This project would benefit the City by reducing the upgrade needs of O.N. Stevens WTP, augmenting the current water supply and initiating a new supply that could be expandable to future reclaimed water customers. A key Nueces County-industry hopes to start the project in July 2016.

Two options are being analyzed for the City of Corpus Christi. A smaller 4 mgd option matches the expected average daily demand of one of the Nueces County-industries for use in their cooling towers. A second larger option of 18 mgd accounts for additional industrial use across the city. A peaking factor of 1.5 is used for both options and water purchases of $1.00 per 1,000 gallons is assumed. The 4 mgd option requires an 18-inch diameter pipeline and 6.9 mgd pumps. A cost summary of this option is shown in Table 5D.5.6. As can be seen from this table the estimated unit cost for this option is $870/ac-ft or $2.67/1,000 gallons. The 18 mgd option requires a 36-inch diameter pipeline and 27.4 mgd pumps. A cost summary of this option is shown in Table 5D.5.7. As can be seen from this table the estimated unit cost for this option is $577/ac-ft or $1.77/1,000 gallons.

Table 5D.5.6.
Cost Estimate Summary from Greenwood WWTP to Nueces County-Industry - 4 mgd
Note: Costs Provided by the City of Corpus Christi

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Pump Stations	$1,610,000
Pipeline (18-inch, 10.3 miles)	$10,860,000
Process Improvements	$5,260,000
TOTAL COST OF FACILITIES	**$17,730,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$3,800,000
Environmental & Archaeology Studies and Mitigation	$0
Land Acquisition and Surveying (44 acres)	$2,000,000
Interest During Construction (4% for 3 years with a 1% ROI)	$2,500,000
TOTAL COST OF PROJECT	**$26,030,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$2,178,000
Operation and Maintenance	
Intake, Pipeline, Pump Station (1% of Cost of Facilities)	$149,000
Pumping Energy Costs (1,280,030 kW-hr @ 0.09 $/kW-hr)	$115,000
Purchase of Water (4,484 ac-ft/yr @ 325.9 $/ac-ft)	$1,461,000
TOTAL ANNUAL COST	**$3,903,000**
Available Project Yield (ac-ft/yr), based on a Peaking Factor of 1	4,484
Annual Cost of Water ($ per ac-ft)	$870
Annual Cost of Water ($ per 1,000 gallons)	$2.67

Note: One or more cost element has been calculated externally.

Table 5D.5.7.
Cost Estimate Summary Corpus Christi to Nueces County-Industry - 18 mgd
Note: Costs Provided by the City of Corpus Christi

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Pump Stations	$3,810,000
Pipeline (36-inch, 10.3 miles)	$27,200,000
Process Improvements	$5,260,000
TOTAL COST OF FACILITIES	**$36,270,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$8,876,000
Environmental & Archaeology Studies and Mitigation	$0
Land Acquisition and Surveying (44 acres)	$2,000,000
Interest During Construction (4% for 3 years with a 1% ROI)	$4,951,000
TOTAL COST OF PROJECT	**$52,097,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$4,360,000
Operation and Maintenance	
Intake, Pipeline, Pump Station (1% of Cost of Facilities)	$367,000
Pumping Energy Costs (3,757,885 kW-hr @ 0.09 $/kW-hr)	$338,000
Purchase of Water (20178 ac-ft/yr @ 325.9 $/ac-ft)	$6,576,000
TOTAL ANNUAL COST	**$11,641,000**
Available Project Yield (ac-ft/yr), based on a Peaking Factor of 1	20,178
Annual Cost of Water ($ per ac-ft)	$577
Annual Cost of Water ($ per 1,000 gallons)	$1.77

Note: One or more cost element has been calculated externally.

5D.5.8.2 Potential Industrial Reuse of Broadway Municipal Effluent Feasibility Study

The potential for industrial reuse of the City of Corpus Christi Broadway WWTP effluent was considered in a 1996 study[18] that evaluated the feasibility for major industries along the Corpus Christi Ship Channel to reuse the Broadway WWTP effluent. Since the Broadway WWTP is located in close proximity to a number of major industries, it was considered by the City as the source of effluent to be evaluated for reuse. Since each industry has their own unique set of water quality needs and constraints that affect their ability to reuse municipal WWTP effluent, the type of industry and their needs influenced the feasibility of wastewater reuse.

[18] Feasibility Study of Industry Reuse of Broadway Municipal Wastewater Treatment Plant Effluent, prepared for the City of Corpus Christi and the Port of Corpus Christi, Board of Trade, July 1996.

The study identified conditions necessary to convey effluent from the Broadway WWTP to the major industries in the area. In addition, this study identified issues associated with industrial reuse in general.

The preliminary feasibility study determined that the Broadway WWTP effluent is a renewable alternative water supply which can be used by industry in their water supply mix. Particularly when drought conditions limit water supplies, the Broadway effluent can be a cost effective water supply option. Depending on the cost of Broadway WWTP effluent water, including pumping and piping delivery costs, operation and maintenance costs, and potential wastewater treatment equipment and chemical costs, reuse of the Broadway WWTP effluent might be an attractive water supply alternative. However, water quality would need to be considered as previous studies have indicated that elevated chloride levels may reduce reuse opportunities. Coordination with each industry on a case-by-case basis would be necessary to determine the most cost-effective plan for industry reuse of the Broadway effluent. The study recommended that a plan for providing Broadway effluent to industries be evaluated along with future plans for long-term operation of the Broadway WWTP.

5D.5.8.3 City of Corpus Christi Broadway WWTP Diversion Project

In 1997, an additional study[19] was undertaken regarding the City of Corpus Christi Broadway WWTP. This plant is the City's oldest WWTP but is in the process of being reconstructed by the City of Corpus Christi. The plant service area has experienced an approximate 39 percent reduction in population due to an out-migration starting in 1960. A feasibility study of Broadway to Greenwood implementation alternatives was completed in late 1999. The wastewater discharges from Greenwood WWTP have decreased from 13,486 ac-ft/yr in 2002 to 5,770 ac-ft/yr in 2013.

Previous 2006 and 2011 Coastal Bend Regional Water Plans included an analysis of potential effluent diversion projects for treated wastewater from Allison WWTP, Broadway, and Greenwood WWTP. The study also evaluated potential impacts on reservoir operations and increases in system yield. A summary of the study results is included in Chapter 11.

5D.5.8.4 Oxy Petrochemicals Municipal Wastewater Reuse Feasibility Study

In 1996, Oxy Petrochemicals, Corpus Christi, Texas (now known as Lyondell Basell), conducted a feasibility study[20] to assess the reuse of the City of Robstown WWTP effluent to supplement their industrial water supply.

Equistar Chemicals, L.P. receives all of its water supply from the City of Corpus Christi. The City water is used for drinking, domestic use, fire suppression, cooling tower make-up, equipment washdown, and other small uses. The City of Robstown WWTP effluent would have been

[19] "City of Corpus Christi Wastewater Facilities Implementation Plan, Oso & Greenwood Service Areas and Broadway Plant Diversion," City of Corpus Christi, February 1997.
[20] "Municipal Wastewater Reuse Feasibility Study, Oxy Petrochemicals, Corpus Christi, Texas," Oxy Petrochemicals, August 1996.

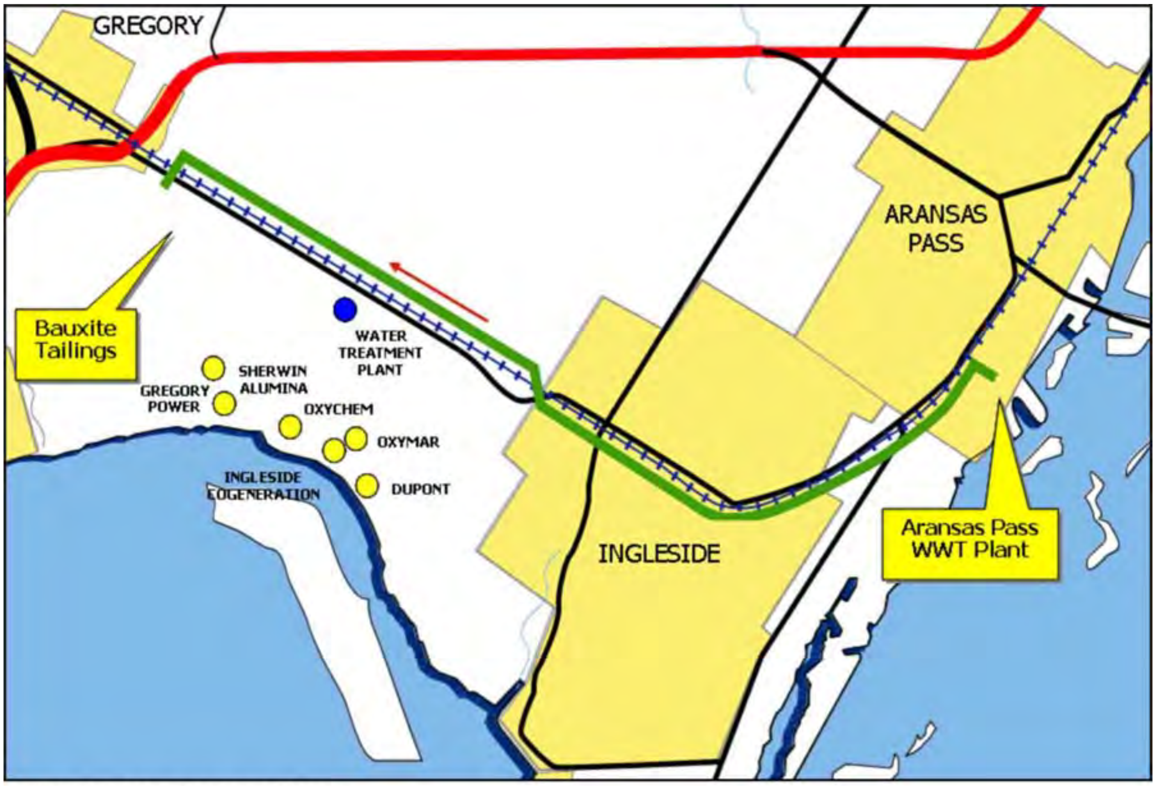
reused as cooling tower make-up water, thus reducing the use of water purchased from the City of Corpus Christi.

5D.5.8.5 Water Supply Effect of Northshore Regional Wastewater Reuse Project of San Patricio County

The Northshore area of San Patricio County includes the Cities of Portland, Gregory, Ingleside, Ingleside-on-the-Bay, and Aransas Pass. The Northshore Regional Wastewater Reuse, Water Supply, and Flood Control Planning Study indicated that municipal wastewater reuse was a cost effective water supply alternative. As a result, the Northshore Resource Conservation Project – Phase I[21] was implemented. This wastewater reuse project includes implementation of the reuse of treated effluent and sewage sludge from the City of Aransas Pass. This reuse project reduces demands on existing freshwater supplies and helps meet water conservation plan requirements for area industries. The City of Aransas Pass WWTP currently has a discharge permit to Redfish Bay but most of the effluent and sludge are piped to the Sherwin Alumina Company and Alcoa.

The Northshore Resource Conservation Project has been developed to implement two conservation measures: 1) beneficial reuse of municipal sewage sludge from the City of Aransas Pass; and 2) replacing some of the freshwater Sherwin Alumina Company uses with reclaimed municipal wastewater. A pipeline was constructed from the City of Aransas Pass WWTP to the Sherwin Alumina Company tailing beds. Figure 5D.5.4 shows the pipeline route and the North Shore area in the vicinity of this project. The pipeline is designed to deliver either wet sludge or a slurry of sludge and reclaimed water and replaces the current use of tanker trucks to transport the sludge, used as a soil amendment for the tailings. The reclaimed water has been used to establish vegetation on barren areas and irrigate areas where vegetation has previously been established.

[21] "Engineering Feasibility Report and Environmental Assessment for the Northshore Resource Conservation Project – Phase I," San Patricio Municipal Water District, June 1997 (Updated October 1999).



Source: San Patricio Municipal Water District

Figure 5D.5.4.
Pipeline Route and the North Shore Area

Sherwin Alumina Company (formerly Reynolds Metals Company), a major area industry located between the Cities of Portland and Ingleside, has been using municipal wastewater from the City of Aransas Pass for non-potable purposes since 1998 and has reduced water use from the CCR/LCC System. The SPMWD, who obtains both treated water and raw water from the CCR/LCC System, supplies municipal and industrial water to the area. In both 2001 and 2002, Sherwin Alumina Company reused 2,688 ac-ft/yr. However, delivery of treated wastewater in 2003 was only 382 ac-ft from the City of Aransas Pass due to wet weather.[22]

In addition, a small portion of the Aransas Pass WWTP effluent has been utilized at the Aransas Pass Nature Area for wetlands enhancement. This project is funded by a Coastal Management Program grant and is not a part of the Northshore Resource Conservation Project. Approximately 10 percent of the current average daily flow of 0.8 mgd (or 800,000 gpd) has been made available for diversion. Additional funding for the Nature Area is being requested from the Texas Parks and Wildlife Department, Coastal Management Program, and the Coastal Bend Bays and Estuaries Program.

[22] Correspondence with Jim Naismith, SPMWD, June 2004.

Recently, SPMWD estimated that they could reduce future water demands by 4 mgd (4,480 ac-ft/yr) by implementing wastewater reuse programs with the City of Portland, Gregory, City of Ingleside, and Oxychem, in addition to continuing reuse projects with Sherwin Alumina Company.[23] A preliminary engineering report has been completed for the Portland Reuse Project.[24] The proposed project would use treated wastewater from the City of Portland's (City) Wastewater Treatment Facility to replace part of the raw water presently being used by Sherwin. The average daily flow from the City's wastewater facility is currently approximately 1.5 mgd and by 2040 is expected to be 2.3 mgd. A treated effluent water pumping station with a flow meter would be constructed on a portion of the Portland wastewater facility site. A 6.7-mile transmission line would be installed to transfer the effluent water from the Portland wastewater facility to the tailing beds located near the Sherwin facility. A small treated sludge pumping station would also be constructed on property at the Portland wastewater facility. The sludge pumping station would include screening, two pumps, valves and a flow meter. The sludge pumps would pump directly into the pressure transmission line. Outlets and connections from the transmission line would be provided for Northshore Country Club, for the tailing bed raw water pond, and for a connection to the Sherwin Alumina Plant. The connection for Northshore will have a flow meter to determine the flow for use on the golf course and in ponds on the golf course. The connection to the tailing bed raw water pond will include valves, a flow meter, fittings, and piping over the top of the pond. The connection for the Sherwin Plant will include valves, piping, fittings, and a flow meter.

Existing pipelines and pumping facilities located at the Sherwin Plant would pump the treated effluent to a remote tailing beds site located north of the plant near Copano Bay. An interconnection pipeline would be constructed at the tailing bed site located north of the Sherwin production facility. A control and SCADA system would be provided to allow the wastewater and sludge flows to be delivered to the correct location. The monitoring and control facilities would occur at the existing District facilities on Highway 361.

A cost summary of this option is shown in Table 5D.5.8. As can be seen from this table the estimated unit cost for this option is $892 per ac-ft or $2.74/1,000 gallons.

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[23] Conversation with Jim Naismith and Don Roach, SPMWD, February 2, 2005.
[24] Naismith Engineering, Inc., Preliminary Engineering Report, Portland Reuse Project, February 2011.

Table 5D.5.8.
Cost Estimate Summary for Portland Reuse Pipeline

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Pump Stations	$2,325,000
Transmission Pipeline (18-inch, 6.7 miles)	$12,509,000
Integration, Relocations, and Other	$566,000
TOTAL COST OF FACILITIES	**$16,500,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$3,904,000
Environmental & Archaeology Studies and Mitigation	$168,000
Land Acquisition and Surveying	$0
Interest During Construction (4% for 1 year with a 1% ROI)	$720,000
TOTAL COST OF PROJECT	**$21,292,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$1,782,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$129,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$86,000
TOTAL ANNUAL COST	**$1,997,000**
Available Project Yield (ac-ft/yr)	2,240
Annual Cost of Water ($ per ac-ft)	$892
Annual Cost of Water ($ per 1,000 gallons)	$2.74

5D.5.8.6 City of Alice Potable and Non-Potable Projects

The City of Alice operates two wastewater treatment plants. One is centrally located in the north-east side of town and the other is located south of the City. On average, the northeast plant treats approximately 0.7 mgd and the south plant treats 1.1 mgd. These are the flows that would be sustainable for consistent use during a 30-day period. Fluctuations in flow will vary by day and by hour. The City is currently looking for potential and beneficial uses both potable and non-potable wastewater effluent.

Both treatment plants could be utilized as non-potable water sources. The northeast plant is located near the city golf course and utilizes most if not all of the effluent produced at the plant. Considering the cost of raw and untreated water from Lake Corpus Christi that would have to be substituted at a higher cost, the use of effluent for golf course irrigation is the best use as long as the City continues golf course irrigation. The South Wastewater Treatment plant currently discharges 100% of its 1.1 mgd effluent into the San Fernando Creek. Due to the South WWTP proximity to the Airport and Commercial/ Industrial development the use of high quality non-potable water could be a viable alternative to drinking water and provide a source for economic development in that area. Figure 5D.5.5 shows the proximity of the North Treatment plant to golf course properties and a potential south plant pipeline route. A cost summary of this option is shown in Table 5D.5.9. As can be seen from this table the estimated unit cost for this option is $1,321/ac-ft or $4.05/1,000 gallons.

The South Wastewater Treatment plant's effluent could also be used for potable reuse. The project would consist of the treatment of effluent at the WWTP with micro filtration and reverse osmosis treatment. It would then be pumped to the raw storage areas at the water treatment plant and processed with water supply from Lake Corpus Christi. With a supply of 1.1 mgd, the reverse osmosis system will yield approximately 75% of the supply or 0.8 mgd. This amount could supply approximately 20% of the current water needs of the City. A suggested route to the water treatment plant is shown in Figure 5D.5.6. A cost summary of this option is shown in Table 5D.5.10. As can be seen from this table the estimated unit cost for this option is $1,523/ac-ft or $4.67/1,000 gallons.

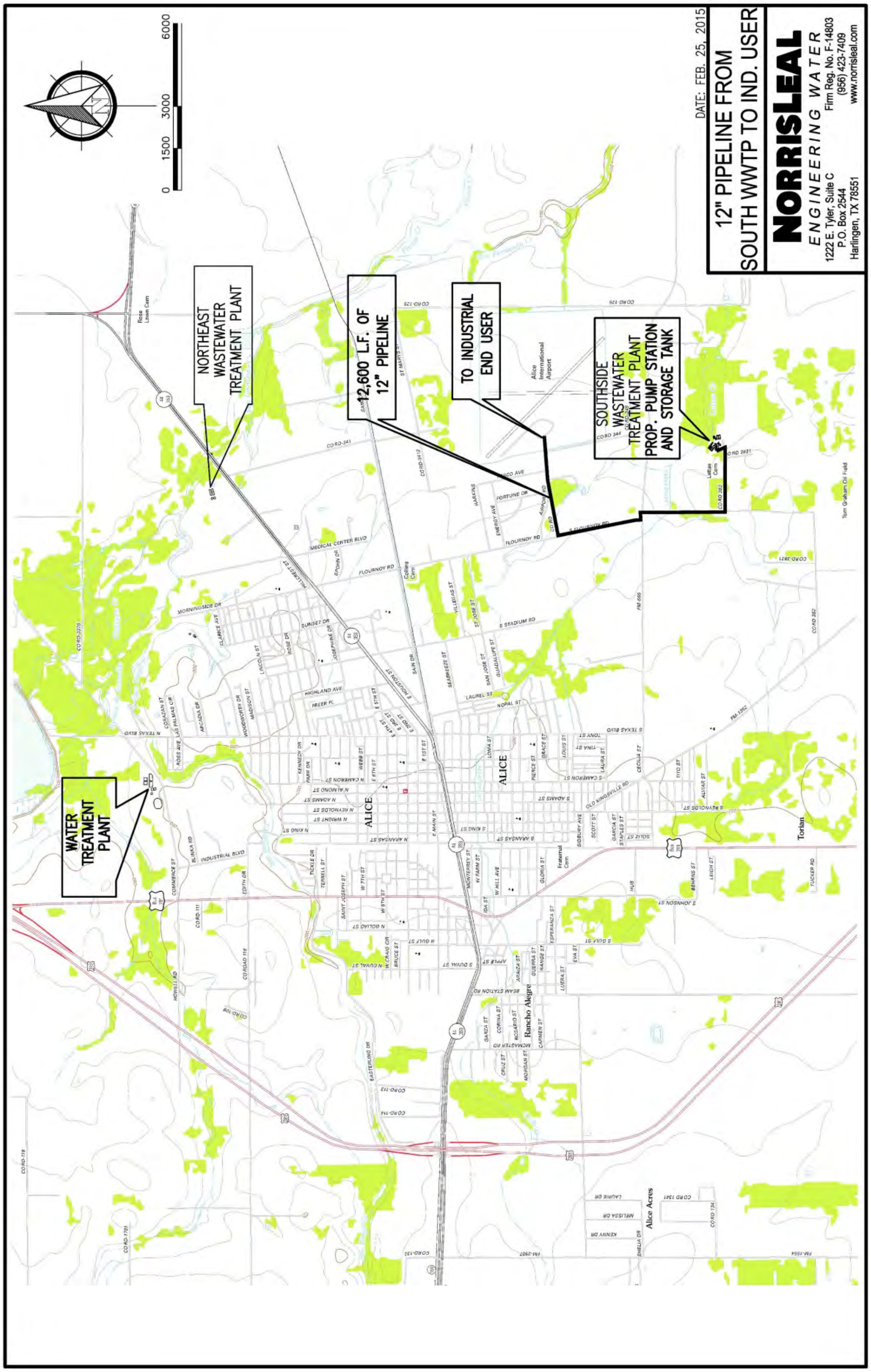

Figure 5D.5.5.
Non-Potable Reuse for Alice

Table 5D.5.9.
Cost Estimate Summary - Alice Non-Potable Reuse
Note: Costs Provided by the City of Alice

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Intake Pump Station	$475,000
Transmission Pipeline (12-inch, 13 miles)	$1,013,000
Transmission Pump Station(s) and Storage Tank(s)	$250,000
Two Water Treatment Plants (1.1 mgd and 1.1 mgd)	$4,924,000
TOTAL COST OF FACILITIES	**$6,662,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$1,999,000
TOTAL COST OF PROJECT	**$8,661,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$725,000
Operation and Maintenance	
Water Treatment Plant	$409,000
Pumping Energy Costs (571244 kW-hr @ 0.09 $/kW-hr)	$51,000
TOTAL ANNUAL COST	**$1,185,000**
Available Project Yield (ac-ft/yr)	897
Annual Cost of Water ($ per ac-ft)	$1,321
Annual Cost of Water ($ per 1,000 gallons)	$4.05

Note: One or more cost element has been calculated externally.

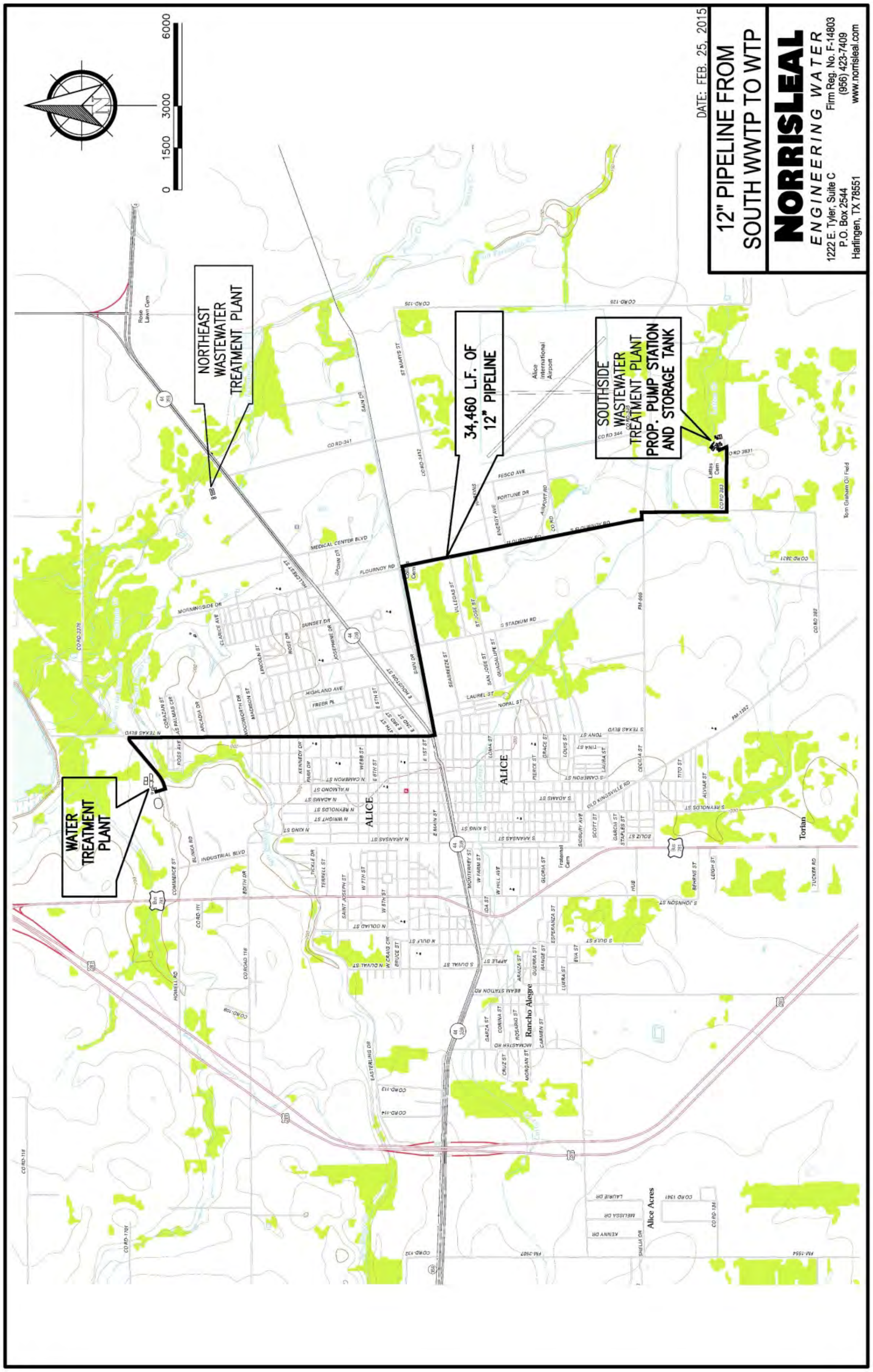

Figure 5D.5.6.
Potable Reuse for Alice

Table 5D.5.10.
Cost Estimate Summary - Alice Potable Reuse
Note: Costs Provided by the City of Alice

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Intake Pump Stations	$575,000
Transmission Pipeline (12-inch, 13 miles)	$2,588,000
Transmission Pump Station(s) and Storage Tank(s)	$250,000
Two Water Treatment Plants (1.1 mgd and 1.1 mgd)	$4,924,000
TOTAL COST OF FACILITIES	**$8,337,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$2,501,000
TOTAL COST OF PROJECT	**$10,838,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$907,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$28,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$14,000
Pumping Energy Costs (571244 kW-hr @ 0.09 $/kW-hr)	$51,000
Purchase of Water (365844 ac-ft/yr @ 1 $/ac-ft)	$366,000
TOTAL ANNUAL COST	**$1,366,000**
Available Project Yield (ac-ft/yr)	897
Annual Cost of Water ($ per ac-ft)	$1,523
Annual Cost of Water ($ per 1,000 gallons)	$4.67

Note: One or more cost element has been calculated externally.

5D.5.8.7 Wastewater Reuse for Landscape and Agricultural Use

In 2002, the City of Corpus Christi studied the feasibility of irrigating City-owned landscape with reclaimed wastewater.[25] The following observations were made regarding specific uses of reclaimed water:

1. Golf course irrigation with reclaimed water was successful;
2. The capital and operating costs, both for treatment and delivery, of irrigating public areas with reclaimed water is, in general, higher than the cost of potable water. The cost of park maintenance will increase with the use of reclaimed water.
3. Agricultural use appears to be economical from a pure cost of water standpoint for supplies up to 7 mgd at a cost of approximately $83 per ac-ft (or $0.26 per $1,000).

[25] HDR, Effluent Reuse Study, February 2002.

However, depending on the crop and rainfall amount, frequency and timing, demand may be sporadic. The cost of the water may not be offset by increased crop yields.

Within the City, various categories of public facilities and recreation areas/undeveloped areas have been identified where landscape irrigation could be applied (Table 5D.5.11).

Table 5D.5.11.
City of Corpus Christi Public Facilities and Recreation/Undeveloped Areas with Landscape Irrigation Needs

Category	***Number***	***Acres***
Beach Parks	4	72
Baseball/Softball Fields	8	383
Golf Courses	2	370
Libraries	5	4.5
Street Medians	34	141
Parks	168	913
Pools	10	9
Road Right-of-Ways	57	51
Recreation Centers	7	2.5
Special Areas (T-Head, L-Head, wildlife area, City Hall, cemeteries, nursery, Botanical Gardens, bayfront areas, Oso Creek areas, etc.)	40	1,098
Senior Citizen Centers	11	19
Total Acres		**3,063**

Source: City of Corpus Christi from 2001 Plan.

In the assessing the feasibility of landscape irrigation, various factors must be considered. These factors affect the capital costs and annual maintenance costs. Such factors include:

- The additional wastewater treatment necessary to meet Texas Administrative Code, Chapter 210, Use of Reclaimed Water standards (Chapter 5D.5.6.1);
- Infrastructure (pumps, piping, distribution system) necessary to deliver the reclaimed wastewater to the site;
- Additional maintenance of irrigated areas (increased frequency of mowing); and
- Long-term potential for chloride build-up in clay soils and the addition of soil amendments.

The quantity of wastewater reused for golf course and/or public park irrigation in the Coastal Bend Region is estimated to be a small percentage of the total municipal wastewater flow. In 2012, the City of Corpus Christi diverted approximately 1,450 ac-ft to area golf courses and a baseball park. This represents approximately 5 percent of the City's wastewater discharge totaling 28,140 ac-ft in 2012 from its six WWTPs. As discussed previously, the City is considering Oso Plant Effluent Reuse Improvements to include two new golf courses and one sports complex that currently irrigate with potable (municipal) water supplies. The City of Corpus Christi is considering providing reclaimed wastewater supplies to King's Crossing Country Club.

A possibility for municipal WWTP effluent reuse that would replace an existing potable water use and thus increase the available CCR/LCC water supply is nursery reuse. Nurseries in the City are wastewater reuse candidates but the capital costs associated with pump stations, piping, and distribution systems would necessitate a feasibility study of such a reuse system. In Corpus Christi, most nurseries are retail sellers, meaning they purchase their stock from wholesale growers. Based on a conversation with a retail nursery owner, the potential for reuse of municipal WWTP effluent for nursery irrigation would be limited. The retail nurseries use City water and typically only have containerized plants, purchased from wholesale sellers. With retail nurseries spread out across the City and the small demand, supplying effluent for reuse would very likely not be cost-effective.

Wholesale nurseries would have the best potential for cost-effective reuse of municipal WWTP effluent as they would use more water for irrigating acres of plants, sod, etc. for supplying retail nurseries. There is only one wholesale grower in Corpus Christi. The larger wholesale growers in this region are located in San Antonio, Houston, and the Rio Grande Valley. Logistically, this wholesale grower is approximately 5.5 miles from the nearest city WWTP (Laguna Madre WWTP). In a conversation with the wholesale grower, he indicated that he uses approximately 30,000 gpd of water during peak use. The water quality of the WWTP effluent would be a major concern. The growers' current water source is a mix of potable water (City of Corpus Christi) and untreated groundwater. The predominant use is groundwater. With the water quality issues, pump station and force main costs, and seasonal demand for the water minimizes the cost-effective use of the wastewater.

The groundwater is used to offset the expense of purchasing potable water and to dilute the salinity, total dissolved solids, and alkalinity concentrations of the potable water. The tropical plants grown at the wholesale nursery have specific water quality tolerances related to those parameters. The nursery owner expressed concern regarding the water quality of the WWTP effluent and the cost effectiveness of treatment or dilution to achieve an acceptable water quality.

5D.5.9 Analyses and Discussion of Consumptive Wastewater Reuse and Advanced Conservation as Related to Estuaries Inflow Requirements

5D.5.9.1 Introduction

Under the 2001 Agreed Order, effluent credits for discharges to Nueces Bay are applied on a one-to-one basis and effluent credits for the Nueces Estuary, excluding Nueces Bay, are set at 54,000 ac-ft/yr until such time as it is shown that actual wastewater flows exceed this amount. If the discharge of treated effluent increases and/or multipliers are applied to compute credits for effluent discharge in the Nueces Delta, releases from the CCR/LCC System to meet monthly desired Nueces Bay inflows can be reduced with a consequent increase in system firm yield. Without implementation of water conservation measures, which restrict water use, wastewater flows are projected to increase at a rate of about 900 ac-ft per year. If selected accelerated conservation measures are implemented, then wastewater flows could be expected to be reduced, depending on the type of conservation measures. For example, if conservation measures that accelerate the retrofit of existing plumbing fixtures to low-flow fixtures are implemented, then wastewater flows would be reduced to the degree the program is effective. However, if conservation measures were selected to limit or reduce summer season irrigation of lawn and landscaped areas, wastewater flows would be unaffected. The benefit of increased water supply associated with advanced conservation must be weighed against the resultant reductions in the steady discharge of treated effluent containing nutrients to primary productivity in the Nueces Estuary.

5D.5.9.2 Environmental Aspect

It has been estimated that between 47 percent and 52 percent of the water diverted and used by the City is returned to various points in the estuary as treated wastewater.[26,27] Presently, the largest portion of these discharges flow into the Nueces River, the Corpus Christi Inner Harbor, Oso Creek, Corpus Christi Bay, and Oso Bay. This alternative involves reusing this treated wastewater: 1) for the irrigation of municipal and residential properties (e.g., golf courses and lawns) and for meeting industrial needs (e.g., cooling water makeup); and 2) moving treated wastewater discharges from their present discharge points to the Nueces Delta (e.g., Rincon Bayou and associated shallow ponds). Since the needs for irrigating lawns and golf courses are sporadic and somewhat unpredictable, and because of the logistical problems inherent in redistributing treated wastewater for municipal and industrial needs as described earlier, it appears unlikely that large volumes of treated wastewater can efficiently be used for these purposes. Thus, the environmental effects of wastewater reuse for municipal irrigation and for meeting certain industrial water needs also would be relatively small. The discharge of treated wastewater to the Nueces Delta offers greater potential for benefits in terms of increasing freshwater availability to meet municipal and industrial requirements in Corpus Christi, while at the same time potentially enhancing the productivity of Nueces Delta. The Coastal Bend Region provides habitat for several endangered species and the resources critical to their continued existence, migratory bird use areas, wetlands, and marine fish and invertebrate nursery areas. Because phytoplankton and emergent plants provide food and habitat for animals, especially during early developmental stages, and these in turn provide food for larger animals, changes in primary productivity and plant diversity can be expected to influence the assemblage of animals resident in the estuary. Previous studies indicate that the Nueces Delta and Nueces Bay are critically important as the site of much of the planktonic primary production that drives biological processes throughout the Nueces Estuary. These studies indicate that treated wastewater could have as much as a five-fold stimulatory effect on primary productivity if discharged into the Nueces Delta rather than being discharged into the Nueces River.[28,29] Therefore, it has been recommended that wastewater be diverted and discharged into the Nueces Delta to help meet the freshwater inflow requirement, as

[26] HDR, et al., Op. Cit., September 1995.
[27] 2003 survey results, as reported in Table 5D.5.1.
[28] HDR et al., "Regional Wastewater Planning Study, Nueces Estuary, Phase I," City of Corpus Christi, et al., November 1991.
[29] HDR et al., "Regional Wastewater Planning Study, Nueces Estuary, Phase II," City of Corpus Christi, et al., March 1993.

specified in the 2001 Agreed Order, under which the CCR/LCC System now operates. This proposed wastewater discharge to the Nueces Delta would increase water availability from the CCR/LCC System if credits at a greater than 1:1 ratio can be obtained, thereby reducing freshwater releases designed to meet Nueces Bay inflow requirements.

5D.5.9.3 Impact Assessment

The 2005 Integrated Monitoring Plan[30] presents a consolidated description of monitoring programs associated with Nueces Delta projects (i.e. Rincon Bayou and Allison Demonstration Projects). The Nueces Delta Mitigation Project, conducted by the U.S. Army Corps of Engineers (USACE) and Corpus Christi Port Authority until August 1997, studied wetland losses due to dredging in the Corpus Christi Ship Channel. Studies designed to assess the effects of diverting wastewater to the Nueces Delta have been conducted by researchers from the University of Texas Marine Science Institute.[31,32] These studies involved determinations of monthly salinity, temperature, dissolved oxygen, dissolved inorganic nitrogen (that is available to support plant growth), phosphate, silicate, and water transparency at 25 sampling stations. Additionally, primary production was measured at five sites. Primary production and phyto-plankton pigment biomass, and the biomass, species diversity and species abundance of emergent vegetation was measured at four sites in each of 1991 and 1992. These studies indicate that primary productivity is positively correlated with the concentration of nutrients in the water. Increased flow and nutrient concentrations appeared to increase the relative abundance and species diversity of emergent vegetation.[33] The effects of wastewater on relative abund-ance and species diversity varied among study sites indicating that other factors, in addition to freshwater flows and nutrient concentrations (e.g., initial species composition and abundance, duration of flooding, and frequency of flooding), may affect the relative abundance and diversity of species. An intensive, 5-year study was conducted for the Allison WWTP Demonstration Project (1999 to 2003) to assess the potential effects of wastewater on the relative abundance and diversity of species in the Nueces Estuary. The concluding report was completed in 2006.[34]

The Rincon overflow channel was restored by the 2001 Agreed Order. Salinity monitors have been positioned throughout the estuary to tract flow rate and retention time of water diverted through the Rincon Pipeline.

Also, a TMDL study is underway by TCEQ and Texas A&M University Corpus Christi to deter-mine the distribution of zinc in water and sediment in Nueces Bay. The TCEQ has included the

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30 City of Corpus Christi, Integrated Monitoring Plan Fiscal Year 2005, January 2005.
31 Whitledge, T.E. and D.A. Stockwell, "The Effects of Mandated Freshwater Releases on the Nutrient and Pigment Environment in Nueces Bay and Rincon Delta: 1990–1994," Water for Texas, Research Leads the Way (Jensen, Red.), Proceedings of the 24th Water for Texas Conference, 1995.
32 Dunton, K.H., B. Hardegree, and T.E. Whitledge, "Annual Variations in Biomass and Distribution of Emergent Marsh Vegetation on the Nueces River Delta," In: Water for Texas, Research Leads the Way (Jensen, Red.), Proceedings of the 24th Water for Texas Conference, 1995.
33 Ibid.
34 Concluding Report: Allison Wastewater Treatment Plant Effluent Diversion Demonstration Project, Volume I: Executive Summary. The University of Austin, Marine Science Institute, Port Aransas, Texas and Texas A&M University-Corpus Christi, Center for Coastal Studies, Corpus Christi, Texas, 2006.

Nueces Bay on the 303(d) list of impaired waters of the State due to contamination of oysters with elevated levels of zinc.

A more recent study[35] was conducted using hydrological data measured by multiple continuous monitors over a 14-year period (1994 to 2008) to determine objective and consistent separation of wet and dry periods. The second part combined wet and dry period information with water quality, benthic macrofauna, and marsh vegetation for comparison of biological responses to inflow events. Benthic macrofauna, vegetation, and water quality samples were collected by three research groups from 10 sites divided into three zones: upper Rincon Bayou, lower Rincon Bayou, and Nueces Bay. Statistical approaches were used to investigate the relationships between each of the biotic communities (macrofauna and vegetation) with water quality variables. The overall results suggest that the benefits of freshwater inflow are restricted even during periods of extended flooding. Treated wastewater within acceptable nutrient limits to target hypersaline, ecologically sensitive areas may show benefits not otherwise achieved with natural riverine flow systems.

Between September 2010 and August 2013, The Coastal Bend Bays and Estuaries Program (CBBEP) published seven reports with the results of studies in the area:

- Rincon Bayou Salinity Monitoring Project - September 2010
- Nueces BBEST Environmental Flows Recommendation Report - October 2011
- Effects of Rincon Bayou Pipeline Inflows on Salinity Structure Within the Nueces Delta, Texas - November 2011
- Spatial Effects of Rincon Bayou Pipeline Freshwater Inflows on Salinity in the Lower Nueces Delta, Texas - August 2012
- Nueces BBASC Environmental Flows Standards and Strategies Recommendation Report - August 2012
- Nueces BBASC Work Plan for Adaptive Management - November 2012
- Nueces Delta Salinity Effects from Pumping Freshwater into Rincon Bayou 2009 to 2013 - August 2013

Four projects were requested as Priority Projects by the Senate Bill 3 - created Nueces River and Corpus Christi and Baffin Bays Basin and Estuary Area Stakeholder Committee (BBASC) and will be completed by the end of August 2015. The first project is a re-examination of the 2001 agreed order monthly targets and safe yield versus current demand on future Nueces Bay and Delta salinity levels evaluations using the Corpus Christi Water Supply Model (CCWSM). Priority Project #2 aims to improve salinity modeling methods for determining environmental inflow regimes for the Nueces Delta and Bay using a 3-D hydrodynamic model. Priority Project #3, which is linked to Priority Project #2, will explore landform modifications to Nueces bay and Nueces Delta. Finally, Priority Project #4 includes development of a nutrient budget for both pre- and post development for the Nueces watershed.

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[35] Response of the Nueces Estuarine Marsh System to Freshwater Inflow: An Integrative Data Synthesis of Baseline Conditions for Faunal Communities, Publication 62, 2009.

5D.5.9.4 Implementation Issues

Major implementation issues include wastewater treatment levels required by regulatory agencies (TCEQ), wastewater discharge permit modifications to allow discharge in the Nueces Delta, and the impacts to the Nueces Delta from the diversion of wastewater. In addition, implementation of these strategies will require NPDES Stormwater Pollution Prevention Plan permits. Cultural resources will also need to be investigated along the pipeline routes and avoided where possible. Implementation of this alternative should be considered in conjunction with the City's wastewater master plan as well as the results of studies from the U.S. Bureau of Reclamation's Rincon Bayou Demonstration Project.

5D.5.10 Evaluation Summary

An evaluation summary of this regional water management option is provided in Table 5D.5.12.

Table 5D.5.12.
Evaluation Summary of the Reclaimed Wastewater Supplies

Impact Category	***Comment(s)***
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	 1. Firm Yield: Highly variable. 2. Poor to Good. 3. Highly variable.
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. Potential for environmental impacts to streams currently receiving wastewater effluent. 2. Environmental impact to estuary in potential reduction of freshwater inflows. 3. None or low impact. 4. None or low impact. 5. None or low impact. 6. Cultural resources investigations will be required for all pipeline routes. 7. The City's Integrated Plan provides ongoing studies of water quality issues of the Nueces Delta. a. Dissolved solids are a concern to be addressed with further studies. b. Salinity is a concern to be addressed with further studies. c. Bacteria is a concern to be addressed with further studies. d. Chlorides are a concern to be addressed. e-h. None or low impact. i. Alkalinity is a concern and will need to be addressed. Zinc in wastewater discharges into Nueces Bay is a concern to be addressed with further studies.
c. Impacts to State water resources	• No negative impacts on other water resources
d. Threats to agriculture and natural resources in region	• Temporary damage due to construction of pipeline(s)
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Standard analyses and methods used for portions
g. Interbasin transfers	• Authorization has been obtained for the Rincon Diversion Project
h. Third party social and economic impacts from voluntary redistribution of water	• Not applicable
i. Efficient use of existing water supplies and regional opportunities	• Provides reuse opportunities of water supplies
j. Effect on navigation	• None

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5D.6

Modify Existing Reservoir Operating Policy and Safe Yield Analyses (N-9)

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5D.6 Modify Existing Reservoir Operating Policy and Safe Yield Analyses (N-9)

5D.6.1 Description of Strategy

In the late 1800s, the Corpus Christi Water Supply Company built a small dam near Calallen, Texas, to keep the saline waters of Nueces Bay from intruding into the fresh waters of the Nueces River and began to develop surface water supplies from the Nueces River. As the City grew and more and more water was needed, the dam at Calallen was raised several times and today the dam has a height of approximately 5.5 ft-msl and a capacity of about 1,175 ac-ft. The City continued to expand and in 1934, La Fruta Dam was constructed on the Nueces River about 35 miles upstream of the Calallen Dam and initially it impounded approximately 60,000 ac-ft of water. In 1958, Wesley Seale Dam was completed just downstream of the old La Fruta Dam, and the new Lake Corpus Christi was formed, which engulfed the old dam and reservoir and expanded storage to about 302,000 ac-ft.

In the late 1960s, following an extreme drought that occurred from 1961 to 1963, planning began for an additional water supply for the City and its growing number of water customers. For more than a decade, studies were performed to evaluate alternative water supply options. Following considerable debate, Choke Canyon Reservoir, located on the Frio River 63.3 river miles upstream of Lake Corpus Christi, was constructed. Choke Canyon Dam was constructed by the U.S. Bureau of Reclamation (USBR). The dam was completed in 1982 and the reservoir first filled to capacity in 1987. Choke Canyon Reservoir has approximately 690,000 ac-ft of conservation storage capacity, based on original USBR estimates. The TWDB has conducted several volumetric surveys for Lake Corpus Christi and Choke Canyon Reservoir[1]. In 2002, a volumetric survey of Lake Corpus Christi was completed by the TWDB and reported the capacity at 256,961 ac-ft. The volumetric survey performed by the TWDB in 1993 reported the capacity of Choke Canyon Reservoir to be 695,271 ac-ft. Today, the City operates these three reservoirs (Calallen, Lake Corpus Christi, and Choke Canyon Reservoir), Lake Texana, and MRP Phase II as a system to supply water for municipal and industrial users of the Coastal Bend Region.

The physical and hydrologic data for the three reservoirs in the Nueces Basin and two river reaches affecting the delivery of raw water from the Nueces River Basin to the City and its customers is summarized in Table 5D.6.1. As indicated in this table, approximately 94 percent of the demand occurs at the Calallen Reservoir pool, while about 73 percent of stored water is located 98 miles upstream at Choke Canyon Reservoir, with the remaining 27 percent of the stored water being located 35 miles upstream in Lake Corpus Christi. Water stored in Choke

[1] In 2012, the TWDB conducted volumetric surveys of Choke Canyon Reservoir and Lake Corpus Christi. The survey was conducted during drought conditions when the reservoirs were not full and some of the results are qualified accordingly. Results of the 2012 TWDB surveys have not been adopted by state or regional agencies. Reductions in volumetric survey data or increased sedimentation rates may have an impact on system yield if significantly different from previous estimates. Future planning efforts should consider new information and update the Corpus Christi Water Supply model, if warranted.

Table 5D.6.1.
Summary of Physical and Hydrologic Data for Three Reservoirs and Two River Reaches

Reservoir or River Reach	Capacity (ac-ft)	Percent of Total System Storage	Average Annual Reservoir Evaporation (feet)	River Reach Distance (miles)	Estimated Delivery Losses (percent)	Percent of System Demand in Area of Reservoir
Choke Canyon Reservoir	695,271[1]	72.9%	3.26	—	—	1%
River Reach between Choke Canyon Reservoir and Lake Corpus Christi	—	—	—	63.3	37.8[2]	—
Lake Corpus Christi	257,260[1]	27%	2.85	—	—	5%
River Reach between Lake Corpus Christi and Calallen	—	—	—	35	11[3]	
Calallen Pool	1,175[4]	0.1%	2.85	—	—	94%
Total	953,706	100%	—	98.3	—	100%

[1] Updated based on TWDB volumetric survey results of Lake Corpus Christi (2002) and Choke Canyon Reservoir (2003).
[2] Includes losses from Lake Corpus Christi to local aquifer, and represents average percentage lost, updated in 2005. The delivery losses do not reflect channel loss results from the single event reported in Phase I - 2011 Plan analysis.
[3] Represents average percentage lost. River reach between Lake Corpus Christi and Calallen was updated to reflect new channel loss information, 2005.
[4] Based on previous 1990 analyses as included in the 2001, 2006, and 2011 Regional Water Plans.

Canyon Reservoir is released into the river channel and delivered to Lake Corpus Christi. Water is then released from Lake Corpus Christi into the Nueces River channel, by which it flows to the Calallen pool. At the Calallen pool, the City and some of its customers divert raw water to their respective treatment plants, from which it is then distributed for use. Studies[2,3,4,5,6] performed throughout the years have indicted that a significant portion of the water that is released from Choke Canyon Reservoir and Lake Corpus Christi is lost to evaporation, evapo-transpiration, and seepage along the river channels as it travels from one reservoir to the next.

As shown in Table 5D.6.1, losses from Choke Canyon Reservoir downstream to, and including losses from, Lake Corpus Christi average 37.8 percent, while losses downstream of Lake Corpus Christi to the Calallen pool average about 11 percent. Under a 2001 Agreed Order from the

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[2] U.S. Bureau of Reclamation (USBR), "Nueces River Basin: A Special Report for the Texas Basins Project," U.S. Dept. of the Interior, December 1983.
[3] USBR, "Nueces River Project, Texas: Feasibility Report," U.S. Dept. of the Interior, July 1971.
[4] HDR Engineering, Inc. (HDR), et al., "Nueces River Basin Regional Water Supply Planning Study – Phase I," Vols. 1, 2, and 3, Nueces River Authority, et al., May 1991.
[5] Rauschuber and Associates, Inc., "Potential for Development of Additional Water Supply from the Nueces River Between Simmons and Calallen Diversion Dam," Subcommittee on Additional Water Supply from the Nueces River Watershed, December 1985.
[6] United States Geological Survey (USGS), "Water Delivery Study, Lower Nueces River Valley, Texas, TWDB Report 75," in cooperation with the Lower Nueces River Water Supply District, May 1968.

TCEQ[7], the City is required to pass specified volumes of inflows to the reservoirs in accordance with a monthly schedule to mitigate the impacts of Choke Canyon Reservoir and maintain the health of the Nueces Estuary. In the 2001 Agreed Order, the City is not required to release when combined reservoir storage is less than 30 percent. All of the above items are significant factors that must be taken into account in the operation of the reservoir system.

The City of Corpus Christi initially had a four-phased operation plan for the CCR/LCC System. The objective of each phase was to provide the people of the Coastal Bend area with a dependable water supply as their needs grow, while at the same time, attempt to meet the need for consistent quality raw water by proper management of the two reservoirs. Additionally, recreational uses of the reservoirs as related to water surface elevations are a concern, as well as adherence to the TCEQ Order that specifies target inflows to the downstream bays and estuaries from wastewater return flows and spills, or releases of inflows from the reservoirs.

The initial operation plan consisted of four phases, with the first phase (Phase I) having been applicable prior to the initial filling of Choke Canyon Reservoir. Under each of the City's operation plan phases, a minimum of 2,000 ac-ft/month is to be released from Choke Canyon Reservoir to meet the instream flow requirements within the water rights permit for Choke Canyon Reservoir.[8] In 1987, Choke Canyon Reservoir officially filled and the operating policy shifted to Phase II. The Phase II policy was intended to apply to the CCR/LCC System until water user demand is more than 150,000 ac-ft/yr. The operational guidelines under this policy are as follows:

1. When conditions are such that the water surface elevation in Lake Corpus Christi is at or below 88 ft-msl and the water surface elevation in Choke Canyon Reservoir is above 204 ft-msl, releases will be made from Choke Canyon Reservoir to maintain the water surface elevation at Lake Corpus Christi at 88 ft-msl; and
2. When Lake Corpus Christi’s water surface elevation is at or below 88 ft-msl and Choke Canyon Reservoir’s water surface elevation is below 204 ft-msl, the Choke Canyon Reservoir release made for the current month will be equal to the release made at Lake Corpus Christi in the previous month.

The Phase II release rules were devised in an effort to minimize the drawdown of Lake Corpus Christi, primarily to ensure a consistent quality of water by mixing the Choke Canyon Reservoir releases with the stored water in Lake Corpus Christi, but also for recreation considerations.

The third operational policy (Phase III) was initially intended to apply to the system when water use is between 150,000 and 200,000 ac-ft annually. This operational policy was promulgated by the USBR and is very similar to the Phase II policy. Under Phase III, when the water surface elevation at Lake Corpus Christi is at or below 88 ft-msl, steps are taken to draw the two reservoirs down together.

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[7] Texas Commission on Environmental Quality (TCEQ), Agreed Order Establishing Operational Procedures Pertaining to Special Condition B, Certificate of Adjudication No. 21-3214, Held by City of Corpus Christ, et al., April 28, 1995.
[8] TCEQ, Certificate of Adjudication No. 21-3214, Held by the City of Corpus Christi, et al.

The fourth operation policy (Phase IV) is the maximum yield policy and was initially intended to apply to the system when water user demand exceeds 200,000 ac-ft annually. Under this policy, the system is operated as follows:

1. When Lake Corpus Christi's water surface elevation is at or below 76 ft-msl and the water surface elevation in Choke Canyon Reservoir is above 155 ft-msl, releases are made from Choke Canyon Reservoir to maintain Lake Corpus Christi at 76 ft-msl; and
2. When Lake Corpus Christi's water surface elevation is at or below 76 ft-msl and Choke Canyon Reservoir's water surface elevation is below 155 ft-msl, Lake Corpus Christi is allowed to draw down to its minimum elevation and Choke Canyon Reservoir releases are made only to meet water supply shortages.

In April 1995, in response to requirements in the water rights permit for Choke Canyon Reservoir[9], a bay and estuary release order (1995 Agreed Order) was adopted governing freshwater pass-through requirements to the Nueces Estuary. The major provisions of the 1995 Agreed Order are as follows:

1. The water passed through from the CCR/LCC System to satisfy the TCEQ bay and estuary release requirement in a given month is limited to no more than the inflow to Lake Corpus Christi as if Choke Canyon Reservoir did not exist.
2. When the System storage is above 70 percent, the monthly bay and estuary release schedule provides for a target of 138,000 ac-ft/yr of water to Nueces Bay and/or the Nueces Delta by a combination of return flows, reservoir releases and spills, and measured runoff downstream of Lake Corpus Christi. When the system storage is less than 70 percent but more than 40 percent, the target schedule is reduced so as to provide 97,000 ac-ft/yr to Nueces Bay and/or the Nueces Delta. In any month when the System storage is less than 40 percent but great than 30 percent, the target Nueces Bay inflow requirement may be reduced to 1,200 ac-ft/month when the City and its customers implement Condition II of the City's Water Conservation and Drought Contingency Plan (Plan). If System storage drops below 30 percent, bay and estuary releases may be suspended when the City and its customers implement Condition III of the Plan.
3. In April 1995, in response to requirements in the water rights permit for Choke Canyon Reservoir[10], a bay and estuary release order (1995 Agreed Order) was adopted governing freshwater pass-through requirements to the Nueces Estuary.

On April 17, 2001, the TCEQ issued an amendment to the 1995 Agreed Order to revise operational procedures in accordance with revisions requested by the City of Corpus Christi. The major provisions of the new 2001 Agreed Order are as follows:

1. Revisions to passage of inflows to Nueces Bay and Estuary at 40 percent and 30 percent reservoir system capacity upon institution of mandatory outdoor watering restrictions. In any month when the System storage is less than 40 percent but greater than 30 percent,

[9] Ibid.
[10] Ibid.

the target Nueces Bay inflow requirement may be reduced to 1,200 ac-ft/month when the City and its customers implement Condition II of the City's Water Conservation and Drought Contingency Plan (Plan). If System storage drops below 30 percent, bay and estuary releases (except for return flows) may be suspended when the City and its customers implement Condition III of the Plan.

2. Supported calculating reservoir system storage capacity based on most recently completed bathymetric surveys; and
3. Included provisions for operating Rincon Bayou diversions and conveyance facility from Calallen Pool to enhance the amount of freshwater to the Nueces Bay and Delta.

5D.6.2 Available Yield

During the mid-1990s, in response to drought conditions, the City of Corpus Christi changed the Reservoir Operating Plan to Phase IV (i.e. Maximum Yield Policy) in order to maximize the yield of the CCR/LCC System. In addition, the City modified the Phase IV Policy to Lake Corpus Christi's target elevation of 74 ft-msl and brought in Lake Texana water supplies in the late-1990s. MRP Phase II supplies from the Colorado River will be integrated into the system in 2015. A summary of the firm yield of the system in 2020 and 2070, assuming Phase IV operations, including water supplies from Lake Texana and MRP Phase II, the 2001 Agreed Order, and computed by the Corpus Christi Water Supply Model (formerly known as the Lower Nueces River Basin and Estuary (NUBAY) Model[11]) is provided in Table 5D.6.2.

Table 5D.6.2.
CCR/LCC/Lake Texana/MRP Phase II System Firm Yields (Phase IV Policy)

Reservoir Sedimentation Year	*CCR/LCC/Lake Texana System Firm Yield (ac-ft/yr)*
2020	259,000
2070	249,000

[11] In 1990, the need for a tool that could be used to evaluate the effects of water supply options in the region, as well as the need to evaluate various reservoir operation policies, led to the development of the Lower Nueces River Basin and Estuary Model – NUBAY (HDR, et al., "Nueces River Basin Regional Water Supply Planning Study – Phase I," Vols. 1, 2, and 3, Nueces River Authority, et al., May 1991). This model operates on a monthly timestep and includes significant droughts in the 1950s, 1960s, 1980s, and 1990s. Computations in the model simulate evaporation losses in the reservoirs, as well as channel losses in the rivers associated with water delivery from Choke Canyon Reservoir to Lake Corpus Christi, and from Lake Corpus Christi to the City's water supply intake at the Calallen diversion dam. The model allows for a variety of sediment conditions ranging from the 1990 storage volumes in the lakes to projected future system storage capacities. The model has been developed and updated through a series of projects since 1991. During the 2006 Plan development, the model was updated to include the new drought of record and currently operates on a 1934 to 2003 period of record (HDR, et al., "Nueces Estuary Regional Wastewater Planning Study, Phase 1," City of Corpus Christi, et al., November 1991; HDR, et al., "Nueces Estuary Regional Wastewater Planning Study, Phase 2," City of Corpus Christi, et al., March 1993; HDR, "Water Supply Update for City of Corpus Christi Service Area," City of Corpus Christi, January 1999; HDR, Supplemental Funding Work Item for 2006 Coastal Bend Regional Water Plan, 2005).

The reservoir system yields tabulated in Table 5D.6.2 are essentially the maximum yields available under the City's current reservoir operating policies and existing schedule governing freshwater pass-throughs to the bay and estuary.

For the 2016 Plan, the CBRWPG adopted[12] the use of safe yield analyses for the CCR/LCC/Lake Texana/MRP Phase II System with a reserve of 125,000 ac-ft in storage during the worst month on record. Safe yield supply represents a more conservative approach to determining minimum annual availability in areas where the severity of droughts is uncertain. In July 2011, the CBRWPG requested use of the Corpus Christi Water Supply Model and safe yield supplies for development of the 2016 Plan. On February 22, 2012, the TWDB approved continued use of safe yield and the Corpus Christi Water Supply Model for the regional CCR/LCC/Texana/MRP Phase II system for development of the 2016 Plan. Safe yield supply is the amount of water that can be withdrawn from a reservoir such that a given volume remains in reservoir storage during the critical month of the drought of record. The surface water availabilities for the largest water rights in the Nueces Basin (i.e. City of Corpus Christi and their customers) are based on safe yield analyses and assume a reserve of 125,000 ac-ft (i.e. one year demand) for future drought conditions. Figure 5D.6.1 shows how 3-year average annual inflows for the major reservoir system have been reduced for each of the past four significant droughts. The model simulates historical hydrology from 1934 to 2003.

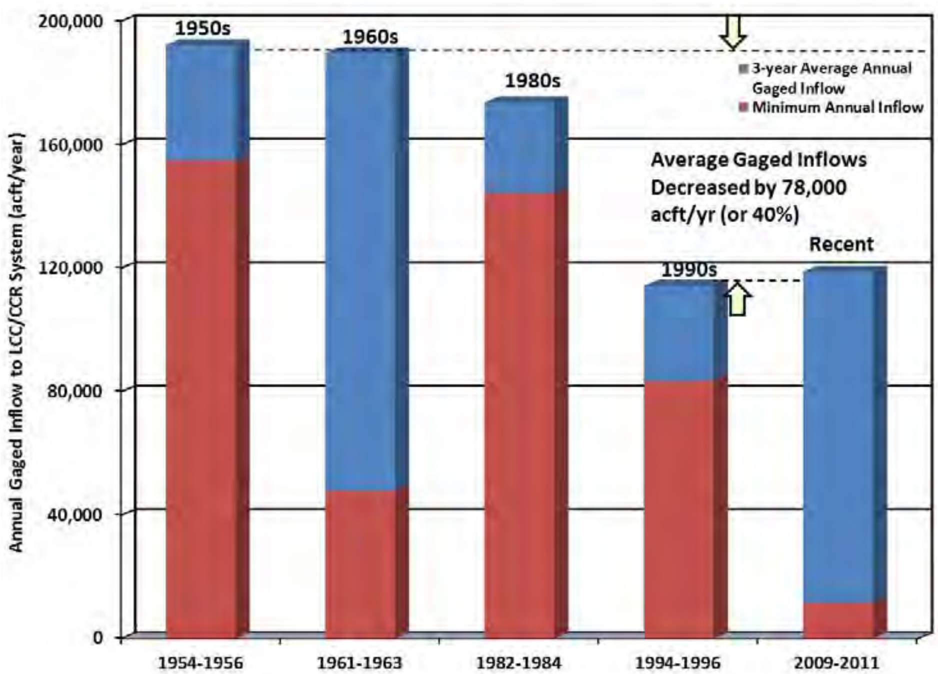

Figure 5D.6.1.
3-Year Reservoir Inflows

[12] CBRWPG adopted use of safe yield reserve of 125,000 ac-ft in November 2014.

A summary of the safe yield of the system in 2020 and 2070, assuming Phase IV operations, including water supplies from Lake Texana and MRP Phase II, and the 2001 Agreed Order, and computed by the Corpus Christi Water Supply Model[13] is provided in Table 5D.6.3.

Table 5D.6.3.
CCR/LCC/Lake Texana/MRP Phase II System Safe Yields (Phase IV Policy)

Reservoir Sedimentation Year	***CCR/LCC/Lake Texana System Safe Yield (ac-ft/yr)***
2020	219,000
2070	214,000

With safe yield supplies, the yield of the system is reduced by 40,000 ac-ft/yr in 2020 and 35,000 ac-ft/yr in 2070, based on sedimentation conditions. Safe yield supplies were considered for water user groups relying on the regional CCR/LCC/Texana/MRP Phase II system, which includes the City of Corpus Christi and their customers (including Wholesale Water Providers).

Since the decision was made in the 1970s to pursue a second reservoir in the Nueces River Basin to enhance the yield of Lake Corpus Christi reservoir, a considerable amount of attention has been given to the potential effects of reduced freshwater inflow to the upper Nueces Bay and Nueces Delta. The previous 2011 Plan provided a brief history of ecological studies in the Nueces Estuary and a management strategy for maximizing the productivity of the Nueces Delta ecosystem and increase the firm yield of the CCR/LCC System by diverting treated effluent from Allison[14], Broadway, and Greenwood WWTPs to the Nueces Bay system. This strategy was removed from active consideration for the 2016 Plan. The results of the 2011 plan analysis are summarized in Section 11.

[13] In 1990, the need for a tool that could be used to evaluate the effects of water supply options in the region, as well as the need to evaluate various reservoir operation policies, led to the development of the Lower Nueces River Basin and Estuary Model – NUBAY (HDR, et al., "Nueces River Basin Regional Water Supply Planning Study – Phase I," Vols. 1, 2, and 3, Nueces River Authority, et al., May 1991). This model operates on a monthly timestep and includes significant droughts in the 1950s, 1960s, 1980s, and 1990s. Computations in the model simulate evaporation losses in the reservoirs, as well as channel losses in the rivers associated with water delivery from Choke Canyon Reservoir to Lake Corpus Christi, and from Lake Corpus Christi to the City's water supply intake at the Calallen diversion dam. The model allows for a variety of sediment conditions ranging from the 1990 storage volumes in the lakes to projected future system storage capacities. The model has been developed and updated through a series of projects since 1991. During the 2006 Plan development, the model was updated to include the new drought of record and currently operates on a 1934 to 2003 period of record (HDR, et al., "Nueces Estuary Regional Wastewater Planning Study, Phase 1," City of Corpus Christi, et al., November 1991; HDR, et al., "Nueces Estuary Regional Wastewater Planning Study, Phase 2," City of Corpus Christi, et al., March 1993; HDR, "Water Supply Update for City of Corpus Christi Service Area," City of Corpus Christi, January 1999; HDR, Supplemental Funding Work Item for 2006 Coastal Bend Regional Water Plan, 2005).
[14] At this time, Allison WWTP effluent delivery to the Nueces Delta has been discontinued since effluent quality does not meet current TCEQ water quality standards for receiving bodies.

5D.6.3 Environmental Issues

The modification of existing reservoir operating policy strategy from firm to safe yield reduces the planned supply (yield) from the LCC/CCR/Lake Texana/MRP Phase II system to account for unprecedented severe drought conditions in the future or underestimation in regional growth. The additional stored water in LCC/CCR under safe yield provisions results in higher system storage levels and therefore more frequent opportunities for larger pass-through events to the Nueces Bay[1] to meet inflow targets of the 2001 TCEQ Agreed Order. With safe yield, the median monthly flow to the Bay is 2,171 ac-ft/mo compared to 1,625 ac-ft/mo under firm yield conditions (increase of 546 ac-ft/mo). A flow frequency showing monthly Bay inflow comparing firm and safe yield is shown in Figure 5D.6.2. This figure shows that the safe yield scenario, with the lower system demand, results in more frequent larger monthly inflows into the Bay. When comparing the annual flow to the Bay and Estuary system over the 70 year model simulation period (1934-2003), the median annual flow with safe yield is 173,742 ac-ft/yr with safe yield, or about 40,000 ac-ft/yr higher than firm yield median annual flow of 133,183 ac-ft/yr.

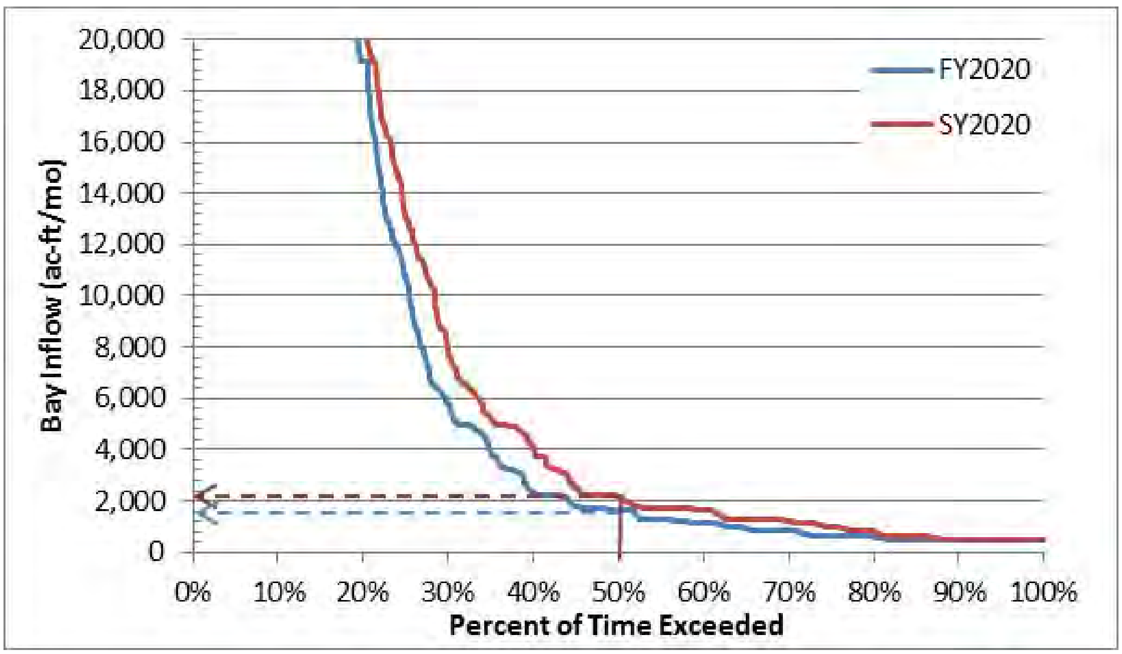

Figure 5D.6.2.
Comparison of Monthly Flow Frequency Distribution for Nueces Bay Inflow for Firm versus Safe Yield

[1] Contingent on inflow into the reservoir system.

5D.6.4 Evaluation Summary

An evaluation summary of this regional water management strategy is provided in Table 5D.6.4.

Table 5D.6.4.
Evaluation Summary of Modifications to Existing Reservoir Operating Policy

Impact Category	*Comment(s)*
a. Water supply:	
1. Quantity	1. No project yield. Safe yield supply is less than firm yield.
2. Reliability	2. Good reliability. Provides storage reserve of 125,000 ac-ft (equal to one year of demand). Drought management measure amid climate uncertainty.
3. Cost of treated water	3. No cost.
b. Environmental factors:	
1. Instream flows	1. None or low impact.
2. Bay and estuary inflows	2. Potential increase to bay and estuary inflows with higher storage levels to maintain safe yield reserve.
3. Wildlife habitat	3. None or low impact.
4. Wetlands	4. None or low impact.
5. Threatened and endangered species	5. None or low impact.
6. Cultural resources	6. None or low impact.
7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	7. None or low impact.
c. State water resources	• No negative impacts on other water resources • Potential benefit to Nueces Estuary from increased fresh water flow.
d. Threats to agriculture and natural resources in region	• None
e. Recreational	• None
f. Equitable comparison of strategies	• Standard analyses and methods used
g. Interbasin transfers	• None
h. Third party social and economic impacts from voluntary redistribution of water	• Not applicable
i. Efficient use of existing water supplies and regional opportunities	• Provides enhanced recreational opportunities for the lakes.
j. Effect on navigation	• None

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5D.7

Gulf Coast Aquifer Supplies

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5D.7 Gulf Coast Aquifer Supplies

The Gulf Coast Aquifer underlies all 11 counties within the Coastal Bend Region and yields moderate to large amounts of fresh and slightly saline water. The Gulf Coast Aquifer, extending from Northern Mexico to Florida, is comprised of five water-bearing formations: Catahoula, Jasper, Burkeville Confining System, Evangeline, and Chicot. The Evangeline and Chicot Aquifers are the uppermost water-bearing formations, are the most productive and, consequently, are the formations utilized most commonly. The Evangeline Aquifer of the Gulf Coast Aquifer System features the highly transmissive Goliad Sands. The Chicot Aquifer is comprised of many different geologic formations; however, the Beaumont and Lissie Formations are predominant in the Coastal Bend Area. The Burkeville Confining System is a limited water-bearing formation and characterized as containing substantial amounts of clay.

The Gulf Coast Aquifer is the primary groundwater resource in the Coastal Bend Region and estimated to constitute 97 percent of the region's groundwater availability according to Modeled Available Groundwater (MAG) values developed by the TWDB. The MAGs used to define groundwater availability for regional water planning were developed based on desired future conditions adopted by local groundwater conservation districts represented in Groundwater Management Area (GMA) 13, GMA 15, and GMA 16.[1] Table 5D.7.1 shows the Gulf Coast Aquifer groundwater availability, projected use by current groundwater users, and estimates on remaining groundwater available for water management strategies. This information serves as a basis for recommended water management strategies which must be MAG-limited according to TWDB guidelines for regional water planning. Several potential projects have been identified and evaluated that exceed the MAGs, which include brackish groundwater supplies discussed in Chapter 5D.8 and treated surface water and raw groundwater blending projects in San Patricio County discussed in Chapter 5D.2. These strategies can be considered as alternative water management strategies, but cannot be identified as a recommended water management strategy without MAG increase.

[1] McMullen County is located in GMA 13. Aransas and a portion of Bee County are located in GMA 15. The remaining Region N counties (Bee, Brooks, Duval, Jim Wells, Kenedy, Kleberg, Live Oak, McMullen, Nueces, and San Patricio) are located in GMA 16.

Table 5D.7.1.
Summary of Gulf Coast Aquifer Supplies in the Coastal Bend Region

County Name	Basin Name	MAG (ac-ft/yr)		Groundwater Use (ac-ft/yr)[1]		Amount Available for WMS (ac-ft/yr)	
		2020	2070	2020	2070	2020	2070
ARANSAS	SAN ANTONIO-NUECES	1,862	1,862	688	688	1,174	1,174
BEE	SAN ANTONIO-NUECES	19,382	19,306	11,233	11,233	8,149	8,073
BEE	NUECES	792	792	682	682	110	110
BROOKS	NUECES-RIO GRANDE	15,595	15,595	6,267	6,267	9,328	9,328
DUVAL	NUECES	364	364	364	364	0	0
DUVAL	NUECES-RIO GRANDE	13,699	13,699	11,661	11,661	2,038	2,038
JIM WELLS	NUECES	3,962	3,962	1,141	1,141	2,821	2,821
JIM WELLS	NUECES-RIO GRANDE	23,924	23,924	8,925	8,925	14,999	14,999
KENEDY	NUECES-RIO GRANDE	51,778	51,778	1,079	1,079	50,699	50,699
KLEBERG	NUECES-RIO GRANDE	50,701	50,701	10,331	10,331	40,370	40,370
LIVE OAK	SAN ANTONIO-NUECES	57	57	0	0	57	57
LIVE OAK	NUECES	11,377	11,377	8,171	8,171	3,206	3,206
MCMULLEN	NUECES	510	510	355	355	560[2]	560[2]
NUECES	SAN ANTONIO-NUECES	179	179	61	61	118	118
NUECES	NUECES	946	946	946	946	0	0
NUECES	NUECES-RIO GRANDE	7,884	7,884	7,151	7,151	733	733
SAN PATRICIO	SAN ANTONIO-NUECES	15,145	15,145	15,145	15,145	0	0
SAN PATRICIO	NUECES	3,868	3,868	3,631	3,631	237	237
Sum for Region N (ac-ft/yr)		**222,025**	**221,949**	**87,831**	**87,831**	**134,194**	**134,118**

[1] Groundwater use is based on well capacity, infrastructure limits, and other factors as discussed in Chapter 4.
[2] Included in the amount available is 405 ac-ft/yr from minor aquifers in McMullen County (Queen City, Sparta, and Yegua Jackson).

5D.7.1 Groundwater Alternative for Municipal Rural Water Systems, Irrigation, and Mining Water Users for the Coastal Bend Region

5D.7.1.1 Description of Strategy

Municipal water systems and other water user groups in the Coastal Plains area of the Coastal Bend Water Planning Region commonly use the Gulf Coast Aquifer for their supply. These sources may be a strong preference because the water is usually readily available, inexpensive, and often suitable for public water supplies with minimal treatment, although elevated concentrations of TDS are present in some areas.

The purposes of this option are to:

- Evaluate aquifers and existing well field(s) of each WUG to meet projected water supply requirements through the year 2070, based on groundwater supply estimates derived from reported well capacity for other wells in the area.

- If additional supplies are needed, identify whether or not additional wells are the most likely water management strategy, or whether an alternative strategy, such as purchase from a wholesale water provider, is recommended.
- If the water needs to be treated, estimate when the expansion is needed and how much the facilities will cost.

The evaluation of individual WUG water systems is at a reconnaissance level and does not include:

- An engineering analysis of the water system as to the current condition or adequacy of the wells, transmission system, and storage facilities;
- A projection of maintenance costs or replacement costs of existing wells and facilities;
- The potential interference of new wells installed by others near the city's wells or at locations identified for new well fields;
- Impact of potential changes in groundwater use patterns in the vicinity of the city's well field and the county;
- Changes in rules and regulations that may be developed and implemented by a ground-water conservation district or the State; nor
- Consideration of additional wells or water treatment for local purposes such as reliability, water pressure, peaking capacity, and localized growth.

The evaluation of each municipal water system consisted of the following steps:

1. Compiled information prepared for the CBRWPG on current and projected population and water demand for each of the WUGs;
2. Estimated well depth and capacity for each WUG based on publicly available information for the water system from published groundwater reports and TCEQ and TWDB records;
3. If the estimated groundwater supply after adjustments was greater than the estimated groundwater demand in the year 2070 and within the MAG, the evaluation concludes that the existing water supply is adequate;
4. If the estimated supply after adjustments was less than the estimated groundwater demand in the year 2070 and within the MAG, the evaluation concluded that an additional water supply would be needed and that supplies up to the MAG are available for meet needs; and
5. If new wells are the most feasible water management strategy, estimated at what decade it is needed and the capital cost of adding the new wells to the water system.

The methodology presented in the following text deals specifically with those entities that show a projected need that is likely to be met through development of local aquifer supplies; in other words, only those entities whose needs exceed the current estimation of local, currently accessible groundwater supply. These entities that report a need during the 2020 to 2070 planning period include:

- McMullen County-Irrigation
- McMullen County-Mining

- San Patricio-Irrigation
- City of San Diego

In addition to the entities listed above, the City of Beeville requested that two gulf coast groundwater projects are included as recommended water management strategies in their water supply plan (Chapter 5B). The City of Beeville currently relies on surface water supplies from the CCR/LCC system and does not report a water supply need during the planning period.

Because no specific project data regarding any of the local groundwater supply water management strategies is available, it is necessary to make a number of assumptions for costing and evaluation. For WUGs with needs to be met and/or recommended groundwater projects from local Gulf Coast Aquifers, characteristic well depth and well capacity (gpm) estimates were developed for costing purposes based on data from existing wells in the vicinity. For mining groundwater use, it was assumed that groundwater would be supplied at a constant annual rate, and that the water would be usable without treatment. For irrigation, it was assumed that all use would occur in 6 months of the year, so a peaking factor of two was used in estimating the number of wells necessary for cost estimation. In addition, it was assumed that irrigation and mining water would be applied without treatment. For the City of San Diego, it was assumed that the water suppliers would need to meet instantaneous peak demand rates of twice the annual average rate. Therefore, twice the number of wells of a given capacity are required to meet the peak demand rate for costing purposes. No pipelines or pump stations were assigned for costing purposes. It was assumed that these proposed wells would connect directly to the demand center or local distribution system, and that the cost of any associated piping would be covered in the 35 percent project cost contingency factor. For the purposes of estimating well pumping power costs, a total dynamic head estimate of 300 feet was assumed — 160 feet to bring water from pumping levels to the ground surface and 140 feet to pump into a pressurized distribution system maintained at 60 psi. This conservative estimate is intended to account for local drawdown and declining water levels with time. For municipal (and county-other) users it was also assumed, in the absence of any specific information to the contrary, that disinfection would be the only treatment needed to make the groundwater supply meet water quality standards, and that adequate treatment capacity would exist to meet peak demand rates.

All cost estimates were performed according to established unified costing tool methodology. All costs were amortized over a 20-year loan period, with debt service and annualized O&M often being a significant proportion of costs. In addition, all wells are costed according to September 2013 pricing, even if they are not scheduled to be needed until later decades. This is to maintain consistency in cost estimates with other projects. However, it should be noted that individual wells are not usually financed in this manner, and managers of affected WUGs may be more interested simply in the estimated capital cost for the wells. Also, cost estimates for new wells serving economic activities such as mining or irrigation are presented as a group with a single unit cost, although in reality these costs will be borne individually by multiple independent parties (farmers, mining operations, manufacturing plants, etc.) when and where the wells are needed and constructed.

5D.7.1.2 Water Availability

All groundwater development alternatives for small municipal and rural water systems, irrigation, and mining water users in the Coastal Bend Region were limited by MAGs and voluntary groundwater transfers available.

5D.7.1.3 Evaluation of Municipal Water Systems and Water Quality

The following rural municipal water systems with a population in excess of about 500 rely completely on local groundwater supplies:

- George West (Live Oak County);
- McCoy WSC (Live Oak County);
- Lake City (San Patricio County);
- Sinton (San Patricio County);
- Freer (Duval County);
- Benavides (Duval County);
- Orange Grove (Jim Wells County);
- Premont (Jim Wells County);
- Falfurrias (Brooks County);
- El Oso WSC (Bee/Live Oak Counties); and
- San Diego (Jim Wells/Duval Counties).

The City of Kingsville relies heavily on groundwater supplies, although it also receives treated surface water from STWA. The needs analysis indicate that the City of San Diego is the only municipal systems listed above with identified projected needs during the planning period.

There is some uncertainty as to the future water quality with prolonged pumping, since TDS exceeds drinking water standards in portions of Jim Wells, Duval, Brooks, and San Patricio counties were rural entities relying on groundwater supplies are located. For drinking water supplies, the public drinking water standard for salinity is 1,000 mg/L of total dissolved solids. If local utilities determine that a water treatment plant to desalinate the local brackish groundwater is needed, then unit costs for municipal water supply will be much higher than those incurred with standard chlorine disinfection methods for potable use of groundwater.

5D.7.1.4 Evaluation of Additional Groundwater Development for Entities with Reported Needs

For purposes of this alternative, additional groundwater development for water user groups are considered in strict accordance with groundwater availability (MAG) and assumes minimal treatment, if any is required. For San Patricio County-Irrigation and McMullen County-Mining, the currently accessible groundwater availability is insufficient to meet the projected demands of rural water suppliers.

The City of San Diego has shortages beginning in 2030, with a maximum shortage of 158 ac-ft/yr by 2070. There is sufficient MAG to fully meet the need. The City of San Diego needs to drill one well for a groundwater supply of 158 ac-ft/yr.

For McMullen County, the maximum shortage that occurs within the planning period after considering conservation is 43 ac-ft/yr for McMullen County-Irrigation (2050) and 3,029 ac-ft/yr for McMullen County-Mining (2030). *Voluntary transfers of 449 ac-ft are assumed to be available from unutilized Gulf Coast aquifer surpluses identified for McMullen County-Other*. Additional groundwater development for these two users is limited by voluntary transfers and MAGs. McMullen County-Irrigation is able to meet its full need with one well. McMullen County-Mining is able to drill three wells for a groundwater supply of 966 ac-ft/yr without violating MAG constraints. An unmet need of 2,063 ac-ft occurs for McMullen County-Mining in 2030 after considering mining conservation and available groundwater supplies. Due to reductions in McMullen County-Mining demand projections after 2030, an unmet need for McMullen County-Mining only occurs from 2020 to 2040.

For San Patricio County, the maximum shortage that occurs within the planning period after considering conservation is 1,396 ac-ft/yr for San Patricio County-Irrigation (2070). *Voluntary transfers of 466 ac-ft are assumed to be available from unutilized Gulf Coast aquifer surpluses identified for the City of Sinton*. Additional groundwater development for irrigation is limited by voluntary transfers and MAGs. San Patricio County-Irrigation is able to drill two wells for a groundwater supply of 703 ac-ft/yr without violating MAG constraints. An unmet need of 693 ac-ft occurs for McMullen County-Mining in the last decade only (2070) after considering mining conservation and available groundwater supplies.

5D.7.1.5 Evaluation of Groundwater Development for the City of Beeville

The City of Beeville does not have any needs identified during the planning time period, but is currently considering development of a 1,491 ac-ft/yr (1.3 mgd) wellfield at Chase Field and a new supply of 0.3 mgd by converting an irrigation to municipal well as shown in Figure 5D.7.1 and Figure 5D.7.2, respectively. Both projects can be developed at requested amounts without violating MAG constraints. The Chase Field project assumes 4 wells at a depth of 560 ft will operate at 230 gpm for 75% of the time to meet supply needs. It is anticipated that no advanced treatment is needed, other than chlorine disinfection.

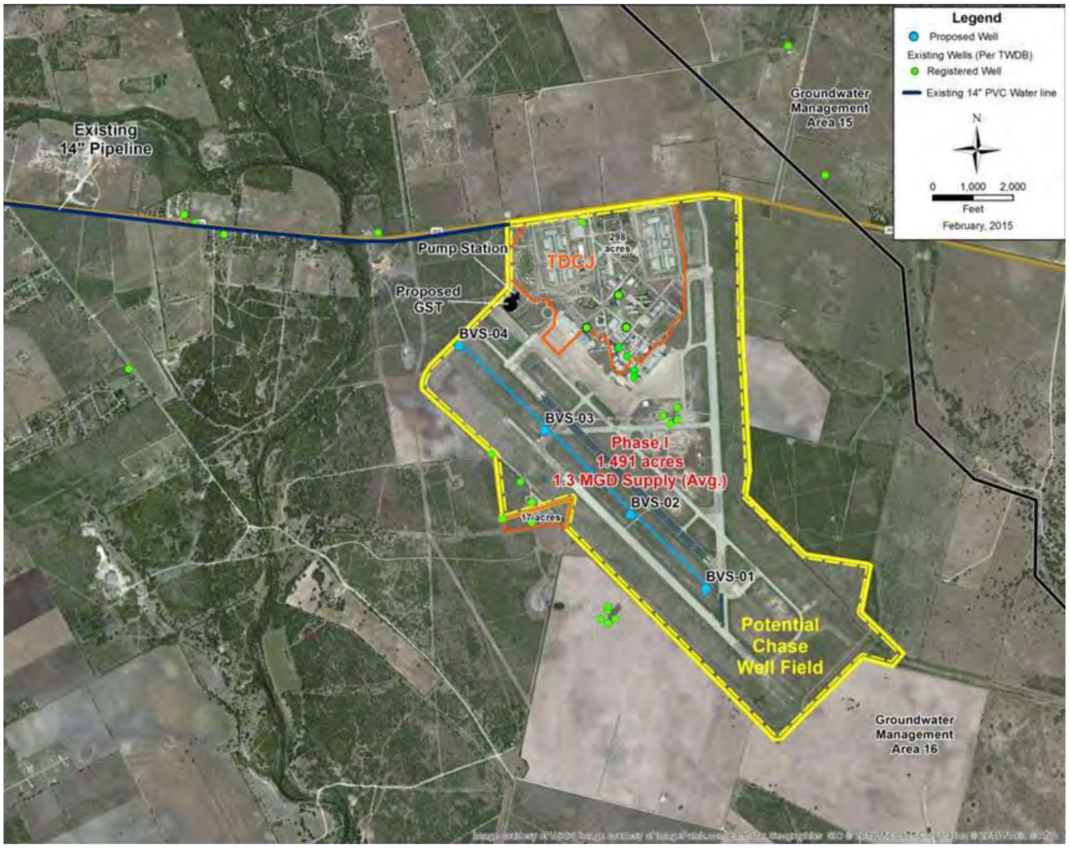


Figure 5D.7.1.
City of Beeville- Chase Field Project

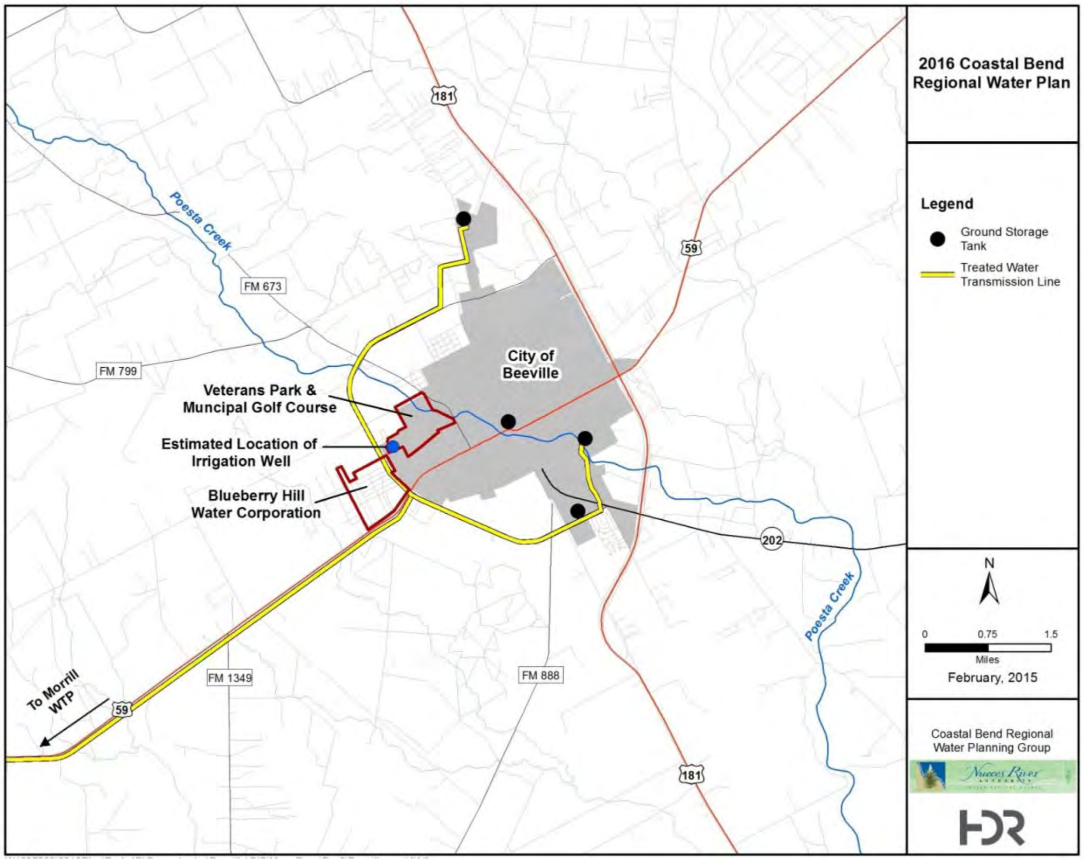


Figure 5D.7.2.
City of Beeville- Irrigation to Municipal Well Conversion Project

5D.7.1.6 Environmental Issues

The pumping of groundwater from the Gulf Coast Aquifer could have a very slight negative impact on baseflow in the downstream reaches of streams in these areas. However, many of the streams are dry most all the time; thus, no measurable impact on wildlife along the streams is expected.

The desalination of slightly saline groundwater produces a concentrate of salts in water that requires disposal. Depending upon location, environmental concerns can be addressed by discharging to saline aquifer by deep well injection, discharging to a salt-water body, or blending with wastewater.

Habitat studies and surveys for protected species may need to be conducted at the proposed well field sites and along any pipeline routes. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primary pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands may be required where impacts are unavoidable.

5D.7.1.7 Engineering and Costing

Cost estimates for new wells were prepared according to the assumptions presented in the previous section. Table 5D.7.2 displays the projected needs, by decade, for each of these entities, and the decades in which additional wells are estimated to be needed. The capital cost, project cost, annual cost, yield, and unit cost (in $/ac-ft and $/1,000 gallons) for water obtained under this strategy are presented in Table 5D.7.3 through Table 5D.7.8 for each entity county.

5D.7.1.8 Implementation Issues

The development of additional wells and the installation and operation of brackish water treatment plant, may have to address the following issues.

- Disposal of salt concentrate from water treatment plant;
- Impact on:
    - Endangered and other wildlife species,
    - Water levels in the aquifer,
    - Baseflow in streams, and
    - Wetlands;
- Capital and operation and maintenance costs;
- Skilled operators of desalination water treatment plants;
- Competition with others for groundwater in the area;
- Detailed feasibility evaluation including test drilling and aquifer water quality testing; and
- The potential for regulations by groundwater conservation districts in the future based on managed available groundwater identified by local districts or Groundwater Management Area, including the renewal of pumping permit at periodic intervals in counties where districts have been organized.

Table 5D.7.2.
Region N Local Gulf Coast Aquifer Supply Water Management Strategy Cost and Schedule Summary

County	User		Needs (ac-ft/yr)						Total Wells
			2020	2030	2040	2050	2060	2070	
Jim Wells/Duval	City of San Diego	Projected Needs	0	28	56	94	128	158	2
		New Wells	1	—	—	—	—	—	
McMullen	Irrigation	Projected Needs-After Conservation	39	40	41	41	43	43	1
		New Wells	1	—	—	—	—	—	
McMullen	Mining	Projected Needs-After Conservation	2,627[1]	3,029[1]	2,862[1]	825	84	0	3
		New Wells	3	—	—	—	—	—	
San Patricio	Irrigation	Projected Needs-After Conservation	0	0	0	0	1	1,396[1]	2
		New Wells	—	—	—	—	2	—	
Bee	City of Beeville-Chase Field	Projected Needs	0	0	0	0	0	0	4
		New Wells	4	—	—	—	—	—	
Bee	City of Beeville-0.3 mgd well conversion	Projected Needs	0	0	0	0	0	0	1
		New Wells	1	—	—	—	—	—	
		New Wells	1	1	—	—	—	—	

[1] Indicates needs exceeding current estimate of local aquifer supply. See text for details.

Table 5D.7.3.
Cost Estimate Summary Water Supply Project Option
September 2013 Prices
Region N Local Gulf Coast Supplies – City of San Diego

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Well Field and Piping	$640,000
Water Treatment Plant (0.3 mgd)	$28,000
TOTAL COST OF FACILITIES	**$668,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$234,000
Environmental & Archaeology Studies and Mitigation	$6,000
Interest During Construction	$32,000
TOTAL COST OF PROJECT	**$940,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$79,000
Operation and Maintenance	
Pipeline (1% of Cost of Facilities)	$6,000
Water Treatment Plant	$17,000
Pumping Energy Costs (40,959 kWh @ 0.09 $/kWh)	$4,000
TOTAL ANNUAL COST	**$120,000**
Available Project Yield (ac-ft/yr)	158
Annual Cost of Water ($ per ac-ft)	$671
Annual Cost of Water ($ per 1,000 gallons)	$2.06

Needs analysis indicates two wells at depth of 580 ft operating at 160 gpm needed by 2030.
Assumes 1/4-mile transmission pipeline for delivery.
Cost estimate assumes delivery must meet peak rate of two times average annual rate.
Cost estimate assumes chlorine disinfection is the only treatment necessary for San Diego groundwater supply.

Table 5D.7.4.
Cost Estimate Summary Water Supply Project Option
September 2013 Prices
Region N Local Gulf Coast Supplies – McMullen County-Irrigation

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Well Fields	$92,000
TOTAL COST OF FACILITIES	**$92,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$32,000
Interest During Construction	$5,000
TOTAL COST OF PROJECT	**$129,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$11,000
Operation and Maintenance	
Wells	$1,000
Pumping Energy Costs (6,019 kWh @ 0.09 $/kWh)	$1,000
TOTAL ANNUAL COST	**$13,000**
Available Project Yield (ac-ft/yr)	43
Annual Cost of Water ($ per ac-ft)	$302
Annual Cost of Water ($ per 1,000 gallons)	$0.93

Needs analysis indicates one well at depth of 600 ft operating at 60 gpm needed by 2020.
Cost estimate assumes delivery must meet seasonal peak rate of two times average annual rate.
Cost estimate assumes no water treatment is needed.

Table 5D.7.5.
Cost Estimate Summary Water Supply Project Option
September 2013 Prices
Region N Local Gulf Coast Supplies – McMullen County-Mining

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Well Fields	$1,206,000
TOTAL COST OF FACILITIES	**$1,206,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$422,000
Interest During Construction	$57,000
TOTAL COST OF PROJECT	**$1,685,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$141,000
Operation and Maintenance	
Wells	$12,000
Pumping Energy Costs (396,841 kWh @ 0.09 $/kWh)	$36,000
TOTAL ANNUAL COST	**$189,000**
Available Project Yield (ac-ft/yr)	966
Annual Cost of Water ($ per ac-ft)	$196
Annual Cost of Water ($ per 1,000 gallons)	$0.60

Needs analysis indicates three wells at depth of 600 ft operating at 250 gpm needed by 2020.
Cost estimate assumes constant, uniform delivery rate (no peaking).
Yield limited by MAG after voluntary redistribution of groundwater from McMullen County-Other.
Cost estimate assumes no environmental studies and mitigation or land acquisition surveying.
Cost estimate assumes no water treatment is needed.

Table 5D.7.6.
Cost Estimate Summary Water Supply Project Option
September 2013 Prices
Region N Local Gulf Coast Supplies – San Patricio County-Irrigation

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Well Fields	$827,000
TOTAL COST OF FACILITIES	**$827,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$289,000
Interest During Construction	$40,000
TOTAL COST OF PROJECT	**$1,156,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$97,000
Operation and Maintenance	
Wells	$8,000
Pumping Energy Costs (75,314 kWh @ 0.09 $/kWh)	$7,000
TOTAL ANNUAL COST	**$112,000**
Available Project Yield (ac-ft/yr)	703
Annual Cost of Water ($ per ac-ft)	$159
Annual Cost of Water ($ per 1,000 gallons)	$0.49

Needs analysis indicates four wells at depth of 450 ft operating at 250 gpm needed by 2050.
Cost estimate assumes delivery must meet seasonal peak rate of two times average annual rate.
Yield limited by MAG after voluntary redistribution of groundwater from City of Sinton.
Cost estimate assumes no environmental studies and mitigation or land acquisition surveying.
Cost estimate assumes no water treatment is needed.

Table 5D.7.7.
Cost Estimate Summary Water Supply Project Option
September 2013 Prices
Region N Local Gulf Coast Supplies – City of Beeville (1.3 mgd Chase Field Project)

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Pump Stations (1.7 mgd)	$851,000
Transmission Pipeline (14-inch, 0.37 mile)	$93,000
Well Fields (4 wells)	$2,119,000
Storage Tanks	$174,000
Treatment Plant (1.7 mgd)	$98,000
TOTAL COST OF FACILITIES	**$3,335,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$1,162,000
Environmental & Archaeology Studies and Mitigation	$88,000
Land Acquisition and Surveying (32 acres)	$30,000
Interest During Construction	$162,000
TOTAL COST OF PROJECT	**$4,777,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$400,000
Operation and Maintenance	
Wells, Pipeline, Pumps	$22,000
Pump Stations	$21,000
Water Treatment Plant	$59,000
Pumping Energy Costs (625,680 kWh @ 0.09 $/kWh)	$56,000
Purchase of Water (1,457 ac-ft/yr @ 101.03 $/ac-ft)	$147,000
TOTAL ANNUAL COST	**$705,000**
Available Project Yield (ac-ft/yr)	1,457
Annual Cost of Water ($ per ac-ft)	$484
Annual Cost of Water ($ per 1,000 gallons)	$1.48

Cost estimate includes four wells at depth of 560 ft operating at 230 gpm by 2020.
Assumes groundwater purchase price of $101 per ac-ft pumped per BDA agreement.
Assumes 14-inch pipeline to City of Beeville will be used for delivery.
Cost estimate assumes seasonal peak rate of 1.32 times average rate.
Cost estimate assumes chlorine disinfection is the only treatment necessary for groundwater supply.

Table 5D.7.8.
Cost Estimate Summary Water Supply Project Option
September 2013 Prices
Region N Local Gulf Coast Supplies – City of Beeville
(0.3 mgd Irrigation to Municipal Well Conversion)

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Transmission Pipeline (6-inch, 0.5 mile)	$48,000
Storage Tank	$96,000
Treatment Plant (0.4 mgd)	$35,000
TOTAL COST OF FACILITIES	**$179,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$60,000
Environmental & Archaeology Studies and Mitigation	$13,000
Interest During Construction	$9,000
TOTAL COST OF PROJECT	**$261,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$22,000
Operation and Maintenance	
Water Treatment Plant	$21,000
Pumping Energy Costs (36,632 kWh @ 0.09 $/kWh)	$3,000
TOTAL ANNUAL COST	**$46,000**
Available Project Yield (ac-ft/yr)	340
Annual Cost of Water ($ per ac-ft)	$135
Annual Cost of Water ($ per 1,000 gallons)	$0.42

Well was installed in September 2014. No debt service payment on existing well.
Cost estimate assumes chlorine disinfection is the only treatment necessary for groundwater supply.

5D.7.1.9 Evaluation Summary

An evaluation summary of this regional water management option is provided in Table 5D.7.9.

Table 5D.7.9.
Evaluation Summary of the Alternative for Municipal Rural Water Systems, Irrigation, and Mining Water Users

Impact Category	*Comment(s)*
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	 1. Firm Yield: Varies from 43 to 1,457 ac-ft. 2. Good reliability, if adequate water quality. 3. Cost varies from $135 to $671 per ac-ft.
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. May slightly decrease instream flow and discharge of freshwater into coastal estuaries due to local groundwater-surface water interaction. 2. May slightly decrease instream flow and discharge of freshwater into coastal estuaries due to local groundwater-surface water interaction. 3. Negligible impacts. 4. Negligible impacts. 5. Negligible impacts. 6. Cultural resources will need to be surveyed and avoided. 7. Negligible impacts. a. Low to moderate impact. b. Low to moderate impact. c. No impact. d. Low to moderate impact. e. Low to moderate impact. f. Low to moderate impact. g-h. Low to moderate impact associated with mining. i. Boron may be a potential water quality concern.
c. Impacts to State water resources	• No negative impacts on water resources other than lowering Gulf Coast Aquifer levels
d. Threats to agriculture and natural resources in region	• May slightly increase pumping costs for agricultural users in the area due to localized drawdowns
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Standard analyses and methods used
g. Interbasin transfers	• None
h. Third party social and economic impacts from voluntary redistribution of water	• None
i. Efficient use of existing water supplies and regional opportunities	• Provides regional opportunities with local resources
j. Effect on navigation	• None
k. Consideration of water pipelines and other facilities used for water conveyance	• None

5D.7.2 Blending Groundwater and Treated Surface Water Strategies

5D.7.2.1 Description of Strategy

This strategy evaluates the potential for blending brackish groundwater that is not desalinated with existing treated surface water supplies. Three independent well fields, as shown in Figure 5D.7.3, are evaluated as brackish groundwater supplies from the Gulf Coast aquifer, including delivery to one or more Region N utilities. A key consideration for this strategy is the quantity of brackish groundwater that can be blended with existing surface water supplies while maintaining blended water quality within acceptable limits. The three blending strategies evaluated are as follows.

1. Brackish Aransas County groundwater blended with treated surface water from San Patricio Municipal Water District (SPMWD)
2. Brackish San Patricio County groundwater blended with treated surface water from SPMWD
3. Brackish Nueces County groundwater blended with treated City of Corpus Christi surface water from the O.N. Stevens WTP

Specific information from three locations is utilized in the evaluation, however, the methodology and findings from these specific locations are generally applicable to any location considering utilizing brackish groundwater blending.

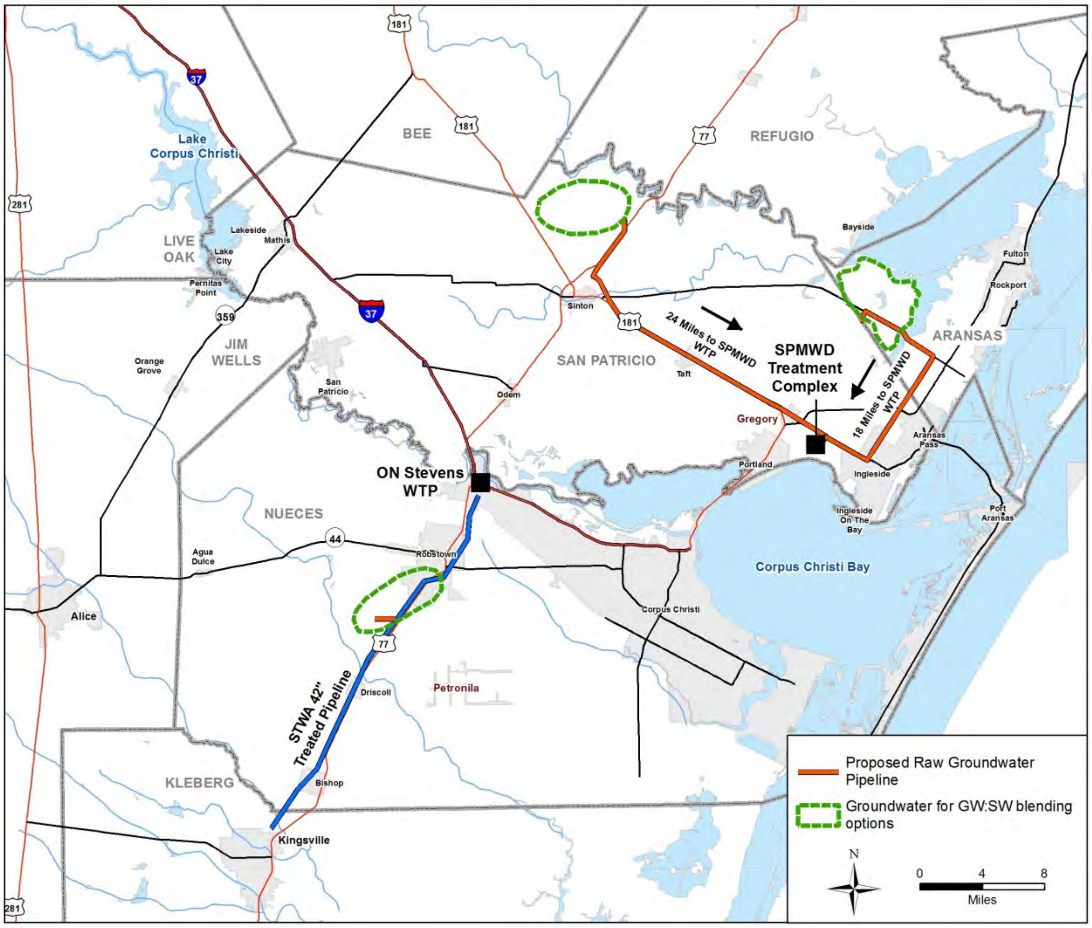


Figure 5D.7.3.
Location of Brackish Groundwater Well Fields

5D.7.2.2 Available Yield and Water Quality

The primary constituents of concern for blending brackish groundwater with treated surface water are shown in Table 5D.7.10.

Table 5D.7.10.
Water Quality Constituents of Groundwater and General Impacts on Blended Water Supply Quality

Water Quality Constituent	_General Impact on Treatment_
Temperature	Groundwater treatment and aesthetics if temperature is much greater than ambient
Alkalinity	Corrosion chemistry
Calcium Hardness	Corrosion chemistry, distribution system scale stability and formation
Total Hardness	Corrosion chemistry, distribution system scale stability and formation
pH	Corrosion chemistry
Total Dissolved Solids (TDS)	Secondary MCL, Finished water quality, corrosion chemistry
Chloride	Secondary MCL, Finished water quality, corrosion chemistry
Sulfate	Secondary MCL, Finished water quality, corrosion chemistry
Iron	Oxidant demand, groundwater treatment requirements
Manganese	Oxidant demand, groundwater treatment requirements
Arsenic	Regulatory limit, groundwater treatment requirements
Radionuclides (radium, gross alpha, uranium)	Regulatory limit, groundwater treatment requirements

There are two broad water quality concerns when considering blending treated surface waters with untreated brackish groundwater. The first concern is meeting regulatory requirements for dissolved constituents present in brackish groundwater such as TDS, chloride, and sulfate along with other contaminants that may be present in any groundwater such as iron, manganese, arsenic, and radionuclides. These dissolved constituents are generally higher in the groundwater than in the surface water and in many cases are above the secondary MCL limits of 1,000 mg/L for TDS, 300 mg/L for chloride, and 300 mg/L for sulfate. The second concern is the potential for distribution system water quality impacts due to the introduction of brackish groundwater with significantly different corrosion chemistry. The addition of non-desalinated brackish groundwater can increase the concentration of ions such as chloride and sulfate that can cause corrosion scale instability resulting in increased corrosion and “red water” even at concentrations well below the secondary MCL. The potential for corrosion issues can be roughly approximated using the below corrosion indices in Table 5D.7.11.

Table 5D.7.11.
Corrosion Indices and Desired Values

Corrosion Indices	*Parameters Used to Calculate*	*Desired Values*
Langlier Saturation Index (LSI)	pH, calcium hardness	> 0.0
Precipitation Potential, mg/L	pH, calcium hardness	4 – 10
Ryzner Index	pH, alkalinity, hardness	< 7.0
Larson Index	chloride, sulfate, alkalinity	< 0.8

The potential for a noticeable change in water quality with the introduction of a new brackish groundwater supply is impacted by the water quality of existing supplies. A water distribution system that has existing water supplies with high concentrations of dissolved constituents will be less likely to experience corrosion related poor water quality or customer complaints when brackish groundwater is introduced. Water quality goals for the system are established for the evaluated locations based on existing water quality compared to blended water quality and standard corrosion indices calculations.

5D.7.2.3 Groundwater Available Yield and Water Quality

Aransas County

Availability

Existing wells within a 5-mile buffer of the proposed Aransas County wellfield were examined to determine availability of groundwater in the area. Data was utilized from the Texas Water Development Board's Groundwater database report (TWDB), Drillers report database (Drillers), and the Brackish Resource Aquifer Characterization System (BRACS). The collected data seen below in Figure 5D.7.4 was used to determine the design depth and yield for wells in the wellfield. It was determined that on average, wells in the proposed well field could produce 75 gpm at an average depth of 400 ft. The total yield of the project is restricted by MAG limitations in Aransas County of 1,174 ac-ft/yr.

Water Quality

Water quality information was compiled from available information in the TWDB and BRACS databases (Table 5D.7.12). The Drillers database did not contain any water quality measurements. While Chloride, Total Dissolved Solids, Alkalinity, Iron, Manganese and Arsenic are all constituents of concern; Chloride was used as the limiting factor. Chloride measurements ranged from 539 mg/L to 2,410 mg/L throughout the area (Figure 5D.7.5). The median chloride concentration was found to be 843 mg/L compared to a 90th percentile value of 2,383 mg/L. Iron, Manganese, and Arsenic concentrations were below limits; however, the small sample size may not represent actual concentrations.

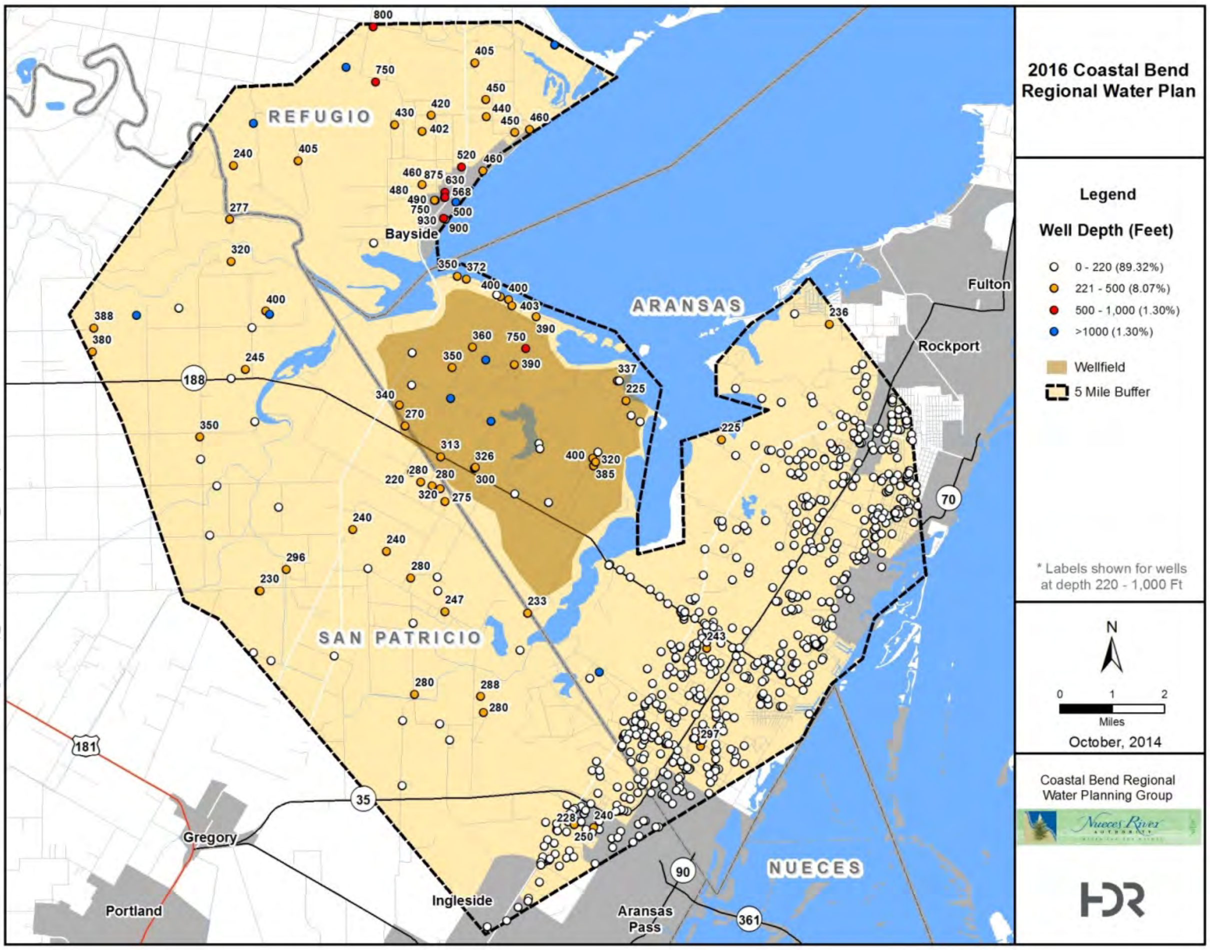


Figure 5D.7.4.
Existing Well Depths around the Aransas County Proposed Wellfield

Table 5D.7.12.
Aransas County Groundwater Quality Summary

Water Quality Parameter	# of Samples	Min	Max	Median	Average	10th to 90th Percentile		Limit
Temperature, ºC	6	26.0	30.0	27.5	27.5	26.0	30.0	N/A
Alkalinity, mg/L as $CaCO_3$	18	236	393	343	333	240	387	N/A
Total Hardness, mg/L as $CaCO_3$	18	20	358	33	87	21	358	N/A
Calcium Hardness, mg/L as $CaCO_3$	18	16	286	26	70	17	286	N/A
pH	9	7.5	8.7	8.2	8.2	7.5	8.7	>7.0
TDS, mg/L	18	1,104	4,552	1,826	2,360	1,272	4,520	<1,000
Chloride, mg/L	18	440	2,410	843	1,184	539	2,383	<300
Sulfate, mg/L	18	0	161	28	37	1	148	<300
Iron, ug/L	1	17.6	17.6	17.6	17.6	17.6	17.6	<300
Manganese, ug/L	1	2.7	2.7	2.7	2.7	2.7	2.7	<50
Arsenic, ug/L	1	1.5	1.5	1.5	1.5	1.5	1.5	<10
Bromide, ug/L	1	6.5	6.5	6.5	6.5	6.5	6.5	N/A
Radionuclides	No data for Radionuclides (Radium, Gross Alpha, Uranium). Historical information indicates radionuclides are well below limits in groundwater region.							

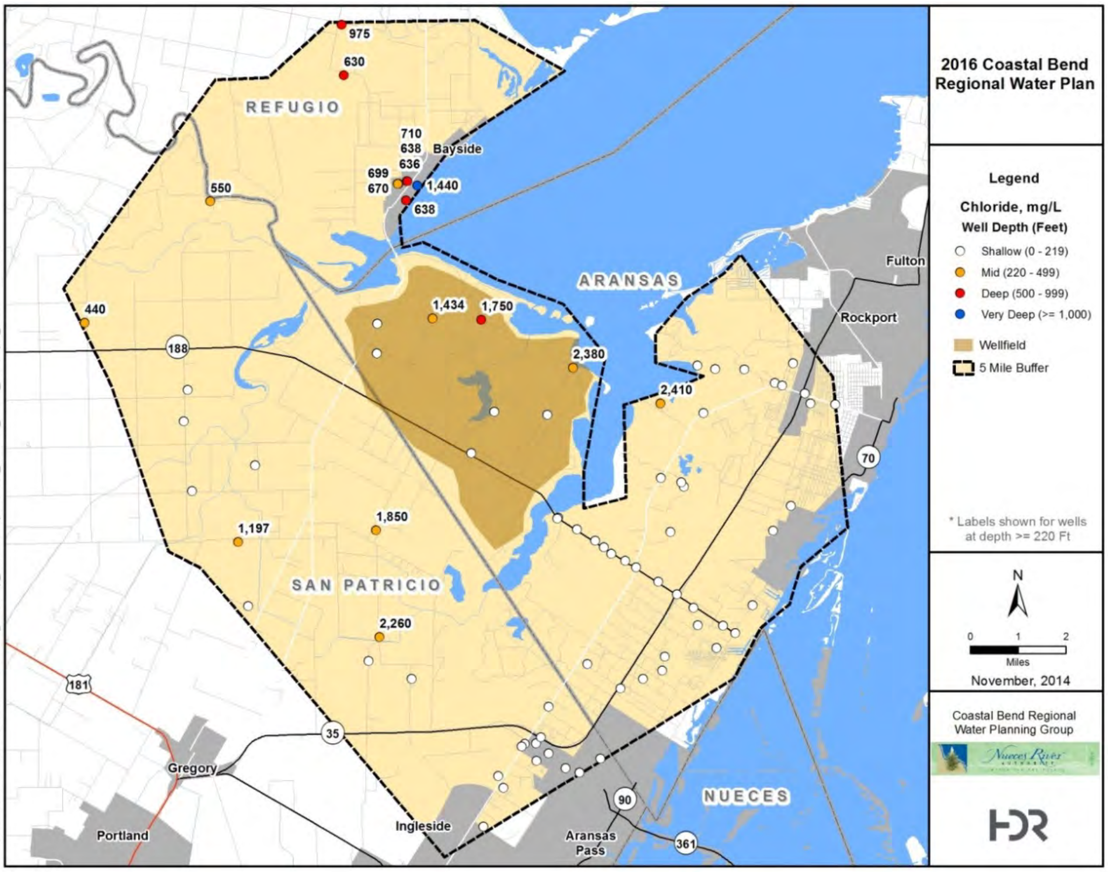


Figure 5D.7.5.
Chloride Concentrations around the Aransas County Proposed Wellfield

Based on additional groundwater data collected by Sherwin Alumina, groundwater conditions likely to be encountered for the Aransas County option is most similar to 90th percentile water quality. The Aransas County option evaluated assumes a groundwater concentration of 2,343 mg/L and produces a finished water concentration of 210 mg/L.

San Patricio County

Availability

Existing wells within a 5-mile buffer of the proposed San Patricio County wellfield were examined to determine availability of groundwater in the area. Data was utilized from the Texas Water Development Board's Groundwater database report (TWDB), Drillers report database (Drillers), and the Brackish Resource Aquifer Characterization System (BRACS). The collected data seen below in Figure 5D.7.6 was used to determine the design depth and yield for wells in the wellfield. It was determined that on average, wells in the proposed well field could produce 250 gpm at an average depth of 600 ft. The MAG in San Patricio County within the San Antonio-Nueces Basin is limited to 15,145 ac-ft/yr, all of which is currently allocated. The San Patricio project requires an increase in the MAG of 2,958 or 28,155 ac-ft/yr, depending on groundwater quality.

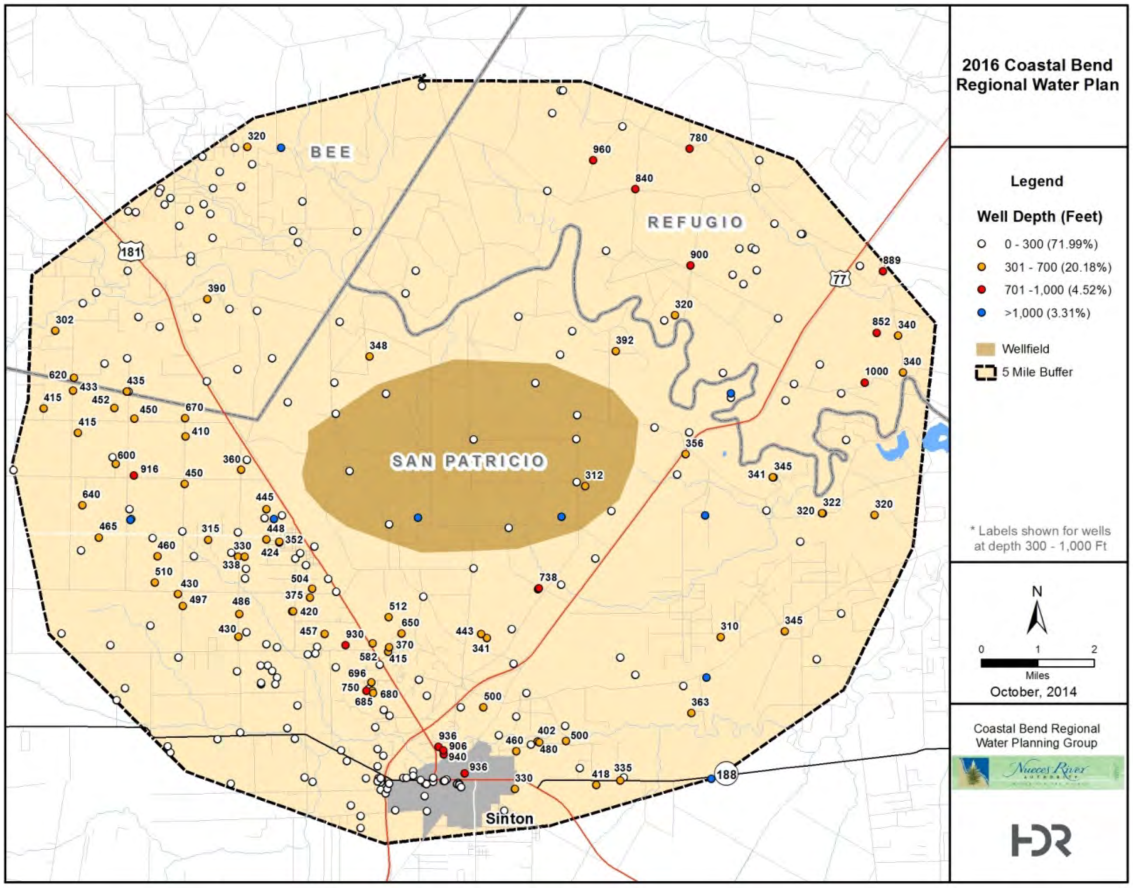


Figure 5D.7.6.
Existing Well Depths around the San Patricio County Proposed Wellfield

Water Quality

Water quality information was compiled from available information in the TWDB and BRACS databases (Table 5D.7.13). The Drillers database did not contain any water quality measurements. While Chloride, Total Dissolved Solids, Alkalinity, Iron, Manganese and Arsenic are all constituents of concern; Chloride was used as the limiting factor. Chloride measurements ranged from 181 mg/L to 1,126 mg/L throughout the area (Figure 5D.7.7). The median chloride concentration was found to be 284 mg/L compared to a 90th percentile value of 1,126 mg/L. Iron and arsenic levels were above limits, therefore, blending greater than 20% San Patricio groundwater may require oxidation, Iron filtration or arsenic removal.

Table 5D.7.13.
San Patricio County Groundwater Quality Summary

Water Quality Parameter	# of Samples	Min	Max	Median	Average	10th to 90th Percentile		Limit
Temperature, ºC	10	25.0	29.0	26.0	26.6	25.1	28.9	N/A
Alkalinity, mg/L as $CaCO_3$	20	239	344	298	303	267	341	N/A
Total Hardness, mg/L as $CaCO_3$	18	5	265	51	93	12	261	N/A
Calcium Hardness, mg/L as $CaCO_3$	18	4	212	40	74	10	209	N/A
pH	21	7.1	8.6	7.9	7.9	7.3	8.3	>7.0
TDS, mg/L	24	638	2,590	914	1,135	706	2,259	<1,000
Chloride, mg/L	26	100	1,340	284	425	181	1,126	<300
Sulfate, mg/L	26	0	198	53	55	0	110	<300
Iron, ug/L	7	15.0	706.0	51.0	136.7	15.0	706.0	<300
Manganese, ug/L	7	1.0	37.9	13.5	16.2	1.0	37.9	<50
Arsenic, ug/L	7	1.5	33.5	2.1	9.4	1.5	33.5	<10
Radionuclides	No data for Radionuclides (Radium, Gross Alpha, Uranium). Historical information indicates radionuclides are well below limits in groundwater region.							

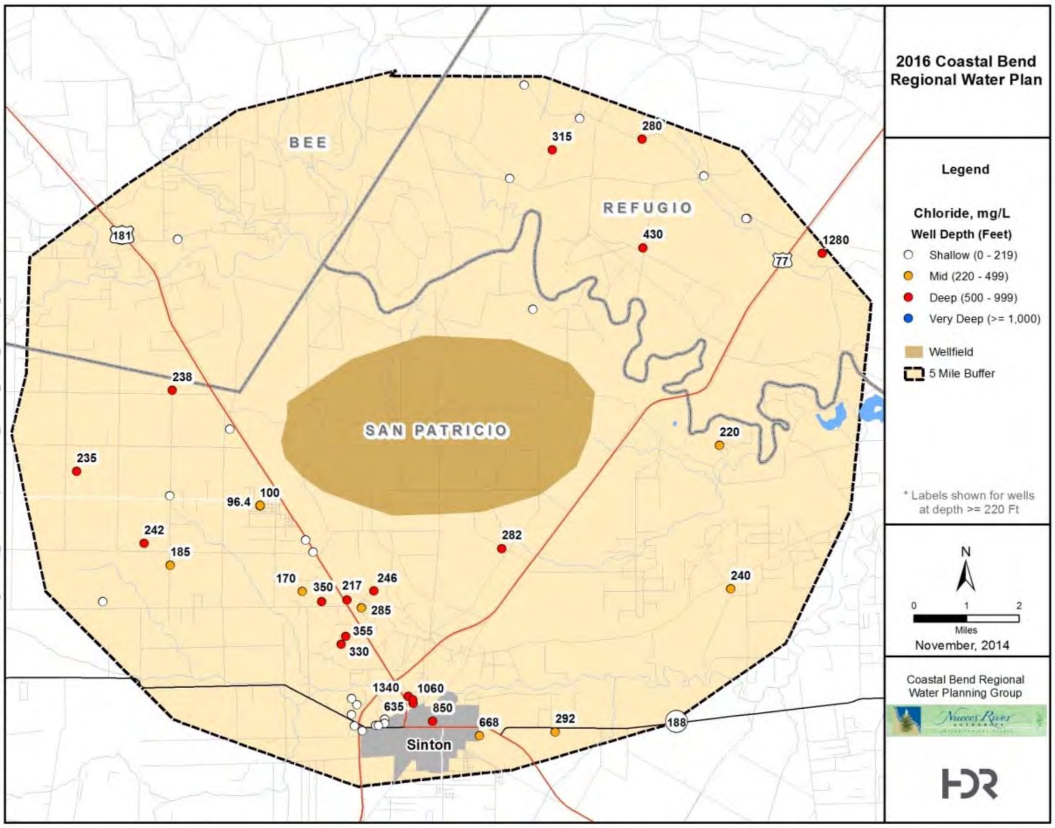


Figure 5D.7.7.
Chloride Concentrations around the San Patricio County Proposed Wellfield

Nueces County

Availability

Existing wells within a 5-mile buffer of the proposed Nueces County wellfield were examined to determine availability of groundwater in the area. Data was utilized from the Texas Water Development Board's Groundwater database report (TWDB), Drillers report database (Drillers), and the Brackish Resource Aquifer Characterization System (BRACS). The collected data seen below in Figure 5D.7.8 was used to determine the design depth and yield for wells in the wellfield. It was determined that on average, wells in the proposed well field could produce 200 gpm at an average depth of 500 ft. The MAG in Nueces County within the Nueces-Rio Grande Basin is limited to 7,884 ac-ft/yr, with 733 ac-ft/yr available after considering current groundwater use through the planning period. The Nueces project does not require a MAG increase.

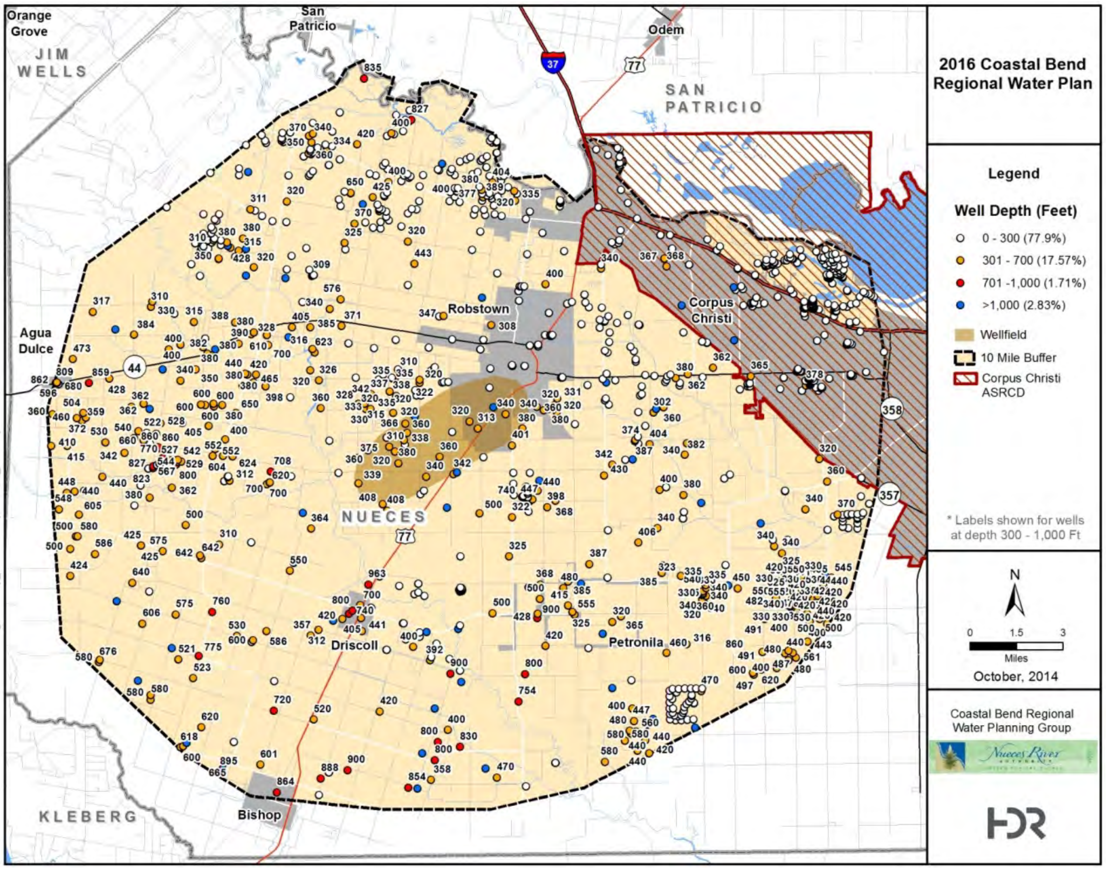


Figure 5D.7.8.
Existing Well Depths around the Nueces County Proposed Wellfield

Water Quality

Water quality information was compiled from available information in the TWDB and BRACS databases (Table 5D.7.14). The Drillers database did not contain any water quality measurements. While Chloride, Total Dissolved Solids, Alkalinity, Iron, Manganese and Arsenic are all constituents of concern; Chloride was used as the limiting factor. Chloride measurements ranged from 307 mg/L to 844 mg/L throughout the area (Figure 5D.7.9). The median chloride concentration was found to be 589 mg/L compared to a 90th percentile value of 844 mg/L. Iron concentrations were found to be above limits for median concentrations, therefore, blending greater than 10% Nueces groundwater may require oxidation, filtration for Iron removal, or Polyphosphate additions.

Table 5D.7.14. Nueces County Groundwater Quality Summary

Water Quality Parameter	# of Samples	Min	Max	Median	Average	10th to 90th Percentile		Limit
Temperature, ºC	38	0.0	29.0	24.0	16.7	0.0	28.0	N/A
Alkalinity, mg/L as $CaCO_3$	43	164	318	251	248	204	298	N/A
Total Hardness, mg/L as $CaCO_3$	43	30	303	87	96	39	154	N/A
Calcium Hardness, mg/L as $CaCO_3$	43	24	242	70	77	31	123	N/A
pH	43	6.9	9.1	8.0	8.0	7.5	8.6	>7.0
TDS, mg/L	45	1,066	2,800	1,687	1,741	1,157	2,406	<1,000
Chloride, mg/L	44	275	980	589	580	307	844	<300
Sulfate, mg/L	44	133	864	294	333	198	617	<300
Iron, ug/L	8	20.0	4000.0	755.0	1348.8	20.0	4000.0	<300
Manganese, ug/L	13	2.9	110.3	20.0	26.8	3.2	87.0	<50
Arsenic, ug/L	13	2.5	26.0	10.0	11.8	3.5	23.6	<10
Radionuclides	No data for Radionuclides (Radium, Gross Alpha, Uranium). Historical information indicates radionuclides are well below limits in groundwater region.							

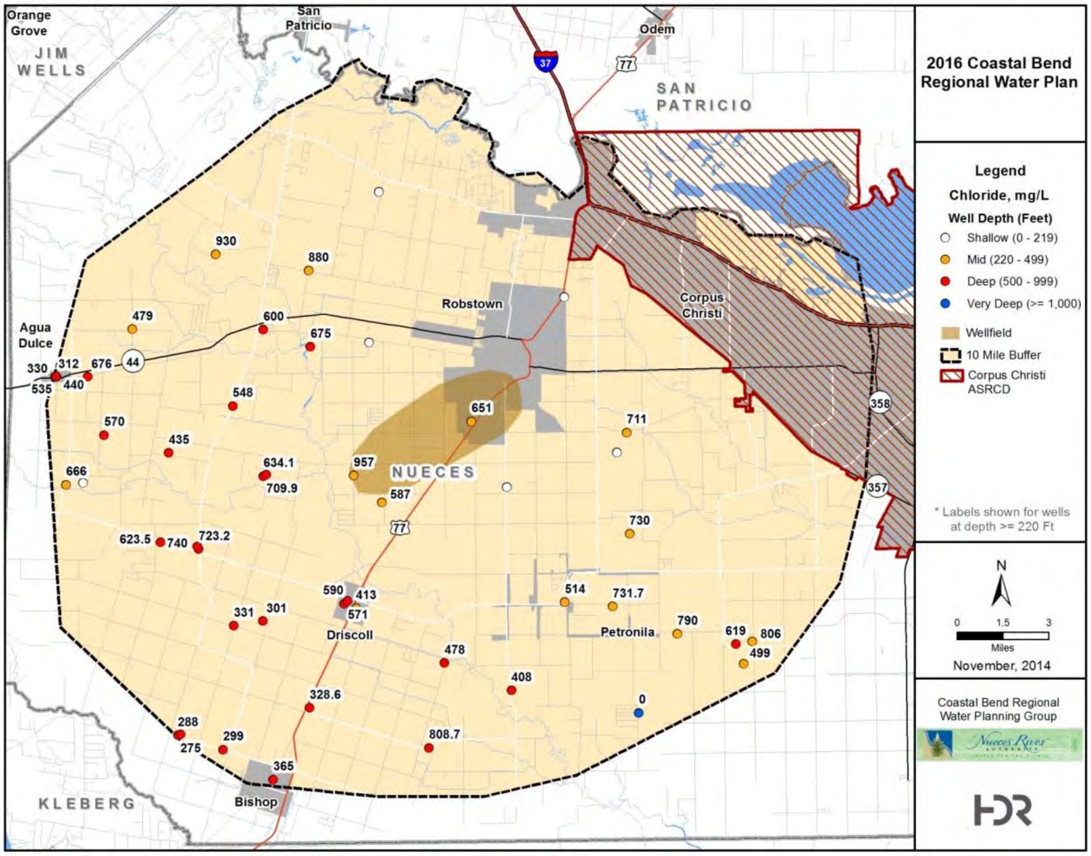


Figure 5D.7.9.
Chloride Concentrations around the Nueces County Proposed Wellfield

5D.7.2.4 Surface Water Quality

A water quality analysis was performed for surface water supplies using TCEQ Surface Water Quality Monitoring (SWQM) data. Water quality information available for the period between January 2010 and September 2014 is summarized in Tables 5D.7.15, 5D.7.16 and 5D.7.17. The surface water quality summary only includes parameters of interest when considering blending treated surface water with brackish groundwater. Constituents in the raw surface water such as iron and manganese will be removed by surface water treatment prior to blending with brackish groundwater and are therefore assumed to be absent for the purposes of the blending evaluation.

Table 5D.7.15. Nueces River Water Quality Summary

Water Quality Parameter	# of Samples	Min	Max	Median	Average	10th to 90th Percentile	
Alkalinity, mg/L as $CaCO_3$	7	159	191	181	178	169	190
Total Hardness, mg/L as $CaCO_3$	7	232	314	282	274	245	308
Calcium Hardness, mg/L as $CaCO_3$	7	186	251	226	219	196	246
pH	13	7.6	8.2	7.9	7.9	7.8	8.0
TDS, mg/L	13	638	844	758	761	659	837
Chloride, mg/L	7	222	318	253	264	229	314
Sulfate, mg/L	7	55	92	73	73	61	89

Table 5D.7.16. Lake Texana River Water Quality Summary

Water Quality Parameter	# of Samples	Min	Max	Median	Average	10th to 90th Percentile	
Alkalinity, mg/L as $CaCO_3$	14	49	114	85	82	57	104
Total Hardness, mg/L as $CaCO_3$	14	43	161	88	85	56	106
Calcium Hardness, mg/L as $CaCO_3$	7	35	129	70	68	45	85
pH	261	7.1	8.8	8.0	8.0	7.7	8.4
TDS, mg/L	247	66	287	133	123	72	153
Chloride, mg/L	14	7	40	19	19	9	31
Sulfate, mg/L	14	4	11	7	7	4	11

Table 5D.7.17.
Colorado River Near Bay City Water Quality Summary

Water Quality Parameter	# of Samples	Min	Max	Median	Average	10th to 90th Percentile	
Alkalinity, mg/L as $CaCO_3$	21	106	209	166	161	125	190
Total Hardness, mg/L as $CaCO_3$	21	106	209	166	161	125	190
Calcium Hardness, mg/L as $CaCO_3$	21	85	167	133	129	100	152
pH	21	7.4	9.4	8.3	8.3	7.8	8.6
TDS, mg/L	21	235	419	298	315	270	413
Chloride, mg/L	21	27	73	43	46	29	68
Sulfate, mg/L	21	27	78	45	48	34	65

The quality of existing surface water supplies from SPMWD and the City of Corpus Christi is the blended water that will be delivered by the Mary Rhodes Pipeline (MRP) including water from the MRP Phase II project that will integrate Colorado River water. Table 5D.7.18 shows the range of water quality for the surface water supply with a blend of the three surface water supplies in the ratio of 40% Nueces River, 35% Lake Texana, and 25% Colorado River.

Table 5D.7.18.
Total Surface Water Supply Quality Summary

Water Quality Parameter	Min	Max	Median	Average	10th to 90th Percentile	
Alkalinity, mg/L as $CaCO_3$	107	169	144	140	119	160
Total Hardness, mg/L as $CaCO_3$	134	234	185	180	148	208
Calcium Hardness, mg/L as $CaCO_3$	108	187	148	144	119	166
pH	7.4	8.7	8.0	8.0	7.8	8.3
TDS, mg/L	337	543	424	426	356	492
Chloride, mg/L	98	160	119	124	102	153
Sulfate, mg/L	30	60	43	44	35	56

5D.7.2.5 Blended Water Quality and Available Yield

Aransas County

The median blended water quality for Aransas brackish groundwater blended with surface water at blend ratios of 0% to 30% is shown in Table 5D.7.19. Water quality values that are outside the desired values are highlighted. Chloride is the limiting constituent with the chloride concentration greater than the 300 mg/L regulatory limit at a blend of 30% Aransas brackish groundwater. The addition of higher salinity groundwater increases the corrosion potential of the blended water as indicated by increasing Larson Index. Although the corrosion indicators are outside the desired value, the historical exposure of the distribution system to somewhat elevated dissolved solids concentrations may mitigate the potential for corrosion issues due to introduction of brackish water. Figures 5D.7.10 and 5D.7.11 summarize the range of TDS and chloride concentrations for blended Aransas brackish groundwater with surface water including the variability due to the range of concentrations in the groundwater data.

Table 5D.7.19.
Aransas County Blended with Surface Water Quality Summary (Median Values)

Constituent	100% SW	0% SW	90% SW	80% SW	70% SW	Desired Values
% Surface Water	**100%**	**0%**	**90%**	**80%**	**70%**	
% Aransas Brackish Groundwater	**0%**	**100%**	**10%**	**20%**	**30%**	
Temperature, ºC	22.9	27.5	23.3	23.8	24.3	<32
Alkalinity, mg/l as $CaCO_3$	144	343	164	184	204	
Hardness, mg/l as $CaCO_3$	185	33	170	155	139	
Calcium Hardness, mg/L as $CaCO_3$	148	26	136	124	112	
pH	8.04	8.20	8.09	8.12	8.14	>7
TDS, mg/L	424	1,825	564	704	844	<1000
Chloride, mg/L	119	843	191	264	336	<210
Sulfate, mg/L	43	28	41	40	38	<300
Iron, mg/L	0.0080	0.0176	0.0090	0.0099	0.0109	<0.3
Manganese, mg/L	0.0010	0.0027	0.0012	0.0013	0.0015	<0.05
Arsenic, mg/L	0.0010	0.0015	0.0011	0.0011	0.0012	<0.01
Langlier Saturation Index (LSI)	0.6	0.3	0.7	0.7	0.7	> 0.0
Precipitation Potential, mg/L	12.1	7.0	14.0	15.5	16.6	4-10 mg/L
Ryzner Index	6.8	7.5	6.8	6.7	6.7	< 7.0
Larson Index	1.5	3.5	1.9	2.2	2.5	< 0.8

Values that exceed desired values are highlighted.

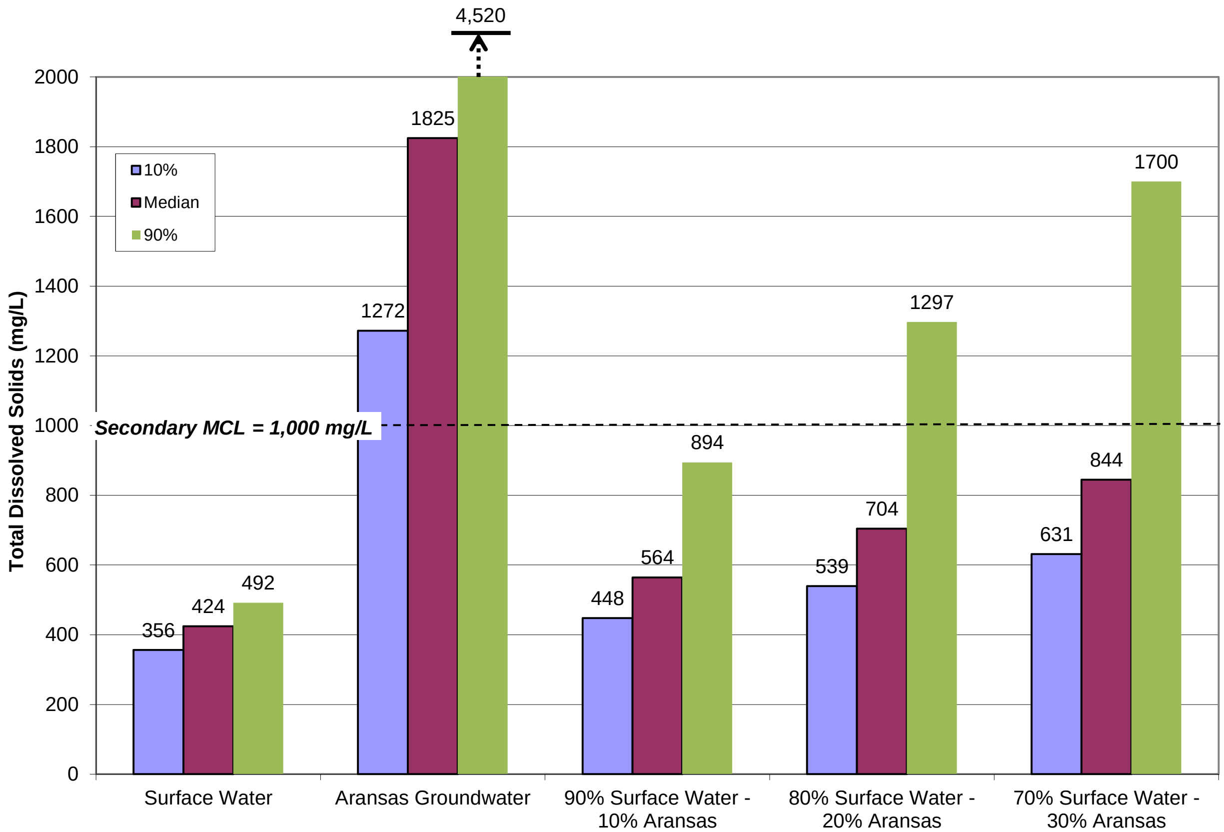


Figure 5D.7.10.
Aransas Groundwater Blended TDS (mg/L)

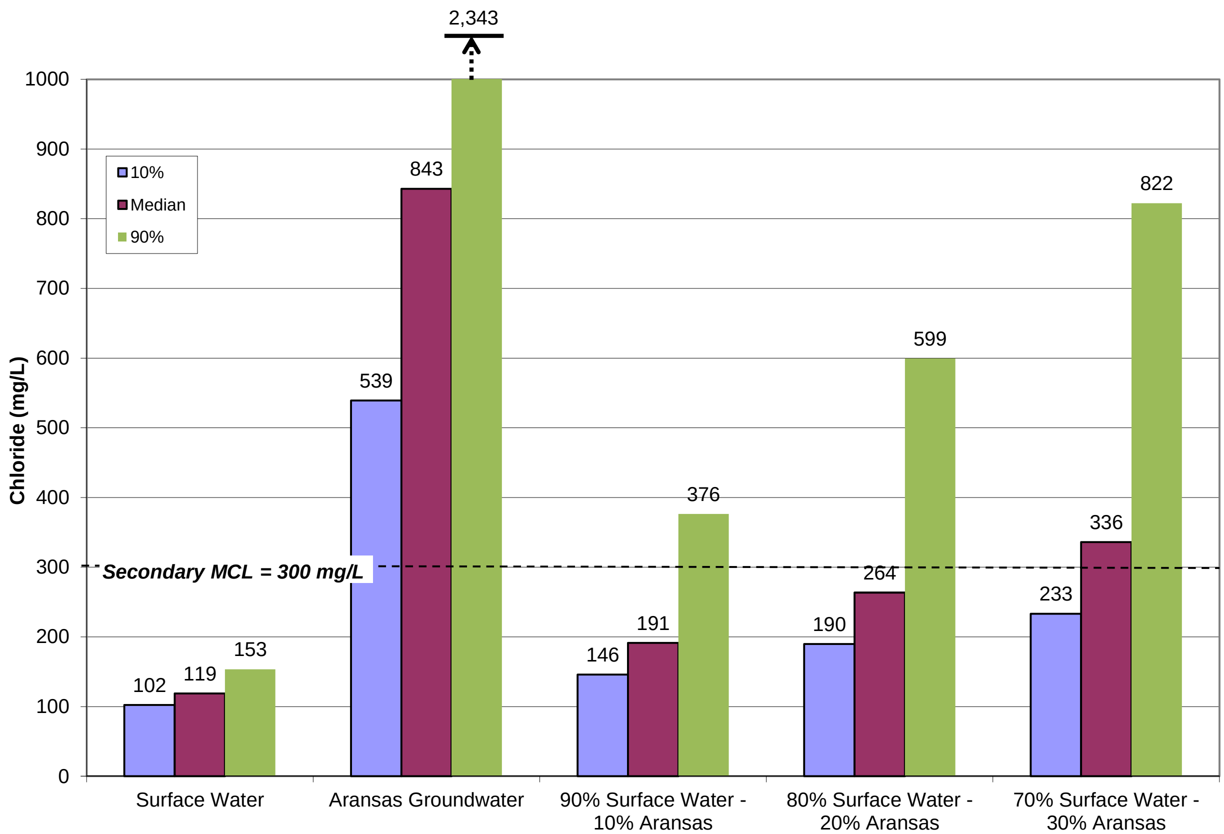


Figure 5D.7.11.
Aransas Groundwater Blended Chloride (mg/L)

San Patricio County

The median blended water quality for San Patricio brackish groundwater blended with surface water at blend ratios of 0% to 30% is shown in Table 5D.7.20. Water quality values that are outside the desired values are highlighted. Chloride is the limiting constituent with the chloride concentration exceeding quality goals as the % blend increases. The corrosion indices for the blended water are similar to existing surface water supplies and do no indicate increasing corrosion potential. Figures 5D.7.12 and 5D.7.13 summarize the range of TDS and chloride concentrations for blended San Patricio brackish groundwater with surface water including the variability due to the range of concentrations in the groundwater data.

Table 5D.7.20.
San Patricio County Blended with Surface Water Quality Summary (Median Values)

Constituent	100% SW	0% SW	90% SW	80% SW	70% SW	Desired Values
% Surface Water	**100%**	**0%**	**90%**	**80%**	**70%**	
% San Patricio Brackish Groundwater	**0%**	**100%**	**10%**	**20%**	**30%**	
Temperature, ºC	22.9	26.0	23.2	23.5	23.8	<32
Alkalinity, mg/l as $CaCO_3$	144	298	159	175	190	
Hardness, mg/l as $CaCO_3$	185	51	172	158	145	
Calcium Hardness, mg/L as $CaCO_3$	148	41	137	127	116	
pH	8.04	7.90	8.02	8.00	7.98	>7
TDS, mg/L	424	914	473	522	571	<1000
Chloride, mg/L	119	284	135	152	168	<210
Sulfate, mg/L	43	53	44	45	46	<300
Iron, mg/L	0.0000	0.0500	0.0050	0.0100	0.0150	<0.3
Manganese, mg/L	0.0000	0.0190	0.0019	0.0038	0.0057	<0.05
Arsenic, mg/L	0.0000	0.0020	0.0002	0.0004	0.0006	<0.01
Langlier Saturation Index (LSI)	0.6	0.2	0.6	0.6	0.6	> 0.0
Precipitation Potential, mg/L	12.1	5.4	13.0	13.7	14.0	4-10 mg/L
Ryzner Index	6.8	7.5	6.8	6.8	6.9	< 7.0
Larson Index	1.5	1.5	1.5	1.5	1.5	< 0.8

Values that exceed desired values are highlighted.

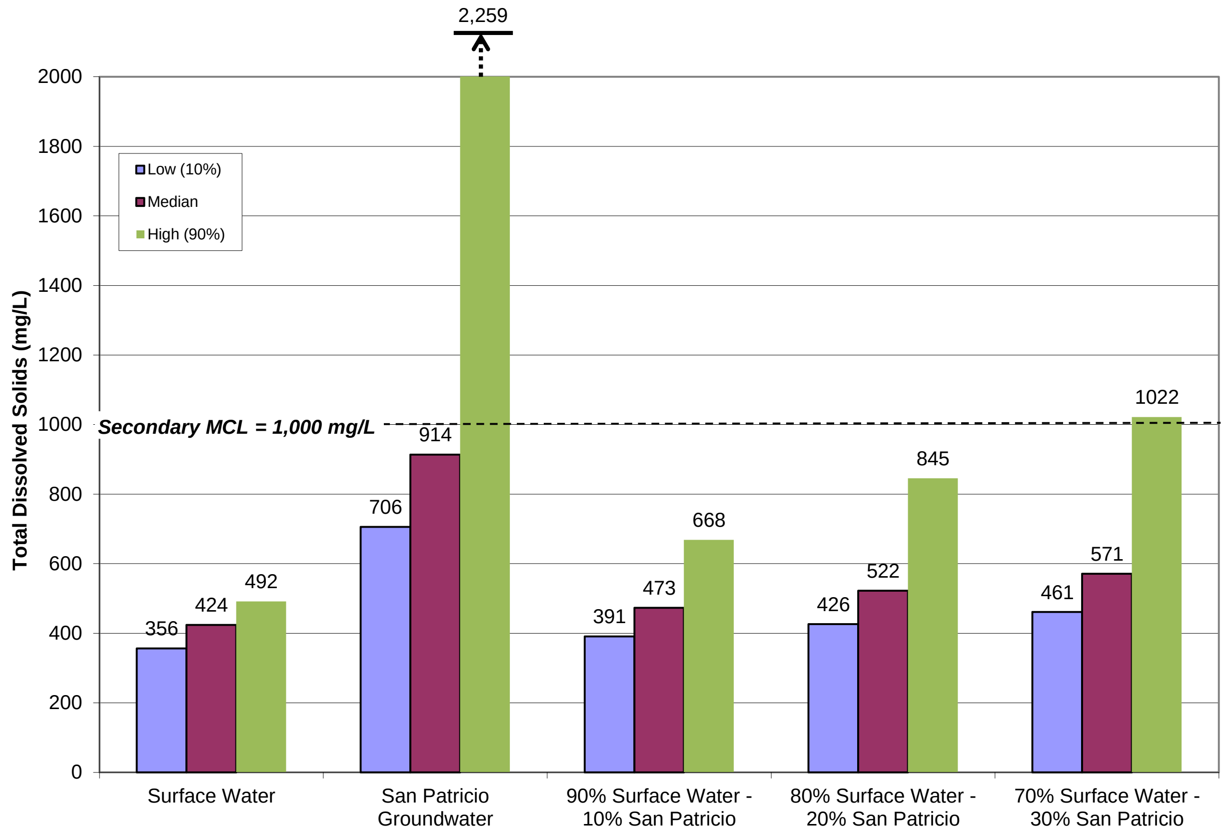


Figure 5D.7.12.
San Patricio Groundwater Blended TDS (mg/L)

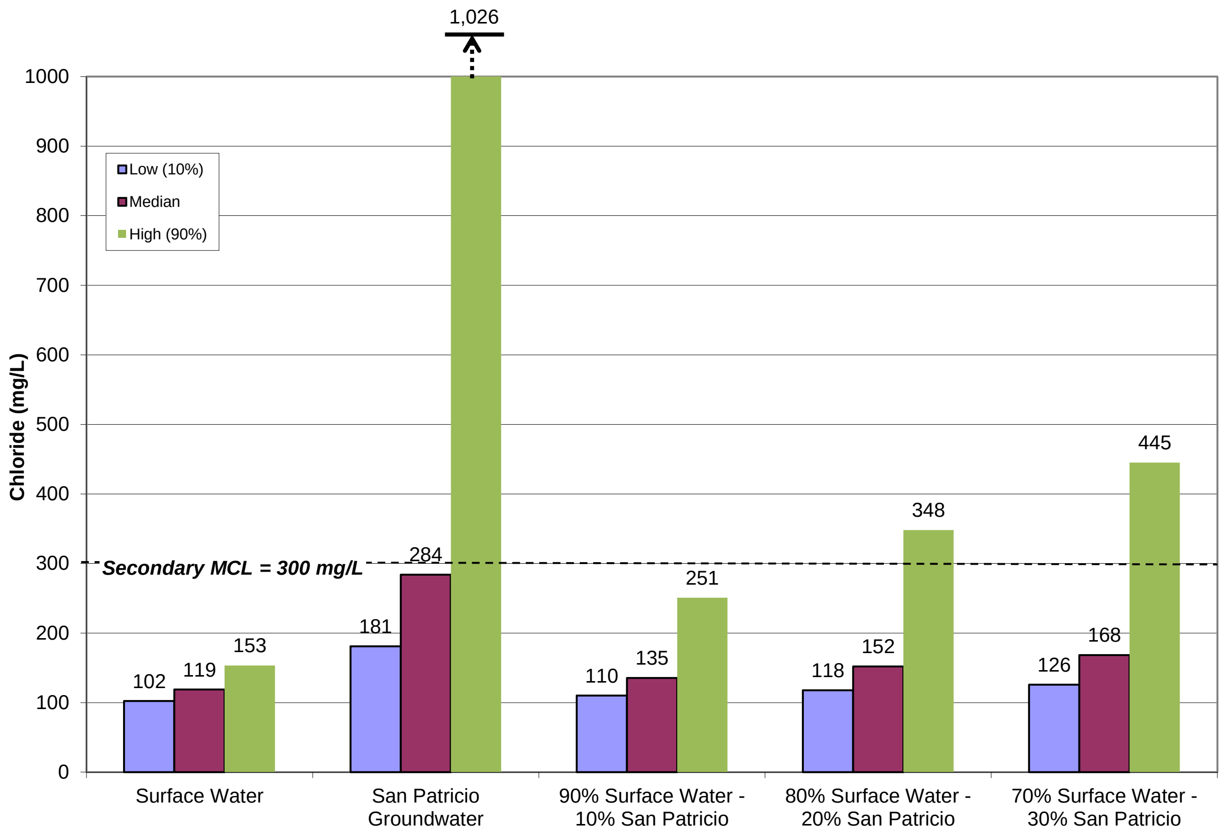


Figure 5D.7.13.
San Patricio Groundwater Blended Chloride (mg/L)

Nueces County

The median blended water quality for Nueces brackish groundwater blended with surface water at blend ratios of 0% to 30% is shown in Table 5D.7.21. Water quality values that are outside the desired values are highlighted. Chloride is the limiting constituent with the chloride concentration exceeding quality goals as the % blend increases. The iron concentration in the groundwater is above the regulatory limit and may require treatment for iron removal at higher blending ratios. The addition of higher salinity groundwater increases the corrosion potential of the blended water as indicated by increasing Larson Index. Although the corrosion indicators are outside the desired value, the historical exposure of the distribution system to somewhat elevated dissolved solids concentrations may mitigate the potential for corrosion issues due to introduction of brackish water. Figures 5D.7.14 and 5D.7.15 summarize the range of TDS and chloride concentrations for blended Nueces brackish groundwater with surface water including the variability due to the range of concentrations in the groundwater data.

Table 5D.7.21. Nueces County Blended with Surface Water Quality Summary (Median Values)

Constituent	100% SW	0% SW	90% SW	80% SW	70% SW	Desired Values
% Surface Water	**100%**	**0%**	**90%**	**80%**	**70%**	
% Nueces Brackish Groundwater	**0%**	**100%**	**10%**	**20%**	**30%**	
Temperature, °C	22.9	24.0	23.0	23.1	23.2	<32
Alkalinity, mg/l as $CaCO_3$	144	251	154	165	176	
Hardness, mg/l as $CaCO_3$	185	87	175	165	156	
Calcium Hardness, mg/L as $CaCO_3$	148	70	140	132	124	
pH	8.04	8.00	8.04	8.03	8.03	>7
TDS, mg/L	424	1,687	551	677	803	<1000
Chloride, mg/L	119	589	166	213	260	<300
Sulfate, mg/L	43	294	68	93	118	<300
Iron, mg/L	0.0080	0.7500	0.0822	0.1564	0.2306	<0.3
Manganese, mg/L	0.0010	0.0200	0.0029	0.0048	0.0067	<0.05
Arsenic, mg/L	0.0010	0.0100	0.0019	0.0028	0.0037	<0.01
Langlier Saturation Index (LSI)	0.6	0.4	0.6	0.6	0.6	> 0.0
Precipitation Potential, mg/L	12.1	9.6	12.3	12.5	12.6	4-10 mg/L
Ryzner Index	6.8	7.2	6.8	6.9	6.9	< 7.0
Larson Index	1.5	4.5	2.0	2.4	2.8	< 0.8

Values that exceed desired values are highlighted.

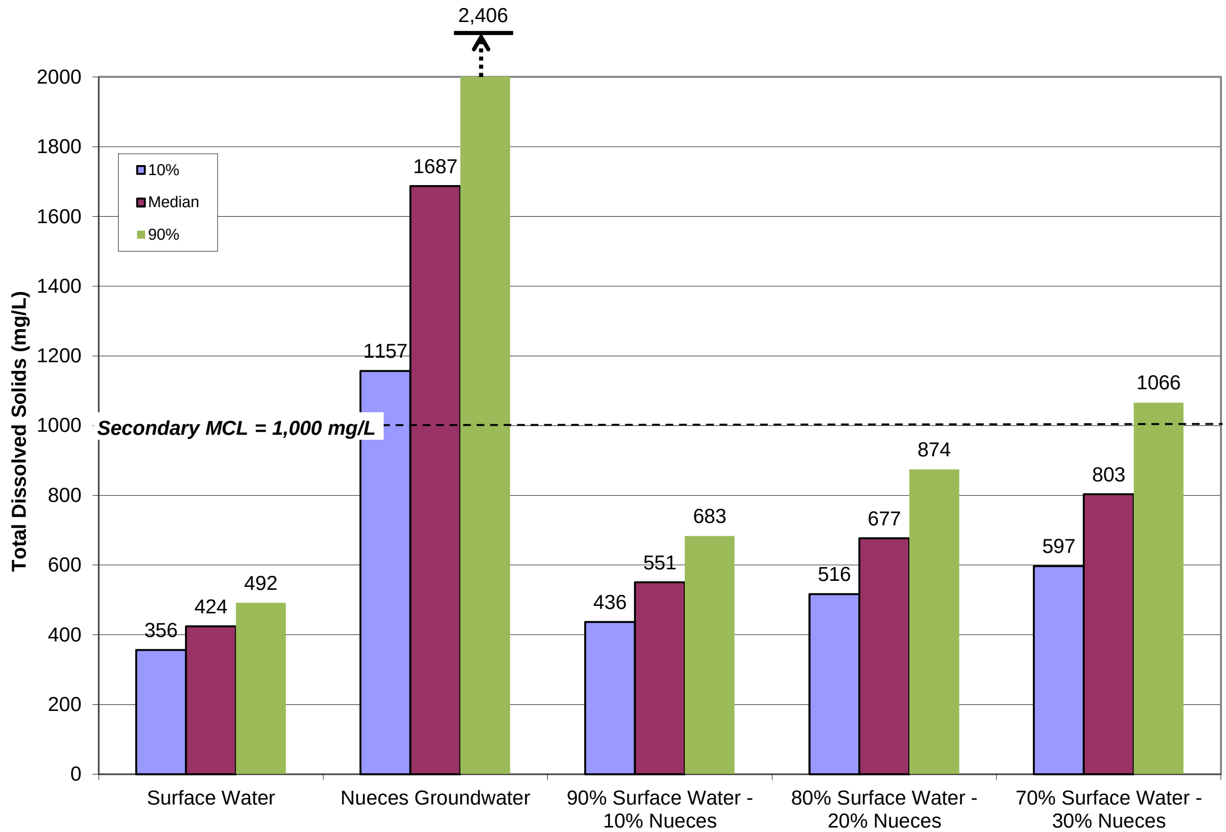


Figure 5D.7.14.
Nueces Groundwater Blended TDS (mg/L)

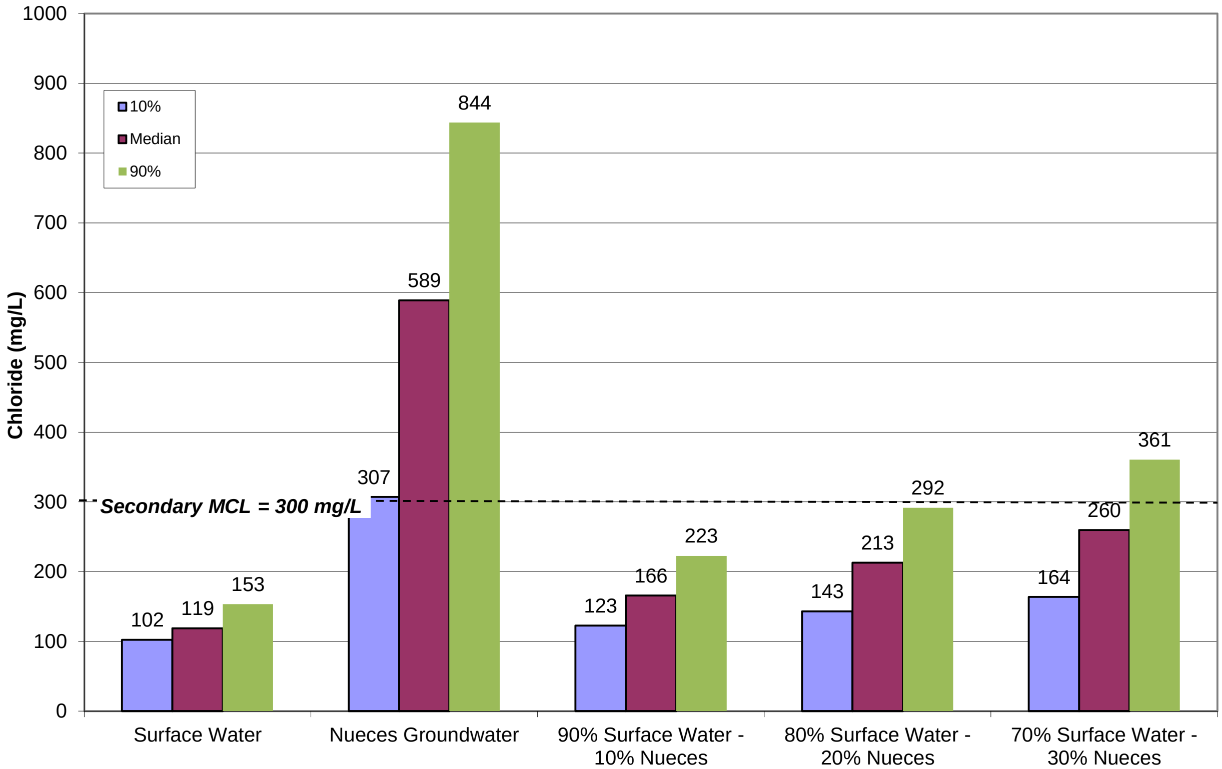


Figure 5D.7.15.
Nueces Groundwater Blended Chloride (mg/L)

Available Yield

The target maximum chloride concentration for the Aransas and San Patricio County brackish groundwater blended with SPMWD is 210 mg/L based on industrial water quality targets. The target maximum chloride concentration for the Nueces County brackish groundwater blended with City of Corpus Christi surface water from O.N. Stevens WTP is 300 mg/L. At these target chloride concentrations the maximum percentage of each of groundwater that can be blended with surface is shown in Figure 5D.7.16.

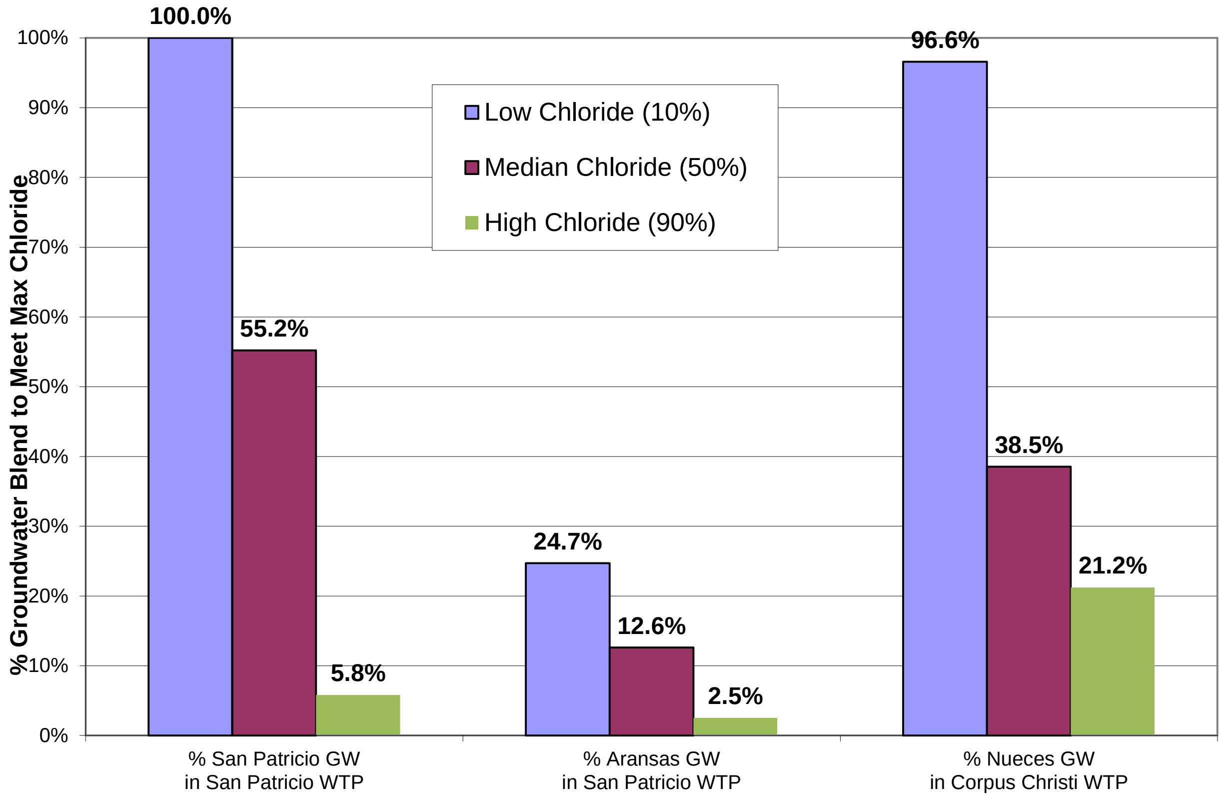


Figure 5D.7.16.
Maximum Brackish Water Blend to Meet Chloride Limits

5D.7.2.6 Environmental Issues

The pumping of groundwater from the Gulf Coast Aquifer could have a very slight negative impact on baseflow in the downstream reaches of streams in these areas. However, many of the streams are dry most all the time; thus, no measurable impact on wildlife along the streams is expected.

The desalinization of slightly saline groundwater produces a concentrate of salts in water that requires disposal. Depending upon location, environmental concerns can be addressed by discharging to a saline aquifer by deep well injection, discharging to a salt-water body, or blending with wastewater.

Habitat studies and surveys for protected species may need to be conducted at the proposed well field sites and along any pipeline routes. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primary pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands may be required where impacts are unavoidable.

5D.7.2.7 Engineering and Costing

Aransas County

The Aransas County project assumes a groundwater blend with high "90% Chloride" concentrations, or concentrations that represent 90% of available water quality records. The limited available groundwater data in the area leaves some uncertainty of the quality that may be present in the target location so using the 90% confidence interval provides a conservative estimate of the brackish groundwater quality. The quantity of brackish groundwater to supply is based on providing the maximum amount of brackish groundwater with 90% chloride concentration that can be blended with existing surface water supplies to provide the total year 2070 SPMWD demand of 51,005 ac-ft/yr while meeting water quality goals. The finished water consisting of a blend of 2.5% Aransas County brackish groundwater with 97.5% surface water will meet the chloride goal of 210 mg/L that historically is seen at the facility, and will be below the 300 mg/L state concentration limit. Based on the information presented above, twelve wells are suggested with an assumed capacity of 75 gpm at a depth of 400 ft. Eighteen miles of twelve inch diameter transmission line will be needed for blending at the SPMWD treatment complex. Chlorine disinfection treatment of groundwater is included to provide flexibility in being able to blend for ultimate use by industries or municipalities. The cost estimate is provided in Table 5D.7.22. The total project cost is estimated at $13,480,000 with an annual cost of $1,326,000. The treated water will cost $1,129 per ac-ft and have a unit cost of $3.47 per 1,000 gallons.

Table 5D.7.22.
Cost Summary Estimate for Aransas County Groundwater Blending

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Pump Station (1.2 mgd)	$836,000
Transmission Pipeline (12-inch, 18 miles)	$6,814,000
Transmission Pump Station and Storage	$204,000
Well Fields (Wells, Pumps, and Piping)	$1,331,000
Water Treatment Plant (Chlorine Disinfection, 1.1 mgd)	$71,000
TOTAL COST OF FACILITIES	**$9,256,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$2,899,000
Environmental & Archaeology Studies and Mitigation	$532,000
Land Acquisition and Surveying (120 acres)	$337,000
Interest During Construction (4% for 1 year with a 1% ROI)	$456,000
TOTAL COST OF PROJECT	**$13,480,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$1,128,000
Operation and Maintenance	
Pipeline, Wells and Storage Tanks (1% of Cost of Facilities)	$83,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$21,000
Water Treatment Plant	$43,000
Pumping Energy Costs (561,592 kW-hr @ 0.09 $/kW-hr)	$51,000
TOTAL ANNUAL COST	**$1,326,000**
Available Project Yield (ac-ft/yr)	1,174
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1	$1,129
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	$3.47

San Patricio County

Two options for blending brackish groundwater from San Patricio County are presented. Option 1 assumes a groundwater blend with “Median Chloride” concentrations, or concentrations that represent the median of available water quality records. The quantity of brackish groundwater to supply is based on providing the maximum amount of brackish groundwater with median chloride concentration that can be blended with existing surface water supplies to provide the total year 2070 SPMWD demand of 51,005 ac-ft/yr while meeting water quality goals. The finished water consisting of a blend of 55.2% San Patricio County brackish groundwater with 44.8% surface water will meet the chloride goal of 210 mg/L that historically is seen at the facility, and will be below the 300 mg/L state concentration limit. Based on the information presented above, 78 wells are suggested with an assumed capacity of 250 gpm at a depth of 600 ft. Twenty-four miles of 36-inch diameter transmission line will be needed for blending at the SPMWD treatment complex. Chlorine disinfection treatment of groundwater is included to provide flexibility in being able to blend for ultimate use by industries or municipalities. The cost estimate is provided in Table 5D.7.23. The total project cost is estimated at $110,706,000 with an annual cost of $14,772,000. The addition of brackish groundwater to the existing treated water system will cost $525 per ac-ft and have a unit cost of $1.61 per 1,000 gallons.

Table 5D.7.23.
Cost Summary Estimate for San Patricio Groundwater Blending- Option 1

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Transmission Pipeline (36-inch, 24 miles)	$30,667,000
Transmission Pump Station(s) and Storage Tank(s)	$6,885,000
Well Fields [Wells, Pumps, and Piping (6-36 inch)]	$40,052,000
Water Treatment Plant (25.1 mgd)	$1,108,000
TOTAL COST OF FACILITIES	**$78,712,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$26,016,000
Environmental & Archaeology Studies and Mitigation	$1,734,000
Land Acquisition and Surveying (201 acres)	$500,000
Interest During Construction (4% for 1 year with a 1% ROI)	$3,744,000
TOTAL COST OF PROJECT	**$110,706,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$9,264,000
Operation and Maintenance	
Pipeline, Wells and Storage Tanks (1% of Cost of Facilities)	$721,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$138,000
Water Treatment Plant	$665,000
Pumping Energy Costs (27,286,643 kW-hr @ 0.09 $/kW-hr)	$2,456,000
Purchase of Water (28,155 ac-ft/yr @ 46.14 $/ac-ft)	$1,299,000
Groundwater District Fees (28,155 ac-ft/yr @ 8.15 $/ac-ft)	$229,000
TOTAL ANNUAL COST	**$14,772,000**
Available Project Yield (ac-ft/yr)	28,155
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1	$525
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	$1.61

Option 2 assumes a groundwater blend with high “90% Chloride” concentrations, or concentrations that represent 90% of available water quality records. The quantity of brackish groundwater to supply is based on providing the maximum amount of brackish groundwater with 90% chloride concentration that can be blended with existing surface water supplies to provide the total year 2070 SPMWD demand of 51,005 ac-ft/yr while meeting water quality goals. The finished water consisting of a blend of 5.8% San Patricio County brackish groundwater with 94.2% surface water will meet the chloride goal of 210 mg/L that historically is seen at the facility, and will be below the 300 mg/L state concentration limit. Based on the information presented above, 8 wells are suggested with an assumed capacity of 250 gpm at a depth of 600 ft. Twenty-four miles of 14-inch diameter transmission line will be needed for blending at the SPMWD treatment complex. Chlorine disinfection treatment of groundwater is included to provide flexibility in being able to blend for ultimate use by industries or municipalities. The cost estimate is provided in Table 5D.7.24. The total project cost is estimated at $24,190,000 with an annual cost of $2,667,000. The addition of brackish groundwater to the existing treated water system will cost $902 per ac-ft and have a unit cost of $2.77 per 1,000 gallons.

Table 5D.7.24.
Cost Summary Estimate for San Patricio Groundwater Blending- Option 2

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Transmission Pipeline (14-inch, 24 miles)	$10,807,000
Transmission Pump Station(s) and Storage Tank(s)	$2,040,000
Well Fields [Wells, Pumps, and Piping (6-14 inch)]	$3,854,000
Water Treatment Plant (Chlorine Disinfection, 2.6 mgd)	$137,000
TOTAL COST OF FACILITIES	**$16,838,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$5,353,000
Environmental & Archaeology Studies and Mitigation	$715,000
Land Acquisition and Surveying (154 acres)	$466,000
Interest During Construction (4% for 1 year with a 1% ROI)	$818,000
TOTAL COST OF PROJECT	**$24,190,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$2,024,000
Operation and Maintenance	
Pipeline, Wells and Storage Tanks (1% of Cost of Facilities)	$150,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$44,000
Water Treatment Plant	$82,000
Pumping Energy Costs (2,295,581 kW-hr @ 0.09 $/kW-hr)	$207,000
Purchase of Water (2,958 ac-ft/yr @ 46.14 $/ac-ft)	$136,000
Groundwater District Fees (2,958 ac-ft/yr @ 8.15 $/ac-ft)	$24,000
TOTAL ANNUAL COST	**$2,667,000**
Available Project Yield (ac-ft/yr)	2,958
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1	$902
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	$2.77

Nueces County

The Nueces project assumes a groundwater blend with “90% Chloride” concentrations, or concentrations that represent 90% of available water quality records. The quantity of brackish groundwater to supply is based on providing the maximum amount of brackish groundwater with 90% chloride concentration that can be blended with existing surface water supplies to provide the total year 2070 STWA demand of 3,334 ac-ft/yr while meeting water quality goals. The finished water consisting of a blend of 21.2% Nueces County brackish groundwater with 97.5% surface water will meet the chloride goal of 300 mg/L that will be below the 300 mg/L state concentration limit. Based on the information presented above, 3 wells are suggested with an assumed capacity of 200 gpm at a depth of 500 ft. Two miles of 6” diameter transmission line will be needed to connect with the STWA 42” transmission line. Chlorine disinfection treatment of groundwater is included. The cost estimate is provided in Table 5D.7.25. The total project cost is estimated at $4,630,000 with an annual cost of $514,000. The treated water will cost $727 per ac-ft and have a unit cost of $2.23 per 1,000 gallons.

Table 5D.7.25. Cost Summary Estimate for Nueces Groundwater Blending Option

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Intake Pump Stations (0.7 mgd)	$805,000
Transmission Pipeline (6-inch, 2 miles)	$252,000
Transmission Pump Station(s) and Storage Tank(s)	$943,000
Well Fields (Wells, Pumps, and Piping)	$1,112,000
Water Treatment Plant (0.7 mgd)	$50,000
Integration, Relocation and Other	$50,000
TOTAL COST OF FACILITIES	**$3,212,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$1,112,000
Environmental & Archaeology Studies and Mitigation	$95,000
Land Acquisition and Surveying (18 acres)	$54,000
Interest During Construction (4% for 1 year with a 1% ROI)	$157,000
TOTAL COST OF PROJECT	**$4,630,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$387,000
Operation and Maintenance	
Pipeline, Wells and Storage Tanks (1% of Cost of Facilities)	$15,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$39,000
Water Treatment Plant	$30,000
Pumping Energy Costs (480,613 kW-hr @ 0.09 $/kW-hr)	$43,000
TOTAL ANNUAL COST	**$514,000**
Available Project Yield (ac-ft/yr)	707
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1	$727
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	$2.23

5D.7.2.8 Implementation Issues

Implementation of the projects which are located in Region N are subject to the rules and management plans of local groundwater conservation districts. San Patricio and Nueces counties have groundwater conservation districts which have groundwater management plans and rules specifying well production and spacing limits. The San Patricio options exceed the MAGs so there will likely be permitting hurdles unless MAG limits are increased. Regulations and permitting by local groundwater districts or Groundwater Management Area associated with managed available groundwater supplies will need to be considered prior to implementation.

The development of additional wells and the installation and operation of brackish groundwater, may have to address the following issues.

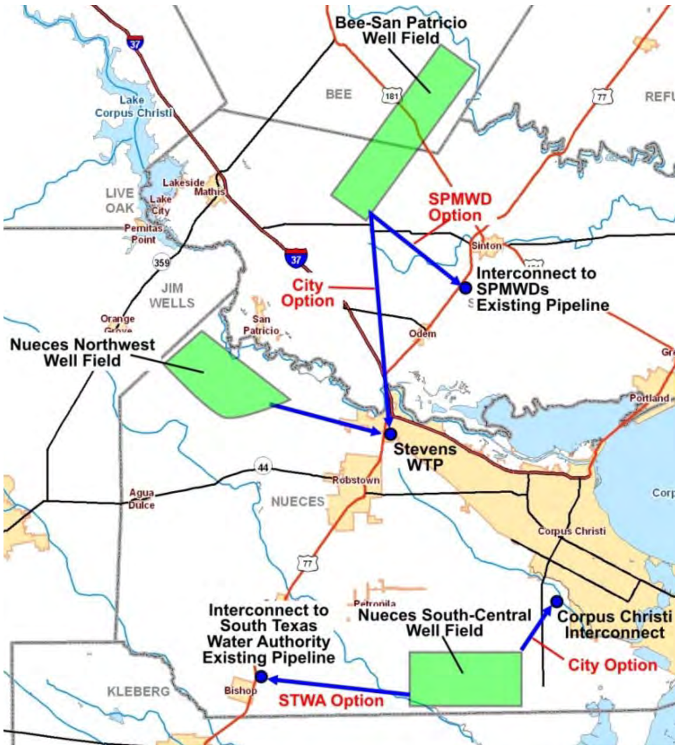
- Impact on:
  - Endangered and other wildlife species;
  - Water levels in the aquifer;
  - Baseflow in streams; and
  - Wetlands.
- Capital and operation and maintenance costs;
- Competition with others for groundwater in the area;
- Detailed feasibility evaluation including test drilling and aquifer water quality testing; and
- The potential for regulations by groundwater conservation districts in the future, including the renewal of pumping permit at periodic intervals in counties where districts have been organized.

5D.7.2.9 Evaluation Summary

An evaluation summary of this regional water management option is provided in Table 5D.7.26.

Table 5D.7.26.
Evaluation Summary of Blending Groundwater and Treated Surface Water Project

Impact Category	***Comment(s)***
a. Water supply:	
1. Quantity	1. Firm Yield: 707 to 28,155 ac-ft/yr.
2. Reliability	2. Water Quality: Fair.
3. Cost of treated water	3. Cost: $525 to $1,129 per ac-ft.
b. Environmental factors:	
1. Instream flows	1. May slightly decrease instream flow and discharge of freshwater into coastal estuaries due to local groundwater-surface water interaction.
2. Bay and estuary inflows	2. May slightly decrease instream flow and discharge of freshwater into coastal estuaries due to local groundwater-surface water interaction.
3. Wildlife habitat	3. Negligible impacts.
4. Wetlands	4. Negligible impacts.
5. Threatened and endangered species	5. Negligible impacts.
6. Cultural resources	6. Cultural resources will need to be surveyed and avoided.
7. Water quality	7. Negligible impacts.
a. dissolved solids	a. Low to moderate impact.
b. salinity	b. Low to moderate impact.
c. bacteria	c. No impact.
d. chlorides	d. Low to moderate impact.
e. bromide	e. Low to moderate impact.
f. sulfate	f. Low to moderate impact.
g. uranium	g-h. Low to moderate impact associated with mining.
h. arsenic	i. Boron may be a potential water quality concern.
i. other water quality constituents	
c. Impacts to State water resources	• No negative impacts on water resources other than lowering Gulf Coast Aquifer; Potential benefit to Nueces Estuary from increased freshwater return flows
d. Threats to agriculture and natural resources in region	• May slightly increase pumping costs for agricultural users in the area due to localized drawdowns
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Standard analyses and methods used
g. Interbasin transfers	• Not applicable to groundwater sources
h. Third party social and economic impacts from voluntary redistribution of water	• May require the purchase of groundwater rights
i. Efficient use of existing water supplies and regional opportunities	• Provides regional opportunities with local resources
j. Effect on navigation	• None



5D.8

Brackish Groundwater Desalination

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5D.8 Brackish Groundwater Desalination

5D.8.1 Regional Well-Field Systems

5D.8.1.1 Description of Strategy

Brackish groundwater supplies have been desalinated to potable standards in areas near Region N and are likely to become more prevalent under the compounding pressures of increasing water demands and climate uncertainty. This strategy includes an evaluation of three independent well fields, as shown in Figure 5D.8.1, for brackish groundwater supplies from the Gulf Coast aquifer, including treatment and delivery to one or more Region N utilities. Although three well fields were considered, it is unlikely that more than one well field would be developed. A key consideration in developing this strategy is groundwater availability. Groundwater availability models (GAM) used to administer permits and manage groundwater resources do not currently delineate between fresh and slightly brackish water. Therefore, brackish water is often included in modeled available groundwater (MAG) estimates, which limits groundwater availability for regional water planning purposes. The projected water use of existing groundwater users and groundwater needed for recommended water management strategies in San Patricio and Nueces Counties are in an amount equal to the MAG. *For any of the three independent well fields to be developed as described below, the MAGs will need to be increased by the withdrawal amount.* Groundwater Management Area 16 is in the process of reviewing and updating the MAGs. If a project sponsor is interested in developing any of the three independent well fields identified by this strategy, it is advisable that they notify Groundwater Management Area 16 as groundwater conservation district regulations may prevent issuance of permits in excess of MAG estimates. With MAG constraints removed, this water management strategy could be developed to meet future water supply needs for the City of Corpus Christi (City), San Patricio Municipal Water District (SPMWD), South Texas Water Authority (STWA), and/or other customers in the region.

The Bee-San Patricio (Bee-SanPat) well field and water facilities are designed to produce an average supply of 21.4 mgd (24,000 ac-ft/yr) at a uniform rate for either the City or SPMWD. Concentrate disposal options include deep-injection wells or a pipeline to Copano Bay. The Nueces Northwest (Nueces NW) well field is located south of the Nueces River and near the Nueces-Jim Wells County line. It is designed to produce an average supply of 16.1 mgd (18,000 ac-ft/yr) at a uniform rate. The treated water is to be delivered to Corpus Christi’s O.N. Stevens Water Treatment Plant (WTP). Concentrate disposal is to deep-injection wells. The Nueces South-Central (Nueces S-C) well field is located just north of the Nueces-Kleberg County line and about mid way between the town of Bishop and Laguna Madre. The project is designed to produce an average annual water supply of 10.7 mgd (12,000 ac-ft/yr). One option is to deliver the water to the City’s distribution system in the southern part of the city; and the other option is to deliver the water to STWA’s distribution pipeline for delivery to STWA customers and/or O.N. Stevens WTP. Concentrate disposal is designed to either be blended in with return flows from the Barney Davis Power Station with discharge to Oso Bay or to deep-injection wells. The MAG estimates for San Patricio and Nueces counties are limiting, and there is not expected to be excess availability to support these projects within the current MAG limits.

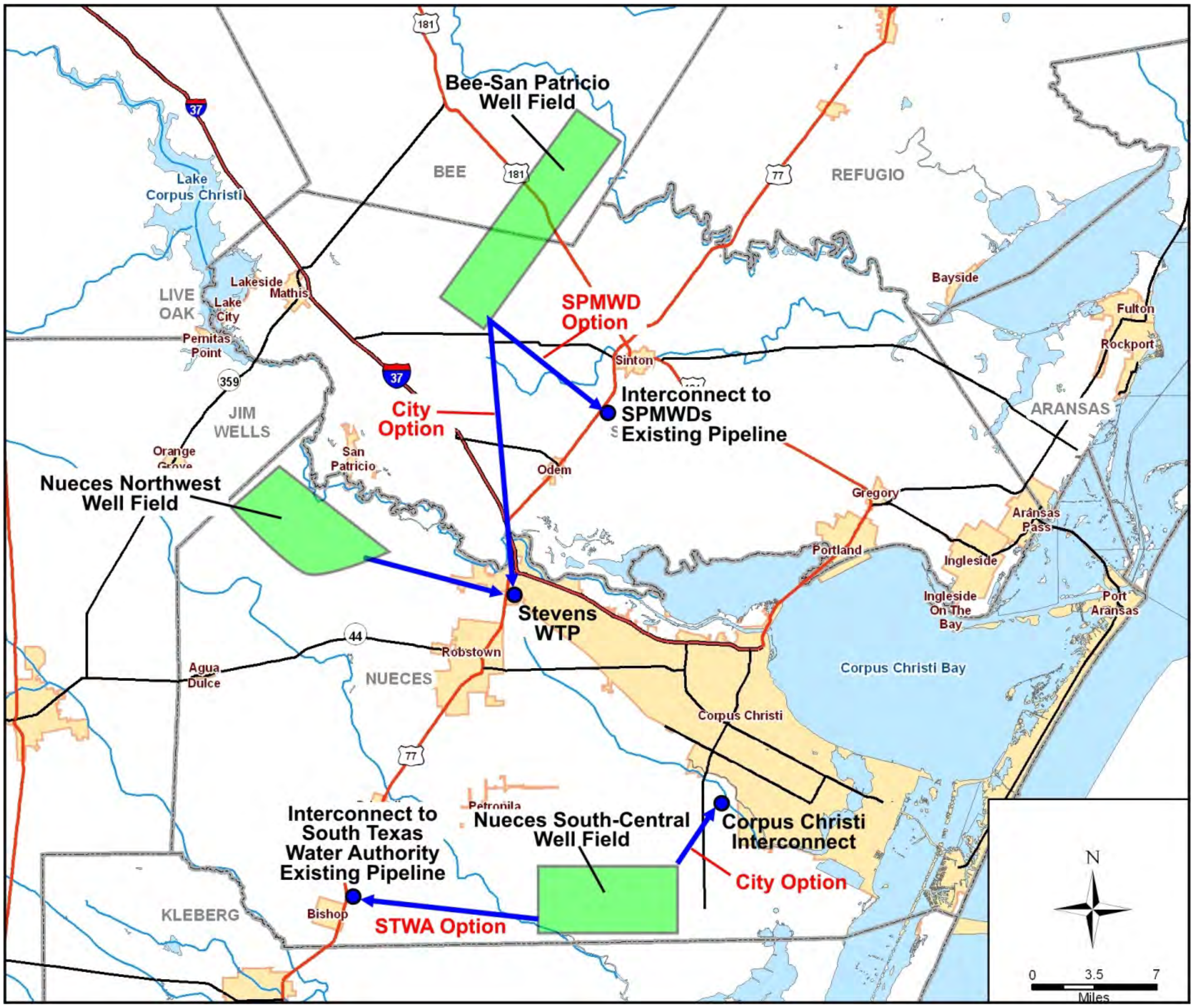

Figure 5D.8.1.
Location of Brackish Groundwater Well Fields

5D.8.1.2 Available Yield

In the Coastal Bend region, the Gulf Coast Aquifer System is the primary source of substantial groundwater supplies. The most productive water-bearing zone is the Goliad Sand, which is also known as the Evangeline Aquifer. The outcrop of the Goliad Sand is about 50 to 75 miles inland. The formation dips toward the coast at about 20 feet per mile. Near the coast, the shallower Chicot Aquifer provides some groundwater supplies. West of the outcrop of the Goliad Sands, the deeper Jasper Aquifer can supply a moderate amount of groundwater in some areas.

Each of the three well fields are designed to produce water from the Evangeline Aquifer. High capacity wells in these areas typically yield about 500 gallons per minute (gpm), but some can yield up to 750 gpm. Well depths increase toward the coast. In the Bee-SanPat, Nueces NW, and Nueces S-C well fields, typical wells depths are about 800, 800 and 1,300 feet[1], respectively. A study of groundwater salinity in the vicinity of these three well field shows total dissolved solid concentrations (TDS) to be about 1,050, 1,750 and 1,900 mg/L, respectively.

An analysis of the impact of developing the three well fields separately was conducted for the 2011 Plan using the Central Gulf Coast Aquifer Groundwater Availability Model (CGCGAM).[2] The cumulative drawdown for background pumping and project pumping from Bee-SanPat resulted in a maximum drawdown of 80 feet after 50 years. The cumulative drawdown for background pumping and project pumping from Nueces NW resulted in a maximum drawdown of 70 feet after 50 years. The cumulative drawdown for background pumping and project pumping from Nueces S-C resulted in a maximum drawdown of 92 feet after 50 years.

Groundwater Management Area (GMA 16) along with local groundwater conservation districts have jurisdictional authority to manage groundwater resources in San Patricio and Nueces Counties. GMA 16 adopted an average drawdown of 94 feet as the desired future condition for the Gulf Coast Aquifer within the boundaries of the GMA. A GMA 16-focused Groundwater Availability Model specifically developed by the TWDB was then used to evaluate desired future conditions and develop MAG values accordingly. As mentioned previously, current users of groundwater in San Patricio and Nueces Counties are expected to use the full MAG amount during the 2020-2070 planning period[3]. *For any of the three independent well fields to be developed as described below, the MAGs will need to be increased by the withdrawal amount.*

5D.8.1.3 Potential Groundwater-Surface Water Interaction

The impact of groundwater pumping on streamflow gains or losses is not an element considered in groundwater availability. However, it is of interest. Using mass balance results from the groundwater model simulations, the impact of streamflow is estimated for each of the projects. The impact can either: 1) reduce the amount of baseflow discharging from the aquifer to the streams; 2) increase the baseflow losses from the stream to the aquifer; or 3) change a stream from gaining flow to losing flow. The streams in the area that are likely to be affected and included in the analysis are between the San Antonio River to the northeast and San Fernando Creek to the southwest. Major streams include the Nueces, Aransas, and Mission Rivers. The net streamflow losses attributed to the project, as calculated previously for the 2011 Plan using the CGCGAM, average 12,600, 13,600 and 0 ac-ft/yr for the Bee-SanPat, Nueces NW and Nueces S-C, respectively. This is about 47, 64 and 0 percent, respectively, of the total amount of water pumped by the brackish water wells in these well fields. For the Bee-SanPat well field, about 22 percent of the streamflow losses are occurring in the Nueces River basin and about 25 percent in the Aransas and Mission River basins. For the Nueces NW well field, essentially all the streamflow losses attributed to the well field are occurring in the Nueces River Basin.

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[1] Deeper wells in Nueces S-C well fields closer to the Coast are needed to access most productive water bearing layers in the Evangeline Aquifer without encountering water with higher salinity.
[2] Chowdhury, A.H., and others, Sept 27, 2004, Groundwater Availability Model of the Central Gulf Coast Aquifer System: Numerical Simulations through 1999, Texas Water Development Board Model Report.
[3] An exception is a small amount of water that is available for additional groundwater development by San Patricio-Irrigation users (recommended strategy) and 707 ac-ft/yr of Nueces County groundwater supplies for blending with treated surface water supplies. Both of these strategies are described in 5D.7.

5D.8.1.4 Environmental Issues

Plans for the proposed water management strategies include three different project areas: Bee-SanPat (two delivery options with two concentrate disposal options), Nueces NW and Nueces S-C (two options). The primary environmental issues related to the development of brackish groundwater desalination of water from the Evangeline Aquifer in Nueces, San Patricio, and/or Bee Counties are the development of the well fields and associated pipelines, development of brackish water treatment facilities, integration into the existing pipeline system, discharge of brine concentrate into bay areas, and the deep well injection of brine concentrate.

All of the proposed project areas are located in the Gulf Coastal Plains of Texas Physiographic Province, specifically in the subprovince of the Coastal Prairies. This area is locally characterized as a nearly flat prairie composed of deltaic sands and muds which terminates at the Gulf of Mexico and includes topography changes of less than one foot per mile. Elevation levels in the Coastal Prairies range from 0 to 300 feet above mean sea level.

Environmental Considerations Associated with Bee-SanPat Project

The Bee-San Patricio project area includes a well field of 36 brackish water wells located along the shared county lines of Bee and San Patricio Counties. This project also includes a treated water pump station and a desalination water treatment plant located adjacent to the well field. Concentrate disposal for this project has two options, deep-injection wells or an approximately 32 mile concentrate disposal pipeline which discharges into Copano Bay in Aransas County.

The concentrate disposal pipeline crosses areas which are primarily used for pasture and crops. Vegetation types found along the pipeline route also include areas of Mesquite-Live Oak-Bluewood Parks. The concentrate disposal pipeline would cross possible wetland areas associated with Chiltipin Creek and the marshy areas near Copano Bay. Planning of the pipeline route should include avoidance of impacts to these wetland areas where possible. The potential environmental effects resulting from the disposal of brine concentrate from the Bee-SanPat project will be sensitive to the siting of the project and its associated pipeline. Although the construction of portions of both the concentrate disposal and treated water pipelines may include the clearing and removal of woody vegetation, destruction of potential habitat can generally be avoided by diverting the corridor through previously disturbed areas.

Estuaries such as those found near Copano Bay serve as critical habitat and spawning grounds for many marine species and migratory birds. Estuaries are marine environments maintained in a brackish state by the inflow of freshwater from rivers and streams. The high productivity characteristic of estuaries arises from their large nutrient input, shallow water, and the ability of a few marine species to thrive in environments continually stressed by low, variable salinities, temperature extremes, and, on occasion, low dissolved oxygen concentrations. The potential environmental effects resulting from the disposal of brine concentrate from the Bee-SanPat project will be sensitive to the siting of the project and its appurtenances. The salinity level of the discharged concentrate is lower than that of the water found within the Copano Bay system, which should minimize its impact on the associated aquatic habitat. Prior to implementation, additional water quality studies of discharge impacts to the Bay system would need to be performed.

The Bee-SanPat well field area is primarily located within an area used for crops; however, it also contains smaller portions of Mesquite-Live Oak-Bluewood Parks vegetation areas. Mesquite-Live Oak-Bluewood Parks areas commonly contain plants such as huisache, grajeno, lotebush, pricklypear, agarita, purple threeawn, and Mexican persimmon. Distribution of this vegetation type is found primarily within the South Texas Plains. Because the well field is located near Papalote Creek, site selection for the wells should include the avoidance of impacts to wetland areas. A preliminary assessment of the impact of operating this well field on groundwater discharge to the Aransas and Nueces Rivers, Lake Corpus Christi and nearby streams suggest that the discharge will be reduced by about 17 cfs (or 12,310 ac-ft) in 2060.

In addition, there are two treated water pipeline options associated with this project. One treated water pipeline runs in a southeast direction for approximately 12 miles before reaching its delivery point at a SPMWD connection site. The second treated water pipeline option travels southeast for approximately 20 miles before terminating at the O.N. Stevens WTP. The SPMWD pipeline potentially crosses marshy and wetland areas associated with Chilitipin Creek, while the O.N. Stevens WTP pipeline route crosses both Chilitipin Creek and the Nueces River. Appropriate pipeline route selection, construction methods and right-of-way selection should avoid or minimize any anticipated impacts to these potential wetland areas.

Environmental Considerations Associated Nueces NW Project

The Nueces NW project includes a brackish water well field of 30 wells located in the upper northwest part of Nueces County, a desalination water treatment plant, treated water pump station, and treated water pipeline. Concentrate disposal for this option includes deep well injection. Brackish water received from the well field would be processed at the desalination water treatment plant, then moved southeast by the treated water pump station through an approximately 5-mile pipeline to its delivery point at the O.N. Stevens WTP.

Vegetation found within the project area is primarily crops, with a small portion of Mesquite-Blackbrush Brush vegetation located within the northern portion of the well field area. Mesquite-Blackbrush Brush vegetation commonly includes species such as lotebush, guajillo, whitebrush, pricklypear, kidneywood, yucca, and purple three-awn. This type of vegetation is found principally on shallow, gravelly or loamy soils in the South Texas Plains. Wetland areas and sand and gravel pits found near the Nueces River may necessitate careful selection of well locations within the well field area to avoid impact to wetlands. A preliminary assessment of the impact of operating this well field on groundwater discharge to the Nueces River, Lake Corpus Christi and nearby streams suggest that the discharge will be reduced by about 18 cfs (or 13,030 ac-ft) after 50 years.

Environmental Considerations Associated Nueces S-C Project

The Nueces S-C project includes two delivery options: 1) to the City's storage facility in their south service area (City option); or 2) to STWA treated water pipeline for delivery to STWA customers and/or O.N. Stevens WTP (STWA option). The City option includes 20 brackish water wells located in southeast Nueces County approximately 13 miles southwest of the City of Corpus Christi. Treated water would then be transported through an approximately 6 mile pipeline to its delivery point, which is located in the southern part of the City's distribution system. Concentrate disposal would pass through a nearby concentrate disposal pump station and along an approximately 9 mile pipeline which would then discharge into the Barney M. Davis Power Station outfall to Oso Bay. Although the construction of portions of both the concentrate disposal and treated water pipelines may include the clearing and removal of woody vegetation, destruction of potential habitat can generally be avoided by diverting the corridor through previously disturbed areas. Prior to implementation, additional water quality studies of discharge impacts to the Bay system would need to be performed.

Estuaries such as those found near Oso Bay serve as critical habitat and spawning grounds for many marine species and migratory birds. Estuaries are marine environments maintained in a brackish state by the inflow of freshwater from rivers and streams. The high productivity characteristic of estuaries arises from their large nutrient input, shallow water, and the ability of a few marine species to thrive in environments continually stressed by low, variable salinities, temperature extremes, and, on occasion, low dissolved oxygen concentrations. The potential environmental effects resulting from the disposal of brine concentrate from the Nueces S-C project will be sensitive to the siting of the project and its appurtenances. The salinity level of the discharged concentrate is lower than that of the water found within the bay system, which should minimize its impact on the associated aquatic habitat.

Vegetation types found within the City Option include primarily crop areas within the well field area and treated water pipeline locations, with the concentrate disposal pipeline located within a Mesquite-Granjeno Park vegetation area. Vegetation in the Mesquite-Granjeno Park areas commonly include bluewood, lotebush, Texas prickly-pear, hooded windmillgrass, croton, silver-leaf nightshade and fireweed. This vegetation type is found principally on sandy or loamy upland soils in the South Texas Plains.

The STWA option includes a brackish well field of 20 wells (or 7 wells for a smaller 4,000 ac-ft/yr delivery option) located in the lower southwest portion of Nueces County, a desalination water treatment plant, treated water pump station, and treated water pipeline. Concentrate disposal for this option includes deep well injection. Treated water from the well field will flow through a 15-mile pipeline to its delivery point which consists of a connection with the existing STWA system. This option is located within an area of vegetation that contains primarily existing croplands. Wetland impacts possibly associated with pipeline crossings at Petronila Creek or its tributaries should be avoided where possible by careful siting and construction.

A preliminary assessment of the impact of operating this well field on groundwater discharge to nearby streams suggest that there will be little or no impact after 50 years.

Area Vegetation and Wildlife Habitat

The brackish water desalination project area is located within the Gulf Prairies and Marshes Vegetational Area. Gulf Prairies have slow surface drainage and elevations that range from sea level to 250 feet. These areas include nearly level and virtually undissected plains. Originally the

Gulf Prairies were composed of tallgrass prairie and post oak savannah. However tree species such as honey mesquite, and acacia, along with other trees and shrubs have increased in this area forming dense thickets in many places. Typical oak species found in this area include live oak (*Quercus virginiana*) and post oak (*Q. stellata*), in addition to huisache (*Acacia smallii*), black-brush (*A. rigidula*), and a dwarf shrub; bushy sea-ox-eye (*Borrichia frutescens*). Principal climax grasses of the Gulf Prairies include gulf cordgrass (*Spartina spartinae*), indiangrass (*Sorghastrum nutans*), and big bluestem (*Andropogon gerardii* var. *gerardii*). Prickleypear (*Opunita* sp.) are common within this area along with forbs including asters (*Aster* sp.), poppy mallows (*Callirhoe* sp.), bluebonnets (*Lupinus* sp.), and evening primroses (*Oenothera* sp.). Gulf Marshes range from sea level to a few feet in elevation, and include low, wet marshy coast areas commonly covered with saline water. These salty areas support numerous species of sedges (*Carex* and *Cyperus* sp.), bulrushes (*Scirpus* sp.), rushes (*Juncus* sp.), and grasses. Aquatic forbs found in these areas generally include pepperweeds (*Lepidium* sp.), smartweeds (*Polygonum* sp.), cattails (*Typha domingensis*) and spiderworts (*Tradescantia* sp.) among others. Game and waterfowl find these low marshy areas to be excellent natural wildlife habitat.

Threatened and Endangered Species (ES)

The Federal Endangered Species Act of 1973, as amended, prohibits the “take” of any threatened or endangered species. The term “take” under the ESA means “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct.” The term “harm” was further defined to include “significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering.” Designation of critical habitat areas has been established for the public knowledge where the publishing of such information would not cause harm to the species. Additional federal protection is extended to migratory birds, and bald and golden eagles under the Migratory Bird Treaty Act (MBTA) as amended, and the Bald and Golden Eagle Protection Act. Protection is also afforded to Texas state-listed species. The Texas Parks and Wildlife Department (TPWD) enforces the state regulations.

The MBTA protects most bird species, including, but not limited to, cranes, ducks, geese, shorebirds, hawks, and songbirds. Migratory bird pathways, stopover habitats, wintering areas, and breeding areas may occur within and adjacent to the pipeline area, and may be associated with wetlands, ponds, shorelines, riparian corridors, fallow fields and grasslands, and woodland and forested areas. Pipeline construction activities could disturb migratory bird habitats and/or species’ activities.

Reasonable and prudent measures should be taken to avoid and minimize the potential effects of the proposed project’s activities on threatened and endangered species, as well as bald eagles. Species’ locations, activities, and habitat requirements should be considered based on U.S. Fish and Wildlife Service and TPWD recommendations.

In Nueces, San Patricio, Aransas, and Bee Counties there may occur 40 state-listed endangered or threatened species and 19 federally-listed endangered or threatened wildlife species, according to the county lists of rare species published by the TPWD. A list of these species, their preferred habitat and potential occurrence in the four county areas is provided in Table 5D.8.1.

Table 5D.8.1.
Federal- and State-Listed Threatened, Endangered, and Species of Concern Listed for Nueces, San Patricio, Aransas, and Bee Counties

Common Name	Scientific Name	Summary of Habitat Preference	Potential Occurrence in Project Area	Federal Status	State Status
Peregrine falcon	*Falco peregrinus anatum* (American)	Open country; cliffs	Nesting/Migrant	DL	T
	Falco peregrinus tundrius (Arctic)	Open country; cliffs	Nesting/Migrant	DL	—
Brown pelican	*Pelecanus occidentalis*	Coastal inlands for nesting, shallow gulf and bays for foraging	Resident	DL	E
Eskimo Curlew	*Numenius borealis*	Nonbreeding in grasslands, pastures and plowed fields	Historic	LE	E
Henslow's sparrow	*Ammodramus henslowii*	Wintering individuals found in weedy fields	Migrant	—	—
Mountain plover	*Charadrius montanus*	Breeding, nesting on shortgrass prairie	Resident	—	—
Northern Aplomado Falcon	*Falco femoralis septentrionalis*	Open country, especially savanna and open woodland, and sometimes in very barren areas; grassy plains and valleys with scattered mesquite, yucca, and cactus	Migrant	LE	E
Piping plover	*Charadrius melodus*	Beaches and flats of coastal Texas	Migrant	LT	T
Reddish egret	*Egretta rufescens*	Coastal inlands for nesting, coastal marshes for foraging	Resident	—	T
Sennett's Hooded Oriole	*Icterus cucullatus sennetti*	Often builds nests in and of Spanish moss feeds on invertebrates, fruit, and nectar	Resident	—	—
Snowy plover	*Charadrius alexandrinus*	Potential migrant, wintering along the coast	Migrant	—	—
Sooty Tern	*Sterna fuscata*	Catches small fish as it hovers or flies over water	Resident	—	T
Southeastern Snowy Plover	*Charadrius alexandrinus tenuirostris*	Wintering migrant along the Texas Gulf Coast beaches and bayside mud or salt flats	Migrant	—	—
Texas Botteri's Sparrow	*Aimophila botterii texana*	Grassland and short-grass plains with scattered bushes or shrubs, sagebrush, mesquite, or yucca; nests on ground of low clump of grasses	Resident	—	T
Western burrowing owl	*Athene cunicularia hypugaea*	Open grasslands, especially prairie	Resident	—	—
Western Snowy Plover	*Charadrius alexandrinus nivosus*	Potential migrant; wintering along the coast	Potential Migrant	—	—
White-faced ibis	*Plegadis chihi*	Prefers freshwater marshes	Resident	—	T
White-tailed hawk	*Buteo albicaudatus*	Coastal prairies, savannahs and marshes in Gulf Coastal Plain	Nesting/Migrant	—	T
Whooping crane	*Grus Americana*	Winters in coastal marshes	Migrant	LE	E
Wood stork	*Mycteria Americana*	Forages in prairie ponds, ditches and shallow standing water; formerly nested in Texas	Migrant	—	T
Aransas short-tailed shrew	*Blarina hylophaga plumbea*	Excavates burrows in sandy soils underlying mottes of live oak trees or in areas with little to no ground cover	Resident	—	—

Common Name	Scientific Name	Summary of Habitat Preference	Potential Occurrence in Project Area	Federal Status	State Status
Black bear	*Ursus americanus*	Historic in bottomland hardwoods and large tracts of inaccessible forested areas	Historic	T/SA;NL	T
Jaguarundi	*Herpailurus yaguarondi*	Thick brushlands, near water favored	Resident	LE	E
Louisiana black bear	*Ursus americanus luteolus*	Historic as possible transient; Bottomland hardwoods and large tracts of inaccessible forested areas	Historic	LT	T
Maritime pocket gopher	*Geomys personatus maritimus*	Found in deep sandy soils; feeds mostly from within burrow on roots and other plant parts	Resident	—	—
Ocelot	*Leopardus pardalis*	Dense chaparral thickets; mesquite-thorn shrub and live oak stands	Resident	LE	E
Plains spotted skunk	*Spilogale putorius interrupta*	Open fields, and prairies	Resident	—	—
Red wolf	*Canis rufus*	Extirpated	Historic	LE	E
Southern yellow bat	*Lasiurus ega*	Associated with trees, such as palm trees	Resident	—	T
West Indian manatee	*Trichechus manatus*	Gulf and bay system; opportunistic, aquatic herbivore	Aquatic Resident	LE	E
White-nosed coati	*Nasua narica*	Woodlands, riparian corridors and canyons	Transient	—	T
Black-spotted newt	*Notophthalmus meridionalis*	Ponds and resacas in south Texas	Resident	—	T
Sheep frog	*Hypopachus variolosus*	Predominantly found in grassland and savannas; moist sites in arid areas	Resident	—	T
South Texas siren	*Siren sp.1*	Wet or sometimes wet areas, such as arroyos, canals, ditches, or even shallow depressions	Resident	—	T
American eel	*Anguilla rostrata*	Coastal waterways to Gulf.	Resident	—	—
Opossum pipefish	*Microphis brachyurus*	Brooding adults found in fresh or low salinity waters and young in more saline waters; Southern coastal areas	Aquatic Resident	—	T
Smalltooth sawfish	*Pristis pectinata*	Young found very close to shore in muddy and sandy bottoms, in sheltered bays, on shallow banks, and in estuaries or river mouths; adult sawfish are encountered in various habitat types	Aquatic Resident	LE	E
Texas pipefish	*Syngnathus affinis*	Corpus Christi Bay; seagrass beds	Aquatic Resident	—	—
Manfreda giant-skipper	*Stallingsia maculosus*	Most skippers are small and stout-bodied; name derives from fast, erratic flight	Resident	—	—
Golden Orb	*Quadrula aurea*	Sand and gravel areas in river basins	Resident	—	T
Atlantic hawksbill sea turtle	*Eretmochelys imbricata*	Gulf and bay system, warm shallow waters especially in rocky marine environments	Aquatic Resident	LE	E
Green sea turtle	*Chelonia mydas*	Gulf and bay systems; shallow water seagrass beds	Aquatic Resident	LT	T
Gulf saltmarsh snake	*Nerodia clarkii*	Saline flats and river mouths	Resident	—	—
Indigo snake	*Drymarchon corais*	South of the Guadalupe River and Balcones Escarpment; mainly in dense riparian corridors	Resident	—	T

Common Name	Scientific Name	Summary of Habitat Preference	Potential Occurrence in Project Area	Federal Status	State Status
Keeled earless lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates	Resident	—	—
Kemp's Ridley sea turtle	*Lepidochelys kempii*	Gulf and bay systems; shallow waters of the Gulf of Mexico	Aquatic Resident	LE	E
Leatherback sea turtle	*Dermochelys coriacea*	Gulf and bay systems; forages in Gulf of Mexico	Aquatic Resident	LE	E
Loggerhead sea turtle	*Caretta caretta*	Gulf and bay systems for juveniles, adults prefer open waters	Aquatic Resident	LT	T
Spot-tailed earless lizard	*Holbrookia lacerate*	Open prairie-brushland	Resident	—	—
Texas diamondback terrapin	*Malaclemys terrapin littoralis*	Coastal marshes and tidal flats	Resident	—	—
Texas horned lizard	*Phrynosoma cornutum*	Varied; sparsely vegetated uplands, grass, cactus, brush	Resident	—	T
Texas scarlet snake	*Cemophora coccinea lineri*	Mixed hardwood scrub on sandy soils	Resident	—	T
Texas tortoise	*Gopherus berlandieri*	Open bush with grass understory; open grass and bare ground avoided	Resident	—	T
Timber/Canebrake rattlesnake	*Crotalus horridus*	Floodplains, riparian zones with dense ground cover	Resident	—	T
Coastal gay-feather	*Liatris bracteata*	Endemic to black clay soils of prairie	Resident	—	—
Elmendorf's onion	*Allium elmendorfii*	Endemic to grassland openings in woodlands	Resident	—	—
Lila de los Llanos	*Echeandia chandleri*	Shrubs or in grassy openings in subtropical thorn shrublands along Gulf Coast	Resident	—	—
Mexican mud-plantain	*Heteranthera mexicana*	Resacas and ephemeral wetlands	Resident	—	—
Plains gumweed	*Grindelia oolepis*	Coastal prairies on heavy clay soils	Resident	—	—
Slender rushpea	*Hoffmannseggia tenella*	Texas endemic; coastal prairie grasslands	Resident	LE	E
South Texas ambrosia	*Ambrosia cheiranthifolia*	Found on grasslands and mesquite-dominated shrublands	Resident	LE	E
Texas windmill-grass	*Chloris texensis*	Texas endemic; sandy to sandy loam soils in bare areas in coastal prairie grassland remnants	Resident	—	—
Tharp's rhododon	*Rhododon angulatus*	Texas endemic; deep, loose sands in sparsely vegetated areas on stabilized dunes of barrier islands	Resident	—	—
Three-flower broomweed	*Thurovia triflora*	Endemic, remnant grasslands and tidal flats	Resident	—	—
Welder machaeranthera	*Psilactis heterocarpa*	Endemic to grasslands and adjacent scrub flats	Resident	—	—

Source: TPWD, Annotated County List of Rare Species, Bee County, May 4, 2009, San Patricio County, May 4, 2009, and Nueces County May 4, 2009.

DL	Delisted	LE	Federally listed endangered
PDL	Proposed for Delisting	LT	Federally listed threatened
—	Not Listed (Species of Concern)	E	State Endangered
T	State Threatened	T/SA	Threatened due to Similarity of Appearance

Inclusion in Table 5D.8.1 does not imply that a species will occur within the project area, but only acknowledges the potential for occurrence in the project area counties. A more intensive field reconnaissance would be necessary to confirm and identify specific species habitat that may be present in the project area.

The proposed projects occur primarily in areas which have been previously developed and used for farming and pasture for a long period of time. Disturbance within these areas due to construction of the pipeline routes and well fields is anticipated to have minimal effect on the existing environment. Although the use of deep well injection methods for disposal of the brine concentrate is not anticipated to impact existing terrestrial species, impacts from the disposal of saline concentrate into Oso or Copano Bays should be carefully monitored in order to minimize any impacts this may have on aquatic species. After a review of the habitat requirements for each listed species, it is anticipated that it is unlikely that this project will have an adverse effect on any federally listed threatened or endangered species, its habitat, or designated habitat, nor would it adversely affect any state endangered species. Although suitable habitat for some listed species may exist within the project areas, no impact is anticipated due to the abundance of similar habit near the project areas and the ability of most species to relocate to those areas if necessary. The presence or absence of potential habitat within an area does not confirm the presence or absence of a listed species. No species specific surveys were conducted in the project area for this report.

Wetland Areas

Potential wetland impacts are expected to include pipeline and well field areas located near rivers, streams, or marshy areas near bays. The wells, collection system within the well field, and transmission systems should be sited in such a way as to avoid or minimize impacts to these sensitive resources. Potential impacts can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetland would be required where impacts are unavoidable.

Cultural Resources

A review of the Texas Historical Commission Texas Historic Sites Atlas data base indicated that there are no National Register Properties listed near any of the proposed project areas. Three Historical Markers have been identified within two of the project areas, one within the Nueces S-C option, and two in the area of the Nueces NW well field. Impact to any of these markers should be easily avoided through planning associated with the development of the well fields and pipeline routes. In addition, there are four cemeteries located near the Nueces S-C and Bee-SanPat project areas which should be avoided by planning and location of the well fields and pipeline routes.

A cultural resource survey of the well field and pipeline routes for each of the proposed project areas will need to be performed consistent with requirements of the Texas Antiquities Commission.

Summary of Overall Possible Environmental Impacts

Because of the relatively small areas involved, construction and maintenance of surface facilities are not expected to result in substantial environmental impacts. Where environmental resources (e.g., endangered species habitat and cultural resource sites) could be impacted by infrastructure, minor adjustments in facility siting and pipeline alignment would generally be sufficient to avoid or minimize adverse effects.

The pumping of groundwater from the Evangeline Aquifer could cause a slight reduction on baseflow in downstream reaches. However, no measurable impact on wildlife along the streams is anticipated from this project. Minor land surface subsidence could potentially occur as a result of lowering of groundwater levels. As a result, drainage patterns and other habitats might change to a small extent.

5D.8.1.5 Engineering and Costing

Bee-SanPat Projects

This project considers two options for delivery of treated water, which are delivery to the O.N. Stevens WTP and to SPMWD's water main near U.S. Hwy 77 and about two miles south of Sinton. There are two options for disposal of concentrate, including deep-well injection and discharge to Copano Bay. The project is designed to yield 21.4 mgd (24,000 ac-ft/yr) and provide a treated water supply with a total dissolved solids concentration of about 400 mg/L. Figures 5D.8.2 and 5D.8.3 show the location of the City and SPMWD options, respectively.

The preliminary water treatment design has the facilities located in the vicinity of the well field. The brackish groundwater does not contain a high level of suspended solids; therefore, only chlorine disinfection is included. Since the source water has relatively low TDS for brackish water, a portion of the raw water can be blended with desalinated, treated water to operate the project more economically while achieving treated water that is comparable to existing supplies.

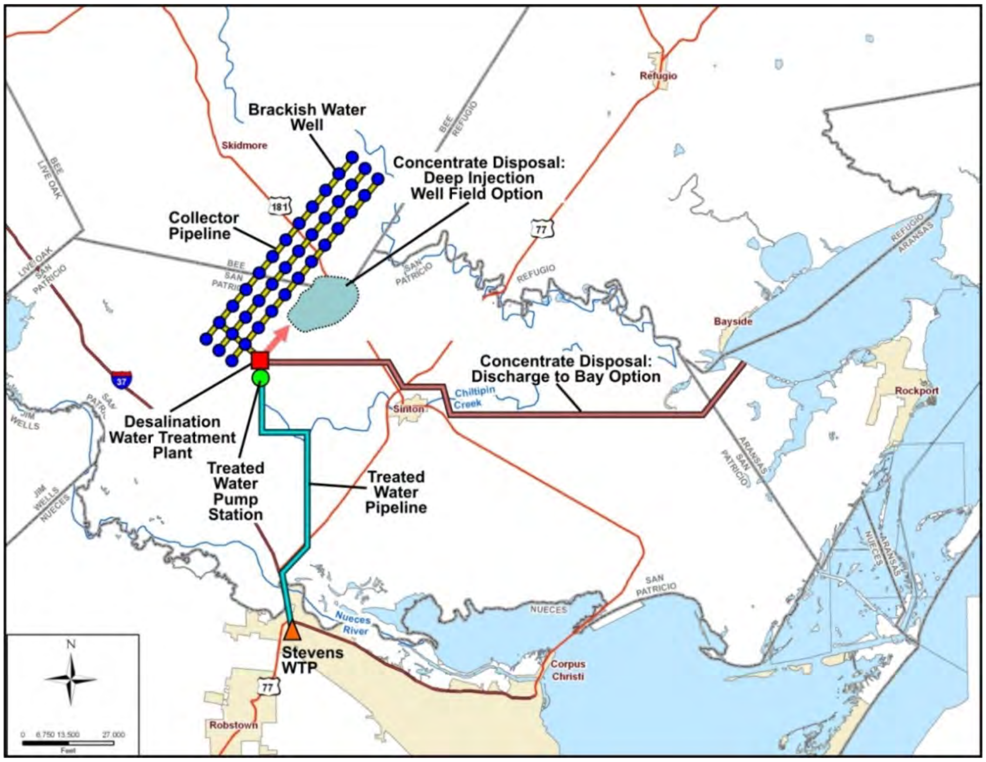


Figure 5D.8.2.
Location of Bee-San Patricio Project for City of Corpus Christi

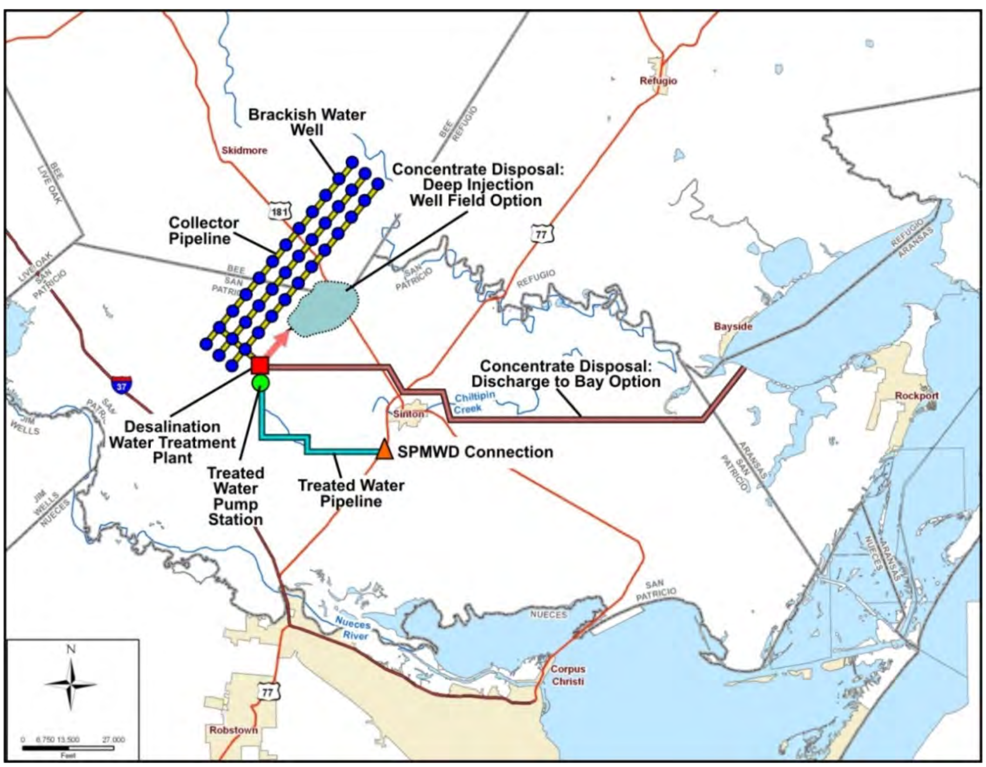
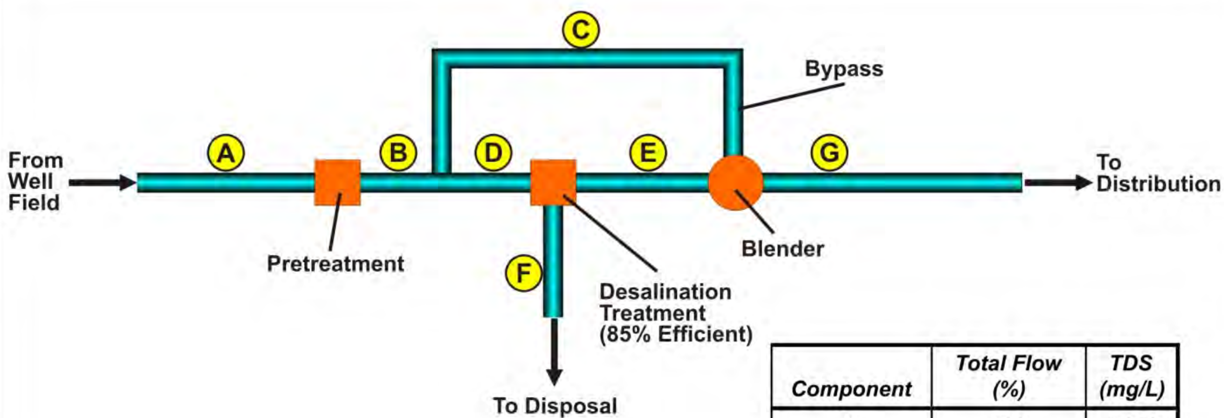


Figure 5D.8.3.
Location of Bee-San Patricio Project for SPMWD

With a source water having a TDS of about 1,050 mg/L and a product water of about 400 mg/L, about 62 percent of the raw well water from the Bee-SanPat project will be sent to the desalination plant to remove inorganic and organic water quality constituents; and, the remaining 38 percent will be blended with the desalinated water. Based on a conventional reverse osmosis (RO) desalination process, the desalination plant recovery rate for this raw water is estimated to be 85 percent, meaning that 85 percent of the water entering the desalination plant passes through as purified water and 15 percent of the water remains as brine. The desalinated water is blended back with the brackish water that bypasses the desalination process to produce the finished water. Overall, this process converts about 90 percent of the raw water produced from the well field into potable water. The remaining 10 percent is a concentrate and is discharged either to deep-injection wells or Copano Bay. The concentrate will have a TDS of about 7,000 mg/L.

Figure 5D.8.4 is provided to illustrate the water treatment system for a typical brackish groundwater desalination treatment plant, the percent of water flowing through each component of the system, and the concentration of the TDS.



Component	Total Flow (%)	TDS (mg/L)
A	100	1,050
B	100	1,050
C	38	1,050
D	62	1,050
E	53	10
F	10	7,000
G	90	400

Figure 5D.8.4.
Flow Diagram for a Typical Brackish Groundwater Desalination Water Treatment Plant

Based on the loss of raw water to concentrate in the desalination process, the well field capacity will need to be about 23.8 mgd. The well field is located in Bee and San Patricio Counties and consists of 36 wells, which includes a contingency of about 10 percent. The wells have an average yield of 500 gpm, are 800 feet deep, spaced about one mile apart, and produce water with a TDS of about 1,050 mg/L. In the well field, the collector pipeline ranges from a diameter of 8 to 36 inches, and includes about 35 miles of pipeline. Well pumps will be sized to deliver the raw water directly to the water treatment plant.

The distribution pipeline for delivery of water to the O.N. Stevens WTP is about 19.2 miles long and has a diameter of 36 inches. For the SPMWD option, the distribution pipeline is about 12.5 miles long and also has a diameter of 36 inches. A pump station is required at the desalination water treatment plant for both options.

For the option to discharge the concentrate to Copano Bay, a 32 mile long, 16-inch diameter pipeline is required. At the terminal end and in the bay, a diffuser will be installed to disperse the concentrate over a relatively large area. For the concentrate disposal option using deep-well injection, five disposal wells are needed. Plans are to screen these wells in the Jasper Aquifer where the TDS is about 20,000 mg/L[4], which is considerably greater than the concentrate. These wells are expected to have a capacity of about 400 gpm and be about 2,800 feet deep.

Cost estimates have been prepared for the two delivery options with two options for concentrate disposal. Tables 5D.8.2 and 5D.8.3 provide cost estimate summaries for delivery to the O.N. Stevens WTP with concentrate disposal to Copano Bay and deep-injection wells, respectively. Tables 5D.8.4 and 5D.8.5 provide cost estimate summaries for delivery to the SPMWD distribution system with concentrate disposal to Copano Bay and deep-injection wells, respectively. The costs assume groundwater leases can be obtained for $46 per ac-ft of raw water. The unit costs for the project with delivery of water to O.N. Stevens WTP with disposal to Copano Bay and deep-injection are $934/ac-ft and $916/ac-ft, respectively. The unit costs for the delivery of water to SPMWD with disposal to Copano Bay and deep-injection wells are $879/ac-ft and $853/ac-ft, respectively.

Nueces NW Project

This project is designed to deliver treated water to the O.N. Stevens WTP. Concentrate disposal is planned for deep-injection wells. The project design is to yield 16.1 mgd (18,000 ac-ft/yr) and provide a treated water supply with a TDS of about 400 mg/L. Figure 5D.8.5 shows the location of the project and facilities.

The preliminary water treatment design has the facilities located in the vicinity of the well field, and has a similar design to the facilities for the Bee-SanPat project. In this part of the Gulf Coast Aquifer, the water in the Evangeline Aquifer has a TDS of about 1,750 mg/L. With a goal of product water having about 400 mg/L of TDS, about 77 percent of the raw well water will be sent to the desalination plant to remove inorganic and organic water quality constituents; and, the remaining 23 percent will be blended with the desalinated water. The desalination plant recovery rate is estimated to be 80 percent. Overall, this process converts about 84 percent of the raw water produced from the well field into potable water. The remaining 16 percent is a concentrate that requires disposal. This concentrate will have a TDS of about 8,750 mg/L.

[4] Ryder, P.D., and Ardis, A.F, 2002, Hydrology of the Texas Gulf Coast Aquifer Systems, U.S. Geological Survey Professional Paper 1416-E, Plate 2.

Table 5D.8.2.
Cost Estimate Summary Water Supply Project Option (Sept 2013Prices)
Bee-San Patricio Well Field with Delivery to Stevens WTP, Concentrate to Bay

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Intake Pump Stations (22.6 mgd)	$5,579,000
Pipeline (Transmission: 36-inch, 19 miles; Concentrate: 16-inch, 32 miles)	$32,130,000
Transmission Pump Station(s) & Storage Tank(s)	$459,000
Well Fields (Wells, Pumps and Piping 8- to 36-inch)	$34,743,000
Discharge into Bay (Pipe and Diffuser)	$231,000
Water Treatment Plant (Desalination and Disinfection)	$31,214,000
TOTAL COST OF FACILITIES	**$104,356,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$34,918,000
Environmental & Archaeology Studies and Mitigation	$2,291,000
Land Acquisition and Surveying (256 acres)	$790,000
Interest During Construction (4% for 1 year with a 1% ROI)	$4,983,000
TOTAL COST OF PROJECT	**$147,338,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$12,329,000
Operation and Maintenance	
Pipeline, Wells and Storage Tanks (1% of Cost of Facilities)	$673,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$139,000
Water Treatment Plant	$5,951,000
Pumping Energy Costs (21202693 kW-hr @ 0.09 $/kW-hr)	$1,908,000
Purchase of Water (26,626 ac-ft/yr @ 46 $/ac-ft)	$1,228,000
Groundwater District Fees (24,000 ac-ft/yr @ 8.15 $/ac-ft)	$196,000
TOTAL ANNUAL COST	**$22,424,000**
Available Project Yield (ac-ft/yr)	24,000
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1	$934
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	$2.87

Table 5D.8.3.
Cost Estimate Summary Water Supply Project Option (Sept 2013 Prices)
Bee-San Patricio Well Field with Delivery to Stevens WTP, Concentrate to Wells

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Intake Pump Stations (22.6 mgd)	$5,314,000
Pipeline (Transmission: 36-inch, 19 miles; Concentrate: 12-inch, 4 miles)	$22,492,000
Transmission Pump Station(s) & Storage Tank(s)	$459,000
Well Fields (Wells, Pumps and Piping 8- to 36-inch)	$41,934,000
Water Treatment Plant (Desalination and Disinfection)	$31,214,000
TOTAL COST OF FACILITIES	**$101,413,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$34,370,000
Environmental & Archaeology Studies and Mitigation	$1,595,000
Land Acquisition and Surveying (140 acres)	$430,000
Interest During Construction (4% for 1 year with a 1% ROI)	$4,824,000
TOTAL COST OF PROJECT	**$142,632,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$11,935,000
Operation and Maintenance	
Pipeline, Wells and Storage Tanks (1% of Cost of Facilities)	$649,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$133,000
Water Treatment Plant	$5,951,000
Pumping Energy Costs (21066252 kW-hr @ 0.09 $/kW-hr)	$1,896,000
Purchase of Water (26,626 ac-ft/yr @ 46 $/ac-ft)	$1,228,000
Groundwater District Fees (24,000 ac-ft/yr @ 8.15 $/ac-ft)	$196,000
TOTAL ANNUAL COST	**$21,988,000**
Available Project Yield (ac-ft/yr)	24,000
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1	$916
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	$2.81

Table 5D.8.4.
Cost Estimate Summary Water Supply Project Option (Sept 2013 Prices)
Bee-San Patricio Well Field with Delivery to U.S. Hwy 77, Concentrate to Bay

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Intake Pump Stations (22.6 mgd)	$4,820,000
Pipeline (Transmission: 36-inch, 12 miles; Concentrate: 16-inch, 32 miles)	$24,873,000
Transmission Pump Station(s) & Storage Tank(s)	$459,000
Well Fields (Wells, Pumps and Piping 8- to 36-inch)	$34,743,000
Storage Tanks (Other than at Booster Pump Stations)	$231,000
Water Treatment Plant (Desalination and Disinfection)	$31,214,000
TOTAL COST OF FACILITIES	**$96,340,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$32,475,000
Environmental & Archaeology Studies and Mitigation	$2,123,000
Land Acquisition and Surveying (228 acres)	$702,000
Interest During Construction (4% for 1 year with a 1% ROI)	$4,608,000
TOTAL COST OF PROJECT	**$136,248,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$11,401,000
Operation and Maintenance	
Pipeline, Wells and Storage Tanks (1% of Cost of Facilities)	$601,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$121,000
Water Treatment Plant	$5,951,000
Pumping Energy Costs (17790089 kW-hr @ 0.09 $/kW-hr)	$1,601,000
Purchase of Water (26,626 ac-ft/yr @ 46 $/ac-ft)	$1,228,000
Groundwater District Fees (24,000 ac-ft/yr @ 8.15 $/ac-ft)	$196,000
TOTAL ANNUAL COST	**$21,099,000**
Available Project Yield (ac-ft/yr)	24,000
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1	$879
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	$2.70

Table 5D.8.5.
Cost Estimate Summary Water Supply Project Option (Sept 2013 Prices)
Bee-San Patricio Well Field with Delivery to U.S. Hwy 77, Concentrate to Wells

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Intake Pump Stations (22.6 mgd)	$4,556,000
Pipeline (Transmission: 36-inch, 12 miles; Concentrate: 12-inch, 4 miles)	$13,667,000
Transmission Pump Station(s) & Storage Tank(s)	$459,000
Well Fields (Wells, Pumps and Piping 8- to 36-inch)	$41,934,000
Water Treatment Plant (Desalination and Disinfection)	$31,214,000
TOTAL COST OF FACILITIES	**$91,830,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$31,457,000
Environmental & Archaeology Studies and Mitigation	$1,427,000
Land Acquisition and Surveying (111 acres)	$342,000
Interest During Construction (4% for 1 year with a 1% ROI)	$4,377,000
TOTAL COST OF PROJECT	**$129,433,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$10,831,000
Operation and Maintenance	
Pipeline, Wells and Storage Tanks (1% of Cost of Facilities)	$561,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$114,000
Water Treatment Plant	$5,951,000
Pumping Energy Costs (17653647 kW-hr @ 0.09 $/kW-hr)	$1,589,000
Purchase of Water (26,626 ac-ft/yr @ 46 $/ac-ft)	$1,228,000
Groundwater District Fees (24,000 ac-ft/yr @ 8.15 $/ac-ft)	$196,000
TOTAL ANNUAL COST	**$20,470,000**
Available Project Yield (ac-ft/yr)	24,000
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1	$853
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	$2.62

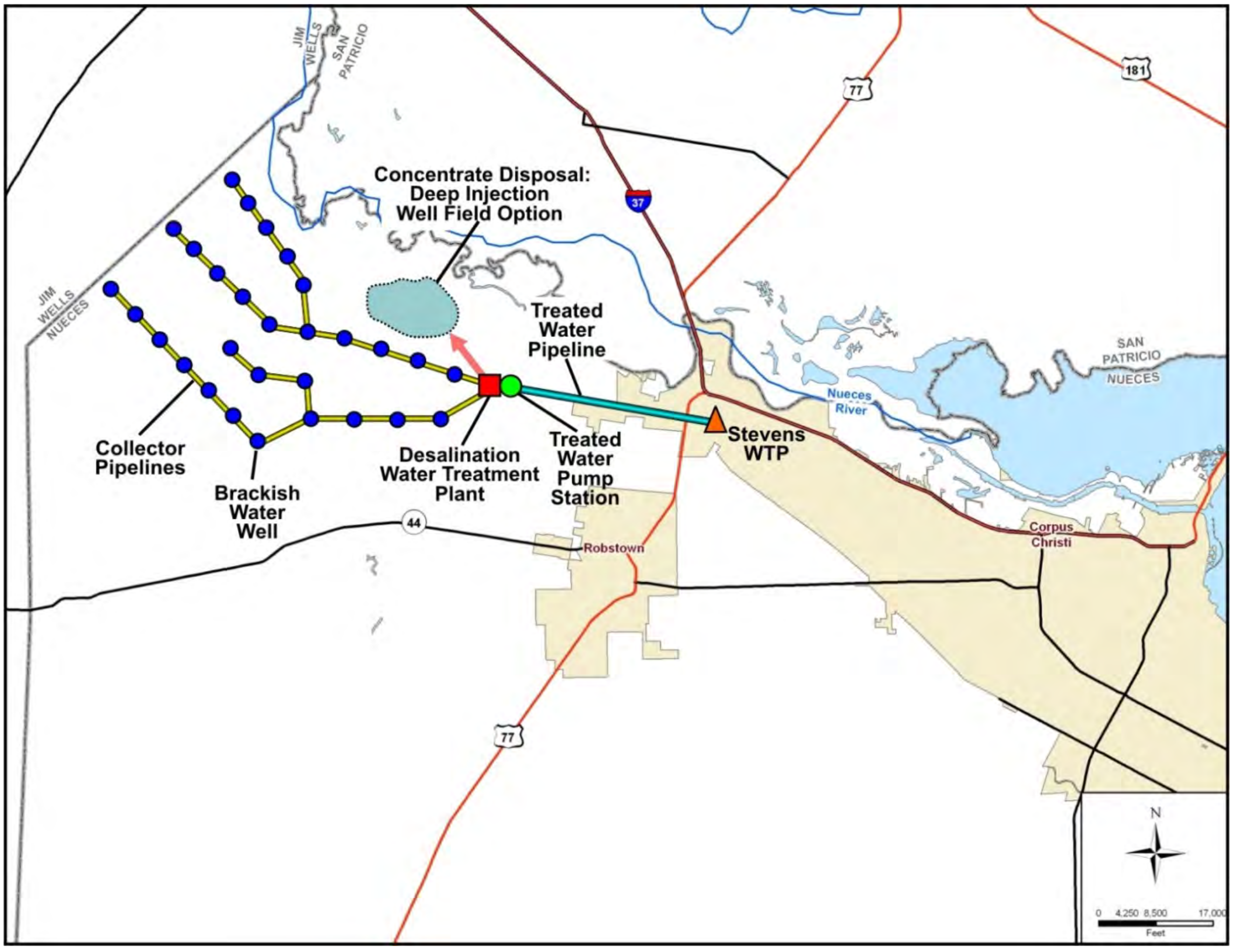


Figure 5D.8.5.
Location of Nueces Northwest Project

Based on the loss of raw water to concentrate in the desalination process, the well field capacity will need to be about 19.1 mgd. The planned well field is located south of the Nueces River, and between the Nueces-Jim Wells county line and U.S. Hwy 77. There are 30 wells, which includes a contingency of about 10 percent. The wells have an average yield of 500 gpm, are 800 feet deep, spaced about one mile apart, and produce water with a TDS of about 1,750 mg/L. In the well field, the collector pipeline ranges from a diameter of 8 to 24 inches and includes about 28 miles of pipeline. Well pumps will be sized to deliver the raw water directly to the water treatment plant.

The delivery pipeline to the O.N. Stevens WTP is about 5.4 miles long and has a diameter of 30 inches. It will require a pump station at the desalination water treatment plant.

Concentrate disposal will be to deep-injection wells. Plans are for 7 injection wells that will be screened in the Jasper Aquifer where the TDS is about 60,000 mg/L (Ryder and Ardis, 2002), which is considerably greater than the concentrate. These wells are expected to have a capacity of about 400 gpm and be about 3,100 feet deep.

Cost estimates have been prepared and are provided in Table 5D.8.6. As shown in the table the unit cost for the delivery of water to O.N. Stevens WTP is $1,031/ac-ft.

Nueces S-C Project

This project is designed with two options. One is to deliver treated water to the City of Corpus Christi's distribution system near the intersection of TX Hwys 286 and 2444 and to dispose the concentrate to Oso Bay through the Barney Davis Power Station. The other option is to delivery treated water to the STWA pipeline near Bishop and dispose of the concentrate to deep-injection wells. This strategy is to make water available for STWA customers and to supplement the supplies at the O.N. Stevens WTP. The projects are designed to yield 10.7 mgd (12,000 ac-ft/yr) at a uniform rate. The project is to provide a treated water supply with TDS of about 400 mg/L. Figures 5D.8.6 and 5D.8.7 show the location of the facilities and each delivery option.

The preliminary water treatment design has the facilities located in the vicinity of the well field and near the pump station for the delivery pipelines. In this part of the Gulf Coast Aquifer, the water in the Evangeline Aquifer has a TDS of about 1,900 mg/L at depths considered in this analysis to sustain long-term pumping. With a goal of product water having about 400 mg/L of TDS, about 79 percent of the raw well water will be sent to the desalination plant to remove inorganic and organic water quality constituents; and, the remaining 21 percent will be blended with the desalinated water. The desalination plant recovery rate is estimated to be 80 percent. Overall, this process converts about 83 percent of the raw water produced from the well field into potable water. The remaining 17 percent is a concentrate and is discharged to deep-injection wells or Barney Davis Power Station. This concentrate will have a TDS of about 9,500 mg/L.

The well field is planned to be along TX Hwy 70 and about midway between Laguna Madre and Bishop. Based on the loss of raw water to concentrate in the desalination process, the well field capacity will need to be about 12.8 mgd. The wells are expected to have an average yield of 500 gpm, are 1,300 feet deep, spaced about one mile apart, and produce water with a TDS of about 1,900 mg/L. There are 20 wells planned, which includes a contingency of about 10 percent. The collector pipeline ranges from a diameter of 8 to 30 inches and includes about 20 miles of pipeline. Well pumps will be sized to deliver the raw water directly to the water treatment plant.

The treated water delivery pipeline to the City distribution system will be about 5.5 miles long and be 24 inches in diameter. For the STWA option, the delivery pipeline will about 15.0 miles long and be 30 inches in diameter. Both options require a pump station at the desalination water treatment plant.

For the concentrate disposal options with discharge at the Barney Davis Power Station, the pipeline will be 9.3 miles long and 16 inches in diameter. For the option with concentrate disposal to deep-injection wells, five wells will be required, with a capacity of about 400 gpm, and a depth of about 3,900 feet. Plans are for injection wells that will be screened in the Jasper Aquifer where the TDS is about 140,000 mg/L (Ryder and Ardis, 2002).

Table 5D.8.6.
Cost Estimate Summary Water Supply Project Option (Sept 2013 Prices)
Nueces Northwest Well Field with Delivery to Stevens WTP, Concentrate to Wells

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Intake Pump Stations (16.9 mgd)	$4,291,000
Pipeline (Transmission: 30-inch, 5 miles; Concentrate: 16-inch, 6 miles)	$7,704,000
Transmission Pump Station(s) & Storage Tank(s)	$546,000
Well Fields (Wells, Pumps and Piping 8- to 30-inch)	$35,701,000
Water Treatment Plant (Desalination and Disinfection)	$33,821,000
TOTAL COST OF FACILITIES	**$82,063,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$28,337,000
Environmental & Archaeology Studies and Mitigation	$1,138,000
Land Acquisition and Surveying (85 acres)	$262,000
Interest During Construction (4% for 1 year with a 1% ROI)	$3,913,000
TOTAL COST OF PROJECT	**$115,713,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$9,683,000
Operation and Maintenance	
Pipeline, Wells and Storage Tanks (1% of Cost of Facilities)	$440,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$107,000
Water Treatment Plant	$6,406,000
Pumping Energy Costs (10446296 kW-hr @ 0.09 $/kW-hr)	$940,000
Purchase of Water (21,465 ac-ft/yr @ 46.138 $/ac-ft)	$990,000
TOTAL ANNUAL COST	**$18,566,000**
Available Project Yield (ac-ft/yr)	18,000
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1	$1,031
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	$3.16

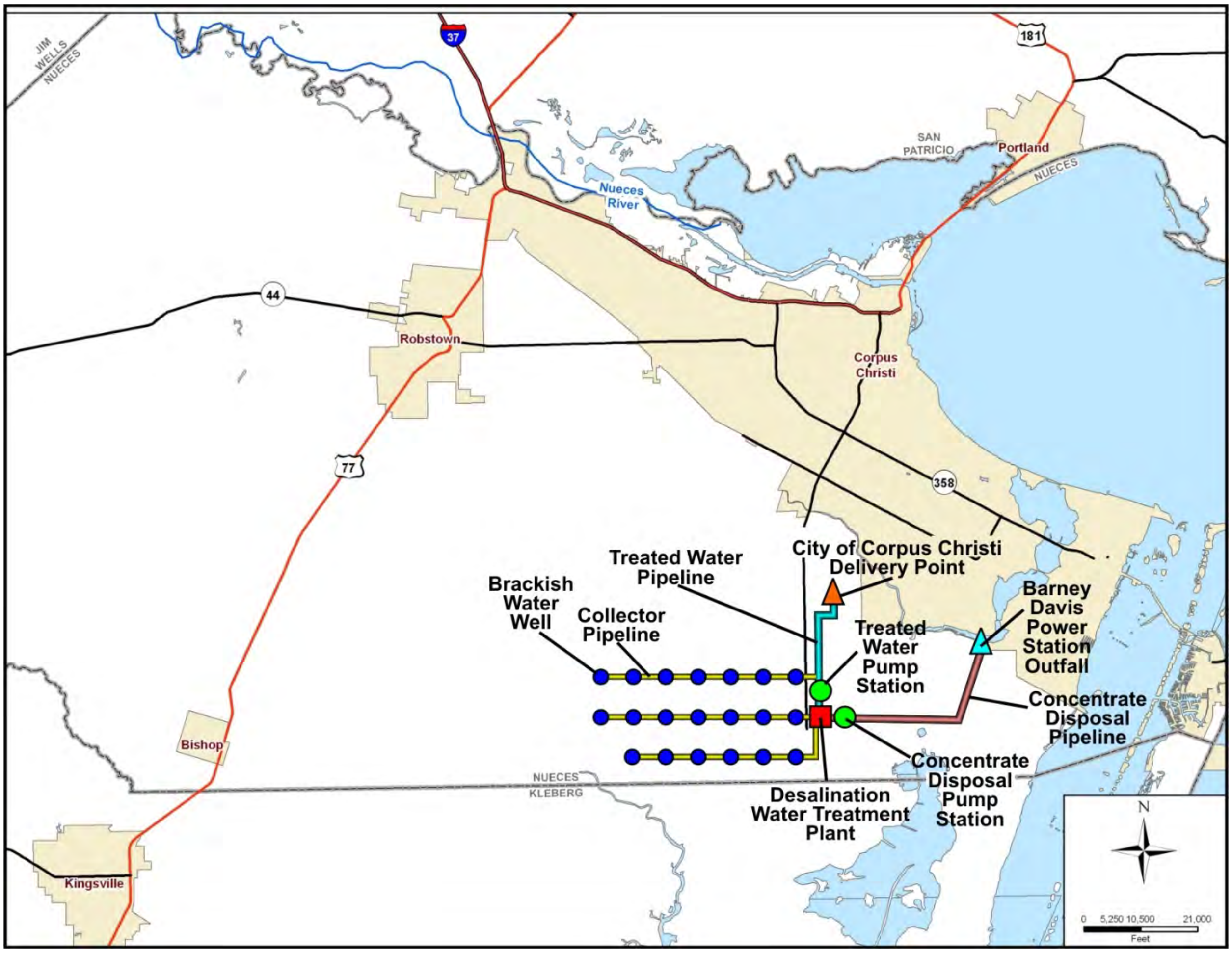


Figure 5D.8.6.
Location of Nueces South-Central Project for Corpus Christi

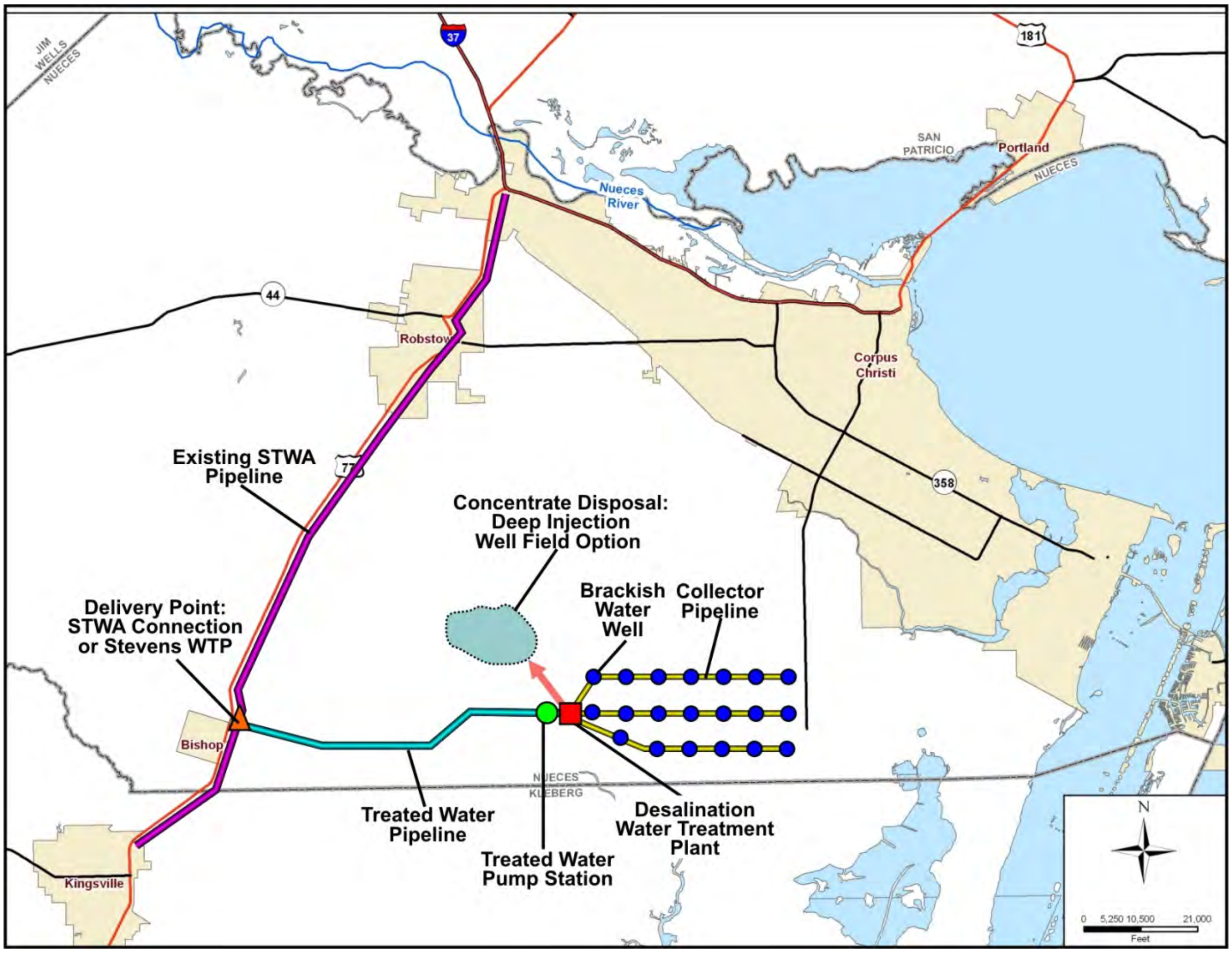


Figure 5D.8.7.
Location of Nueces South-Central Project for South Texas Water Authority and Corpus Christi

Cost estimates are provided in Table 5D.8.7 for the City option and in Table 5D.8.8 for the STWA option. The unit cost for the City option is $1,133/ac-ft; and, the unit costs for the STWA option is $1,252/ac-ft. If the STWA option is downsized to provide a uniform supply of 4,000 ac-ft/yr of treated water to the STWA pipeline, the unit cost would be about $1,560 ac-ft.

Table 5D.8.7.
Cost Estimate Summary Water Supply Project Option (Sept 2013 Prices)
Nueces South-Central Well Field with Delivery to City and Barney Davis PS

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Intake Pump Stations (11.3 mgd)	$3,733,000
Pipeline (Transmission: 24-inch, 6 miles; Concentrate: 14-inch, 9 miles)	$6,072,000
Transmission Pump Station(s) & Storage Tank(s)	$447,000
Well Fields (Wells, Pumps and Piping 8- to 18-inch)	$22,067,000
Water Treatment Plant (Desalination and Disinfection)	$21,765,000
TOTAL COST OF FACILITIES	**$54,084,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$18,626,000
Environmental & Archaeology Studies and Mitigation	$942,000
Land Acquisition and Surveying (88 acres)	$272,000
Interest During Construction (4% for 1 year with a 1% ROI)	$2,588,000
TOTAL COST OF PROJECT	**$76,512,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$6,403,000
Operation and Maintenance	
Pipeline, Wells and Storage Tanks (1% of Cost of Facilities)	$286,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$93,000
Water Treatment Plant	$4,163,000
Pumping Energy Costs (15746871 kW-hr @ 0.09 $/kW-hr)	$1,417,000
Purchase of Water (26,626 ac-ft/yr @ 46 $/ac-ft)	$1,228,000
TOTAL ANNUAL COST	**$13,590,000**
Available Project Yield (ac-ft/yr)	12,000
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1	$1,133
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	$3.47

Table 5D.8.8.
Cost Estimate Summary Water Supply Project Option (Sept 2013 Prices)
Nueces South-Central Well Field with Delivery to STWA and Concentrate to Wells

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Intake Pump Stations (11.3 mgd)	$3,430,000
Pipeline (Transmission: 30-inch, 15 miles; Concentrate: 14-inch, 2 miles)	$16,013,000
Transmission Pump Station(s) & Storage Tank(s)	$447,000
Well Fields (Wells, Pumps and Piping 8- to 36-inch)	$28,295,000
Water Treatment Plant (Desalination and Disinfection)	$21,765,000
TOTAL COST OF FACILITIES	**$69,950,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$23,682,000
Environmental & Archaeology Studies and Mitigation	$1,003,000
Land Acquisition and Surveying (100 acres)	$308,000
Interest During Construction (4% for 1 year with a 1% ROI)	$3,324,000
TOTAL COST OF PROJECT	**$98,267,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$8,223,000
Operation and Maintenance	
Pipeline, Wells and Storage Tanks (1% of Cost of Facilities)	$448,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$86,000
Water Treatment Plant	$4,163,000
Pumping Energy Costs (9779902 kW-hr @ 0.09 $/kW-hr)	$880,000
Purchase of Water (26,626 ac-ft/yr @ 46 $/ac-ft)	$1,228,000
TOTAL ANNUAL COST	**$15,028,000**
Available Project Yield (ac-ft/yr)	12,000
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1	$1,252
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	$3.84

Summary of Cost

A comparison of the unit water cost of delivered treated water for the three projects with various delivery and concentrate disposal options shows the large projects produce water at a lower cost than the small projects. For an example with concentrate being injected to deep wells, the largest (Bee-SanPat, SPMWD option), medium (Nueces NW) and smallest (Nueces S-C, STWA option) costs are $853, $1,031 and $1,252 per ac-ft, respectively. These costs are not directly comparable because of differences in water delivery, but the project cost comparisons suggest reducing a large project by a third increases the unit water cost by 15-20 percent; and, reducing the project by half increases the unit cost by 35-45 percent.

5D.8.1.6 Implementation Issues

The brackish groundwater supply analyses considered for this water management strategy were based on drawdown criteria adopted by the Coastal Bend Regional Water Planning Group. For future planning efforts, water availability estimates provided by Groundwater Management Area 16 and local groundwater conservation districts will need to be considered when determining available groundwater supplies.

Implementation of the Brackish Groundwater Desalination Projects includes the following issues:

- Permitting desalination concentrate discharge to Copano and Oso Bays for some options;
- Verification of the Gulf Coast Aquifer water quality for concentrations of the dissolved constituents such as TDS, chloride, sulfate, iron, manganese, radium, uranium, and arsenic;
- Deep-injection well permits concentrate disposal from TCEQ;
- Purchase or lease of property for well field, and coordination with landowners;
- Skilled operators of desalination water treatment plants;
- Impact of water levels in the aquifer, potential intrusion of saline groundwater, land surface subsidence, and streamflow;
- USACE Section 10 and 404 dredge and fill permits for pipelines;
- General Land Office Sand and Gravel Removal permit for pipeline and crossings of streams and roads;
- General Land Office Easement for use of State-owned lands, if any;
- Texas Parks and Wildlife Department Sand, Gravel, and Marl permit; and
- Mitigation requirements would vary depending on impacts, but could include vegetation restoration, wetland creation or enhancement, or additional land acquisition.

5D.8.1.7 Evaluation Summary

An evaluation summary of this regional water management strategy is provided in Table 5D.8.9.

Table 5D.8.9.
Evaluation Summary of the Brackish Groundwater Desalination Option

Impact Category	***Comment(s)***
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	 1. Variable, well field capacities ranges from up to about 24,000 ac-ft/yr. 2. High reliability. 3. Generally moderate to high cost; between $828 to $1,151/ac-ft for projects ranging from 12,000 to 24,000 ac-ft/yr.
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. Moderate impact. 2. None to low. However, greatest impact is during low-flow conditions. 3. Disposal of concentrated brine with bay option may impact fish and wildlife habitats or wetlands. 4. None to low. 5. None identified. Project can be adjusted to bypass sensitive areas. Endangered species survey will be needed to identify impacts. 6. Cultural resources survey will be needed to identify any significant sites. 7. 7a-b. Total dissolved solids and salinity of water is removed with reverse osmosis treatment. Brine concentrated disposal issues will need to be evaluated. 7d-i. Chloride, sulfate, uranium and arsenic concentrations in groundwater will need to be considered prior to implementation of project.
c. Impacts to State water resources	• Little to minor negative impacts on surface water resources
d. Threats to agriculture and natural resources in region	• Temporary damage due to construction of pipeline
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Standard analyses and methods used for portions • Brackish groundwater desalination cost modeled after bid and manufacturers' budgets, but not constructed, comparable project
g. Interbasin transfers	• Not applicable
h. Third party social and economic impacts from voluntary redistribution of water	• Not applicable
i. Efficient use of existing water supplies and regional opportunities	• Provides regional opportunities for water that would otherwise be unused
j. Effect on navigation	• None
k. Consideration of water pipelines and other facilities used for water conveyance	• Construction and maintenance of transmission pipeline corridor. Possible impact to wildlife habitat along pipeline route and right-of-way.

5D.8.2 City of Alice- Jasper Wellfield

5D.8.2.1 Description of Strategy

The City of Alice is considering a Brackish Groundwater strategy as part of an Alternate Water Feasibility Study[5]. This write-up associated with this strategy was provided by the City of Alice. No additional analyses were conducted. The primary proposed well locations are located at the existing Alice Water Treatment Plant (WTP) located on FM 3376. The alternate well locations would be on the existing Lake Findley site and are estimated to have a similar yield and depth as the primary location at the WTP. The City's study estimates a finished supply of 3,363 ac-ft/yr produced from two Jasper wells. Based on resistivity logs in the Jasper aquifer in this area, it is estimated the TDS is around 1,600 to 2,100 mg/L with a possible TDS maximum of approximately 3,000 mg/L. Given that the expected TDS of the groundwater exceeds current drinking water standards, a proposed treatment facility is necessary to treat the water prior to distribution.

The primary locations of the proposed wells at the WTP are 2,000 ft apart as shown in Figure 5D.8.8. Also shown are the proposed treatment facilities and the relationship of the wells to the proposed and existing facilities.

Figure 5D.8.8.
Location of Brackish Groundwater Well Fields

[5] NorrisLeal, Preliminary Report for Alternate Water Sources for Alice, Texas, February 5, 2015.

The alternate locations of the proposed wells are on the Lake Findley site and are identified in Figure 5D.8.9. The proposed treatment facilities if constructed at the alternate site and the relationship of the wells to the proposed facilities are also shown.

Figure 5D.8.9.
Alternative Location of Brackish Groundwater Well Fields

5D.8.2.2 Available Yield

As part of the study, wells in the area of the proposed site were analyzed. Existing abandoned wells in the area are 800 to 900 ft deep and the most productive depth of the Jasper formation in the area according to the City of Alice's study is between 1,600 to 1,800 ft deep. Wells at this depth are estimated to produce up to 2 mgd each (1,309 gpm). A raw water quality test showed the TDS concentrations in the area to be between 1,600 and 1,300 mg/L. It is proposed to have 2 wells that are expected to produce a combined total of 4 million gallons per day (mgd), for a finished supply of 3,363 ac-ft/yr (3 mgd) with a product water quality of 300 mg/L for TDS. This project will fit within current MAG restrictions without over drafting. Prior to final design, test wells should be drilled to confirm the groundwater yield and quality.

5D.8.2.3 Environmental Issues

The main environmental issue associated with the Jasper Well fields project is the disposal of the brackish concentrate.

The concentrate generated by each RO train will be directed to a common header that will in turn be routed for discharge to the San Diego Creek.

The effluent from the RO facility will be piped downstream to San Diego Creek which is an intermittent stream that flows into San Fernando Creek which is a freshwater tributary to Baffin Bay, 70 miles downstream of Corpus Christi. With limited freshwater inflow, evaporation far exceeds precipitation in the bay, resulting in a hypersaline estuary. During prolonged drought there is a fragile balance facing high salinity cycles when inflow ceases and summer and winter temperatures become extreme.[6]

5D.8.2.4 Engineering and Costing

Two wells were assumed at a depth of 1,700 feet with an average flow of 1,045 gpm. Less than 1 mile of 16-inch diameter piping was used for transmission from the wells to the treatment facilities. Capital costs for the project were provided by the City of Alice in February 2015 and utilized in the TWDB costing model to determine contingency, maintenance, annual and unit costs. Total project costs for the two wells and associated infrastructure totaled $33,277,000. Assuming a 20 year debt service at a rate of 5.5% an annual cost of $4,956,000 was estimated. With a finished water project yield of 3,363 ac-ft/yr, a unit cost of $1,474/ac-ft of supply can be seen in Table 5D.8.10. Potential treatment options for the facility include a filtration pre-treatment system and anti-scalent chemical dosing, two 1.25 mgd reverse osmosis trains in parallel configuration with energy recovery process, and post-treatment for corrosion control. The final design will stabilize the reverse osmosis water by bypassing and blending a portion of the raw brackish groundwater with the permeate water. The proportion of the blend will be determined when the final water well water quality is confirmed to reach the desired goal. A degasifier system will be used to strip unwanted gas, such as carbon dioxide and hydrogen sulfide, from the permeate water, thereby utilizing fewer chemicals and reducing O&M costs. A stabilization system will be used to properly condition the water supply so that it is not corrosive before it is delivered into the finished water transmission and distribution systems. The product water would then be delivered to processes for disinfection and storage in the existing ground storage tanks.

Dissolved minerals rejected by the RO membranes (concentrate) will be concentrated by each RO train at a rate of 0.5 mgd by volume.

[6] http://www.texasbeyondhistory.net/coast/images/ap6.html

Table 5D.8.10.
Cost Estimate Summary Water Supply Project Option (Sept 2013 Prices)
City of Alice-Jasper Well Field

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Intake Pump Stations (4 mgd)	$900,000
Transmission Pipeline (16 in dia., 1 miles)	$368,000
Well Fields (Wells, Pumps, and Piping)	$14,450,000
Chlorine Disinfection Treatment Plant (1.7 mgd)	$9,730,000
TOTAL COST OF FACILITIES	**$25,448,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$7,679,000
Land Acquisition and Surveying (13 acres)	$150,000
TOTAL COST OF PROJECT	**$33,277,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$2,785,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$702,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$23,000
Water Treatment Plant	$1,369,000
Pumping Energy Costs (858,414 kW-hr @ 0.09 $/kW-hr)	$77,000
TOTAL ANNUAL COST	$4,956,000
Available Project Yield (acft/yr)	3,363
Annual Cost of Water ($ per acft), based on a Peaking Factor of 1.39	$1,474
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1.39	$4.52
Note: One or more cost element has been calculated externally.	
Costs provided by the City of Alice, October 2015. Costs do not explicitly include environmental and archaeological studies/mitigation, or interest during construction.	

5D.8.2.5 Implementation Issues

The brackish groundwater supply analyses considered for this water management strategy were based on a previous Alternative Water Feasibility Study.

Implementation of the Brackish Groundwater Desalination Projects includes the following issues:

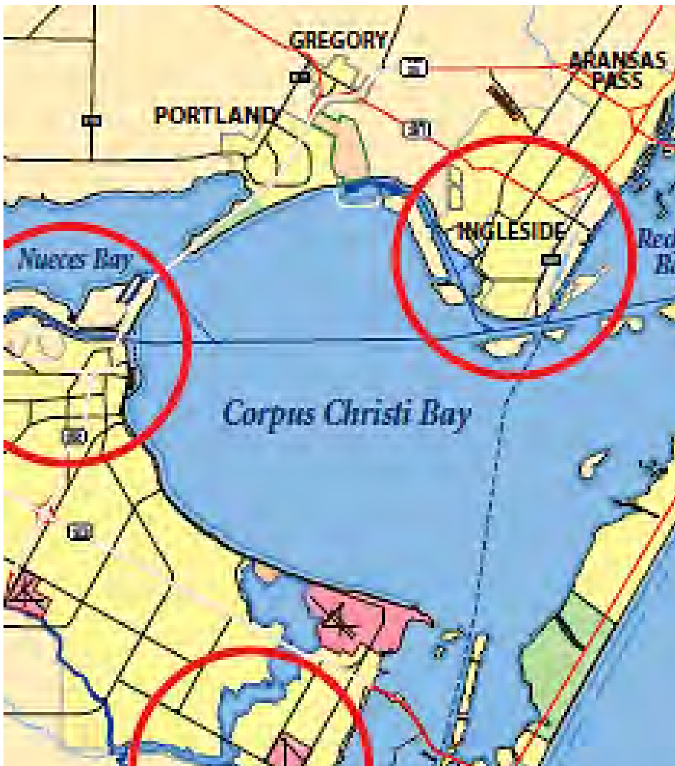
- Permitting desalination concentrate discharge to San Fernando Creek and Baffin Bay;
- Verification of the Gulf Coast Aquifer water quality for concentrations of the dissolved constituents such as TDS, chloride, sulfate, iron, manganese, radium, uranium, and arsenic;
- Purchase or lease of property for well field, and coordination with landowners;
- Skilled operators of desalination water treatment plants;
- Impact of water levels in the aquifer, potential intrusion of saline groundwater, land surface subsidence, and streamflow;
- USACE Section 10 and 404 dredge and fill permits for pipelines;
- General Land Office Sand and Gravel Removal permit for pipeline and crossings of streams and roads;
- General Land Office Easement for use of State-owned lands, if any;
- Texas Parks and Wildlife Department Sand, Gravel, and Marl permit; and
- Mitigation requirements would vary depending on impacts, but could include vegetation restoration, wetland creation or enhancement, or additional land acquisition.

5D.8.2.6 Evaluation Summary

An evaluation summary of this regional water management strategy is provided in Table 5D.8.11.

Table 5D.8.11.
Evaluation Summary of the City of Alice Brackish Groundwater Desalination Option

Impact Category	Comment(s)
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	1. Yield: 3,363 ac-ft/yr. 2. High reliability. 3. Generally moderate to high cost; $1,474 per ac-ft.
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other quality constituents	1. None to low impact. 2. Moderate impact. However, greatest impact is during low-flow conditions to Baffin Bay. 3. Disposal of concentrated brine may impact wildlife habitats or wetlands. 4. None to low. 5. None identified. Project can be adjusted to bypass sensitive areas. Endangered species survey will be needed to identify impacts. 6. Cultural resources survey will be needed to identify any significant sites. 7. 7a-b. Total dissolved solids and salinity of water is removed with reverse osmosis treatment. Brine concentrated disposal issues will need to be evaluated. 7d-i. Chloride, sulfate, uranium and arsenic concentrations in groundwater will need to be considered prior to implementation of project.
c. Impacts to State water resources	• Little to minor negative impacts on surface water resources
d. Threats to agriculture and natural resources in region	• Temporary damage due to construction of pipeline
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Standard analyses and methods used for portions • Brackish groundwater desalination cost modeled after bid and manufacturers' budgets, but not constructed, comparable project
g. Interbasin transfers	• Not applicable
h. Third party social and economic impacts from voluntary redistribution of water	• Not applicable
i. Efficient use of existing water supplies and regional opportunities	• Provides regional opportunities for water that would otherwise be unused
j. Effect on navigation	• None
k. Consideration of water pipelines and other facilities used for water conveyance	• Construction and maintenance of transmission pipeline corridor. Possible impact to wildlife habitat along pipeline route and right-of-way.



5D.9

Seawater Desalination and Variable Salinity Program

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5D.9 Seawater Desalination and Variable Salinity Program

5D.9.1 Description of Strategy

Desalting seawater from the Gulf of Mexico is a potential source of freshwater supplies for municipal and industrial uses. In August 2004, the City of Corpus Christi (City) conducted a feasibility study[1] funded by the Texas Water Development Board (TWDB) of a large-scale seawater desalination facility in the Region N area. For the 2006 and 2011 Coastal Bend Regional Water Plans, a large-scale 25 to 100 mgd seawater desalination facility co-sited with the Barney M. Davis Power Station in Corpus Christi near Laguna Madre, Oso Bay, and Corpus Christi Bay was considered. Favorable factors for the Barney Davis power station location included: use of cooling plant effluent for diluting concentrate, ability to use the existing seawater intake infrastructure at the power plant, and close proximity to the water distribution system. The desalination concentrate was considered to be piped out to the open Gulf of Mexico to be discharged in waters over 30 feet deep. The 2011 Coastal Bend Plan estimated the cost of a 25 mgd seawater desalination facility at Barney M. Davis Power Station with 5-mile pipeline delivery to proposed distribution center on the south side of town at $1,696 per ac-ft (or $5.21 per 1,000 gallons) based on September 2008 dollars. Blending with brackish groundwater, previously evaluated in the 2006 Plan, was eliminated from further consideration based on the lack of availability of groundwater at suitable quality (summarized in Chapter 11). The seawater desalination facility co-sited with Barney M. Davis Power Station was included as an alternate strategy in the 2011 Coastal Bend Regional Water Plan at the 25 mgd size, which was subsequently updated through amendment in August 2014 to be listed as a recommended strategy in the 2011 Coastal Bend Plan to meet needs beginning in 2020.

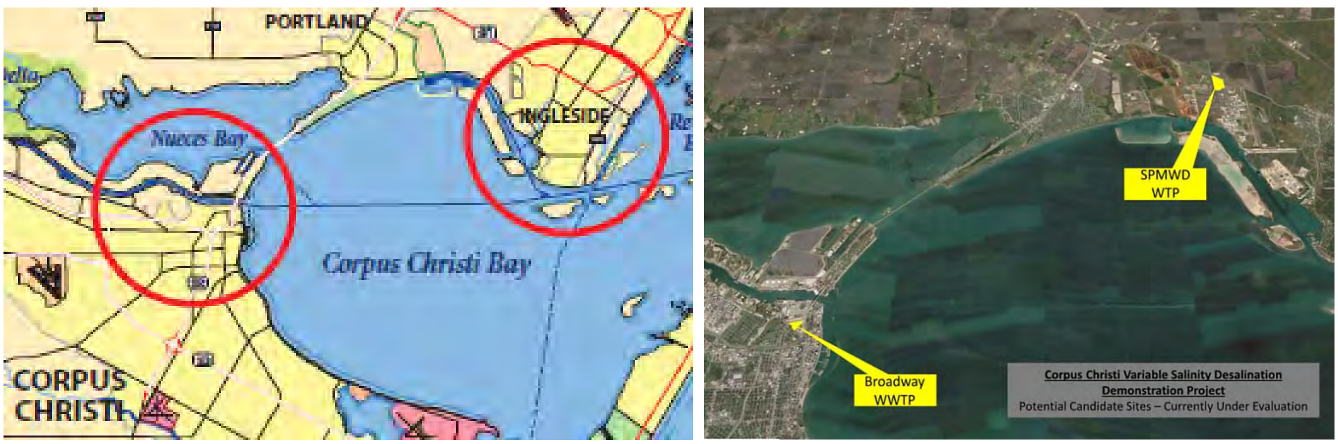
The City, as a wholesale water provider, continues to evaluate seawater desalination options, including variable desalination programs and combinations with brackish groundwater resources to address future industrial development and anticipated population growth associated with new industry and Eagleford Shale production. In April 2014, the Corpus Christi City Council voted to accept a federal, U.S. Bureau of Reclamation grant and transfer funds from the City's Raw Water Supply Development Fund for a City of Corpus Christi Desalination Program Pilot Study. In July 2014, Corpus Christi City Council considered and subsequently adopted a resolution to the 84th Texas Legislature to appropriate funding for FY 16-17 biennium and partnering with local sponsors to implement desalination projects.

The City is conducting a 30-month, $3 million demonstration program with support from the U.S. Bureau of Reclamation to design, construct, and operate a demonstration desalination plant for industrial and drinking water purposes. The objectives of the program are to evaluate the feasibility of seawater desalination and develop cost estimates, to test emerging technologies,

[1] City of Corpus Christi, Draft Report "Large Scale Demonstration Desalination Feasibility Study," August 2004.

and to identify and assess site options and requirements for a full-scale facility.[2] With the results of the study, the City will consider moving forward with a full-scale desalination project. During preliminary studies, the Barney M. Davis Power Station option was removed from further consideration due to a lack of interest by the power station to participate, as well as location not being favorable with respect to anticipated industrial and municipal growth areas.[3] As of April 2015, two potential sites are being considered by the City of Corpus Christi to provide additional supplies of 20 mgd for Nueces and San Patricio County industries and municipal customers in the region: Ingleside and Inner Ship Channel. These locations are shown in Figure 5D.9.1.

Based on feedback from the sponsor, the Inner Ship site located south of Nueces Bay near the Broadway WWTP is the recommended location for seawater desalination water management strategy. Conveyance and infrastructure details are being evaluated by the City, and future planning cycles will include updates to reflect the City's plans. The program continues to consider processing variable amounts of lower salinity brackish groundwater and seawater in the same facility, but details are unavailable at this time.



Source: Corpus Christi Desalination Demonstration Project Fact Sheet, June 2014 (http://www.cctexas.com/Assets/Departments/Water/Files/DesalFactSheet.pdf) and City of Corpus Christi, email October 2015

Figure 5D.9.1.
Proposed Location for Seawater Desalination Program

5D.9.1.1 General Desalination Background

Commercially available processes that are commonly used to desalt seawater to produce potable water are:

- Distillation (thermal) Processes; and
- Membrane (non-thermal) Processes.

[2] City of Corpus Christi website, "Corpus Christi Desalination Demonstration Project", June 2014. http://www.cctexas.com/Assets/Departments/Water/Files/DesalFactSheet.pdf
[3] City of Corpus Christi staff, February 2015.

The following section describes each of these processes and discusses a number of issues that should be considered before selecting a process for desalination of seawater. Coastal seawater desalination projects are either in operation or under construction in Florida and California, but there are no seawater desalination plants operating in Texas.[4]

Distillation (Thermal) Processes

Distillation processes produce purified water by vaporizing a portion of the saline feedstock to form steam. Since the salts dissolved in the feedstock are nonvolatile, they remain unvaporized and the steam formed is captured as a pure condensate. Distillation processes are normally very energy-intensive, expensive, and are generally used for large-scale desalination of seawater. Heat is usually supplied by steam produced by boilers or from a turbine power cycle used for electric power generation. Distillation plants are commonly dual-purpose facilities that produce purified water and electricity. According to a recent study by the City of Corpus Christi, geothermal energy is better suited to thermal desalination rather than to reverse osmosis membrane processes.[5]

In general, for a specific plant capacity, the equipment in distillation plants tends to be much larger than membrane desalination equipment. However, distillation plants do not have the stringent feedwater quality requirements of membrane plants. Due to the relatively high temperatures required to evaporate water, distillation plants have high energy requirements, making energy a large factor in their overall water cost. Their high operating temperatures can result in scaling (precipitation of minerals from the feedwater), which reduces the efficiency of the evaporator processes, because once an evaporator system is constructed, the size of the exchange area and the operating profile are fixed, leaving energy transfer as a function of only the heat transfer coefficient. Therefore, any scale that forms on heat exchanger surfaces reduces heat transfer coefficients. Under normal circumstances, scale can be controlled by chemical inhibitors, which inhibit but do not eliminate scale, and by operating at temperatures of less than 200 degrees Fahrenheit.

Distillation product water recoveries normally range from 15 to 45 percent, depending on the process. The product water from these processes is nearly mineral-free, with very low total dissolved solids (TDS) (less than 25 mg/L). However, this product water is extremely aggressive and is too corrosive to meet the Safe Drinking Water Act corrosivity standards without post-treatment. Product water can be stabilized by chemical treatment or by blending with other potable water.

The three main distillation processes in use today are Multistage Flash Evaporation (MSF), Multiple Effect Distillation (MED), and Vapor Compression (VC). All three of these processes utilize an evaporator vessel that vaporizes and condenses the feedstock. The three processes differ in the design of the heat exchangers in the vessels and in the method of heat introduction into the process. Since there are no distillation processes in Texas that can be shown as

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[4] City of Corpus Christi website, "Corpus Christi Desalination Demonstration Project", June 2014. http://www.cctexas.com/Assets/Departments/Water/Files/DesalFactSheet.pdf

[5] City of Corpus Christi, Variable Salinity Desalination Demonstration Project "Technical Memorandum No. 1-Desalination Technology Research Project No. E13063", September 2014.

comparable installations, distillation will not be considered here. However, there are membrane desalination operations in Texas, so the following discussion and analyses are based upon information from the use of membrane technology for desalination.

Membrane (Non-Thermal) Processes

The two types of membrane processes use either pressure — as in reverse osmosis (RO) — or electrical charge — as in electrodialysis reversal (EDR) — to reduce the mineral content of water. Both processes use semi-permeable membranes that allow selected ions to pass-through while other ions are blocked. EDR uses direct electrical current applied across a vessel to attract the dissolved salt ions to their opposite electrical charges. EDR can desalinate brackish water with TDS up to several thousand milligrams per liter, but energy requirements make it economically uncompetitive for seawater, which contains approximately 35,000 mg/L TDS. As a result, only RO is used for seawater desalination.

RO utilizes a semi-permeable membrane that limits the passage of salts from the saltwater side to the freshwater side of the membrane. Electric motor-driven pumps or steam turbines (in dual-purpose installations) provide the 800 to 1,200 pounds per square inch (psi) pressure to overcome the osmotic pressure and drive the freshwater through the membrane, leaving a waste stream of brine/concentrate. The basic components of an RO plant include pre-treatment, high-pressure pumps, membrane assemblies, and post-treatment. Pretreatment is essential because feedwater must pass through very narrow membrane passages during the process and suspended materials, biological growth, and some minerals can foul the membrane. As a result, virtually all suspended solids must be removed and the feedwater must be pre-treated so precipitation of minerals or growth of microorganisms does not occur on the membranes. This is normally accomplished by using various levels of filtration and the addition of various chemical additives and inhibitors. Post-treatment of product water is usually required prior to distribution to reduce its corrosivity and to improve its aesthetic qualities. Specific treatment is dependent on product water composition.

A "single-pass/stage" seawater RO plant will produce water with a TDS of 300 to 500 mg/L, most of which is sodium and chloride. The product water will be corrosive, but this may be acceptable, if a source of blending water is available. If not, and if post-treatment is required, the various post-treatment additives may cause the product water to exceed the desired TDS levels. In such cases, or when better water quality is desired, a "two-pass/stage" RO system is used to produce water typically in the 200 mg/L TDS range. In a two-pass RO system, the concentrate water from the first RO pass/stage is further desalted in a second RO pass/stage, and the product water from the second pass is blended with product water from the first pass.

Recovery rates up to 45 percent are common for a two-pass/stage seawater RO facility. RO plants, which comprise about 47 percent of the world's desalting capacity, range from a few gallons per day to 35 mgd. The largest RO seawater plant in the United States is the 25 mgd plant in Tampa Bay, Florida. The current domestic and worldwide trend seems to be for the adoption of RO when a single purpose seawater desalting plant is to be constructed. RO membranes have been improved significantly over the past two decades (i.e. the membranes have been improved with respect to efficiency, longer life, and lower prices). Municipal use desalination plants in Texas that use lake water, river, or groundwater are shown in Table 5D.9.1. The plant capacities range from 0.1 mgd (Homestead MUD-El Paso) to 10 mgd (Lake Granbury).

Table 5D.9.1. Municipal Use Desalt Plants in Texas (>25,000 gpd as of April 2015)

Location	***County***	***Source***	***Raw Water TDS (mg/L), estimate***	***Target TDS for Finished Water (mg/L)***	***Total Capacity (mgd)***	***Desalt Capacity (mgd)***	***Membrane Type[1]***	***Membrane Recovery (%)***
Big Bend Motor Inn	Brewster	Groundwater	1694	300	0.057	0.057	RO	0.75
Abilene, City of	Taylor	Surface Water	1,500	500	7.95	3	RO	0.65-0.78
Bardwell, City of	Ellis	Groundwater	No Data	400	0.252	0.036	RO	0.6
Bayside, City of	Refugio	Groundwater	2500	350	0.045	-	RO	No Data
Beckville, City of	Panola	Groundwater	1200	100	0.216	0.216	RO	0.75
Brady, City of	McCulloch	Surface Water	1200-1600	No Data	3	1.5	RO	0.75
Clarksville City, City of	Gregg	Groundwater	No Data	No Data	0.288	0.288	RO	0.75
Evant, City of	Coryell	Groundwater	1100	800	0.1	0.08	RO	0.8
Ft. Stockton, City of	Pecos	Groundwater	1500	1000	6.5	6.5	RO	0.8
Granbury, City of (IDLE)	Hood	Surface Water	No Data	No Data	0.462	0.35	RO	No Data
Hubbard, City of	Hill	Groundwater	2793	No Data	0.648	0.432	RO	0.62
Kenedy, City of	Karnes	Groundwater	1500	No Data	2.86	0.72	RO	0.67
Laredo, City of	Webb	Groundwater	2112	250	0.1	0.1008	RO	0.76
Los Ybanez, City of (IDLE)	Dawson	Groundwater	No Data	No Data	-	-	RO	No Data
Robinson, City of	McLennan	Surface Water	750	50	2.3	1.6	RO	0.75
Seadrift, City of	Calhoun	Groundwater	2200	400	0.61	0.524	RO	0.7
Seymour, City of	Baylor	Groundwater	800	400	3	3	RO	0.81
Sherman, City of	Grayson	Surface Water	No Data	440	11	7.5	EDR	0.85
Tatum, City of	Rusk	Surface Water	1200	320	0.324	0.288	RO	0.75
Cypress WTP	Wichita	Surface Water	3500	200	10	-	RO	0.71
Dell City	Hudspeth	Groundwater	1466	435	0.1	0.1	EDR	0.75
DS Waters of America, LP	Waller	Groundwater	470	36	0.09	-	RO	0.75
Esperanza Fresh Water Supply	Hudspeth	Groundwater	No Data	No Data	0.023	-	RO	No Data
Fort Hancock RO Plant 1	Hudspeth	Groundwater	No Data	No Data	0.43	0.43	RO	0.78
Holiday Beach WSC	Aransas	Groundwater	2000	450	0.15	-	RO	0.7
Horizon Regional MUD RO Plant	El Paso	Groundwater	No Data	80	6	3.3	RO	0.75
K.B. Hutchison Desalination Plant	El Paso	Groundwater	2000-3000	450-500	27.5	15	RO	0.825
Lake Granbury	Hood	Surface Water	No Data	35	12.5	7.5	RO	0.85
Longhorn Ranch Motel	Brewster	Groundwater	3500	No Data	0.023	0.023	RO	No Data
Midland Country Club	Midland	Groundwater	3840	200	0.023	0.11	RO	0.8
North Alamo WSC (Doolittle)	Hidalgo	Groundwater	2500	500	3.5	3	RO	No Data
North Alamo WSC (Lasara)	Willacy	Groundwater	No Data	500	1.2	1	RO	No Data
North Alamo WSC (Owassa)	Hidalgo	Groundwater	2000	500	2	1.5	RO	No Data

Location	***County***	***Source***	***Raw Water TDS (mg/L), estimate***	***Target TDS for Finished Water (mg/L)***	***Total Capacity (mgd)***	***Desalt Capacity (mgd)***	***Membrane Type[1]***	***Membrane Recovery (%)***
North Cameron/ Hidalgo WA	Cameron	Groundwater	3500	200	2.5	2	RO	0.75
Oak Trail Shores	Hood	Surface Water	No Data	No Data	1.584	-	RO	No Data
Possum Kingdom WSC	Palo Pinto	Surface Water	2400	50-100	1	-	RO	0.75
River Oaks Ranch	Hays	Groundwater	1500	300	0.1152	0.1152	RO	0.7
Southmost Regional Water Authority	Cameron	Groundwater	3500	500	7.5	6	RO	0.75
Sportsmans World MUD	Palo Pinto	Surface Water	No Data	300	0.083	0.083	RO	0.5
Study Butte Terlingua Water System	Brewster	Groundwater	1425	200	0.14	0.144	RO	0.75
The Cliffs	Palo Pinto	Surface Water	No Data	400	0.381	0.381	RO	0.8
Valley MUD #2	Cameron	Groundwater	3500	400	1	0.5	RO	0.75
Veolia WTP (IDLE)	Jefferson	Surface Water	No Data	No Data	0.245	0.066	RO	0.8
Victoria Road RO Plant	Hidalgo	Groundwater	4000	150	2.25	2	RO	0.75
Water Runner Inc.	Midland	Groundwater	790	No Data	0.028	2.16	RO	0.95
Windermere Water System (IDLE)	Travis	Groundwater	900	No Data	2.88	1	RO	No Data

[1] RO = Reverse Osmosis EDR = Electrodialysis Reversal
Source: TWDB Desalination Plant Database, 2010

5D.9.1.2 Examples of Relevant Existing Desalt Projects

Seadrift, TX: In 1996, Seadrift (retail population 1,890) was dependent on the Gulf Coast Aquifer for its water supply. TDS and chlorides had reached unacceptable levels of 1,592 mg/L and 844 mg/L, respectively. These values exceeded the primary drinking water standard for TDS (1,000 mg/L) and the secondary drinking water standard for chlorides (300 mg/L). Since the community was not located near an adequate quantity of freshwater or a wholesaler of drinking water, the decision was made to install RO to treat this slightly brackish groundwater. The city installed pressure filters, two RO units, antiscalant chemical feed equipment, and a chlorinator. The capital cost for the system was $1.2 million and the annual operation and maintenance (O&M) cost is $56,000, resulting in a total debt service plus O&M cost of about $0.88 per 1,000 gallons treated by RO. The capital cost included the cost of facilities in addition to the RO units and their appurtenant equipment. Product water from the RO units is blended with groundwater to meet an acceptable quality level. About 60 percent of the total is from the desalt units.

Tampa, FL: The water utility, Tampa Bay Water, selected a 30-year design, build, operate, and own (DBOO) proposal to construct a nominal 25 mgd seawater desalt plant. The plant will use RO as the desalt process. The proposal included total capitalization and operations costs for producing high quality drinking water (chlorides less than 100 mg/L). The total cost to Tampa Bay Water in the original proposal was to be $2.08 per 1,000 gallons on a 30-year average, with first year cost being $1.71 per 1,000 gallons. However, subsequent issues with the original design including significant problems in obtaining adequate pretreatment have increased the projected total cost to Tampa Bay Water by $0.72 per 1,000 gallons for a total projected cost of $2.80 per 1,000 gallons on a 30-year average.[6] The results of Tampa Bay's competition has attracted international interest in the current cost profile of desalting seawater for drinking water supply, since these costs are only about one-half the levels experienced in previous desalination projects.

Tampa Bay Water selected the winning proposal from four DBOO proposals submitted, which ranged from $2.08 to $2.53 per 1,000 gallons. The factors listed below may be all or partially responsible for these seemingly low costs:

- Salinity at the Tampa Bay sites ranges from 25,000 to 30,000 mg/L, lower than the more common 35,000 mg/L for seawater. RO cost is sensitive to salinity.
- The power cost, which is interruptible, is below $0.04 per kilowatt-hour (kWh).
- Construction cost savings through using existing power plant canals for intake and concentrate discharge.
- Economy of scale at 25 mgd.
- Amortizing over 30 years.
- Use of tax-exempt bonds for financing.

The Tampa bids contrast with another current large-scale desalination project in which distillation is proposed. The current desalt project of the Singapore Public Utility Board, which proposes a 36 mgd multi-stage flash distillation plant, will cost an estimated $5.76 per 1,000 gallons for the first year operation.[7]

City of Corpus Christi Desalination Study: The TWDB-funded several studies to evaluate the feasibility of large-scale desalination in Texas. As part of this initiative, the City was selected as one of three potential locations for large-scale seawater desalination and a feasibility study was conducted. The draft report[8] from this study was completed in August 2004. The study evaluated several options and concluded that the most feasible large-scale desalination project for the City's area was a 25 mgd seawater desalination treatment plant located at the Barney M. Davis Power Station.

5D.9.2 Available Yield

Seawater from the Gulf of Mexico is assumed to be available in an unlimited quantity within the context of a supply for the Coastal Bend Region. Also, it is assumed that the cost of Gulf water is zero prior to extraction from the source. The City of Corpus Christi and port industries are currently considering finished desalination supplies of 20 mgd (22,420 ac-ft/yr).

5D.9.3 Environmental Issues

The two project areas for the proposed desalination plant being considered by the City of Corpus Christi are located near Ingleside and the Inner Ship Channel. Although the Inner Ship Channel

[6] Associated Press, "Tampa Bay Water to Hire Group to Fix Desalination Plant," September 21, 2004.
[7] Desalination & Water Reuse Quarterly, vol. 7/4, Feb/Mar 1998.
[8] City of Corpus Christi, Draft Report "Large Scale Demonstration Desalination Feasibility Study," August 2004.

site is the recommended water management strategy, both sites are considered in this environmental discussion. The Ingleside option is located near the San Patricio Municipal Water District Water Treatment Plant between Nueces and Corpus Christi Bay; the Inner Ship Channel is near the Broadway Wastewater Treatment Plant near the northeast of Corpus Christi Bay.

Estuaries and bays serve as critical habitat and spawning grounds for many marine species and migratory birds. Estuaries are marine environments maintained in a brackish state by the inflow of freshwater from rivers and streams. The high productivity characteristic of estuaries arises from the abundance of terrigenous nutrient input, shallow water, and the ability of a few marine species to exploit environments continually stressed by low, variable salinities, temperature extremes, and, on occasion, low dissolved oxygen concentrations. The potential environmental effects resulting from the construction of a desalination plant in the vicinity of Nueces Bay and/or Corpus Christi Bay will be sensitive to the siting of the plant and its appurtenances. Environmental analyses including impingement and entrainment will need to be considered as part of the intake evaluation. Although specific siting information for the desalination concentrate is still being studied as part of the Corpus Christi Desalination Demonstration Project, it is likely that the brine concentrate resulting from desalination would be discharged to the open Gulf of Mexico on Inner Ship Channel in waters over 30 feet deep unless a beneficial use of reject brine is determined during the Demonstration Project. The outfall for brine concentrate will need to consider impacts to the estuary. For purposes of this analysis, it is assumed that the outfall will be located and constructed so as to result in little or no effect upon the environment at the discharge location. Prior to construction, an environmental impact statement will need to be conducted to evaluate all potential impacts to the environment, and identify best management practices to eliminate or reduce adverse impacts.[9]

Environmental impacts associated with transmission pipelines, construction right-of-way, and other infrastructure delivery components will need to be evaluated as part of the environmental impact statement. Destruction of potential habitat can be avoided by diverting the corridor through previously disturbed areas. A cultural resource survey of the plant and pipeline routes will need to be performed consistent with requirements of the Texas Antiquities Commission. Because of the relatively small areas involved, construction and maintenance of surface facilities are not expected to result in substantial environmental impacts. Where environmental resources (e.g., endangered species habitat and cultural resource sites) could be impacted by infrastructure, changes in facility siting and pipeline alignment would generally be sufficient to avoid or minimize adverse effects.

HB 2031, passed by the 84th Legislature, requires consultation with TWDB and the General Land Office regarding siting of seawater desalination intakes and discharges to minimize ecological impacts.

[9] City of Corpus Christi Desalination Demonstration Project Fact Sheet (http://www.cctexas.com/Assets/Departments/Water/Files/DesalFactSheet.pdf)

5D.9.4 Engineering and Costing

The City of Corpus Christi is currently considering two potential sites: Ingleside and Inner Ship Channel. A recent City study[10] reports:

- Total estimated construction costs for a 20 mgd facility located in Ingleside at $248 million.
- Lifecycle water production costs, at the fence, are estimate to be $4.45 per 1,000 gallons at Ingleside.
- Lifecycle water production costs, at the fence, are estimate to be $4.35 per 1,000 gallons for a plant located at the O.N. Stevens WTP.

Details regarding intake, desalination process, concentrate disposal outfall, site-specific environmental impacts, storage needs, and route/costs for transmission and delivery is unavailable at this time.

Energy is the largest operational cost of a desalination facility, and energy use is directly proportional to salinity of the source water. The annual total treatment energy needed to operate the 20 mgd desalination facility at Ingleside is 84,899,000 kW-hr per year resulting in an annual energy cost of $7,641,000, assuming energy costs of $0.09 per kW-hr according to TWDB guidance. The annual total treatment energy needed to operate the 20 mgd desalination facility in the Inner Harbor is 80,811,000 kW-hr per year, which results in an annual energy cost of $7,273,000. Using the Unified Costing Model tool for regional water planning according to TWDB guidelines, which includes a higher cost for operations and maintenance is expected to result in an annual cost around $41,345,000. This results in a unit cost of water of $1,844 per ac-ft (or $5.56 per 1000 gallons) for Ingleside and Inner Harbor sites, respectively. Private industry partnerships and funding structures may be considered to help reduce costs and minimize treatment plant operation and maintenance risks assumed by City operators, which may account for costing differences as compared to information shown in Table 5D.9.2. The information presented in Table 5D.9.2 was developed based on capital costs, project costs, and annual water productions costs provided by the City of Corpus Christi and is relevant for desalination facility at the fence. Delivery costs to industries or municipal distribution system are not included.

[10] City of Corpus Christi, Variable Salinity Desalination Demonstration Project "Technical Memorandum No. 1 - Desalination Technology Research Project No. E13063", September 2014.

Table 5D.9.2.
Cost Estimate Summary 20 mgd Desalination Project (Sept 2013 Prices)
Note: Capital Cost, Total Cost, and Annual Costs provided by the City of Corpus Christi

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Water Treatment Plant (Desalination and Disinfection)	$167,047,000
TOTAL COST OF FACILITIES	**$167,047,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$65,167,000
Interest During Construction (4% for 2 years with a 1% ROI)	$15,786,000
TOTAL COST OF PROJECT	**$248,000,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$20,192,000
Operation and Maintenance	
Water Treatment Plant*	$4,326,560 to $4,682,000
Treatment Energy Costs (80,811,000 or 84,899,000 kW-hr @ 0.09 $/kW-hr)	$7,273,000 to $7,641,000
TOTAL ANNUAL COST	**$31,797,560 to $32,515,000**
Available Project Yield (ac-ft/yr)	22,420
Annual Cost of Water ($ per ac-ft)	$1,418 - $1,450
Annual Cost of Water ($ per 1,000 gallons)	$4.35 - $4.45

* Note: The Water Treatment Plant O&M costs were calculated by taking the difference in annual cost provided by the City minus debt service and pumping energy costs. The pumping energy costs were based on total treatment energy needs provided by Freese and Nichols, March 16, 2015 for 20 mgd plant at Ingleside location.

5D.9.5 Implementation Issues

Permitting of this facility will require extensive coordination with all applicable regulatory entities. Permitting and construction of the intake and concentrate pipeline will be major project components.

The installation and operation of a seawater desalination water treatment plant may have to address the following issues.

- Disposal of concentrated brine from desalination water treatment plant;
- Permitting and constructing concentrate pipeline through seagrass beds and barrier island;
- Impact on the bays from removing water for consumptive use and altering existing power plant water rights permit;
- Confirming that blending desalted seawater with other water sources in the municipal demand distribution system can be successfully accomplished;

- High power requirements for desalination process dependent on large, reliable power source;
- Skilled operators of desalination water treatment plants;
- Permitting of a pipeline across rivers, highways, and private rural and urban property; and
- Possibility of using a design, build, operate contract for a desalination water treatment plant.

5D.9.6 Evaluation Summary

An evaluation summary of this regional water management strategy is provided in Table 5D.9.3.

Table 5D.9.3.
Evaluation Summary of the Seawater Desalination Option

Impact Category	***Comment(s)***
a. Water supply:	
1. Quantity	1. Project size: 22,420 ac-ft/yr; actual water supply virtually unlimited.
2. Reliability	2. Highly reliable quantity.
3. Cost of treated water	3. Cost between $1,418 to $1,450/ac-ft.
b. Environmental factors:	
1. Instream flows	1. None or low impact.
2. Bay and estuary inflows	2. Environmental impact to estuary.
3. Wildlife habitat	3. Disposal of concentrated brine created from process may impact fish and wildlife habitats or wetlands.
4. Wetlands	4. Disposal of concentrated brine created from process may impact fish and wildlife habitats or wetlands.
5. Threatened and endangered species	5. None identified. Endangered species survey will be needed to identify impacts.
6. Cultural resources	6. Cultural resources survey will be needed to identify any significant sites.
7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	7. 7a-b. Total dissolved solids and salinity of water is removed with reverse osmosis treatment. Brine concentrate disposal issues will need to be evaluated.
c. Impacts to State water resources	• No negative impacts on other water resources
d. Threats to agriculture and natural resources in region	• Temporary damage due to construction of pipeline
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Standard analyses and methods used for portions • Seawater desalination cost modeled after bid and manufacturers' budgets, but not constructed, comparable project
g. Interbasin transfers	• Not applicable
h. Third party social and economic impacts from voluntary redistribution of water	• Not applicable
i. Efficient use of existing water supplies and regional opportunities	• Provides regional opportunities
j. Effect on navigation	• None
k. Consideration of water pipelines and other facilities used for water conveyance	• Construction and maintenance of transmission pipeline corridor (in future). Possible impact to wildlife habitat along pipeline route and right-of-way.

5D.10

Potential Water System Interconnections

5D.10 Potential Water System Interconnections

5D.10.1 Description of Strategy

In addition to providing backup water supplies for emergencies, water system interconnections are another potential source of freshwater supplies for municipal and industrial uses for this region. This section describes additional community water system candidates located in Duval, Jim Wells, Brooks, Kleberg and San Patricio Counties for interconnection within the Coastal Bend Region. Yields were determined by the maximum demands for each entity over the planning period and infrastructure constraints. For San Diego in Duval County, an additional analysis was run based on needs rather than the demand. Costs were calculated using the TWDB Unified Costing Model.

There are certain municipal water systems that rely totally on local groundwater. Many of these groundwater systems operate under one or more of the following conditions:

- Insufficient groundwater supply
- Insufficient well capacity
- Unsuitable water quality

The Trans-Texas Water Program Phase II Report[1] listed 24 municipal water systems in the Coastal Bend Area that have converted at least a part of their groundwater supply to the regional surface water system. This list is shown in Table 5D.10.1. Most of the water systems shown on this list have converted totally to the regional surface water system.

One example of an existing connection between the regional surface water system and a local groundwater system is the City of Kingsville in Kleberg County. The City maintains its groundwater supply as its primary source but also has pipeline connection to receive treated surface water from the South Texas Water Authority's (STWA) surface water system.

The interconnection strategies for Duval, Jim Wells, and Brooks counties are dependent on Alice's Water Treatment Plant which has a treated water capacity of 7,560 ac-ft/yr. The City of Alice used 4,000 ac-ft of water in 2012 meaning that there will be approximately 3,560 ac-ft/yr of water available for potential interconnect strategies. If all of the interconnection strategies that rely on Alice's Water Treatment Plant were to be implemented there would need to be an additional capacity of 2,486 ac-ft/yr.

[1] HDR Engineering, Inc. (HDR), "Trans-Texas Water Program - Corpus Christi Study Area - Phase II Report," City of Corpus Christi, et al, September 1995.

Table 5D.10.1.
Public Water Suppliers That Have Converted Totally or Partially to Surface Water from the Choke Canyon/Lake Corpus Christi/Lake Texana (CCR/LCC/Lake Texana) System

Water Supplier	Conversion Date	Currently Supplied By[1]
Aransas County		
Rockport	1970	Aransas Co. CRD/ San Patricio/Corpus Christi
Copano Cover Water Co.	1972	Rockport
Peninsula Water Co.	1978	Rockport
Bee County		
Beeville	1985	—
Jim Wells County		
Alice	1965	—
Jim Wells Co. FWSD 1	1980	Alice
Kleberg County		
Kingsville	1985	South Texas Water Authority
Ricardo WSC	1985	South Texas Water Authority
U.S. Naval Air Station-Kingsville	N/A	City of Kingsville
McMullen County		
Choke Canyon Water System	1991	—
Nueces County		
Aqua Dulce	1985	South Texas Water Authority
Bishop	1985	South Texas Water Authority
Driscoll	1985	South Texas Water Authority
Nueces Co. WCID #3-Robstown	1985	Nueces River[1]
Nueces Co. WCID #4-Port Aransas	1958	Corpus Christi & San Patricio MWD
Nueces Co. WCID #5-Banquette Area	1985	South Texas Water Authority
San Patricio County		
Odem	1954	San Patricio MWD
Aransas Pass	1962	San Patricio MWD
Ingleside	1955	San Patricio MWD
Gregory	1954	San Patricio MWD
Mathis	1980	—
Portland	1954	San Patricio MWD
Taft	1965	San Patricio MWD

[1] All surface water is supplied from the CCR/LCC/Lake Texana System under water rights held by the City of Corpus Christi except for Robstown, which has their own water rights from the Nueces River at Calallen through NCWCID # 3.

5D.10.2 Available Yield

5D.10.2.1 Duval County

In 1996, TWDB funded a regional water supply study for Duval and Jim Wells Counties.[2] The study evaluated several alternative surface water supply systems from the City of Alice to various combinations of cities in Duval County. Those cities included San Diego, Freer, Benavides, Realitos, and Concepcion. The alternatives evaluated are:

- Alternative 1 - Alice to San Diego, Benavides, Realitos, Concepcion, and Freer (Figure 5D.10.1)
- Alternative 2 - Alice to San Diego, Benavides and Freer (Figure 5D.10.2)
- Alternative 3 - Alice to San Diego and Benavides (Figure 5D.10.3)
- Alternative 4 - Alice to San Diego and Freer (Figure 5D.10.4)
- Alternative 5A - Alice to San Diego all demands (Figure 5D.10.5)
- Alternative 5B - Alice to San Diego Needs Only (Figure 5D.10.5)

An interconnection to the CCR/LCC/Lake Texana System to serve community water systems in Duval County via the City of Alice is feasible because the City of Alice has existing raw water pump capacity, treatment capacity, and high service pump capacity to meet the projected peak day demands for all cities in the study area through the near-term (2040) and long-term (2070) planning horizon.

Required regional facilities would include transmission lines ranging in size from 6-inch to 18-inch diameters, and intermediate storage and booster pump stations. Total capital costs and annual costs (debt service, power cost, operation and maintenance (O&M) cost, and treated water cost) were estimated for each alternative and are included in Tables 5D.10.2 through 5D.10.7.

The 1996 Regional Water Supply Study recommended that surface water projects in Duval County be initiated, constructed, financed, operated and maintained by the Duval County Conservation and Reclamation District (DCCRD).

[2] Naismith Engineering, Inc. (NEI), et al., "Regional Water Supply Study, Duval and Jim Wells County, Texas," Nueces River Authority, et al., October 1996.

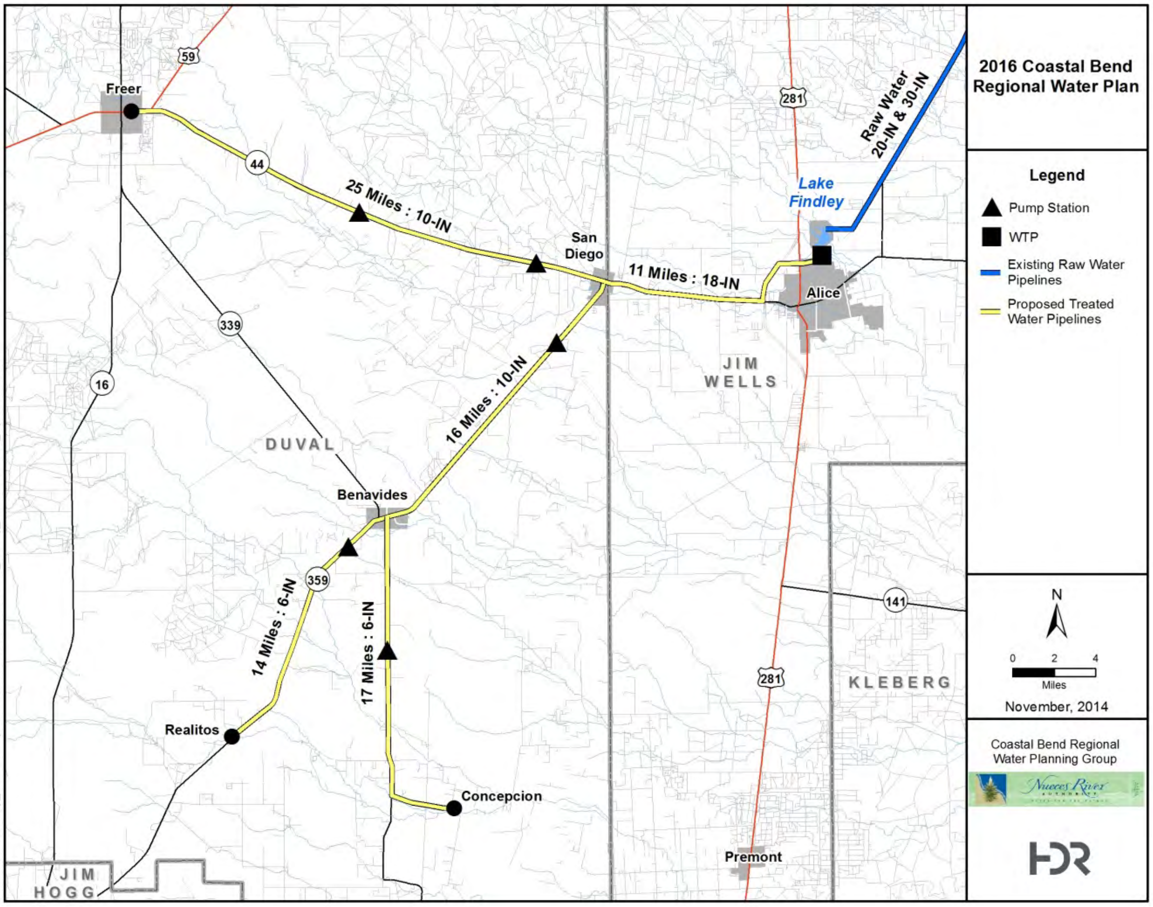

Figure 5D.10.1.
Duval County Interconnection Alternative 1

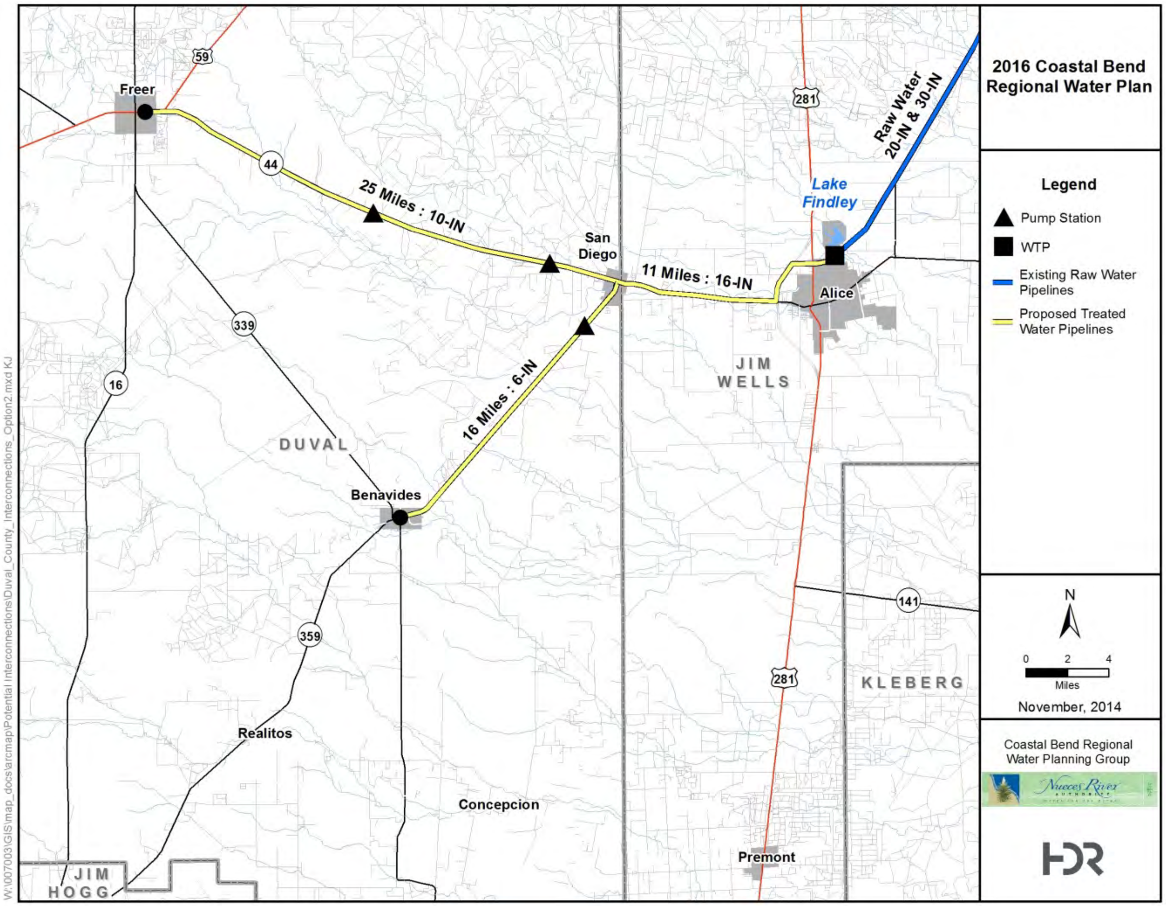

Figure 5D.10.2.
Duval County Interconnection Alternative 2

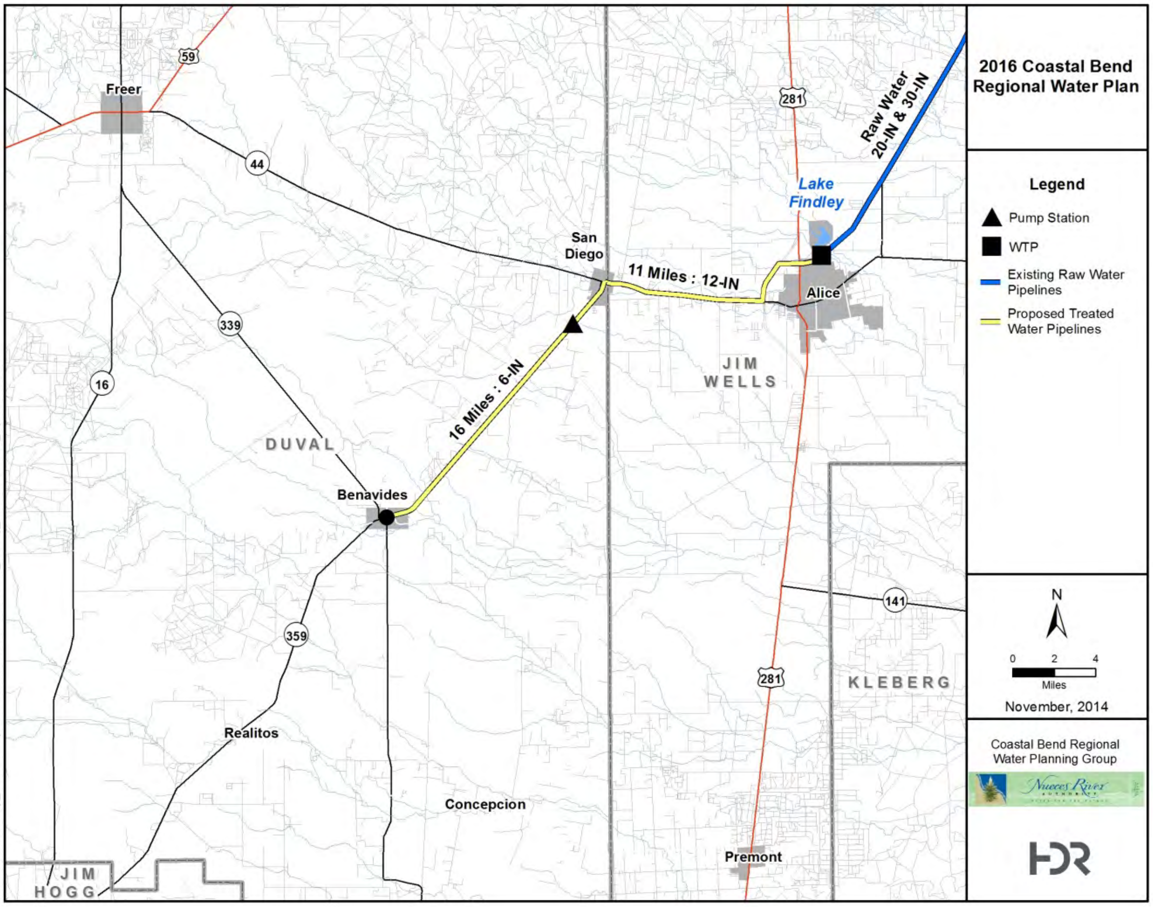

Figure 5D.10.3.
Duval County Interconnection Alternative 3

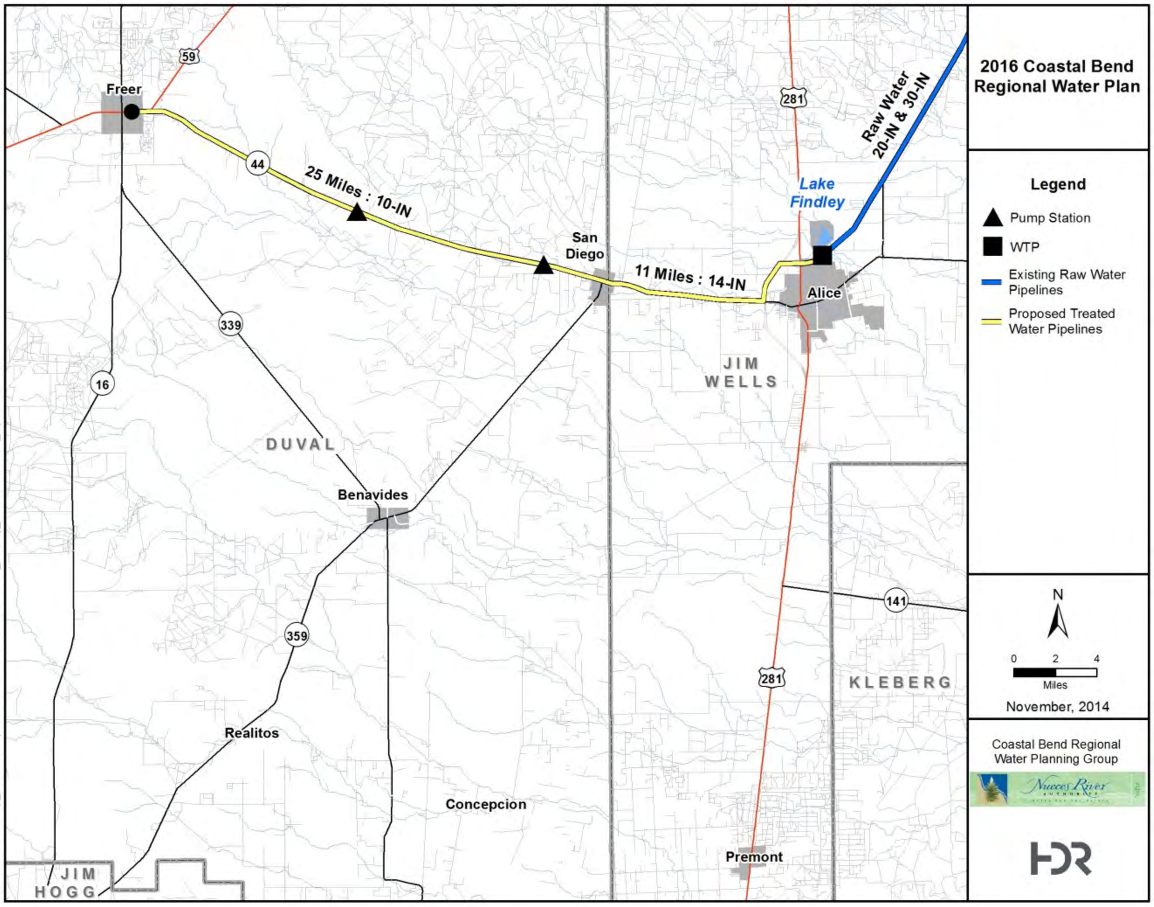

Figure 5D.10.4.
Duval County Interconnection Alternative 4

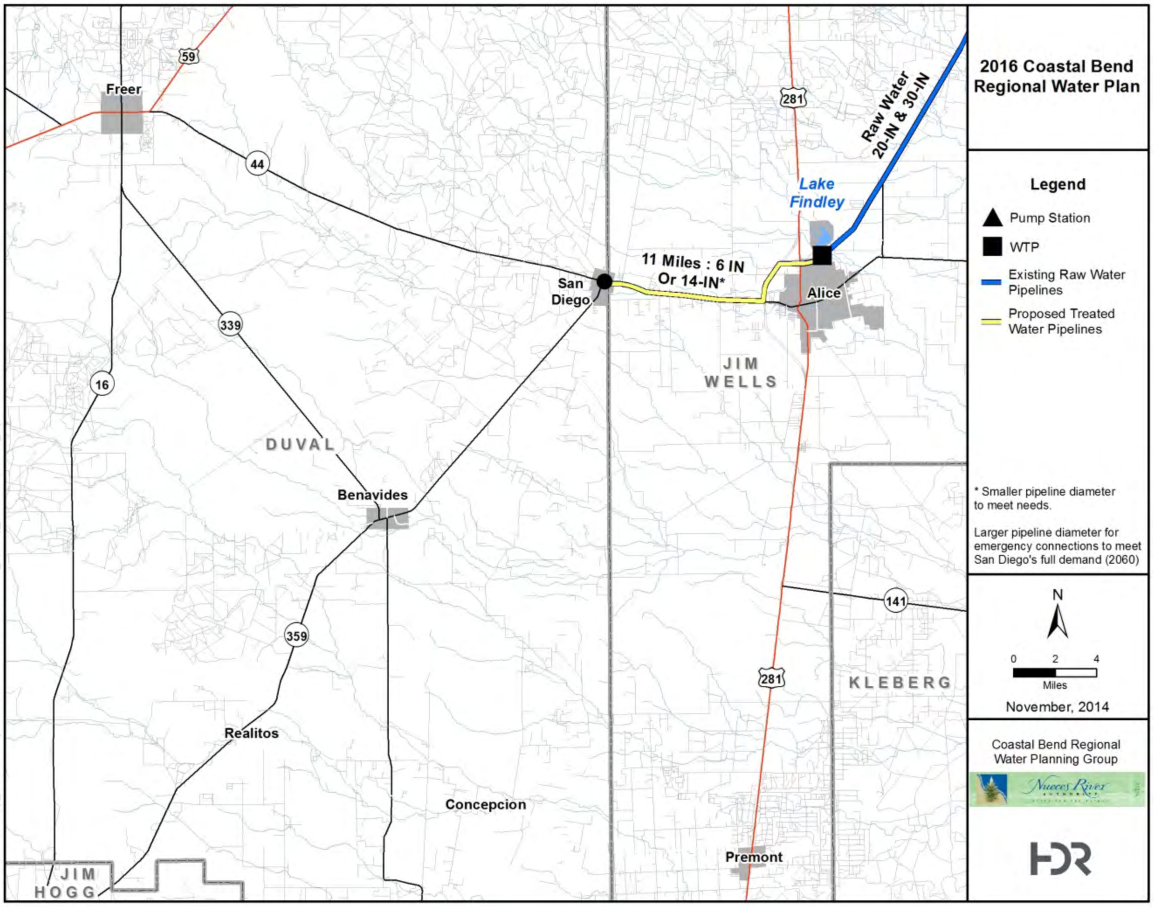

Figure 5D.10.5.
Duval County Interconnection Alternative 5

Table 5D.10.2.
Cost Estimate Summary
Regional Surface Water Supply
Duval County Interconnection Alternative 1[1] (September 2013 Prices)

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Transmission Pipeline (Size Varies)	$15,520,000
Pump Stations and Storage Tanks	$7,786,000
TOTAL COST OF FACILITIES	**$23,306,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$7,381,000
Environmental & Archaeology Studies and Mitigation	$2,129,000
Land Acquisition and Surveying (337 acres)	$793,000
Interest During Construction (4% for 1 year with a 1% ROI)	$1,177,000
TOTAL COST OF PROJECT	**$34,786,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$2,911,000
Operation and Maintenance	
Intake, Pipeline, Pump Station (1% of Cost of Facilities)	$337,000
Pumping Energy Costs (2480040 kW-hr @ 0.09 $/kW-hr)	$223,000
Purchase of Water (2,708 ac-ft/yr @ 815 $/ac-ft)	$2,206,000
TOTAL ANNUAL COST	**$5,677,000**
Available Project Yield (ac-ft/yr), based on a Peaking Factor of 1.5	2,708
Annual Cost of Water ($ per ac-ft)	$2,096
Annual Cost of Water ($ per 1,000 gallons)	$6.43

[1] Interconnection between Alice Water Authority WTP and San Diego, Freer, Benavides, Realtos and Conception.

Table 5D.10.3.
Cost Estimate Summary
Regional Surface Water Supply
Duval County Interconnection Alternative 2[1] (September 2013 Prices)

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Transmission Pipeline (Size Varies)	$10,148,000
Pump Station(s) and Storage Tank(s)	$4,973,000
TOTAL COST OF FACILITIES	**$15,121,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$4,785,000
Environmental & Archaeology Studies and Mitigation	$1,346,000
Land Acquisition and Surveying (213 acres)	$501,000
Interest During Construction (4% for 1 year with a 1% ROI)	$762,000
TOTAL COST OF PROJECT	**$22,515,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$1,884,000
Operation and Maintenance	
Intake, Pipeline, Pump Station (1% of Cost of Facilities)	$221,000
Pumping Energy Costs (1785108 kW-hr @ 0.09 $/kW-hr)	$161,000
Purchase of Water (2,098 ac-ft/yr @ 815 $/ac-ft)	$1,710,000
TOTAL ANNUAL COST	**$3,976,000**
Available Project Yield (ac-ft/yr), based on a Peaking Factor of 2	2,098
Annual Cost of Water ($ per ac-ft)	$1,895
Annual Cost of Water ($ per 1,000 gallons)	$5.82

[1] Interconnection between Alice Water Authority WTP and San Diego, Freer and Benavides.

Table 5D.10.4.
Cost Estimate Summary
Regional Surface Water Supply
Duval County Interconnection Alternative 3[1] (September 2013 Prices)

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Transmission Pipeline (Size Varies)	$4,223,000
Pump Stations	$2,769,000
TOTAL COST OF FACILITIES	**$6,992,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$2,236,000
Environmental & Archaeology Studies and Mitigation	$701,000
Land Acquisition and Surveying (109 acres)	$256,000
Interest During Construction (4% for 1 year with a 1% ROI)	$357,000
TOTAL COST OF PROJECT	**$10,542,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$882,000
Operation and Maintenance	
Intake, Pipeline, Pump Station (1% of Cost of Facilities)	$109,000
Pumping Energy Costs (795238 kW-hr @ 0.09 $/kW-hr)	$72,000
Purchase of Water (1,344 ac-ft/yr @ 815 $/ac-ft)	$1,094,000
TOTAL ANNUAL COST	**$2,157,000**
Available Project Yield (ac-ft/yr), based on a Peaking Factor of 2	1,344
Annual Cost of Water ($ per ac-ft)	$1,605
Annual Cost of Water ($ per 1,000 gallons)	$4.92

[1] Interconnection between Alice Water Authority WTP and San Diego and Benavides.

Table 5D.10.5.
Cost Estimate Summary
Regional Surface Water Supply
Duval County Interconnection Alternative 4[1] (September 2008 Prices)

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Transmission Pipeline (14-inch pipe, 11 miles)	$8,165,000
Pump Stations and Storage Tanks	$4,100,000
TOTAL COST OF FACILITIES	**$12,265,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$3,884,000
Environmental & Archaeology Studies and Mitigation	$933,000
Land Acquisition and Surveying (146 acres)	$343,000
Interest During Construction (4% for 1 year with a 1% ROI)	$610,000
TOTAL COST OF PROJECT	**$18,035,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$1,509,000
Operation and Maintenance	
Intake, Pipeline, Pump Station (1% of Cost of Facilities)	$179,000
Pumping Energy Costs (1570736 kW-hr @ 0.09 $/kW-hr)	$141,000
Purchase of Water (1,826 ac-ft/yr @ 815 $/ac-ft)	$1,488,000
TOTAL ANNUAL COST	**$3,317,000**
Available Project Yield (ac-ft/yr), based on a Peaking Factor of 2	1,826
Annual Cost of Water ($ per ac-ft)	$1,817
Annual Cost of Water ($ per 1,000 gallons)	$5.57

[1] Interconnection between Alice Water Authority WTP and San Diego and Freer.

Table 5D.10.6.
Cost Estimate Summary
Regional Surface Water Supply
Duval County Interconnection Alternative 5A[1] (September 2013 Prices)

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Transmission Pipeline	$2,395,000
Pump Station	$1,096,000
TOTAL COST OF FACILITIES	**$3,491,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$1,102,000
Environmental & Archaeology Studies and Mitigation	$298,000
Land Acquisition and Surveying (47 acres)	$110,000
Interest During Construction (4% for 1 year with a 1% ROI)	$176,000
TOTAL COST OF PROJECT	**$5,177,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$433,000
Operation and Maintenance	
Intake, Pipeline, Pump Station (1% of Cost of Facilities)	$51,000
Pumping Energy Costs (409670 kW-hr @ 0.09 $/kW-hr)	$37,000
Purchase of Water (1,072 ac-ft/yr @ 815 $/ac-ft)	$874,000
TOTAL ANNUAL COST	**$1,395,000**
Available Project Yield (ac-ft/yr), based on a Peaking Factor of 2	1,072
Annual Cost of Water ($ per ac-ft)	$1,301
Annual Cost of Water ($ per 1,000 gallons)	$3.99

[1] Interconnection between Alice Water Authority WTP and San Diego.

Table 5D.10.7.
Cost Estimate Summary
Regional Surface Water Supply
Duval County Interconnection Alternative 5B[1] (September 2013 Prices)

Item	Estimated Costs for Facilities
CAPITAL COST	
Transmission Pipeline	$1,234,000
Pump Stations	$767,000
TOTAL COST OF FACILITIES	**$2,001,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$638,000
Environmental & Archaeology Studies and Mitigation	$298,000
Land Acquisition and Surveying (47 acres)	$110,000
Interest During Construction (4% for 1 year with a 1% ROI)	$107,000
TOTAL COST OF PROJECT	**$3,154,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$264,000
Operation and Maintenance	
Intake, Pipeline, Pump Station (1% of Cost of Facilities)	$32,000
Pumping Energy Costs (58429 kW-hr @ 0.09 $/kW-hr)	$5,000
Purchase of Water (158 ac-ft/yr @ 815 $/ac-ft)	$129,000
TOTAL ANNUAL COST	**$430,000**
Available Project Yield (ac-ft/yr), based on a Peaking Factor of 2	158
Annual Cost of Water ($ per ac-ft)	$2,722
Annual Cost of Water ($ per 1,000 gallons)	$8.35

[1] Interconnection between Alice Water Authority WTP and San Diego's Needs Only.

5D.10.2.2 Jim Wells County

The 1996 Regional Water Supply Study[3] also included two alternative surface water supply systems to deliver water from the CCR/LCC System, via the City of Alice, to Orange Grove (Figure 5D.10.6) and Premont (Figure 5D.10.7) in Jim Wells County. Required regional facilities for Jim Wells County options would include new transmission lines ranging in size from 8-inches to 10-inches in diameter. Associated total capital costs and annual costs (debt service, O&M cost, and treated water cost) were estimated for each alternative and are included in Table 5D.10.8 and Table 5D.10.9.

It may be feasible for Orange Grove to tap into the City of Alice's 20-inch raw water line from Lake Corpus Christi and construct a 0.5 mgd water treatment plant. Due to TWDB funding constraints, this option was not prioritized for analysis but can be considered in future planning cycles based on interest from Orange Grove or the City of Alice.

The City of Alice is considering an interconnection to South Texas Water Authority's treated water line near Agua Dulce, which is summarized in Chapter 5D.10.2.6.

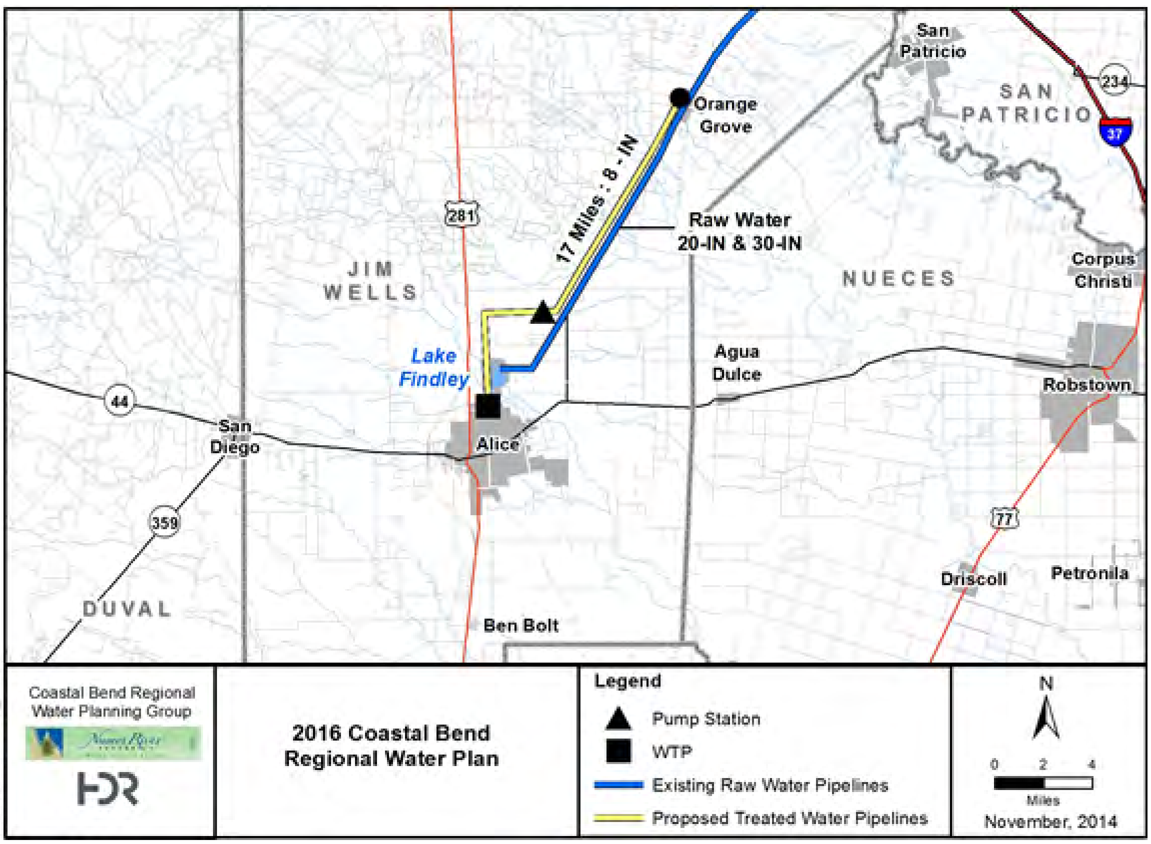

Figure 5D.10.6.
Jim Wells County Interconnection Alternative 1

[3] Ibid.

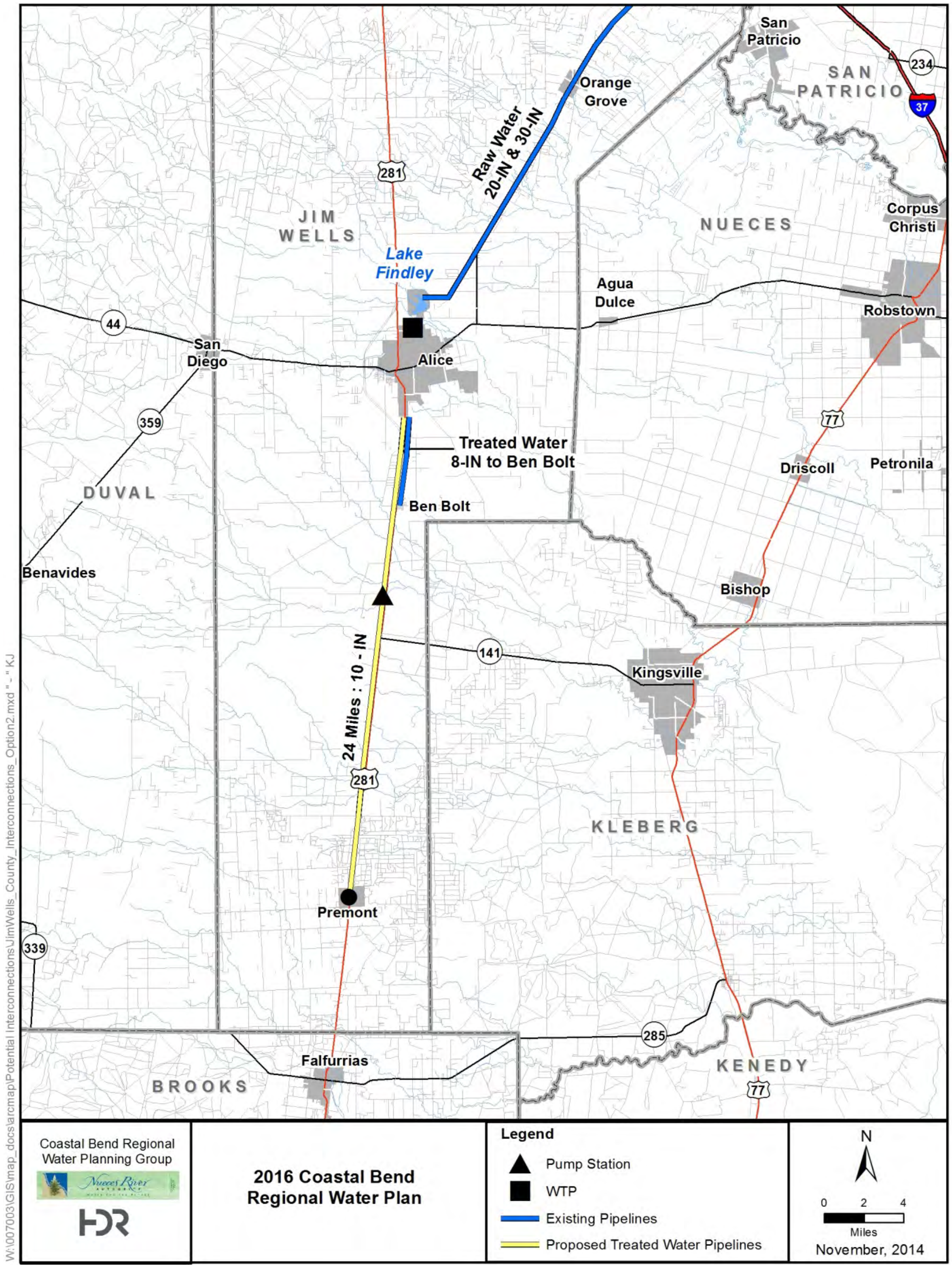

Figure 5D.10.7.
Jim Wells County Interconnection Alternative 2

Table 5D.10.8.
Cost Estimate Summary
Regional Surface Water Supply
Jim Wells County Interconnection Alternative 1[1] (September 2013 Prices)

Item	Estimated Costs for Facilities
CAPITAL COST	
Transmission Pipeline (8-inch diameter, 17 miles)	$2,709,000
Pump Station(s) and Storage Tank(s)	$1,774,000
TOTAL COST OF FACILITIES	**$4,483,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$1,433,000
Environmental & Archaeology Studies and Mitigation	$449,000
Land Acquisition and Surveying (71 acres)	$219,000
Interest During Construction (4% for 1 year with a 1% ROI)	$231,000
TOTAL COST OF PROJECT	**$6,815,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$570,000
Operation and Maintenance	
Intake, Pipeline, Pump Station (1% of Cost of Facilities)	$69,000
Pumping Energy Costs (693795 kW-hr @ 0.09 $/kW-hr)	$62,000
Purchase of Water (494 ac-ft/yr @ 815 $/ac-ft)	$403,000
TOTAL ANNUAL COST	**$1,104,000**
Available Project Yield (ac-ft/yr), based on a Peaking Factor of 1.5	494
Annual Cost of Water ($ per ac-ft)	$2,235
Annual Cost of Water ($ per 1,000 gallons)	$6.86

[1] Interconnection between Alice Water Authority WTP and Orange Grove.

Table 5D.10.9.
Cost Estimate Summary
Regional Surface Water Supply
Jim Wells County Interconnection Alternative 2[1] (September 2013 Prices)

Item	Estimated Costs for Facilities
CAPITAL COST	
Transmission Pipeline (10-inch diameter, 23 miles)	$4,042,000
Pump Station(s) and Storage Tank(s)	$2,181,000
TOTAL COST OF FACILITIES	**$6,223,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$1,976,000
Environmental & Archaeology Studies and Mitigation	$596,000
Land Acquisition and Surveying (93 acres)	$285,000
Interest During Construction (4% for 1 year with a 1% ROI)	$318,000
TOTAL COST OF PROJECT	**$9,398,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$786,000
Operation and Maintenance	
Intake, Pipeline, Pump Station (1% of Cost of Facilities)	$92,000
Pumping Energy Costs (475909 kW-hr @ 0.09 $/kW-hr)	$43,000
Purchase of Water (929 ac-ft/yr @ 815 $/ac-ft)	$757,000
TOTAL ANNUAL COST	**$1,678,000**
Available Project Yield (ac-ft/yr), based on a Peaking Factor of 1.5	929
Annual Cost of Water ($ per ac-ft)	$1,806
Annual Cost of Water ($ per 1,000 gallons)	$5.54

1 Interconnection between Alice Water Authority WTP and Premont.

5D.10.2.3 Brooks County

The TWDB water demand projections show an increase in water demand for Falfurrias from 2011 to 2070. If future regional surface water supply facilities are constructed from Alice to Premont, it may be feasible to extend the system an additional 10.5 miles to Falfurrias (Figure 5D.10.8). The 8" pipe carrying supply from south Alice to Ben Bolt is not large enough for the additional flow to Brooks County. A parallel 14" pipe would be needed for the last two miles of the existing distribution system. Total capital costs and annual costs for regional surface water supply facilities to serve Premont and Falfurrias are shown in Table 5D.10.10.

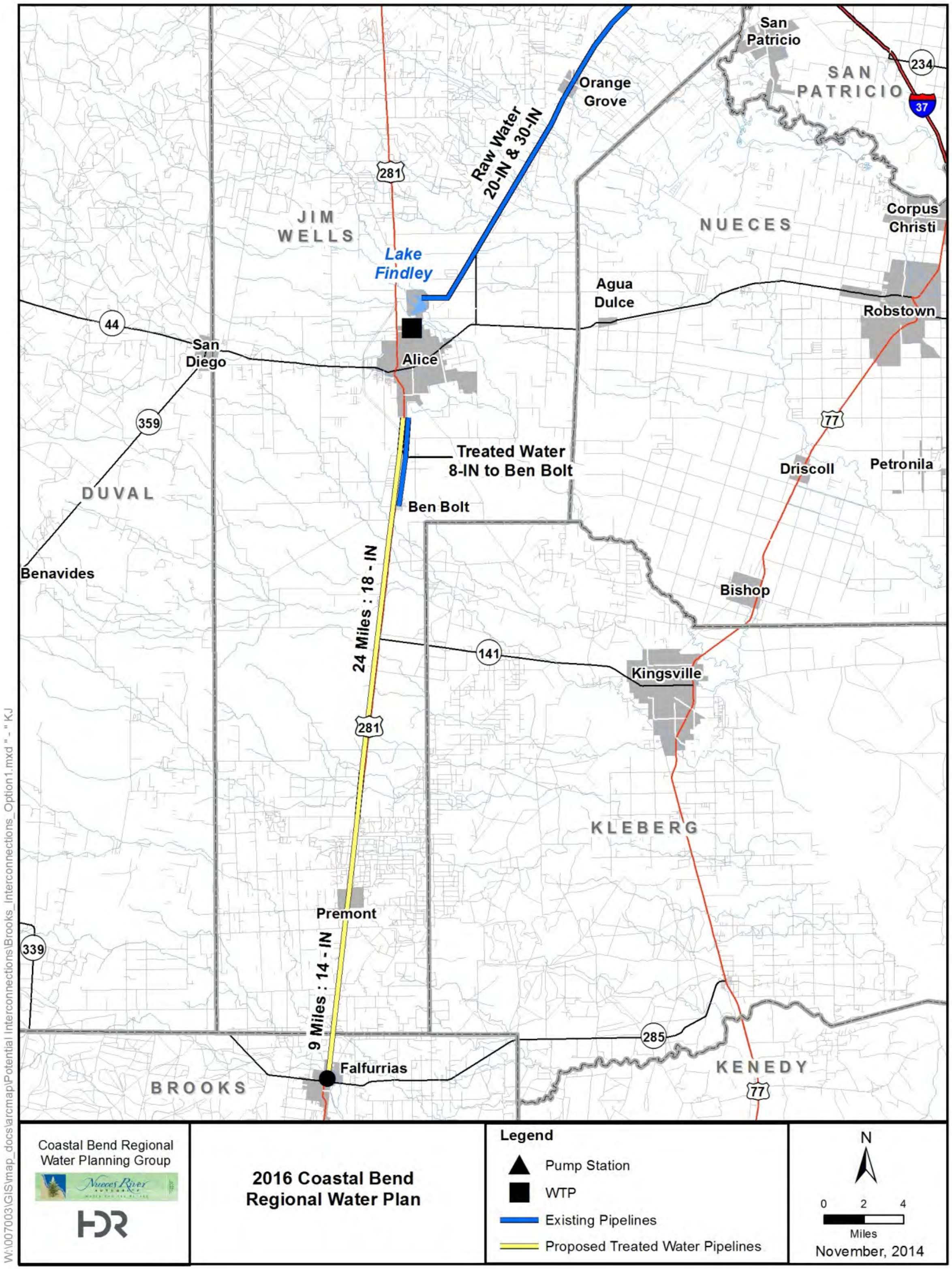

Figure 5D.10.8.
Brooks County Interconnection Alternative 1

Table 5D.10.10.
Cost Estimate Summary
Regional Surface Water Supply
Jim Wells and Brooks County Interconnection Alternative 1[1] (September 2013 Prices)

Item	Estimated Costs for Facilities
CAPITAL COST	
Transmission Pipeline (18-inch diameter, 34 miles)	$12,218,000
Pump Station(s) and Storage Tank(s)	$2,425,000
TOTAL COST OF FACILITIES	**$14,643,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$4,514,000
Environmental & Archaeology Studies and Mitigation	$852,000
Land Acquisition and Surveying (127 acres)	$393,000
Interest During Construction (4% for 1 year with a 1% ROI)	$715,000
TOTAL COST OF PROJECT	**$21,117,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$1,767,000
Operation and Maintenance	
Intake, Pipeline, Pump Station (1% of Cost of Facilities)	$183,000
Pumping Energy Costs (798059 kW-hr @ 0.09 $/kW-hr)	$72,000
Purchase of Water (2,844 ac-ft/yr @ 815 $/ac-ft)	$2,318,000
TOTAL ANNUAL COST	**$4,340,000**
Available Project Yield (ac-ft/yr), based on a Peaking Factor of 1.5	2,844
Annual Cost of Water ($ per ac-ft)	$1,526
Annual Cost of Water ($ per 1,000 gallons)	$4.68

[1] Interconnection between Alice Water Authority WTP and Premont and Falfurrias.

5D.10.2.4 San Patricio County

In San Patricio County, the City of Sinton, along with water supply corporations located in the communities of Edroy and St. Paul, and several residential communities located along Lake Mathis, still rely on groundwater supplies.

Water supply for the City of Sinton is located in two well fields located along US 181 in the vicinity of the Rob and Bessie Welder Park. In the early 1980s, the City of Sinton recognized that its municipal water supply, which was originally developed in the 1940s and 50s, was rapidly deteriorating and affecting its ability to reliably serve potable water to its customers. The corrosive nature of the groundwater supplies from the well fields located approximately 3 miles northwest of the city was causing severe deterioration of the well field casings, screens, and pumping units.

In 1983, the first of three 12-inch diameter stainless steel wells were constructed for the City of Sinton. The well design included under reaming and gravel packing of the water bearing zones which produced adequate water from depths of approximately 300 to 700 feet. While water quality in the Sinton municipal well field area meets established published secondary drinking water standards, the chemical constituents of total dissolved solids and chlorides only marginally meets these standards.

When developing the final replacement well in the Sinton west field constructed in 1993, careful review of well field logs still could not predict the water quality which would be produced from the final constructed well. When the well was turned on, water quality parameters exceeded secondary drinking water standards for chlorides. Chloride levels for this well fell in the range of 300 to 325 ppm. Permission was sought from the Texas Water Commission (now the Texas Commission on Environmental Quality (TCEQ)) to allow the City of Sinton to blend its water with its other water well resources in order that water supply delivered to its customers would fall within the recommended secondary drinking water standards. To this date, the City of Sinton is still mandated by the TCEQ to operate this water blending plan.

Water well capacity for the City of Sinton is expected to be sufficient to meet the population demands through the year 2070. However, if groundwater quality continues to degrade, the City of Sinton could either construct a water treatment facility or connect directly to the San Patricio Municipal Water District's (SPMWD) treated surface water system. The SPMWD could either provide raw water through its 36-inch Nueces River transmission line or its connection to the Mary Rhodes pipeline. Treatment for potable use purposes would be required.

A direct connection to the SPMWD's 24-inch treated water transmission line would require approximately 8 miles of 12-inch waterline (Figure 5D.10.9). Connections and modifications to the City of Sinton's ground storage and pump stations would also be required. Total costs to establish an interconnection for Sinton to the regional surface water system are shown in Table 5D.10.11.

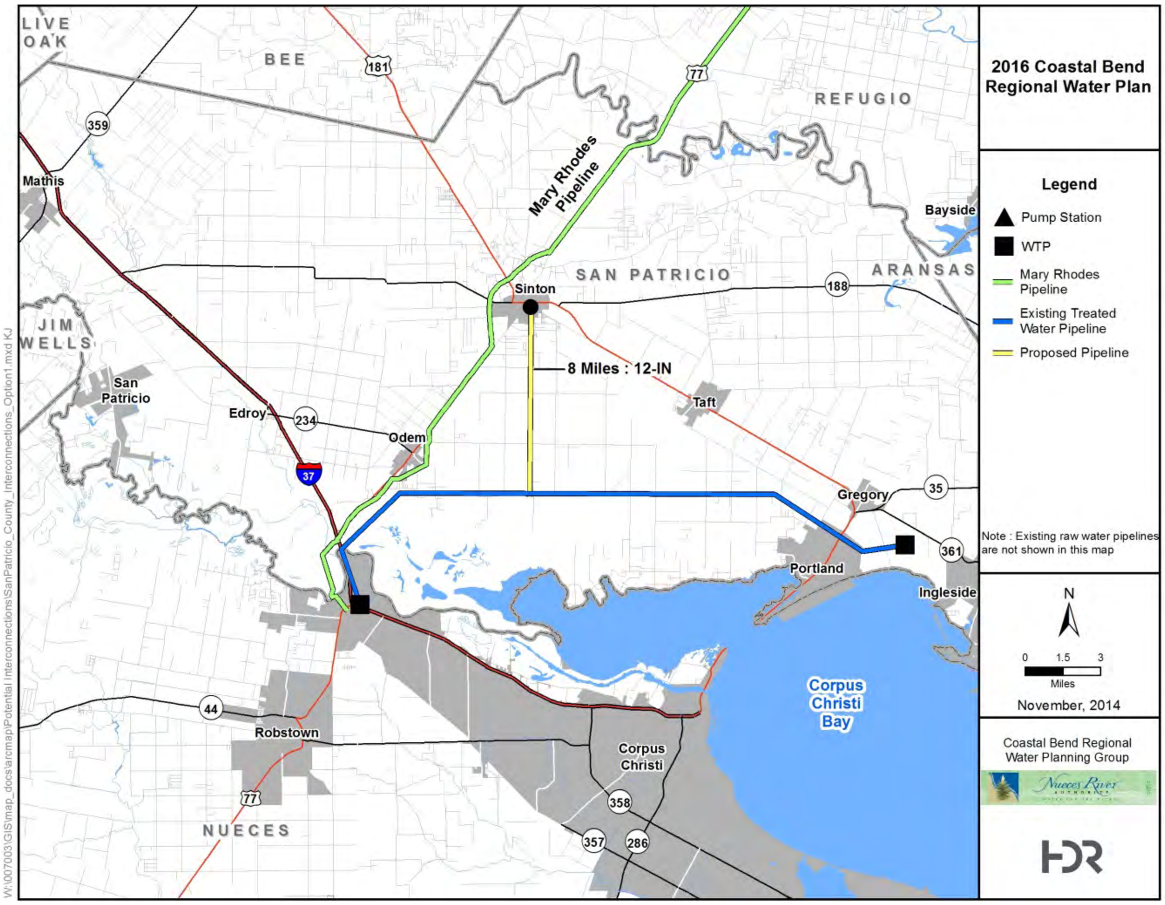

Figure 5D.10.9.
San Patricio County Interconnection Alternative 1

Table 5D.10.11.
Cost Estimate Summary
Regional Surface Water Supply
San Patricio County Interconnection Alternative 1[1] (September 2013 Prices)

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Transmission Pipeline (12-inch diameter, 8 miles)	$1,445,000
Pump Station Modification	$314,791
TOTAL COST OF FACILITIES	**$1,759,791**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$848,000
Environmental & Archaeology Studies and Mitigation	$202,000
Land Acquisition and Surveying (32 acres)	$100,000
Interest During Construction (4% for 1 year with a 1% ROI)	$133,000
TOTAL COST OF PROJECT	**$3,042,791**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$327,000
Operation and Maintenance	
Intake, Pipeline, Pump Station (1% of Cost of Facilities)	$44,000
Pumping Energy Costs (339745 kW-hr @ 0.09 $/kW-hr)	$31,000
Purchase of Water (1,507 ac-ft/yr @ 815 $/ac-ft)	$1,228,000
TOTAL ANNUAL COST	**$1,630,000**
Available Project Yield (ac-ft/yr), based on a Peaking Factor of 1.5	1,507
Annual Cost of Water ($ per ac-ft)	$1,082
Annual Cost of Water ($ per 1,000 gallons)	$3.32

1 Interconnection between San Patricio Municipal Water District transmission main and Sinton.

Water service for the community of Edroy, Texas located along US 77 west of Odem, Texas is provided by San Patricio County Municipal Utility District 1 (District #1). In 1985, District #1 constructed a community water system complete with two wells, storage facilities and distribution lines. Approximately 200 connections are served through this system. Although the groundwater supply marginally meets secondary drinking water standards, the water is high in hydrogen sulfide (H_2S) making it extremely corrosive. From its initial operations, District #1 has utilized an aeration tower and the addition of chlorine to oxidize the hydrogen sulfide to acceptable odor levels. Corrosion to pump station equipment has been a continual problem. Original construction of the wells for the water supply for the community was based on an economic decision at the time and was limited to available grant funding. It has been anticipated that a conversion to treated surface water via the SPMWD may be required in the future.

During the mid 1990s, the TWDB Economic Development Assistance Program (EDAP) for San Patricio County identified a project which would have extended an 8-inch water line from the SPMWD 24-inch treated water line to the community of Edroy. This plan included an expansion to the District #1 service area, a new elevated storage tank, pumping facilities, and an interconnection to the existing Edroy system. Figure 5D.10.10 outlines the recommended EDAP plan. The cost of construction for these facilities is shown in Table 5D.10.12.

An additional groundwater project to provide redundancy for Mathis's demands is also being considered as shown in Figure 5D.10.11. Six (6) local groundwater wells would be needed to provide 1,400 ac-ft of supply to Mathis. The wells are assumed to have a capacity of 350 gpm and a drawdown of 50 ft. Six miles of 6" piping will be needed along with groundwater pumps, the costs for this project are summarized in Table 5D.10.13.

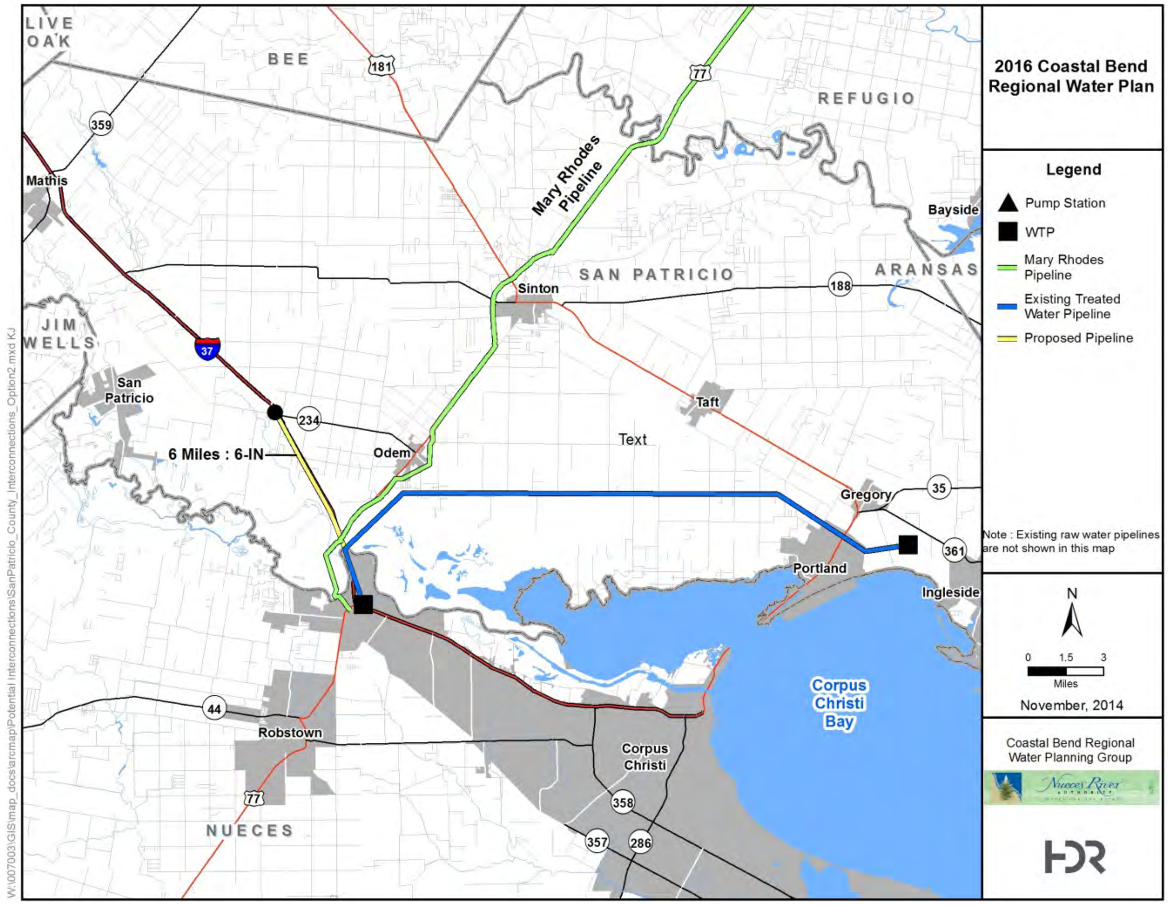

Figure 5D.10.10.
San Patricio County Interconnection Alternative 2

Table 5D.10.12. Cost Estimate Summary Regional Surface Water Supply San Patricio County Interconnection Alternative 2[1] (September 2013 Prices)

Item	Estimated Costs for Facilities
CAPITAL COST	
Transmission Pipeline (6-inch diameter, 6 miles)	$528,000
Intake Pump Station (0.2 mgd)	$671,000
TOTAL COST OF FACILITIES	**$1,199,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$393,000
Environmental & Archaeology Studies and Mitigation	$164,000
Land Acquisition and Surveying (27 acres)	$15,000
Interest During Construction (4% for 1 year with a 1% ROI)	$62,000
TOTAL COST OF PROJECT	**$1,833,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$153,000
Operation and Maintenance	
Intake, Pipeline, Pump Station (1% of Cost of Facilities)	$22,000
Pumping Energy Costs (33748 kW-hr @ 0.09 $/kW-hr)	$3,000
Purchase of Water (125 ac-ft/yr @ 645 $/ac-ft)	$81,000
TOTAL ANNUAL COST	**$259,000**
Available Project Yield (ac-ft/yr), based on a Peaking Factor of 1.5	125
Annual Cost of Water ($ per ac-ft)	$2,072
Annual Cost of Water ($ per 1,000 gallons)	$6.36

[1] Interconnection between San Patricio Municipal Water District transmission main and Edroy.

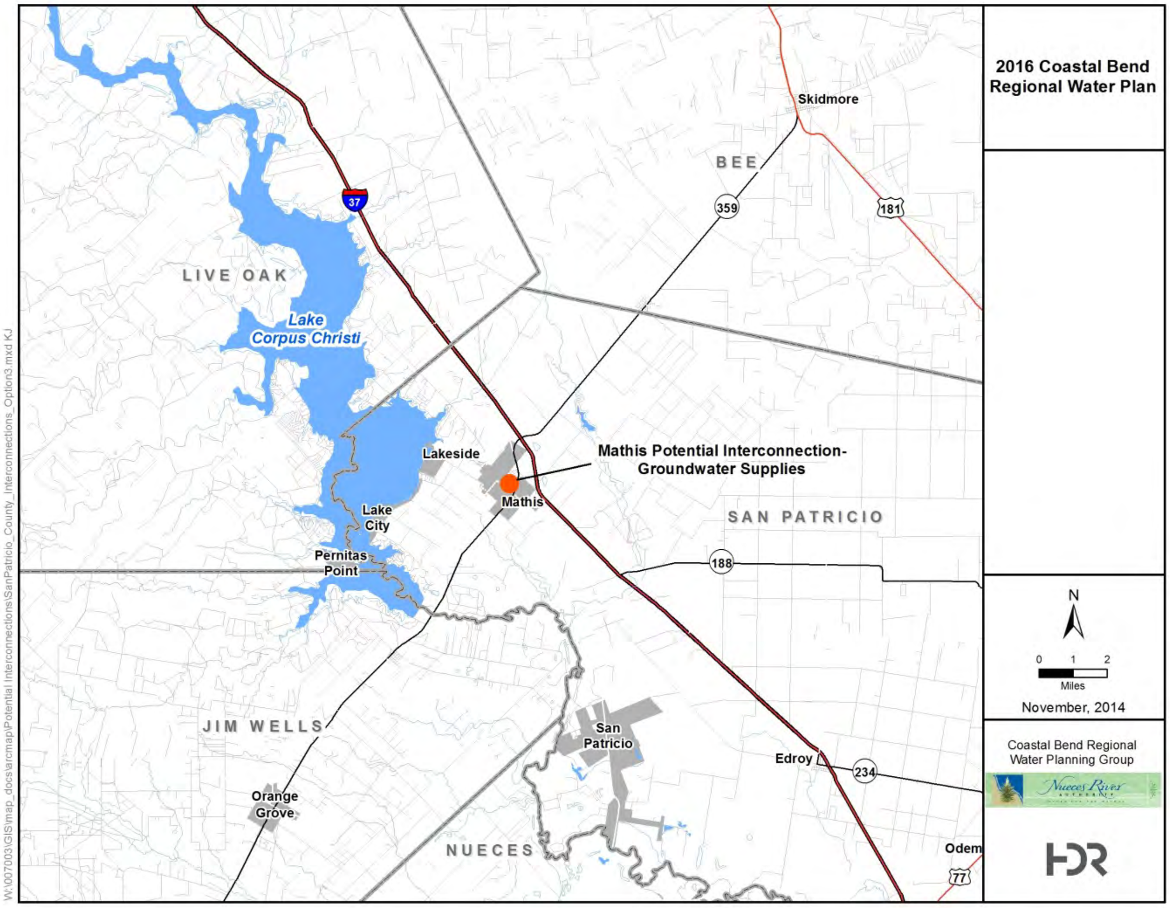

Figure 5D.10.11.
San Patricio County Interconnection Alternative 3

Table 5D.10.13.
Cost Estimate Summary
Regional Surface Water Supply
San Patricio County Interconnection Alternative 3[1] (September 2013 Prices)

Item	*Estimated Costs for Facilities*
CAPITAL COST	
Power Connection	$50,000
Well Fields (Wells, Pumps and Piping)	$1,143,000
Storage Tanks (Other Than at Booster Pump Stations)	$130,000
Water Treatment Plants (0.6-mgd Brackish GW and 0.6-mgd Chlorine Disinfection)	$2,599,000
TOTAL COST OF FACILITIES	**$3,922,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$1,373,000
Environmental & Archaeology Studies and Mitigation	$49,000
Land Acquisition and Surveying (4 acres)	$13,000
Interest During Construction (4% for 1 year with a 1% ROI)	$188,000
TOTAL COST OF PROJECT	**$5,545,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$464,000
Operation and Maintenance	
Intake, Pipeline, Pump Station (1% of Cost of Facilities)	$14,000
Water Treatment Plant (2.5% of Cost of Facilities)	$503,000
Concentrate Disposal	$50,000
Pumping Energy Costs (148631 kW-hr @ 0.09 $/kW-hr)	$13,000
TOTAL ANNUAL COST	**$1,044,000**
Available Project Yield (ac-ft/yr)	700
Annual Cost of Water ($ per ac-ft)	$1,491
Annual Cost of Water ($ per 1,000 gallons)	$4.58

[1] Groundwater supplies for Mathis.

5D.10.2.5 Kleberg/Brooks/Jim Wells County

A third strategy for Jim Wells County supplies water from Kingsville to Riviera, Falfurrias and Premont (Figure 5D.10.12).

Required regional facilities for this regional strategy would include new transmission lines ranging in size from 10-inches to 18-inches in diameter. Associated total capital costs and annual costs (debt service, O&M cost, and treated water cost) were estimated and are included in Table 5D.10.14.

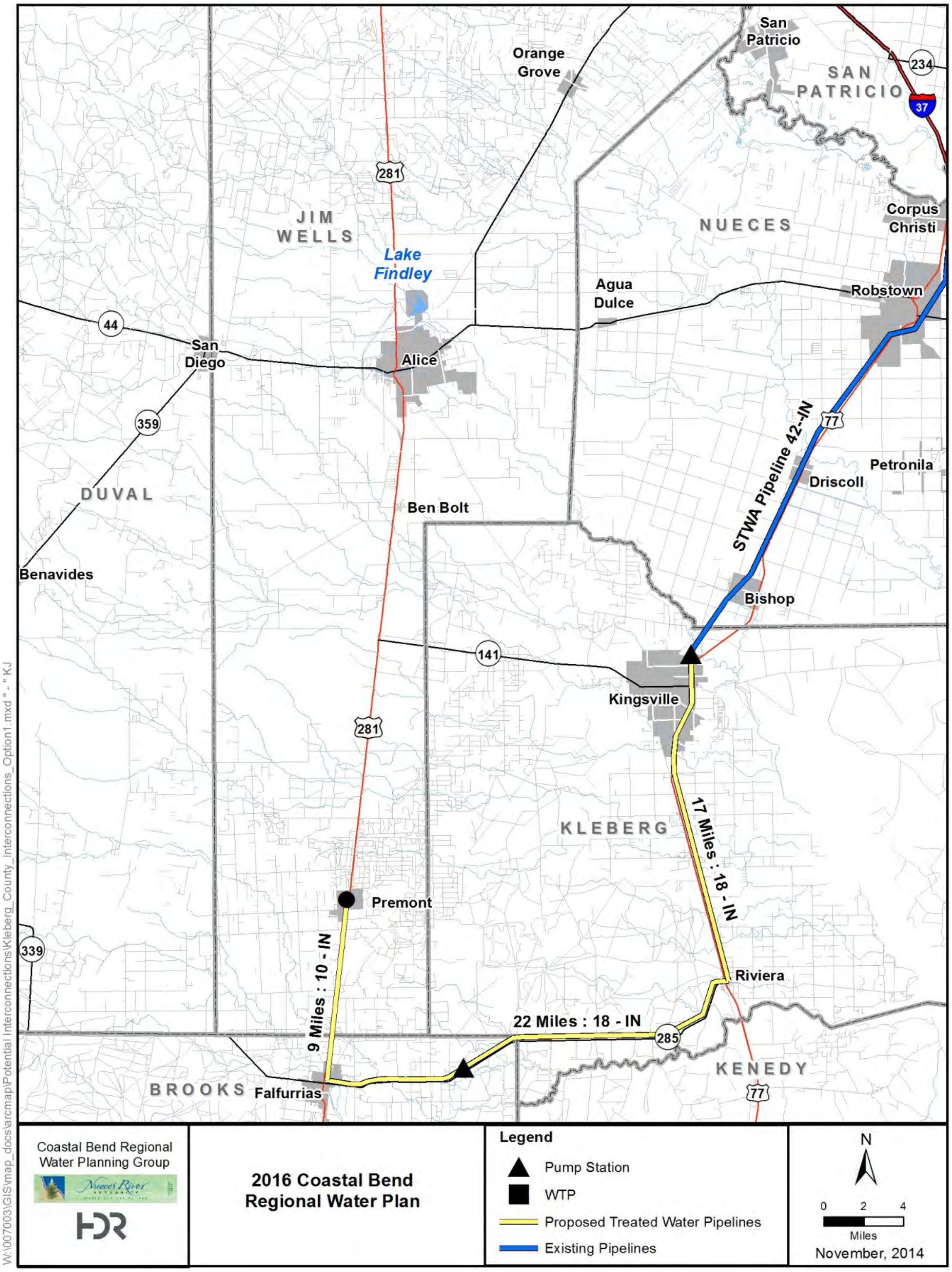

Figure 5D.10.12.
Kleberg/Brooks/Jim Wells County Interconnection Alternative 1

Table 5D.10.14.
Cost Estimate Summary
Regional Surface Water Supply
Kleberg/Brooks/Jim Wells County Interconnection Alternative 1[1] (September 2013 Prices)

Item	Estimated Costs for Facilities
CAPITAL COST	
Transmission Pipeline (Diameter Varies, 48 miles)	$19,431,000
Pump Station(s) and Storage Tank(s)	$4,923,000
TOTAL COST OF FACILITIES	**$24,354,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$7,552,000
Environmental & Archaeology Studies and Mitigation	$1,239,000
Land Acquisition and Surveying (186 acres)	$573,000
Interest During Construction (4% for 1 year with a 1% ROI)	$1,181,000
TOTAL COST OF PROJECT	**$34,899,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$2,920,000
Operation and Maintenance	
Intake, Pipeline, Pump Station (1% of Cost of Facilities)	$317,000
Pumping Energy Costs (2441899 kW-hr @ 0.09 $/kW-hr)	$220,000
Purchase of Water (3,023.74 ac-ft/yr @ 896 $/ac-ft)	$2,709,000
TOTAL ANNUAL COST	**$6,166,000**
Available Project Yield (ac-ft/yr), based on a Peaking Factor of 1.5	3,024
Annual Cost of Water ($ per ac-ft)	$2,039
Annual Cost of Water ($ per 1,000 gallons)	$6.26

[1] Interconnection from Kingsville to Riviera, Falfurrias and Premont.

5D.10.2.6 STWA Connection to the City of Alice

The City of Alice is considering an interconnection to the South Texas Water Authority (STWA) 12-inch diameter pipeline at Agua Dulce, located 11.4 miles from the City of Alice as shown in Figure 5D.10.13. The yield of the project is estimated at 2,800 ac-ft/yr, or 2.5 mgd. Facilities needed includes: transmission pipeline, storage tank, and booster pump station to deliver treated water from Agua Dulce to the City of Alice. The Alice Water Authority does not estimate implementation issues for this interconnection. However, it may require negotiations with the City of Corpus Christi if the City of Alice requires additional supplies of 2.5 mgd from STWA. STWA is a wholesale treated water customer of the City of Corpus Christi. STWA treated water costs of $2.75 per 1,000 gallons were assumed. Associated total capital costs and annual costs (debt service, O&M cost, and treated water cost) were provided by the Alice Water Authority and are included in Table 5D.10.15.

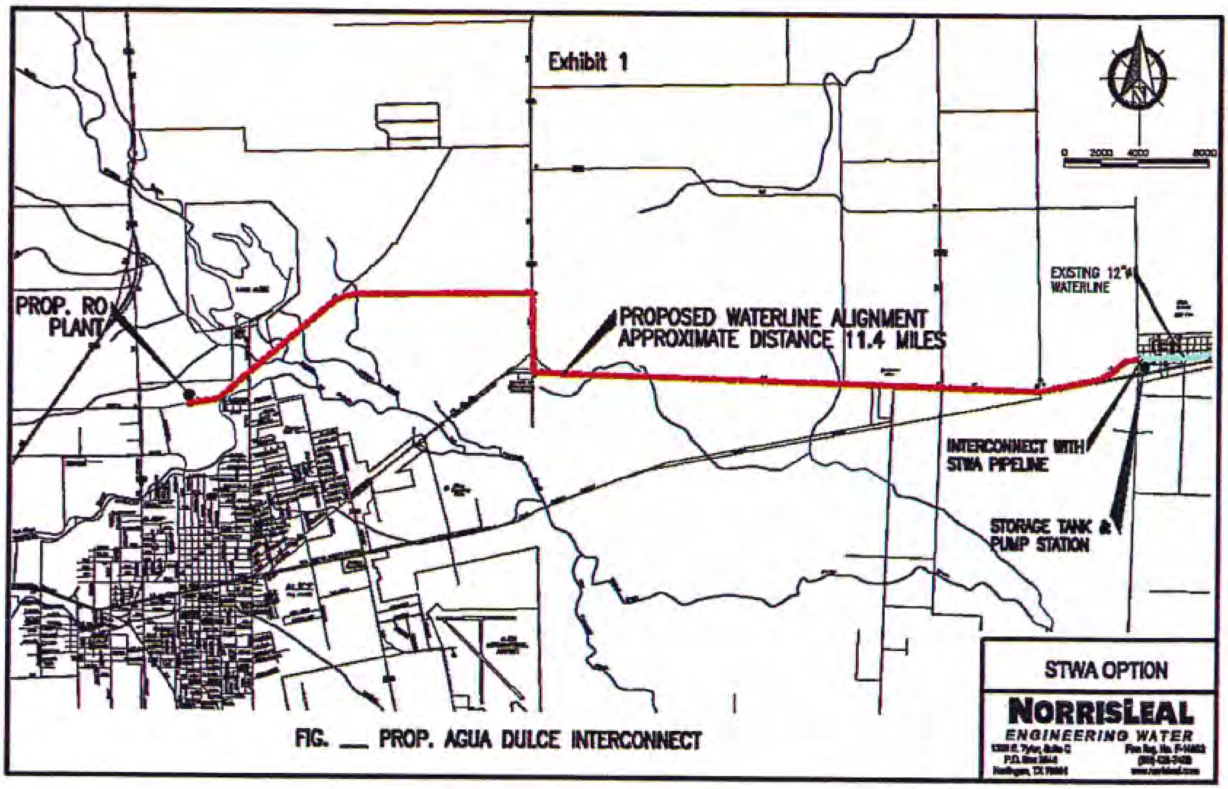

Figure 5D.10.13.
Proposed STWA to City of Alice Interconnection
Source: Alice Water Authority Water Supply Evaluation Report, 2015

Table 5D.10.15.
Cost Estimate Summary
STWA Treated Water Line at Agua Dulce to the City of Alice (September 2013 Prices)

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Transmission Pipeline (16 in dia, 12 miles)	$3,912,000
Pump Station(s) and Storage Tank(s)	$600,000
TOTAL COST OF FACILITIES	**$4,512,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$1,354,000
TOTAL COST OF PROJECT	**$5,866,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$491,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tank (1% of Cost of Facilities)	$43,000
Pump Stations (2.5% of Cost of Facilities)	$6,000
Pumping Energy Costs (2,141,889 kW-hr @ 0.09 $/kW-hr)	$193,000
Purchase of Water (2,800 ac-ft/yr @ 896 $/ac-ft)	$2,509,000
TOTAL ANNUAL COST	**$3,242,000**
Available Project Yield (ac-ft/yr)	2,800
Annual Cost of Water ($ per ac-ft)	$1,158
Annual Cost of Water ($ per 1,000 gallons)	$3.55

[1] No costs provided for Environmental & Archaeology Studies, Land Acquisition and Surveying, or Interest During Construction.

5D.10.3 Environmental Issues

Environmental issues related to the potential water system interconnections in the Coastal Bend Region can be categorized as follows:

- Effects related to pipeline construction and maintenance; and
- Effects resulting from changes in Nueces River flows, including inflows to the Nueces Estuary.

The various proposed pipelines required for the water system interconnections are within Duval, Jim Wells, Brooks, Kleberg and San Patricio Counties. The pipelines are intended to transfer water between the municipal and industrial demands of these counties. The construction of these pipelines would result in soil and vegetation disturbance within the pipeline construction corridor. Longer-term impacts would be confined to the maintained right-of-way. Several studies are required before the proposed pipelines are constructed. The studies include, but are not limited to, environmental, habitat, and cultural resources studies.

Implementation of the water system interconnections would place an increased demand on the CCR/LCC/Lake Texana System. This will impact reservoir levels, streamflows, and inflows to the Nueces Estuary. An evaluation of these impacts may be required before the water system interconnections are implemented, although the anticipated impacts are negligible.

Implementation of water system interconnections in San Patricio County are expected to reduce chlorides for Sinton and hydrogen sulfide for Edroy and help to ensure Safe Drinking Water Act standards.

5D.10.4 Evaluation Summary

An evaluation summary of this regional water management strategy is provided in Table 5D.10.16.

Table 5D.10.16.
Evaluation Summary of the Potential Water System Interconnections

Impact Category	***Comment(s)***
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	1. Firm yield: Range from 2,800 ac-ft/yr to 125 ac-ft/yr, depending on interconnection project. 2. Good reliability. 3. Generally high project cost; between $2,722 to $336 per ac-ft.
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	1. Possible low impact. 2. Possible low impact. 3. Construction and maintenance of transmission pipeline corridor(s) may impact wildlife species. 4. None or low impact. 5. Endangered species survey will be needed to avoid significant sites. 6. Cultural resource survey will be needed to avoid significant sites. 7. May potentially enhance water quality for rural communities. 7d. May improve water quality issues associated with chlorides for Sinton. 7f. May improve water quality issues associated with high hydrogen sulfide for Edroy.
c. Impacts to State water resources	• No negative impacts on other water resources
d. Threats to agriculture and natural resources in region	• Temporary damage due to construction of pipeline(s)
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Standard analyses and methods used for portions
g. Interbasin transfers	• Not applicable
h. Third party social and economic impacts from voluntary redistribution of water	• Not applicable
i. Efficient use of existing water supplies and regional opportunities	• Provides regional opportunities
j. Effect on navigation	• None

5D.11

Local Balancing Storage Reservoir

5D.11 Local Balancing Storage Reservoir

5D.11.1 Description of Water Management Strategy

The 2016 Coastal Bend Regional Water Plan water management strategies are sized and scheduled to meet seasonal and daily variations of demand, but, without storage, some current and proposed supplies may not be fully reliable during extended droughts. In such cases, a need for surface reservoirs, large scale Aquifer Storage and Recovery (ASR) systems, or multi-purpose reservoirs that are adequate in size to store surplus flows of surface water during periods of high streamflows, including flood flows, to be available during extended periods of drought may be warranted. This local balancing storage water management strategy involves implementing a surface storage facility for Nueces County WCID #3.

Nueces County WCID #3 has three permits for a combined total of 11,546 ac-ft/yr[1]. Nueces County WCID #3 is a Wholesale Water Provider and provides treated water supplies to the City of Robstown, San Pedro subdivision, and River Acres WSC. The total water demand for Nueces County WCID #3's current municipal customers is projected to be 3,538 ac-ft/yr by 2070. The permitted water rights mentioned above can provide a firm yield of 1,955 ac-ft/yr during drought of record conditions[2], leaving a shortage of 1,583 ac-ft/yr. The local balancing storage reservoir strategy is recommended for the purpose of storing and recovering surplus supply to meet demands during times of low availability. A balancing storage component that is integrated into the water production and water treatment system has the potential to reduce costs and increase reliability and efficiency of the water management strategies necessary to meet projected need.

5D.11.2 Available Yield

Available yield associated with the local balancing storage was determined using the Nueces River Basin WAM to simulate operations of the run of river rights and water management strategies. The results of the water availability modeling suggested that the minimum month of availability required an additional 196 ac-ft of supply that could be provided by the balancing reservoir. Considering evaporative losses, a 350 ac-ft local balancing storage reservoir is needed. The projected yield of the strategy will be 1,583 ac-ft/yr.

5D.11.3 Environmental Issues

Potential environmental issues associated with implementation of the local balancing storage reservoir includes consideration and mitigation of affected aquatic and terrestrial habitats, cultural resources, and threatened and endangered species, in accordance with applicable state and federal requirements.

[1] Associated with Certificate of Adjudication 2466_1 through 2466_4 for municipal (4,246 ac-ft/yr) and irrigation (7,300 ac-ft/yr) purposes.

[2] Certificate of Adjudication 2466_1 is permitted for 3,500 ac-ft/yr and has a priority date of February 7, 1909. It is the only one of the four water rights for which water is available for diversion during the minimum month of the drought of record. During the worse month of the drought of record (August 1995), the flow available for diversion during the minimum month is only 56% of the supply needed by the water right.

5D.11.4 Engineering and Costing

Estimated costs for development of balancing storage assume that 350 ac-ft of storage is needed for minimum month demand and evaporation conditions. The pumps are sized based on total storage needed, 2-mgd pump station[3], and 10-inch diameter piping to and from terminal storage. Cost estimates were computed for capital costs, annual debt service, operation and maintenance, power, and land. These costs are summarized in Table 5D.11.1. The project costs, including capital, are estimated to be $8,182,000. As shown, the annual costs, including debt service, operation and maintenance, power, and treatment plant operation are estimated to be $1,316,000. This option produces raw water at a unit cost of $463 per ac-ft and treated water at an estimated cost of $831 per ac-ft ($2.55 per 1,000 gallons). The treatment costs are based on cost estimates for treatment at O.N. Stevens WTP, operated by the City of Corpus Christi.

5D.11.5 Implementation Issues

Potentially significant implementation issues associated with a balancing reservoir include the following:

- Quantification and consideration of any potential effects on water rights, streamflows, and freshwater inflows to bays and estuaries to the extent required by TCEQ rules and applicable state and federal law.
- Run-of-river water rights often require surface storage and/or groundwater to firm up supply for municipal water use and a determination as to the most economically feasible of these is necessary.
- Acquisition of State, Federal, and Local permits.
- Environmental studies.
- Relocations of affected roads, railroads, utilities, and cultural resources.

5D.11.6 Evaluation Summary

It is assumed that Nueces County WCID #3 will implement this strategy to reliably meet the needs of its water supply customers. An evaluation summary of this water management option is provided in Table 5D.11.2.

[3] Calculation based on 162 ac-ft/mo (1.7 mgd) needed to firm up minimum month conditions based on historical usage patterns for diversion of 3,500 ac-ft/yr.

Table 5D.11.1.
Cost Estimate Summary for Local Balancing Storage Reservoir

Item	*Costs for Facilities*
CAPITAL COST	
Off-Channel Storage/Ring Dike (Conservation Pool 350 ac-ft, 20 acres)	$3,511,000
Transmission Pipeline (10-inch diameter, 1 mile)	$235,000
Intake Pump Stations (2 mgd)	$2,016,000
TOTAL COST OF FACILITIES	**$5,762,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$2,005,000
Environmental & Archaeology Studies and Mitigation	$81,000
Land Acquisition and Surveying (20 acres)	$57,000
Interest During Construction (4% for 1 year with a 1% ROI)	$277,000
TOTAL COST OF PROJECT	**$8,182,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$264,000
Reservoir Debt Service (5.5 percent, 40 years)	$313,000
Operation and Maintenance	
Pipeline, Wells and Storage Tanks (1% of Cost of Facilities)	$2,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$50,000
Dam and Reservoir (1.5% of Cost of Facilities)	$53,000
Pumping Energy Costs (553405 kW-hr @ 0.09 $/kW-hr)	$50,000
TOTAL ANNUAL COST	**$732,000**
Available Project Yield (ac-ft/yr), based on a Peaking Factor of 1	1,583
Annual Cost of Raw Water ($ per ac-ft)	$462
Annual Cost of Water ($ per 1,000 gallons)	$1.42
Annual Cost of Treated Water ($ per ac-ft), with treatment costs of $369 ac-ft	$831

Table 5D.11.2.
Evaluation Summary of Nueces County WCID #3 Local Balancing Storage Reservoir

Impact Category	*Comment(s)*
a. Water Supply 1 Quantity 2. Reliability	 1. Firm Yield: 1,583 ac-ft/yr 2. Cost: Moderate cost as compared to other strategies.
b. Environmental factors 1. Instream flows 2. Bay and Estuary Inflows 3. Wildlife Habitat 4. Wetlands 5. Threatened and Endangered Species 6. Cultural Resources 7. Water Quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. Some impact due to increased diversions from the Nueces River, when available, for terminal storage needs during droughts. 2. Some impact due to increased diversions from the Nueces River, when available, for terminal storage needs during droughts. 3. None or low impact. 4. None or low impact. 5. None or low impact. 6. No cultural resources affected. 7. None or low impact.
c. Impacts to State water resources	• No apparent negative impacts on water resources
d. Threats to agriculture and natural resources in region	• None
e. Recreational impacts	• None
f. Equitable Comparison of Strategies	• Standard analyses and methods used
g. Interbasin transfers	• None
h. Third party social and economic impacts from voluntary redistribution of water	• None
i. Efficient use of existing water supplies and regional opportunities	• None
j. Effect on navigation	• None
k. Consideration of water pipelines and other facilities used for water conveyance	• None

5D.12

Lavaca Off-Channel Reservoir Project (N-12)

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5D.12 Lavaca Off-Channel Reservoir Project (N-12)

5D.12.1 Description of Strategy

The Lavaca-Navidad River Authority (LNRA) has considered multiple scenarios for construction of new reservoir storage, including both on- and off-channel reservoirs. The *Lavaca River Water Supply Project Feasibility Study*, completed in 2011 by Freese & Nichols, Inc., compared a variety of these configuration options, as shown in Figure 5D.12.1 below, and recommended the most feasible scenarios for implementation including either the West Off-Channel Reservoir Project or the East Off-Channel Reservoir Project Alternative B. LNRA's Strategic Resource Management Plan (revised 2013) includes the development of an off-channel option as the preferred approach. A summary of the strategy is provided in this Plan. Additional details regarding the strategy scenarios can be found in the above-mentioned *Lavaca River Water Supply Project Feasibility Study*.

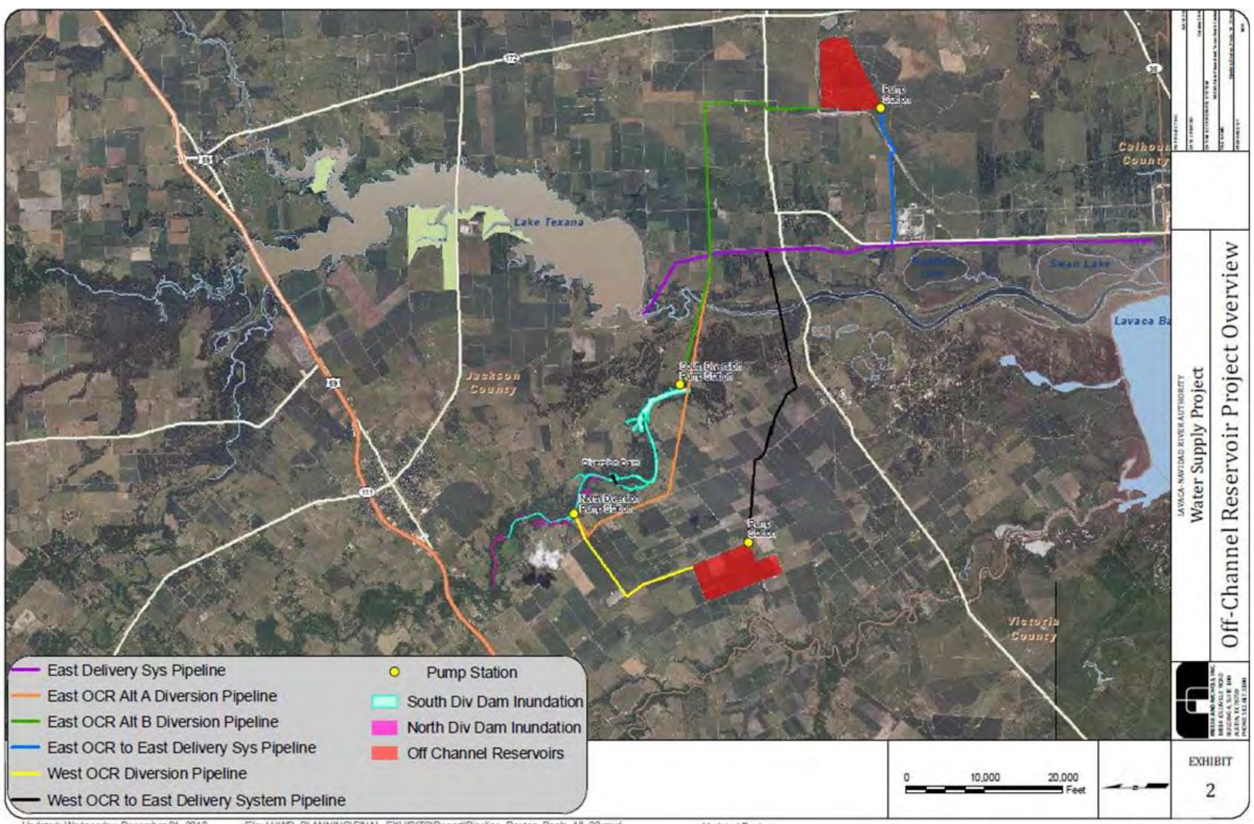

Figure 5D.12.1.
Off-Channel Reservoir Project Location

In both cases of the West Off-Channel and East Off-Channel B Reservoirs, the minimum facility requirements would include the storage reservoir and associated pump stations to deliver water from the river to the reservoir. Diversion points and conceptual level pipeline alignments are different in each scenario and shown in Figure 5D.12.1 above. Two pump stations are required for both off-channel alternatives, including a Lavaca River diversion pump station to divert flows and an off-channel reservoir pump station to deliver raw water to the existing LNRA East Delivery System pipeline.

The associated pump station would turn on when there is sufficient storage in the off-channel reservoir and when there is sufficient depth of water covering the inlet pipe. The amount of water pumped is limited primarily to flow conditions in the river and would likely be restricted to short-duration, high flow events. Thus the associated river pump would be required to pump at significantly high rates in order to capture flood flows. A diversion dam to increase the in-channel storage and optimize pumping opportunities is also considered in the scenarios in order to increase firm yield. A relatively small amount of in-channel storage could increase the project yield at minimal cost compared to the cost of increasing the size of the off-channel reservoir in order to store more water.

The West Off-Channel Reservoir project includes a diversion dam structure (North Diversion Dam) on the Lavaca River, a raw water diversion pump station on the Lavaca River, a raw water diversion pipeline from the diversion pump station to the off-channel reservoir, the West Off-Channel Reservoir, a raw water delivery pump station at the off-channel reservoir, and a raw water delivery pipeline from the West Off-Channel Reservoir to the existing LNRA East Delivery System pipeline serving customers to the south.

The East Off-Channel Reservoir Alternative B project utilizes an alternative diversion dam on the Lavaca River referred to as the South Diversion, a raw water diversion pump station on the Lavaca River, a raw water diversion pipeline from the diversion pump station to the off-channel reservoir, the East Off- Channel Reservoir, a raw water delivery pump station at the off-channel reservoir, and a raw water delivery pipeline from the East Off-Channel Reservoir to the existing LNRA East Delivery System pipeline serving customers to the south.

Based on feedback from the LNRA, East Off-Channel Reservoir Alternative B is the recommended off-channel reservoir water management strategy.

5D.12.2 Available Yield

The firm yield of the Lavaca Off-Channel Reservoir project was analyzed, using an unmodified version of the TCEQ WAM Run 3, to have no negative impacts to the freshwater inflows to Lavaca Bay as dictated by the latest TCEQ environmental flow standards adopted August 2012. Additions and changes to the Base Lavaca WAM to create the strategy analysis are in the Attachment.

The firm yield of the reservoir was determined to be approximately 16,963 ac-ft/yr. This firm yield would increase LNRA's supply as a wholesale water provider. A portion of the yield is identified to meet existing manufacturing water needs in Region L, Calhoun County. The remaining yield would be available to meet potential water needs for municipal, industrial, or other water users in Region P (Jackson County), Region L, or Region N.

The proposed location of the off-channel reservoir is such that it is downstream of all TCEQ adopted environmental flow standard instream flow measurement points along the Lavaca River. The only TCEQ standard that needs to be met is the Bay and Estuary Freshwater Inflow standards for the Lavaca Bay System. The Standards are identified in Table 5D.12.1. Projects requiring new water rights permits shall not cause or contribute to an impairment of the inflow regimes described below.

Table 5D.12.1.
Bay and Estuary Freshwater Inflow Standards for the Lavaca Bay System

Inflow Regime	Spring Inflow Quantity (ac-ft)	Fall Inflow Quantity (ac-ft)	Intervening Inflow Quantity (ac-ft)	Annual Strategy Frequency
Subsistence	13,500	9,600	6,900	96%
Base Dry	55,080	39,168	28,152	82%
Base Average	127,980	91,080	65,412	46%
Base Wet	223,650	158,976	114,264	28%

The Lavaca off-channel reservoir project was modeled so that the model incorporating the strategy either met or exceeded the required annual strategy frequency for each seasonal period; or if the Base Lavaca WAM did not meet the required annual strategy frequency, then the strategy model did not decrease it further. The frequency attainment results are shown in Table 5D.12.2 for the Base WAM and the Strategy WAM, respectively.

Table 5D.12.2.
Base WAM and Lavaca OCR Results

Onset Period	Subsistence		Base Dry		Base Avg.		Base Wet	
	Count	%	Count	%	Count	%	Count	%
Base WAM Results								
Springtime	51	89%	45	79%	38	67%	25	44%
Fall	45	79%	32	56%	19	33%	16	28%
Intervening 6 mo	55	96%	52	91%	45	79%	39	68%
Lavaca OCR Results								
Springtime	51	89%	45	79%	37	65%	24	42%
Fall	45	79%	32	56%	19	33%	16	28%
Intervening 6 mo	55	96%	52	91%	45	79%	38	67%

5D.12.3 Environmental Issues

The Lavaca OCR project involves the building of an approximately 1,019 acre OCR about six miles southwest of Lake Texana in Jackson County. The purpose of this OCR is to store excess river water which is available during high flow events via an intake and pipeline from the Lavaca River. The stored water would then be transferred via a pipeline from the OCR to the existing LNRA East Delivery System pipeline to serve area needs and stabilize an otherwise interruptible water source.

The proposed Lavaca River OCR and associated pipeline routes are situated within the Western Gulf Coastal Plain Ecoregion, in an area designated as the Northern Humid Gulf Coastal Prairies.[1] Deltaic sands, silts, and clays underlie much of this area, which occurs on a gently sloping coastal plain. The original vegetation within this region included primarily grass-lands with a few clusters of oaks (*Quercus* spp.) or maritime woodlands. Historically dominant grassland species include little bluestem (*Schizachyrium scoparium*), yellow Indiangrass (*Sorghastrum nutans*), brownseed paspalum (*Paspalum plicatulum*), gulf muhly (*Muhlenbergia capillaris*), and switchgrass (*Panicum virgatum*). The majority of this region is currently utilized as cropland, rangeland, pasture, or urban land, with woodlands occurring only as remnant riparian strips.[2] Construction of the off-channel reservoir is planned within an area normally used for agriculture; however the pipeline and pump station construction may include the clearing and removal of some areas of riparian vegetation along the Lavaca River and areas southwest of Lake Texana.

The project also occurs within an area known as the Texan Biotic Province.[3] Mammals typical of this province include the Virginia opossum (*Didelphis virginiana*), fox squirrel (*Sciurus niger*), fulvous harvest mouse (*Reithrodontomys fulvescens*), and swamp rabbit (*Sylvilagus aquaticus*). Typical anuran species within this area include the Gulf Coast toad (*Bufo valliceps*), green treefrog (*Hyla cinerea*), bullfrog (*Rana catesbeiana),* and eastern narrowmouth toad (*Microhylla carolinensis*).

In addition, the Lavaca River location where the new diversion pipeline to the Lavaca River OCR originates is listed by the Texas Parks and Wildlife Department (TPWD) as occurring within an Ecologically Significant Stream Segment, a designation which signifies areas of unique ecological value.

Table 5D.12.3 lists nine federally-listed endangered or threatened wildlife and plant species, 22 state-listed endangered and threatened wildlife and plant species, and additional state and federal species of concern that may occur in Jackson County. Information found within this table originates from the county lists of rare species provided by the TPWD online in their "Annotated County Lists of Rare Species".

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[1] Griffith, G.E., Bryce, S.A., Omernik, J.M., Comstock, J.A., Rogers, A.C., Harrison, B., Hatch, S.L., and Bezanson, D., 2004, Ecoregions of Texas (color poster with map, descriptive text, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:2,3000,000).
[2] Gould, F. W., "The Grasses of Texas," Texas A&M University Press, College Station, Texas, 1975.
[3] Blair, W. Frank, "The Biotic Provinces of Texas," Texas Journal of Science 2(1):93-117, 1950.

Inclusion in Table 5D.12.3 does not mean that a species will occur within the project area, but only acknowledges the potential of its occurrence in Jackson County. In addition to the county list, the TPWD Natural Diversity Database (NDD) was reviewed for known occurrences of listed species within or near the project area.

Listed species may have habitat requirements or preferences that suggest they could be present within the project area. However, the presence or absence of potential habitat does not confirm the presence or absence of a listed species. No species specific surveys were conducted in the project area for this report. Surveys for protected species should be conducted within the proposed construction corridors where preliminary evidence reveals preferred habitat or indicates their potential presence.

Table 5D.12.3.
Endangered, Threatened, and Species of Concern for Jackson County

Common Name	***Scientific Name***	***Summary of Habitat Preference***	***Listing Entity***		***Potential Occurrence in County***
			USFWS	***TPWD***	
Birds					
Peregrine Falcon	*Falco peregrinus*	Two subspecies, listing statuses differ; see *anatum* and *tundrius* descriptions below.	DL	T	Possible Migrant
American Peregrine Falcon	*Falco peregrinus anatum*	Resident and local breeder in West Texas. Migrant across the state.	DL	T	Possible Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Migrant throughout the state.	DL		Possible Migrant
Bald eagle	*Haliaeetus leucoephalus*	Found primarily near rivers and large lakes.	DL	T	Possible Migrant
Brown pelican	*Pelecanus occidentalis*	*Largely coastal and near shore areas.*	DL		Resident
Henslow's Sparrow	*Ammodramus henslowii*	Found in weedy fields or cut-over areas			Resident
Interior least tern	*Sterna antillarum athalassos*	Nests along sand and gravel bars in braided streams	LE	E	Resident
Mountain Plover	*Charadrius montanus*	Non-breeding, shortgrass plains and fields			Nesting/ Migrant
Reddish Egret	*Egretta rufescens*	Resident of Texas Gulf coast.		T	Resident
Snowy Plover	*Charadrius alexandrines*	Potential migrant, winters along coast			Migrant
Sooty Tern	*Sterna fuscata*	Usually flies or hovers over water.		T	Resident
Southeastern Snowy Plover	*Charadrius alexandrines tenuirostris*	Wintering migrant along the Texas Gulf Coast.			Migrant
Sprague's Pipit	*Anthus spragueii*	Migrant found in Texas only during winter. Strongly tied to native upland prairie, locally common in coastal grasslands.	C		Possible Migrant

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
Western Burrowing Owl	*Athene cunicularia hypugaea*	Open grasslands, especially prairie, plains and savanna			Resident
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes.		T	Resident
White-tailed hawk	*Buteo albicaudatus*	Found near the coast on prairies, cordgrass flats, and scrub-live oak.		T	Resident
Whooping Crane	*Grus americana*	Potential migrant	LE	E	Potential Migrant
Wood Stork	*Mycteria Americana*	Forages in prairie ponds, ditches, and shallow standing water, formerly nested in TX.		T	Migrant
Fishes					
American eel	*Anguilla rostrata*	Coastal waterways below reservoirs to gulf.			Resident
Smalltooth sawfish	*Pristis pectinata*	Young found very close to shore in muddy and sandy bottoms, adults occur in various habitat types.	LE	E	Resident
Mammals					
Louisiana black bear	*Ursus americanus luteolus*	Possible transient; bottomland hardwoods and forested areas.	LT	T	Possible Transient
Plains spotted skunk	*Spilogale putorius interrupta*	Found in open fields, prairies and croplands.			Resident
Red wolf	*Canis rufus*	Extirpated species formerly known throughout the eastern half of Texas.	LE	E	Extirpated
West Indian manatee	*Trichechus manatus*	Aquatic herbivore found in the gulf and bay system	LE	E	Possible Migrant
Mollusks					
Texas fatmucket	*Lampsilis bracteata*	Found in streams and rivers on sand, mud, and gravel substrates in the Colorado and Guadalupe river basins; intolerant of impoundments.	C	T	Resident
Reptiles					
Green sea turtle	*Chelonia mydas*	Gulf and bay systems.	LT	T	Resident
Gulf saltmarsh snake	*Nerodia clarkia*	Found on saline flats.			Resident
Kemp's Ridley sea turtle	*Lepidochelys kempii*	Found in gulf and bay systems.	LE	E	Resident
Loggerhead sea turtle	*Caretta caretta*	Gulf and bay systems for juveniles, ocean for adults.	LT	T	Resident
Texas diamondback terrapin	*Malaclemys terrapin littoralis*	Found in coastal marshes and tidal flats.			Resident
Texas horned lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands.		T	Resident

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
Texas scarlet snake	*Cemophora coccinea lineri*	Mixed hardwood scrub on sandy soils.		T	Resident
Texas tortoise	*Gopherus berlandieri*	Open brush w/ grass understory.		T	Resident
Timber/ Canebrake rattlesnake	*Crotalus horridus*	Floodplains, upland pine, deciduous woodlands, riparian zones.		T	Resident
Plants					
Shinner's sunflower	*Helianthus occidentalis ssp. Plantagineus*	Found on prairies on the Coastal Plain			Resident
Threeflower broomweed	*Thurovia triflora*	Endemic: near coast.			Resident
Welder machaeranthera	*Psilactis heterocarpa*	Texas endemic found on grasslands.			Resident

LE/LT=Federally Listed Endangered/Threatened
DL=Federally Delisted
E, T=State Listed Endangered/Threatened
Blank = Considered rare, but no regulatory listing status

Source: TPWD, Annotated County List of Rare Species, Jackson County (updated 6/1/2012).

The Migratory Bird Treaty Act protects most bird species, including, but not limited to, cranes, ducks, geese, shorebirds, hawks, and songbirds. Migratory bird pathways, stopover habitats, wintering areas, and breeding areas may occur within and adjacent to the project area, and may be associated with wetlands, ponds, shorelines, riparian corridors, fallow fields and grasslands areas. Although construction of the proposed off-channel reservoir could remove some habitats utilized by certain migratory bird species, it would create additional habitats for others.

Two bird species federally or state listed as endangered are included in the project area county. These include the interior least tern (*Sterna antillarum athalassos*), and whooping crane (*Grus americana*). The interior least tern and whooping crane are seasonal migrants which could pass through the project area. The interior least tern typically nests on bare or sparsely vegetated areas associated with streams or lakes, such as sand and gravel bars, beaches, islands, and salt flats. The main whooping crane flock nests in Canada and migrates annually to their wintering grounds in and around the Aransas National Wildlife Refuge near Rockport on the Texas coast. Whooping cranes occasionally utilize wetlands as an incidental rest stop during this migration.

Avian species listed by the State of Texas as threatened include the peregrine falcon (*Falco peregrinus*), bald eagle (*Haliaeetus leucocephalus*), reddish egret (*Egretta rufescens*), sooty tern (*Sterna fuscata*), white-faced ibis (*Plegadis chihi*), white-tailed hawk (*Buteo albicaudatus*), and wood stork (*Mycteria Americana*). The reddish egret, sooty tern and white-faced ibis are resident bird species within the project area. The peregrine falcon, bald eagle, snowy plover, southeastern snowy plover, and wood stork are migratory species which may occur infrequently within the project area. The peregrine falcon includes two subspecies which migrate across the state from more northern breeding areas in the U.S. and Canada to winter along the coast. The majority of nesting bald eagle pairs currently reported are found along major rivers and near reservoirs in Texas. Bald eagles are opportunistic predators, feeding primarily on fish captured in the shallow water of both lakes and streams or scavenged food sources. These birds may utilize tall trees near perennial water as roosting or nesting sites. Bald eagles are documented by the NDD in areas near Lake Texana.

Many of the listed species found within the project area, such as the Texas Tortoise (*Gopherus berlandieri*), Texas scarlet snake (*Cemophora coccinea lineri*), and timber/canebrake rattlesnake (*Crotalus horridus* are dependent on shrubland or riparian habitats which should be avoided wherever possible. The NDD indicates that the Texas diamondback terrapin (*Malaclemys terrapin littoralis)* has been documented near the mouth of the Lavaca River where it empties into the Lavaca Bay. This reptilian species of concern prefers a habitat which consists of coastal marshes and tidal flats.

Destruction of potential habitat has been minimized by the selection of an OCR project area which lies within previously disturbed areas of cropland. No designated critical habitat areas occur within the project area.[4] Care should be taken to ensure minimum impacts from construction to the existing riparian and wetland areas located along the Lavaca River and below Lake Texana. It is not anticipated that this project will have any permanent adverse effect on any state or federally listed threatened or endangered species or their designated critical habitat.

Habitat studies and surveys for protected species and cultural resources may need to be conducted at the proposed off channel site, and along the pipeline routes. Specific project features, such as pipelines, and off-channel reservoirs generally have sufficient design flexibility to avoid most impacts or significantly mitigate potential impacts to geographically limited environmental and cultural resource sites. Field surveys conducted at the appropriate phase of development should be employed to minimize the impacts of construction and operation on sensitive resources.

Potential wetland impacts are expected to primarily include the raw water pipeline crossing of the Lavaca River and wetland areas which occur south of Lake Texana. These impacts can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

A review of the Texas Historical Commission Texas Historic Sites Atlas database indicated that there are four small cemeteries and two historical markers which occur within or near the area proposed for the construction of the pipeline routes between the OCR and Lake Texana. Avoidance of these areas should be possible through appropriate siting of the project pipelines.

The proposed off-channel reservoir scenario would have substantially less impacts on valuable habitat than the considered on-channel reservoir option. In the off-channel scenarios, some

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[4] USFWS. Critical Habitat Portal. Accessed online at http://ecos.fws.gov/crithab/ on January 15, 2014.

habitat would be altered or lost as a result of temporary flooding and the area impacted would be smaller than that of the on-channel reservoir. The impact of the proposed off-channel reservoir scenarios appears to have minimal or no impact on threatened and endangered species.

The proposed off-channel reservoir scenarios would have a marginal impact on local agricultural activities. Siting of the project and inundation of the off-channel reservoir would remove approximately 1,200 acres of agricultural land from production but would have minimal influence given the large quantity of agricultural land in the area. The proposed off-channel reservoir scenarios would have no impact on navigation. Any diversion dam structure would need to consider navigation impacts.

5D.12.4 Engineering and Costing

Costs for the construction of the off-channel reservoir scenarios are provided in Table 5D.12.4. Costs assumed the more expensive East Off-Channel Alternative B, which is within approximately 10% of the cost of the West Off-Channel scenario. The costs were taken from the Lavaca River Water Supply Project Feasibility Study, and the costs were converted from December 2010 to September 2013. Actual costs could vary significantly due to project implementation requirements. The costs do not include water treatment or raw water purchase.

The total land acquisition and surveying costs related to the 1,065-acre project amounts to $3,276,000. Of this, 1,019 acres is associated with the reservoir footprint at a cost of $3,133,000 (or 96%). The remaining 46 acres associated with land and surveying of acreage associated with appurtenances is $143,000.

Table 5D.12.4.
Cost Estimate Summary for Lavaca Off-Channel Reservoir Project

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Off-Channel Reservoir (Conservation Pool ac-ft, acres)	$63,002,000
Intake Pump Stations (200 and 10 mgd)	$21,454,000
Transmission Pipeline (84-inch pipe for 10 miles; 30-inch pipe for 3.5 miles)	$33,088,000
Integration, Relocations & Other	$5,669,000
TOTAL COST OF FACILITIES	**$123,213,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$41,470,000
Environmental & Archaeology Studies and Mitigation	$3,523,000
Land Acquisition and Surveying (1,200 – 1,300 acres)	$3,276,000
Interest During Construction (4% for 1 year with a 1% ROI)	$6,003,000
TOTAL COST OF PROJECT	**$177,485,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$6,918,000
Reservoir Debt Service (5.5 percent, 40 years)	$5,909,000
Operation and Maintenance	
Intake, Pipeline, Pump Station (1% of Cost of Facilities)	$867,000
Dam and Reservoir (1.5% of Cost of Facilities)	$945,000
Pumping Energy Costs (727187 kW-hr @ 0.09 $/kW-hr)	$65,000
TOTAL ANNUAL COST	**$14,704,000**
Available Project Yield (ac-ft/yr), based on a Peaking Factor of 1	16,963
Annual Cost of Water ($ per ac-ft)	$867
Annual Cost of Water ($ per 1,000 gallons)	$2.66
Annual Cost of Treated Water ($ per ac-ft), with $369 treatment costs assumed	$1,236
Annual Cost of Treated Water ($ per 1,000 gallons)	$3.79

Note: Cost estimate provided by Region P, January 2015.

5D.12.5 Implementation Issues

The off-channel reservoir alternatives minimize challenges to implementation as compared to the on- channel scenario. Water rights, land acquisition, and relocation of infrastructure are considerations in the feasibility of this strategy. The evaluation of this strategy assumes that a new water right permit would be obtained for the project. As such, the TCEQ-adopted, Senate Bill 3-developed environmental flow standards, effective August 30, 2012, would need to be met in order for TCEQ to approve the permit.

Water Rights and Permit Modification

Under Certificates of Adjudication No. 16-2095, 16-2095A, 16-2095B, 16-2095C, and 16-2095D, LNRA is authorized to impound and divert water in the Lavaca and Navidad River basins for municipal, industrial, and recreational uses. These permits allow the use of water from two separate reservoirs, one on the Navidad River (existing Palmetto Bend Dam/Lake Texana) and one on the Lavaca River (proposed Palmetto Bend Stage II).

LNRA is authorized to impound up to 170,300 ac-ft of water in Lake Texana on the Navidad River and an additional 93,340 ac-ft in the proposed Palmetto Bend Stage II reservoir on the Lavaca River. LNRA is authorized to divert and use up to 79,000 ac-ft from Lake Texana for municipal and industrial uses and an additional 36,000 ac-ft (not including bay and estuary maintenance flows) from Palmetto Bend Stage II reservoir for municipal and industrial uses. Diversions are currently limited by location to two points on Lake Texana (East and West Delivery System Pump Stations) and by rate to up to 330 cfs total from Lake Texana. The impoundment and diversions of water each have a priority date of May 15, 1972.

In addition to the permit limitations specified above, the impoundment and diversion of water from Lake Texana is further subject to a bay and estuary release schedule. Inflows into Lake Texana are subject to release from Lake Texana as a function of both reservoir capacity and season. The existing permits further specify that prior to commencement of construction of Palmetto Bend Stage II reservoir, or any diversion of water from Stage II reservoir, upon the joint recommendation of LNRA, TWDB, and Texas Parks and Wildlife Department (TPWD), LNRA shall submit an application to the TCEQ to establish a schedule for the release of freshwater inflows from Stage II reservoir. In establishing the Stage II release schedule, the TCEQ may consider the modification to the Lake Texana release schedule. LNRA shall retain the right to withdraw its application at any time prior to any final decision by the TCEQ and upon withdrawal, the Lake Texana release schedule shall remain unchanged.

The existing water rights permits for Lake Texana and Stage II reservoirs would need to be modified to incorporate changes associated with the proposed Lavaca River Off-Channel Reservoir project. These modifications may include an additional diversion point on the Lavaca River, the impoundment of water in an off-channel reservoir as opposed to the currently permitted on-channel Stage II reservoir, likely changes in the amounts and distribution currently permitted for industrial and municipal uses, potential addition of agricultural use, and a proposed bay and estuary (i.e. pass-through) schedule for the proposed Lavaca River Off-Channel Reservoir project.

It should be noted that these changes in conditions to the existing permit would likely require a major permit modification and require public notification. In addition, it should also be noted that any of these permit modifications, and specifically the required bay and estuary release schedule, could potentially reduce the project yield from the existing Lake Texana and/or the proposed Lavaca River Off-Channel Reservoir project.

5D.12.6 Evaluation Summary

An evaluation summary of this regional water management strategy is provided in Table 5D.12.5.

Table 5D.12.5.
Evaluation Summary of the Lavaca Off-Channel Reservoir Project

Impact Category	***Comment(s)***
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	 1. Firm yield: 16,963 ac-ft 2. Good reliability. 3. Moderate cost; $1,236 per ac-ft.
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. Generally decreases instream flow below diversion. 2. General reduction in bay and estuary inflows. 3. Construction and maintenance of off-channel reservoir site and transmission pipeline corridor(s) may impact wildlife species. 4. Low impact to wetlands. 5. Likely low impact to endangered species. Endangered species survey will be needed to avoid significant sites. 6. Cultural resources survey will be needed to avoid significant sites. 7. Minimal impact to water quality.
c. Impacts to State water resources	• No negative impacts on other water resources
d. Threats to agriculture and natural resources in region	• None
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Standard analyses and methods used for portions
g. Inter-basin transfers	• May be required for use in Region N.
h. Third party social and economic impacts from voluntary redistribution of water	• Not applicable
i. Efficient use of existing water supplies and regional opportunities	• Maximizes opportunities to capture water from a large drainage area during high/moderate inflow events after environmental instream flow requirements are satisfied. Less evaporative losses expected than traditional reservoir.
j. Effect on navigation	• None

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ATTACHMENT

```
                              Additions_changes_to_Lavaca_Base_WAM.txt
Additions/Changes made to Lavaca Base WAM for Lavaca off-channel reservoir analysis.


The strategy model would not meet the subsistence and base dry B&E requirements during the initial
trials, so I attempted to force it to meet the base dry requirements. The base average and base wet
requirements had no problem being met, so I didn't worry about those as much.
**
** AECOM entered use coefficients to meet Base Dry B&E requirements
********************use coefficients for OCR**********************************
**
UCMEDIAN     1960   18360   18360   18360   18360    1960
UC           1960   13056   13056   13056    1960    1960
**
*****************************************************************************************

Some of these control points did not end up being needed (early trial runs), but I haven't
removed them.
** AECOM entered control points for off-channel reservoir
********************CONTROL POINTS for OCR****************************************
**
CP WQ002    20955                         5               GS300       -2
CP 20955   WQ002A                         5               GS300       -2
CPNEWOCR      OUT                         2      NONE     GS300       -3
CPWQ002A   WQ002B                         5                NONE       -2
CPWQ002B   WQ002C                         5                NONE       -2
CPWQ002C   WQ002D                         5                NONE       -2
CPWQ002D    DV212                         5                NONE       -2
**
*********************************************************************************************

LNRA wanted to keep the Stage II on-channel reservoir in the model, but junior to the
new off-channel reservoir.  To continue to meet the B&E requirements, I inserted the instream
flow cards again one day senior to the Stage II diversions.
*********************************************************************************************
**AECOM entered instream flow requirements meeting SB3 Base Dry B&E prior to subordinate Stage II
diversions
**
IF 20955   122408  MEDIAN20170101         1               IFMETESTON
WR 20955     12.0        20170101    1    1       1.0   20955                    METEST      OCR
IF 20955        0  MEDIAN20170101         1               IFMETESTOF
**
IF 20955   122408  MEDIAN20170101         1               MEDIAN-REG
TO      6             LIM      0.1      10.0                          METEST
**AECOM modifies Stage II project to be subordinate to Lavaca OCR
**Change priority date from 19720515 to 20170102 (two days junior to OCR, one day junior to B&E)
**Bay and Estuary flows (2095_5) subordinate to CCEFN flows. Change PD from 19931006 to 20170102
**Change storage capacity from 62454 to 52046 to agree with Reservoir Site Protection Study (TWDB, 2008)
**begin Stage 2 of Texana Project
WR WQ002     7150        120170102   1    1      0.00                        61602095_3 TEXANA2
WSSTAGE2    52046
WR WQ002    22850        220170102   1    1      0.00                        61602095_4 TEXANA2
WSSTAGE2    52046
WR WQ002    18122  BAYES120170102    1    1       1.0   20955                    2095_5
**
**WR WQ002    18122  BAYES119931006    1    1      0.0                          2095_5
**end Stage 2 of Texana Project
***********************************************************************************************************


*******************************************************************************************************
**AECOM add SB3 Base Dry B&E requirements as instream flows for OCR
**
**use dummy water rights to check if diversions can be made under Base Dry B&E requirements.
**Return flows diverted by dummy rights to same control point from which diverted to preserve
**mass balance.
**
IFWQ002A   122408  MEDIAN20161231         1               IFMETESTON
WRWQ002A     12.0        20161231    1    1       1.0  WQ002A                    METEST      OCR
IFWQ002A        0  MEDIAN20161231         1               IFMETESTOF
**
**Utilize diversions made by dummy water rights to set the appropriate instream flow
**requirement for Base Dry B&E requirements.  Since WRAP mdoel protects downstream
**water rights, IF requirement to protect ds senior wr is unnecessary and commented out.
**
**Base Dry IF
IFWQ002D   122408  MEDIAN20161231         1               MEDIAN-REG
TO      6             LIM      0.1      10.0                          METEST
*************************************************************************************
**
**

                                          Page 1
```

```
                              Additions_changes_to_Lavaca_Base_WAM.txt
*****************************************************************************
**AECOM diversion for Lavaca OCR (using storage/pumping recommended in 2011 Lavaca River Water Supply
**Project Feasibility Study for LNRA)
**
WR WQ002       0      120161231   1   1                                        Fill  NEWOCR
** 25,000 ac-ft capacity
WSNEWOCR   25000  0.0024        1  969.85
SO                      WQ002
** 200 MGD (224,182 ac-ft/yr) pump stations diversion rate.  ML record in ac-ft/mo.
ML 19027 17339.2 19027.1 18413.3 19027.1 18413.3 19027.1 19027.1 18413.3 19027.1 18413.3 19027.1
**
**      Modeled as new WR with Priority Date set at 12/31/2016
WR WQ002 16963.0      120161231   3   1                                       NewWR1    9991
WSNEWOCR   25000
**end of diversion additions
*******************************************************************************************

This change was made to the model in the previous planning cycle, so I included it as well. It just
adjusts
the area volume curve of the Stage II on-channel reservoir.
*******************************************************************************************************
** Modify stage 2 reservoir to match Reservoir Site Protection Study (TWDB, 2008)
** area capacity of Stage 2 taken from HDR document to RPG dated 10/19/1999
** AECOM commented out
**SVSTAGE2   62454   57676   40543   23475   11695    4980    1819     596     152       0
**SA          4887    4679    3888    2940    1774     914     352     138      40       0
SVSTAGE2   52046   35152   19182    8360    2927    1127     507     161       5       0
SA          4564    3688    2725    1649     609     159      92      49      16       0
**
*********************************************************************************************************
***
```

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LAVACA OFF-CHANNEL RESERVOIR PROJECT COST TABLE

October 2014

Project Costs from 2011 Lavaca Water Supply Project Feasibility Study (Project Formosa Alt B, 200MGD) converted from December 2010 to September 2013.

OPINION OF PROBABLE CONSTRUCTION COST **SEPTEMBER 2013**

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
	DIVERSION DAM				$ 3,746,439
	Mobilization (5%)	1	LS	$ 173,160	$ 173,160
	Clearing And Grubbing	5	acres	$ 5,340	$ 26,700
	Care Of Water	1	LS	$ 266,750	$ 266,750
	Excavation	4667	CY	$ 5	$ 23,335
	Earthfill	2074	CY	$ 6	$ 12,444
	Concrete	2100	CY	$ 480	$ 1,008,000
	Gates	99000	LB	$ 11	$ 1,089,000
	Gate Operation Equipment	1	LS	$ 1,067,000	$ 1,067,000
	Revegetation	5	acres	$ 16,010	$ 80,050
	OFF CHANNEL RESERVOIR				$ 63,001,586
	Mobilization (5%)	1	LS	$ 2,893,060	$ 2,893,060
	Clearing And Grubbing	1170	AC	$ 5,340	$ 6,247,800
	Care Of Water	1	LS	$ 53,350	$ 53,350
	Excavation	4800000	CY	$ 3	$ 15,364,800
	Earthfill	4500000	CY	$ 4	$ 19,206,000
	Spillway	1	LS	$ 266,750	$ 266,750
	Slope Protection	225000	CY	$ 64	$ 14,404,500
	Underdrain System	30300	LF	$ 64	$ 1,939,806
	Flex Base Road	9000	CY	$ 43	$ 384,120
	Revegetation	140	AC	$ 16,010	$ 2,241,400
	200 MGD PUMP STATION				$ 7,039,080
	Sitework	1	LS	$ 533,500	$ 533,500
	Care of Water	1	LS	$ 106,700	$ 106,700
	50 MGD Vertical Turbine Pump	4	EA	$ 640,200	$ 2,560,800
	36" Discharge Piping	40	LF	$ 580	$ 23,200
	36" Pump Control Valve	4	EA	$ 160,050	$ 640,200
	72" Discharge Header	75	LF	$ 1,150	$ 86,250
	Wetwell				
	Excavation	17250	CY	$ 11	$ 189,750
	Concrete	350	CY	$ 850	$ 297,500
	Backfill (10' Flowable, 5' Select Fill)	15770	CY	$ 19	$ 299,630
	Foundation	1	LS	$ 533,500	$ 533,500
	Pump Building	5400	SF	$ 270	$ 1,458,000
	Electrical Room	1875	SF	$ 80	$ 150,000
	Bridge Crane	1	LS	$ 160,050	$ 160,050
	200 MGD PUMP STATION INTAKE				$ 4,265,000
	Intake Structure and Screen	1	LS	$ 3,201,000	$ 3,201,000
	60" Intake Pipe	2800	LF	$ 380	$ 1,064,000
	200 MGD PUMP STATION PIPELINE				$ 30,160,000
	84" Pipe	52000	LF	$ 580	$ 30,160,000
	200 MGD PUMP STATION ELECTRICAL				$ 3,307,720
	1750 HP, 4160V Soft Starter	4	EA	$ 186,730	$ 746,920
	SCADA and Instrumentation	1	LS	$ 213,400	$ 213,400
	Miscellaneous Electrical	1	LS	$ 426,800	$ 426,800
	1750 kW Generator	3	EA	$ 640,200	$ 1,920,600
	10 MGD PUMP STATION				$ 1,811,475
	Sitework	1	LS	$ 213,400	$ 213,400
	Care of Water	1	LS	$ 53,350	$ 53,350
	5 MGD Vertical Turbine Pump	3	EA	$ 160,050	$ 480,150

LAVACA OFF-CHANNEL RESERVOIR PROJECT COST TABLE

October 2014

	12" Discharge Piping	40	LF	$	190	$	7,600
	12" Pump Control Valve	3	EA	$	53,350	$	160,050
	30" Discharge Header	50	LF	$	480	$	24,000
	Excavation	2520	CY	$	10	$	25,200
	20" Suction Piping	60	LF	$	210	$	12,600
	36" Pump Barrels	3	EA	$	16,010	$	48,030
	Backfill (10' Flowable, 5' Select Fill)	2475	CY	$	53	$	131,175
	Foundation	1	LS	$	213,400	$	213,400
	Pump Building	1508	SF	$	270	$	407,160
	Electrical Room	442	SF	$	80	$	35,360
	10 MGD INTAKE					**$**	**590,500**
	Intake Structure and Screen	1	LS	$	533,500	$	533,500
	30" Intake Pipe	300	LF	$	190	$	57,000
	10 MGD PIPELINE					**$**	**2,928,000**
	30" Pipe	18300	LF	$	160	$	2,928,000
	10 MGD PUMP STATION ELECTRICAL					**$**	**693,550**
	100 HP, 480V Soft Starter	3	EA	$	53,350	$	160,050
	SCADA and Instrumentation	1	LS	$	106,700	$	106,700
	Miscellaneous Electrical	1	LS	$	213,400	$	213,400
	400 kW Generator	1	EA	$	213,400	$	213,400
	IMPACTS					**$**	**5,669,260**
	20" Natural Gas Pipeline Relocation	28000	LF	$	150	$	4,200,000
	Low Water Crossing Replacement	1	LS	$	1,469,260	$	1,469,260
		Construction (Capital) Cost Subtotal				**$**	**123,212,610**

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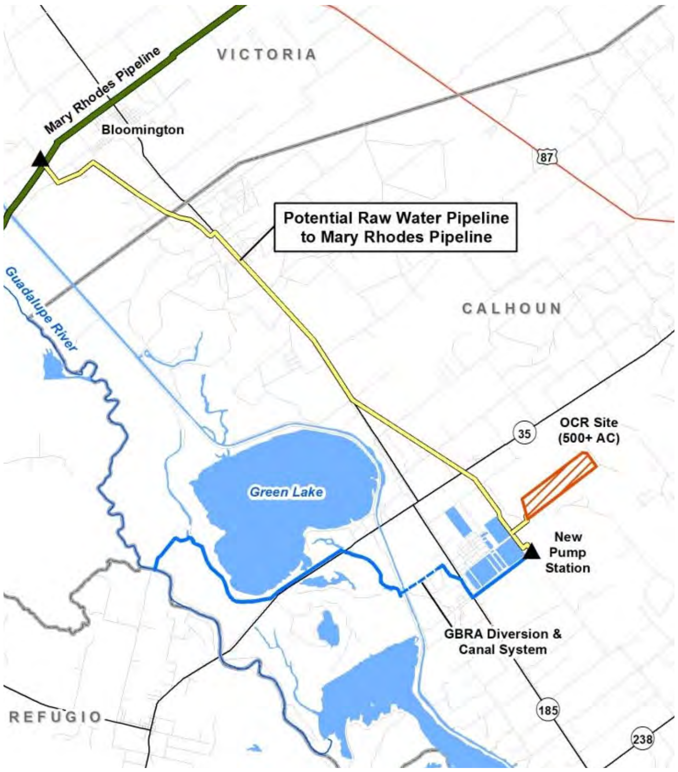

5D.13

GBRA Lower Basin Storage Project

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5D.13 GBRA Lower Basin Storage Project

5D.13.1 Description of Water Management Strategy

The Guadalupe-Blanco River Authority (GBRA) and Dow Chemical Company (Dow), individually and collectively, own surface water rights in the lower Guadalupe - San Antonio River Basin (the GBRA/Dow Water Rights) authorizing diversions totaling from the run-of-river flow of the Guadalupe River totaling 175,501 ac-ft/yr. Table 5D.13.1 lists the individual water rights owned by GBRA and Dow and provides their individual permit number, certificate of adjudication number, priority date, annual diversion, authorized uses, and ownership. Water available for diversion under these rights for use by GBRA or Dow is governed by the complex interactions of natural, anthropogenic, and legal factors including rainfall, runoff, springflow, evaporation, aquifer recharge, diversions by other water right owners, reservoir operations, off-channel storage, treated effluent from municipal and industrial water users, terms and conditions of contracts between GBRA and Dow, terms and conditions of the water rights, and the prior appropriation doctrine as enforced by the South Texas Watermaster of the Texas Commission on Environmental Quality (TCEQ). Given that the GBRA/Dow Water Rights point of diversion near Tivoli is below the San Antonio River confluence and that they are senior in priority to most upstream water rights in both the Guadalupe and San Antonio River Basins, it is recognized that they are quite reliable but not firm.

Table 5D.13.1.
GBRA/Dow Water Rights in the Lower Guadalupe River Basin

Permit Number	Certificate of Adjudication	Priority Date	Annual Diversion (ac-ft/yr)	Authorized Uses	Ownership
1319	18-5173	02/03/1941	2,500	Irrigation/Industrial	GBRA/Dow
1362	18-5174	06/15/1944	1,870	Irrigation/Industrial	GBRA/Dow
1564	18-5175	02/13/1951	940	Irrigation/Industrial/ Mining/Livestock	GBRA/Dow
1592	18-5176	06/21/1951	9,944	Irrigation/Industrial/ Municipal	GBRA/Dow
1375	18-5177	01/03/1944	10,000	Irrigation/Industrial/ Municipal	Dow
		01/03/1944	32,615	Irrigation/Industrial/ Municipal	GBRA/Dow
		01/26/1948	8,632	Irrigation/Industrial	GBRA/Dow
1614	18-5178	01/07/1952	106,000	Irrigation/Industrial/ Municipal	GBRA/Dow
1562	18-3863	03/01/1951	3,000	Irrigation/Industrial/ Municipal	GBRA
2120	18-5484	05/15/1964	N/A	Diversion Dam & Salt Water Barrier	GBRA
Total = 175,501 ac-ft/yr					

To firm up the run-of-river supplies of water available under the GBRA/Dow Water Rights, an off-channel reservoir (OCR) near the GBRA Main Canal and Dow Seadrift Operations facilities is considered for implementation. Although final site selection has yet to be completed, the OCR could be located approximately 3 miles east of Green Lake as illustrated in Figure 5D.13.1. The off-channel reservoir would likely have a water depth of about 25 feet and be capable of impounding approximately 12,500 ac-ft of water. A pressure pipeline would transport water diverted from the GBRA Main Canal to the OCR site and a gravity outlet pipeline would return stored water to the GBRA Main Canal.

Figure 5D.13.1.
GBRA Lower Basin Storage Example Off-Channel Site Location

Although the project site is located in the lower Guadalupe - San Antonio River Basin in the South Central Texas Region (Region L), inter-regional opportunities exist for project sponsors in the Coastal Bend Region (Region N) and other regions to participate in development of the GBRA Lower Basin Storage Project. The City of Corpus Christi's Mary Rhodes Pipeline and Bloomington Pump Station, which delivers Lake Texana and Colorado River supplies to the Coastal Bend Region, is located 15 miles north of the OCR and could be used to deliver raw water supplies from the project to O.N. Stevens WTP in Nueces County or SPMWD water treatment plant complex in San Patricio County[1] for treatment, if needed, prior to distribution to water users. Depending on water availability in accordance with water right/contract provisions, the Mary Rhodes Pipeline could have an unassigned, remaining capacity of up to 15,000 to

[1] Subject to the City's contract agreement maximums and delivery rates of Mary Rhodes Pipeline supplies to SPMWD.

35,000 ac-ft/yr to deliver additional water supplies through the Mary Rhodes Pipeline for integration into the regional CCR/LCC/Texana/MRP Phase II system.[2] A map showing the proximity of the OCR to Mary Rhodes Pipeline is included as Figure 5D.13.2.

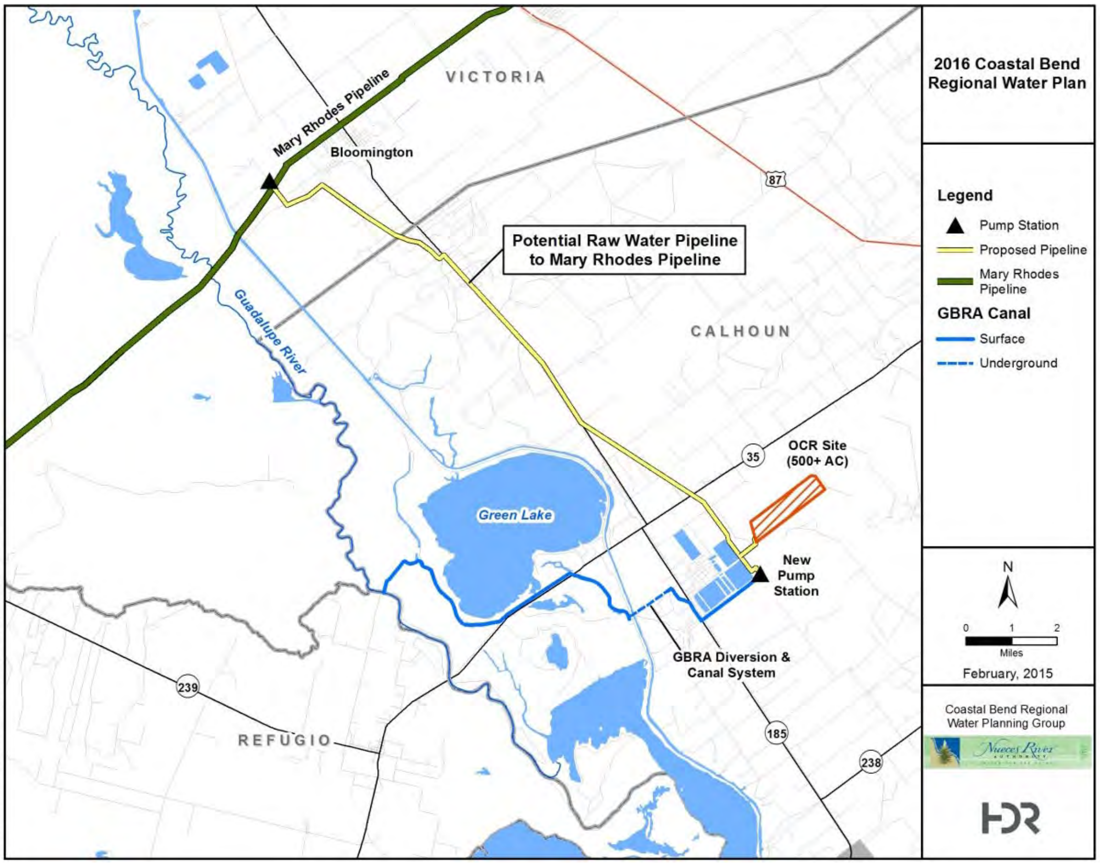

Figure 5D.13.2.
Example Conceptual Route for Delivery of GBRA Lower Basin Stored Water to the Mary Rhodes Pipeline at Bloomington Pump Station

5D.13.2 Water Availability

The firm yield of the GBRA Lower Basin Storage project was analyzed, using an unmodified version of the TCEQ WAM Run 3, to have no negative impacts to the freshwater inflows as dictated by the latest TCEQ environmental flow standards adopted August 2012

Initial water availability calculations were performed using the Guadalupe - San Antonio River Basin Water Availability Model (GSA WAM). The GSA WAM is a monthly time-step computer model used to estimate regulated streamflow and water available for diversion under existing water rights on a priority basis subject to technical assumptions regarding natural, anthropo-

[2] Assumes the Mary Rhodes delivery system will be operated to prioritize MRP Phase II supplies (up to 35,000 ac-ft/yr) and Lake Texana supplies (up to 53,840 ac-ft/yr for base contract and interruptible).

genic, and legal factors. General technical assumptions used for the applications of the GSA WAM summarized herein include:

a. Surface water rights modeled at full consumptive amounts per certificates of adjudication and permits.

b. Edwards Aquifer withdrawals, critical period management, and resulting springflows consistent with the approved Habitat Conservation Plan (Phase I) developed through the Edwards Aquifer Recovery Implementation Program.

c. Subordination of all senior Guadalupe River hydropower water rights to Canyon Reservoir.

d. For firm water supply modeling purposes, the total run-of-river supply of water available under the GBRA/Dow Water Rights at any time is assumed to be allocated first to satisfy projected demands for firm water at that time among all present and future GBRA customers and then, to the extent additional run-of-river water is available, to storage in the proposed off-channel reservoir.

e. For firm water supply modeling purposes, projected demands for firm water by all present and future GBRA customers are assumed to be in accordance with current GBRA planning.

f. Two alternative assumptions regarding treated wastewater:

    i. 100% direct re-use of all treated wastewater throughout both the Guadalupe and San Antonio River Basins (unmodified TCEQ WAM Run 3).

    ii. Treated wastewater discharges reported for 2011 adjusted for 2011 direct reuse commitments.

    Note: For firm water supply modeling purposes, future increases in discharges of treated wastewater above those assumed under alternative ii will result in a firm supply greater than the alternative ii supply.

g. Multiple regulated streamflow extractions from each GSA WAM simulation were necessary to account for the effects of diversions by INVISTA/DuPont (CA# 18-3861) on firm supply available to the GBRA/Dow Water Rights on a daily basis. The only large non-GBRA/Dow water right in either the Guadalupe River Basin or the San Antonio River Basin having a priority date senior to some (and junior to other) GBRA/Dow Water Rights is held by INVISTA/DuPont.

A specially-designed Microsoft Excel workbook was applied to disaggregate monthly regulated streamflow values from the GSA WAM to daily values using historical daily streamflow patterns and obtain estimates of firm water supply available under the GBRA/Dow Water Rights on a daily basis. Historical daily streamflow patterns representative of the Guadalupe River near Tivoli are based on flows for the Guadalupe River at Victoria (USGS# 08176500), Coleto Creek near Victoria (USGS# 08177500), and the San Antonio River at Goliad (USGS# 08188500) obtained from project files for a 1998 study for the 1934 through 1989 period. These daily streamflow values were then used, along with applicable seasonal demand patterns associated with assumed types of use, to determine the firm supply available under the GBRA/Dow Water Rights on a daily basis without the proposed off-channel reservoir. The firm supplies available from the GBRA/Dow Water Rights without the proposed off-channel reservoir assuming 100% direct reuse of all treated wastewater in the two River Basins and assuming 2011 discharges of treated wastewater are about 15,000 ac-ft/yr and 42,500 ac-ft/yr, respectively. The security of supply of these firm supply figures likely are not truly comparable to firm supplies with the proposed off-channel reservoir because, without the off-channel reservoir, there is no allowance for even short time periods during which the run-of-river flows could drop below those assumed in the modeling. On the other hand, these firm supply figures also do not account for any storage between diversion from the Guadalupe River and ultimate users. Dow, Seadrift Coke, INEOS Nitriles, and the Port Lavaca Water Treatment Plant do, however, have on-site storage that could be drawn upon for short periods during which water from the river is limited or unavailable. Hence, the total firm water supply on a daily basis without the proposed off-channel reservoir may in fact be incrementally lesser or greater than the amounts presented herein.

Firm water supplies available on a daily basis under the GBRA/Dow Water Rights can be enhanced with development and integration of off-channel storage. Analyses of potential enhancement of firm water supplies with off-channel storage are based on:

a. Off-channel reservoir capacity of approximately 12,500 ac-ft;
b. Simplified off-channel reservoir operations simulations assuming maximum and minimum water depths of 25 feet and approximately 3 feet, respectively;
c. Delivery of water into off-channel reservoir at a maximum rate of 50 cfs; and
d. Historical net evaporation from the GSA WAM.

Under the above assumptions, firm water supply could be increased from 15,000 ac-ft/yr to 66,800 ac-ft/yr (51,800 ac-ft/yr increase) with the addition of a 12,500 ac-ft off-channel storage reservoir assuming 100% direct reuse of all treated wastewater in the two River Basins. Assuming 2011 discharges of treated wastewater, firm water supply could be increased from 42,500 ac-ft/yr to 118,000 ac-ft/yr (75,500 ac-ft/yr increase) with the addition of a 12,500 ac-ft off-channel storage reservoir. As indicated above, future increases in discharges of treated wastewater above 2011 discharges would result in a firm supply greater than 118,000 ac-ft/yr. Additionally, the firm supply would also be increased by increasing the rate of delivery of water into the off-channel reservoir above the assumed maximum rate of 50 cfs.

Based on information provided by Region L, it is assumed that at least 20,000 ac-ft/yr of reliable yield is available from the GBRA Lower Basin Storage Project after taking into account other potential project participants. The delivery of supplies through the Mary Rhodes Pipeline to Region N would allow flexibility to operate the new supplies generated by the project in conjunction with Lake Texana and Colorado supplies to optimize total water delivery from the Colorado, Lavaca-Navidad, and Guadalupe - San Antonio Basins. Through system optimization of these supplies from the east, it reduces reliance on the Nueces Basin for regional water supply while continuing to reliably meet future water demands in the Coastal Bend Region amid high growth trends and drought uncertainty. This strategy assumes a project yield of 20,000 ac-ft/yr is available for delivery to Region N wholesale water providers and/or water user groups.

5D.13.3 Environmental Issues

The GBRA Lower Basin Storage water management strategy includes the diversion of water from the Guadalupe River via the Calhoun Canal System to an off-channel reservoir located east of Green Lake in Calhoun County. The off-channel reservoir will facilitate water storage which will be utilized by municipal and industrial operations. Facilities needed for this new water management strategy will include an off-channel reservoir, a new pump station and intake on the GBRA Main Canal, and piping to and from the off-channel reservoir.

The project area is located in the Gulf Coastal Plains of Texas Physiographic Province, specifically in the subprovince of the Coastal Prairies. This area is locally characterized as a nearly flat prairie composed of deltaic sands and muds which terminates at the Gulf of Mexico and includes topography changes of less than one foot per mile. Elevation levels in the Coastal Prairies range from 0 to 300 feet above mean sea level. Land uses found within the proposed on-site storage area include primarily farm, pasture, and range areas.

The off-channel reservoir area is found within the Gulf Prairies and Marshes Vegetational Area. Gulf Prairies have slow surface drainage and elevations that range from sea level to 250 feet. These areas include nearly level and virtually undissected plains. Originally, the Gulf Prairies were composed of tallgrass prairie and post oak savannah. However, tree species such as honey mesquite (*Prosopis glandulosa*) and acacia (*Acacia* ssp.), along with other trees and shrubs, have increased in this area forming dense thickets in many places. Typical oak species found in this area include live oak (*Quercus virginiana*) and post oak (*Q. stellata*), in addition to huisache (*Acacia smallii*), black-brush (*A. rigidula*), and a dwarf shrub identified as bushy sea-ox-eye (*Borrichia frutescens*). Principal climax grasses of the Gulf Prairies include gulf cordgrass (*Spartina spartinae*), indiangrass (*Sorghastrum nutans*), and big bluestem (*Andropogon gerardii* var. *gerardii*). Prickly pear (*Opunita* spp.) are common within this area, along with forbs including asters (*Aster* sp.), poppy mallows (*Callirhoe* sp.), bluebonnets (*Lupinus* sp.), and evening primroses (*Oenothera* spp.).

Gulf Marshes range from sea level to a few feet in elevation, and include low, wet marshy coastal areas commonly covered with saline water. These salty areas support numerous species of sedges (*Carex* and *Cyperus* sp.), bulrushes (*Scirpus* sp.), rushes (*Juncus* sp.), and grasses. Aquatic forbs found in these areas generally include pepperweeds (*Lepidium* sp.), smartweeds (*Polygonum* sp.), cattails (*Typha domingensis*) and spiderworts (*Tradescantia* sp.) among others. Upland game and waterfowl find these low marshy areas to be excellent natural wildlife habitat.

The federal Endangered Species Act of 1973, as amended, prohibits the “take” of any threatened or endangered species. The term “take” under the ESA means “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct.” The term “harm” was further defined to include “significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering." Designation of critical habitat areas has been established for the public knowledge where the publishing of such information would not cause harm to the species. Additional federal protection is extended to migratory birds, and bald and golden eagles under the Migratory Bird Treaty Act (MBTA) as amended, and the Bald and Golden Eagle Protection Act. Protection is also afforded to Texas state-listed species by the Texas Parks and Wildlife Department (TPWD) through state regulations.

The MBTA protects most bird species, including, but not limited to, cranes, ducks, geese, shorebirds, hawks, and songbirds. Migratory bird pathways, stopover habitats, wintering areas, and breeding areas may occur within and adjacent to the off-channel reservoir area, and may be associated with wetlands, ponds, shorelines, riparian corridors, fallow fields and grasslands, and woodland and forested areas. Reservoir and other construction activities could disturb migratory bird habitats and/or species' activities.

Reasonable and prudent measures should be taken to avoid and minimize the potential effects of the proposed project activities on threatened and endangered species as well as bald eagles. Species' locations, activities, and habitat requirements should be considered based on U.S. Fish and Wildlife Service (USFWS) and TPWD recommendations.

Thirty state-listed endangered or threatened species and 16 federally-listed endangered or threatened wildlife species may occur in Calhoun County, according to the county lists of rare species published by the TPWD. A list of these species, their preferred habitats, and potential occurrence in Calhoun County is provided in Table 5D.13.2. Inclusion in Table 5D.13.2 does not imply that a species will occur within the project area, but only acknowledges the potential for its occurrence in Calhoun County. A more intensive field reconnaissance would be necessary to confirm and identify specific suitable habitat that may be present in the project area.

Table 5D.13.2. Endangered, Threatened, and Species of Concern for Calhoun County

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Federal Status	State Status	Potential Occurrence in County
AMPHIBIANS								
Black-spotted newt	Notophthalmus meridionalis	1	2	2	Found in wet or sometimes wet areas on the Gulf Coastal Plain	--	T	Resident
Sheep frog	Hypopachus variolosus	1	2	2	Found predominantly in grassland and savanna in moist sites of arid areas	--	T	Resident
Southern crawfish frog	Lithobates areolatus areolatus	1	1	1	Found in abandoned crawfish holes and small mammal burrows	--	--	Resident
BIRDS								
Peregrine falcon	*Falco peregrinus anatum* (American)	0	2	0	Open county; cliffs	DL	T	Nesting/ Migrant
	Falco peregrinus tundrius (Arctic)	0	1	0	Open county; cliffs	DL	--	Nesting/ Migrant
Bald eagle	*Haliaeetus leucocephalus*	1	2	2	Large bodies of water with nearby resting sites	DL	T	Nesting/ Migrant
Brown pelican	*Pelecanus occidentalis*	0	1	0	Coastal inlands for nesting, shallow gulf and bays for foraging	DL	--	Resident
Eskimo curlew	*Numenius borealis*	0	3	0	Historic and non-breeding	LE	E	Historic Resident
Henslow's sparrow	*Ammodramus henslowii*	0	1	0	Wintering individuals found in weedy fields or cut-over areas	--	--	Migrant
Mountain plover	*Charadrius montanus*	0	1	0	Breeding, nesting on shortgrass prairie	--	--	Resident
Northern Aplomado Falcon	*Falco femoralis septentrionalis*	0	3	0	Found in open country, especially savanna and open woodland	LE	E	Resident
Piping plover	*Charadrius melodus*	1	2	2	Beaches and flats of coastal Texas	LT	T	Migrant
Red knot	*Clidris canutus rufa*	0	1	0	Migrant, nesting in the arctic and flying to South America during winter	C	--	Migrant
Reddish egret	*Egretta rufescens*	1	2	2	Coastal inlands for nesting, coastal marshes for foraging	--	T	Resident
Snowy plover	*Charadrius alexandrinus*	1	1	1	Potential migrant, wintering along the coast	--	--	Migrant
Sooty tern	*Sterna fuscata*	1	2	2	Catches small fish as it hovers or flies over water	--	T	Resident
Southeastern snowy plover	*Charadrius alexandrinus tenuirostris*	1	1	1	Wintering migrant along coast	--	--	Migrant

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Federal Status	State Status	Potential Occurrence in County
Sprague's Pipit	*Anthus spragueii*	1	1	1	Migrant in winter, found in native upland prairie and coastal grasslands	C	--	Migrant
Western burrowing owl	*Athene cunicularia hypugaea*	1	1	1	Open grasslands, especially prairie	--	--	Resident
Western snowy plover	*Charadrius alexandrinus nivosus*	0	1	0	Uncommon breeder in Panhandle. Potential migrant	--	--	Migrant
White-faced ibis	*Plegadis chihi*	1	2	2	Prefers freshwater marshes	--	T	Resident
White-tailed hawk	*Buteo albicaudatus*	0	2	0	Coastal prairies, savannahs and marshes in Gulf Coastal Plain	--	T	Resident
Whooping crane	*Grus Americana*	1	3	3	Winters in coastal marshes	LE	E	Migrant
Wood stork	*Mycteria Americana*	1	2	2	Forages in prairie ponds, ditches and shallow standing water; formerly nested in Texas	--	T	Migrant
FISHES								
American eel	*Anguilla rostrata*	1	1	1	Coastal waterways to Gulf.	--	--	Resident
Opossum pipefish	*Microphis brachyurus*	1	2	2	Brooding adults found in fresh or low salinity waters and young in more saline waters; Southern coastal areas	--	T	Aquatic Resident
Smalltooth sawfish	*Pristis pectinata*	1	3	3	Found in sheltered bays, on shallow banks and in estuaries or river mouths	LE	E	Aquatic Resident
MAMMALS								
Black bear	*Ursus americanus*	0	2	0	Possible as transient in bottomland hardwoods and inaccessible forested areas	T/SA; NL	T	Historic
Jaguarundi	*Herpailurus yaguarondi*	1	3	3	Thick brushlands near water	LE	E	Resident
Louisiana black bear	*Ursus americanus luteolus*	0	2	0	Possible as transient in bottomland hardwoods and inaccessible forested areas	LT	T	Historic
Ocelot	*Leopardus pardalis*	1	3	3	Dense chaparral thickets; mesquite-thorn shrub and live oak stands	LE	E	Resident
Plains spotted skunk	*Spilogale putorius interrupta*	1	1	1	Open fields, and prairies	--	--	Resident
Red wolf	*Canis rufus*	0	3	0	Extirpated	LE	E	Historic
West Indian manatee	*Trichechus manatus*	0	3	0	Gulf and bay system; opportunistic, aquatic herbivore	LE	E	Aquatic Resident
MOLLUSKS								
Creeper (squawfoot)	*Strophitus undulates*	1	1	1	Freshwater mussel in Colorado, Guadalupe, San Antonio, Neches, and Trinity River basins	--	--	Resident

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Federal Status	State Status	Potential Occurrence in County
REPTILES								
Atlantic hawksbill sea turtle	*Eretmochelys imbricate*	0	3	0	Gulf and bay systems; warm shallow waters in rocky marine environments	LE	E	Aquatic Resident
Green sea turtle	*Chelonia mydas*	0	2	0	Gulf and bay systems; shallow water	LT	T	Aquatic Resident
Gulf saltmarsh snake	*Nerodia clarkii*	1	1	1	Saline flats and river mouths	--	--	Resident
Kemp's Ridley sea turtle	*Lepidochelys kempii*	0	3	0	Gulf and bay systems; shallow waters	LE	E	Aquatic Resident
Leatherback sea turtle	*Dermochelys coriacea*	0	3	0	Gulf and bay systems	LE	E	Aquatic Resident
Loggerhead sea turtle	*Caretta caretta*	0	2	0	Gulf and bay systems	LT	T	Aquatic Resident
Texas diamondback terrapin	*Malaclemys terrapin littoralis*	1	1	1	Coastal marshes and tidal flats	--	--	Resident
Texas horned lizard	*Phrynosoma cornutum*	1	2	2	Varied; sparsely vegetated uplands	--	T	Resident
Texas scarlet snake	*Cemophora coccinea lineri*	0	2	0	Mixed hardwood scrub	--	T	Resident
Texas tortoise	*Gopherus berlandieri*	1	2	2	Open bush with grass understory	--	T	Resident
Timber rattlesnake	*Crotalus horridus*	1	2	2	Floodplains, riparian zones with dense ground cover	--	T	Resident
PLANTS								
Three-flower broomweed	*Thurovia triflora*	1	1	1	Endemic, remnant grasslands and tidal flats	--	--	Resident

DL = Delisted
T/SA; NL= Threatened by similarity of appearance, not listed
PD = Proposed for Delisting
LE = Federally listed endangered
LT = Federally listed threatened
Blank = Not Federally or State Listed but considered a Species of Concern
E = State Endangered
T = State Threatened
TPWD, 2015. Annotated County List of Rare Species – Calhoun County, revised 12/11/2014.
USFWS, 2015. Endangered Species List for Texas. http://ecos.fws.gov/tess_public/reports/species-by-current-range-county?fips=48057 accessed online February 25, 2015.

Three bird species federally or state listed as endangered are included in the project area. These include the eskimo curlew (*Numenius borealis*), northern aplomado falcon (*Falco femoralis septentrionalis*), and whooping crane (*Grus americana*). The eskimo curlew is a historic resident of the area, the northern aplomado falcon is a resident species, and the whooping crane is a seasonal migrant which could pass through the project area. The main whooping crane flock nests in Canada and migrates annually to their wintering grounds in and around the Aransas National Wildlife Refuge near Rockport on the Texas coast. Whooping cranes occasionally utilize wetlands as an incidental rest stop during this migration. Habitat elements which are attractive to these bird species may be present on or adjacent to the proposed off-channel reservoir site or pipeline route.

Avian species federally or state listed as threatened include the peregrine falcon (*Falco peregrinus*), reddish egret (*Egretta rufescens*), sooty tern (*Sterna fuscata*), white-faced ibis (*Plegadis chihi*), white-tailed hawk (*Buteo albicaudatus*), wood stork (*Mycteria Americana*), piping plover (*Charadrius melodus*), and bald eagle (*Haliaeetus leucocephalus*). The peregrine falcon includes two subspecies which migrate across the state from more northern breeding areas in the U.S. and Canada to winter along the coast. The majority of nesting bald eagle pairs currently reported are found along major rivers and near reservoirs in Texas. Bald eagles are opportunistic predators, feeding primarily on fish captured in the shallow water of both reservoirs and streams or scavenged food sources. These birds may utilize tall trees near perennial water as roosting or nesting sites. Bald eagles occur as migrants within south Texas and have been documented as occurring near the project area. The remaining bird species, excluding the white-tailed hawk, are generally found within marshy or wet areas foraging for food. Development of the off-channel reservoir could provide additional habitat for those species which prefer a wet environment.

Listed terrestrial reptile species found within Calhoun County, such as the Texas tortoise, Texas scarlet snake, and the Texas horned lizard are dependent on shrubland or riparian habitats which should to be avoided wherever possible. Although suitable habitat for the state threatened Texas horned lizard may exist within the project area, no impact to this species is anticipated due to the abundance of similar habit near the project area and this species' ability to relocate to those areas if necessary. The timber rattlesnake, a state-threatened species, may be found in the riparian woody vegetation of the area. Destruction of these potential habitats can be minimized by selecting previously disturbed areas, such as croplands for project construction. Selection of a pipeline right-of-way alongside existing habitat could also be beneficial to some wildlife species by providing edge habitat; however, the majority of these areas within the project area are small and fragmented. Care should be taken to ensure minimum impacts to existing habitat areas.

In addition to the Calhoun County list of rare species, the TPWD Texas Natural Diversity Database (TXNDD) map data was reviewed for known occurrences of listed species within or near the canal, pipeline, or proposed reservoir areas. This information indicated that there were several reported sightings of the state threatened bald eagle (*Haliaeetus leucoephalus*), within the surrounding area. Occurrences of three species of concern, the Texas diamondback terrapin (*Malaclemys terrapin littoralis*), Gulf saltmarsh snake (*Nerodia clarkia*), and threeflower broomweed (*Thurovia triflora*) are documented within 10 miles of the proposed project area. No specific sightings of any endangered or threatened species were documented at the example project site shown in Figure 5D.13.1. The presence or absence of potential habitat within an area does not confirm the presence or absence of a listed species. No species specific surveys were conducted in the project area for this report.

After a review of the habitat requirements for each listed species, it is not anticipated that this project will have any permanent adverse effect on any federally listed threatened or endangered species, its habitat, or designated habitat, nor would it adversely affect any state listed species.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of publically available Geographic Information System (GIS) records obtained from the Texas Historical Commission, there are no State Historic Sites, National Register Properties or Districts, cemeteries or Historical Markers within 2.5 miles of the project area.

A review of archaeological resources in the proposed project area should be conducted during the project planning phase. Because the owner or controller of the project will likely be a political subdivision of the State of Texas (i.e. river authority, municipality, county, etc.), they will be required to coordinate with the Texas Historical Commission prior to project construction.

5D.13.4 Engineering and Costing

Relying in part on an available feasibility study and integrating current TWDB guidance for regional water planning, a cost estimate summary for the GBRA Lower Basin Storage water management strategy has been prepared and is provided as Table 5D.13.3. Included in the costs for this strategy are the embankment and appurtenant facilities for the off-channel reservoir, a 50 cfs raw water intake and pump station, a 42-inch transmission pipeline, and a 72-inch outlet pipeline. As indicated above, the sizes and capacities of some facilities may be increased to increase the firm supply, thereby resulting in increased costs. Additionally, depending upon the location(s) and type(s) of use for water supplies associated with the strategy, additional facilities and costs could include transmission and treatment facilities for service to project participants and customers.

For the GBRA Lower Basin Storage project (Table 5D.13.3), the total land acquisition and surveying costs related to the *entire* 636-acre project amounts to $1,561,000. Of this, 625 acres is associated with the reservoir footprint at a cost of $1,503,750 (or 96%). The remaining 11 acres associated with land and surveying of acreage associated with appurtenances is $57,250.

Table 5D.13.3.
GBRA Lower Basin Storage Cost Estimate

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Off-Channel Reservoir (12,500 ac-ft Conservation Storage)	$38,210,000
Intake and Pump Station (34 mgd)	$7,883,000
Inlet and Outlet Pipelines (42-inch and 72-inch, approximately 3 miles)	$13,038,000
Inlet, Outlet and Outfall Structures with Flow Control Facilities	$2,516,000
TOTAL COST OF FACILITIES	**$61,647,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$20,925,000
Environmental & Archaeology Studies and Mitigation	$1,502,000
Land Acquisition and Surveying (636 acres)	$1,561,000
Interest During Construction (4% for 2 years with a 1% ROI)	$4,908,000
TOTAL COST OF PROJECT	**$90,543,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$2,691,000
Reservoir Debt Service (5.5 percent, 40 years)	$3,638,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$343,000
Off-Channel Reservoir	$573,000
Pumping Energy Costs (181,399 kW-hr @ 0.09 $/kW-hr)	$16,000
TOTAL ANNUAL COST	**$7,261,000**
Available Project Yield (ac-ft/yr)	51,800
Annual Cost of Water ($ per ac-ft)	$140
Annual Cost of Water ($ per 1,000 gallons)	$0.43

Based on the above assumptions, the total project and annual costs are $90,543,000 and $7,261,000, respectively, including debt service and operation and maintenance for the 12,500 ac-ft off-channel reservoir and associated facilities. For a firm yield of 51,800 ac-ft/yr (which assumes 100% direct reuse of all treated wastewater in both the Guadalupe and San Antonio River Basins), these annual costs translate to an annual unit cost of $140/ac-ft/yr for raw water at the GBRA Main Canal during the debt service period. For a firm yield of 75,500 ac-ft/yr (with inclusion of net historically-discharged effluent), these annual costs translate to an annual unit cost of $96/ac-ft/yr for raw water at the GBRA Main Canal during the debt service period. Some participants or customers may incur additional costs for purchase of water, transmission facilities, treatment, and/or integration as discussed in the example below.

An additional cost analysis was prepared to estimate the cost for Region N associated with participating in the project for a firm yield of 20,000 ac-ft (Table 5D.13.4), based on prorated portion of Region N's supply as compared to the total supply and cost of GBRA's Lower Basin Storage project shown in Table 5D.13.4 (i.e. 38.6% for 20,000 ac-ft of the 51,840 ac-ft project yield). All common project elements (OCR, Pump Stations, and associated facilities) were costed on a prorata basis. Transmission pipeline and integration costs to deliver OCR stored supplies to the Mary Rhodes Pipeline near Bloomington Pump Station (15.8 miles) and costs for 2 million gallons of storage were assigned solely to Region N. The transmission pipeline was sized for peaking of 1.5 times average day delivery for operational flexibility. Annual costs include energy needed to pump stored supplies a distance of 15.8 miles to the Mary Rhodes Pipeline (5,664,625 kW-hr @ $0.09 $/kW-hr) and raw water purchase of 20,000 ac-ft/yr at $100 per ac-ft.[3]

For Table 5D.13.4 related to the *portion of the project relevant to Region N interests (338 acres)*, the total land acquisition and surveying costs amounts to $930,000. Of this, 241 acres is associated with the reservoir footprint at a cost of $581,000. The remaining 97 acres associated with land and surveying of acreage associated with the pipeline right of way and appurtenances costs $349,000. The land requirements comprise a large percentage of the total project (37%), primarily associated with right of way needs for the 36-inch diameter 16-mile pipeline for delivery of off-channel reservoir stored supplies to the Mary Rhodes Pipeline near the Bloomington Pump Station.

Region N's portion of total project and annual costs are $72,546,000 and $8,849,000, respectively, including debt service and operation and maintenance for participation in the 12,500 ac-ft off-channel reservoir and associated facilities on a prorata share basis. For a firm yield of 20,000 ac-ft/yr, these annual costs translate to an annual unit cost of $442 per ac-ft/yr for raw water at the Mary Rhodes Pipeline during the debt service period. This cost assumes that pending upgrades to the Mary Rhodes Pipeline to operate at full design capacity are complete at no cost to this water supply strategy. Assuming a treatment cost of $369 per ac-ft comparable to other Region N-water management strategies, the annual unit cost of treated water is estimated to be $811 per ac-ft/yr.

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[3] Assumed at typical interruptible raw water rate. The cost estimate includes prorated costs for participating in the OCR construction to firm up run-of-the-river water rights. Accordingly, the 20,000 ac-ft/yr is considered firm.

Table 5D.13.4.
Cost Estimate Summary for GBRA Lower Basin Storage Relevant to Region N Interest

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Prorated Portion of GBRA's Lower Basin Storage (38.6%)	$14,753,000
Prorated Portion of Intake and Pump Station (26.8 mgd), Inlet/Outlet Pipelines and Outfall Structures	$12,317,000
Transmission Pipeline (36-inch, 15.8 miles)	$20,785,000
Storage Tanks (Other than Booster Pump Stations)	$1,237,000
Integrations, Relocations, and Other	$481,000
TOTAL COST OF FACILITIES	**$49,573,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$16,311,000
Environmental & Archaeology Studies and Mitigation	$985,000
Land Acquisition and Surveying (20 acres)	$930,000
Interest During Construction (4% for 1 year with a 1% ROI)	$4,747,000
TOTAL COST OF PROJECT	**$72,546,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$4,184,000
Reservoir Debt Service (5.5 percent, 40 years)	$1,405,000
Operation and Maintenance	
Pipeline, Wells and Storage Tanks (1% of Cost of Facilities)	$221,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$308,000
Dam and Reservoir (1.5% of Cost of Facilities)	$221,000
Pumping Energy Costs (553405 kW-hr @ 0.09 $/kW-hr)	$510,000
Purchase of Water (20,000 ac-ft/yr @ 100 $/ac-ft)	$2,000,000
TOTAL ANNUAL COST	**$8,849,000**
Available Project Yield (ac-ft/yr)	20,000
Annual Cost of Raw Water ($ per ac-ft), based on a Peaking Factor of 1.5	$442
Annual Cost of Raw Water ($ per 1,000 gallons)	$1.36
Annual Cost of Treated Water ($ per ac-ft), with treatment costs of $369/ac-ft	$811
Annual Cost of Treated Water ($ per 1,000 gallons), with treatment costs of $369/ac-ft	$2.49

5D.13.5 Implementation Issues

An institutional arrangement may be needed to implement this project, including financing on a regional basis.

1. It may be necessary to obtain the following permits or authorizations:
   a. TCEQ interbasin transfer, depending upon location(s) of use.
   b. USACE Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   c. GLO sand and gravel removal permits.
   d. TPWD sand, gravel, and marl permit.
2. Permitting, at a minimum, will require these studies:
   a. Habitat mitigation plan.
   b. Environmental studies.
   c. Cultural resources survey.
3. Land and right of way access for the transmission line to deliver project supplies to the Mary Rhodes Pipeline will need to be acquired through either negotiations or condemnation.

5D.13.6 Evaluation Summary

An evaluation summary of this water management option is provided in Table 5D.13.5.

Table 5D.13.5.
Evaluation Summary of GBRA Lower Basin Storage Project

Impact Category	Comment(s)
a. Water supply:	
1. Quantity	1. Firm Yield (Region N's portion): 20,000 ac-ft/yr. Firm Yield (total project): 51,800 ac-ft/yr.
2. Reliability	2. Highly reliable quantity.
3. Cost of treated water	3. Moderate cost of $811 per ac-ft.
b. Environmental factors:	
1. Instream flows	1. Although source water is available under existing water rights, there may be some impact due to increased diversions from the Lower Guadalupe River. With Region N participation and project integration into the CCR/LCC/Texana/MRP Phase II system, increases in instream flows in the Nueces River may occur due to reduced water supply demands on the CCR/LCC system and consequently higher inflow pass-through targets according to 2001 Agreed Order provisions.
2. Bay and estuary inflows	2. Although source water is available under existing water rights, there may be some impact due to increased diversions from the Lower Guadalupe River, when available, for OCR storage needs to firm yield during droughts. With Region N participation and project integration into the CCR/LCC/Texana/MRP Phase II system, increases in instream flows in the Nueces River may occur due to reduced water supply demands on the CCR/LCC system and consequently higher inflow pass-through targets according to 2001 Agreed Order provisions.
3. Wildlife habitat	3. Some impact and wildlife habitat disturbance due to off-channel reservoir, intake, and transmission pipeline construction.
4. Wetlands	4. Low impact.
5. Threatened and endangered species	5. Several threatened and endangered species are listed in Calhoun County. It is not anticipated that this project will have any permanent adverse effect on any federally listed threatened or endangered species, its habitat, or designated habitat nor would it adversely affect any state listed species. Reasonable and prudent measures should be taken to avoid and minimize the potential effects of the proposed project activities on threatened and endangered species as well as bald eagles.
6. Cultural resources	6. No cultural resources affected.
7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	7. Low impact. a,b,d. May possibly increase dissolved solids, salinity, and chlorides in the Lower Guadalupe River downstream of the GBRA Diversion System during periods when permitted run-of-the-river water is diverted to the OCR.

Impact Category	Comment(s)
c. Impacts to State water resources	• No apparent negative impacts on water resources
d. Threats to agriculture and natural resources in region	• None
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Standard analyses and methods used
g. Interbasin transfers	• New authorization required for use outside of GBRA statutory district and within the San Antonio-Nueces Coastal Basin. More requirements must be met to obtain new authorization for uses in the Nueces River Basin or Nueces- Rio Grande Coastal Basin.
h. Third party social and economic impacts from voluntary redistribution of water	• None
i. Efficient use of existing water supplies and regional opportunities	• This project promotes efficient use of existing supplies and presents opportunities for regional supply development
j. Effect on navigation	• None
k. Consideration of water pipelines and other facilities used for water conveyance	• Reasonable and prudent measures should be taken to avoid and minimize the potential effects of the pipeline construction on the environment

5D.14

San Patricio Municipal Water District - Transmission and Industrial Water Treatment Plant Improvements (N-15)

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5D.14 San Patricio Municipal Water District – Transmission and Industrial Water Treatment Plant Improvements (N-15)

5D.14.1 Description of Strategy

San Patricio Municipal Water District (SPMWD) serves as a major wholesale water provider in the Coastal Bend Region providing potable water supplies to municipalities in San Patricio and Aransas counties in addition to raw and treated water supplies to industries located in San Patricio County. SPMWD has a water supply agreement with the City of Corpus Christi to receive up to 41,200 ac-ft/yr of raw water and 10,000 ac-ft/yr of treated water from the regional CCR/LCC/Texana/MRP Phase II multi-basin water supply system. SPMWD has a 36-inch pipeline from the Mary Rhodes Pipeline and a 36- inch pipeline from the Nueces River Calallen Pool intake to deliver raw supplies to the SPMWD Water Treatment Plant complex located southeast of Gregory. SPMWD has a 24-inch line to receive of up to 10,000 ac-ft/yr treated water supplies from the City of Corpus Christi. Pump station and transmission pipe improvements are needed to fully utilize contracted supplies.

San Patricio County is expecting significant industrial water demand increases in the future based on industrial growth with current manufacturing users and interest by new customers. SPMWD has received new industrial water contract requests from potential customers and estimates an *additional* industrial water demand of 23 mgd (or 25,781 ac-ft/yr) by 2020 beyond increases projected for current customers.[1] In March 2013, the Coastal Bend Regional Water Planning Group recommended increases in TWDB draft water demand projections for San Patricio County-manufacturing water users based on SPMWD's water supply plan, which showed industrial raw and treated water use increasing from 10.3 mgd (actual) in 2010 to a projected demand of 35.4 mgd (or 39,737 ac-ft/yr) by 2020. San Patricio manufacturing water demands are projected to increase to 56,991 ac-ft/yr by 2070 assuming the TWDB's decadal growth rate of 6-8% from 2030 to 2070 for San Patricio County manufacturing users. The TWDB approved use of these projections in the 2016 Plan.

SPMWD's customer water demands amount to 50,191 ac-ft/yr in 2020. As mentioned previously, SPMWD has a water supply agreement with the City of Corpus Christi to receive up to 51,200 ac-ft/yr (total) through a combination of raw and treated water supplied from the regional CCR/LCC/Texana/MRP Phase II multi-basin water supply system. SPMWD will need to increase contracted supplies from the City of Corpus Christi or develop new raw water supplies beginning in 2030 to meet water demands through 2070 (Table 4.24). Raw water shortages[2] of 2,553 ac-ft/yr are projected for San Patricio- Manufacturing in 2030 and projected to increase to 16,764 ac-ft/yr by 2070. For the purposes of this water management strategy, it is assumed that SPMWD and the City of Corpus Christi will develop recommended water management

[1] San Patricio Municipal Water District, February 2013.
[2] Assuming 70% of water provided by SPMWD to San Patricio County industries is treated and 30% is raw water.

strategies (Chapter 5) to provide additional raw water supplies as needed. This water management strategy focuses on transmission and industrial water treatment plant improvements needed to address treated water shortages.

The SPMWD Water Treatment Plant complex includes municipal and industrial WTPs to provide treated water supplies for its customers. The potable (municipal) water plant has a peak capacity of 20.9 mgd and is capable of delivering 10.4 mgd average day (or 11,658 ac-ft/yr) assuming a 2:1 peak to average day ratio based on historical use. The maximum treated water demand for SPMWD's municipal customers during the 2020-2070 planning period is 11,433 ac-ft/yr in 2070 (Table 4.24). No additional capacity improvements for the municipal water treatment plant are anticipated to be needed to meet 2070 water demands.

SPMWD is currently able to provide treated water for industries in an amount up to 21.6 mgd (peak), or 18.8 mgd average day (21,043 ac-ft/yr).[3] The treated water demand for SPMWD's industrial customers ranges from 27,494 in 2020 to 39,572 ac-ft/yr in 2070 (Table 4.24)[4], which results in additional industrial water treatment capacity of 6,451 to 18,529 ac-ft/yr needed by 2020 and 2070, respectively.

5D.14.2 Available Yield

Pump station improvements are needed for the existing transmission lines to fully deliver supplies up to contracted amount and additional raw water needed to meet demands through 2070. The 36-inch pipeline from the Mary Rhodes Pipeline is currently able to deliver 28.5 mgd. With pump station improvements, it will be capable of delivering 40.7 mgd. SPMWD has already purchased land for the pump station and improvements will be constructed within existing right-of-way. The 36-inch raw water pipeline from Calallen Pool is currently able to deliver 26.1 mgd. The 24-inch treated water pipeline from Corpus Christi delivers 5.5 mgd, which will increase to 10 mgd with pump station. SPMWD has already purchased land for the pump stations and improvements will be constructed within existing right-of-way. The cost estimate provided in Table 5D.14.1 includes pump station improvements to deliver adequate raw water to the treatment plant complex to meet needs through 2070.

SPMWD Industrial WTP improvements are needed to increase average day treatment capacity by 18,529 ac-ft/yr to meet San Patricio manufacturing needs.

[3] According to email correspondence with Brian Williams, SPMWD, February 2015. Includes SPMWD-industrial plant, treated water contract with City of Corpus Christi, and additional 2 mgd (peak) capacity improvements currently being constructed. Email correspondence with Brian Williams, SPMWD. Assumes 1.29 peak: average day for SPMWD's industrial plant and 2 mgd capacity improvements, based on 2011 water use patterns. Assumes treated water from City of Corpus Christi is delivered at constant rate (1:1 peak to average day).
[4] Assuming 70% of water provided by SPMWD to San Patricio County industries is treated and 30% is raw water.

Table 5D.14.1.
Cost Estimate Summary for SPMWD Transmission and Industrial WTP Improvements

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Pump Stations (40 mgd and 10 mgd)	$9,400,000
Water Treatment Plant (21.4 mgd)	$32,357,000
TOTAL COST OF FACILITIES	**$41,757,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$14,615,000
Environmental & Archaeology Studies and Mitigation	$20,000
Land Acquisition and Surveying	$0
Interest During Construction (4% for 1 year with a 1% ROI)	$1,974,000
TOTAL COST OF PROJECT	**$58,366,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$4,884,000
Operation and Maintenance	
Pipeline, Wells and Storage Tanks (1% of Cost of Facilities)	$235,000
Water Treatment Plant	$3,236,000
Purchase of Water (18,529 ac-ft/yr @ 358.49 $/ac-ft)	$6,642,000
TOTAL ANNUAL COST	**$14,997,000**
Available Project Yield (ac-ft/yr)	18,529
Annual Cost of Water ($ per ac-ft)	$809
Annual Cost of Water ($ per 1,000 gallons)	$2.48

5D.14.3 Environmental Issues

The environmental impact of transmission and industrial water treatment plant improvements is estimated to be negligible. The transmission pipeline and pump station enhancements will not involve construction in undeveloped areas, or excavation outside of existing pipeline right-of-ways. The processing of more water daily by the WTP could allow for increased consumption if demand estimates materialize, which may increase B&E inflows.

5D.14.4 Engineering and Costing

The capital costs of pump station improvements includes $4.4 million for the 36-inch pipeline from the Mary Rhodes Pipeline and $5 million for the 24-inch treated water pipeline from Corpus Christi as provided in the cost estimate from SPMWD.

A water treatment plant expansion by 21.4 mgd is needed to increase average day treatment capacity by 18,529 ac-ft/yr, assuming a 1.3:1 peak to average day rate. Table 5D.14.1 summarizes the capital and annual costs for transmission and WTP improvements. A purchase water cost from the City of Corpus Christi is estimated at $1.10 per 1,000 gallons (or $358 per ac-ft). The unit cost of water is $809 per ac-ft.

5D.14.5 Implementation Issues

Implementation of this water management strategy will require a National Pollutant Discharge Elimination System (NPDES) Stormwater Pollution Prevention Plan Permit. The sequencing of construction will have to take into account the fact that the SPMWD-industrial WTP will need to continue operating throughout the construction process due to sensitive industrial processes which rely on continuous treatment operation. Modular improvements should be considered, when at all possible, to avoid potential service interruptions.

5D.14.6 Evaluation Summary

An evaluation summary of this water management option is provided in Table 5D.14.2.

Table 5D.14.2.
Cost Estimate Summary for SPMWD Transmission and Industrial WTP Improvements

Impact Category	Comment(s)
a. Water supply:	
1. Quantity	1. 18,529 ac-ft/yr.
2. Reliability	2. High reliability.
3. Cost of treated water	3. $809 per ac-ft.
b. Environmental factors:	
1. Instream flows	1. Negligible impact.
2. Bay and estuary inflows	2. Negligible impact. The SPMWD Transmission and Industrial WTP Improvements may have minor increases in return flows to Nueces Bay and Estuary.
3. Wildlife habitat	3. Negligible impact. The SPMWD Transmission and Industrial WTP Improvements will not disturb unaltered and/or new land.
4. Wetlands	4. Negligible impact.
5. Threatened and endangered species	5. Negligible impact. The SPMWD Transmission and Industrial WTP Improvements will not disturb unaltered and/or new land.
6. Cultural resources	6. Negligible impact. All work on SPMWD property or existing right-of-way should be no impact.
7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	7. Low or no impact. The SPMWD Transmission and Industrial WTP Improvements will likely produce water of higher quality than the original source water (including lowered TDS), as the facility would remove solids.
c. Impacts to State water resources	• No apparent negative impacts on water resources
d. Threats to agriculture and natural resources in region	• None
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Standard analyses and methods used
g. Interbasin transfers	• Not applicable
h. Third party social and economic impacts from voluntary redistribution of water	• None
i. Efficient use of existing water supplies and regional opportunities	• Improvement over current conditions
j. Effect on navigation	• None
k. Consideration of water pipelines and other facilities used for water conveyance	• None

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5D.15

O.N. Stevens Water Treatment Plant Improvements

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5D.15 O.N. Stevens Water Treatment Plant Improvements

5D.15.1 Description of Strategy

The O.N. Stevens Water Treatment Plant (WTP) provides treated water supplies to the City of Corpus Christi (City) and its customers. The City expects to experience increasing municipal and industrial water demands due to a growing population, enterprise, and commerce. Despite the successful water conservation efforts of the City's industrial customers, raw and treated water demand is increasing due to increased manufacturing. Not only have manufacturers indicated that they will need increasing amounts of water in the coming years, other water users have approached the City about various efforts slated to come online in the next several years with increasing rates of water consumption over a 10-year period. The projected growth in manufacturing and steam-electric demand, in combination with municipal demand, requires that the City develop additional treated water supply over the next few years.

Although the O.N. Stevens WTP is currently rated at 167 mgd by the TCEQ, the City currently can produce only 159 mgd of treated water through the O.N. Stevens WTP (the sole source of treated water for the City municipal supply, various large industrial users, and the South Texas Water Authority)[1] due to a hydraulic bottleneck at the front end of the O.N. Stevens WTP. SPMWD receives treated water supplies from the O.N. Stevens WTP and treats raw water supplies from the CCR/LCC/Lake Texana/MRP Phase II system with their own water treatment plant. Re-designing the influent end of the plant will allow the plant, operating under acceptable TCEQ detention rates, to produce 194 mgd which would increase the amount of treated water supplies needed to meet increasing water demands for City customers and improve supply reliability. Additional system improvements to the water treatment plant will provide operational cost savings from increased reliability and functionality. The proposed O.N. Stevens Water Treatment Plant Improvements are as follows:

- Raw Water Influent Improvements – these improvements will address the current hydraulic bottleneck at the O.N. Stevens WTP front end that limits total plant capacity to 159 mgd. This project, in combination with uprating the current filter system through TCEQ, will increase total plant capacity to 194 mgd.
- Nueces River Raw Water Intake Pump Station Improvements – these improvements will increase the reliability of water delivery to O.N. Stevens from the Calallen Pool.
- O.N. Stevens WTP High Service Building No. 3 – these improvements will replace the deteriorating, original 1954 High Service No. 1 Building, resulting in improved reliability and efficiency of the pump station and increasing the Plant's firm pumping capacity to 177.6 mgd required by TCEQ with future expansion capacity to 194 mgd.

[1] The City of Corpus Christi, STWA, and some industrial users rely solely on the O.N. Stevens WTP for treated water supplies, and do not have backup treatment plants or treated water furnished from other sources.

The Raw Influent Improvements would allow for blending and pre-sedimentation of 100% of the source water which would increase finished water quality, as well as allow for a more uniform treatment regimen which would save operational costs. Full blending and full pre-sedimentation will also accomplish the goal of increasing the quality of the partially treated water that is provided to local industry. Raw Influent Improvements will also increase security at the O.N. Stevens WTP as currently the influent pipelines emerge in an open top meter vault only a few feet from a major road, which is a security concern.

The Nueces River Raw Water Intake Pump Station Improvements will upgrade the pump station in order to increase the reliability of water delivery to O.N. Stevens WTP. The upgrades will also increase the operational capability of the pump station and provide operational cost savings from the increased reliability and capabilities of the improved pump station, including new pump motors and motor starters to be installed.[2]

The O.N. Stevens WTP High Service Building No. 3 will replace the existing High Service No. 1 Building which has been in service since 1954. The overall capacity of existing high service pumping complex does not meet the TCEQ requirement of 177.6 mgd, as stipulated in the Alternative Capacity Requirement exception granted to the City in 2012. Additionally, a recent condition assessment of the existing pumps revealed heavy corrosion on their discharge heads which would limit their usable life. The new High Service Building No. 3 is being designed to address both the capacity and reliability concerns associated with pumping complex. The O.N. Stevens WTP High Service Building No. 3 is not anticipated to generate additional water supply prior to or at the WTP, which is a prerequisite for regional water planning water management strategies according to TWDB guidelines. Therefore, a further evaluation of this project is not included in the available yield and cost discussion below.

In addition to the projects detailed above, the City anticipates the need for additional water treatment plant improvements to the chemical feed system, electrical distribution system, process monitoring instrumentation and automation system, and residual solids handling and water recovery facilities. Such improvements are not fully discussed in this water management strategy and are not included in the cost estimate.

5D.15.2 Available Yield

Although the City is continuing to develop additional raw water supplies, such as Mary Rhodes Phase II (MRP Phase II) project, the industrial customers downstream of the O.N. Stevens WTP may face a supply deficit without the proposed O.N. Stevens WTP improvements as they depend on partially and/or fully treated supplies from O.N. Stevens WTP which currently has a hydraulic bottleneck at the front end of their treatment train that limits water treatment plant production. With raw water influent improvements, the O.N. Stevens WTP capacity will increase to 194 mgd (peak day).

[2] The O.N. Stevens WTP currently contains emergency generators. Proposed water treatment improvements would be added to the existing electrical distribution system.

At a current peak water treatment capacity of 159 mgd, the City is able to produce on average 113.6 mgd[3] (or 127,314 ac-ft/yr). Assuming the same peak to average day ratio, increasing the O.N. Stevens WTP capacity to 194 mgd will produce 139 mgd, on average, (or 155,339 ac-ft/yr) which is 28,025 ac-ft more than the amount that can be currently produced.[4] Table 5D.15.1 shows the additional yield assumed from the O.N. Stevens WTP expansion constrained to raw water safe yield supplies from the LCC/CCR/Texana/MRP Phase II system. If no additional raw water supplies are developed, it is assumed that unutilized (surplus) raw water from manufacturing would be used, and the additional treated supply shown in Table 5D.15.1 would be limited by raw water availability. Without raw water constraints, the treatment plant will produce an additional 28,025 ac-ft/yr.

Table 5D.15.1.
Additional Yield from O.N. Stevens WTP Improvements[1]

Improvements	*2020*	*2030*	*2040*	*2050*	*2060*	*2070*
Raw Water Influent Improvements[2]	28,025	17,696	7,643	0	0	0
Nueces River Raw Water Intake Pump Station	0	0	0	0	0	0
Total increase (ac-ft/yr)	28,025	17,696	7,643	0	0	0

[1] The additional yield is based on an improved O.N. Stevens WTP capacity of 194 mgd. Based on the City's most recent 5-year water use data, the O.N. Stevens WTP provides treated water supplies at a peak to average day ratio of 1.4:1. Using this peaking ratio, the 194 mgd peak capacity WTP would have an average day capacity of 139 mgd.
[2] The yield associated with raw water influent improvements was calculated based on information shown in Table 4.24 and limited by existing raw water supplies. The City has a contract with SPMWD to provide up to 51,200 ac-ft/yr, including 41,200 ac-ft/yr raw water supplies and 10,000 ac-ft/yr treated water supplies.

5D.15.3 Environmental Issues

A summary of environmental issues by water treatment plant improvement component is included in Table 5D.15.2. There is little to no environmental impact from the proposed O.N. Stevens WTP projects. The majority of the work will be on existing facilities and structures.

Table 5D.15.2.
Environmental Issues City of Corpus Christi Water Supply Improvements

Water Management Strategy/Component	*Environmental Impact*
Raw Influent Improvements	Negligible impact. Possibility of processing more water daily by the WTP could allow for increased consumption if the demand manifests itself, but also increased B&E inflows possible as well.
Nueces River Raw Water Pump Station Improvements	Negligible impact. Upgrades to existing facility will not involve construction in river or alteration of flows, excavation, or dredging.

[3] Assumes a peak to average day rate of 1.4: 1 comparable with recent water use records.
[4] Assumes no raw water shortage.

5D.15.4 Engineering and Costing

Figure 5D.15.1 show the facilities required to develop the Raw Influent Improvements. The improved headworks piping at O.N. Stevens will also allow for 100% blending and pre-sedimentation of source waters which will effect water quality improvements and chemical cost savings per unit.

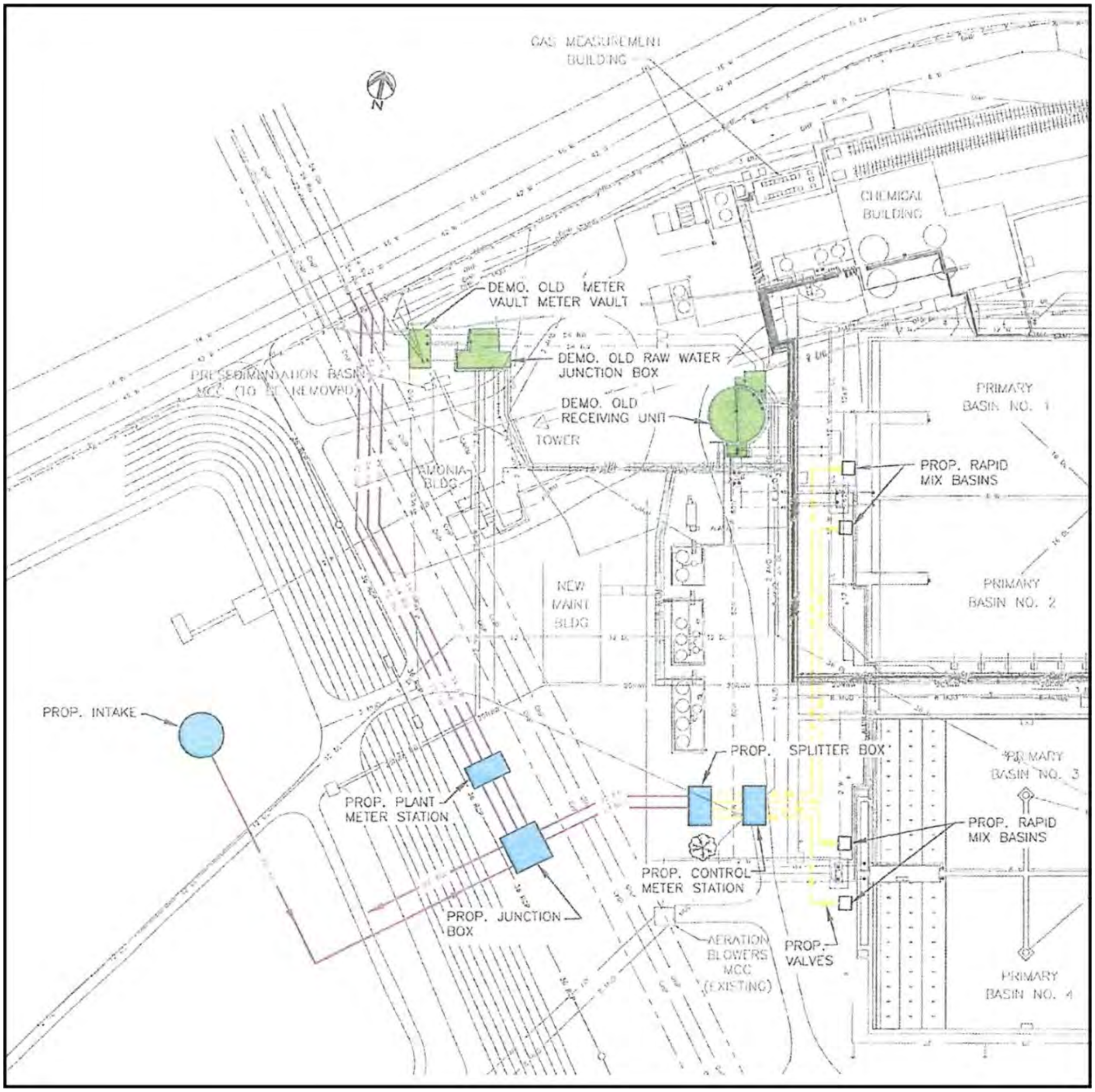

Figure 5D.15.1.
O.N. Stevens Water Treatment Plant Raw Water Influent Improvements

Table 5D.15.3 summarizes the capital and annual costs for the City's O.N Stevens WTP Improvements, while Table 5D.15.4 summarizes the available project yield subject to raw water constraints and the annual cost of water, including treated water costs with assumption of $369 per ac-ft used for other water management strategies. It is important to note that yield declines in decades subsequent to 2020 due to the need to maintain raw water supplies up to safe yield capacity constraints. With addition of new raw water supplies during the projection period, the supplies generated by O.N. Stevens WTP improvements will amount to 28,025 ac-ft/yr or raw water project yield whichever is the smaller amount.

Table 5D.15.3.
Cost Estimate Summary for O.N. Stevens WTP Improvements

Item	***Estimated Costs for Facilities***
CAPITAL COST	
Raw Influent Improvements	$18,753,525
Nueces River Raw Water Intake Pump Station Improvements	$10,762,015
TOTAL COST OF FACILITIES	**$29,515,540**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$10,330,000
Interest During Construction (4% for 3 years with a 1% ROI)	$4,184,000
TOTAL COST OF PROJECT	**$44,029,540**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$3,684,000
Operation and Maintenance	$738,000
Pumping Energy Costs ($0.09 per kW-hr)	$1,259,000
TOTAL ANNUAL COST	**$5,681,000**

Table 5D.15.4.
Unit Cost of Water Summary

	Year					
	2020	***2030***	***2040***	***2050***	***2060***	***2070***
Available Project Yield (ac-ft/yr)	28,025	17,696	7,643	—	—	—
Annual Cost of Raw Water ($ per ac-ft)	$203	$321	$261	—	—	—
Annual Cost of Treated Water ($ per ac-ft)	$572	$690	$630	—	—	—

5D.15.5 Implementation Issues

Implementation of these water management strategies will require a National Pollutant Discharge Elimination System (NPDES) Stormwater Pollution Prevention Plan Permit.

There are limited chances for participation by partners. To the extent these improvements will provide improvements in water quality or supply for wholesale finished or wholesale partially treated or wholesale raw water customers, there may be partnership opportunities with the wholesale customers.

The sequencing of construction will have to take into account the fact that the O.N. Stevens WTP is the City's only water treatment plant, so it has to keep operating throughout the construction process. There is detention time of only a few hours in the clearwells to allow for switching over to the new hydraulic structures near the end of construction. The Raw Influent Improvements Component is the only portion of the proposed improvements that will require special sequencing consideration.

5D.15.6 Evaluation Summary

An evaluation summary of this water management option is provided in Table 5D.15.5.

Table 5D.15.5.
Evaluation Summary of O.N. Stevens Water Treatment Plant Improvements

Impact Category	***Comment(s)***
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	 1. Ranges from 763 ac-ft/yr to 28,025 ac-ft/yr, with current supplies only. With no raw water constraints, the treated supply is 28,035 ac-ft/yr. 2. High reliability. 3. Ranges from \$203 to \$321 per ac-ft (raw water) or \$572 to \$690 per ac-ft (treated water).
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. Negligible impact. The O.N. Stevens WTP Solids Handling Facilities will reduce demand on river water. 2. Negligible impact. The O.N. Stevens WTP Solids Handling Facilities may have minor reduction in inflows to tidal portion of the Nueces River. 3. Negligible impact. The O.N. Stevens WTP Solids Handling Facilities will preserve minimum water levels in the Audubon Society Rookery. 4. Low or no impact. 5. Negligible impact. The O.N. Stevens WTP Solids Handling Facilities will preserve minimum water levels in the Audubon Society Rookery. 6. Negligible impact. All work on O.N. Stevens WTP property should be no impact. 7. Low or no impact. The O.N. Stevens WTP Solids Handling Facilities will likely produce water of higher quality than the original source water (including lowered TDS), as the facility would remove solids.
c. Impacts to State water resources	• No apparent negative impacts on water resources
d. Threats to agriculture and natural resources in region	• None
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Standard analyses and methods used
g. Interbasin transfers	• Not applicable
h. Third party social and economic impacts from voluntary redistribution of water	• None
i. Efficient use of existing water supplies and regional opportunities	• Improvement over current conditions
j. Effect on navigation	• None
k. Consideration of water pipelines and other facilities used for water conveyance	• None

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6

Impacts of Regional Water Plan and Consistency with Protection of Resources

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Chapter 6: Impacts of Regional Water Plan and Consistency with Protection of Resources

The guidelines for the 2016 Regional Water Plans include describing major impacts of recommended and alternative water management strategies on key parameters of water quality identified by the regional water planning group. This also includes consideration of third party social and economic impacts associated with voluntary redistribution of water from rural and agricultural areas, and affects of ground and surface water interrelationships on water resources of the state. Furthermore, 2016 Regional Water Plans should consider statutory provisions regarding inter-basin transfers of surface water including summation of water needs in basins of origin and receiving basins, as well as how the regional plan is consistent with protection of natural resources. The plan development was guided by the principal that the designated water quality and related water uses as shown in the state water quality management plan shall be improved or maintained.

6.1 Impacts of Water Management Strategies on Key Parameters of Water Quality

The CBRWPG identified the following key parameters of water quality to consider for water management strategies in the 2016 Regional Water Plan. The selection of key water quality parameters are based on water quality concerns identified in the Nueces River Authority's Basin Highlights Report, water user concerns expressed during CBRWPG meetings, and water quality studies conducted for water management strategies included in previous and current Plans and other regional studies. The Coastal Bend Region identified water quality parameters for recommended and alternative water management strategies, as shown in Figures 6.1 and 6.2.

The major impacts of recommended water management strategies on these key parameters of water quality are described in greater detail in the respective water management strategy summary (Chapter 5D). These identified water quality concerns present challenges that may need to be overcome before the water management strategy can be used as a water supply. For water quality parameters that cannot be fully addressed due to lack of available information or inconclusive water quality studies, the water management summary write-ups include recommendations for further studies prior to implementation as a water management strategy.

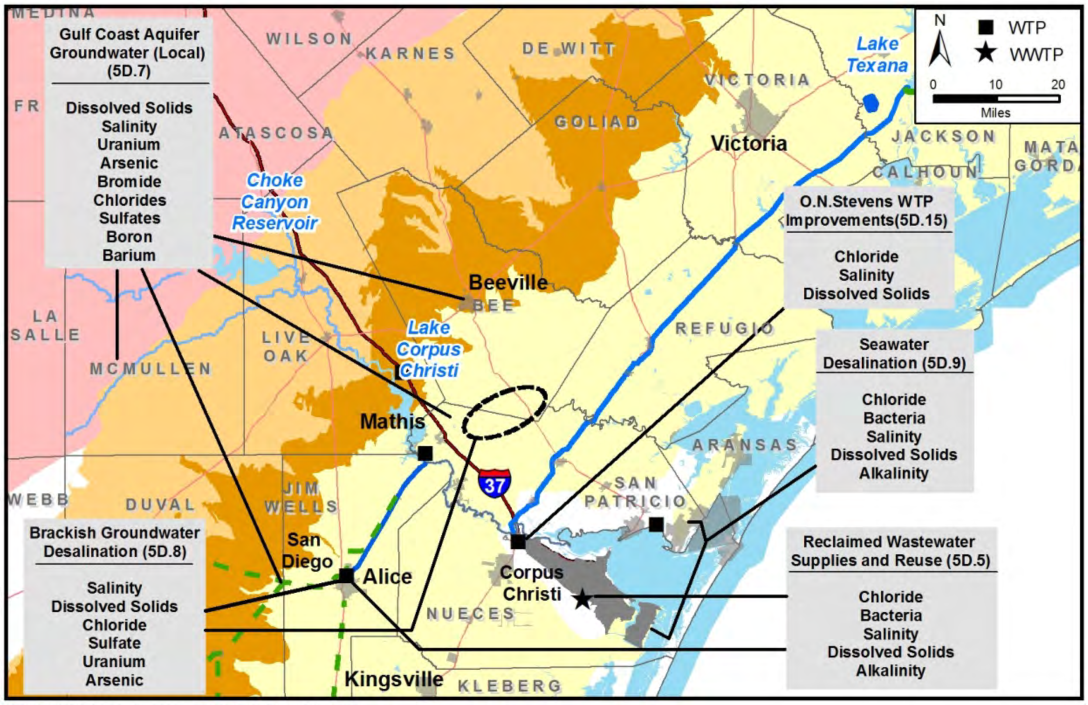

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Figure 6.1.
Water Quality Parameters to Consider for Water Management Strategies (1 of 2)

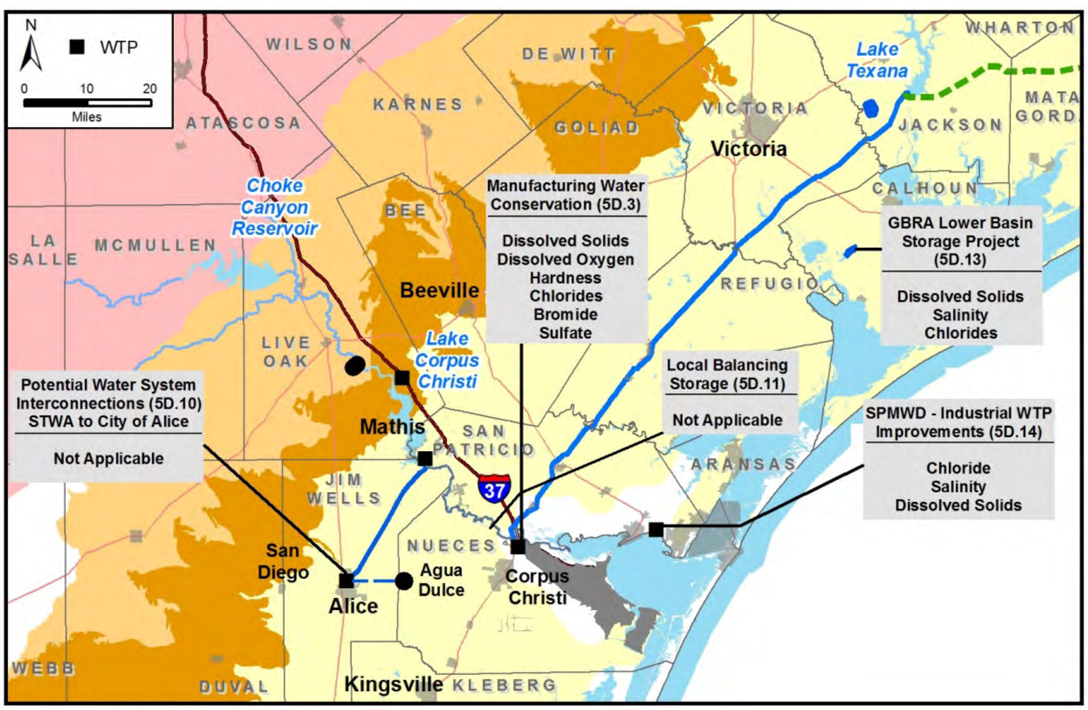

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Figure 6.2.
Water Quality Parameters to Consider for Water Management Strategies (2 of 2)

6.2 Impacts of Moving Water from Rural and Agricultural Areas

Several opportunities for voluntary redistribution exist for the Coastal Bend Region, including reallocating surface water through utilization of unused supply and sales of existing rights, or reallocating groundwater MAG through transfer of unused supply for entities with a surplus of groundwater to entities needing to drill additional wells as discussed in Chapter 5D.7.

Reallocation of unutilized surface water supply was considered but not recommended as a water management strategy. Based on existing water supply contract relationships, it is anticipated that the City of Three Rivers will continue to meet water needs for Live Oak-Manufacturing. Similarly, Nueces County WCID #3 will continue to meet the needs for Robstown and River Acres WSC by implementing the recommended strategies identified in Chapter 5 for Robstown. The impacts of voluntary redistribution of un-utilized surface water supply are expected to have minimal or no impacts on third party users or rural and agricultural areas.

Reallocation of unutilized groundwater supply was recommended as a water management strategy to transfer 449 ac-ft/yr of water to McMullen County- Irrigation and McMullen County-Mining from McMullen County-Other; and to transfer up to 466 ac-ft/yr of water to San Patricio County-Irrigation from the City of Sinton as discussed in Chapter 5D.7. The strategy did not assume an interconnection, but rather that the groundwater entity of origination would not pump surplus groundwater and the receiving entity would drill additional well(s) near their location of use within the same aquifer and river basin as the donor. The impacts of voluntary redistribution of un-utilized ground water supply are expected to have minimal or no impacts on third party users or rural and agricultural areas and do not violate any MAG constraints.

The water management strategies recommended to meet water needs (Chapter 5) do not include transferring water needed by rural and agricultural users and, therefore, are not considered to impact them.

6.3 Groundwater and Surface Water Interrelationships Impacting Water Resources of the State

The Nueces River from Three Rivers to the Calallen Pool (including Lake Corpus Christi), hereafter referred to as the Lower Nueces Basin, is hydraulically connected to underlying Goliad Sands and alluvial sands of the Gulf Coast Aquifer. During the development of the 2011 Plan, studies were conducted to evaluate stream flow interaction with alluvial sands of the Gulf Coast Aquifer downstream of CCR to LCC using data collected during a field channel loss study and are summarized in Chapter 11. Groundwater and surface water interaction in the Lower Nueces Basin is very complex and could vary significantly based on seasonal events, antecedent drought or wet conditions and prolonged drought or wet conditions that could impact storage and released water from LCC. Additional studies were performed as presented in Chapter 5D.3 to evaluate groundwater and surface water interrelationships considered to potentially impact Lower Nueces Basin water quality that may affect water supplies diverted from the Calallen Pool. Studies are on-going by the City of Corpus Christi and others to help characterize and identify sources of water quality fluctuations in the Lower Nueces Basin. Key water quality parameters of consideration are shown in Figure 6.2.

The Coastal Bend Region recognizes the importance of considering groundwater and surface water interaction when managing water resources and evaluating development of future water supplies. The Region encourages groundwater conservation districts and groundwater management areas to consider protection of springs and groundwater-surface water interaction during when considering new DFCs.

6.4 Interbasin Transfers

A number of interbasin transfer permits exist in the Coastal Bend Regional Planning Area as discussed in Chapter 3. These permits include authorizations for diversions from river basins north of the planning region into the Nueces River Basin. Both major interbasin transfer permits provide water to the City of Corpus Christi and include supplies from the Lavaca-Navidad and Colorado River Basins. The City of Corpus Christi benefits from an interbasin transfer permit[1] and a contract with the Lavaca Navidad River Authority (LNRA) to divert 41,840 ac-ft/yr on a firm basis and up to 12,000 ac-ft/yr on an interruptible basis from Lake Texana in the Lavaca-Navidad River Basin to the City's O.N. Stevens Water Treatment Plant. In addition, a second permit[2] allows diversion of up to 35,000 ac-ft/yr of run-of-river water on the Colorado River. Analyses of this water right, one of the most senior in the Colorado River Basin, indicate that most of the time the full 35,000 ac-ft/yr is available from this run-of-river right.[3] Based on results of a water availability analysis using information from the updated Colorado WAM (1940-2013) and simulating the most recent drought in the Colorado WAM (2011-2013) to coincide with the drought of record simulated in the Corpus Christi Water Supply Model (1994-1996), the MRP Phase II supplies adds 27,000 to 29,000 ac-ft/yr to the safe yield during drought conditions.

This Plan includes a portion of supplies from the GBRA Lower Basin Storage Project as a recommended water management strategy for the Coastal Bend Region. In accordance with Texas Water Code provisions, the projected shortage in the Guadalupe – San Antonio River Basin is 435,410 ac-ft/yr and is assigned to 88 water user groups in 14 counties.[4] The shortages are projected by Region L to be met by GBRA Mid-Basin (ASR), GBRA Lower Basin Storage (portion of yield), GBRA Lower Basin new appropriation, Integrated Water-Power Project, Victoria County- Steam Electric Canal Diversion Project, SAWS Seawater Desalination, Reuse, and groundwater supplies. Water supply delivery from the GBRA Lower Basin Storage Project (Region L) to Coastal Bend Region requires a new interbasin authorization required for use outside of GBRA statutory district and within the San Antonio-Nueces Coastal Basin. More

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[1] TCEQ, Certificate of Adjudication No. 16-2095C, held by Lavaca-Navidad River Authority and Texas Water Development Board (TWDB), October 21, 1996.
[2] TCEQ, Certificate of Adjudication No. 14-5434B, held by the City of Corpus Christi (via the Garwood Irrigation Company), October 13, 1998.
[3] Based on Corpus Christi Water Supply Model simulations conducted in February 2015 which placed the recent drought on the Colorado (2011-2013) on drought of record conditions in the Nueces Basin (1994-1996).
[4] South Central Texas Regional Planning Group Initially Prepared Plan, draft estimates provided April, 23, 2015.

requirements must be met to obtain new authorization for uses in the Nueces River Basin or Nueces- Rio Grande Coastal Basin. Details on this strategy are presented in Chapter 5D.13.

The Lavaca Off-Channel Reservoir Storage project from the Lavaca Region (Region P) to the Coastal Bend Region requires an interbasin transfer prior to project implementation. In accordance with Texas Water Code provisions, the projected shortage in the Lavaca Region is 50,285 ac-ft/yr and is assigned to Wharton County-Irrigation users in the Colorado-Lavaca and Lavaca Basins.[5] The shortages are projected by Region P to be met through conservation efforts and firmed-up surface water supplies from the Colorado River in Region K. However, the LNRA has been approached by local industries requesting additional supplies of 10,000 ac-ft/yr. Accordingly, the water supply from the Lavaca Off-Channel Reservoir that is potentially available for Coastal Bend Region purposes is 6,963 ac-ft/yr. This strategy is not listed as a recommended water management strategy for the Coastal Bend Region. Additional details regarding this potential interbasin transfer is included in Chapter 5D.12.

6.5 Consistency with Protection of Water Resources, Agricultural Resources, and Natural Resources

The 2016 Coastal Bend Regional Water Plan (2016 Plan) is consistent with long-term protection of the state's water resources, agricultural resources, and natural resources and is developed based on guidance principles outlined in the Texas Administrative Code Chapter 358 - State Water Planning Guidelines. The 2016 Plan was produced with an understanding of the importance of orderly development, management, and conservation of water resources and is consistent with all laws applicable to water use for the state and regional water planning areas. Furthermore, the plan was developed according to principles governing surface water and groundwater rights. The 2001 TCEQ Agreed Order governing freshwater pass-throughs to the Nueces Estuary was strictly adhered to for current surface water supply projects and future water management strategies. For groundwater, the 2016 Plan also recognized principles for groundwater use in Texas and the authority of groundwater conservation districts and groundwater management areas within the Coastal Bend Region. The modeled available groundwater (MAG) estimates developed by the TWDB based on desired future conditions developed by groundwater conservation districts and groundwater management areas was used to determine groundwater availability. The CBRWPG recognizes the need to protect groundwater quality.

The 2016 Plan identifies actions and policies necessary to meet the Coastal Bend Region's near and long-term water needs by developing and recommending water management strategies to meet their needs with reasonable cost, good water quality, and sufficient protection of agricultural and natural resources of the state. The Coastal Bend Region recommended water management strategies that considered public interest of the state, wholesale water providers, protection of existing water rights, and opportunities that encourage voluntary transfers of water resources while balancing economic, social, and ecological viability. When needs could not be met economically with water management strategies, a socioeconomic impact analysis was

[5] Lavaca Regional Planning Group Initially Prepared Plan, draft estimates provided April, 23, 2015.

performed by the TWDB to estimate the economic loss associated with not meeting these needs (electronic Appendix - Final Plan only).

The 2016 Plan considered environmental information resulting from site-specific studies and ongoing water development projects when evaluating water management strategies. Water management strategies have the potential of impacting instream flows and inflows to bay and estuary systems. For the 2016 Plan, recommended water management strategies either originate from neighboring basins outside the Nueces Basin or groundwater projects that are expected to have minimal to no cumulative adverse effect on Nueces River instream flows and inflows to the Nueces estuary. A list of endangered and threatened species in the Coastal Bend Region for each county was obtained from the U.S. Fish and Wildlife Service and discussed in Chapter 1. Possible habitats for endangered and threatened species were considered for each water management strategy (Section 5D). The 2001 Agreed Order includes operational procedures for CCR and LCC and requires passage of inflows to the Nueces Bay and Estuary based on maximum harvest studies and inflow recommendations to maintain the health of the Nueces Estuary. It is likely that with addition of water supplies from Lake Texana and the Colorado River from adjacent basins, water stored in CCR and LCC is at a higher percent storage capacity than what would have occurred if CCR and LCC were solely responsible for meeting the needs of the City of Corpus Christi and its customers at the same demand. The water supply diversification that has occurred in the region has aided to promote recreational uses at the lakes.

Due to most areas having an underlying impervious clay layer, there has not been much opportunity for springs to form in the Coastal Bend Region.

The 2016 Plan consists of initiatives to respond to drought conditions and includes drought contingency measures by regional entities (Chapter 7). As a further drought protection provision, the Coastal Bend Region adopted use of safe yield analyses for purposes of determining water supply. The use of safe yield analyses anticipates that a future drought may occur that is greater in severity than the worst drought of record and reserves a certain amount of water in storage (i.e. 125,000 ac-ft, or one year demand) for such an event. Use of safe yield for the major water supplies in the Nueces River Basin is justified based on previous droughts in the basin over the past 70 years. Figure 6.3 shows how 3-year average annual inflows for the major reservoir system have been reduced for each of the past four significant droughts.

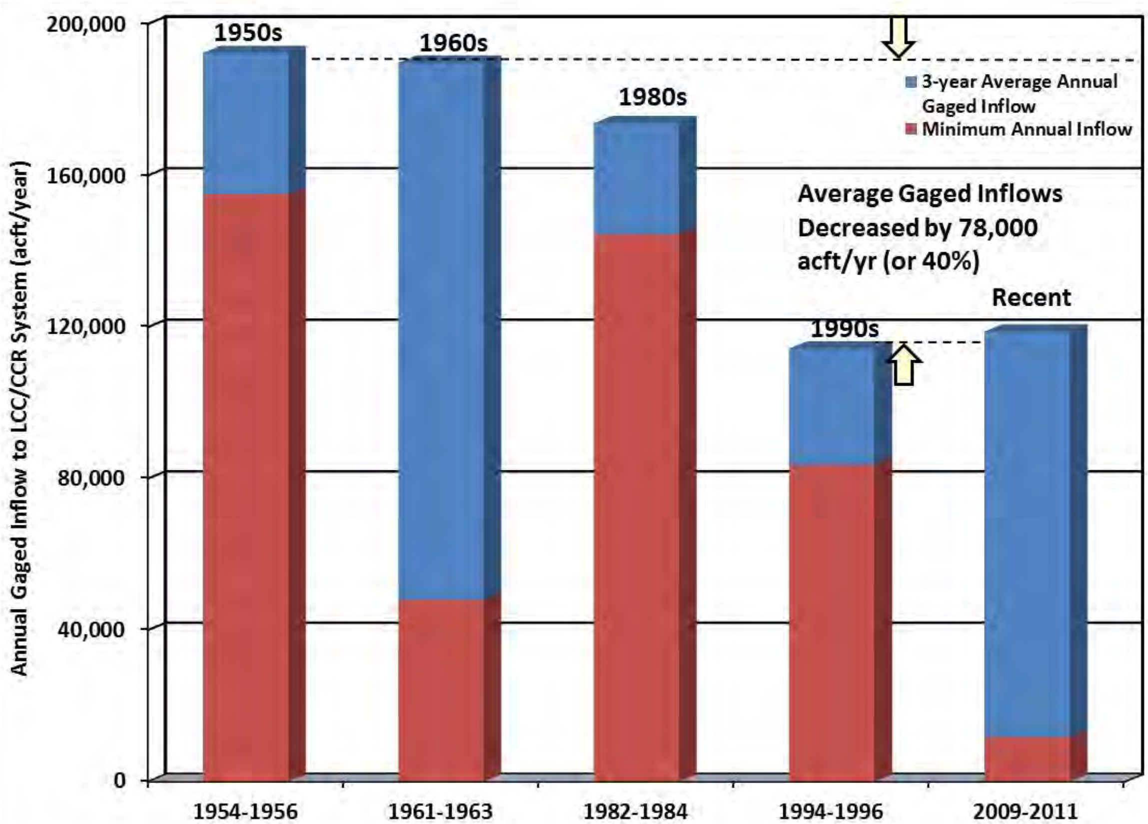

Figure 6.3.
3-Year Reservoir Inflows

The Coastal Bend Region conducted numerous meetings during the 2016 planning cycle, with meetings open to the public and decisions based on accurate, objective, and reliable information. The Region coordinated water planning and management activities with local, regional, State and Federal agencies and participated in interregional communication with the South Central Texas Region (Region L) and Lavaca Region (Region P) to identify common needs and worked together with Region L and Region P to develop interregional strategies in an open, equitable, and efficient manner. The Coastal Bend Region considered recommendations of stream segments with unique ecological value by Texas Parks and Wildlife and sites of unique value for reservoirs. At this time, the Coastal Bend Region recommends that no stream segments with unique ecological value be designated. The Planning Group developed policy recommendations for the 2016 Plan including protection of water quality, consideration of environmental issues, interbasin transfers, groundwater management, request for additional studies for water supply projects (such as desalination), and continued funding for regional water planning efforts. The Planning Group policy recommendations are included in Chapter 8.

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Drought Response Information, Activities, and Recommendations

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Chapter 7: Drought Response Information, Activities, and Recommendations

Droughts are of great importance to the planning and management of water resources in Texas. Although droughts can occur in all climatic zones, they have the greatest potential for environmental and public health concern in arid regions such as Texas. It is not uncommon for mild droughts to occur over short periods of time in the state, however, there is no reliable way to fully predict how long or severe a drought will be until it is over. The best defense available to WUGs in drought prone areas, such as those in Region N, is proper planning and preparation for worst case scenarios with contingencies for drought uncertainty. This requires understanding of drought patterns and the historical droughts in the region.

With population growth expected to continue in the Region N area based on TWDB projections, the demand for water will continue to increase. This growing demand compounded by climate uncertainty and extended drought periods makes planning even more important to prevent shortages, deterioration of water quality and lifestyle/financial impacts on water suppliers and users. This chapter presents information on Region N's drought preparedness, including regional droughts of record, current model drought contingency plans, emergency interconnects, and responses to local drought conditions.

7.1 Droughts of Record in the RWPA

7.1.1 Background

One of the best tools in drought preparedness is a thorough understanding of the drought of record (DOR), or the worst drought to occur for a particular area during the available period of record. However, there are many ways that the "worst drought" can be defined (degree of dryness, agricultural impacts, socioeconomic impacts, effects of precipitation, etc.). Regional planning focuses on the hydrological drought or the drought with the largest shortfalls on surface and/or subsurface water supply. The frequency and severity of hydrological drought is often defined on a watershed or river basin scale, although it could be different from one area to the next, even within a planning region.

7.1.2 Current Drought of Record

In terms of severity and duration, the drought from 1992-2002 is considered the DOR for the Region N Planning area. The critical drawdown was 51 months from June 1992 to August 1996 during which time the reservoirs went from full to a minimum storage of 25.5% before inflows restored lake storage. From 1994-1996, inflows into LCC and CCR were 40% less (or 78,000 ac-ft/yr less) than the inflows from 1954-1956 that would have reached LCC and CCR. The 1990s drought has been used by water resource engineers and managers as a benchmark drought for water supply planning in Region N since the 2006 Plan.

The most recent drought beginning in 2007 has been discussed but not confirmed as the new DOR for Region N. A discussion of current drought conditions is provided below.

A large amount of water supplied to the region is provided from Lake Texana in Region P and the Colorado River (Mary Rhodes Phase II) in Region K which helps mitigate drought impacts in the Nueces Basin. For example, on March 24, 2015, while the combined capacity of Choke Canyon Reservoir and Lake Corpus Christi was at 33.2% the capacity of Lake Texana was 100.6%. Often drought occurs at different times and at different levels of severity in the Nueces, Lavaca-Navidad, and Colorado River basins. This frequent situation gives the City flexibility in operating the CCR/LCC/Texana/MRP Phase II system to optimize water supplies[1]. The DOR for the Lavaca-Navidad and Colorado River basins are December 1952 to April1957 and May 1947 to April 1957, respectively.[2]

7.1.3 Corpus Christi Water Supply Model

Engineers and planners often use surface water models to demonstrate the effects of historical droughts on water supply. Surface water effects are more readily observed than groundwater; and although reservoirs may have not been constructed before historic droughts they can be simulated and assessed using historic hydrology. The main tool used to observe the performance of Region N reservoirs under historic drought conditions is the Corpus Christi Water Supply Model (CCWSM). This model simulates operations of the CCR/LCC/Lake Texana System and Mary Rhodes Phase 2 diversions from the Lower Colorado River in addition to adhering to the pass-through schedule from the 2001 Agreed Order between the City and TCEQ governing freshwater inflows to the Nueces Estuary. Actual pass-through information can be accessed from the Nueces River Authority website.

The Corpus Christi Water Supply Model includes hydrologic information from 1934 through 2003 and calculates the 1990s drought as the DOR for Region N. However, it has not been updated to include information from more recent periods of drought, such as the 2011 drought. The combined storage of Lake Corpus Christi and Choke Canyon reservoir can be seen in Figure 7.1. This graph shows that the duration and severity of the 1990's drought is still greater than the current drought, however, the since the current drought is ongoing the extent has not yet been determined.

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[1] Subject to permitted or contracted supply amounts.
[2] Email correspondence with Regions K and P, February 18, 2015.

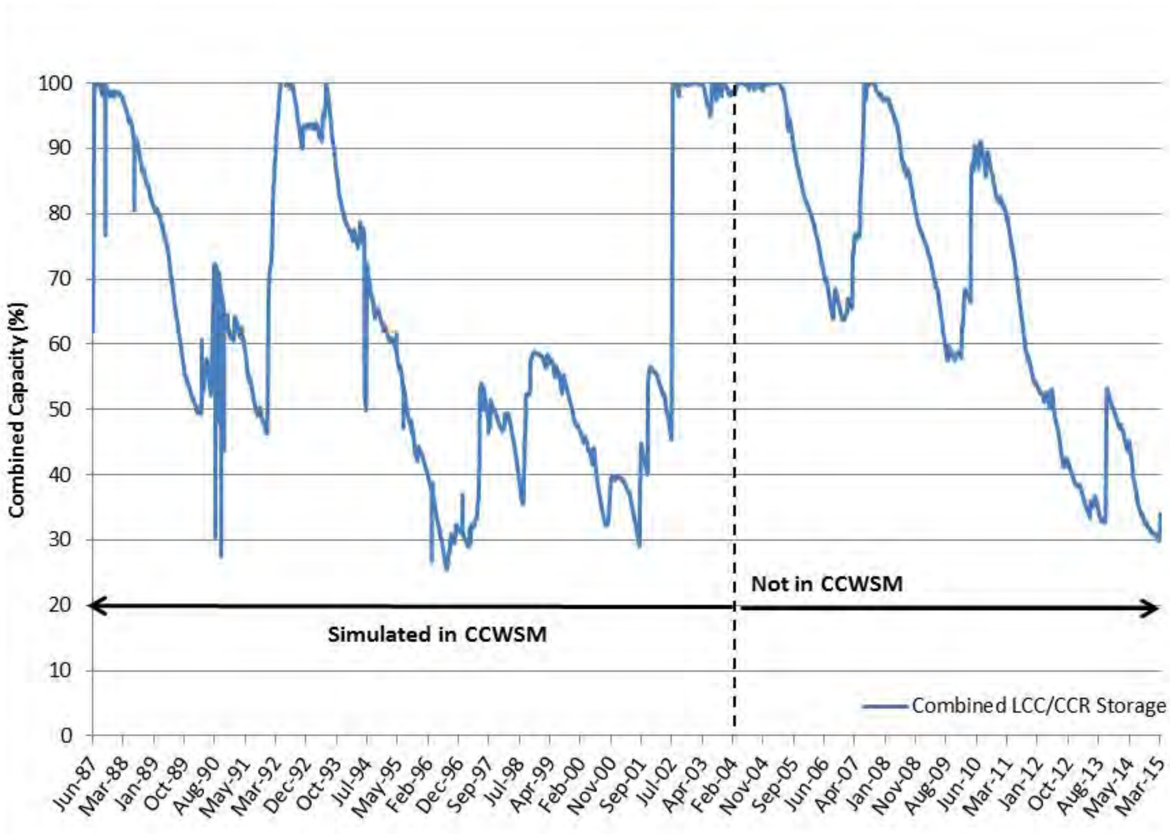

Figure 7.1.
Combined Lake Corpus Christi and Choke Canyon Reservoir Storage

7.1.4 Recent Drought Discussion

Throughout the 2011 water year, a severe drought occurred from decreased precipitation resulting in substantial declines in streamflow throughout the state. Record high temperatures also occurred June through August leading to an increase in evaporation rates. Net evaporation was so high that by August 4, 2011, state climatologist John Nielson-Gammon declared 2011 to be the worst 1-year drought on record in Texas.[3] The 2011 water year statewide annual precipitation was 11.27 inches, more than 2 inches below the previous record in 1956 of 13.91 inches.

The lowest recorded annual inflow into the LCC and CCR system in the Nueces Basin occurred in 2011 at 11,800 ac-ft. The three year average annual inflow from 2009 to 2011 was 119,000 ac-ft/yr, which is slightly above the 1994-1996 inflow conditions.[4]

[3] Winters, K.E., 2013, A historical perspective on precipitation, drought severity, and streamflow in Texas during 1951-56 and 2011: U.S. Geological Survey Scientific Investigations Report 2013-5113, p.1 http://pubs.usgs.gov/sir/2013/5113.
[4] The three year period from 2009 to 2011 is the lowest three year inflow period from 2007-2014.

While the ongoing water drought is severe and can provide helpful information to water planners and managers throughout the state, the duration of the 1990's drought combined with the over all severity for Region N suggests that it is still the best choice as the DOR for regional planning purposes at this time. The lowest percent combined storage of Lake Corpus Christi and Choke Canyon Reservoir was recorded in August 1996 at 25.53%. On March 8th of 2015, the combined storage was at it's lowest since the 1990s drought at 29.9%. Depending on how long it takes for the system to recover from the current drought, the DOR could change in future planning cycles.

In an attempt to account for current and future drought uncertainty, Region N's water supply from the CCR/LCC/Texana/MRP2 system is based on maintaining a safe yield reserve of 125,000 ac-ft during the DOR represented in the model. Furthermore, the Colorado WAM which was recently updated through December 2013 by TCEQ to include the recent drought was used to estimate water availability for the MRP2 supplies integrated into the City of Corpus Christi's water system.

7.2 Current Drought Preparations and Response

7.2.1 Current Drought Preparations and Responses WUG Level Planning

Water User Groups in Region N prepare for drought by implementing their drought contingency plans and participating in planning discussions. The regional planning process attempts to meet projected water demands during a drought of equal severity to the DOR. WUGs that provide accurate information to the Texas Water Development Board and consider recommendations accepted by the regional planning group should be able to supply water to customers throughout drought periods. In addition, all wholesale Water Providers and most municipalities develop individual drought contingency plans (DCPs) or emergency action plans to be implemented at various stages of a Drought.

7.2.2 Overall Assessment of Local Drought Contingency Plans

While it's difficult to perfectly predict the timing, severity and length of a drought, it is an inevitable component in Texas. For this reason, it is critical to plan for these occurrences with policy outlining adjustments to the use, allocation and conservation in response to drought conditions. Drought and other circumstances that interrupt the reliable supply or water quality of a source often lead to water shortages. When water shortages occur there is generally a greater demand on the already decreased supply as individuals may attempt to keep lawns green. In the twenty months from June 2013 to February 2015 when once a week watering was implemented, the residential water use was reduced by 18% (or total of 5-6% for all users).[5] This behavior reduces the rate of water supply depletion during drought.

TCEQ requires all wholesale public water suppliers, retail public water suppliers serving 3,300 connections or more, and irrigation districts to submit drought contingency plans. In accordance

[5] Email correspondence from Brent Clayton, March 2015.

with the requirements of Texas Administrative Code §288(b), DCPs must be updated every 5 years and adopted by retail public water providers. The TCEQ defines a DCP as "A strategy or combination of strategies for temporary supply and demand management responses to temporary and potentially recurring water supply shortages and other water supply emergencies." [6] According to a TCEQ handbook[7], the underlying philosophy of drought contingency planning is that:

- While often unpreventable, short-term water shortages and other water supply emergencies can be anticipated;
- The potential risks and impacts of drought or other emergency conditions can be considered and evaluated in advance of an actual event; and, most importantly; and
- Response measures and best management practices can be determined with implementation procedures defined, again in advance, to avoid, minimize, or mitigate the risks and impacts of drought-related shortages and other emergencies.

Model Drought Contingency plans are available on TCEQ's website; however, it is not possible to create a DCP that will adequately address local concerns throughout the State of Texas. The conditions that define a water shortage are location specific and may vary for water users that use groundwater versus surface water or those that have sole-source of supply versus those with a multiple source, diversified water system. While the approach to planning may be different between entities all DCPs should include:

- Specific, quantified targets for water use reductions,
- Drought response stages,
- Triggers to begin and end each stage,
- Supply management measures,
- Demand management measures,
- Descriptions of drought indicators,
- Notification procedures,
- Enforcement procedures,
- Procedures for granting exceptions,
- Public input to the plan,
- Ongoing public education,
- Adoption of plan, and
- Coordination with regional water planning group.

For water suppliers such as those in Region N, the primary goal of DCP development is to have a plan that can reliably provide an uninterrupted supply of water in an amount that can satisfy essential human needs. A secondary but also important goal is to minimize negative impacts on quality of life, the economy and the local environment. In order to meet these goals, action needs to be taken quickly which is why an approved DCP needs to be in place before drought conditions occur.

[6] http://www.twdb.texas.gov/conservation/training/archives/more-than-a-drop-workshop/doc/5_%20TCEQ%20Rules.pdf.
[7] https://www.tceq.texas.gov/assets/public/comm_exec/pubs/archive/rg424.pdf.

In accordance with Texas Administrative Code, most Region N entities have submitted DCPs to be implemented during drought conditions. Region N was able to obtain DCPs from all four wholesale water providers, the Lavaca Navidad River Authority, and 26 municipal WUGs and county-other entities as seen in Table 7.1. These plans identify multiple triggers for initiation and termination of drought stages, responses to be implemented and reduction targets based on each stage. The plans also include information regarding public notification procedures and enforcement measures. Some WUGs or WWPs have included a method of granting a variance should the need arise. The most recent DCPs for each entity in Region N range in date from 2000 to 2014. Detailed DCP information for the four wholesale water providers who supply water to the majority of WUGs in the region can be found in Tables 7.2 to 7.6.

Table 7.1.
Region N Entities with Available DCP

Region	County Name	WUG	DB17 CityNum	DCP on File	DCP Date
Wholesale Water Providers and Lavaca Navidad River Authority					
N	NUECES	CORPUS CHRISTI	0135	x	2015
N	SAN PATRICIO & NUECES	SPMWD	n/a	x	2014
N	KLEBERG	SOUTH TEXAS WATER AUTHORITY	n/a	x	2013
N	NUECES	NUECES COUNTY WCID #3	n/a	x	2013
N	JACKSON	LNRA	n/a	x	2014
Water User Groups					
N	ARANSAS	ARANSAS PASS	0023	x	2008
N	ARANSAS	ROCKPORT	0511	x	2013
N	LIVE OAK	THREE RIVERS	0604	x	2014
N	BEE	BEEVILLE	0045	x	2015
N	DUVAL	SAN DIEGO	0534	x	2000
N	JIM WELLS	ALICE	0006	x	2014
N	JIM WELLS	ORANGE GROVE	0444	x	2000
N	KLEBERG	KINGSVILLE	0323	x	2002
N	KLEBERG	RICARDO WSC	4316	x	2013
N	LIVE OAK	EL OSO WSC	4104	x	2009
N	LIVE OAK	MCCOY WSC	4250	x	2009
N	NUECES	NUECES WSC	4501	x	2013
N	NUECES	RIVER ACRES WSC	4320	x	2000
N	SAN PATRICIO	ODEM	0437	x	2014
N	SAN PATRICIO	INGLESIDE	0296	x	2014
N	SAN PATRICIO	TAFT	0592	x	2013
N	SAN PATRICIO	PORTLAND	0478	x	2013
N	SAN PATRICIO	RINCON WSC	4470	x	2009
County-Other Entities					
N	ARANSAS	Aransas County MUD #1	n/a	x	2009
N	BEE	Blueberry Hills	n/a	x	2005
N	ARANSAS	Copano Heights Water Company	n/a	x	2005
N	HIDALGO	Escondido Creek Estates	n/a	x	2000
N	DUVAL	Freer WCID	n/a	x	2000
N	MCMULLEN	McMullen County WCID #2	n/a	x	2002
N	KLEBERG	Riviera	n/a	x	2000
N	KLEBERG	Baffin Bay WSC	n/a	x	2014
N	BEE	Pettus MUD	n/a	x	2000

Table 7.2.
City of Corpus Christi Surface Water Sources Drought Contingency Response

Drought Contingency Stage	***Reservoir System Storage***	***Actions***
Stage I – Mild	*Always in Effect	• Water customers are requested to voluntarily limit the irrigation of landscaped areas to once per week and are requested to practice water conservation and to minimize or discontinue non-essential water use. • All operations of the City of Corpus Christi shall adhere to water use restrictions prescribed for Stage 2 of the DCP.
Stage II – Moderate	*Less than 80%	• City Manager issues a public notice implementing required water conservation measures. • More repair crews will be used if necessary to repair leaks. • Irrigation of landscaped areas with hose-end sprinklers or automatic irrigation systems shall be limited to once per week based on the City Manager's watering schedule. • Fire hydrant use is restricted to the interest of public health and safety. • Prohibits use of water for Golf Course irrigation is restricted to water days unless the course uses a source other than Corpus Christi Utilities. • Use of water to maintain integrity of building foundations is limited to watering days and hand held hose or drip irrigation. • Target water demand reduction of 10 percent, including for wholesale water contracts.
Stage III – Severe	*Less than 30%	In addition to Actions under Stage II, take the following actions: • Irrigation of landscaped areas with hose-end sprinklers or automatic irrigation systems shall be limited to once every other week. • The watering of golf course fairways with potable water is prohibited. • Target water demand reduction of 15 percent, including for wholesale water contracts. • Flushing of water mains is eliminated unless in interest of public safety.
Stage IV – Critical	* less than 20%	• Irrigation of landscaped areas shall be prohibited at all times. • Use of water to wash any motor vehicle, motorbike, boat, trailer, or other vehicle not occurring on the premises of a commercial car wash and not in the immediate interest of public health, safety, and welfare is prohibited. • The filling, refilling, or adding of water to swimming pools, wading pools, and jacuzzi-type pools, and water parks (unless utilizing water from a non-city alternative source) is prohibited. Fountains may operate to maintain equiptment. • Target water demand reduction of 30 percent, including for wholesale water contracts.
Stage V - Emergency	Not Applicable	• Irrigation of landscaped area is absolutely prohibited. • Use of water to wash any motor vehicle, motorbike, boat, trailer, or other vehicle is absolutely prohibited. • Associated uses of water not related to business process which are discretionary, such as equipment washing, shall be deferred until the Stage 5 emergency has been terminated.

* CCR/LCC combined storage
** Other purposes include vehicle washing, indoor and outdoor pools, golf course irrigation, and use of water for the integrity of building foundations.

Table 7.3.
San Patricio Municipal Water District Drought Contingency Response

Drought Contingency Stage	***Reservoir System Storage***	***Actions***
Stage I – Mild	*Below 50% or Lake Texana <40%	• District Manager issues a public notice to inform water users of the Corpus Christi water supply region to begin voluntary conservation measures. • Target water demand reduction of 5 percent, including for wholesale water contracts.
Stage II – Moderate	*Between 40% and 30%	• District Manager issues a public notice implementing required water conservation measures. • Irrigation of landscaped areas with hose-end sprinklers or automatic irrigation systems shall be limited to once per week. • District Manager issues a lawn watering schedule and designates watering days and specific exemptions for **other purposes. • Prohibits use of water to wash down of any sidewalks, walkways, driveways, parking lots, tennis courts, or other hard-surfaced areas, except if it is in the interest of public health and safety. • Prohibits use of water to wash down buildings or structures for purposes other than immediate fire protection without permit granted by the District Manager. • Prohibits use of water for dust control without permit granted by the District Manager. • Target water demand reduction of 10 percent, including for wholesale water contracts.
Stage III – Severe	*Equal to or less than 30%	In addition to Actions under Stage II, take the following actions: • Irrigation of landscaped areas with hose-end sprinklers or automatic irrigation systems shall be limited to once every other week. • The watering of golf course fairways with potable water is prohibited. • Target water demand reduction of 15 percent, including for wholesale water contracts.
Stage IV – Critical	*Equal to or less than 20%	• Irrigation of landscaped areas shall be prohibited at all times. • Use of water to wash any motor vehicle, motorbike, boat, trailer, or other vehicle not occurring on the premises of a commercial car wash and not in the immediate interest of public health, safety, and welfare is prohibited. • The filling, refilling, or adding of water to swimming pools, wading pools, and jacuzzi-type pools, and water parks (unless utilizing water from a non-city alternative source) is prohibited. • The use of water to maintain the integrity of a building foundation is permitted on the designated watering day and shall be done by hand or drip irrigation method. • Target water demand reduction of 30 percent, including for wholesale water contracts.

* CCR/LCC combined storage
** Other purposes include vehicle washing, indoor and outdoor pools, golf course irrigation, and use of water for the integrity of building foundations.

Table 7.4.
South Texas Water Authority Drought Contingency Response

Drought Contingency Stage	***Reservoir System Storage***	***Actions***
Stage I – Mild Water Shortage Conditions	*Below 50% or Lake Texana <40%	1. Notify all its wholesale water customers regarding the initiation of the drought response stage. 2. Provide reports to the City of Corpus Christi with information regarding current wholesale customer usage. 3. Initiate preparations for the implementation of pro rata curtailment of water diversions and/or deliveries by preparing a monthly water usage allocation baseline for each wholesale customer. 4. Contact wholesale water customers to discuss water supply and/or demand conditions and request that wholesale water customers initiate voluntary measures to reduce water use. 5. Request wholesale customers and assist in the effort to organize a committee of business, industrial, and residential representatives to make recommendations for the necessary regulations and prohibitions. 6. Provide a report to news media with information regarding current water supply and/or demand conditions, projected water supply and demand conditions if drought conditions persist, and consumer information on water conservation measures and practices. 7. Target water demand reduction of 5 percent.
Stage II – Moderate Water Shortage Conditions	*Between 40% and 30%	In addition to Actions 1-3 under Stage I, take the following actions: 8. Request wholesale customers continue with conditions set during Stage I. In addition, request that wholesale customers consider implementation of additional regulations and prohibitions. 9. Contact with wholesale water customers to discuss water supply and/or demand conditions and the possibility of pro rata curtailment of water diversion and/or deliveries. 10. Request wholesale water customers to initiate mandatory measures to reduce non-essential water use. 11. Target water demand reduction of 10 percent.
Stage III – Severe Water Shortage Conditions	*Equal to or less than 30%	12. Request wholesale customers continue with conditions set during Stage II. In addition, request that wholesale customers consider implementation of additional regulations and prohibitions. 13. Provide reports to the City of Corpus Christi with information regarding current wholesale customer usage. 14. Target water demand reduction of 15 percent.
Stage IV – Critical Water Shortage Conditions	*Equal to or less than 20%	15. Request wholesale customers continue with conditions set during Stage III. In addition, request that wholesale customers consider implementation of additional regulations and prohibitions. 16. Provide reports to the City of Corpus Christi with information regarding current wholesale customer usage. 17. Target water demand reduction of 30 percent.

*CCR/LCC combined storage

Table 7.5.
Nueces County WCID #3 Drought Contingency Response

Drought Contingency Stage	Reservoir System Storage	Actions
Stage I – Water Shortage Possibility	Below 50%	• The District will notify all its customers regarding the initiation of the drought response stage. • Target water demand reduction of 10 percent, preferable during times of peak water use. • The District will minimize routine flushing of water mains. • Use of water from fire hydrant should be limited to activities necessary to maintain public health, safety, and welfare; use of water from designated fire hydrants for construction purposes may be allowed under special permit. • Agricultural irrigation shall be limited to once per week. • Stage 1 Drought Condition Water Rates may be initiated.
Stage II – Water Shortage Watch	Between 40% and 30%	• The District will notify all its customers regarding the initiation of the drought response stage. • Target water demand reduction of 15 percent, preferable during times of peak water use. • The district will minimize and/or discontinue routine flushing of water mains. • Agricultural irrigation shall be limited to twice per month. • Stage 2 Drought Condition Water Rates may be initiated.
Stage III – Water Shortage Warning	Between 35% and 30%	• The District will notify all its customers regarding the initiation of the drought response stage. • Target water demand reduction of 20 percent, preferable during times of peak water use. • The district will discontinue flushing of water mains. • New service connections to the District's water system may be prohibited where some other source independent of the District's water system is existing and in use. • The use of potable water for all non-essential water features may be discontinued. • The use of water for construction purposes from designated fire hydrants under special permit may be discontinued. • Agricultural irrigation shall be limited to once per month. • Stage 3 Drought Condition Water Rates may be initiated.
Stage IV – Water Shortage Emergency	Less than 30%	• The District will notify all its customers regarding the initiation of the drought response stage. • Target water demand reduction of 25 percent, preferable during times of peak water use. • The district will discontinue flushing of water mains. • No applications for new, additional, further expanded, or increases-in-size water service connections, meters, service lines, pipeline extensions, mains, or other water service facilities of any kind will be allowed, approved, or installed except as approved by the District. • Residential and commercial customers will be allowed a maximum of 6,000 gallons per month per connection unless different arrangements have been made showing an absolute necessity. • Agricultural irrigation water will be eliminated. • Any variation of the rules for a different watering plan must be presented and approved. • Suspension of service may be enforced for willful violators after a written notice of violation is delivered. • Stage 4 Drought Condition Water Rates may be initiated.

Table 7.6.
Lavaca Navidad River Authority's Drought Contingency Response

Drought Condition	Trigger	Actions
Condition I – Mild Water Shortage Condition	Lake Texana Reservoir elevation is at or below elevation 43.00 ft msl	1. LRNA will notify TCEQ Watermaster of reservoir condition. 2. Inform public, giving notice of reservoir condition to the customers served by the LNRA system and upstream water rights permit holders. 3. *Impacts permit holders upstream of Lake Texana who divert water for irrigation purposes.* Diversions must cease within 24 hours following the time when the reservoir level drops below elevation 43.00 ft msl.
Condition II – Moderate Water Shortage Condition	Lake Texana Reservoir elevation is at or below elevation 39.95 ft msl	In addition to Actions 1–3 under Conditions I, take the following actions 4. *Impacts freshwater releases to bays and estuaries.* LNRA may reduce the volume of freshwater releases to bays and estuaries to 5 cubic feet per second, when Lake Texana reaches roughly 78% of the reservoir capacity. 5. Target water demand reduction of 5 percent of the use that would have occurred in the absence of drought contingency measures. 6. Notify TPWD of reservoir condition and change in B&E release schedule. 7. Include recommendations to conserve water in information to the public.
Condition III – Severe Water Shortage Condition	Lake Texana Reservoir elevation is at or below elevation 35.00 ft msl Water supply emergency occurs or drought worse than the Drought of Record is declared	8. LRNA will notify TCEQ Watermaster and Dam Safety Team of reservoir condition. 9. Inform public, giving notice of reservoir condition and delivery volume. 10. Implement pro rata reduction of water deliveries to industrial and municipal customers. 11. Through the news media, the public should be advised daily of the trigger conditions, the mandatory reduction, and that water users conserve water.
Condition IV – Critical Water Shortage Condition	Contamination of water supply source Failure or damage to the operating structures due to a natural or catastrophic event Water supply emergency occurs or drought worse than the Drought of Record is declared	12. LRNA will notify TCEQ Watermaster and Dam Safety Team of reservoir condition. 13. Inform public, giving notice of reservoir condition and delivery volume. 14. Implement pro rata reduction of water deliveries to industrial and municipal customers. 15. Through the news media, the public should be advised daily of the trigger conditions, the mandatory reduction, and that water users conserve water.

7.2.3 Summary of Existing Triggers and Responses

Through timely implementation of drought response measures it is possible to meet the goals of the DCP by avoiding, minimizing or mitigating risks and impacts of water shortages and Drought. In order to accomplish this, DCPs are built around a collection of drought responses and triggers based on various drought stages. Stages are generally similar for all DCP's but can vary from entity to entity. Stage one will normally represent mild water shortage conditions and the severity of the situation will increase through the stages until emergency water conditions are reached and in some cases a water allocation stage is determined.

Region N compiled stage, trigger and response information for 31 DCPs in the region and LNRA including those from WWPs, WUGs and County-Other suppliers. The majority of the DCPs in the region have a voluntary Stage I and Mandatory Stage II and III categories. Most entities included a Stage IV and a few entities specified a Stage V scenario. Target reductions, triggers and responses are included for most stages. Triggers for individual Region N water user groups can be found in Table 7.7 and corresponding responses can be found in Table 7.8.

Table 7.7.
Region N DCP Drought Triggers

Water Systems	(SW/ GW)	Stage I (Voluntary)	Stage II	Stage III	Stage IV (If applicable)	Stage V
Water User Groups						
City of Aransas Pass (Aransas County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/AransasPass.pdf	SW	***Mild Water Shortage Conditions*** When the LCC/CCR system storage falls below 50% of maximum capacity.	***Moderate Water Shortage Conditions*** When the LCC/CCR system storage falls below 40% of maximum capacity.	***Severe Water Shortage Conditions*** When the LCC/CCR system storage falls below 30% of maximum capacity.	***Critical Water Shortage Conditions*** When the LCC/CCR system storage falls below 15% of maximum capacity. Whenever there is an interruption in the City of Corpus Christi or SPMWD's raw water supply. When there is a mechanical breakdown in the City of Corpus Christi or SPMWD's WTP which causes plant shutdown for an extended period of time.	***Emergency Water Shortage Conditions*** When the City Council or their designee determines that a water supply emergency exists. Major water line breaks, or pump or system failures occur, which cause unprecedented loss of capability to provide water service. Natural or man-made contamination of the water supply source(s).
City of Rockport (Aransas County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Rockport.pdf	SW	***Mild Water Shortage Conditions*** When the LCC/CCR system storage falls below 50% of maximum capacity. OR Lake Texana storage declines below 40%	***Moderate Water Shortage Conditions*** When the LCC/CCR system storage falls below 40% of maximum capacity.	***Severe Water Shortage Conditions*** When the LCC/CCR system storage falls below 30% of maximum capacity.	***Critical Water Shortage Conditions*** When the LCC/CCR system storage falls below 20% of maximum capacity.	***Emergency Water Shortage Conditions*** When the City Council or their designee determines that a water supply emergency exists. Major water line breaks, or pump or system failures occur, which cause unprecedented loss of capability to provide water service. Natural or man-made contamination of the water supply source(s).
City of Three Rivers (Live Oak County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/3rivers.pdf	SW	***Mild Water Shortage Conditions*** When CCR storage falls below 50% of maximum capacity. OR When the City of Corpus Christi declares this water shortage condition. OR When there is high demand on the system.	***Moderate Water Shortage Conditions*** When CCR storage falls below 40% of maximum capacity. OR When the City of Corpus Christi declares this water shortage condition. OR When daily water demand exceeds 85% of capacity for 3 consecutive days.	***Severe Water Shortage Conditions*** When CCR storage falls below 30% of maximum capacity. OR When the City of Corpus Christi declares this water shortage condition. OR When daily water demand exceeds 90% of capacity for 3 consecutive days.	***Critical Water Shortage Conditions*** When CCR storage falls below 20% of maximum capacity. OR When the City of Corpus Christi declares this water shortage condition. OR When daily water demand exceeds 95% of capacity for 3 consecutive days.	***Emergency Water Shortage Conditions*** Major limitations to water system components, water productions or distribution limitations, or supply contamination.

Water Systems	(SW/ GW)	Stage I (Voluntary)	Stage II	Stage III	Stage IV (If applicable)	Stage V
Baffin Bay WSC https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Baffin%20Bay%20WSC_DCP.pdf	SW	***Mild Conditions*** Consumption reaches 80% of Daily Max for 3 days. OR Supply is 20% greater than average previous month consumption OR Extended perios of low rain and daily use has risen 20% over same time last year.	***Moderate Conditions*** Consumption reaches 90% of Daily Max for 3 days. OR Water level in any storage tank cannot be replenished for 3 consecutive days.	***Severe Conditions*** Failure of major system component reducing minimum pressure in system below 20 psi for at least a day. OR Consumption of 95% or more of the maximum available for 3 days OR Natural of man made disaster, or safety risk to public		
City of Beeville (Bee County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Beeville_DCP_2014.pdf	SW	***Mild Water Shortage Condition*** Lake Levels <50%	***Moderate Water Shortage Condition*** Lake Levels< 40%	***Severe Water Shortage Condition*** Lake Levels < 30%	***Severe Water Shortage*** Lake Levels < 20%	***Emergency Water Shortage*** In the case of an emergency
San Diego (Duval County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/SanDiego.pdf	GW	***Mild Water Shortage Conditions*** Annually, beginning on May 1 through October 31 of every year. When the water supply available to the San Diego Municipal Utility District No. 1 is equal or less than 70% of storage capacity. When the static water level in the San Diego Municipal Water Utility District No. 1 well(s) is equal or less than 100 feet above water pump level. When the specific capacity of the San Diego Municipal Utility District No. 1 well(s) is equal to or less than 70% of the well's original specific capacity. When total daily water demands equal or exceed one million gallons for 3 consecutive days.	***Moderate Water Shortage Conditions*** Water levels fall below 70% of storage capacity. Water demands exceed 70% of water well capacity. When the static water level in the San Diego Municipal Utility District No. 1 well(s) is equal to or less than 100 feet above water pumps.	***Severe Water Shortage Conditions*** Water levels fall below 50% of storage capacity. Water demands exceed 90% of water well capacity. When the static water level in the San Diego Municipal Utility District No. 1 well(s) is equal to or less than 100 feet above water pumps. System outages due to equipment failure.	***Emergency Water Shortage Conditions*** Major water line breaks, or pump or system failures occur, which cause unprecedented loss of capability to provide water service OR Natural or man-made contamination of the water supply source(s).	

Water Systems	*(SW/ GW)*	*Stage I (Voluntary)*	*Stage II*	*Stage III*	*Stage IV (If applicable)*	*Stage V*
City of Alice (Jim Wells County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Alice.pdf	*SW*	***Mild Water Shortage Conditions*** When the LCC water elevation is below 88 feet.	***Moderate Water Shortage Conditions*** When the LCC water elevation is below 86 feet.	***Severe Water Shortage Conditions*** When the LCC water elevation is below 82 feet.	***Critical Water Shortage Conditions*** When the LCC water elevation is below 74 feet.	***Emergency Water Shortage Conditions*** Major line breaks, or pump or system failures occur, which cause unprecedented loss of capacity to provide water service. Natural or man-made contamination of water supply source(s).
City of Orange Grove (Jim Wells County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/OrangeGrove.pdf	*GW*	***Mild Water Shortage Conditions (voluntary)*** When the static water level in City Water Well No. 4 is equal or more than 140 feet below the top of the casing. When total daily water demands equals or exceeds 90% of system safe operating capacity which is 750,000 gallons per day, for 10 consecutive days.	***Moderate Water Shortage Conditions*** When the static water level in City Water Well No. 4 drops to 150 feet below the top of the casing.	***Severe Water Shortage Conditions*** When the static water level in City Water Well No. 4 reaches 160 feet below the top of the casing.	***Critical Water Shortage Conditions*** When the static water level in City Water Well No. 4 reaches 165 feet below the top of the casing.	***Emergency Water Shortage Conditions*** Major line breaks, or pump or system failures occur, which cause unprecedented loss of capacity to provide water service. Natural or man-made contamination of water supply source(s).
City of Kingsville (Kleberg County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Kingsville.pdf	*GW*	***Mild Water Shortage Conditions*** Capacity of groundwater wells <= 90% capacity AND Total daily water demand exceeds 6 million gallons for 3 consecutive days	***Moderate Water Shortage Conditions*** Capacity of groundwater wells <= 85% capacity AND Total daily water demand exceeds 7 million gallons for 3 consecutive days	***Severe Water Shortage Conditions*** Capacity of groundwater wells <= 80% capacity AND Total daily water demand exceeds 7.5 million gallons for 3 consecutive days	***Emergency Water Shortage Conditions*** Major water line breaks, or pump or system failures occur, which cause unprecedented loss of capability to provide water service. Natural or man-made contamination of the water supply source(s).	***Water Allocation*** City manager determines that water shortage conditions threaten public health, safety and welfare.

Water Systems	(SW/ GW)	Stage I (Voluntary)	Stage II	Stage III	Stage IV (If applicable)	Stage V
Ricardo WSC (Kleberg County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Ricardo.pdf	SW	***Mild Water Shortage Conditions*** When the LCC/CCR system storage falls below 50% of maximum capacity. OR Lake Texana storage declines below 40%	***Moderate Water Shortage Conditions*** When the LCC/CCR system storage falls below 40% of maximum capacity.	***Severe Water Shortage Conditions*** When the LCC/CCR system storage falls below 30% of maximum capacity.	***Critical Water Shortage Conditions*** When the LCC/CCR system storage falls below 20% of maximum capacity.	***Emergency Water Shortage Conditions*** When the City Council or their designee determines that a water supply emergency exists. Major water line breaks, or pump or system failures occur, which cause unprecedented loss of capability to provide water service. Natural or man-made contamination of the water supply source(s).
El Oso Water Conservation District (Service area includes 500 square miles located in Karnes, Bee, Wilson, and Live Oak Counties) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Eloso.pdf	GW	***Mild Water Shortage Conditions*** Well flow from any regularly used well is less than 90% of full capacity. A storage facility is not filled for 72 consecutive hours. An elevated storage tank is out of service due to repainting or other required maintenance.	***Moderate Water Shortage Conditions*** Well flow from any regularly used well is less than 80% of full capacity. A storage facility is not filled for 96 consecutive hours.	***Severe Water Shortage Conditions*** Well flow from any regularly used well is less than 70% of full capacity. A storage facility is not filled for 120 consecutive hours.	***Critical Water Shortage Conditions*** Well flow from any regularly used well is less than 60% of full capacity. A storage facility is not filled for 144 consecutive hours.	***Emergency Water Shortage Conditions*** Major water line breaks, or pump or system failures occur, which cause unprecedented loss of capability to provide water service. Natural or man-made contamination of the water supply source(s).
McCoy Water Supply Corporation (Service area includes 608 square miles located in Atascosa, Wilson, and Live Oak Counties) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/McCoy.pdf	GW	***Mild Water Shortage Conditions*** Well flow from any regularly used well is less than 90% of full capacity. A storage facility is not filled for 72 consecutive hours. An elevated storage tank is out of service due to repainting or other required maintenance.	***Moderate Water Shortage Conditions*** Well flow from any regularly used well is less than 80% of full capacity. A storage facility is not filled for 96 consecutive hours.	***Severe Water Shortage Conditions*** Well flow from any regularly used well is less than 70% of full capacity. A storage facility is not filled for 120 consecutive hours.	***Critical Water Shortage Conditions*** Well flow from any regularly used well is less than 60% of full capacity. A storage facility is not filled for 144 consecutive hours.	***Emergency Water Shortage Conditions*** Major water line breaks, or pump or system failures occur, which cause unprecedented loss of capability to provide water service. Natural or man-made contamination of the water supply source(s).

Water Systems	(SW/ GW)	Stage I (Voluntary)	Stage II	Stage III	Stage IV (If applicable)	Stage V
Nueces WSC (Nueces County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/NuecesWSC.pdf	SW	***Mild Water Shortage Conditions*** When the LCC/CCR system storage falls below 50% of maximum capacity. OR Lake Texana storage declines below 40%.	***Moderate Water Shortage Conditions*** When the LCC/CCR system storage falls below 40% of maximum capacity.	***Severe Water Shortage Conditions*** When the LCC/CCR system storage falls below 30% of maximum capacity.	***Critical Water Shortage Conditions*** When the LCC/CCR system storage falls below 20% of maximum capacity.	***Emergency Water Shortage Conditions*** When the City Council or their designee determines that a water supply emergency exists. Major water line breaks, or pump or system failures occur, which cause unprecedented loss of capability to provide water service. Natural or man-made contamination of the water supply source(s).
River Acres WSC (Nueces County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/RiverAcres.pdf	SW	***Water Shortage Possibility*** When notification is received requesting initiation of this stage.	***Water Shortage Warning*** When notification is received requesting initiation of this stage.	***Water Shortage Conditions*** When notification is received requesting initiation of this stage.	***Water Shortage Emergency*** When notification is received requesting initiation of this stage.	
City of Ingleside (San Patricio County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Ingleside.pdf	***SW***	***Water Shortage Possibility*** When the city manager initiates this stage.	***Water Shortage Watch*** When the city manager initiates this stage.	***Water Shortage Warning*** When the city manager initiates this stage.	***Water Shortage Emergency*** When the city manager initiates this stage.	
City of Taft (San Patricio County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Taft.pdf	***SW***	***Mild Water Shortage Conditions*** When the City of Corpus Christi and/or the San Patricio Municipal Water District declares this water shortage condition.	***Moderate Water Shortage Conditions*** When the City of Corpus Christi and/or the San Patricio Municipal Water District declares this water shortage condition.	***Severe Water Shortage Conditions*** When the City of Corpus Christi and/or the San Patricio Municipal Water District declares this water shortage condition.	***Emergency Water Shortage Conditions*** When the City of Corpus Christi and/or the San Patricio Municipal Water District declares this water shortage condition.	***Water Allocation*** When the City of Corpus Christi and/or the San Patricio Municipal Water District declares this water shortage condition. Major water line breaks, or pump or system failures occur, which cause unprecedented loss of capability to provide water service. Natural or man-made contamination of the water supply source(s).

Water Systems	(SW/ GW)	Stage I (Voluntary)	Stage II	Stage III	Stage IV (If applicable)	Stage V
City of Portland (San Patricio County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Portland.pdf	SW	***Mild Water Shortage Conditions*** When the LCC/CCR system storage is below 50% of maximum capacity. When Lake Texana storage is below 40% of maximum capacity.	***Moderate Water Shortage Conditions*** When the LCC/CCR system storage is estimated to be less than 40% of maximum capacity but greater than 30%.	***Severe Water Shortage Conditions*** When the LCC/CCR system storage is estimated to be less than or equal to 30% of maximum capacity.	***Critical Water Shortage Conditions*** When the LCC/CCR system storage is estimated to be less than or equal to 20% of maximum capacity.	***Emergency Water Shortage Conditions*** When the City of Corpus Christi determines that a water supply emergency exists based on: Major line breaks, or pump or system failures occur, which cause unprecedented loss of capacity to provide water service. Water production or distribution system limitations. Natural or man-made contamination of water supply source(s).
Rincon WSC (San Patricio County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Rincon.pdf	SW	***Water Watch*** Any short-term or long-term situation requiring a 10% reduction in water consumption.	***Water Alert*** Any short-term or long-term situation requiring an 11% to 20% reduction in water consumption.	***Water Warning*** Any short-term or long-term situation requiring a 21% to 35% reduction in water consumption.	***Water Emergency*** Any short-term or long-term situation requiring a 36%or greater reduction in water consumption.	
City of Odem (San Patricio County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Odem.pdf	SW	***Mild Water Shortage Conditions*** When the LCC/CCR system storage falls below 50% of maximum capacity. OR Lake Texana storage declines below 40% Water demand reaches 85% of firm production capacity OR A water system issue reduces capacity below 85% during high demand periods.	***Moderate Water Shortage Conditions*** When the LCC/CCR system storage falls below 40% of maximum capacity. Water demand reaches 90% of firm production capacity OR A water system issue reduces capacity below 75% during high demand periods.	***Severe Water Shortage Conditions*** When the LCC/CCR system storage falls below 30% of maximum capacity. Water demand reaches 95% of firm production capacity OR A water system issue reduces capacity below 70% during high demand periods.	***Critical Water Shortage Conditions*** When the LCC/CCR system storage falls below 20% of maximum capacity. Water demand reaches 100% of firm production capacity.	***Emergency Water Shortage Conditions*** Extended period of the Severe or Critical condition. Major water line breaks, or pump or system failures occur, which cause unprecedented loss of capability to provide water service. Natural or man-made contamination of the water supply source(s).
County-Other Entities						
Aransas County MUD #1 (Aransas County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/AransasMUD.pdf	***GW***	***Mild Drought Conditions (voluntary)*** When demand on the District's water supply reaches or exceeds 70% of the production capacity of such facilities for 5 consecutive days.	***Moderate Drought Conditions*** When demand on the District's water supply reaches or exceeds 90% of the production capacity of such facilities for 3 consecutive days.	***Severe Drought Conditions*** When demand on the District's water supply reaches or exceeds 100% of the production capacity of such facilities for 24 hours.		

Water Systems	(SW/ GW)	Stage I (Voluntary)	Stage II	Stage III	Stage IV (If applicable)	Stage V
Blueberry Hills (Bee County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/BlueberryHills.pdf	GW	***Customer Awareness*** Every April 1st, the utility will mail a public announcement to its customers.	***Voluntary Water Conservation*** Overnight Recovery fails to restore 90% of full storage capacity. Production or distribution limitations.	***Mandatory Water Use Restrictions*** Overnight Recovery fails to restore 85% of full storage capacity. Production or distribution limitations.	***Critical Water Use Restrictions*** Overnight Recovery fails to restore 80% of full storage capacity. Production or distribution limitations.	
Copano Heights Water Company (Aransas County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Copano.pdf	SW	***Customer Awareness*** Every April 1st, the utility will mail a public announcement to its customers.	***Voluntary Water Conservation*** Pump Flow < 180 gpm or Total Daily Demand as 60% of pumping capacity	***Mandatory Water Use Restrictions*** Pump Flow < 170 gpm or Total Daily Demand as 70% of pumping capacity	***Critical Water Use Restrictions*** Pump Flow < 160 gpm or Total Daily Demand as 80% of pumping capacity	
Escondido Creek Estates (Hidalgo County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Escondido.pdf	GW	***Customer Awareness*** Every April 1st, the utility will mail a public announcement to its customers.	***Voluntary Water Conservation*** Overnight Recovery fails to restore 90% of full storage capacity. Production or distribution limitations.	***Mandatory Water Use Restrictions*** Overnight Recovery fails to restore 85% of full storage capacity. Production or distribution limitations.	***Critical Water Use Restrictions*** Overnight Recovery fails to restore 80% of full storage capacity. Production or distribution limitations.	
Freer WCID (Duval County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Freer.pdf	***GW***	***Mild Water Shortage Conditions (voluntary)*** Annually, beginning May 1 through September 1. When the static level in the Freer WCID is equal to or less than 10 feet above sea level. When the specific capacity of the Freer WCID wells are equal to or less than 70% of the well's original specific capacity. When total daily water demand equals or exceeds 700,000 gallons for 10 consecutive days or 700,000 gallons on a single day.	***Moderate Water Shortage Conditions*** When total daily water demand equals or exceeds 700,000 gallons for 10 consecutive days or 700,000 gallons on a single day.	***Severe Water Shortage Conditions*** When the specific capacity of the Freer WCID wells is equal to or less than 70% of the well's original specific capacity.	***Critical Water Shortage Conditions*** When the static water level in the Freer WCID wells is equal to or less than 10 feet above sea level.	
McMullen County WCID #2 (McMullen County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/McMullen.pdf	***GW***	***Mild Water Shortage Conditions (voluntary)*** When total daily water demands equals or exceeds 2 million gallons on 3 consecutive days or 2.2 million gallons on a single day.	***Moderate Water Shortage Conditions*** When total daily water demands equals or exceeds 2 million gallons on 3 consecutive days or 2.2 million gallons on a single day and/or continually falling treated water reservoir levels do not refill above 90% overnight.	***Severe Water Shortage Conditions*** When total daily water demands equals or exceeds 2 million gallons on 3 consecutive days or 2.2 million gallons on a single day and/or continually falling treated water reservoir levels do not refill above 80% overnight.	***Critical Water Shortage Conditions*** When total daily water demands equals or exceeds 2 million gallons on 3 consecutive days or 2.2 million gallons on a single day and/or continually falling treated water reservoir levels do not refill above 75% overnight.	***Emergency Water Shortage Conditions*** Major line breaks, or pump or system failures occur, which cause unprecedented loss of capacity to provide water service. Natural or man-made contamination of water supply source(s).

Water Systems	***(SW/ GW)***	***Stage I (Voluntary)***	***Stage II***	***Stage III***	***Stage IV (If applicable)***	***Stage V***
Riviera (Kleberg County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Riviera.pdf	GW	***Customer Awareness*** Every April 1st, the utility will mail a public announce-ment to its customers.	***Voluntary Water Conservation*** Overnight Recovery rate reaches 4 ft. 17 Pump hours per day.	***Mandatory Water Use Restrictions*** Overnight Recovery rate reaches 2 ft. 20 Pump hours per day.	***Critical Water Use Restrictions*** Overnight Recovery rate reaches 0 ft. 22 Pump hours per day.	
Pettus MUD (Bee County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/PettusMUD.pdf	***GW***	***Mild Water Shortage Conditions*** Total daily water demand equals or exceeds 85% of the systems safe operating capacity for three consecu-tive days or equals or exceeds 90% of system capacity on a single day.	***Moderate Water Shortage Conditions*** Total daily water demand equals or exceeds 90% of the systems safe operating capacity for three consecu-tive days or equals or exceeds 95% of system capacity on a single day.	***Severe Water Shortage Conditions*** Total daily water demand equals or exceeds 95% of the systems safe operating capacity for three consecu-tive days or equals or exceeds 100% of system capacity on a single day.	***Critical Water Shortage Conditions*** Total daily water demand equals or exceeds 100% of the systems safe operating capacity for three consecu-tive days or equals or exceeds 100% of system capacity on a single day.	***Emergency Water Shortage Conditions*** Designee determines that a water supply emergency exists based on: Major water line breaks, or pump or system failures occur, which cause unprecedented loss of capability to pro-vide water service. Natural or man-made contamination of the water supply source(s).

Table 7.8. Region N DCP Responses for Each Trigger Level

Water Systems	*(SW/ GW)*	*Stage I (Voluntary)*	*Stage II*	*Stage III*	*Stage IV (If applicable)*	*Stage V*
Water User Groups						
City of Aransas Pass (Aransas County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/AransasPass.pdf	*SW*	***Mild Water Shortage Conditions*** *Achieve a voluntary 10% reduction in daily water demand.* All customers will be notified. Industrial customers, wholesale customers, and certain commercial customers will be required to develop and submit individual Water Rationing Plans to the City. All operations of the City of Aransas Pass shall adhere to water use restrictions.	***Moderate Water Shortage Conditions*** *Achieve a 15% reduction in daily water demand.* All City-owned facilities and operations will be placed on mandatory conservation practices. Restrictions on irrigation of landscaped areas, vehicle washing, use of water for pools, and ponds. Prohibits: Wash down of hard-surfaced areas and structures for purposes other than immediate fire protection; use of fire hydrants for any purpose other than firefighting; use of water for dust control; flushing gutters; failure to repair controllable leak(s).	***Severe Water Shortage Conditions*** *Achieve a 25% reduction in daily water demand.* Continuation of restrictions set forth in previous conditions and implementation of additional regulations and prohibitions. Certain industrial and commercial water users, which are not essential to the health and safety of the community, will be prohibited from water usage. Additional restrictions on irrigation of landscaped areas, watering of golf course, and use of water for construction purposes.	***Critical Water Shortage Conditions*** *Achieve a 35% reduction in daily water demand.* Additional restrictions on irrigation of landscaped areas and use of water for washing vehicles. The use of water for any type of pool is prohibited. No application for new, additional, expanded, or increased-in-size water service connections, meters, service lines, pipeline extensions, mains, or water service facilities of any kind shall be approved during this stage.	***Emergency Water Shortage Conditions*** *Achieve a 45% reduction in daily water demand.* Continuation of restrictions set forth in previous conditions and implementation of additional regulations and prohibitions. Irrigation of landscaped areas and use of water to wash any vehicle is prohibited.
City of Three Rivers (Live Oak County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/3rivers.pdf	*SW*	***Mild Water Shortage Conditions*** *Achieve a 5% reduction in water use.* Formal public notice of drought stage 1; notify TCEQ. Initiate increased public information campaign. Retail customers requested to follow stage 1 watering schedule. Increase leak detection activities.	***Moderate Water Shortage Conditions*** *Achieve a 10% reduction in water use.* Formal public notice of drought stage 2; notify TCEQ. Increase utility oversight of water use restrictions. Retail customers requested to follow stage 2 watering schedule. Increase utility oversight of water waste.	***Severe Water Shortage Conditions*** *Achieve a 15% reduction in water use.* Formal public notice of drought stage 3; notify TCEQ. Increase utility enforcement of water use restrictions. Retail customers requested to follow stage 3 watering schedule. Increase utility enforcement of water waste.	***Critical Water Shortage Conditions*** *Achieve a 30% reduction in water use.* Formal public notice of drought stage 4; notify TCEQ. Increase utility enforcement of water use restrictions. Retail customers requested to follow stage 3 watering schedule. No watering. Consider surcharges for excessive use.	***Emergency Water Shortage Conditions*** *Achieve necessary water use reduction.* Contact county and state emergency management coordinators; notify TCEQ. Implementation of appropriate emergency procedures. Consideration of water purchases by truckload or in bottles.

Water Systems	(SW/ GW)	Stage I (Voluntary)	Stage II	Stage III	Stage IV (If applicable)	Stage V
City of Rockport (Aransas County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Rockport.pdf	SW	***Mild Water Shortage Conditions*** *Achieve a voluntary 5% reduction in daily water demand.* All customers are requested to limit landscape irrigation to once per week. Customers are requested to practice water conservation (minimize or discontinue use for non essential purposes) All operations of the City of the city will adhere to water use restrictions.	***Moderate Water Shortage Conditions*** *Achieve a 10% reduction in daily water demand.* Use more repair crews for quicker response for water line leak repair. City crews monitor compliance with stage 2 restrictions on daily rounds. Restrictions on irrigation (Once per week) of landscaped areas, vehicle washing, use of water for pools, and ponds. Prohibits: Wash down of hard-surfaced areas and structures for purposes other than immediate fire protection; use of fire hydrants for any purpose other than firefighting; use of water for dust control; flushing gutters; failure to repair controllable leak(s).	***Severe Water Shortage Conditions*** *Achieve a 15% reduction in daily water demand.* Eliminate Main Flushing unless needed for safety. Review customer water usage. Continuation of restrictions set forth in previous conditions and implementation of additional regulations and prohibitions. Irrigation limited to once every other week. Additional restrictions on irrigation of landscaped areas, watering of golf course, and use of water for construction purposes.	***Critical Water Shortage Conditions*** *Achieve a 30% reduction in daily water demand* Landscaped watering prohibited at all times The use of water for any type of pool or vehicle is prohibited. Upon written notice cut off willful violators.	***Emergency Water Shortage Conditions*** *Achieve a 50% reduction in daily water demand.* Continuation of restrictions set forth in previous conditions and implementation of additional regulations and prohibitions. Call 10 largest users and spread message of major outage. Business process discretionary practices are prohibited.
Baffin Bay WSC https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Baffin%20Bay%20WSC_DCP.pdf	SW	***Mild Conditions*** Outside water use restrictions, reduced flushing operations, encouraged customer use reduction	***Moderate Conditions*** Prohibited outside water us, public service announcements	***Severe Conditions*** All outside watering prohibited, Use will be restricted to a percentage of previous months use, corporation shall continue enforcement and educational efforts.		
City of Beeville (Bee County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Beeville_DCP_2014.pdf	SW	***Mild Water Shortage Possibility*** *Water customers are requested to voluntarily limit the irrigation of landscaped areas to once per week and are requested to practice water conservation and to minimize or discontinue non-essential water use.*	***Moderate Water Shortage Warning*** *Achieve a 10% reduction in average raw water consumption. All customers will be notified. Follow Corpus Christi DCP*	***Severe Water Shortage Conditions*** *Achieve a 15% reduction in average raw water consumption. All customers will be notified. Follow Corpus Christi DCP*	***Critical Water Shortage*** *Achieve a 30% reduction in average raw water All customers will be notified. Follow Corpus Christi DCP*	***Emergency Water*** *All non-essential water uses must cease in accordance with the Corpus Christi DCP. All customers will be notified.*

Water Systems	***(SW/ GW)***	***Stage I (Voluntary)***	***Stage II***	***Stage III***	***Stage IV (If applicable)***	***Stage V***
San Diego (Duval County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/SanDiego.pdf	***GW***	***Mild Water Shortage Conditions*** Customers requested to voluntarily limit irrigation to twice a week at night. And to discontinue or minimize non-essential use. All operations of the City shall adhere to water use restrictions prescribed.	***Moderate Water Shortage Conditions*** *Achieve a reduction in daily water use.* Restrictions on irrigation of landscaped areas, vehicle washing, use of water for hydrants pools, and ponds. Prohibits: Wash down of hard-surfaced areas and structures for purposes other than immediate fire protection; use of water for dust control; flushing gutters; failure to repair controllable leak(s).	***Severe Water Shortage Conditions*** *Achieve an appropriate reduction in daily water use.* Phase 2 restrictions and Prohibitions. Prohibited: irrigation, pool use, vehicle washing construction and hydrant use under special permit	***Mild Water Shortage Conditions*** Water use may be rationed	
City of Alice (Jim Wells County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Alice.pdf	***SW***	***Mild Water Shortage Conditions*** *Achieve a voluntary 10% reduction in total water use, daily water demand.* Weekly reports are provided to the news media. Wholesale water customers are contacted to discuss conditions and to request voluntary measures. Customers requested to voluntarily limit irrigation to twice a week. And to discontinue or minimize non essential use. Flushing of water mains and watering of parks facilities is reduced. Alternative water sources are investigated. City operations shall adhere to Stage 2 water use restrictions.	***Moderate Water Shortage Conditions*** *Achieve a 15% reduction in total water use, daily water demand.* Wholesale water customers are contacted weekly requested to implement mandatory measures. Restrictions on irrigation of landscaped areas, vehicle washing, use of water for pools, and ponds. Prohibits: Wash down of hard-surfaced areas and structures for purposes other than immediate fire protection; use of fire hydrants for any purpose other than firefighting; use of water for dust control; flushing gutters; failure to repair controllable leak(s). Serving water to patrons unless requested.	***Severe Water Shortage Conditions*** *Achieve a 20% reduction in daily water demand.* Wholesale water customers are contacted to discuss conditions and to request additional mandatory measures. Continuation of restrictions set forth in previous conditions and implementation of additional regulations and prohibitions. Additional restrictions on irrigation of landscaped areas, watering of golf course, and use of water for construction purposes. Pro Rata curtailment of water diversions and/or deliveries for retail customers is initiated.	***Emergency Water Shortage Conditions*** *Reduce water use to less than 25% of the City's maximum daily supply capacity.* Utility directors of each wholesale water customer are contacted. Additional restrictions on irrigation of landscaped areas and water use for fountains or ponds. The use of water to wash any vehicle or for any type of pool is prohibited. Applications for new, additional, expanded, or increased-in-size water service connections, meters, service lines, pipeline extensions, mains, or water service facilities of any kind shall require approval.	***Water Allocation*** *Achieve a 45% reduction in daily water demand.* Water is allocated according to the water allocation plan.

Water Systems	***(SW/ GW)***	***Stage I (Voluntary)***	***Stage II***	***Stage III***	***Stage IV (If applicable)***	***Stage V***
City of Orange Grove (Jim Wells County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/OrangeGrove.pdf	***GW***	***Mild Water Shortage Conditions*** *Achieve a voluntary 10% reduction in total water use.* All customers will be notified. Restricted use of water for ornamental fountains or ponds. All operations of the City shall adhere to water use restrictions prescribed for Stage II of the plan. Customers requested to practice conservation and minimize non essential use	***Moderate Water Shortage Conditions*** *Achieve a 20% reduction in total water use.* Restrictions on irri-gation of landscaped areas, vehicle washing, and use of water for pools. All restaurants are prohibited from serving water to patrons except upon request of the patron. Prohibits: Wash down of hard-surfaced areas and structures for purposes other than immediate fire protection; use of fire hydrants for any purpose other than firefighting; use of water for dust control; flushing gutters; failure to repair controllable leak(s). Restaurants can not provide water unless requested.	***Severe Water Shortage Conditions*** *Achieve a 30% reduction in total water use.* Additional restrictions on irrigation of landscaped areas, watering of golf course, and use of water for construction purposes.	***Critical Water Shortage Conditions*** *Achieve a 40% reduction in total water use.* Prohibits: Irrigation of landscaped areas, use of water to wash any vehicle, use of water for any type of pool. Further Restrictions: Irrigation of landscaped areas, use of water to wash any vehicle, No application for new, additional, expanded, or increased-in-size water service connections, meters, service lines, pipeline extensions, mains, or water service facilities of any kind shall be approved during this stage.	***Emergency Water Shortage Conditions*** *Achieve a 40% reduction in total water use.* Prohibits: Irrigation and vehicle washing.
City of Kingsville (Kleberg County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Kingsville.pdf	***GW***	***Mild Water Shortage Conditions*** *Achieve a voluntary 10% reduction in total water use.* All customers will be notified. Restricted use of water for ornamental fountains or ponds. All operations of the City shall adhere to water use restrictions prescribed for Stage II of the plan. Restricted flushing of water mains. Meetings are schedules with large industrial and commercial water users to exchange information regarding methods of saving water.	***Moderate Water Shortage Conditions*** *Achieve a 15% reduction in total water use.* Restrictions on irri-gation of landscaped areas, vehicle washing, and use of water for pools. All restaurants are prohibited from serving water to patrons except upon request of the patron. Prohibits: Wash down of hard-surfaced areas and structures for purposes other than immediate fire protection; use of fire hydrants for any purpose other than firefighting; use of water for dust control; flushing gutters; failure to repair controllable leak(s).	***Severe Water Shortage Conditions*** *Achieve a 25% reduction in total water use.* Additional restrictions on irrigation of landscaped areas, watering of golf course, and use of water for construction purposes.	***Emergency Water Shortage Conditions*** *Achieve a 35% reduction in total water use.* Prohibits: Irrigation of landscaped areas, use of water to wash any vehicle, use of water for any type of pool. No application for new, additional, expanded, or increased-in-size water service connections, meters, service lines, pipeline extensions, mains, or water service facilities of any kind shall be approved during this stage.	***Water Allocation*** The City Manager is authorized to allocate water according to the water allocation plan.

Water Systems	***(SW/ GW)***	***Stage I (Voluntary)***	***Stage II***	***Stage III***	***Stage IV (If applicable)***	***Stage V***
Ricardo WSC (Kleberg County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Ricardo.pdf	***SW***	***Mild Water Shortage Conditions*** *Achieve a voluntary 5% reduction in daily water demand.* All customers will be notified. Restrictions on irrigation of landscaped areas.	***Moderate Water Shortage Conditions*** *Achieve a 10% reduction in daily water demand.* Restrictions on irrigation of landscaped areas, vehicle washing, use of water for pools, ornamental fountains, or ponds, use of water for dust control, and wash down of buildings and structures. Prohibits: Wash down of hard-surfaced areas other than for immediate fire protection	***Severe Water Shortage Conditions*** *Achieve a 15% reduction in daily water demand.* Additional restrictions on irrigation of landscaped areas, watering of golf course, and use of water for construction purposes. Water rate surcharges may be implemented for residential customers.	***Critical Water Shortage Conditions*** *Achieve a voluntary 30% reduction in daily water demand.* Prohibits: Irrigation of landscaped areas Additional restrictions on vehicle washing, use of water for pools, and use of water for building integrity. Water rate surcharges are implemented for retail and wholesale customers. Water rate surcharges may be implemented for residential customers. Upon written notice cut off willful violators. Applications for new, additional, expanded, or increased-in-size water service connections, meters, service lines, pipeline extensions, mains, or water service facilities of any kind may not be approved during this stage.	***Emergency Water Shortage Conditions*** *Achieve a voluntary 50% reduction in daily water demand.* Contact the largest ten water customers affected Prohibits: Irrigation of landscaped areas, use of water to wash any vehicle, and associated uses of water not related to business processes which are discretionary. Water rate surcharges may be implemented for residential customers.
El Oso Water Conservation District (Service area includes 500 square miles located in Karnes, Bee, Wilson, and Live Oak Counties) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Eloso.pdf	***GW***	***Mild Water Shortage Conditions*** *Achieve a voluntary 20% reduction in total water use.* All customers will be notified. All operations of the corporation shall adhere to water use restrictions prescribed for Stage II of the plan.	***Moderate Water Shortage Conditions*** *Achieve a 30% reduction in total water use.* Restrictions on irrigation of landscaped areas, vehicle washing, and use of water for pools, ornamental fountains, or ponds. All restaurants are prohibited from serving water to patrons except upon request of the patron. Prohibits: Wash down of hard-surfaced areas other than for immediate fire protection; use of fire hydrants for any purpose other than firefighting; use of water for dust control; flushing gutters; failure to repair controllable leak(s).	***Severe Water Shortage Conditions*** *Achieve a 40% reduction in total water use.* Additional restrictions on irrigation of landscaped areas, watering of golf course, and use of water for construction purposes.	***Critical Water Shortage Conditions*** *Achieve a 50% reduction in total water use.* Prohibits: Irrigation of landscaped areas, use of water to wash any vehicle, use of water for any type of pool. No application for new, additional, expanded, or increased-in-size water service connections, meters, service lines, pipeline extensions, mains, or water service facilities of any kind shall be approved during this stage.	***Emergency Water Shortage Conditions*** *Achieve a 60% reduction in total water use.* Prohibits: Irrigation of landscaped areas and use of water to wash any vehicle.

Water Systems	(SW/ GW)	Stage I (Voluntary)	Stage II	Stage III	Stage IV (If applicable)	Stage V
McCoy Water Supply Corporation (Service area includes 608 square miles located in Atascosa, Wilson, and Live Oak Counties) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/McCoy.pdf	GW	***Mild Water Shortage Conditions*** *Achieve a voluntary 20% reduction in total water use.* All customers will be notified. All operations of the corporation shall adhere to water use restrictions prescribed for Stage II of the plan.	***Moderate Water Shortage Conditions*** *Achieve a 30% reduction in total water use.* Restrictions on irrigation of landscaped areas, vehicle washing, and use of water for pools, ornamental fountains, or ponds. All restaurants are prohibited from serving water to patrons except upon request of the patron. Prohibits: Wash down of hard-surfaced areas other than for immediate fire protection; use of fire hydrants for any purpose other than firefighting; use of water for dust control; flushing gutters; failure to repair controllable leak(s).	***Severe Water Shortage Conditions*** *Achieve a 40% reduction in total water use.* Additional restrictions on irrigation of landscaped areas, watering of golf course, and use of water for construction purposes.	***Critical Water Shortage Conditions*** *Achieve a 50% reduction in total water use.* Prohibits: Irrigation of landscaped areas, use of water to wash any vehicle, use of water for any type of pool. No application for new, additional, expanded, or increased-in-size water service connections, meters, service lines, pipeline extensions, mains, or water service facilities of any kind shall be approved during this stage.	***Emergency Water Shortage Conditions*** *Achieve a 60% reduction in total water use.* Continuation of restrictions set forth in previous conditions and implementation of additional regulations and prohibitions. Prohibits: Irrigation of landscaped areas and use of water to wash any vehicle.

Water Systems	***(SW/ GW)***	***Stage I (Voluntary)***	***Stage II***	***Stage III***	***Stage IV (If applicable)***	***Stage V***
Nueces WSC (Nueces County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/NuecesWSC.pdf	***SW***	***Mild Water Shortage Conditions*** *Achieve a voluntary 5% reduction in daily water demand.* All customers will be notified. Restrictions on irrigation of landscaped areas.	***Moderate Water Shortage Conditions*** *Achieve a 10% reduction in daily water demand.* Restrictions on irrigation of landscaped areas, vehicle washing, use of water for pools, ornamental fountains, or ponds, use of water for dust control, and wash down of buildings and structures. Prohibits: Wash down of hard-surfaced areas other than for immediate fire protection.	***Severe Water Shortage Conditions*** *Achieve a 15% reduction in daily water demand.* Additional restrictions on irrigation of landscaped areas, watering of golf course, and use of water for construction purposes. Water rate surcharges may be implemented for residential customers.	***Critical Water Shortage Conditions*** *Achieve a voluntary 30% reduction in daily water demand.* Prohibits: Irrigation of landscaped areas Additional restrictions on vehicle washing, use of water for pools, and use of water for building integrity. Water rate surcharges are implemented for retail and wholesale customers. Water rate surcharges may be implemented for residential customers. Upon written notice cut off willful violators. Applications for new, additional, expanded, or increased-in-size water service connections, meters, service lines, pipeline extensions, mains, or water service facilities of any kind may not be approved during this stage.	***Emergency Water Shortage Conditions*** *Achieve a voluntary 50% reduction in daily water demand.* Contact the largest ten water customers affected Prohibits: Irrigation of landscaped areas, use of water to wash any vehicle, and associated uses of water not related to business processes which are discretionary. Water rate surcharges may be implemented for residential customers.
River Acres WSC (Nueces County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/RiverAcres.pdf	***SW***	***Water Shortage Possibility*** Restrictions on irrigation of landscaped areas.	***Water Shortage Watch*** Additional restrictions on irrigation of landscaped areas, vehicle washing, and use of water for pools, ornamental fountains, or ponds, and wash down of buildings and structures. Prohibits: Wash down of hard-surfaced areas other than for immediate fire protection; use of fire hydrants for any purpose other than firefighting; use of water for dust control; flushing gutters; failure to repair controllable leak(s).	***Water Shortage Warning*** Additional restrictions on irrigation of landscaped areas and new service connections to the City's water system. Mandatory water use limits go into effect. All restaurants are prohibited from serving water to patrons except upon request of the patron. The use of water for any type of pool is prohibited.	***Water Shortage Emergency*** Water allocations to commercial and industrial customers are established. Maximum monthly water use and revised rate schedules established for residential customers. No outside water use Any application for new, additional, expanded, or increased-in-size water service connections, meters, service lines, pipeline extensions, mains, or water service facilities of any kind shall be must be approved.	

Water Systems	***(SW/ GW)***	***Stage I (Voluntary)***	***Stage II***	***Stage III***	***Stage IV (If applicable)***	***Stage V***
City of Ingleside (San Patricio County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Ingleside.pdf	***SW***	***Water Shortage Possibility*** All municipal operations are placed on mandatory conservation. Restrictions on irrigation of landscaped areas.	***Water Shortage Watch*** Additional restrictions on irrigation of landscaped areas, vehicle washing, and use of water for pools, ornamental fountains, or ponds, and wash down of buildings and structures. Prohibits: Wash down of hard-surfaced areas; use of fire hydrants for any purpose other than firefighting; use of water for dust control; flushing gutters; failure to repair defective plumbing and controllable leak(s).	***Water Shortage Warning*** Additional restrictions on irrigation and new service connections to the City's water system. Mandatory water use limits go into effect. All restaurants are prohibited from serving water to patrons except upon request of the patron. The use of water for any type of pool is prohibited.	***Water Shortage Emergency*** Water allocations to commercial and industrial customers are established. Maximum monthly water use and re-vised rate schedules established for resi-dential customers. Any application for new, additional, expanded, or increased-in-size water service connections, meters, service lines, pipeline extensions, mains, or water service facilities of any kind must be approved.	
City of Taft (San Patricio County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Taft.pdf	***SW***	***Mild Water Shortage Conditions*** *Achieve a voluntary 5% reduction in total water use.* All customers will be notified. All operations of the City shall adhere to water use restrictions prescribed for Stage II of the plan.	***Moderate Water Shortage Conditions*** *Achieve a voluntary 10% reduction in total water use.* Restrictions on irri-gation of landscaped areas, vehicle wash-ing, and use of water for pools, ornamental fountains, or ponds, and wash down of buildings and structures. All restaurants are prohibited from serv-ing water to patrons except upon request of the patron. Prohibits: Wash down of hard-surfaced areas other than for immediate fire protection; use of fire hydrants for any purpose other than firefighting; use of water for dust control; flushing gutters; failure to repair controllable leak(s).	***Severe Water Shortage Conditions*** *Achieve a voluntary 15% reduction in total water use.* Continuation of restrictions set forth in previous conditions and implementation of additional regulations and prohibitions. Additional restrictions on irrigation of landscaped areas, watering of golf course, and use of water for construction purposes.	***Critical Water Shortage Conditions*** *Achieve a voluntary 30% reduction in total water use.* Additional restrictions on irrigation of landscaped areas and use of water for washing vehicles. The use of hose-end sprinklers and water for any type of pool is prohibited. No application for new, additional, expanded, or increased-in-size water service connections, meters, service lines, pipeline extensions, mains, or water service facilities of any kind shall be approved during this stage.	***Emergency Water Shortage Conditions*** *Achieve a voluntary 30% reduction in total water use.* Continuation of restrictions set forth in previous conditions and implementation of additional regulations and prohibitions. Prohibits: Irrigation of landscaped areas and use of water to wash any vehicle.

Water Systems	(SW/ GW)	Stage I (Voluntary)	Stage II	Stage III	Stage IV (If applicable)	Stage V
City of Portland (San Patricio County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Portland.pdf	SW	***Mild Water Shortage Conditions*** *Achieve a 5% reduction in daily water demand.* Minimize or discontinue water system flushing and utilize reclaimed water for non-potable uses to the greatest extent possible. Water customers will be requested to voluntarily limit landscape irrigation to once a week. Water customers will be requested to limit or discontinue non essential use.	***Moderate Water Shortage Conditions*** *Achieve a 10% reduction in daily water demand. More repair crews may be used for quicker response to water-line leaks.* Water customers are monitored for compliance. Additional restrictions on irrigation of landscaped areas, vehicle washing, use of water to maintain buildings, and use of water for pools, fountains, hydrants or ponds. Prohibits: Wash down of hard-surfaced areas and structures for purposes other than immediate fire protection; use of fire hydrants for any purpose other than firefighting; use of water for dust control; flushing gutters.	***Severe Water Shortage Conditions*** *Achieve a 15% reduction in daily water demand.* Additional restrictions on irrigation of landscaped areas and the flushing of water mains. Water customers are monitored for compliance and violators are notified.	***Critical Water Shortage Conditions*** *Achieve a 30% reduction in daily water demand.* Water meters of willful violators are disconnected as necessary to prevent wasting of water. Prohibits irrigation of landscaped areas. Additional restrictions on the use of water to wash any vehicle or for any type of pool.	***Emergency Water Shortage Conditions*** *Achieve a 50% reduction in daily water demand.* Prohibits: Irrigation of landscaped areas and use of water to wash any vehicle. Business process water shall be reduced to a basic amount necessary.
Rincon WSC (San Patricio County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Rincon.pdf	SW	***Water Watch*** *Achieve a 10% reduction in total water use.* All customers will be notified. Disseminate water conservation information to retail customers. Minimize water system flushing and system water-waste. Intensify efforts of the Leak Detection and Repair Program.	***Water Alert*** *Achieve a 11% to 20% reduction in total water use.* Additional restrictions on irrigation of land-scaped areas, and ornamental ponds. Establish mandatory water consumption restrictions. All water taken from flush valves, other than for flushing purposes shall be metered, and the Corporation shall charge for this water in accordance with the current rate schedule. Prohibits: Wash down of hard-surfaced areas; and water to run or accumulate in any gutter or street.	***Water Warning*** *Achieve a 21% to 35% reduction in total water use.* Additional landscape irrigation restrictions. Except when empty, all swimming pools shall be covered when not in use. Restricted use of water to wash any vehicle.	***Water Emergency*** *Achieve a 36% or greater reduction in total water use.* Prohibition of all non-essential water use, unless necessary for the preservation of health and safety and welfare. Water usage for livestock is exempt.	

Water Systems	***(SW/ GW)***	***Stage I (Voluntary)***	***Stage II***	***Stage III***	***Stage IV (If applicable)***	***Stage V***
City of Odem (San Patricio County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Odem.pdf	SW	***Mild Water Shortage Conditions*** All customers will be notified. Water customers will be requested to voluntarily limit landscape irrigation to once a week. Commercial customers will be requested to voluntarily reduce use. Reduced watering of public parks and facilities.	***Moderate Water Shortage Conditions*** All customers will be notified. Additional restrictions on irrigation of landscaped areas, vehicle washing, use of water to maintain buildings, and use of water for pools, fountains, hydrants or ponds. Prohibits: Wash down of hard-surfaced areas and structures for purposes other than immediate fire protection; use of fire hydrants for any purpose other than firefighting; use of water for dust control; flushing gutters.	***Severe Water Shortage Conditions*** All customers will be notified. Additional restrictions on landscape irrigation and commercial nursery facilities. All restaurants are prohibited from serving water to patrons except upon request of the patron. Mandatory water use limits go into effect.	***Critical Water Shortage Conditions*** All customers will be notified. Prohibits irrigation of landscaped areas. Additional restrictions on the use of water for new agricultural land, to wash any vehicle, for building integrity, or for any type of pool. Drought surcharges are applied to deter discretionary water use.	***Emergency Water Shortage Conditions*** All customers will be notified. Prohibits irrigation of landscaped areas and use of water to wash any vehicle.
County-Other Entities						
Aransas County MUD #1 (Aransas County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/AransasMUD.pdf	***GW***	***Mild Drought Conditions (voluntary)*** *Target Reduction in Well Run Time = 5%* All customers will be notified. Restricted landscape irrigation.	***Moderate Drought Conditions*** *Target Reduction in Well Run Time = 10%* All outdoor water use must be conducted with a hand-held hose with a manual on-off nozzle. Restricted street washing, fire hydrant flushing, and filling of swimming pools.	***Severe Drought Conditions*** *Target Reduction in Well Run Time = 15%* All outdoor water use is prohibited. A surcharge equal to 200% of the applicable rate for all water used in excess of 10,000 gallons/month shall be imposed on all customers.		
Blueberry Hills (Bee County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/BlueberryHills.pdf	***GW***	***Customer Awareness*** Water customers requested to limit non essential use	***Voluntary Water Conservation*** *Achieve 25% reduction in total use* Restricted days/hours for outside watering Restriction on wasting water (gutter flushing etc.)	***Mandatory Water Conservation*** *Achieve 40% reduction in total use* Further restrictions on days/hours for outside watering, vehicle washing, pool filling, hydrant use. Prohibited: wash down of hard surfaces, dust control, gutter flushing, other water wasting.	***Critical Water Conservation*** *Achieve 55% reduction in total use* Prohibited: all outdoor water use, vehicle washing.	

Water Systems	***(SW/ GW)***	***Stage I (Voluntary)***	***Stage II***	***Stage III***	***Stage IV (If applicable)***	***Stage V***
Copano Heights Water Company (Aransas County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Copano.pdf	***SW***	***Customer Awareness*** Water customers requested to limit non essential use	***Voluntary Water Conservation*** *Achieve 5% reduction in total use* Restricted days/hours for outside watering Restriction on wasting water (gutter flushing etc.)	***Mandatory Water Conservation*** *Achieve 15% reduction in total use* Further restrictions on days/hours for outside watering, vehicle washing, pool filling, hydrant use. Prohibited: wash down of hard surfaces, dust control, gutter flushing, other water wasting.	***Critical Water Conservation*** *Achieve 15% reduction in total use* Prohibited: all outdoor water use, vehicle washing.	
Escondido Creek Estates (Hidalgo County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Escondido.pdf	***GW***	***Customer Awareness*** Water customers requested to limit non essential use	***Voluntary Water Conservation*** Restricted days/hours for outside watering Restriction on wasting water (gutter flushing etc.)	***Mandatory Water Conservation*** Further restrictions on days/hours for outside watering, vehicle washing, pool filling, hydrant use. Prohibited: wash down of hard surfaces, dust control, gutter flushing, other water wasting.	***Critical Water Conservation*** Prohibited: all outdoor water use, vehicle washing.	
Freer WCID (Duval County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Freer.pdf	***GW***	***Mild Water Shortage Conditions*** *Achieve a voluntary 25% reduction in total water use.* All customers will be notified and asked to limit non essential use Restricted use of water for ornamental fountains or ponds. All operations of Freer W.C.I.D. adhere to water use restrictions prescribed for Stage II of the plan.	***Moderate Water Shortage Conditions*** *Achieve a 30% reduction in total water use.* Restrictions on irrigation of landscaped areas, vehicle washing, and use of water for pools. Prohibits: Wash down of hard-surfaced areas and structures for purposes other than immediate fire protection; use of fire hydrants for any purpose other than firefighting; use of water for dust control; flushing gutters; failure to repair controllable leak(s).	***Critical Water Shortage Conditions*** *Achieve a 40% reduction in total water use.* Additional restrictions on irrigation of landscaped areas, watering of golf course, and use of water for construction purposes.	***Emergency Water Shortage Conditions*** *Achieve a 50% reduction in total water use.* Prohibits: Irrigation of landscaped areas, use of water to wash any vehicle, use of water for any type of pool. No application for new, additional, expanded, or increased-in-size water service connections, meters, service lines, pipeline extensions, mains, or water service facilities of any kind shall be approved during this stage.	

Water Systems	***(SW/ GW)***	***Stage I (Voluntary)***	***Stage II***	***Stage III***	***Stage IV (If applicable)***	***Stage V***
McMullen County WCID #2 (McMullen County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/McMullen.pdf	***GW***	***Mild Water Shortage Conditions*** *Achieve a voluntary 10% reduction in total water use.* All customers will be notified and asked to limit non essential use Restricted use of water for ornamental fountains or ponds. All operations of Freer WCID adhere to water use restrictions prescribed for Stage II of the plan.	***Moderate Water Shortage Conditions*** *Achieve a 25% reduction in total water use.* Restrictions on irrigation of landscaped areas, vehicle washing, and use of water for pools. All restaurants are prohibited from serving water to patrons except upon request of the patron. Prohibits: Wash down of hard-surfaced areas and structures for purposes other than immediate fire protection; use of fire hydrants for any purpose other than firefighting; use of water for dust control; flushing gutters; failure to repair controllable leak(s).	***Critical Water Shortage Conditions*** *Achieve a 50% reduction in total water use.* Additional restrictions on irrigation of landscaped areas, watering of golf course, and use of water for construction purposes. No application for new, additional, expanded, or increased-in-size water service connections, meters, service lines, pipeline extensions, mains, or water service facilities of any kind shall be approved during this stage.	***Emergency Water Shortage Conditions*** *Achieve a 75% reduction in total water use.* Prohibits: Irrigation of landscaped areas, use of water to wash any vehicle, use of water for any type of pool.	
Riviera (Kleberg County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/Riviera.pdf	***GW***	***Customer Awareness*** Water customers requested to limit non essential use	***Voluntary Water Conservation*** Restricted days/hours for outside watering Restriction on wasting water (gutter flushing etc.)	***Mandatory Water Conservation*** Further restrictions on days/hours for outside watering, vehicle washing, pool filling, hydrant use. Prohibited: wash down of hard surfaces, dust control, gutter flushing, other water wasting.	***Critical Water Conservation*** Prohibited: all outdoor water use, vehicle washing.	
Pettus MUD (Bee County) https://www.nueces-ra.org/CP/RWPG/dcp_pdf/PettusMUD.pdf	***GW***	***Mild Water Shortage Conditions*** All customers will be notified and asked to limit non essential use Raise Public Awareness	***Moderate Water Shortage Conditions*** Initiate mandatory restrictions on non-essential use (lawn watering etc.)	***Severe Water Shortage Conditions*** Additional restrictions on irrigation of landscaped areas, watering of golf course, and use of water for construction purposes. Initiate water surcharge	***Critical Water Shortage Conditions*** Initiate enforcement, fees, fines, and surcharges	***Emergency Conditions*** Initiate emergency response conditions

Note: Stages 2- 5 for all drought contingency plans include continuation of restrictions set forth in previous conditions and implementation of additional regulations and prohibitions.

7.2.4 Coastal Bend RWPG Drought Response Recommendations

On May 8, 2014, a subcommittee[8] of the Coastal Bend Regional Water Planning Group was formed to develop drought response recommendations and compile information about emergency interconnects in the region. The subcommittee met on July 14, 2014 and prepared the following recommendations which were adopted by the Coastal Bend Regional Water Planning Group on August 14, 2014:

- The Coastal Bend Regional Water Planning Group supports drought response triggers and actions identified in local WUG drought contingency plans for each existing source (see Tables 7.2 to 7.8).
- The Coastal Bend Regional Water Planning does not recommend alternative drought management water management strategies for water user group and wholesale water providers.
- The Coastal Bend-specific model drought contingency plan includes a list of common drought response measures in the Coastal Bend Region and TCEQ model drought contingency plan.

7.3 Existing and Potential Interconnects

A goal of the regional planning process is to ensure a connected supply that meets or exceeds DOR demands for the next 50 years. However, it is also important for regions to plan for emergency supplies in the event of a prolonged drought or an interruption/impairment of supply from an existing source. An interconnection between two collaborating municipal water user groups (WUGs) can serve as an alternative means of providing drinking water in case of these events in lieu of trucking in supply or other expensive options. In compliance with Texas Administrative Code (TAC), Chapter 357 Regional Water Planning Guidelines, available information on existing major water infrastructure facilities that may be used for interconnections in event of an emergency shortage of water was collected.

In 2013, HDR sent all municipal water user groups and wholesale water providers in the region a survey regarding population, water demand projections, water supply and use. As part of the survey, individual municipalities and wholesale water providers were asked to confirm or update information regarding the existence of emergency interconnects integrated with their system and the provider of the potential emergency supply. Of the 49 Municipal WUGs and WWPs in Region N, only 4 reported having emergency interconnects and 1 reported a potential future interconnect in the survey. Additional existing and potential interconnects have been identified throughout the planning process and are also listed in Table 7.9 below.

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[8] Coastal Bend Drought Response Subcommittee participants included: Ms. Teresa Carrillo, Mr. Martin Ornelas, Ms. Carola Serrato, Mr. Mark Scott, and Mr. Jace Tunnell.

Table 7.9. Potential Emergency Supply Options for Small WUGs

Entity								Implementation Requirements		
Water User Group	**County**	**2020 Population**	**2020 Demand (ac-ft)**	**Local Groundwater Well**	**Brackish Groundwater Well**	**Truck in Water**	**Supply from Nearby Entity**	**Known Existing Interconnect**	**Potential Entity Providing Supply**	**Type of Infrastructure Required**
AGUA DULCE	NUECES	892	132	X	X	X				Well, Pipeline, Transportation
ARANSAS COUNTY-OTHER	ARANSAS	13,003	1,446	X		X				Well, Pipeline, Transportation
ARANSAS PASS	ARANSAS	8,702	1,244	X		X				Well, Pipeline, Transportation
BEE COUNTY-OTHER	BEE	19,576	2,725	X		X				Well, Pipeline, Transportation
BENAVIDES	DUVAL	1,470	236			X	X		Alice	Pipeline, Transportation
BISHOP	NUECES	3,446	594	X	X	X	X			Well, Pipeline, Transportation
BROOKS COUNTY-OTHER	BROOKS	2,566	326			X				
DRISCOLL	NUECES	812	105	X	X	X				Well, Pipeline, Transportation
DUVAL COUNTY-OTHER	DUVAL	4,330	549			X				
EL OSO WSC	LIVE OAK	1,047	226			X	X		Karnes City	Pipeline, Transportation
FALFURRIAS	BROOKS	5,217	1,677			X	X		Alice or Premont	Pipeline, Transportation
FREER	DUVAL	3,042	650			X	X		Alice	Pipeline, Transportation
FULTON	ARANSAS	1,435	278	X	X	X				Well, Pipeline, Transportation
GEORGE WEST	LIVE OAK	2,478	454			X	X		Three Rivers	Pipeline, Transportation
GREGORY	SAN PATRICIO	2,024	339	X		X				Well, Pipeline, Transportation
INGLESIDE ON THE BAY	SAN PATRICIO	653	77			X	X		SPMWD	Pipeline, Transportation
JIM WELLS COUNTY-OTHER	JIM WELLS	18,575	2,634	X		X				Well, Pipeline, Transportation
KENEDY COUNTY-OTHER	KENEDY	463	244			X				Transportation
KLEBERG COUNTY-OTHER	KLEBERG	3,568	601			X	X		Ricardo WSC	Pipeline, Transportation
LAKE CITY	SAN PATRICIO	541	64			X	X		Mathis	Pipeline, Transportation
LIVE OAK COUNTY-OTHER	LIVE OAK	6,499	802	X		X				Well, Pipeline, Transportation

Entity								Implementation Requirements		
Water User Group	**County**	**2020 Population**	**2020 Demand (ac-ft)**	**Local Groundwater Well**	**Brackish Groundwater Well**	**Truck in Water**	**Supply from Nearby Entity**	**Known Existing Interconnect**	**Potential Entity Providing Supply**	**Type of Infrastructure Required**
MATHIS	SAN PATRICIO	5,244	670			X	X		Interconnection to MRP supplies through Corpus Christi	Pipeline, Transportation
MCCOY WSC	LIVE OAK	172	22			X	X		Three Rivers	Pipeline, Transportation
MCMULLEN COUNTY-OTHER	MCMULLEN	734	97			X				
NUECES COUNTY-OTHER	NUECES	11,826	1,554	X		X				Well, Pipeline, Transportation
NUECES WSC	NUECES	2,553	333		X	X	X	Nueces County WCID # 3	Nueces County WCID #3	Pipeline, Transportation
ODEM	SAN PATRICIO	2,535	379	X	X	X	X		GW	Well, Pipeline, Transportation
ORANGE GROVE	JIM WELLS	1,452	376			X	X		Alice	Pipeline, Transportation
PORT ARANSAS	NUECES	3,827	2,251		X	X	X			Pipeline, Transportation
PREMONT	JIM WELLS	2,923	710			X	X		Alice	Pipeline, Transportation
RICARDO WSC	KLEBERG	2,919	341		X	X	X	City of Kingsville	City of Kingsville	Pipeline, Transportation
RINCON WSC	SAN PATRICIO	3,441	346	X	X	X	X		Sinton	Well, Pipeline, Transportation
RIVER ACRES WSC	NUECES	2,662	426			X	X		Corpus Christi	Pipeline, Transportation
ROBSTOWN	NUECES	12,467	2,957			X	X		STWA	Pipeline, Transportation
SAN DIEGO	DUVAL	4,865	910			X	X		Alice	Pipeline, Transportation
SAN PATRICIO COUNTY-OTHER	SAN PATRICIO	11,172	1,584	X		X				Well, Pipeline, Transportation
SINTON	SAN PATRICIO	6,011	1,409			X	X		SPMWD	Pipeline, Transportation
TAFT	SAN PATRICIO	3,235	464			X	X		Sinton	Pipeline, Transportation
THREE RIVERS	LIVE OAK	1,873	325	X		X				Well, Pipeline, Transportation

7.4 Emergency Response to Local Drought Conditions or Loss of Municipal Supply

The regional and state water plans aim to prepare entities for worst case drought scenarios based on the DOR as described in Chapter 7.1. However, entities may find themselves in unanticipated conditions facing a loss of municipal supply. While rare, it is important to have a back up plan in case of infrastructure failure or water supply contamination. This is especially important for smaller entities which rely on a sole source of supply or a sole wholesale water provider. While many entities and wholesale water providers have DCP's as described in Chapter 7.2, it is less common for small municipalities or county-other WUGs to have these emergency plans. An analysis of a broad range of emergency response options was performed for small WUGs with 2010 Census populations less than 7,500 as well as for all County-Other WUGs in the Region.

The Region N drought response and compile emergency connections subcommittee identified 35 potential interconnects not reported by the 2013 WUG survey. These potential emergency interconnects were assigned under the general principle that entities relying on surface water supplies would consider groundwater; and entities relying on groundwater supplies would consider surface water supplies from the nearest neighboring water system.

A broad range of emergency situations could result in a loss of a reliable municipal supply and it is not possible to plan one solution to meet any possible emergency, for that reason a range of possible responses were selected for each entity based on source type and location. A WUG utilizing groundwater was analyzed for potential additional fresh water and brackish water wells based on the existence of appropriate aquifers in the area. MAG availability was not considered since the wells are assumed temporary over the course of an emergency. Surface water WUGs were analyzed for curtailment of junior water rights, no releases from upstream reservoirs were considered since most surface water users in the region rely on Corpus Christi reservoirs.

A nearby entity that could provide supply in the case of an isolated incident was identified for each WUG if existing or potential interconnects were known. In addition, trucking in water was considered as a supply option under severe circumstances. Any infrastructure required for implementation of the options was noted as well. A total of 38 entities were analyzed, including 11 County-Other WUGs. The results of this analysis are summarized in Table 7.9. Information on existing and potential interconnect supply capacity or location was generally not available from either source. In accordance with Texas Water Code §16.053(r) the information gathered is considered confidential and is submitted to the executive administrator but not included in the regional plan.

7.5 Region Specific Drought Response Recommendations and Model Drought Contingency Plans

7.5.1 Region Specific Drought Response Recommendations

Region N acknowledges that DCPs are a useful drought management tool for entities with both surface and groundwater sources and recommends that all entitles consider adopting a DCP in preparation for drought conditions. The region also recommends that in accordance with TCEQ guidelines, entities update their DCPs every 5 years as triggers can change as wholesale and retail water providers reassess their contracts and supplies. Region N obtained 31 drought contingency plans from across the region. Fifteen of these participating water providers and WUGs rely solely on surface water, 11 entities rely solely on groundwater and 5 of them utilize both sources to meet needs.

An analysis was performed based on the known DCPs to determine the most common drought contingency measures used in Region N. A summary of the results is shown in Table 7.10 and the detailed information is found in Table 7.11. Region N suggests that entities without a DCP could determine which drought contingency measures to consider by considering the measures adopted by regional WUGS with similar populations and supply types.

Table 7.10.
Region N Drought Contingency Summary

Common Drought Contingency Measure	Number of Region N DCPs Recommending
Watering schedules/ Landscape irrigation restrictions	29
Water demand reduction targets	26
Potable water use restrictions	10
Vehicle washing restrictions	25
Restrictions on wash down of hard-surfaces, buildings, and/or structures	25
Restrictions on new service connections, pipeline extensions, etc.	16
Restrictions on serving water to patrons at restaurants	16
Restrictions on flushing gutters, controllable leaks, and/or permitting water to run or accumulate	26
Restrictions on the use of water for pools, ponds, or fountains	27
Restrictions on use of water for dust control	22
Others	29

Table 7.11. Common Drought Response Measures

Wholesale Water Provider/Water User Group	Census 2010 (For Water User Groups Only)	DCP Available	Date	Drought Contingency Measures											Water Supplies	
				Watering schedules/ Landscape irrigation restrictions	Water demand reduction targets	Potable water use restrictions	Vehicle washing restrictions	Restrictions on wash down of hard-surfaces, buildings, and/or structures	Restrictions on new service connections, pipeline extensions, etc.	Restrictions on serving water to patrons at restaurants	Restrictions on flushing gutters, controllable leaks, and/or permitting water to run or accumulate	Restrictions on the use of water for pools, ponds, or fountains	Restrictions on use of water for dust control	Others	SW	GW
Wholesale Water Providers																
City of Corpus Christi		Y	2015	√	√	√	√	√				√		√	√	
SPMWD		Y	2014	√	√	√	√	√				√	√	√	√	
South Texas Water Authority		Y	2013		√									√	√	
Nueces County WCID #3		Y	2013	√	√	√			√		√			√	√	
LNRA		Y	2014		√									√	√	
Water User Groups																
Aransas Pass	8,204	Y	2008	√	√		√	√	√	√	√	√	√	√	√	√
Rockport	8,766	Y	2013	√	√		√	√			√	√	√	√	√	
Baffin Bay WSC	N/A	Y	2015	√			√	√			√	√				
Beeville	12,863	Y	2014	√	√	√	√	√				√		√	√	
City of Three Rivers	1,848	Y	2014	√	√		√	√			√	√	√		√	√
San Diego MUD #1	4,488	Y	2000	√	√		√	√			√	√	√	√		√
Alice	19,104	Y	2014	√	√		√	√	√	√	√	√	√	√	√	
Orange Grove	1,318	Y	2000	√	√		√	√	√	√	√	√	√	√		√
Kingsville	26,213	Y	2002	√	√		√	√	√	√	√	√	√	√	√	√
Ricardo WSC	2,631	Y	2013	√	√	√	√	√	√	√	√	√		√	√	√
El Oso WSC	1,019	Y	2009	√	√		√	√	√	√	√	√	√	√		√
McCoy WSC	169	Y	2009	√	√		√	√	√	√	√	√	√	√		√
Nueces WSC	2,322	Y	2013	√	√	√	√	√	√	√	√	√		√	√	
River Acres WSC	2,421	Y	2000	√	√	√	√	√	√	√	√	√	√	√	√	
Odem	2,389	Y	2014	√	√	√	√	√	√	√	√	√		√	√	
Ingleside	9,387	Y	2014	√		√	√	√	√	√	√	√	√	√	√	√
Taft	3,048	Y	2013	√	√		√	√	√	√	√	√	√	√	√	
Portland	15,099	Y	2013	√	√	√	√	√	√	√	√	√	√	√	√	
Rincon WSC	3,243	Y	2009	√	√		√				√	√		√	√	
County-Other Entities																
Aransas County MUD #1		Y	2009	√							√			√		√
Blueberry Hills		Y	2005	√	√		√	√			√	√	√	√		√
Copano Heights Water Company		Y	2005	√	√		√	√			√	√	√		√	
Escondido Creek Estates		Y	2000	√			√			√	√	√	√	√		√
Freer WCID		Y	2000	√	√		√	√	√	√	√	√	√	√		√
McMullen WCID #2		Y	2002	√	√		√	√	√	√	√	√	√	√		√
Riviera		Y	2000	√			√	√			√	√	√	√		√
Pettus MUD		Y	2000	√			√	√			√	√		√		√

7.5.2 Model Drought Contingency Plans

TCEQ has prepared model drought contingency plans for wholesale and retail water suppliers to provide guidance and suggestions to entities with regard to the preparation of drought contingency plans. Not all items in the model will apply to every systems situation, but the overall model can be used as a starting point for most entities. The TCEQ model drought contingency plans can be found on TCEQ's website: https://www.tceq.texas.gov/permitting/water_rights/contingency.html/#contents. Region N appointed a subcommittee on May 8, 2014, comprised of its members, to prepare drought response recommendations for Region N consideration. The subcommittee met on July 14 and developed a recommendation, which was approved by Region N on August 14, 2014, to include all TCEQ model drought contingency plans.

Region N recommends that a list of the common drought contingency measures for the Coastal Bend Region (Table 7.11) be considered, in addition to TCEQ Model DCPs for Region N entities wishing to develop a new DCP. A region-specific model drought contingency plan is included in the electronic Appendix B (compact disk).

7.6 Drought Management WMS

The Coastal Bend Regional Water Planning Group adopted safe yield measures when considering water supplies for nearly 80% of the regional water demands. The regional water plan is developed to meet projected water demands with a safe yield reserve of 125,000 ac-ft in CCR/LCC storage during worse historical drought conditions as a provision for future drought uncertainty. The Coastal Bend Regional Water Planning Group sees the purpose of the planning as ensuring that sufficient supplies are available to meet future water demands. Additional drought management recommendations have not been made by Region N as a water management strategy for specific WUG needs. Reducing water demands during a drought as a defined water management strategy does not ensure that sufficient supplies will be available to meet the projected water demands; but simply eliminates the demands.

While Region N encourages entities in the region to promote demand management during a drought, it should not be identified as a "new source" of supply. Recommending demand reductions as a water management strategy is antithetical to the concept of planning to meet projected water demands. It does not make more efficient use of existing supplies as does conservation, but instead effectively turns the tap off when the water is needed most. It is planning to not meet future water demands. At Region N's request, the TWDB will be conducting a Socio-economic Analysis of Not Meeting Needs for the 2016 Final Plan.

While Drought Management WMS are not supported by Region N, DCPs are encouraged for all entities and the region supports the implementation of the drought responses outlined in these DCPs when corresponding triggers occur. While the relief provided from these DCP responses can prolong supply and reduce impacts to communities, they are not seen as reliable for all entities under all potential droughts.

7.7 Other Drought Recommendations

7.7.1 Model Updates

It is of utmost importance that regional water planning groups have the most up-to-date information available to make decisions. The Corpus Christi Water Supply Model is used to determine both the DOR and the firm yield of reservoirs, but has not been updated since 2003. Region N recommends that the Texas legislature approve a budget for TCEQ to pursue updated WAMs and Water Supply Models before the next regional planning cycle. This will be especially important if the duration of the recent drought continues or the severity increases.

7.7.2 Monitoring and Assessment

Region N recommends that all entities monitor the drought situation around the state and locally in order to prepare and facilitate decisions. Several state and local agencies are monitoring and reporting on conditions with up to date information. A few informative sources are listed below.

- Nueces River Authority Pass-Through Data: https://www.nuecesra.org/CP/CITY/passthru/index.php.
- TWDB Drought Information: http://waterdatafortexas.org/drought/.
- TCEQ Drought Information: https://www.tceq.texas.gov/response/drought.

In addition, Region N supports the efforts of the Texas Drought Preparedness Council (DPC) and recommends that entities review information developed by the council. The DPC was established by the legislature in 1999 and is composed of 15 representatives from several state agencies. The council is responsible for assessment and public reporting of drought monitoring and water supply conditions, advising the governor on drought conditions, and ensuring effective coordination among agencies. The DPC is currently promoting outreach to inform entities of the assistance they can provide and looking for input as to how they can be more useful. Region N suggests that entities take advantage of the resources available to them through the DPC such as the Drought Annex which describes the activities that help minimize potential impacts of drought and outlines an effective mechanism for proactive monitoring and assessment and was published in 2014. More information on the DCP can be found here: http://www.txdps.state.tx.us/dem/CouncilsCommittees/droughtCouncil/stateDroughtPrepCouncil.htm.

The State Drought Preparedness Plan, issued by the DPC in February 2006, emphasizes the importance of pro-active drought monitoring and provides agency resources that collect drought-related data and provide assistance. The State Drought Preparedness Plan presents resources that are available for mitigation and preparedness, response, and recovery. It continues by identifying climatological, agriculture, and water availability indices for each of ten climatic regions in Texas to consider when assessing drought severity. The Coastal Bend Region (Region N) counties are located in two climatic regions (Region 7 and 8) and, as discussed in the report, “climatic regions are so large, that drought indices developed across regions of this magnitude routinely mask smaller, regional drought problems and emerging drought conditions”. For this reason, Region N considered the State Drought Preparedness

Plan and information from the DPC but selected information provided by local, approved drought contingency plans for development of drought response recommendations.

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8

Legislative Recommendations, Unique Stream Segments, and Reservoir Sites

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Chapter 8: Legislative Recommendations, Unique Stream Segments, and Reservoir Sites

Each of the 16 regional water planning groups may make recommendations to the TWDB regarding legislative and regional policy recommendations; identification of unique ecological stream segments; and identification of sites uniquely suited for reservoirs. The Coastal Bend RWPG selected a subcommittee to consider legislative and regional policy recommendations, which were adopted by the Coastal Bend Region. The following are the Coastal Bend Region's recommendations regarding these matters.

8.1 Legislative and Regional Policy Recommendations

Under the authority of Senate Bill 1, the Coastal Bend RWPG has developed the following legislative and regional policy recommendations.

8.1.1 General Policy Statement

I. The Texas Legislature is urged to declare that: i) all water resources of the State are hydrologically inter-related and should be managed on a "conjunctive use" basis, wherever possible; ii) existing water supplies should be more efficiently and effectively used through improved conservation and system operating policies; and iii) water re-use should be promoted, wherever practical, taking into account appropriate provisions for protection of downstream water rights, domestic and livestock uses, and environmental flows.

II. The Coastal Bend Region urges the legislature to support policies and programs to meet Texas' water supply needs and prepare for and respond to drought conditions.

III. The Texas Legislature should continue to provide funding to the TWDB and other state agencies for water conservation initiatives, including providing technical support and assistance to water user groups regarding public information programs; leak detection, repair, and monitoring; meter testing and replacement; or other best management practices included in their water conservation programs.

8.1.2 Interbasin Transfers

I. The Texas Legislature is urged to repeal the "Junior Rights" provision and the additional application requirements for interbasin transfers that were included in Senate Bill 1.

8.1.3 Desalination

I. The Texas Legislature is urged to direct TCEQ to investigate the current regulatory status of the “concentrate” or “reject water” produced during the desalination of brackish ground water, brackish surface water and seawater in industrial and municipal treatment processes and compare these to reject water requirements for the oil and gas industry and arrive at a common set of standards for the disposal of these waste products so that safe, economical methods of disposal will be available to encourage the application of these technologies in Texas.

II. The Texas Legislature is urged to direct TCEQ to work with TWDB and TPWD to develop information on the potential environmental impacts of concentrate discharges from seawater desalination facilities and to facilitate the permitting of these discharges into tidal waters where site specific information shows that minimal environment damage would occur.

III. Texas Legislature is urged to amend state laws governing the procurement of professional services by public agencies in order to allow municipalities, water districts, river authorities, smaller communities, and other public entities, provided that they have the expertise, to utilize alternative delivery methods for public work projects, including desalination facilities. For example, some large-scale desalination facilities are now constructed using CMAR (Construction-Management-at-Risk) method, allowing for a cost-effective transfer of project risks to the private sector.[1]

8.1.4 Groundwater Management

I. The Texas Legislature is urged to provide funding for the Groundwater Management Areas to support their efforts towards the evaluation of groundwater availability and desired future conditions.

II. TWDB, TCEQ, and the Texas Railroad Commission are urged to expand and intensify their activities in collecting, managing, and disseminating information on groundwater conditions and aquifer characteristics throughout Texas.

III. TWDB is urged to continue funding for updates to the groundwater availability models at least on a five-year basis, specifically the Groundwater Management Area 16 Groundwater Flow Model covering the Coastal Bend Region.

IV. The Texas Legislature is urged to require the Texas Railroad Commission to cooperate with TWDB and TCEQ to encourage oil and gas well drillers to furnish e-logs, well logs, and other information and require logging of shallow, groundwater bearing formations to facilitate the better identification of aquifer characteristics.

V. The Texas Legislature is urged to appropriate additional funds for TWDB to continue and expand their statewide groundwater data program and to appropriate new funds, through

[1] “Large-Scale Seawater Desalination and Alternative Project Delivery”, Design-Build DATELINE, February 2005.

regional institutions such as Texas A&M University–Corpus Christi and Texas A&M University–Kingsville, for a regional research center to support research, data collection, monitoring, modeling, and outreach related to groundwater management activities in the Coastal Bend region of Texas.

VI. The Texas Legislature is urged to make funds available through regional water planning groups and groundwater conservation districts to educate the citizens of Texas about groundwater issues, as well as the powers and benefits of groundwater conservation districts.

VII. TCEQ is urged to amend rules and regulations to require routine water quality monitoring, by a non-partisan third-party, of mining operations and enforcement of water quality standards, including in situ mining and those with deep well injection practices.

VIII. The Texas Legislature is urged to prohibit in-situ mining in aquifers that serve as drinking water sources for residents and livestock.

IX. The Railroad Commission is urged to continue its identification of improperly plugged and abandoned oil and gas wells that adversely affect local groundwater supplies. Funding should be provided to address known problems and/or force responsible parties to properly plug abandoned wells, including oil, gas, and water wells.

X. The TWDB is urged to consider local mining projects (such as natural gas from the Eagleford shale) when developing mining water demand projections in the future for regional planning. The TWDB is urged to continue to provide guidance on how planning groups should address local mining water projects, especially those associated with gas production from the Eagleford shale or other projects with variable, and often indeterminate production timelines.

8.1.5 Surface Water Management

I. The Texas Legislature is urged to provide funding for the development of periodic updates to surface water availability models, (WAMs), with specific consideration to updating the Nueces River Basin WAM through any new drought period.

II. The TCEQ is urged to enforce existing rules and regulations with respect to water impoundments.

8.1.6 Regional Water Resources Data Collection and Information Management

I. The Texas Legislature is urged to provide SB1 planning funds, through the Coastal Bend RWPG to a regional institution, to support regional water resources data collection and activities to develop and maintain a “Regional Water Resources Information Management System” for the Coastal Bend area.

8.1.7 Role of the RWPGs

I. The RWPG should play a role in facilitating public information/public education activities that promote a wider understanding of state and regional water issues and the importance of long-range regional water planning.

II. The Texas Legislature is urged to continue funding the TWDB to provide support for state mandated regional water planning group activities.

III. Public entities in the Coastal Bend Water Planning Region are urged to provide their share of continued funding for the administrative support activities that facilitate the Coastal Bend RWPG activities.

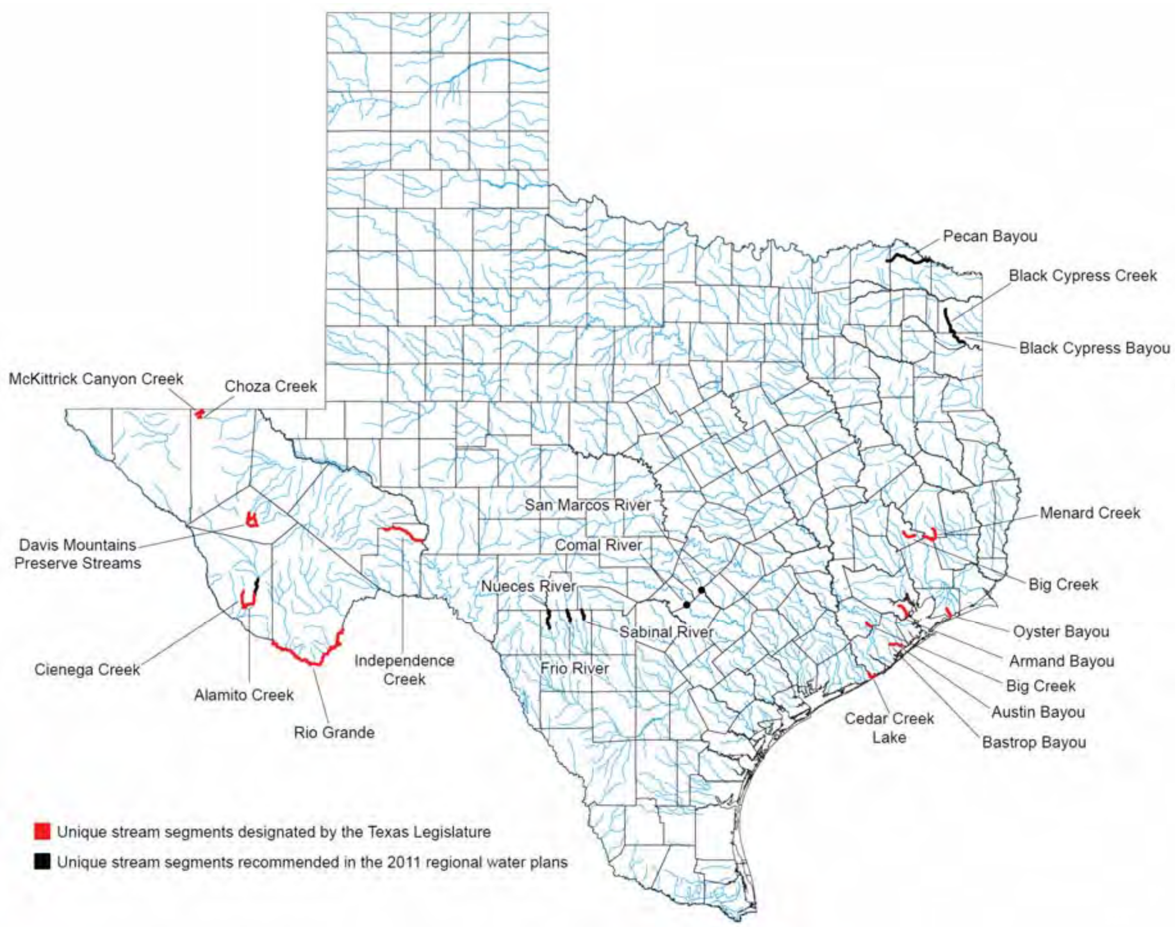
8.2 Identification of River and Stream Segments Meeting Criteria for Unique Ecological Value

Planning groups may recommend the designation of river or stream segments of unique ecological value located within their planning area. The following criteria can be used as a basis for designating stream segments of unique ecological value: biological function, hydrologic function, riparian conservation areas, high water quality, exceptional aquatic life, high aesthetic value, and threatened or endangered species/unique communities.[2] The TWDB considers planning group recommendations of unique reservoir sites from adopted regional water plans when developing the State Water Plan.

According to Texas Water Code, Section 16.051, the State Water Plan is to include TWDB recommendations to the legislature for designation of river and stream segments of unique ecological value. If the legislature then designates a river or stream segment of unique value, it means that a state agency or political subdivision of the state may not finance construction of a reservoir on the designated river or stream segment.

The Coastal Bend Region considered TPWD's 2002 recommendations of four stream segments in Region N for designation of ecologically significant value: Aransas River Tidal (Segment 2003), Nueces River Tidal (Segment 2101), Nueces River (below Lake Corpus Christi) (Segment 2102), and Nueces River (above Lake Corpus Christi) (Segment 2103).[3] In December 2009, the Coastal Bend Region recommended that no river or stream segments within the Coastal Bend Region be identified at this time. The unique stream segments of unique ecological value for protection recommended in the 2012 State Water Plan and designated by the Texas Legislature are presented in Figure 8.1. There are no river or stream segments in the Region N area designated by the 2012 State Water Plan or Texas Legislature as having unique ecological value.

[2] TWDB, 2012 State Water Plan.
[3] Texas Parks and Wildlife, Ecologically Significant River and Stream Segments of Coastal Bend Water Planning Area (Region N), August 2002.



Source: TWDB, Water for Texas 2012 State Water Plan.

Figure 8.1.
2012 State Water Plan - Designated and Recommended Unique Stream Segments

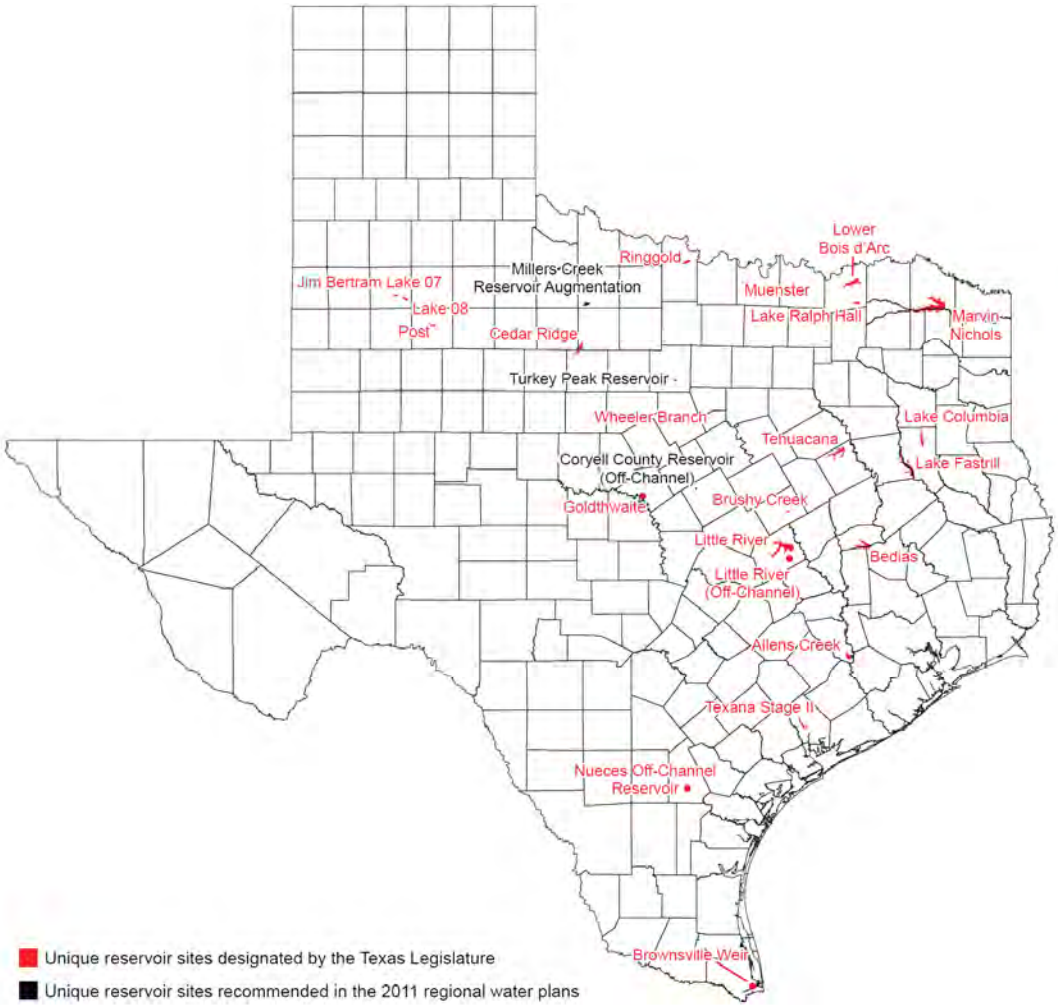
8.3 Identification of Sites Uniquely Suited for Reservoirs

Planning groups may recommend a site as unique for reservoir construction if: 1) site-specific reservoir development is recommended as a specific water management strategy or an alternative scenario in an adopted regional water plan; or 2) the site is uniquely suited to provide water supply for the current planning period or beyond 50-years. The TWDB considers planning group recommendations of unique sites for reservoir construction from adopted regional water plans when developing the State Water Plan.

According to Texas Water Code, Section 16.051, the State Water Plan is to include TWDB recommendations to the legislature for unique reservoir sites. If the legislature designates a site of unique value for the construction of a reservoir, a state agency or political subdivision of the state may not obtain a fee title or an easement that would significantly prevent the construction of a reservoir on a designated site.

No sites uniquely suited for on-channel reservoirs in the Nueces Basin were identified by the Coastal Bend Region. However, the Coastal Bend Region supports the legislative action to identify general areas for reservoir sites.

A map showing the 2012 State Water Plan recommended unique reservoir sites and those designated by the 80th Texas Legislature as sites of unique value for reservoir construction is shown in Figure 8.2. Of these, 2 of the 26 sites were shown previously in the 2011 Region N Plan as recommended or alternative water management strategies to provide future supplies to the Coastal Bend Region: Nueces off-channel reservoir and Stage II - Lake Texana. Since the 2011 Region N Plan, both reservoirs have been removed from active study and further water supply for the Coastal Bend Region.



Source: TWDB, Water for Texas 2012 State Water Plan.

Figure 8.2.
2012 State Water Plan - Designated and Recommended Unique Reservoir Sites

The Lavaca Navidad River Authority (LNRA) is considering an off-channel variation of Stage II Lake Texana (Palmetto Bend) which is included in the 2016 Region N Plan. The Coastal Bend Region supports initiatives by Region P and Lavaca Navidad River Authority (LNRA) regarding the Lavaca Off-Channel Reservoir Project. However, the Coastal Bend Region does not recommend specific tracts of land for the Lavaca Off-Channel Reservoir Project and encourages those wishing to pursue such options to discuss with property owners and mediate if necessary prior to Federal, State, or local recommendation of specific location(s).

8.4 Additional Recommendations

The following additional recommendations are under consideration by the Coastal Bend RWPG:

1. The Texas Legislature is urged to support studies of construction and implementation of a pilot desalination plant to quantify and qualify impacts of operating a brackish or seawater desalination facility in the Coastal Bend Region.

2. The Texas Legislature is urged to support studies to closely monitor discharges from sand and gravel operations in the Lower Nueces River.

3. Studies of the potential to develop a large-scale, multiyear ASR system in the Gulf Coast Aquifer should be continued to help drought-proof the Region.

4. Studies of desalination options to further reduce the cost of using seawater and/or brackish groundwater should be continued.

5. Studies should be undertaken to analyze the effects/costs of new EPA Safe Drinking Water Act requirements regarding the treatment of problematic constituents in groundwater on users in the Coastal Bend Region.

6. Feasibility studies should be undertaken to optimize and reduce, if possible, the costs of water system interconnects for the cities of San Diego, Freer, Benavides, Premont, and Falfurrias to improve the quantity and quality of potable water available to these cities. Additionally, an evaluation should be undertaken of the feasibility of a regional desalination facility for the treatment of poor quality groundwater to improve the quality of potable water to these cities.

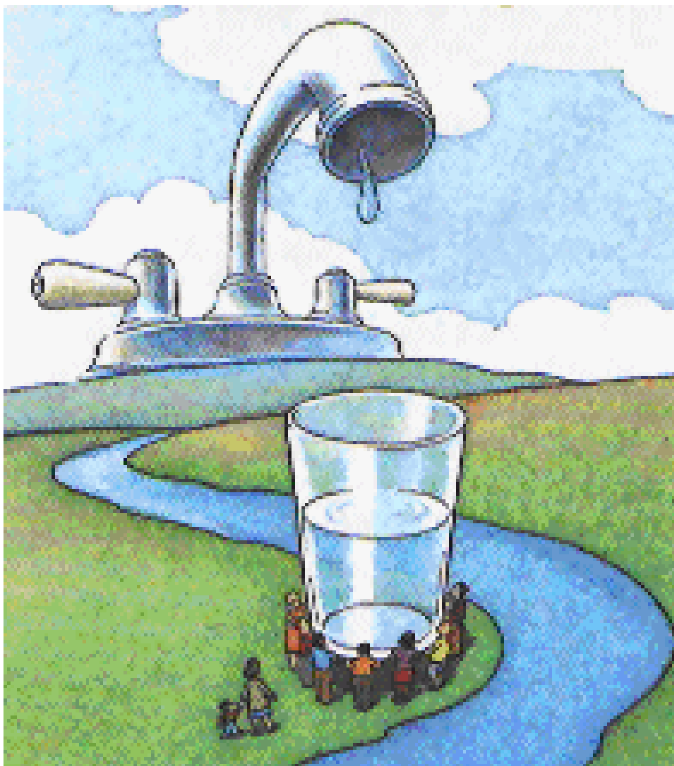
7. Feasibility studies should be undertaken to identify opportunities/costs to develop regional groundwater systems that could utilize poor quality groundwater in conjunction with a desalination treatment plant to more effectively manage groundwater resources within the Coastal Bend Region.

8. A detailed inventory of irrigation systems, crops, and acreage should be undertaken to more accurately estimate irrigation demands in the region.

9. Environmental studies of the segments of the Frio and Nueces Rivers downstream of Choke Canyon Reservoir to the Calallen Pool intakes should be undertaken to fully evaluate the potential impacts of reduced instream flows, including groundwater recharge.

10. The Coastal Bend Region should perform environmental field studies of potentially unique stream segments and potential unique reservoir sites provided additional clarification is provided by the Texas Legislature regarding the repercussions of identifying a stream segment as unique.

11. The Coastal Bend Region recognizes the importance of considering groundwater and surface water interaction when managing water resources and evaluating development of future water supplies. The Region encourages groundwater conservation districts and groundwater management areas to consider protection of springs and groundwater-surface water interaction during when considering new DFCs.



9

Infrastructure Financing

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Chapter 9: Infrastructure Financing

9.1 Introduction

Senate Bill 2 (77th Texas Legislature) requires that regional water plans include a description of financing needed to implement recommended water management strategies and projects, including how local governments and others propose to pay for water management strategies identified in the plan. The TWDB issued an Infrastructure Financing Report (IFR) Survey requesting information from water user groups with reported water needs any time during the 2016 regional water planning period from Year 2020 to 2070.

9.2 Objectives of the Infrastructure Financing Report

The primary objective of the Infrastructure Financing Report is to determine the financing options proposed by political subdivisions to meet future water infrastructure needs (including the identification of any State funding sources considered).

9.3 Methods and Procedures

For the Coastal Bend Regional Water Planning Area, water user groups and wholesale water providers having water needs and recommended water management strategies with an associated capital cost in the regional plan were surveyed using a customized questionnaire provided by the TWDB. The TWDB prepared nine IFR questionnaires for the Coastal Bend Region directed to six (6) municipal water user groups and wholesale water providers, two (2) irrigation water user groups, and one (1) mining water user group.

For each project with an identified capital cost, the survey respondents were asked to enter only the amounts that they wish to receive from the TWDB program listed below:

- Planning, Design, and Permitting: Costs were entered into this category if the entity wanted to participate in the TWDB programs offering subsidized interest and deferral of principal and interest for planning, design, and permitting costs.
- Construction Funding: Costs were entered into this category if the entity wants to obtain subsidized interest for all construction costs, including planning, design, and construction.
- State Participation: Percentage of costs was entered into this category if the entity wanted to participate in the State Participation Program. State Participation funding offers partial interest and principal deferral for the incremental cost of project elements which are designed and built to serve needs beyond 10 years.

9.4 Survey Responses

The Coastal Bend RWPG emailed a survey package with supporting documentation to representatives for the following nine (9) water user groups: the City of Corpus Christi; San Patricio Municipal Water District; Nueces County WCID #3; the City of Alice; the City of Beeville; the City of San Diego; Irrigation-McMullen County, Irrigation-San Patricio County, and Mining-McMullen County. The three non-municipal water user groups were sent to Lonnie Stewart, who serves as a representative of the Groundwater Conservation Districts in San Patricio and McMullen Counties.

Comments were received from seven (7) of the nine water user groups who were sent the survey. Follow-up emails were sent to the other two water user groups.

As shown in Table 9-1, the 7 responses represent about 98 percent of the estimated capital costs of water management strategies included in the Regional Water Plan. Of those responding, for which total capital costs are around $502 million the survey shows that approximately $499 million would be sought through the state participation programs. The completed IFR survey collection spreadsheet requested by the TWDB is included as an electronic Appendix on compact disk (Appendix F).

With respect to the role of the State in financing the recommended water supply projects, significant State participation is required in order to provide adequate funding for the implementation of water management strategies in the plan.

Table 9.1. Summary of Responses to the Infrastructure Financing Survey

Sponsor Entity Name	Received Response to Survey	ProjectName	Capital Cost[a]	Planning, Design, Permitting and Acquisition Funding		Construction Funding		Percent State Participation in Owning Excess Capacity
				Amount	Year of Need	Amount	Year of Need	
ALICE	Yes	STWA INTERCONNECTIONS	$5,866,224	$676,872	2020	$5,189,352	2020	0%
ALICE	Yes	BRACKISH GROUNDWATER DEVELOPMENT	$33,300,000	$4,000,000	2016	$29,300,000	2017	0%
ALICE	Yes	REUSE - ALICE	$8,700,000	$1,000,000	2030	$7,700,000	2030	0%
ALICE	Yes	MUNICIPAL WATER CONSERVATION - PIPELINE REPLACEMENT	$22,400,000	$2,600,000	2024	$19,800,000	2025	0%
BEEVILLE	Yes	CHASE WELL FIELD	$4,777,000	$1,442,000	2016	$3,335,000	2017	0%
BEEVILLE	Yes	WELL CONVERSION PROJECT	$261,000	$0		$0		0%
CORPUS CHRISTI	Yes	ADDITIONAL REUSE - CORPUS CHRISTI	$52,097,000	$18,233,950	2021	$33,863,050	2025	0%
CORPUS CHRISTI	Yes	O.N. STEVENS WTP IMPROVEMENTS	$44,029,540	$15,410,339	2020	$28,619,201	2020	0%
CORPUS CHRISTI	Yes	SEAWATER DESALINATION	$248,000,000	$86,800,000	2021	$161,200,000	2027	0%
IRRIGATION, MCMULLEN	Yes	GULF COAST AQUIFER SUPPLIES	$129,000	not to be funded by State Programs				0%
IRRIGATION, SAN PATRICIO	Yes	GULF COAST AQUIFER SUPPLIES	$1,156,000	not to be funded by State Programs				0%
MINING, MCMULLEN	Yes	CARRIZO AQUIFER	$783,194	not to be funded by State Programs				0%
MINING, MCMULLEN	Yes	GULF COAST AQUIFER SUPPLIES	$195,362	not to be funded by State Programs				0%
MINING, MCMULLEN	Yes	MINOR AQUIFER	$706,444	not to be funded by State Programs				0%
NCWCID #3	No	LOCAL BALANCING STORAGE	$8,182,000	No Response Received				
SAN DIEGO	No	GULF COAST AQUIFER SUPPLIES	$940,000	No Response Received				
SAN PATRICIO MWD	Yes	INDUSTRIAL WTP IMPROVEMENTS	$58,366,000	$20,428,100	2019	$37,937,900	2019	0%
SAN PATRICIO MWD	Yes	PORTLAND REUSE	$21,291,600	$4,791,600	2016	$16,500,000	2017	0%

[a] Project sponsors indicated a different capital cost on the form than shown in the Regional Plan for the following strategies: City of Alice- Brackish Groundwater Development; City of Alice- Reuse; City of Alice- Pipeline Replacement; and San Patricio Municipal Water District- Portland Reuse.

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10

Public Participation, Adoption, Submittal, and Approval of Regional Plan

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Chapter 10: Public Participation, Adoption, Submittal, and Approval of Regional Plan

10.1 Public Involvement Program

The public involvement program was incorporated at the onset of the Coastal Bend Regional Water Planning Group (CBRWPG) water planning process in order to maximize the opportunity for public review and input into the process of developing the water plan as well as critique of the Initially Prepared Regional Water Plan.

The public involvement program included:

- An opportunity at all RWPG meetings for the public to comment on any aspect of the plan or planning process;
- Press releases and notices of public meetings; and
- Dedicated website for Coastal Bend RWPG information.
- Public Hearing for Initially Prepared Plan:
  June 11, 2015 at 1:30 pm
  Johnny Calderon County Building
  711 Main Street, Robstown, TX 78380

The CBRWPG conducted all business in meetings that were posted and held in accordance with the Texas Open Meetings Act. The plan was developed in accordance with Texas Administrative Code public participation requirements.

10.2 Coordination with Wholesale Water Providers

Information was provided by wholesale water providers located in the Coastal Bend Planning Region throughout development of the plan. Wholesale water providers were contacted to confirm water supplies and future water supply plans prior to identifying feasible water management strategies. Furthermore, wholesale water providers were provided water supply plan information from the technical consultant for review and comment prior to providing to the CBRWPG for consideration.

Representatives from water supply entities within the CBRWPG were also regularly notified of all CBRWPG meetings and public informational meetings.

10.3 Coastal Bend Regional Water Planning Group Meetings

The CBRWPG regularly met in accordance with the approved bylaws. The CBRPWG has met on a more frequent basis as needed in order to facilitate and direct the water planning of the region. The following is a summary of the meetings:

Coastal Bend RWPG Meetings	
February 10, 2011	May 8, 2014
April 14, 2011	August 14, 2014
July 14, 2011	November 13, 2014
November 3, 2011	January 15, 2015
January 19, 2012	February 12, 2015
August 16, 2012	March 12, 2015
March 7, 2013	April 9, 2015
June 13, 2013	June 11, 2015
August 8, 2013	October 15, 2015
November 14, 2013	November 12, 2015
February 13, 2014	

The CBRWPG requested that the TWDB execute the initial contract to develop the 2016 Regional Water Plan on February 10, 2011.

The CBRWPG also designated several subcommittees in order to expedite more specific work efforts and further increase the effectiveness and timeliness of the planning process. The following summarizes these committee and subcommittee meetings.

Review Non-municipal Water Demand Projections

- Designated by the CBRWPG: November 3, 2011
- Subcommittee meeting: Email correspondence

Prioritize List of New Water Management Strategies for Evaluation

- Designated by the CBRWPG: January 19, 2012
- Subcommittee meeting: November 26, 2012

Development of Strategy for Prioritization of Projects

- Designated by the CBRWPG: February 13, 2014
- Subcommittee meeting: April 3, 2014

Subcommittee to Identify Emergency Interconnections/Drought Response Recommendations

- Designated by the CBRWPG: May 8, 2014
- Subcommittee meeting: July 14, 2014

Subcommittee on Policy Recommendations

- Designated by the CBRWPG: January 15, 2015
- Subcommittee meeting: February 12, 2015

The CBRWPG approved the Initially Prepared Plan on April 9, 2015 for submittal to the Texas Water Development Board. The TWDB approved responses to their comments on October 12, 2015 and the CBRWPG approved responses to all comments received on the Initially Prepared Plan on October 15, 2015. The CBRWPG approved the Final Plan on November 12, 2015. The comments received on the Coastal Bend Initially Prepared Plan with approved responses are included in Appendix 3.

10.4 Regional Water Planning Group Chairs Conference Calls and Meetings

The Texas Water Development Board held conference call meetings with Regional Water Planning Group chairs to provide guidance and respond to issues regarding the planning process on May 23, 2014, July 31, 2014 and October 6, 2015.

10.5 Coordination with Other Regions

Several coordination calls between the CBRWPG technical consultant and Lavaca RWPG and the South Central Texas RWPG consultants occurred during development of the initially prepared plan.

There are no known interregional coordination conflicts for any recommended or alternative water management strategies in the 2016 Coastal Bend Plan.

10.6 Coordination with Other Entities

Two surveys were sent out to all municipal water user groups and wholesale water providers in an attempt to gather utility-specific information to assist in developing the 2016 Plan. The Phase I survey was sent out in April 2013. The Phase II survey was sent out in October 2013. Frequent coordination calls occurred between individual water user groups and the technical consultant to confirm water supplies and future water supply plans.

Additional surveys were sent to WUGs and WWPs in September to gather information on infrastructure financing (Chapter 9) and implementation of recommended water management strategies from the 2011 Plan (Chapter 11).

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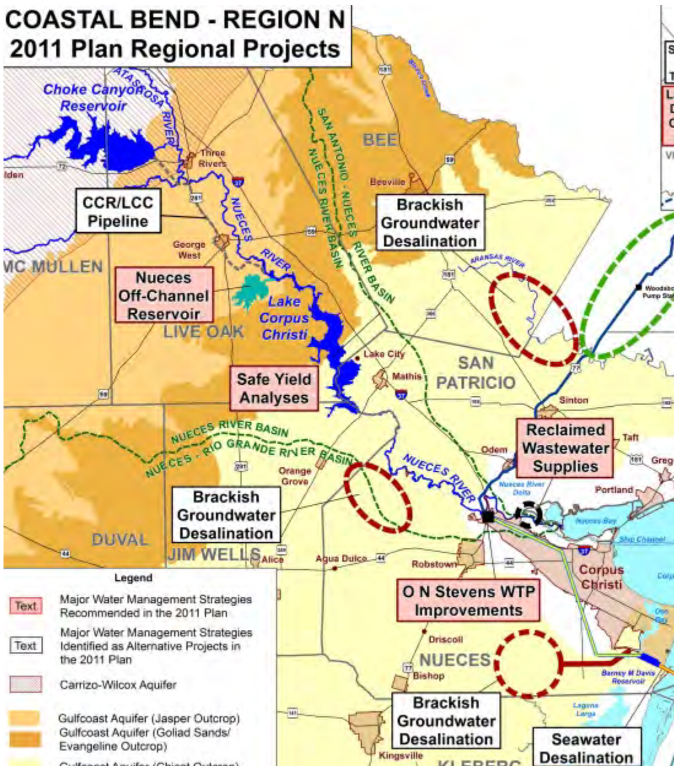

11

Implementation and Comparison to Previous Regional Water Plans

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Chapter 11: Implementation and Comparison to Previous Regional Water Plan(s)

11.1 Implementation of Previous Regional Water Plan

In response to Senate Bill 660 (82nd Legislative Session), the TWDB issued guidance that requires each region to report the level of implementation of previously recommended water management strategies meeting needs.

The 2011 Region N Plan included 34 recommended water management strategies, of which 15 (or 44% of the total strategies) were related to voluntary water conservation. A survey was sent to Region N WUGs and WWPs regarding the status of recommended strategies presented in the 2011 Region N Plan. The survey included information regarding the project description and infrastructure type. The WUGs and WWPs were asked to provide an update on the level of implementation currently achieved, the initial volume of water provided, the funds expended to date, project cost, funding source and year the project went online. If the project was a phased project, the WUGs were asked about the ultimate volume, project cost, and year that the project will reach maximum capacity. If the project was not implemented, the WUGs were asked to comment on why that was the case. The survey also had a column regarding inclusion in the 2016 plan for both phased and non-implemented projects.

Comments were received from five WUG/WWPs representatives by November 1, 2015, representing 18 of the 34 water management strategies that were recommended in the 2011 Plan. Results of the survey are summarized in Table 11.1. There are three recommended water management strategies from the 2011 Region N Plan that have been implemented: Mary Rhodes Pipeline Phase II, Port Aransas- water conservation, and Duval- Mining water conservation. A completed spreadsheet with implementation status for 2011 WMSs requested by the TWDB is included in Report 24 in Appendix 1.

Table 11.1.
Summary of Project Implementation

Responding Entity	WUG/WWP	Projects Implemented	Projects Under Construction	Projects in Design	Projects in Study
Corpus Christi	Corpus Christi	1	1	0	2
Alice	City of Alice	0	0	0	0
Port Aransas	Port Aransas/Nueces County WCID #4	1	0	0	0
San Patricio Municipal Water District	Manufacturing - San Patricio County	0	0	0	1
Local GCD representative	Kleberg County-Other	0	0	0	0
Local GCD representative	McMullen County-Other	0	0	0	0
Local GCD representative	Irrigation, Bee County	0	0	0	0
Local GCD representative	Irrigation, Live Oak	0	0	0	0
Local GCD representative	Irrigation, San Patricio	0	0	0	0
Local GCD representative	Mining, Live Oak	1	0	0	0

11.2 Comparison to Previous Regional Water Plan

The Coastal Bend Regional Water Planning Group has studied numerous water management strategies as part of previous regional water planning efforts as summarized in Table 11.2. Many of these strategies are no longer actively being considered by local sponsors and, therefore, were not evaluated as part of the 2016 Regional Water Plan. This chapter summarizes strategies previously evaluated in the 2011 Regional Water Plan to retain this knowledge and for efficiency should these strategies become applicable during future planning cycles.

The total water demand projected for the region in the 2016 Regional Water Plan is generally the same as compared to the 2011 Regional Water Plan (± 2% for each decade). Municipal water demand projections are 9-17% lower in the 2016 Plan than in the 2011 Plan for each decade, amounting to 128,510 ac-ft/yr by the 2070 decade as compared to the previous plan projection of 151,474 ac-ft/yr by 2060. Non-Municipal demands, however, are 11-15% higher in the 2016 Plan than in the 2011 Plan, and are projected to increase from 149,889 ac-ft/yr in 2020 to 214,734 ac-ft/yr by 2070. Nearly 60% of the non-municipal demand for the region is attributable to manufacturing in Nueces and San Patricio Counties. In the 2011 Plan, the total water demands for all entities in the region were projected to increase from 232,503 ac-ft/yr in 2010 to 324,938 ac-ft/yr in 2060. The total water demand projections for the 2016 Plan increase from 261,970 ac-ft/yr in 2020 to 343,244 ac-ft/yr in 2070.

Table 11.2. Summary of Water Management Strategies from Previous Coastal Bend Regional Water Plans

Water Management Strategies	2001 Plan	2006 Plan	2011 Plan[A]	2016 Plan
**Recommended Strategies (2001, 2006, or 2011 Plan)**				
Municipal Water Conservation	√	√	√	√
Irrigation Water Conservation	√	√	√	√
Manufacturing Water Conservation and Nueces River Water Quality Issues	√	√	√	√
Mining Water Conservation		√	√	√
ON Stevens WTP Improvements			√	√
SPMWD Industrial WTP Improvements				√
Reclaimed Wastewater Supplies and Reuse[B]		√	√	√
Gulf Coast Aquifer Supplies	√ [C]	√	√	√
Modify Existing Reservoir Operating Policy[B]		√ [D]	√ [D]	√
CCR and LCC Pipeline[B]		√ [E]	√ [G]	
Voluntary Redistribution of Available Supplies (and Federal or State Opportunities to Participate in Regional Projects)	√	√ [F]	√ [F]	√ [H]
Nueces Off-Channel Reservoir near Lake Corpus Christi		√	√	
Stage II of Lake Texana[B]		√	√ [G]	
Lavaca River Diversion and Off-Channel Reservoir			√	√
Garwood Pipeline (and other interbasin transfers)	√	√	√	
Seawater Desalination	√	√	√ [G]	√
Brackish Groundwater Desalination			√ [G]	√
Potential Water System Interconnections	√			√
Interruptible Lake Texana Supplies (2001 Plan)	√			
Recycle and Reuse of Groundwater or Use of Non-Potable Supplies (for Mining Water Users)	√			
Aquifer Storage and Recovery (ASR)	√	√		
Local Balancing Storage Reservoir (Nueces County WCID #3)				√
GBRA Lower Basin Storage Project				√
Studied and Considered (Not Recommended in 2001, 2006, or 2011 Plans)				
Carrizo-Wilcox Aquifer Supplies	√	√	√	
Sediment Removal in Lake Corpus Christi	√			
Brush Management	√	√	√	
Weather Modification	√	√	√	
Water Quality (TDS Study) - Lake Corpus Christi, Lake Texana, and Calallen Pool			√	

[A] The 2011 Plan also included five (5) special studies related to water supply development.
[B] Studied and considered in the 2001 Plan, but not recommended.
[C] Included short-term overdrafting in the 2001 Plan for generally small groundwater needs.
[D] Safe yield analysis was recommended strategy in 2006 and 2011 Plans.
[E] CCR/LCC Pipeline was revised from 2-way pipeline (in 2001 Plan) to 1-way pipeline from CCR to LCC.
[F] Includes USCOE Nueces Feasibility Study project opportunities.
[G] Considered an alternative water management strategy in the 2011 Plan.
[H] Voluntary Redistribution of Available Supplies included in Gulf Coast Aquifer Supplies (5D.7) for the 2016 Plan. Federal or State Opportunities to Participate in Regional Projects was not included in the 2016 Plan.

The drought of record in the Lower Nueces Basin is the drought of the 1990s, which was most severe from 1992-1996. The drought of record did not change between the 2011 and 2016 Regional Water Plans, although more recent droughts, as discussed in Section 7.1.4, may alter the drought of record in future planning cycles. A comparison of water modeling assumptions is provided in Table 11.3.

Table 11.3.
Comparison of Water Modeling Assumptions Used to Develop the 2016 and 2011 Plans

2016 Plan	***2011 Plan***
Groundwater Availability based on **Modeled Available Groundwater**	Groundwater Availability based on **Central Gulf Coast GAM analyses and Region N-adopted criteria for acceptable drawdown and water quality**
MRP Phase II added. Existing Supply from CCR/LCC/Lake Texana/**MRP Phase II** System based on Corpus Christi Water Supply Model safe yield analysis (**12 month storage reserve**) for the City of Corpus Christi and its customers only	Existing Supply from CCR/LCC/Lake Texana System based on Corpus Christi Water Supply Model safe yield analysis (**6 month storage reserve**) for the City of Corpus Christi and its customers only
Run of the river water rights in the Nueces Basin, firm yield supplies based on minimum annual supply that could be diverted **limited by minimum month conditions**.	Run of the river water rights in the Nueces Basin, firm yield supplies based on minimum annual supply that could be diverted.
New Surface WMSs conform to TCEQ Environmental Flow Standards	New Surface WMSs conform to **2001 Agreed Order Provisions or Consensus Criteria for Environmental Flow Needs**

Nearly 75% of the water used in the region comes from surface water supplies originating from the CCR/LCC/Texana/MRP Phase II system. The surface water availability increased in the 2016 Plan as compared to 2011 Plan with the addition of supplies from the MRP Phase II project. However, with the change in safe yield assumptions from a 6-month reserve to 12-month reserve (or 125,000 ac-ft during drought of record) the additional increase in system availability with the new project amounts to 15,000 ac-ft/yr. As discussed previously, the modeling assumptions used to develop groundwater availability for the 2016 Plan are different than those used for the 2011 Plan. The groundwater availability in the 2016 Plan amounts to twice the groundwater availability shown in the 2011 Plan. The 2016 Plan groundwater availability based on MAGs is approximately 227,000 ac-ft, as compared to 109,351 ac-ft in the 2011 Plan.

Existing water supplies for Region N entities have changed significantly since the last planning cycle. Municipal supplies have decreased on average by 12,400 ac-ft/yr for the comparable planning decades of 2020 through 2060. Non-Municipal WUG supplies have increased by an average of 66,000 ac-ft/yr over the same four planning decades. Some of this is due to the shift towards regional water supplies meeting the increased projected industrial water demands while projected municipal water demands have declined. Since most of the expected industrial growth occurs in San Patricio and Nueces counties, the regional CCR/LCC/Texana/MRP Phase II can accommodate flexibility in delivery of these supplies subject to physical delivery constraints and contract provisions. Overall the total difference in existing supplies between planning cycles range from 58,000 ac-ft increase in 2020 to 52,000 ac-ft increase in 2060. Much of this is attributable to existing groundwater supplies which increased on average by 31,200 ac-ft/yr for the comparable planning decades of 2020 through 2060.

Municipal and non-municipal need projections are lower in the 2016 Plan due to declines in municipal water demands and additional supplies that are available through groundwater and surface water supplies from MRP Phase II. The total WUG needs for the 2016 Plan increase from 10,807 ac-ft in 2020 to 50,950 ac-ft in 2070, and are larger than the needs in the 2011 Plan until 2030. The 2011 Plan showed needs of 3,404 ac-ft in 2010 that increase to 75,744 ac-ft by 2060. The 2016 Plan projections for Wholesale Water Provider (WWP) needs are less for every comparable decade than the 2011 Plan projections. The WWP needs are currently projected to increase from 8,034 ac-ft in 2020 to 46,550 ac-ft in 2070.

11.3 Summary of Water Management Strategies from the 2011 Regional Water Plan No Longer Relevant or Actively Evaluated in the 2016 Regional Water Plan

11.3.1 Carrizo- Wilcox Aquifer Supplies (previous N-6)

The City of Corpus Christi (City) owns a standby groundwater supply system of four wells located near the City of Campbellton in Atascosa County that are not currently in use (Figure 11.1). The option no longer being considered involves pumping water from the Campbellton well field and conveying it via pipeline to CCR, approximately 20 miles to the south. In order to bring the wells online, they will need to be inspected and redeveloped to maximize productivity. Well pumps will need to be purchased and installed, and a well field collection system of pipelines must be constructed to deliver the water to a terminal storage tank. From this storage tank, the water will be pumped via pipeline across the Atascosa River and over the Lipan Hills to CCR.

The proposed project was sized to convey 6 mgd of groundwater from the Campbellton well field to CCR. This is equivalent to approximately 1,000 gallons per minute from each of the four wells on a continual basis. Results of the cost estimate indicate that total capital costs for infrastructure associated with the project would be approximately $13,608,000. Annual costs would be on the order of $3,521,000. For the proposed project yield of 3,200 ac-ft/yr, this is equivalent to a unit cost of water of $1,100 per ac-ft. A summary of the Campbellton well strategy is provided in Table 11.4.

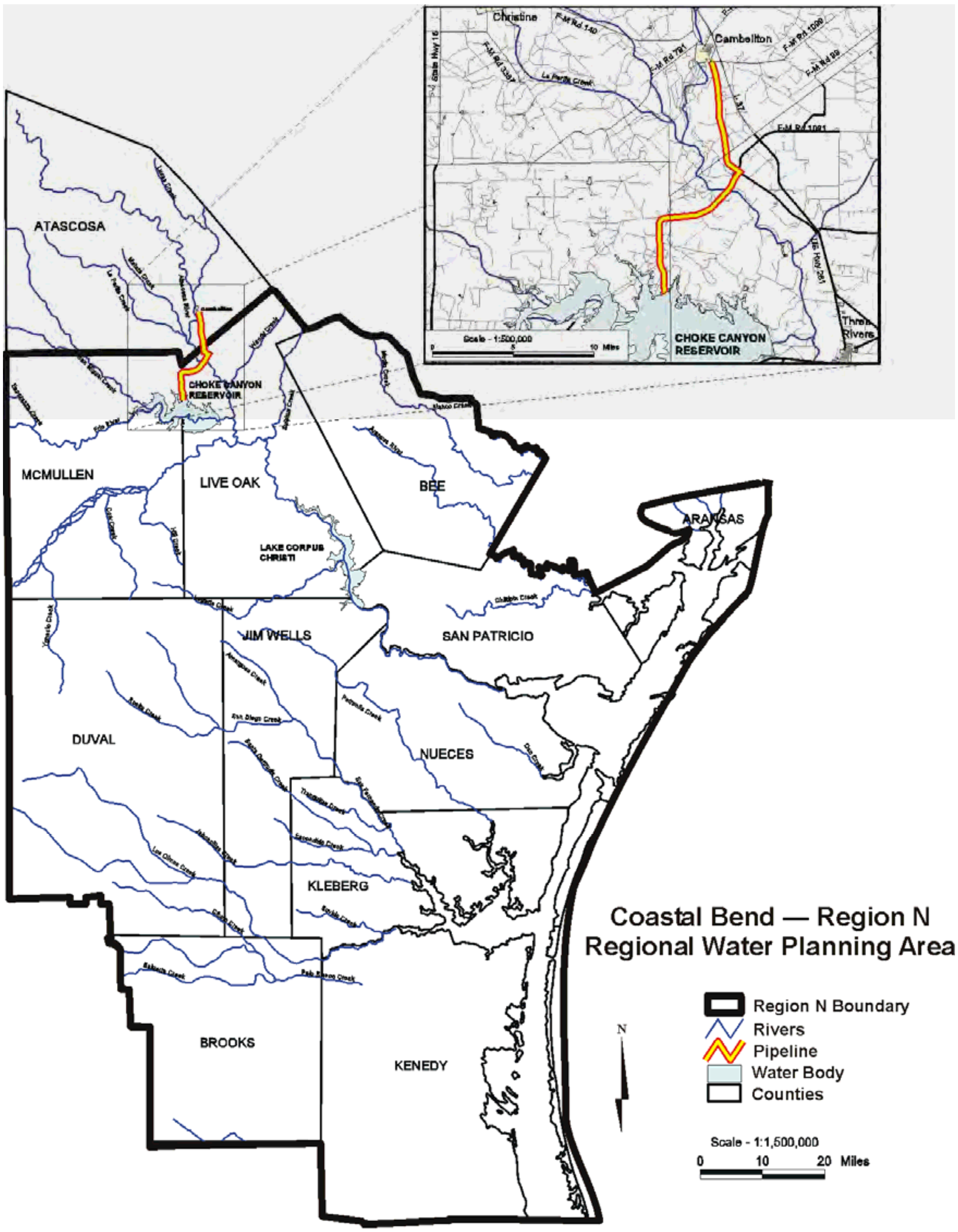

Figure 11.1.
Carrizo-Wilcox Supply Option

Table 11.4.
Evaluation Summary of Campbellton Well Option to Enhance Water Supply Yield

Impact Category	***Comment(s)***
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	 1. Firm yield: 3,200 ac-ft/yr. 2. Good, assuming ability to pump 6,720 ac-ft/yr and recovery of 48 percent. 3. Cost: $1,100 per ac-ft/yr.
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. Increase flows to CCR. 2. Slight increase in bay and estuary inflows. 3. Pipeline construction may temporarily disrupt local wildlife. 4. Minimal impact (pipeline crossing Atascosa River.). 5. Minimal impact along pipeline route. 6. Cultural resources will need to be avoided when facilities are constructed. 7. May have impacts to CCR due to mixing of groundwater with surface water supplies. b. Groundwater may be slightly saline. f. Groundwater may contain high sulfur content.
c. Impacts to State water resources	• Will result in lowering of groundwater levels in Campbellton area over time. No other apparent negative impacts on other water resources
d. Threats to agriculture and natural resources in region	• None
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Cost model for option is based on literature values
g. Interbasin transfers	• Potential for interbasin transfer or exchange for other water with Region L
h. Third party social and economic impacts from voluntary redistribution of water	• Not applicable
i. Efficient use of existing water supplies and regional opportunities	• Slight improvement over current conditions
j. Effect on navigation	• None
k. Consideration of water pipelines and other facilities used for water conveyance	• Potential impacts to wildlife habitat

11.3.2 Gulf Coast Aquifer Supplies (portion of previous N-7)

The existing regional water system operated by the City of Corpus Christi (City) consists of — the CCR/LCC System in the Nueces Basin and Lake Texana in the Lavaca River Basin. One 2011 option considered conjunctive use of groundwater with the existing surface water supplies and evaluates the feasibility of securing groundwater supplies from the Gulf Coast Aquifer in Refugio County. For the conjunctive use of groundwater from the Gulf Coast Aquifer in Refugio County option, groundwater would be developed from two well fields along a southwest-northeast line about 3 miles west of the City of Refugio as shown in Figure 11.2. In addition, a brackish groundwater project in San Patricio and Bee Counties was evaluated to produce up to 24,000 ac-ft/yr. A smaller project was proposed to utilize fresh water supplies as may be available in Bee and San Patricio Counties for SPMWD and the City as shown in Figure 11.3.

Twenty-eight wells were assumed for the conjunctive use strategy. The annual costs, including power and the purchase of groundwater, are estimated to be $12,996,000 for 28,000 ac-ft of water. This option produces raw water delivered to the O.N. Stevens WTP at an estimated cost of $463 per ac-ft. If treatment of water is necessary, the treated water cost is $789 per ac-ft (assuming treatment costs of $326 per ac-ft) as shown in Table 11.5. Eleven wells were assumed for the future water supply projects in Bee and San Patricio Counties. The annual costs are estimated to be $9,494,000 for 18,000 ac-ft of water. This option produces raw water at an estimated cost of $527 per ac-ft. Assuming treatment costs of $326 per ac-ft, the treated water cost is $853 per ac-ft as shown in Table 11.6.

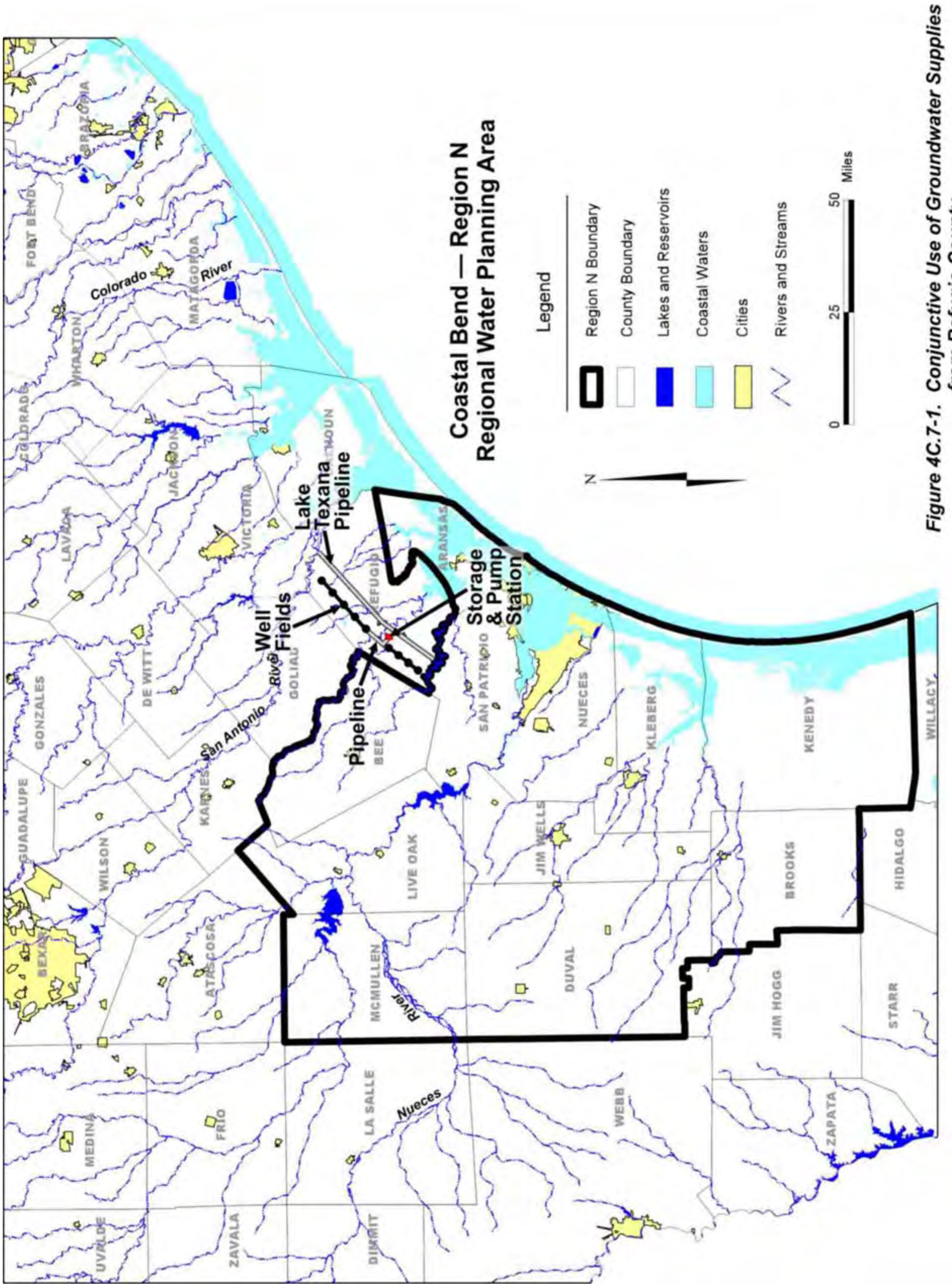

Figure 11.2.
Conjunctive Use of Groundwater Supplies from Refugio County

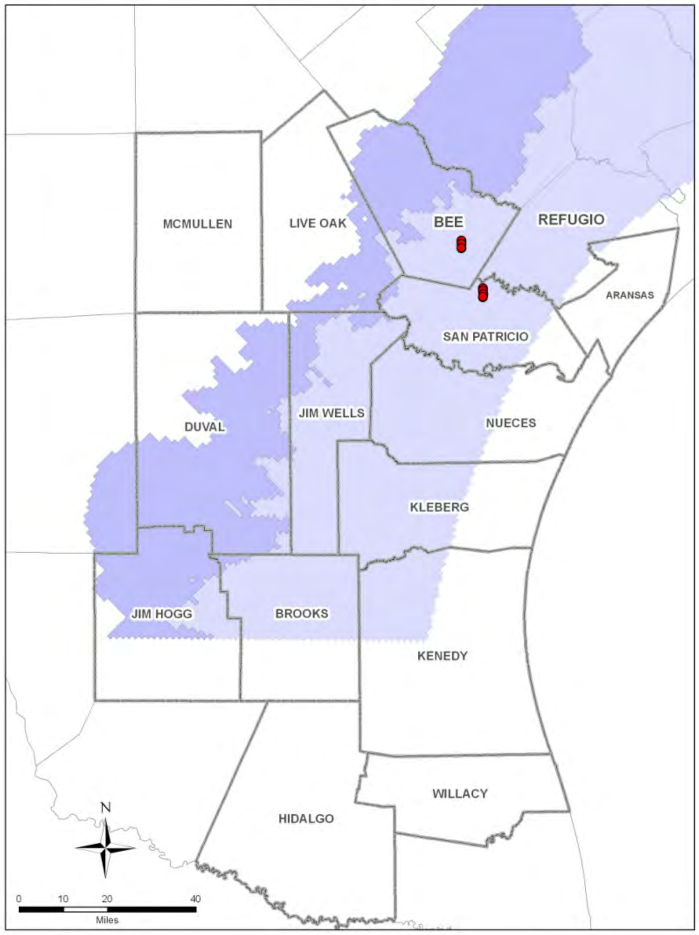

Figure 11.3.
Project Locations in the Evangeline Aquifer

Table 11.5.
Evaluation Summary of the Refugio County Groundwater

Impact Category	***Comment(s)***
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	 1. Firm Yield: 28,000 ac-ft/yr. 2. Water Quality: Fair. 3. Low Cost: $463 per ac-ft (raw), or $789 per ac-ft (if treated).
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. May slightly decrease instream flow and discharge of freshwater into coastal estuaries due to local groundwater-surface water interaction. 2. May slightly decrease instream flow and discharge of freshwater into coastal estuaries due to local groundwater-surface water interaction. 3. Negligible impacts. 4. Negligible impacts. 5. Negligible impacts. 6. Cultural resources will have to be surveyed and avoided. 7. Low impacts. a. Total dissolved solids are generally high and may require blending with higher quality water. b. High salinity is a potential concern to address during the early phases of project development. c. Negligible impacts. d-e. Groundwater may contain high chloride and bromide levels and may require blending with higher quality water. f-i. Negligible impacts.
c. Impacts to State water resources	• No negative impacts on water resources other than the Gulf Coast Aquifer • Potential benefit to Nueces Estuary from increased freshwater return flows
d. Threats to agriculture and natural resources in region	• May slightly increase pumping costs for agricultural users in the area due to localized drawdowns
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Standard analyses and methods used
g. Interbasin transfers	• Not applicable to groundwater sources
h. Third party social and economic impacts from voluntary redistribution of water	• May require the purchase of groundwater rights
i. Efficient use of existing water supplies and regional opportunities	• Provides regional opportunities
j. Effect on navigation	• None

Table 11.6.
Evaluation Summary of the Alternative for Groundwater Export Projects for the Gulf Coast Aquifer

Impact Category	*Comment(s)*
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	 1. Firm Yield: 18,000 ac-ft/yr. 2. Water Quality: Fair. 3. Cost: $527 per ac-ft (raw), or $853 per ac-ft (treated).
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. May slightly decrease instream flow and discharge of freshwater into coastal estuaries due to local groundwater-surface water interaction. 2. May slightly decrease instream flow and discharge of freshwater into coastal estuaries due to local groundwater-surface water interaction. 3. Negligible impacts. 4. Negligible impacts. 5. Negligible impacts. 6. Cultural resources will have to be surveyed and avoided. 7. Negligible impacts. a. Low to moderate impact. b. Low to moderate impact. c. No impact. d. Low to moderate impact. e. Low to moderate impact. f. Low to moderate impact. g-h. Low to moderate impact associated with mining. i. Boron may be a potential water quality concern.
c. Impacts to State water resources	• No negative impacts on water resources other than the Gulf Coast Aquifer • Potential benefit to Nueces Estuary from increased freshwater return flows
d. Threats to agriculture and natural resources in region	• May slightly increase pumping costs for agricultural users in the area due to localized drawdowns
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Standard analyses and methods used
g. Interbasin transfers	• Not applicable to groundwater sources
h. Third party social and economic impacts from voluntary redistribution of water	• May require the purchase of groundwater rights
i. Efficient use of existing water supplies and regional opportunities	• Provides regional opportunities with local resources
j. Effect on navigation	• None

11.3.3 Potential Aquifer Storage and Recovery (from the Gulf Coast Aquifer) (previous N-8)

A previous Region N evaluation considered ASR operated on a multi-year basis and uses a dual-purpose well, or well field, to inject treated water into the Gulf Coast aquifer for storage. The water would be recovered at a later date and evaluated for increased yield to the CCR/ LCC/Lake Texana System on a long-term basis. The option evaluated would function as a regional facility in the Robstown-Driscoll area on a long-term cycle, at the proposed location shown in Figure 11.4. The system would serve customers in the City of Corpus Christi area with a reserve of water for drought or emergencies.

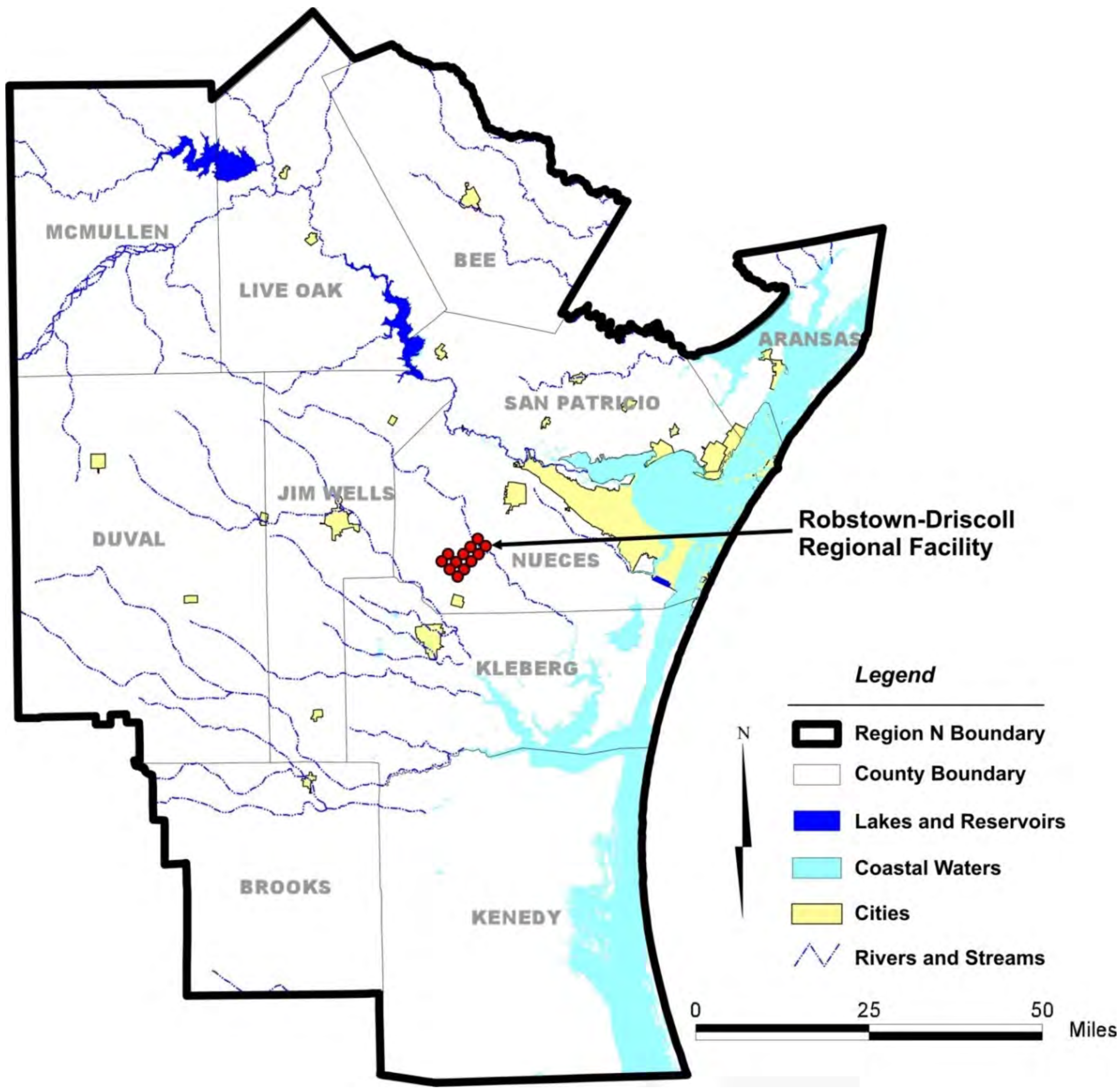

Figure 11.4.
Location of ASR Facility

It was initially believed that water savings would be achieved by reduced evaporation from the CCR/LCC Reservoirs and by recovery of water when the CCR/LCC System is spilling. However, after numerous model simulations, it was determined that the best ASR can provide is a yield equal to the yield of the system without ASR. The multi-year ASR operation was not recommended as a viable management strategy to provide additional supply to the CCR/LCC/ Texana water supply system so costs are not included. A summary of the Robstown-Driscoll regional ASR option that was studied is provided in Table 11.7.

Table 11.7. Evaluation Summary of the Robstown-Driscoll Regional ASR Facility

Impact Category	*Comment(s)*
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	 1. Very limited firm yield. 2. Not applicable. 3. Unit cost would be high.
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. Minor impacts during construction of wells and pipelines. 2. None or low impact. 3. None or low impact. 4. None or low impact. 5. None or low impact. 6. Cultural resources survey will be needed to avoid impacts to any site. 7. None or low impact. b. The proposed Robstown-Driscoll Regional Facility has slightly saline water. This is not expected to significantly affect recovery of water.
c. Impacts to State water resources	• No negative impacts
d. Threats to agriculture and natural resources in region	• Negligible
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Not applicable
g. Interbasin transfers	• None
h. Third party social and economic impacts from voluntary redistribution of water	• None
i. Efficient use of existing water supplies and regional opportunities	• Increases utilization of water treatment and transmission facilities
j. Effect on navigation	• None

11.3.4 CCR/LCC System Yield Recovery (portion of Modify Existing Reservoir Operating Policy and Safe Yield Analyses previous N-9)

In this water management strategy evaluated during previous planning efforts, the Corpus Christi Water Supply Model (previously identified as the NUBAY model) was used to evaluate the increase in CCR/LCC System firm yield due to alternative reservoir operating policies regarding freshwater inflows to upper Nueces Bay and Estuary. In the analysis, it was assumed that effluent from the City of Corpus Christi's wastewater treatment plants (WWTP) would be diverted to the Rincon Delta in exchange for freshwater pass-throughs from the CCR/LCC System. Three scenarios for the additional effluent diversions were analyzed: 4 mgd from Allison WWTP (no additional infrastructure needed), 9 mgd from Allison and Broadway WWTPs (shown in Figure 11.5), and 20 mgd from Allison, Broadway and Greenwood WWTPs (shown in Figure 11.6).

The three scenarios were costed for delivery of additional wastewater effluent from the City's WWTPs to the Rincon Delta. Scenario 1 (4 mgd) requires no construction of new facilities, only increased pumping and O&M costs ($5.57/ac-ft) for the increased diversion. The total project cost for building the transmission facilities for Scenario 2 (9 mgd) comes to $35,287,000 with an annual cost of $3,547,000. The estimated project cost associated with Scenario 3 (20 mgd) is $47,107,000 resulting in an annual cost of $5,120,000. A summary of these three CCR/LCC system recovery options is provided in Table 11.8.

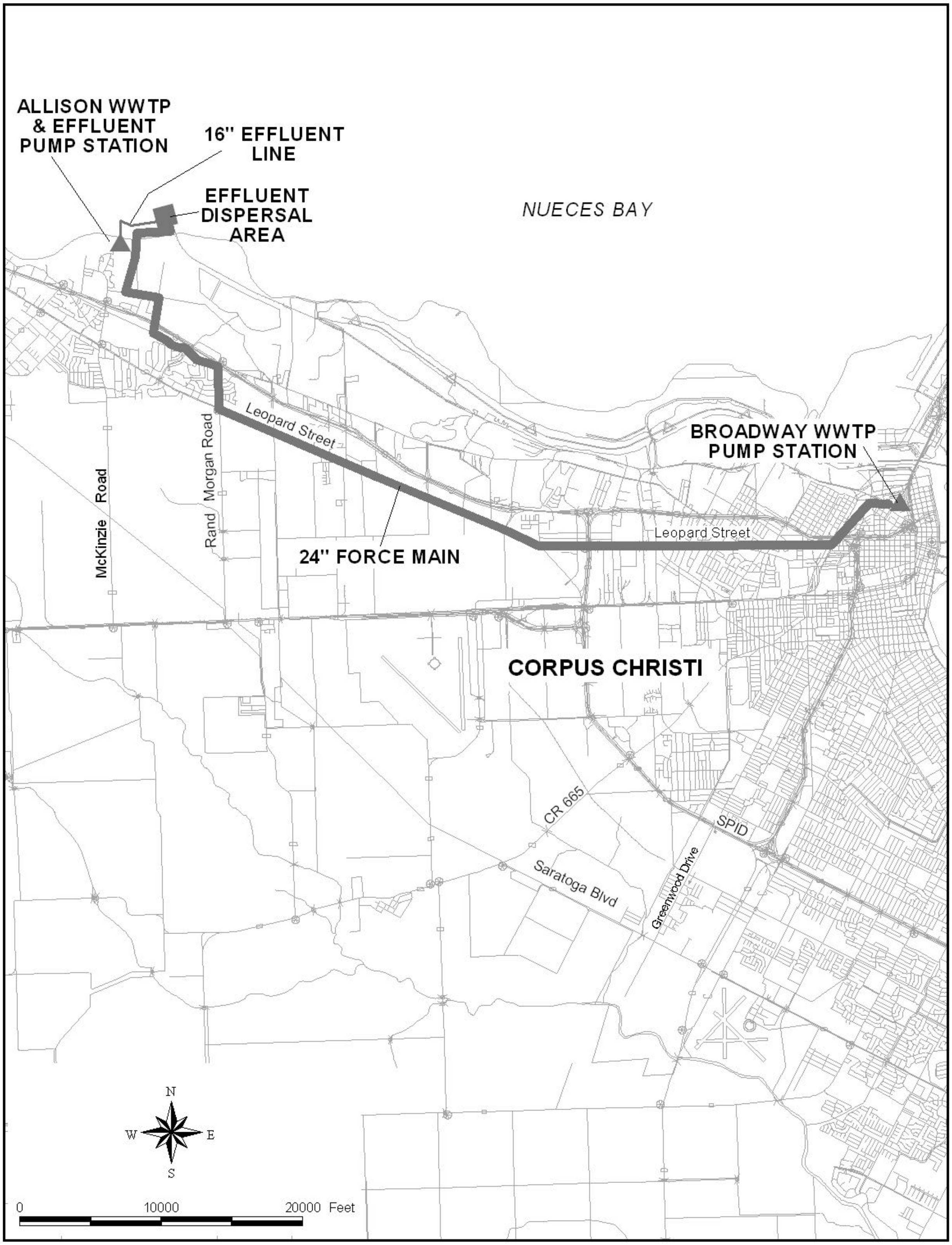

Figure 11.5.
Effluent Diversion Scenario 2

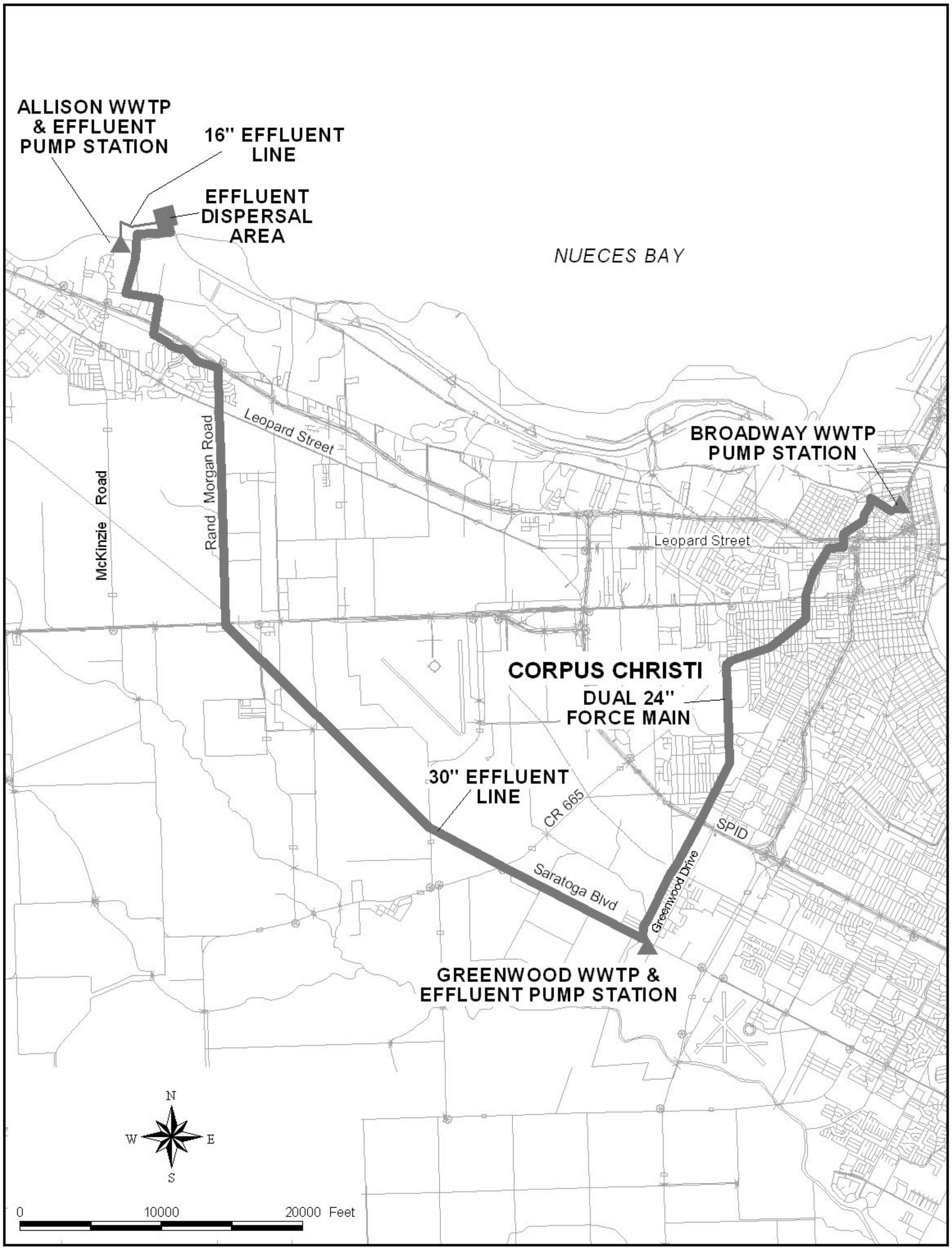

Figure 11.6.
Effluent Diversion Scenario 3

Table 11.8.
Evaluation Summary of Modifications to CCR/LCC System Recovery

Impact Category	*Comment(s)*
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	 1. Firm Yield: 7,100 to 13,100 ac-ft/yr (in 2010). 2. Good reliability. 3. Generally low cost; between $4 and $563 per ac-ft.
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. Increases in freshwater inflow to Upper Nueces Bay. Potential environmental impact due to reduced freshwater inflow to Estuary. 2. Positive impacts to biological activity in the Nueces Estuary & Upper Nueces Delta by increasing returned flows. Potential environmental impact due to reduced freshwater inflow to Estuary. 3. None or low impact. 4. None or low impact. 5. Positive impacts to biological activity in the Nueces Estuary & Upper Nueces Delta by increasing returned flows. Potential environmental impact due to reduced freshwater inflow to Estuary. 6. Cultural resources survey will be needed to avoid any significant sites. 7. The City's Integrated Plan provides ongoing studies of water quality issues of the Nueces Delta. a. Dissolved solids are a concern to be addressed with further studies. b. Salinity is a concern to be addressed with further studies. c. Bacteria is a concern to be addressed with further studies. d. Chlorides are a concern to be addressed. e-h. None or low impact. i. Alkalinity a concern and will need to be addressed.
c. Impacts to State water resources	• No negative impacts on other water resources • Potential benefit to Nueces Estuary from increase in freshwater return flows
d. Threats to agriculture and natural resources in region	• None
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Standard analyses and methods used
g. Interbasin transfers	• Potentially could require the transfer of water from the Nueces River Basin to the San Antonio-Nueces Coastal Basin
h. Third party social and economic impacts from voluntary redistribution of water	• Not applicable
i. Efficient use of existing water supplies and regional opportunities	• Provides enhanced recreational opportunities (birding in Upper Nueces Delta)
j. Effect on navigation	• None

11.3.5 Pipeline between Choke Canyon Reservoir and Lake Corpus Christi (previous N-10)

A March 2008 channel loss study showed that losses in the natural streams between CCR and LCC could possibly be prevented by use of a transmission pipeline. A previously presented pipeline went southeasterly from CCR crossed the Nueces River, and terminated on the upper west side of LCC, as shown in Figure 11.7. The pipeline operation would require an intake at CCR and an outlet structure at LCC. CCR is required to continue its release of 33 cfs for senior water rights and environmental considerations even with the pipeline in operation to deliver water supply releases.

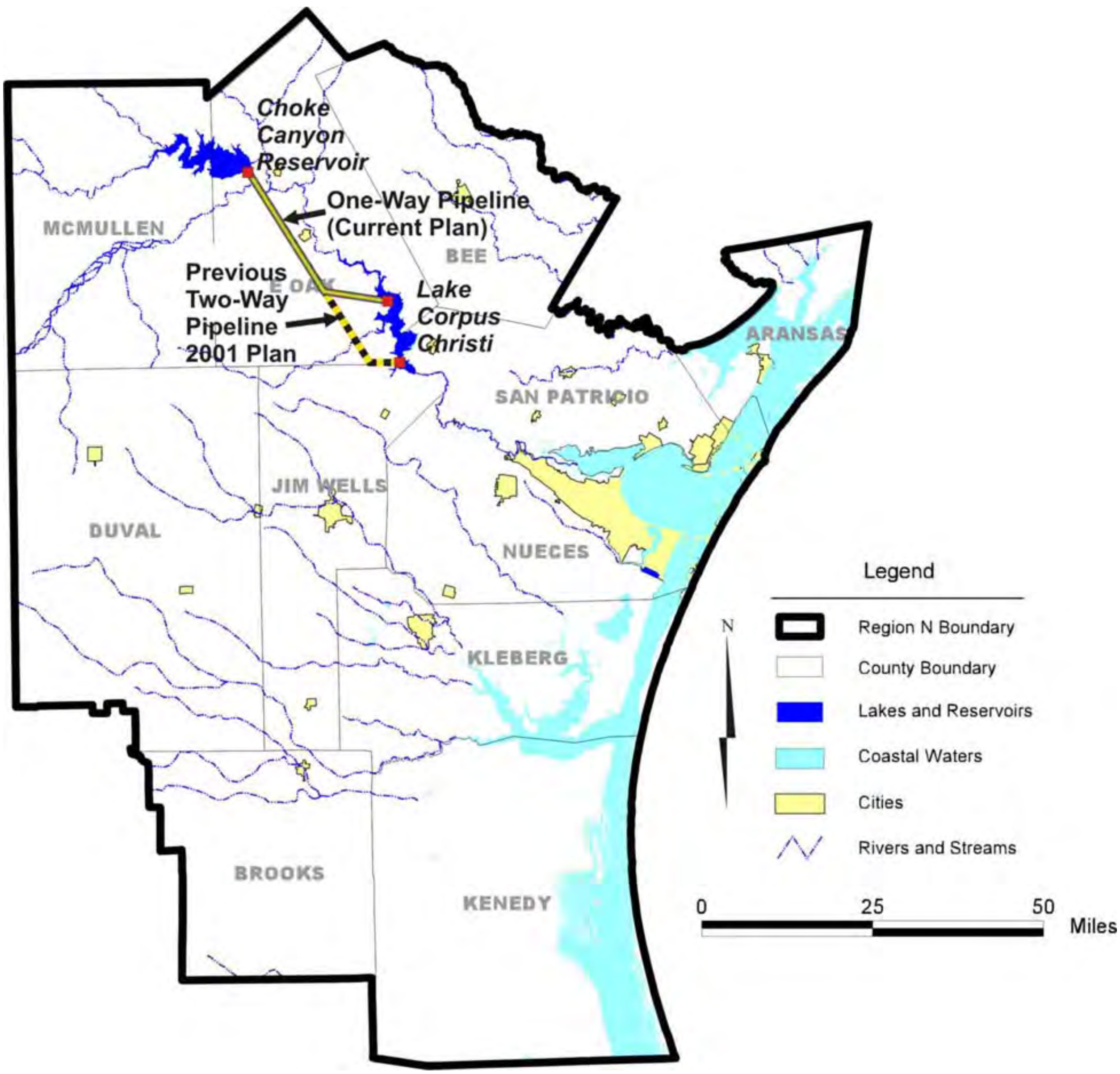

Figure 11.7.
Pipeline between Choke Canyon Reservoir and Lake Corpus Christi

Simulations were made for the historical period from 1934 to 2003 using the City of Corpus Christi's Phase IV Operations Plan, the 2001 TCEQ Agreed Order, and 2010 reservoir sedimentation conditions. Although a 300 cfs CCR/LCC pipeline is capable of delivering 39,500 ac-ft/yr as a stand-alone project, when operated conjunctively with the Nueces OCR it would be expected to provide a firm yield of 33,700 ac-ft/yr (or a reduction of 5,800 ac-ft/yr). A pipeline linking CCR to LCC with a delivery rate of 300 cfs is estimated to provide a firm yield of 33,700 ac-ft at unit raw water cost of $402 per ac-ft ($1.23 per 1,000 gallons). With treatment costs assumed at $326 per ac-ft, treated water supplies from this project would be $728 per ac-ft ($2.23 per 1,000 gallons). With federal or state participation in the project, the firm yield is reduced to 21,905 ac-ft/yr at an overall treated water cost of $588 per ac-ft. A summary of the CCR/LCC pipeline, with federal participation, is provided in Table 11.9.

Table 11.9. Evaluation Summary for Pipeline between Choke Canyon Reservoir and Lake Corpus Christi

Impact Category	*Comment(s)*
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	 1. Reduced Firm Yield (with Federal or State participation): 21,905. 2. Good reliability. 3. Generally low raw water cost of $262 per ac-ft with Federal or State participation. With $326 added for treatment, cost of treated water is $588 per ac-ft.
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. Reduction in streamflows between Choke Canyon Reservoir and Lake Corpus Christi. 2. Increase in streamflows below Lake Corpus Christi and freshwater inflows to Nueces Estuary. 3. Low impact to wildlife habitat. 4. Low impact to wetlands. 5. Low impact to threatened and endangered species. 6. Cultural resources survey needed to avoid impacts. 7. Low impact to water quality. a-b. Will improve dissolved solids and salinity levels at CCR by reducing evaporation from reservoir.
c. Impacts to State water resources	• No negative impacts on other water resources
d. Threats to agriculture and natural resources in region	• None
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Standard analyses and methods used
g. Interbasin transfers	• Not applicable
h. Third party social and economic impacts from voluntary redistribution of water	• Not applicable
i. Efficient use of existing water supplies and regional opportunities	• Reduces losses in the CCR/LCC System
j. Effect on navigation	• None

11.3.6 Nueces Off-Channel Reservoir near Lake Corpus Christi (previous N-11)

The Coastal Bend Region relies predominantly upon surface water supplies from two reservoirs located in the Nueces River Basin: Choke Canyon Reservoir (CCR) and Lake Corpus Christi (LCC). The yield of the system is affected by the storage capacity of LCC and its limited ability to capture a significant portion of large storm events that travel down the Nueces River. The Nueces OCR, at the proposed location shown in Figure 11.8, could be operated to capture water that would otherwise spill from LCC while still maintaining desired freshwater inflows to the Nueces Bay and Estuary (B&E) and could potentially be operated to reduce flood events downstream of LCC.

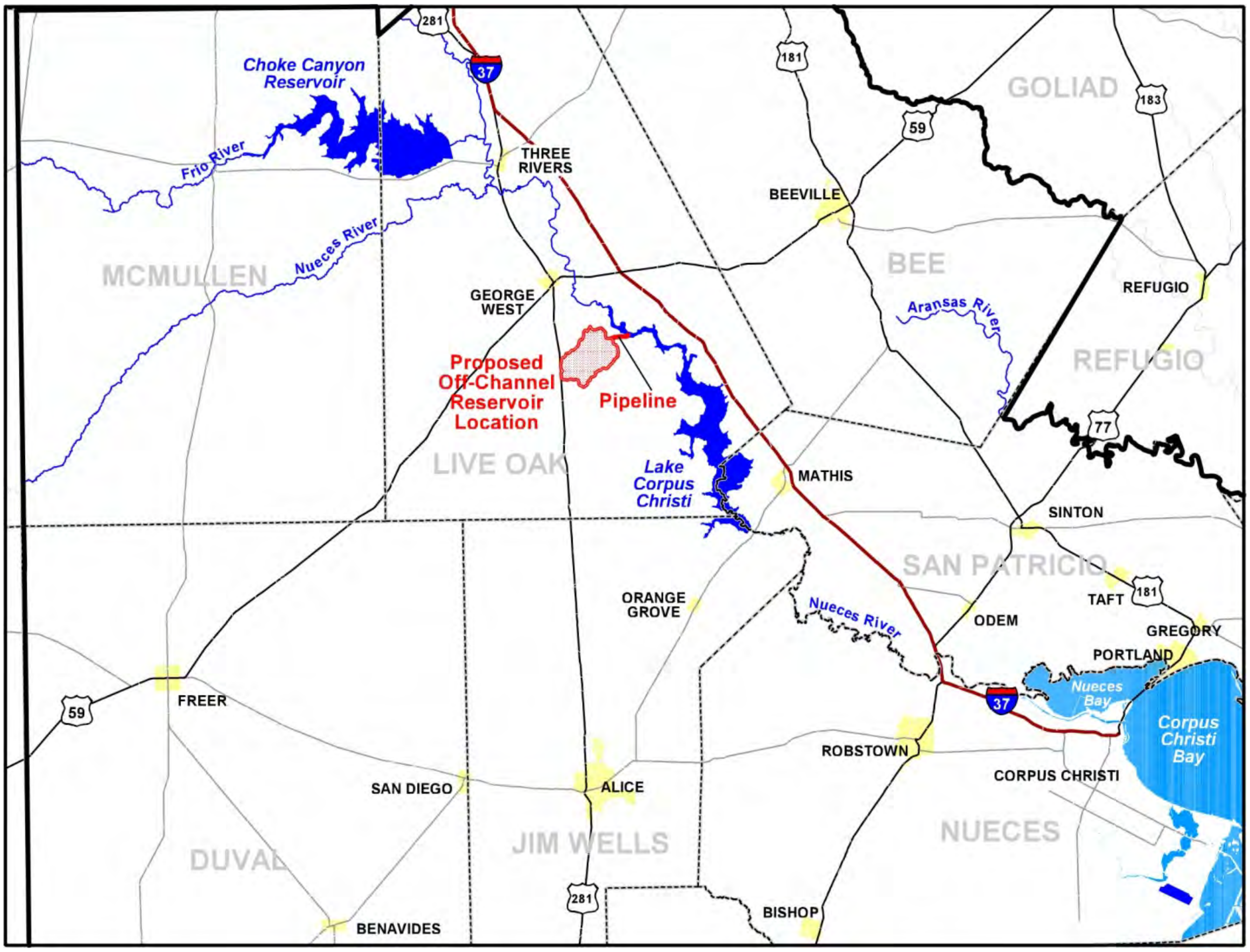

Figure 11.8.
Nueces Off-Channel Reservoir and Pipeline to Lake Corpus Christi

Operational parameters for the reservoir and pipeline operations at the Nueces OCR were developed to identify the optimum set of LCC elevation triggers, pipeline capacity and Nueces OCR storage capacity. Of the 24 combinations of reservoir size and pipeline delivery rate, the preferred size for a Nueces OCR is 280,000 ac-ft with a pipeline delivery rate between 1,250 cfs and 1,500 cfs. A 280,000 ac-ft Nueces OCR at pipeline delivery rate of 1,250 cfs is estimated to provide a firm yield of 46,677 ac-ft at unit raw water cost of $570 per ac-ft ($1.75 per 1,000 gallons). A 280,000 ac-ft Nueces OCR at a pipeline delivery rate of 1,500 cfs is estimated to provide a firm yield of 48,296 ac-ft at unit raw water cost of $598 per ac-ft ($1.48 per 1,000 gallons). With federal or state participation in the project, the firm yield is reduced to 30,340 or 31,392 ac-ft/yr depending on diversion rate at an overall treated water cost between $389 and $409 per ac-ft. A summary of the Nueces off-channel reservoir, with federal participation, is provided in Table 11.10.

11.3.7 Federal or State Opportunities to Participate in Regional Projects (part of previous N-12)

Four projects considered as separate water management strategies for the 2011 plan (Nueces off-channel reservoir, CCR/LCC pipeline, seawater desalination, and brackish groundwater desalination) include discussion of opportunities for federal or state participation. Some of these projects could potentially serve to mitigate the effects of the recharge enhancement projects. Costs to implement these projects could potentially be reduced through federal or state participation. For example, the total project cost of the Nueces off-channel reservoir was estimated at $300,577,000 for a yield of 46,677 ac-ft/yr. When considering annual program costs, the unit cost would be approximately $896 per ac-ft for treated water supplies. Assuming federal funding participation of 65%, the total project cost would be reduced to $105,201,950. For the purposes of the plan, it was assumed that with federal or state participation, 35% of the total project water supply is dedicated for ecosystem restoration or other federal or state designnated purpose. The annual cost (including operations and maintenance costs and reduced debt service) would be $11,805,950, which results in a unit cost of $389 per ac-ft for raw water supplies ($715 per ac-ft for treated water supplies), or about 80% of the unit cost without federal participation.

For brackish groundwater and seawater desalination options, based on assumptions of 65% of federal or state funding participation for debt service costs and water supplies of 65% of project potential (with 35% dedicated for ecosystem restoration or other purposes), federal or state participation would not be anticipated to reduce annual unit costs of water and therefore was not recommended for these water management strategies in the 2011 Plan.

Table 11.10.
Evaluation Summary for Nueces Off-Channel Reservoir 280,000 ac-ft With Pipeline Delivery of 1,250 or 1,500 cfs

Impact Category	Comment(s)
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	 1. Reduced Firm Yield (with Federal or State participation): 30,340 to 31,392 ac-ft/yr. 2. Firm Supply. 3. Generally low raw water cost between $389 to $409 per ac-ft. With $326 added for treatment, cost of treated water is $715 to $734 per ac-ft.
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. Generally decreases streamflows below LCC. 2. Slight decrease in freshwater inflows to Nueces Bay. Increase freshwater inflows to Nueces Estuary, primarily attributable to increased return flows with increased water demands. 3. Some impact to wildlife habitat. Inundated land area for off-channel reservoir. 4. Low impact to wetlands. 5. Low impact to threatened and endangered species. 6. No cultural resources identified in project area based on Texas Historical Commission data. 7. Minimal impact to water quality.
c. Impacts to State water resources	• No negative impacts on other water resources
d. Threats to agriculture and natural resources in region	• None
e. Recreational impacts	• Benefits with higher LCC water level with 83 ft-msl trigger
f. Equitable comparison of strategies	• Standard analyses and methods used
g. Interbasin transfers	• Not applicable
h. Third party social and economic impacts from voluntary redistribution of water	• Not applicable
i. Efficient use of existing water supplies and regional opportunities	• Maximizes opportunities to capture water from a large drainage area
j. Effect on navigation	• None

11.3.8 Palmetto Bend Stage II (Lavaca-Navidad River Basin) (part of N-13)

This strategy addressed an on-channel option for stage II of Lake Texana. Palmetto Bend Stage II was assumed to be constructed at the alternative site located approximately 1.4 miles upstream of the original site, as shown in Figure 11.9. Target inflow was defined based on criteria established for salinity and nutrient inflow, in addition to necessary long-term inflow to produce 98% of maximum population for nine key estuarine species.

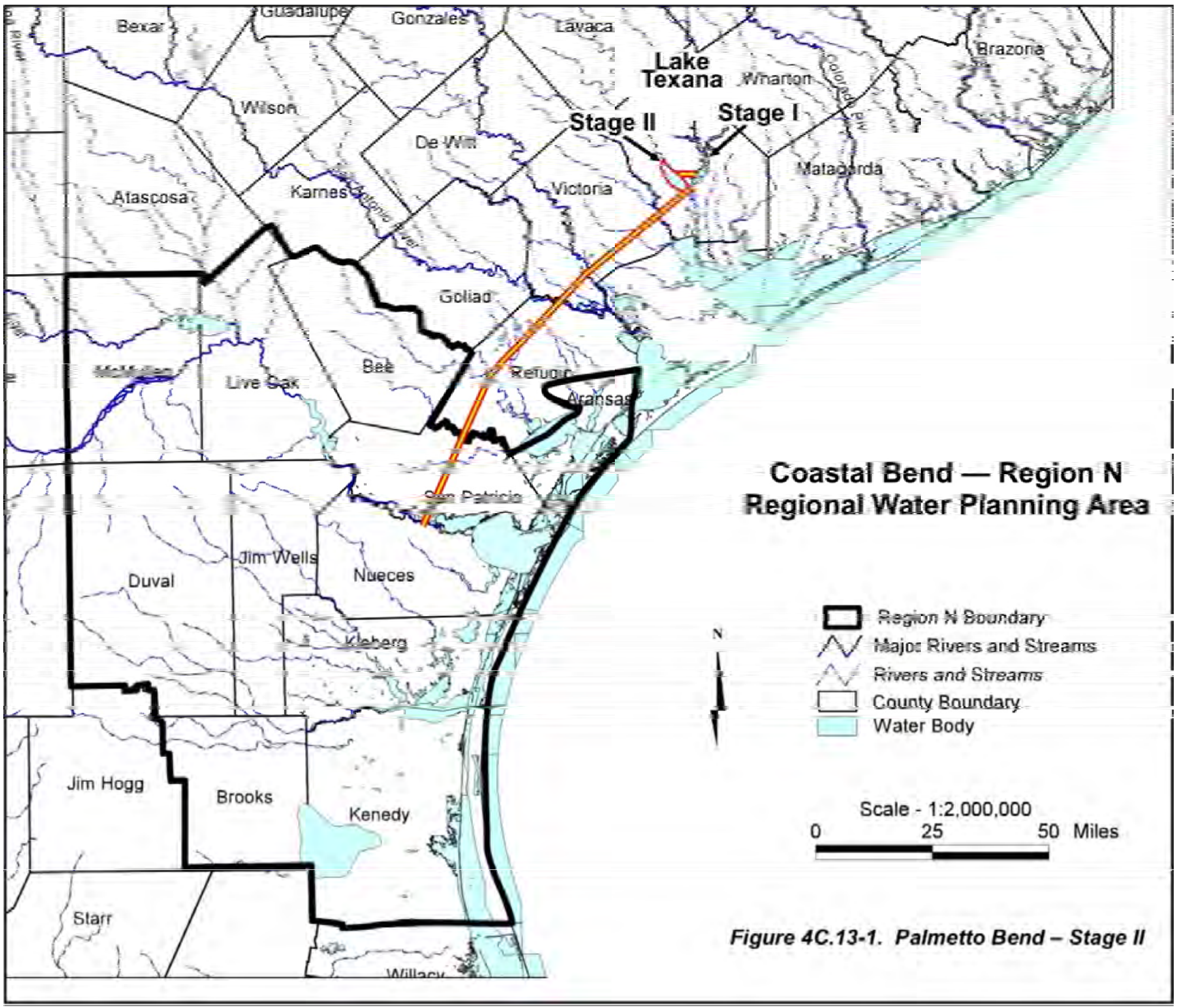

Figure 11.9. Palmetto Bend – Stage II

The firm yield of Palmetto Bend Stage II was estimated by using the TCEQ Lavaca River Basin water availability model (BOR, 2001; February 24, 2003 version) data sets and the Water Rights Analysis Package. The development of Palmetto Bend Stage II would result in approximately 22,964 ac-ft of water. The total project cost with the reservoir is $232,828,000. The total annual cost of constructing Palmetto Bend Stage II and delivering the firm yield to Corpus Christi is $20,377,000. Dividing annual cost by the Year 2060 firm yield of 22,964 equated to an annual cost of $887 per ac-ft or $2.72 per 1,000 gallons as shown in Table 11.11.

11.3.9 Brush Management (previous N-15)

The interest in brush management as a means to increase water supply has its roots in: 1) the belief that Texas rangelands changed after settlement and use by Europeans from predominantly open grasslands to increasing domination of brush; and 2) the significantly greater interception of water by brush than grasses. Interception losses in Texas range from 14 percent for grass to 46 percent for live oak and 73 percent for juniper.[1] Thus, a strategy of limiting brush cover and increasing grass cover would presumably increase runoff and/or deep percolation. In terms of water supply, yield is the quantity of water available in a year for municipal, industrial, agricultural, and other uses. However, increasing the quantity of water that is not intercepted by brush on rangelands does not necessarily increase yield as defined by water supply. This is because there are other factors that could prevent this water from being available.

The cost of enhanced water yield from brush management cannot be estimated for the Coastal Bend Region because associated hydrologic data are not adequate to determine any increases in water supply yield for Choke Canyon Reservoir/Lake Corpus Christi system. However, the costs of brush management can be reasonably estimated because of the studies of brush management practices in Texas. The average annual cost per acre for each county was determined by dividing estimated annual costs by the estimated acreages which are the estimated areas that might increase runoff and/or deep percolation as a result of brush management. Estimated annual costs of brush management in counties in the Coastal Bend Region range from $881,269 in Aransas County to $15.9 million in Kenedy County. A summary of the brush management option previously studied is provided in Table 11.12.

[1] Thurow, T. L. and Hester, J. W., "How an Increase in Juniper Cover Alters Rangeland Hydrology," Proceedings Juniper Symposium, Texas A&M Agricultural Experiment Station Technical Report 97-1, 1997.

Table 11.11.
Evaluation Summary of Palmetto Bend Stage II

Impact Category	***Comment(s)***
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	 1. Firm Yield: 22,964 ac-ft/yr. 2. Good reliability. 3. Raw water cost is $887 per ac-ft. Assuming $326 per ac-ft for treatment, treated water cost is $1,213 per ac-ft.
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. Reduces instream flows. Stage II releases in accordance with the Consensus Criteria were considered prior to determining yield. 2. Negligible impact to Lavaca Bay. 3. Construction of reservoir may have negative impact on wildlife habitat. 4. None or low impact. 5. No federal or state protected species are known to be present within the reservoir area. 6. Cultural resources will need to be surveyed and mitigation for significant sites before this project is implemented. 7. Impacts to water quality will need to be evaluated prior to implementing project.
c. Impacts to State water resources	• No apparent negative impacts on other water resources • Potential benefit to river segment before dam due to increased low flows
d. Threats to agriculture and natural resources in region	• Purchase of reservoir land will result in reduced agricultural uses
e. Recreational impacts	• Increase in recreational use opportunities
f. Equitable comparison of strategies	• Standard analyses and methods used
g. Interbasin transfers	• Requires transfer of water from Lavaca-Navidad River Basin to Nueces River Basin
h. Third party social and economic impacts from voluntary redistribution of water	• Not applicable
i. Efficient use of existing water supplies and regional opportunities	• Provides regional opportunities
j. Effect on navigation	• None
k. Consideration of water pipelines and other facilities used for water conveyance	• Pipeline from Stage II to Lake Texana may impact wildlife habitat. Field surveys should be conducted to minimize impacts to protected species and vegetation.

Table 11.12.
Evaluation Summary of Brush Management to Enhance Water Supply Yield

Impact Category	***Comment(s)***
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	 1. Indeterminate reliable quantity. 2. Unknown. 3. Unknown.
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. May increase water runoff and instream flows. 2. May increase bay and estuary inflows. 3. Brush control techniques may adversely affect existing wildlife populations. 4. None or low impact. 5. May have negative affect on habitats for endangered species. 6. Chemical brush management methods may result in residual chemicals in aquifers and streams. 7. None or low impact.
c. Impacts to State water resources	• No apparent negative impacts on other water resources • Potential benefit to Gulf Coast and Carrizo-Wilcox water resources due to increased water for recharge • Potential benefit to surface reservoirs from increased runoff
d. Threats to agriculture and natural resources in region	• Potential threats to habitat due to removal of brush
e. Recreational impacts	• Could impact hunting
f. Equitable comparison of strategies	• Cost model for brush management is based on literature values • No estimate made for cost of water supply yield because yield not determined
g. Interbasin transfers	• Not applicable
h. Third party social and economic impacts from voluntary redistribution of water	• Not applicable
i. Efficient use of existing water supplies and regional opportunities	• Improvement over current conditions
j. Effect on navigation	• None

11.3.10 Weather Modification (previous N-16)

Cloud seeding with silver iodide increases rain generated by these clouds by extending the life of the clouds, by allowing the clouds to enlarge laterally so that they cover more area, and by slightly increasing the height of the clouds. The current weather modification programs in South Central Texas and counties where they operate are presented in Figure 11.10. Although these weather modification projects could potentially provide additional water opportunities for Region N, to determine these benefits would require additional studies to translate increased annual flow to Choke Canyon Reservoir and Lake Corpus Christi to firm yield.

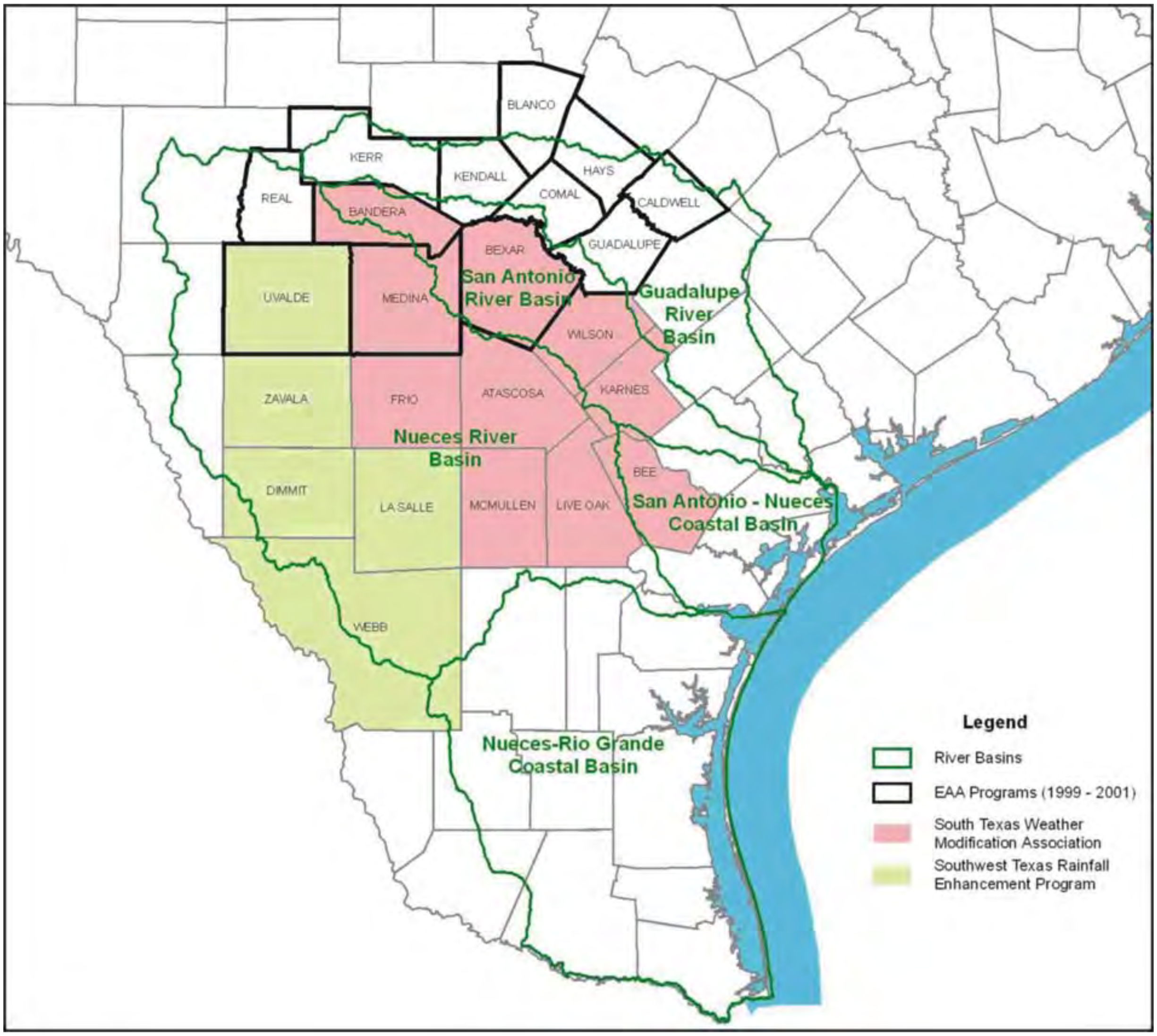

Figure 11.10.
South Central Texas Weather Modification Programs

The 2006 South Central Texas Regional Water Plan estimated unit water costs for weather modification which ranged from $74-$77 per ac-ft.[2] These costs are based on increases in sustained yield from the Edwards Aquifer (1,916 ac-ft/yr and 488 ac-ft/yr attributed to weather modification in the Nueces Basin and Blanco Basin, respectively). For the Nueces Recharge Basin, the total annual cost for a weather modification program for Edwards, Real, Kinney, and Uvalde Counties (3,693,440 acres) is estimated at $147,740, assuming an annual cost of $0.04 per acre. For the Blanco Recharge Basin, the total annual cost for a weather modification program for Blanco and Hays Counties (901,120 acres) is estimated at $36,050, assuming an annual cost of $0.04 per acre. A summary of the weather modification option previously studied is provided in Table 11.13.

[2] These unit costs were not updated by the South Central Texas Regional Water Planning Group as part of the 2011 planning cycle. However, using the updated Construction Cost Index (CCI) value, these costs would likely be 31 to 32% higher if updated to September 2008 dollars.

Table 11.13.
Evaluation Summary of Weather Modification to Enhance Water Supplies

Impact Category	***Comment(s)***
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	 1. Variable, indeterminate quantity. 2. Low, uncertain timing. 3. Low cost.
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. May slightly increase instream flows. 2. May slightly increase bay and estuary flows. 3. None or low impact. 4. None or low impact. 5. None or low impact. 6. None or low impact. 7. Low impact with potential for limited benefits.
c. Impacts to State water resources	• No apparent negative impacts on other water resources • Potential benefit to Gulf Coast and Carrizo Aquifers water resources due to increased water for recharge • Potential benefit to farmers and ranchers through increased rainfall
d. Threats to agriculture and natural resources in region	• Potential threats due to limited potential for increased flooding
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Cost reported in annual unit area cost only
g. Interbasin transfers	• Not applicable
h. Third party social and economic impacts from voluntary redistribution of water	• Not applicable
i. Efficient use of existing water supplies and regional opportunities	• Improvement over existing conditions
j. Effect on navigation	• None
k. Consideration of water pipelines and other facilities used for water conveyance	• None

11.3.11 Desalination (N-17)

Both the 2006 and 2011 plans considered desalting seawater from the Gulf of Mexico as a potential source of freshwater supplies for municipal and industrial uses at the location of Barney M. Davis Power Station in Corpus Christi. Strategies were evaluated for a base option and an alternative option each at 4 different yields (25 mgd, 50 mgd, 75 mgd, and 100 mgd). The base option includes a 29-mile pipeline from the desalination plant to the Stevens WTP or 5-mile pipeline to a delivery location towards the south of the City's service area. Once the desalted water is pumped to the Stevens WTP, it can be mixed with treated surface water and put into the City's distribution system. The alternative option takes advantage of the City's plans to develop a new water distribution center on the south side of town. If developed, the desalination plant could pump water 5 miles to the proposed distribution center, saving capital and operating costs in transmission of the potable desalt water into the City's system.

For the base option, project costs would range from $324,634,000 to $940,565,000, increasing from the 25 mgd to the 100 mgd option. Annual costs follow a similar pattern and range from $54,014,000 to $177,700,000. The unit costs per ac-ft of supply range from $1,587 to $1,929 per ac-ft. For the alternative option, project costs would range from $260,914,000 to $794,207,000, increasing from the 25 mgd to the 100 mgd option. Annual costs follow a similar pattern and range from $47,498,000 to $151,061,000. The unit costs per ac-ft of supply range from $1,349 to $1,696. A summary of the seawater desalination options previously studied is provided in Table 11.14.

A 2006 evaluation considered including brackish groundwater as a raw water source or as a supplement to seawater. Three options are included for utilizing the estimated 18 mgd brackish groundwater yield from the northwest and south central well fields, as shown in Figure 11.11. The first option is a combination of 18 mgd of brackish groundwater and 23 mgd of seawater to produce a finished water flow of 25 mgd. The second option is a combination of 18 mgd of brackish groundwater and 10 mgd of seawater to produce a finished water flow of 19 mgd. The third option is desalination of the 18 mgd of brackish groundwater without blending any seawater to produce a finished water flow of 14 mgd.

Two engineering options were considered, a base option with a 29-mile pipeline and an alternate option with a 5-mile pipeline. For the base option, project costs would range from $120,420,000 to $201,474,000, increasing from the 14 mgd to the 25 mgd option. Annual costs follow a similar pattern and range from $13,708,000 to $27,608,000. The unit costs per ac-ft of supply range from $874 to $986 in the same order. For the alternative option, project costs would range from $152,560,000 to $84,420,000, increasing from the 14 mgd to the 25 mgd option. Annual costs follow a similar pattern and range from $23,371,000 to $10,630,000. The unit costs per ac-ft of supply range from $835 to $678 in the same order. A summary of the combined brackish groundwater and seawater desalination option previously studied is provided in Table 11.15.

Table 11.14.
Evaluation Summary of the Seawater Desalination Option

Impact Category	***Comment(s)***
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	 1. Variable, ranges from 28,000 to 112,000 ac-ft/yr (for 2006 Plan); actual water supply virtually unlimited. 2. Highly reliable quantity. 3. Generally high cost; between $1,349 and $1,929 per ac-ft.
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. None or low impact. 2. Environmental impact to estuary. 3. Disposal of concentrated brine created from process may impact fish and wildlife habitats or wetlands. 4. Disposal of concentrated brine created from process may impact fish and wildlife habitats or wetlands. 5. None identified. Endangered species survey will be needed to identify impacts. 6. Cultural resources survey will be needed to identify any significant sites. 7. a-b. Total dissolved solids and salinity of water is removed with reverse osmosis treatment. Brine concentrate disposal issues will need to be evaluated.
c. Impacts to State water resources	• No negative impacts on other water resources
d. Threats to agriculture and natural resources in region	• Temporary damage due to construction of pipeline
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Standard analyses and methods used for portions • Seawater desalination cost modeled after bid and manufacturers' budgets, but not constructed, comparable project
g. Interbasin transfers	• Not applicable
h. Third party social and economic impacts from voluntary redistribution of water	• Not applicable
i. Efficient use of existing water supplies and regional opportunities	• Provides regional opportunities
j. Effect on navigation	• None
k. Consideration of water pipelines and other facilities used for water conveyance	• Construction and maintenance of transmission pipeline corridor. Possible impact to wildlife habitat along pipeline route and right-of-way

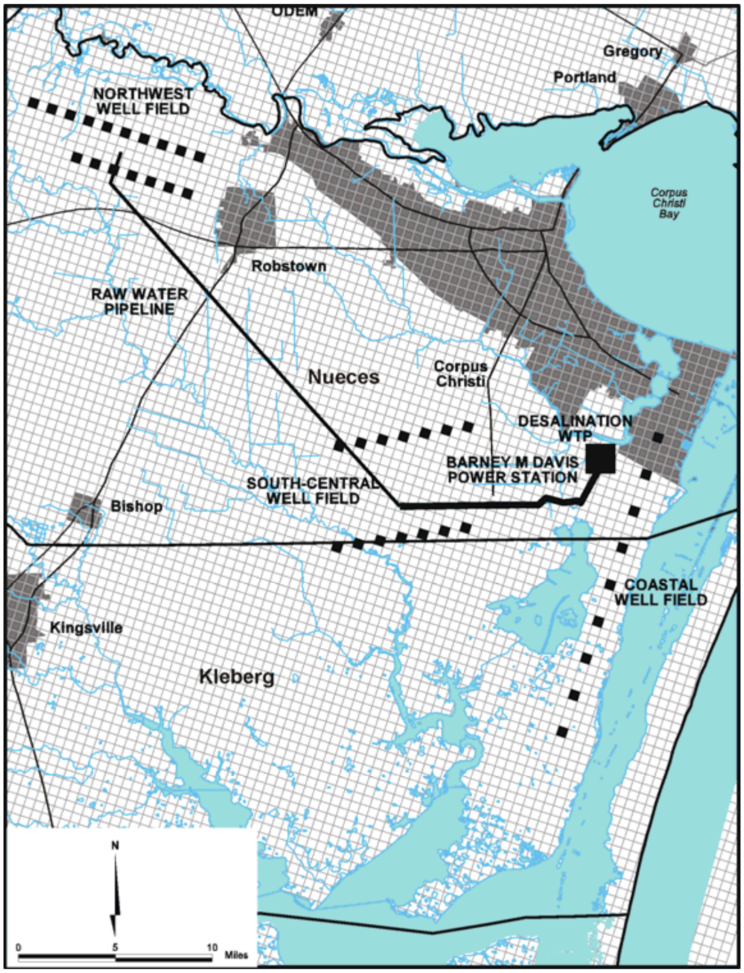

Figure 11.11.
Combined Seawater and Brackish Groundwater Desalination at Barney M. Davis Power Plant

Table 11.15.
Summary Evaluation of the Combined Seawater and Brackish Groundwater Desalination Option

Impact Category	*Comment(s)*
a. Water supply: 1. Quantity 2. Reliability 3. Cost of treated water	 1. Variable, ranges from 15,680 to 28,000 ac-ft/yr (for 2006 Plan); actual water supply limited by brackish groundwater yield with maximum product water yield of 25 mgd. 2. Highly reliable quantity. 3. Generally high cost; between $986 to $678 per ac-ft. Cost could potentially be reduced through Federal participation as may be available through the USACE Nueces River Basin Feasibility Study.
b. Environmental factors: 1. Instream flows 2. Bay and estuary inflows 3. Wildlife habitat 4. Wetlands 5. Threatened and endangered species 6. Cultural resources 7. Water quality a. dissolved solids b. salinity c. bacteria d. chlorides e. bromide f. sulfate g. uranium h. arsenic i. other water quality constituents	 1. None or low impact. 2. Environmental impact to estuary. 3. Disposal of concentrated brine created from process may impact fish and wildlife habitats or wetlands. 4. Disposal of concentrated brine created from process may impact fish and wildlife habitats or wetlands. 5. None identified. Endangered species survey will be needed to identify impacts. 6. Cultural resources survey will be needed to identify any significant sites. 7. a-b. Total dissolved solids and salinity of water is removed with reverse osmosis treatment. Brine concentrate disposal issues will need to be evaluated.
c. Impacts to State water resources	• No negative impacts on other water resources other than lowering Gulf Coast Aquifer levels
d. Threats to agriculture and natural resources in region	• Temporary damage due to construction of pipeline • Insignificant due to water use since very little of water is suitable for use by agriculture
e. Recreational impacts	• None
f. Equitable comparison of strategies	• Standard analyses and methods used for portions. Seawater desalination cost modeled after bid and manufacturers' budgets, but not constructed, comparable project.
g. Interbasin transfers	• Not applicable
h. Third party social and economic impacts from voluntary redistribution of water	• Not applicable
i. Efficient use of existing water supplies and regional opportunities	• Provides regional opportunities
j. Effect on navigation	• None

11.3.12 Sediment Removal in Lake Corpus Christi (from 2001 Plan)

The accumulation of sediment in Lake Corpus Christi is a long-term concern. The 2001 Costal Bend Regional Water Plan studied a water supply option that involved the dredging of Lake Corpus Christi. A maintenance dredging program to offset the annual sedimentation rate of 1,223 ac-ft will require that approximately 2 million cubic yards (CY) (in situ volume) of sediment be dredged each year. An accelerated dredging program to restore Lake Corpus Christi storage capacity to 1959 conditions (302,160 ac-ft) will require that approximately 163 million CY (in situ volume) of sediment be dredged by the year 2020. The accelerated program would require the removal of about 6 million CY (in situ volume) of sediment each year. A cutterhead Suction dredge was assumed for the analysis.

Costs were estimated using unit costs for each element of construction from the 1997 White Rock Restoration Project. The cost of mobilization and demobilization was calculated as $200,000. The dredging was expected to cost $6,505,640, booster stations and piping was projected at $3,500,000 and $4,399,00, respectively. Finally the disposal area costs were calculated to be 2,300,000 for a total project cost of $16,904,640 for 3,235,000 cubic yards of dredging. A summary of the sediment removal in LCC option previously studied is provided in Table 11.16. Note: An updated volumetric survey completed by the TWDB resulted in a lower sedimentation rate estimate in LCC, which may reduce the sediment removal quantity and increase unit costs.

Table 11.16.
Summary Evaluation of the Sediment Removal in Lakes in Corpus Christi

Impact Category	***Comment(s)***
a. Quantity, reliability, and cost of treated water	• Long-term yield (30 yr) = 9,000 ac-ft/yr • High cost: $3,404 to $3,737 per ac-ft
b. Environmental factors	• Disturbance of sediments in LCC • Disposal of removed sediments • Cultural resources will need to be surveyed and avoided, where possible
c. State water resources	• Potential negative impacts on water quality in LCC during dredging
d. Threats to agriculture and natural resources in region	• Potential threats to habitat due to disposal of dredge material
e. Recreational	• None
f. Comparison and consistency equities	• Standard analyses and methods used
g. Interbasin transfers	• Not applicable
h. Third-party social and economic impacts from voluntary redistribution of water	• Not applicable
i. Efficient use of existing water supplies and regional opportunities	• Provides for improved efficient use of LCC
j. Effect on navigation	• None

11.4 Summary of Phase I Studies - 2011 Coastal Bend Regional Water Plan

During the 3rd round of regional water planning, the Texas Water Development Board provided funding to regional water planning groups to analyze and further evaluate feasible water management strategies based on competitive funding proposals and selection. The Coastal Bend Regional Water Planning Group receiving funding for 5 studies:

- Study 1 – Evaluation of Additional Potential Regional Water Supplies for Delivery through the Mary Rhodes Pipeline, Including Gulf Coast Groundwater and Garwood Project
- Study 2 – Optimization and Implementation Studies for Off-Channel Reservoir
- Study 3 – Implementation Analysis for Pipeline from CCR to LCC, Including Channel Loss Study Downstream of Choke Canyon Reservoir
- Study 4 – Water Quality Modeling of Regional Water Supply System to Enhance Water Quality and Improve Industrial Water Conservation
- Study 5 – Region-Specific Water Conservation Best Management Practices (BMPs)

11.4.1 Evaluation of Additional Potential Regional Water Supplies for Delivery through the Mary Rhodes Pipeline, Including Gulf Coast Groundwater and Garwood Project (Study 1)

This study: 1) included an evaluation of water quality of potential new supplies; 2) identified potential blending and water chemistry issues; and 3) considered reservoir system operations with possible future supplies from the Gulf Coast Aquifer, Garwood project supplies for two delivery scenarios around and through Lake Texana, and additional Lake Texana water supplies as may be available through projects being considered by the Lavaca-Navidad River Authority.

A modified version of the Corpus Christi Water Quality and Treatment Model was utilized to analyze water quality and treatment requirements when blending different water sources. The model was developed to simulate treatment processes currently utilized at the O.N. Stevens WTP. Five blending scenarios were evaluated. The blending analysis did not indicate any large treatment issues at the O.N. Stevens WTP when blending groundwater supplies from the Gulf Coast Aquifer, surface water supplies from the Garwood Project, or additional supplies from Lake Texana with existing supplies from the Nueces River and Lake Texana.

The Corpus Christi Water Supply Model (CCWSM) was then used to evaluate various reservoir system operations and delivery scenarios with potential new supplies delivered through the MRP. System operations for five different combinations of existing and potential future water supplies through the MRP were simulated using the CCWSM at a fixed demand of 175,000 ac-ft/yr. The five operating scenario combinations considered current and potential future water supplies for delivery through the MRP and, on average, the amount of MRP capacity in use ranged from 47% to 100%. Essentially, as more water supplies are available for delivery through the MRP, the supplies needed from the Choke Canyon Reservoir and Lake

Corpus Christi (CCR/LCC) System decreases for a fixed demand. This results in more water stored in the CCR/LCC System, which increases reservoir pass-throughs of freshwater for the Nueces Bay and Estuary according to provisions of the 2001 Agreed Order.

11.4.2 Optimization and Implementation Studies for Off-Channel Reservoir (Study 2)

The 2006 Coastal Bend Regional Water Plan (2006 Plan) and the 2007 State Water Plan included the Nueces Off-Channel Reservoir (OCR) near Lake Corpus Christi as a recommended future water management strategy for the Coastal Bend Region to meet needs by Year 2040. Federal interests are studying opportunities for flood damage reduction, ecosystem restoration, and/or water supply benefits in South Texas. During the 2007 Texas legislative session, the Nueces Off-Channel Reservoir site was designated as one of 19 unique reservoir sites in the State of Texas. The TWDB Reservoir Site Protection Study recommended the Nueces Off-Channel Reservoir as one of the top-ranked sites in Texas for protection or acquisition.

The OCR is a water management strategy that could be used to: 1) enhance the system yield of Choke Canyon Reservoir (CCR) and Lake Corpus Christi (LCC); 2) capture water that would otherwise spill from LCC; and 3) reduce flood events downstream of LCC (to a lesser extent) while still maintaining desired freshwater inflows to the Nueces Bay and Estuary pursuant to the Texas Commission on Environmental Quality (TCEQ) 2001 Agreed Order.

The 2006 Plan analysis showed the optimal size for the OCR is between 200,000 and 300,000 ac-ft, with a diversion pipeline delivery rate between 750 and 1,500 cfs.

This study included further analysis of the OCR as a water management strategy for the Coastal Bend Region. The purposes of this study were to identify a preferred location for the OCR considering potential environmental impacts, optimize its capacity and diversion pipeline delivery rate, and evaluate alternative reservoir operating policies to assist with effective management of system storage and water supply yields.

The results of this study show that the optimal size for the OCR based on acceptable cost and project yield is 280,000 ac-ft with a pipeline delivery rate of between 1,250 cfs and 1,500 cfs. The results from this study were used to update the Off-Channel Reservoir near Lake Corpus Christi water management strategy.

11.4.3 Implementation Analysis for Pipeline from CCR to LCC, Including Channel Loss Study Downstream of Choke Canyon Reservoir (Study 3)

The primary objective of this study was to evaluate stream flow interaction with alluvial sands of the Gulf Coast Aquifer downstream of CCR to LCC using data collected during a field channel loss study. A channel loss study was conducted from March 3-28, 2008, during a fairly wet hydrologic period with LCC water levels ranging from 93.5 ft-msl to 93.8 ft-msl (or 96.1% - 98.3% LCC water storage capacity).

An overall 87 percent delivery rate (or 13 percent channel loss) from CCR to the Nueces River at Three Rivers Gage was measured during the channel loss study. These data agree closely with the City of Corpus Christi's previously estimated 84 percent delivery factor from CCR to Three Rivers. From the Nueces River near Three Rivers to the Nueces River downstream of the confluence with Sulphur Creek near Oakville (a distance of 7.4 river miles), the data indicate between an 11 percent and 13 percent gain in stream flow. Based on this study, an overall channel loss was estimated to be between 2 and 3 percent for the 17.4 river mile stretch from CCR to the Nueces River near Sulphur Creek. This is significantly less than the results from previous studies which estimated channel losses from CCR to LCC over a distance of about 63 miles at about 37.8 percent (a delivery factor of 62.2 percent).

The groundwater and surface water interaction downstream of CCR to LCC is very complex and could vary significantly based on seasonal events, antecedent drought or wet conditions and prolonged drought or wet conditions that could impact storage in LCC. When LCC is at or near storage capacity (conservation pool elevation of 94 ft-msl), the alluvium system influenced by LCC stores water which would be expected to result in less channel losses from the Three Rivers Gage to LCC. The channel loss study was conducted when LCC was nearly full. Furthermore, after prolonged drought periods there could be less water stored in LCC and it would be expected that the alluvium system will act somewhat like a sponge and absorb streamflow traveling down the Nueces River towards LCC, resulting in higher channel losses. The results from this study were considered during the update of the Pipeline from CCR to LCC water management strategy.

11.4.4 Water Quality Modeling of Regional Water Supply System to Enhance Water Quality and Improve Industrial Water Conservation (Study 1)

In this study, a water quality component was added to the Corpus Christi Water Supply Model (CCWSM) to simulate chloride and TDS levels at the three water supply reservoirs and the Calallen Pool for a hydrologic period from 1934 to 2003. The CCWSM enhanced with the water quality database is capable of simulating chlorides and TDS for the existing CCR/LCC/Lake Texana system for various potential reservoir operating conditions. There are five municipal and industrial water supply intakes in the Calallen Pool area that have reported chlorides and TDS fluctuations. By using the CCWSM to evaluate the effects of various reservoir operations upon quality of water of the Calallen Pool, overall water quality of the Calallen Pool can be stabilized and the reliability of regional water supplies can be increased which will reduce water consumption and treatment costs. For example, poor raw water quality causes more water to be used in industrial cooling towers; therefore improvements to water quality will directly support industrial water conservation.

The calibrated CCWSM was used to evaluate four reservoir operating scenarios to determine the impacts to reservoir and Calallen Pool water quality, including: 1) variable trigger levels for water delivery from CCR to LCC; 2) safe versus firm yield; 3) constant versus a seasonal monthly delivery pattern from Lake Texana; and 4) monthly variable LCC trigger levels for water delivery from CCR.

For simulations with variable trigger levels for water delivery from CCR to LCC (Scenario 1), the higher trigger level of 86 ft-msl showed lower median chloride levels in CCR. There were no significant impacts to LCC, Calallen Pool, or Lake Texana water quality with variable trigger levels. For the safe versus firm yield evaluation (Scenario 2), median chloride levels increased about 13% and 10% for CCR and Calallen Pool, respectively, with safe yield analyses. For the seasonal versus monthly delivery pattern from Lake Texana (Scenario 3), no significant changes were reported to CCR, LCC, Calallen Pool, or Lake Texana water quality. With monthly variable LCC trigger levels in the summer (83 ft-msl) as compared to a constant LCC trigger level at 74 ft-msl (Scenario 4), median chloride levels decreased about 5% in CCR.

11.4.5 Region N-Specific Water Conservation Best Management Practices (Study 5)

This study included gathering information for current water conservation programs in the Coastal Bend Region, developing a list of water conservation best management practices (BMPs) to promote to regional water users, distributing a water conservation survey throughout the Coastal Bend Region requesting voluntary feedback, and evaluating survey results. The survey had a response rate of 29% (21 responses out of 72 requests) for rural and urban communities throughout the eleven-county Coastal Bend Region for a range of utility sizes from small water supply corporations to the largest wholesale water provider in the region, the City of Corpus Christi. The completed surveys included system-specific information about voluntary water conservation programs implemented by water users in the Coastal Bend Region, including: the amount of reduction in water consumption, program goals, costs, currently implemented BMPs, interest in additional water conservation BMPs, and challenges in implementing future water conservation measures.

According to survey responses, the primary objectives of water conservation programs in the Coastal Bend Region are to reduce: 1) unaccounted for water; 2) per capita consumption; and/or 3) seasonal and peak water demands. The main reasons cited for a lack of interest in adding new BMPs to existing water conservation programs are cost and a lack of staff. In the future, the Texas Legislature should continue to provide funding to the TWDB and other state agencies for water conservation initiatives, including providing technical support and assistance to water user groups regarding public information programs; adoption of conservation rates; tracking the effectiveness of implemented BMPs; leak detection, repair, and monitoring; meter testing and replacement; or other BMPs included in their water conservation programs. Additional water conservation grants or low-interest loans may also provide needed assistance for water user groups that may be interested in implementing voluntary BMPs in the future.