Brazoria County Regional Water Facility Study

For Brazosport Water Authority

FINAL REPORT

TWDB Regional Facility Planning Grant

Project Contract No. 124-832-1449

December 2013

Prepared in association with:

SUSAN ROTH water and wastewater consulting

INTERA Geosciences & Engineering

CDM Smith

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Section 1
Executive Summary

1.1 Introduction

The regional water facility master plan provides information on the population growth, water demand growth in Brazoria County through year 2040. This master plan also presents and evaluates water treatment and transmission alternatives for Brazoria County to meet the growing water demands. Although all the population and water demand in Brazoria County is included in this master plan, specific attention was paid to the participants in the master plan. The participants include:

- Texas Water Development Board
- Brazosport Water Authority (primary applicant)
- Brazoria County
- Brazoria County Groundwater Conservation District
- City of Alvin
- City of Angleton
- City of Brazoria
- City of Clute
- City of Freeport
- City of Lake Jackson
- City of Manvel
- City of Oyster Creek
- City of Richwood
- City of Pearland
- Phillips 66
- Dow Chemical
- Ineos O&P USA
- Gulf Coast Water Authority
- Port Freeport

1.2 Sources of water

Groundwater in Brazoria County is derived from the Evangeline and Chicot Aquifers of the Gulf Coast Aquifer System, with the majority of the water coming from the Chicot Aquifer. Based on information prepared by the Texas Water Development Board, the Modeled Available Groundwater (MAG) for Brazoria County is 50,400 acre-feet per year. The existing groundwater.

usage in Brazoria County has exceeded the MAG in several years. **Figure 1-1** shows the estimate of groundwater usage without alternative to its continued use.

The Brazoria County Groundwater Conservation District (Conservation District) permits new wells in Brazoria County except those drilled for individual domestic use and those drilled for irrigation. Irrigation wells and individual wells are registered with the Conservation District. Permitted wells are required to report and pay for their annual usage. Registered wells do not have this requirement. At this time, a Groundwater Reduction Plan (GRP) for Brazoria County does not exist

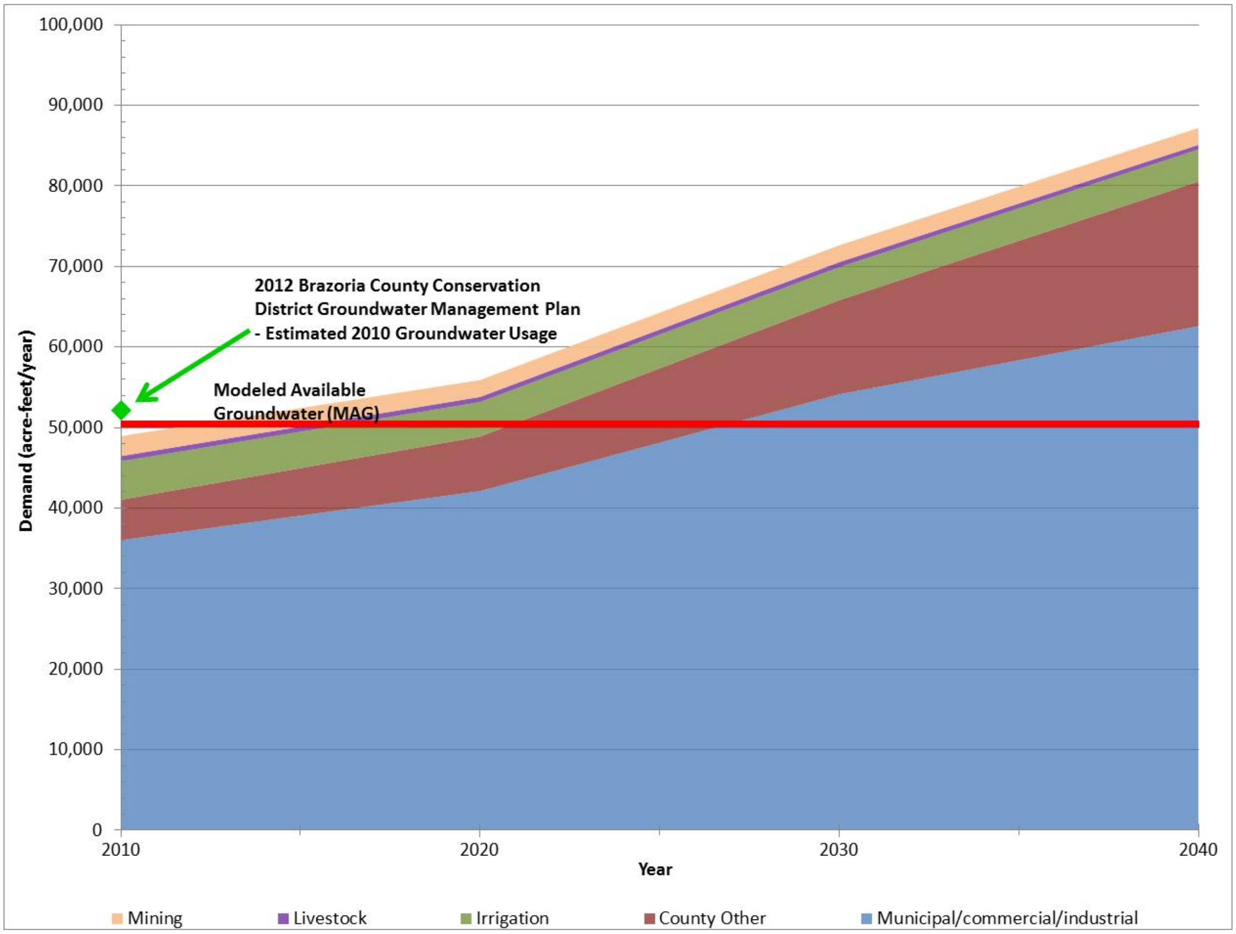


Figure 1-1
Water Demand Growth Relative to MAG

Surface water in Brazoria County primarily is derived from the Brazos River. Other sources of surface water are the San Bernard River in western Brazoria County and Chocolate Bayou in eastern Brazoria County. There are several reservoirs in Brazoria County that provide surface water storage to specific industries. For example, the Dow and Brazosport Water Authority (BWA) water right diversions are routed through the Harris and Brazoria Reservoirs, owned and operated by Dow, and the storage in these reservoirs provide water to Dow and BWA during times that the flow in the Brazos River is less than what is needed for their operations.

Studies by INTERA using monthly hydrology have shown that surface water from the Brazos River is available on a long-term average approximately 90 percent of the time. Daily hydrologic studies by INTERA also show that during drought years such as 2009 and 2011 that run-of-the river water will not be available for diversion and use for up to eight months of the year. The lack of surface water availability is dealt with by major water users and providers by either having surface water reservoirs, long-term contract water, or annual interruptible water contracts. Future surface water availability will remain an issue until the Brazos River Authority's (BRA) system wide permit is granted and/or Allens Creek Reservoir is constructed.

1.3 Population and Water Demand Projections

The population in the study area has increased significantly over the past 10 years and is projected to double over the next 20 years. Section 4 presents a detailed discussion on the development of population projections. The population of Brazoria County is projected to grow from 359,000 in 2010 to as low as 445,000 (TWDB 2011 Region H Water Plan) to as high as 938,000 (Harris County Toll Road Authority – TxDOT Traffic and Revenue Study) in 2040.

Based on the population projections and per capita water usages presented in Section 4, water demands for each entity for a five-year period were determined. **Figure 1-2** presents the maximum day water demand projections for the participating cities, Texas Department of Criminal Justice (TDCJ) prison units, and Pearland; reference **Appendix D** for a complete summary of water demand projections for the project participants.

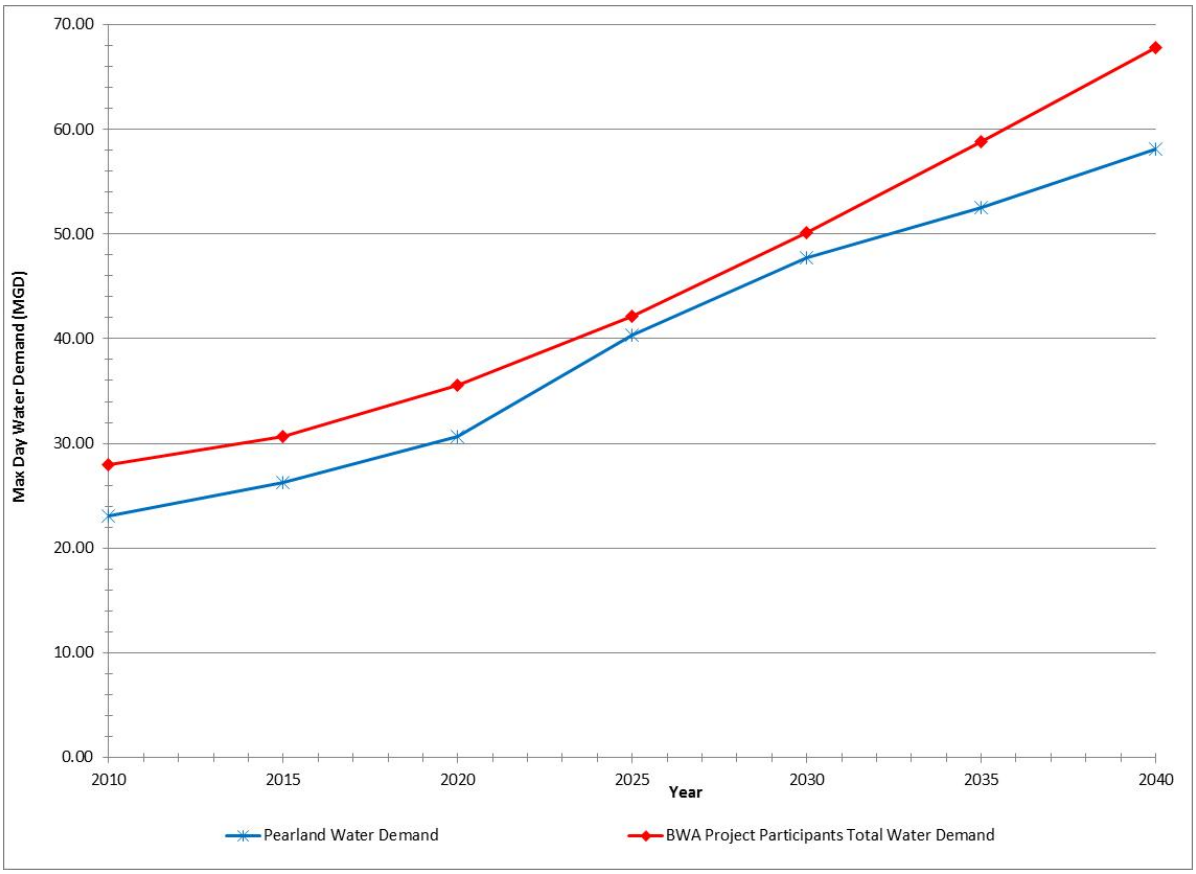


Figure 1-2
Maximum Day Water Demand Projections for BWA Project Participants and Pearland

1.4 Determination of Alternatives

Several drivers have led to the need for Brazoria County to evaluate its water facilities, some of which include groundwater demands in excess of the MAG, growth in water demands and unreliability in surface water systems. Based on engineering judgment and inputs provided by the project participants, six initial alternatives were developed and presented. The six initial alternatives are described in detail in Section 6. Subsequent discussions were held and comments collected from the project participants concerning the six initial alternatives with the goal of selecting the top three alternatives for further evaluation. Based on the comments during the screening phase, three of the six alternatives were modified and chosen for further evaluation. These three alternatives are summarized below and described in detail in Section 6. Because of the surface water conditions in Brazoria County, two evaluations of the alternatives were conducted. The first evaluation assumed 10 percent of the surface water supply would be purchased each year using annual interruptible water supply contracts. The second evaluation assumed purchase of sufficient contract water so that the estimated eight month gap in surface water availability can be accommodated.

- ***Alternative 2: BWA WTP Expands to Meet Current Customer Demands (10% Water Shortage Purchase), New Plant on Harris Reservoir –*** Existing BWA WTP would be expanded to meet the 2040 max day demands of Angleton, Brazoria, Clute, Freeport, Lake Jackson, Oyster Creek, Richwood, TDCJ Clemens Unit, TDCJ Wayne Scott Unit and Dow. The new Northern Brazoria Regional WTP will be constructed on the north side of Harris Reservoir and serve Manvel, TDCJ Darrington Unit, TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit, and the County Other Future Districts population growth that is projected to occur along Highway 288.

- ***Alternative 2: BWA WTP Expands to Meet Current Customer Demands (67% Water Shortage Purchase), New Plant on Harris Reservoir –*** This alternative is the same as Alternative 2, with the exception of the water shortage planning.

- ***Alternative 3: BWA WTP Expansion (10% Water Shortage Purchase), New Plant in Manvel –*** BWA WTP would expand to meet the 2040 max day demands of Angleton, Brazoria, Clute, Freeport, Lake Jackson, Oyster Creek, Richwood, TDCJ Clemens Unit, TDCJ Wayne Scott Unit and Dow, plus added service to TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit, and half of the County Other Future Districts. A new North Brazoria Regional WTP will be constructed in northwestern Manvel to serve Manvel, TDCJ Darrington Unit and half the additional County Other Future Districts population growth that is projected to occur along Highway 288.

- ***Alternative 3: BWA WTP Expansion (67% Water Shortage Purchase), New Plant in Manvel –*** This alternative is the same as Alternative 3, with the exception of the water shortage planning.

- ***Alternative 6: BWA WTP Expands to Meet Existing plus New Customer Demands (10% Water Shortage Purchase), New WTP on Harris Reservoir –*** Existing BWA WTP would expand to meet the 2040 max day demands of Angleton, Brazoria, Clute, Freeport, Lake Jackson, Oyster Creek, Richwood, TDCJ Clemens Unit, TDCJ Wayne Scott Unit and Dow and would add service to Sweeny, Jones Creek, Surfside Beach and Phillips 66. The new Northern Brazoria Regional WTP will be constructed on the north side of Harris Reservoir to serve Manvel, TDCJ Darrington Unit, TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit, Bailey's Prairie, Holiday Lakes, West Columbia, Varner Creek, and the County Other Future Districts population growth that is projected to occur along Highway 288.

- ***Alternative 6: BWA WTP Expands to Meet Existing plus New Customer Demands (67% Water Shortage Purchase), New WTP on Harris Reservoir –*** This alternative is the same as Alternative 6, with the exception of the water shortage planning.

- ***Alternative 3 – Brackish: BWA WTP Expands/Brackish Groundwater RO Plant to Meet Current Customer Demands, New Plant in Manvel –*** This alternative is the same as Alternative 3, except the initial 10 MGD expansion in 2015 would be the construction of a reverse osmosis (RO) plant treating brackish groundwater at the existing BWA WTP site. The second expansion of 7 MGD in 2035 would be an expansion to the current BWA conventional filtration treatment process.

- ***Alternative 3 – Seawater: BWA WTP Expands/Seawater RO Plant to Meet Current Customer Demands, New Plant in Manvel –*** This alternative is the same as Alternative 3, except the initial 10 MGD expansion in 2015 would be the construction of a reverse osmosis (RO) plant treating seawater at the existing BWA WTP site. The second expansion of 7 MGD in 2035 would be an expansion to the current BWA conventional filtration treatment process.

- ***Alternative 3 BWA – Brackish: Brackish Groundwater RO Plant at BWA WTP Site –*** An RO Plant treating brackish groundwater would be constructed at the site of the existing BWA WTP to meet the 2040 max day demands from Angleton, Brazoria, Clute, Freeport, Lake Jackson, Oyster Creek, Richwood, TDCJ Clemens Unit, TDCJ Wayne Scott Unit, TDCJ Darrington Unit, TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit, Manvel, Dow and County Other Future Districts. The existing BWA WTP would continue to operate at its rated capacity.

- ***Alternative 3 BWA – Seawater: Seawater RO Plant at BWA WTP Site –*** This alternative is the same as Alternative 3 BWA – Brackish, except the water supply would be seawater as opposed to brackish groundwater.

1.5 Economic Analysis and Financial Evaluation

The economic analysis is used as a way of comparing each alternative on the even level, based on capital and operations and maintenance (O&M) costs. The economic analysis included the present worth value of capital costs for: current plant upgrade, new and expanded water treatment capacity, raw water intake, raw water and high service pump stations and transmission pipelines, as well as the present worth value for O&M costs from 2013 through 2040. **Figures 1-3, 1-4 and 1-5** show the results of the economic evaluation.

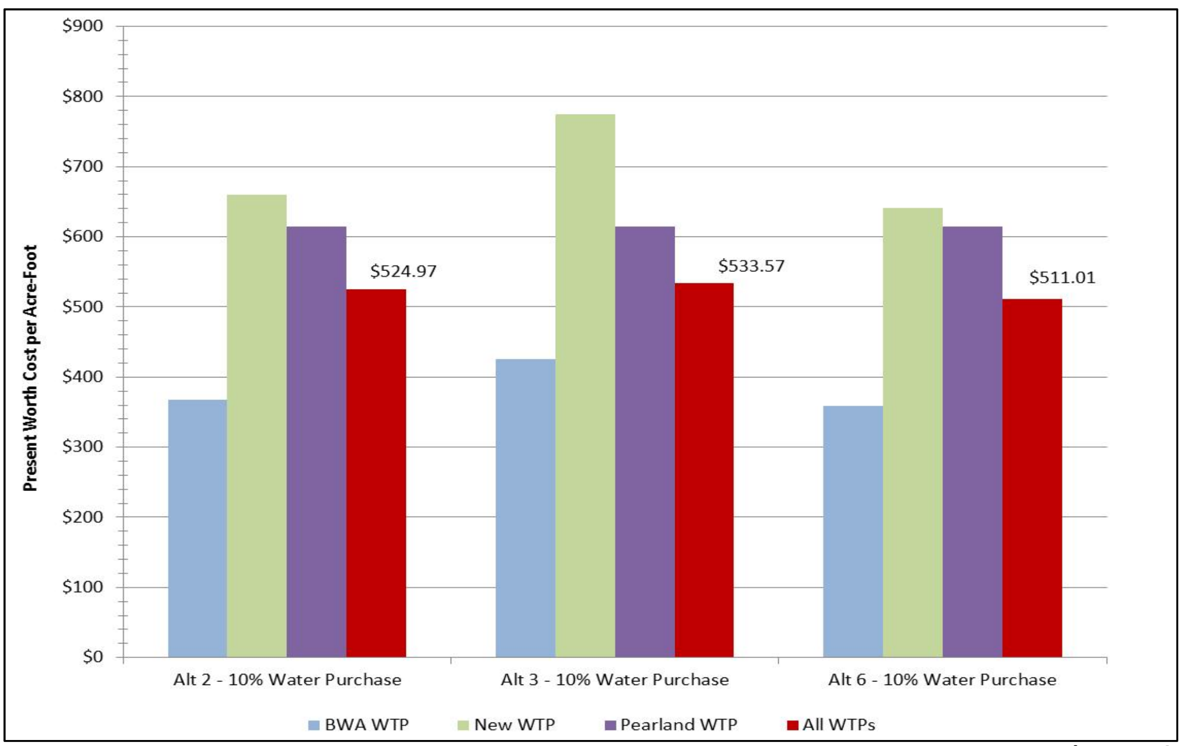


Figure 1-3
Summary of Present Worth Analysis for 10 Percent Water Purchase Alternatives

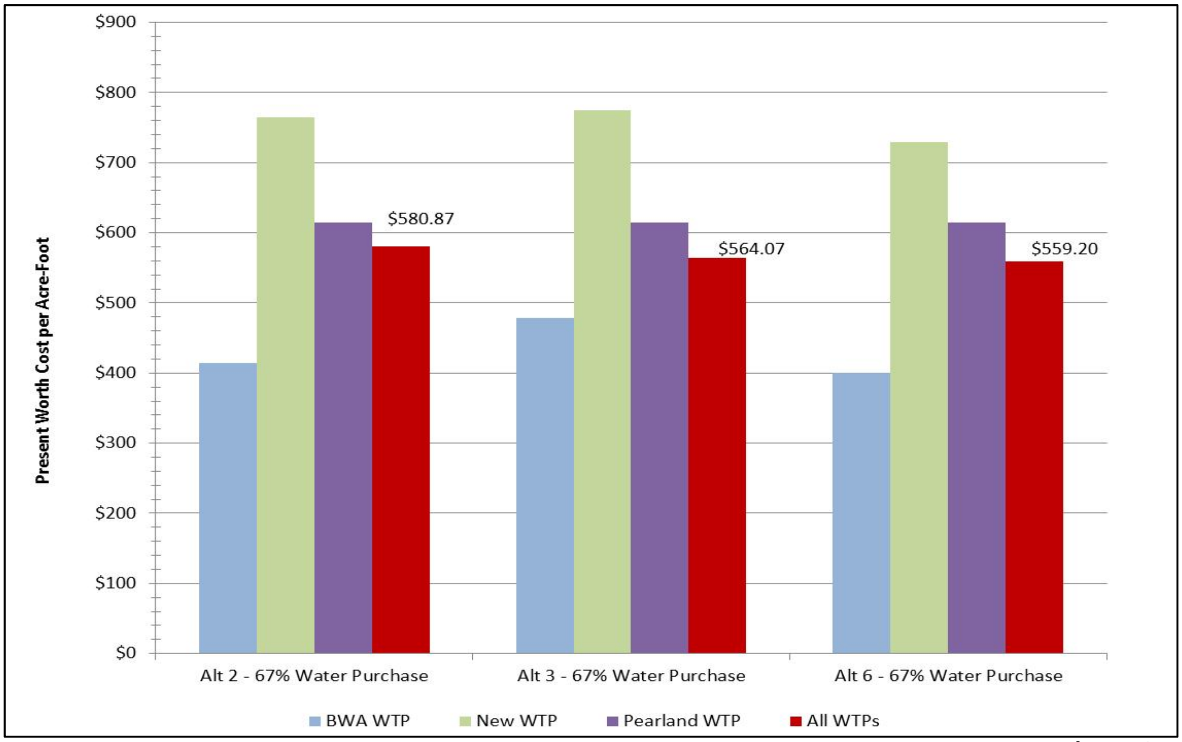


Figure 1-4
Summary of Present Worth Analysis for 67 Percent Water Purchase Alternatives

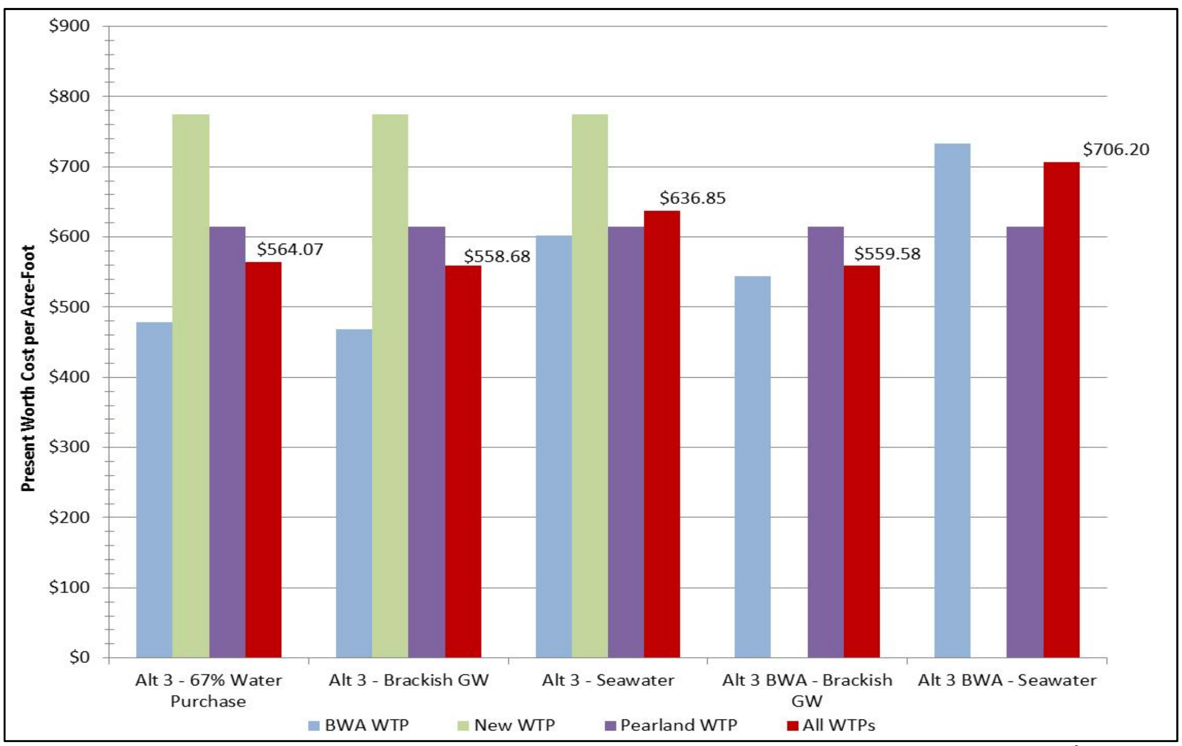


Figure 1-5
Summary of Present Worth Analysis for Alternative 3 Options

For the financial evaluation, CDM Smith took a closer look at the variations of Alternative 3. A review of the alternatives shows that the variations of Alternative 3 are fairly similar in their economic analysis, so a financial analysis is another way of differentiating the alternatives. Additionally, for added safety and reliability within the system, from this point forward, CDM Smith only considered options that had 67 percent water shortage planning. For the financial evaluation, based on the annual expenditures and average annual water sold, determine a cost per $1,000 gallons. **Figure 1-6** shows the results of the financial evaluation. Note, since all costs are expected to inflate over time, the red line in the figure shows the baseline of the current cost for BWA treated water inflated through 2040.

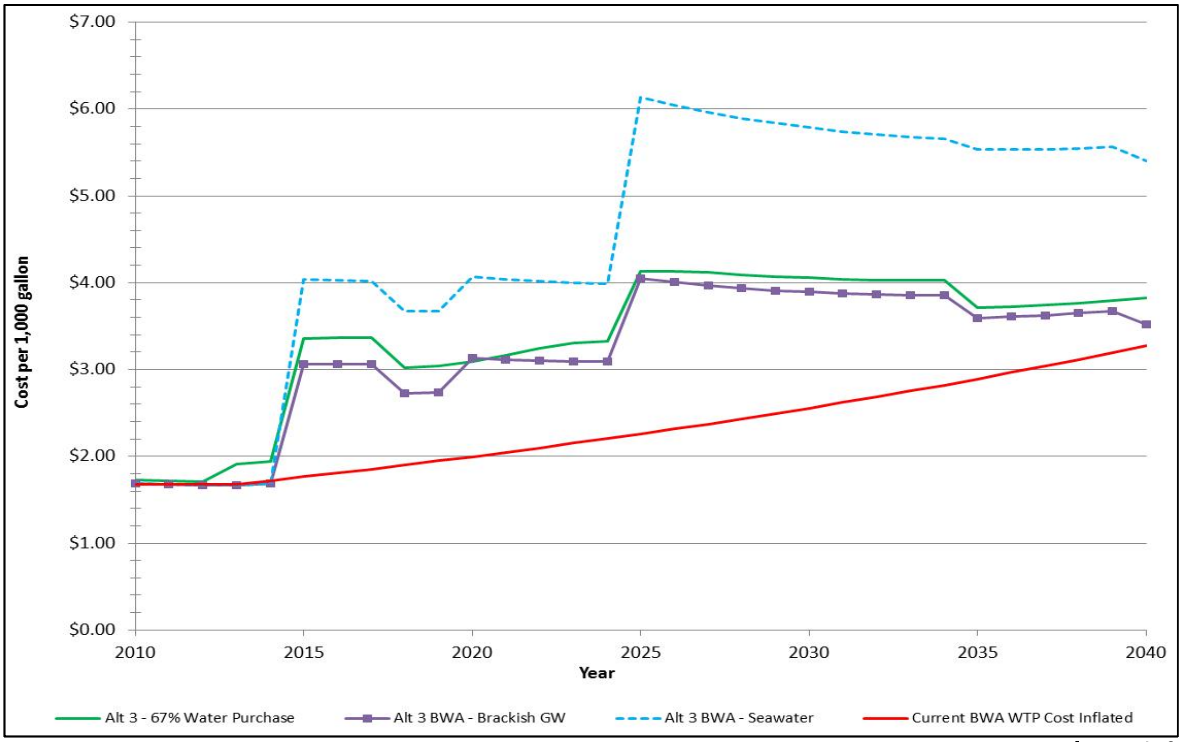


Figure 1-6
Financial Evaluation of Alternative 3 with 67 Percent Water Shortage Purchase and Alternative 3 BWA

1.6 Final Recommendations

The recommended facility plans for Brazoria County are based on several factors: the overall economics based on a present worth analysis, a financial analysis of the impact on the cost of water to participating customers, and the availability of groundwater and surface water. The recommended facility plan is also based on an implementation plan that allows the recommended plan to be permitted, constructed and operational in a reasonable amount of time and a facility plan that has adequate operations, management and governance. Below the recommended facility plan for each entity is provided.

1.6.1 City of Pearland

The City of Pearland has recently completed a Water Master Plan and the City has identified its path forward with its water supply and facilities. The City will continue to use groundwater from the Gulf Coast Aquifer System to meet a portion of its needs. The City is currently an equity partner in the City of Houston's Southeast Water Purification Plant and has a contract to buy additional wholesale water from the City of Houston. Finally, the City of Pearland has a contract with GCWA for 10,000 acre-ft per year of raw water. The City plans to build a surface water treatment plant that will eventually be 20 MGD to meet the buildout needs of its water service area defined by its Certificate of Convenience and Necessity (CCN).

1.6.2 City of Alvin

The future water demands in Alvin are projected to be 6.1 MGD in 2040. The City has 8.4 MGD in wells currently completed in the Gulf Coast Aquifer System. These wells are sufficient to meet the water needs of the City of Alvin during the period of this master plan. No regional water facilities are needed or recommended for the City of Alvin through the study period.

1.6.3 City of Manvel

Growth in the City of Manvel will increase its max day water demands from less than 1 MGD to over 7.4 MGD. The City's existing groundwater wells can only meet slightly more than 1 MGD. The future water demands of the City of Manvel if not met by additional groundwater wells in the Gulf Coast Aquifer System, will have to be met by other means. It is recommended that the City of Manvel should meet its future water demands by regional Alternative 3 BWA – Brackish. BWA has excess capacity in its existing water treatment and transmission system and can deliver up to 5 MGD to the north side of the City of Angleton. With the addition of ground storage, booster pumping and a water transmission line from Angleton to Manvel, BWA could have additional water service to the City of Manvel in only a couple of years.

1.6.4 Brazosport Water Authority Participating Customers

The seven cities that are BWA participating customers will continue to use the contract water purchased from BWA. The participating customers will also continue to use their groundwater wells to the extent they are already completed and operational. The drilling of additional wells is not recommended to meet the water facility needs of these participants. With groundwater usage in the County already exceeding the MAG, it is recommended that the BWA customers rely on their existing and future contracts with BWA to meet their water supply needs.

The following participating customers will need additional contracted water from BWA by the end of the study period in 2040.

- City of Angleton 3.92 MGD
- City of Brazoria 0.48 MGD
- City of Lake Jackson 2.42 MGD
- City of Richwood 0.45 MGD

The existing BWA water treatment facilities, pumping facilities and transmission mains have the capacity to meet these future demands.

County other existing water user groups will continue to meet their water needs through the continued use of their existing wells completed in the Gulf Coast Aquifer System. There is a substantial population in Brazoria County that has individual wells completed in the Gulf Coast Aquifer System that serve the domestic needs of individual households. These domestic demands will continue to be met by the Gulf Coast Aquifer System.

It has been assumed that there will be substantial population growth in future municipal utility districts or similar districts in the SH 288 corridor between the City of Manvel and the City of Angleton. It is recommended that BWA expand its water treatment, pumping and transmission system to serve the population in these future districts. This approach to providing water to County Other Future Districts is included in Alternative 3 BWA – Brackish.

Alternative 3 BWA – Brackish, which includes Brackish Groundwater Desalination (BGD), is the recommended alternative for Brazoria County. Alternative 3 BWA – Brackish takes advantage of available treatment and transmission capacity in the existing BWA system to provide water to the County Other Future Districts, the City of Manvel and the Darrington and Ramsey prison units. As Angleton and areas north of Angleton grow, additional transmission facilities from the BWA WTP to Angleton will be necessary. As noted in Section 7, present worth costs for the alternatives are fairly similar; however, Alternative 3 BWA – Brackish would be simpler to implement than other regional options, and the option to add the smaller entities in Brazoria County in the future would remain a possibility. Additionally, this alternative has the added benefit of diversifying BWA's water sources and is not relying on future water supplies to provide firm surface water.

Although there is excess treatment capacity at the BWA WTP, the availability of raw water is dependent on the BWA's run-of-the-river rights. To firm up this water supply, it is recommended that the BWA start pursuing the construction of brackish groundwater wells, a well collection system, and a brackish groundwater desalination plant using reverse osmosis (RO) membranes. The capacity of the RO plant needed to firm up the existing BWA surface WTP is 10 MGD. The total treatment capacity of the brackish groundwater and surface water treatment plants would eventually be expanded to 54.8 MGD. This WTP capacity plus the existing groundwater capacity would meet the 2040 water demands of Alternative 3 BWA – Brackish.

It is recommended that BWA initiate design and construction of improvements to its existing plant that includes a new 10 million gallon (MG) clearwell, high service pump station, yard piping improvements, electrical improvements and SCADA improvements. The cost of the proposed improvements to the BWA WTP total approximately $14 million. It is also recommended that BWA conduct a pilot of the brackish groundwater desalination using RO. A pilot is not required by TCEQ for this process, but there are potential water quality issues including iron and manganese, organics and biologic fouling, and silt production that could negatively impact a desalination facility. A pilot would provide an opportunity for these potential issues to be discovered and addressed.

It is recommended that BWA secure property on the north side of Angleton for the construction of the tank farm and booster pump station that will allow for regional water service north of Angleton. The first customers of this system would be the TDCJ Ramsey and Darrington Prison Units. Having the storage and booster facility near Angleton also provides the potential of regional water service to future districts and developments along SH 288 between Angleton and Manvel. The construction of the first ground storage tank and booster pump station is estimated to cost $11.7 million. The construction of this facility is not required until contracts for water service north of Angleton have been secured.

Section 2
Introduction

This regional water facility master plan summarizes the work performed over the past several months to document the population growth, water demand growth, and water treatment and transmission alternatives for Brazoria County to meet the growing water demands. Although all the population and water demand in Brazoria County is included in this master plan, specific attention was paid to the participants in the master plan. The participants include:

- Texas Water Development Board (TWDB)
- Brazosport Water Authority (primary applicant)
- Brazoria County
- Brazoria County Groundwater Conservation District
- City of Alvin
- City of Angleton
- City of Brazoria
- City of Clute
- City of Freeport
- City of Lake Jackson
- City of Manvel
- City of Oyster Creek
- City of Richwood
- City of Pearland
- Phillips 66
- Dow Chemical
- Ineos O&P USA
- Gulf Coast Water Authority
- Port Freeport

2.1 Project Background

In the fall of 2011, a select task force formed by the Brazoria County Commissioner's Court, called "Water for Our Future Task Force" finalized a report on water issues in Brazoria County. This report was prepared at the request of the Commissioner's Court to determine what options were available to meet the growing water needs in Brazoria County sparked by the drought conditions of 2011. The following is a summary of the recommendations of the Task Force:

- The 2011 Region H Water Plan Water Management Strategies (WMS) identified for Brazoria County are appropriate but not exhaustive. A plan is only a plan without execution. The next step is to prioritize WMS and secure funding for supported projects and determine and address any remaining gap.

- It will be necessary for Brazoria County entities (Municipalities, Industry, Agriculture, Water Wholesaler, Conservationist, Environmentalist, Economic Development, etc.) to take ownership, for their respective water shortfall, for identifying best initiatives and/or projects to ensure a reliable freshwater source for current and future demand.

- It will become increasingly important to embrace systems approaches that recognize one change in a watershed affects all other elements of that same system (e.g. groundwater and surface water interrelation, etc.).

- Education and awareness specific to conservation, albeit the smallest by volume of the suggested WMS, should continue to be in the forefront as this is the single most focus area that each and every individual can proactively make a difference. There is a vast amount of materials that many of the local and state agencies make available. One excellent available conservation resource is the Texas Water Development Board "Water IQ program."

The Task Force, like the work in Region H, has a focus that is primarily on water supply. The purpose of this facility master plan is to fill the gap between water supplies and facilities needed to treat and deliver the water to persons and entities that demand it. Although the focus of this master plan is the treatment and transmission infrastructure required to deliver water to persons and entities that need it, it is not possible to ignore the water supply issues in Brazoria County. These issues will be discussed in the framework of water facilities and the final recommendations will be made with the water supply issues of Brazoria County taken into account. To the extent that this master plan is about treatment and transmission facilities and not water supplies, this regional water facility master plan addresses the first three recommendations made by the Water for Our Future Task Force. This water facility master plan:

- Evaluates water facilities that meet the water needs of the County given the water supply availability;

- Provides a means for the participants to take ownership for their water facility needs in a regional framework; and

- Addresses the fourth recommendation by including conservation as an integral part of the plan.

2.2 Scope of Work

The scope of work for this study involves evaluating the feasibility of developing regional water treatment and transmission facilities to serve existing and future development in Brazoria County. The following items were included in the study from an engineering standpoint, as well as to satisfy the requirements of the TWDB grant program:

- Population and Water Demand Projections – Population and growth projections, number of existing water connections, utility development agreements and additional water system information were collected from each of the participants. This data was used to develop population and water demand projections for each participant in five year increments through year 2040.

- Regional Transmission Alternatives – Options were developed for connecting existing water systems participating in the study into an overall regional water distribution system.

- Regional Water Treatment Alternatives – Various options were developed that included expanding existing infrastructure, as well as constructing new regional infrastructure to serve the study area.

- Implementation Schedule – An implementation plan was developed for the phased construction of regional distribution and treatment facilities for the study area through 2040. This plan takes into consideration the existing distribution and treatment capacities, water quality issues, future developments, anticipated growth and cost-effectiveness.

- Cost Estimates and Recommendations – An economic analysis including the capital and O&M costs for each identified entity for the various options was performed. The capital and O&M costs for the final regional distribution and treatment system alternatives were combined and converted to present worth.

- Funding Options – Potential funding sources and traditional financing programs for the construction of various options of the Brazoria County Regional Water Systems were explored.

- Water Conservation and Drought Contingency Plans – TWDB requires project participants receiving grant funding through the Regional Water and Wastewater Facilities Planning Grant Program to prepare and implement water conservation and drought contingency plans. Copies of both of these plans from each of the project participants are in **Appendix A.**

Information about each of the items listed in the scope of work is detailed in the following sections of the report.

Section 3
Description of Study Area

The study area for this regional water facility master plan is all of Brazoria County. Brazoria County had a 2010 population of 305,649. This population is a 63,882 increase over the 2000 population. The projections for future growth that are discussed in Section 4 indicate that the County population will continue to grow. The remainder of this Section presents basic information on the study area and sources of water for Brazoria County.

3.1 Physical Aspects

Brazoria County is located in the Region H regional planning area. The county is located south of Harris County and the City of Houston. Brazoria County also borders Fort Bend County on its north and west and Galveston County to its east. Matagorda County borders Brazoria County to the south. The total land area in Brazoria County is 1,358 sq. mi.

Brazoria County is home to several large industrial complexes including Dow Chemical, Phillips 66 and Ineos O&P. There are also several Texas Department of Criminal Justice correctional units in Brazoria County. In 2010, private non-farm employment was over 70,000 and the manufacturers in Brazoria County shipped in excess of $31 billion in products. In 2002 there were over 2,400 farms in Brazoria County covering over 613,000 acres. These farms had a market production of more than $47 million in 2002.

There are several wildlife refuges along the Gulf Coast in Brazoria County. These refuges are the San Bernard National Wildlife Refuge, Brazoria National Wildlife Refuge, Peach Point Wildlife Management Area and the Nannie M. Stringfellow Wildlife Management Area. A map showing many of these features is shown in **Figure 3-1**.

Other physical aspects discussed in the following sections include hydrology, geology, and transportation.

3.1.1 Hydrology

There are several rivers, streams, and bayous located in Brazoria County. The primary hydrologic feature is the Brazos River, which empties into the Gulf of Mexico in southern Brazoria County. The San Bernard River is located in western Brazoria County and also empties into the Gulf of Mexico in Southern Brazoria County. Several Bayous drain the eastern portion of the county. The Bastrop Bayou complex drains into Christmas and Bastrop Bay and Chocolate Bayou drains into Chocolate Bay. These major surface water features are shown on Figure 3-1.

The average annual rainfall in Brazoria County is 57 inches per year. On an annual average basis, 5.875 million acre-feet per year flows past the stream gauge on the Brazos River at Rosharon. The minimum flow for the Brazos River at Rosharon occurred in 2011 and was 694,300 acre-feet per year. On an annual average basis, 382,300 acre-feet per year flows past the stream gauge on the San Bernard River near Boling. The minimum flow for the San Bernard River near Boling occurred in 1956 and was 27,400 acre-feet per year. On an annual average basis, 83,400 acre-feet per year flows past the stream gauge on Chocolate Bayou near Alvin. The minimum flow for the Chocolate Bayou near Alvin occurred in 2000 and was 14,045 acre-feet per year.

3.1.2 Geology

The follow section was excerpted from *Texas Water Development Board Report 163, Groundwater Resources of Brazoria County, Texas* (Sandeen and Wesselman, United States Geological Survey, 1973).

> *Most of the county is a nearly flat plain which rises to the northwest. The surface of the plain is the top of the Beaumont Clay. The Beaumont surface, composed mostly of clay type soils, rises from a minimum altitude of several feet in the southeastern part of the county to about 65 feet in the northern part. The rest of the land surface is composed of coastal swamps, the Gulf of Mexico beach, the bay beaches, and two river valley systems that transect the plain in a general northwest southeast direction. The southeast corner of the county is a peninsula, the southwest extension of the Galveston Island barrier beach. Most of the surface sediments in the beach and river areas are sands.*
>
> *The outcrops of the rest of the Beaumont Clay and of the older underlying units are in the counties northwest of Brazoria County. These units are also transected by the river valleys filled with Quaternary alluvium. With the exceptions of the Goliad Sand and Quaternary alluvium, the outcrops occur as bands roughly paralleling the coast line.*
>
> *The formations dip toward the Gulf at an angle greater than the slope of the land surface; therefore, they occur at progressively greater depths and thicken in a gulfward direction. The only noticeable displacements of younger beds by these structures are those that occur in the immediate vicinity of the seven salt domes which penetrate them. These are the Damon Mound, West Columbia, Allen, Clemens, Bryan Mound, Stratton Ridge, and Hoskin Mound Domes. The land surface is distinctly elevated over four of these domes. Damon Mound, which rises approximately 80 feet above the surrounding plain to an altitude of 146 feet, is the highest point in Brazoria County. Electrical logs indicate saline water occurring at shallow depths over and near the Danbury Dome, but this dome is not known to pierce the aquifers.*

3.1.3 Transportation

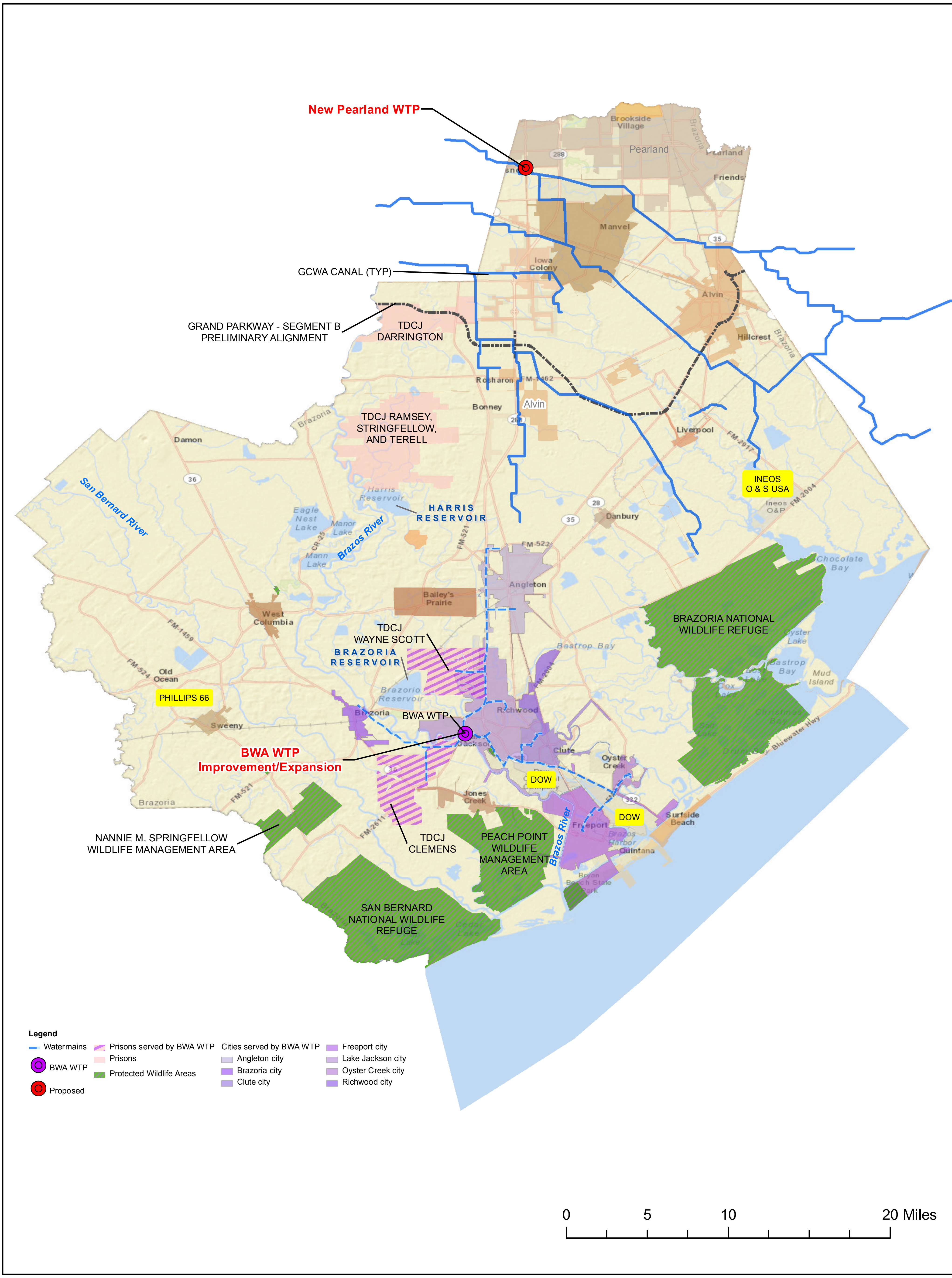
Primary transportation routes include SH 288, SH 6, SH 35 and SH 36. The planned Grand Parkway will also travel through Brazoria County. These major transportation routes are shown on Figure 3-1.

3.2 Sources of Water

There is significant municipal, manufacturing and agriculture demand of groundwater and surface water in Brazoria County. Region H estimates for 2010 and 2040 for each of these classifications is shown in **Table 3-1**.

Table 3-1 Region H Water Demand Estimates for Brazoria County

Water Use Category	Total Water Demand Estimates by Year (acre-feet per year)		% Increase from 2010 to 2040
	2010	2040	
Municipal	47,184	65,134	38
Agricultural	136,647	117,402	-14
Manufacturing	260,239	333,348	28



CDM Smith
Riata Corporate Park
12357-A Riata Trace Parkway, Suite 210
Austin, TX 78727

Brazoria County Overview

Brazosport Water Authority

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

Figure 3-1
Brazoria County Overview

3.2.1 Groundwater Resources

Groundwater in Brazoria County is derived from the Evangeline and Chicot Aquifers of the Gulf Coast Aquifer System with the majority of the water coming from the Chicot Aquifer. The TWDB uses Groundwater Availability Modeling (GAM) to determine Modeled Available Groundwater (MAG) for these aquifers. Based on "GAM Run 10-038 MAG," prepared by the Texas Water Development Board, Brazoria County has 50,396 acre-feet per year in MAG. The Chicot Aquifer is predicted to provide 48,125 acre-feet per year and the Evangeline Aquifer is predicted to provide 2,271 acre-feet per year. In the Region H study the MAG is rounded to 50,400 acre-feet per year.

The Brazoria County Groundwater Conservation District (Conservation District) permits new wells in Brazoria County except those drilled for individual domestic use and those drilled for irrigation. Irrigation wells and individual wells are registered with the Conservation District. Permitted wells must report their annual usage to the Conservation District and pay $0.03 per 1,000 gallon used. Registered wells are not required to report and pay for their annual usage. The Conservation District recently updated its Groundwater Management Plan. At this time, a Groundwater Reduction Plan (GRP) for Brazoria County does not exist.

Brazoria County is bordered by Galveston, Harris and Fort Bend Counties. All three of these counties have subsidence districts and all three counties have been required to implement GRPs. Information that CDM Smith has collected and information reported by the Brazoria County Groundwater Conservation District (BCGCD) shows that groundwater usage in the county has exceeded the MAG in several years. Population projections show that groundwater usage, without alternatives, will continue to increase well beyond the MAG.

The Region H estimate of groundwater usage in Brazoria County by municipal, industrial and agriculture in year 2000 is shown in **Table 3-2**. Also shown is the percent of groundwater usage in each category. Municipal uses are by far the largest user of groundwater in the County

Table 3-2 Region H Estimates of Usage

Water Use Category	Year 2000 Groundwater Usage (acre-feet per year)	Percent of County's Total Groundwater Used (%)
Municipal	26,796	72.6
Agricultural	7,990	21.6
Manufacturing	2,139	5.8

Of the participants in this study, all but the City of Freeport and City of Brazoria obtain a portion of their water supply from groundwater. The BWA participating cities of Angleton, Clute, Lake Jackson, Oyster Creek and Richwood obtain a portion of their water supply from the groundwater. The cities of Manvel and Alvin obtain all of their water supply from groundwater. The City of Pearland obtains a portion of its water supply from groundwater and a portion of its water supply through the City of Houston.

Several water user groups in the County (County Other WUG) and all rural residents (County Other Domestic) on individual domestic wells rely solely on groundwater. Because of the historic availability of groundwater in Brazoria County, there has been no reason to develop rural water systems to provide water to the rural residents of the County. As the County population continues to grow, providing water supplies that are an alternative to groundwater to the cities and other municipal districts is important so that the groundwater remains available to the rural residents. To this end, in this study we have assumed that the municipalities will fully utilize existing groundwater wells, but that any water demands in excess of their existing groundwater supply will be met by an alternative source. The County Other WUG and County Other Domestic will still push the groundwater demand beyond the MAG, but with the concentrated demands by the municipalities controlled, subsidence in the county should be managed.

Work done as part of this study shows that less than half of the water in the Evangeline and Chicot Aquifers is fresh (i.e., has TDS concentrations in less than 1,000 mg/L). The work prepared by INTERA contained in **Appendix B** shows that over 60 percent of the water in the Chicot Aquifer is slightly saline to brackish.

3.2.2 Surface Water Resources

Surface water in Brazoria County primarily is derived from the Brazos River. Other sources of surface water are the San Bernard River in western Brazoria County and Chocolate Bayou in eastern Brazoria County. There are several reservoirs in Brazoria County that provide surface water storage to specific industries. For example, the Harris and Brazoria Reservoirs are owned and operated by Dow and provide water to Dow and Brazosport Water Authority (BWA) during times that the flow in the Brazos River is less than what is needed for their operations.

Most of the surface water users in Brazoria County have run-of-the-river water rights permits. These permits are satisfactory more than 90 percent of the time based on the Water Availability Model (WAM). However, there are long periods when the flow in the river is less than required. This was observed most recently during the droughts of 2009 and 2011. During these low flow periods in the river, water available from the river can be supplemented by water stored in the reservoirs (such as Dow's Brazoria and Harris Reservoirs). If low flow periods persist longer than what the reservoirs can accommodate, some water providers have water contracts with BRA for stored water and many of the water users purchase an annual interruptible supply from BRA to supplement their run-of-the-river rights. At the current time, BRA does not have additional contract water to sell nor is there firm water available in the Brazos River.

Large surface water suppliers in Brazoria County include Gulf Coast Water Authority (GCWA) and BWA. GCWA has 379,932 acre-feet per year of surface water rights. GCWA also has 45,000 acre-feet per year of water contracts with BRA. GCWA has a contract to provide the City of Pearland 10,000 acre-feet per year of surface water through its surface water canal system. GCWA has stated that they do not have firm water to contract to any entity in Brazoria County at this time. BWA has contracts to provide treated water to its participating customers which include; Angleton, Brazoria, Clute, Freeport, Lake Jackson, Oyster Creek and Richwood. BWA also sells water to the Texas Department of Criminal Justice (TDCJ) at the Clemens and Wayne Scott Units and to Dow. The BWA has a surface water right of 45,000 acre-feet per year with a priority date of 1960 which it purchased from Dow. This water right is firmed up by water in the Brazoria and Harris Reservoirs and by interruptible water purchases. The BWA water treatment plant has a rated capacity of 17.97 MGD. BWA has contracts to supply 9.18 MGD.

Water management strategies to increase surface water supplies for Brazoria County include obtaining supply in Allens Creek Reservoir, expanding the Dow Harris Reservoir, constructing a GCWA Reservoir and constructing a Brazoria County Reservoir. During the 2011 drought, surface water was not available to BWA for up to eight months even with stored water available in the existing Brazoria and Harris Reservoirs. Modeling by INTERA, included in Appendix B, shows that with the expansion of the Harris Reservoir, the period when surface water would not be available during the 2011 drought was reduced to six months. Dow is moving forward with construction of the expanded Harris Reservoir, but its completion date is not known at this time. Allens Creek Reservoir already has a water rights permit and its ownership is shared between the City of Houston with 70 percent and BRA with 30 percent. A portion of the 99,000 acre-feet per year yield of this reservoir would be available to meet future water demands in Brazoria County. The capital and operating costs of this reservoir are already included in BRA's projected cost of system water. The Region H Plan shows construction of Allens Creek Reservoir occurring after 2020. The

GCWA Reservoir is described in the Region H Plan as an off-channel reservoir designed to increase the firm yield of the GCWA water rights. The reservoir would yield 39,500 acre-feet per year. This reservoir is planned to be constructed after 2030. The Brazoria County reservoir is described in the Region H Plan as an off-channel reservoir to divert and hold currently unappropriated flows in the Brazos River. The water from this reservoir would be available to meet the needs in Brazoria County. The reservoir would yield 24,000 acre-feet per year. The reservoir is planned to be constructed after 2060.

3.3 Regional Study Water Supplies

Several alternatives for treatment and transmission facilities are evaluated in this master plan. Although this master plan is primarily focused on facilities such as water treatment plants and pipelines, it is not possible to make recommendations on facilities without some knowledge regarding whether there is water available to treat. Furthermore, the economics of the alternatives evaluated depend on the quantity of raw water purchased and the unit cost of raw water.

The primary source of surface water for Brazoria County is the Brazos River, but water availability in the river is variable. Currently, the variability of run-of-the-river water is firmed up by the purchase of interruptible water supplies from BRA. When contract water from the BRA is available, it would be purchased to firm up the availability of surface water in the river. To that end, CDM Smith has developed alternatives and evaluated alternatives using several surface water supply scenarios. The first surface water scenario, which is the current approach, recognizes that surface water is, on average, available 90 percent of the time and funds are set aside every year to purchase up to 10 percent of the expected WTP average demand in a given year. These funds would be saved and used to purchase interruptible water when needed.

As water users in the upper Brazos River basin utilize more of their contracted water, less interruptible water will be available. Furthermore, if BRA obtains its system wide permit and when Allens Creek reservoir is constructed, there will be more pressure on entities to purchase contracted water in lieu of interruptible water. Therefore, for the second surface water scenario, the alternatives assumed that in the future those entities with run-of-the-river rights will back these supplies with water contracted from BRA. Based on the hydrology developed by INTERA, it was assumed that a water contract equal to eight months of usage would be necessary to firm up the run-of-the-river rights. This approach was used for alternatives where BWA was serving surface water in the County.

For new facilities in the northern part of the county near Manvel that do not currently have run-of-the-river rights, it was assumed that all the water for such facilities would be purchased from the BRA. This surface water would be diverted from the river and pumped to an existing quarry/reservoir owned by the City of Manvel. The new treatment plant would be constructed near this reservoir.

Because of the availability of brackish groundwater, desalination of brackish groundwater using reverse osmosis (RO) technology is included as a supply for the third scenario. The location of the brackish groundwater plant is limited to downstream of State Highway 332 because of the ability to permit a discharge of high TDS water in this segment of the river. Seawater desalination is also included in the facility plan and is a source of supply. The seawater desalination plant would also be located south of State Highway 332 because of reasons stated above and due to access to seawater.

Section 4
Growth Projections

4.1 Population Projections

The population in the study area has increased significantly over the past 10 years and is projected to double over the next 20 years. In order to accurately capture the population growth of the study area, the following information was collected from each participant:

- Current population and growth projections;
- Number of existing water connections;
- Water system information;
- Utility development agreements for planned developments; and
- Build-out schedules and conceptual plans of planned developments.

In addition, individual meetings were held with each of the industrial project participants to obtain water treatment, transmission system and water demand information. A separate meeting was also held with the Brazoria County Groundwater Conservation District to collect groundwater usage data for the County.

This information, along with population and growth projection data obtained from the 2010 U.S. Census Bureau, *TWDB 2011 Region H Water Plan,* Houston-Galveston Area Council (HGAC) Traffic Analysis Zones (TAZ), Harris-Galveston Subsidence District (HGSD) and the *Harris County Toll Road Authority and TxDOT: Investment Grade Traffic and Revenue (T&R) Study (March 2012)* was used to develop population projections for each entity in five-year increments through a 2040 planning horizon. **Table 4-1** summarizes the population and growth projections from the sources cited above; this data was used for comparison purposes.

Table 4-1 Brazoria County – Population & Growth Projections

Reference	Brazoria County Population, Year 2010	Brazoria County Population 2040	Annual Population Growth Projection
2010 U.S. Census Bureau	313,166	---	---
TWDB 2011 Region H Water Plan	305,649	444,981	1.26%
Harris-Galveston Subsidence District	313,166	465,198	1.33%
Harris County Toll Road Authority-TxDOT Traffic and Revenue Study	358,749	937,816	3.25%

In Figures 4-1 through 4-3, targeted areas for population growth identified by the HGAC through its planning efforts for Brazoria County, in conjunction with the Harris County Toll Road Authority and TxDOT Traffic and Revenue Study, are shown below. The areas representing the highest population density in 2010 are highlighted in bright red in **Figure 4-1**. The northern region and other areas within Brazoria County that show the greatest amount of change in population density from 2010 to 2025 and then from 2010 to 2040 are highlighted in bright red in **Figures 4-2 and 4-3,** respectively.

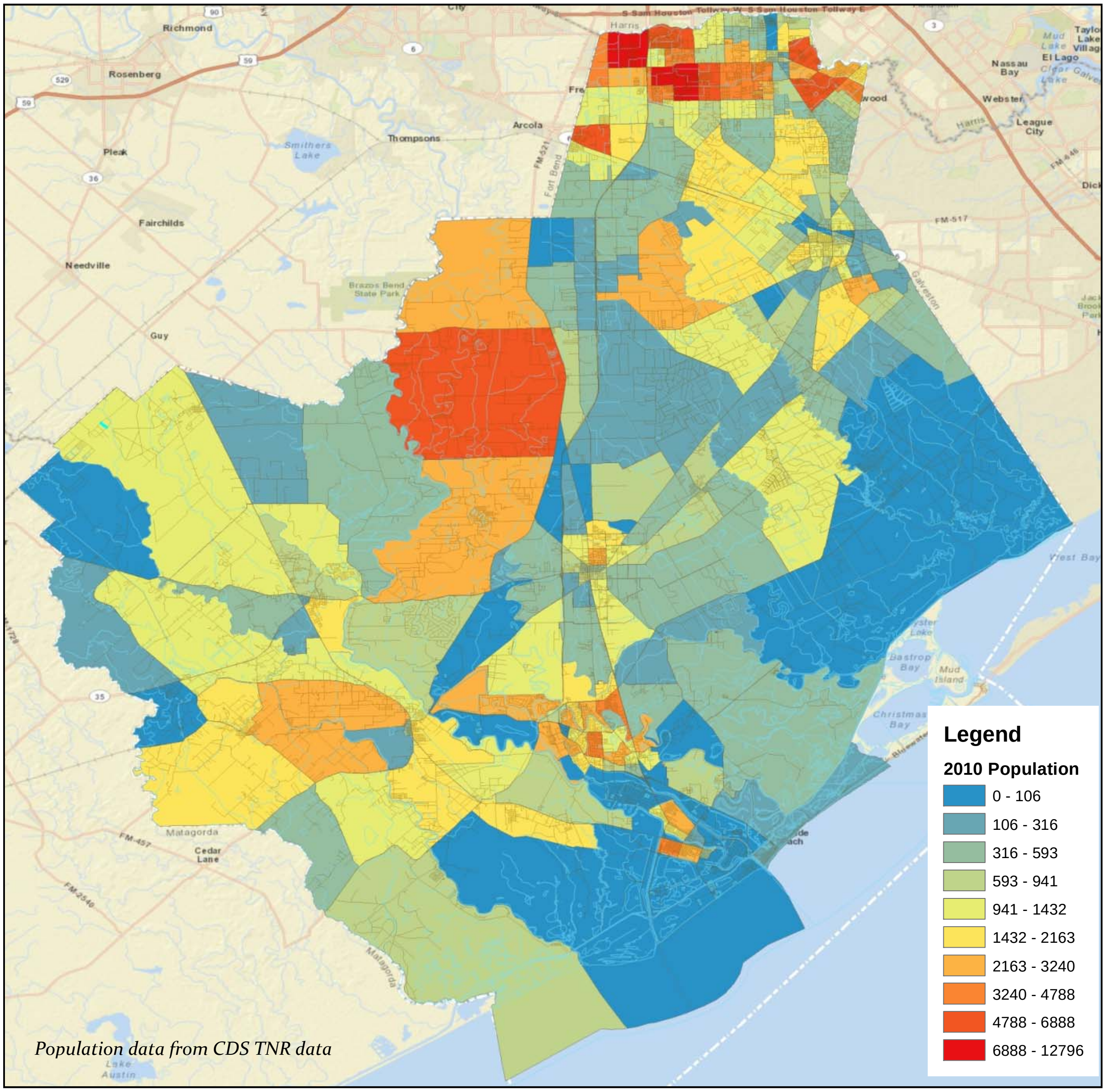


Figure 4-1
Brazoria County – 2010 Population Density

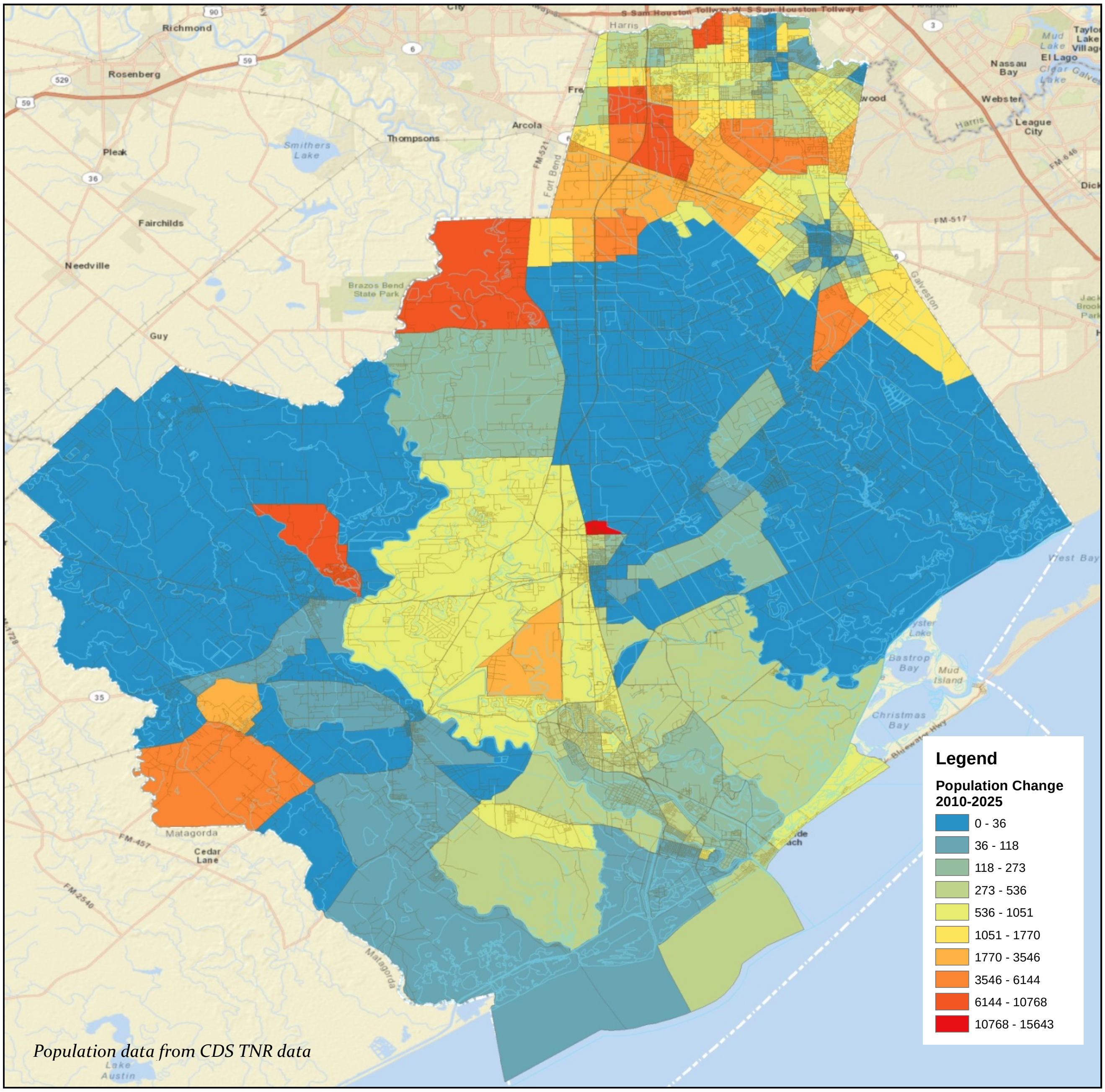


Figure 4-2
Brazoria County – Change in Population Density (2010-2025)

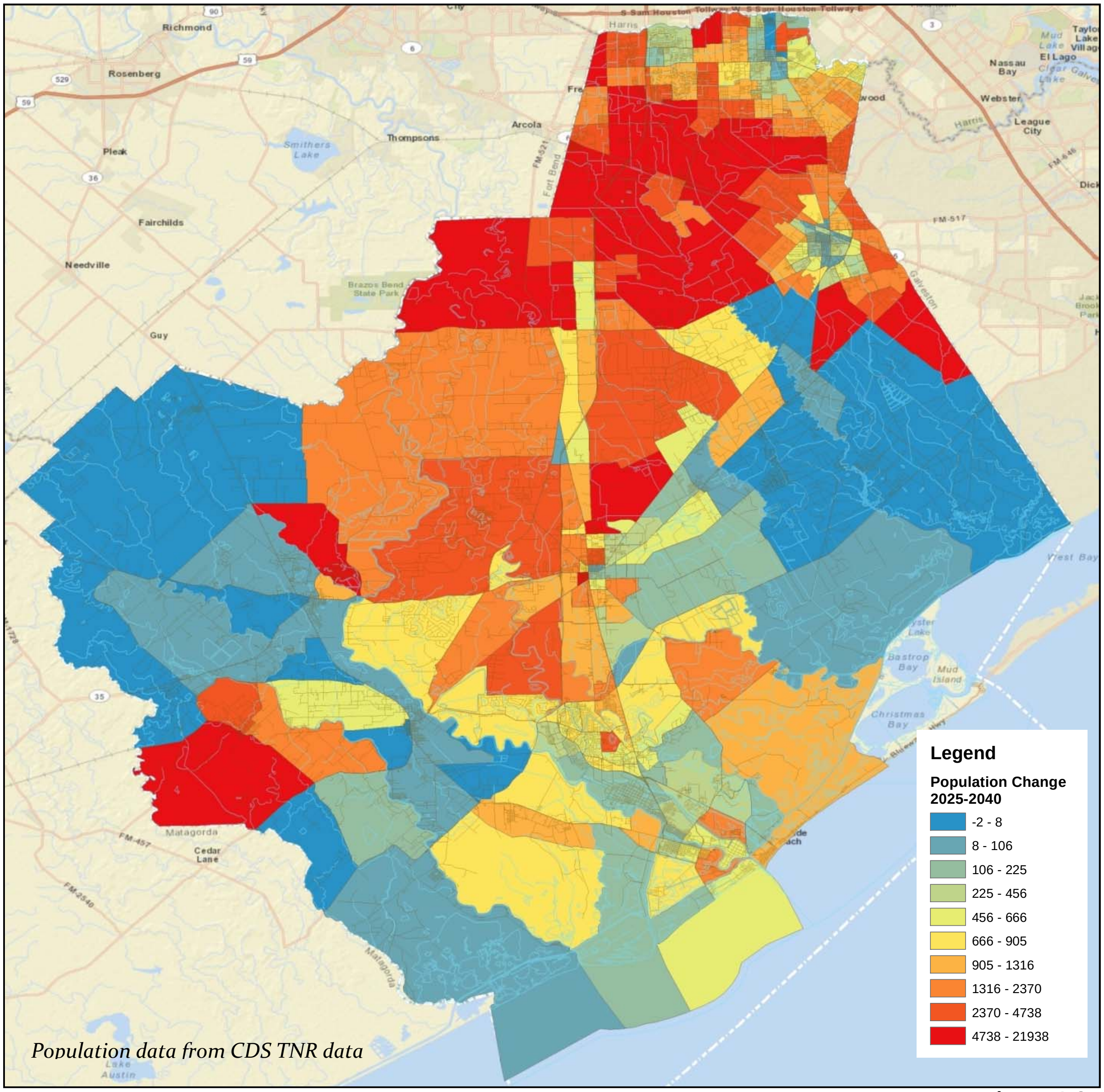


Figure 4-3
Brazoria County – Change in Population Density (2010-2040)

Based on the information collected at the beginning of the study, population projections were developed for each entity; these projections were based on the 2010 U.S. Census Bureau figures, each entity's own self-prepared population projections, and/or growth rates outlined in the *TWDB 2011 Region H Water Plan*. **Table 4-2** summarizes the self-prepared population projections in five-year increments from 2010 through 2040 for the participating cities and Texas Department of Criminal Justice (TDCJ) prison units located in Brazoria County. Reference **Appendix C** for a complete summary of population projections for the project participants.

Table 4-2 Population Projections - Project Participants Self-Prepared Data

Entity	Annual % Increase	Population Projections						
		2010	2015	2020	2025	2030	2035	2040
City of Alvin	1.1	24,236	25,736	27,236	28,736	30,236	31,736	33,236
City of Angleton	3.0	18,862	21,866	25,349	29,386	34,067	39,493	45,783
City of Brazoria	1.0	3,019	3,173	3,335	3,505	3,684	3,872	4,069
City of Clute	0.8	11,211	11,667	12,141	12,634	13,148	13,682	14,238
City of Freeport	-0.5	12,049	11,751	11,460	11,176	10,900	10,630	10,367
City of Lake Jackson	1.3	26,883	27,999	30,607	33,830	36,130	38,946	39,916
City of Manvel	7.8	5,179	7,539	10,976	15,978	23,261	33,862	49,296
City of Oyster Creek	0.5	1,192	1,222	1,253	1,285	1,317	1,350	1,384
City of Pearland	2.1	119,752	136,200	153,200	170,200	187,200	204,200	221,200
City of Richwood	2.4	3,510	4,000	4,654	5,349	6,091	6,634	7,233
TDCJ Clemens Unit	0	1,546	1,546	1,546	1,546	1,546	1,546	1,546
TDCJ Wayne Scott Unit	0	1,419	1,419	1,419	1,419	1,419	1,419	1,419
TDCJ Darrington Unit	0	2,501	2,501	2,501	2,501	2,501	2,501	2,501
TDCJ Ramsey Unit, Stringfellow Unit, and Terell Unit	0	5,877	5,877	5,877	5,877	5,877	5,877	5,877
TOTAL	-	237,236	262,496	291,553	323,423	357,376	395,747	438,066

Population projections were also included for small water systems and water user groups (WUGs) based on the *TWDB 2011 Region H Water Plan*. This population is referred to in this report as County Other WUG. Population growth for the new municipal utility districts (MUDs) along the State Highway 288 corridor was estimated based on the HGAC TAZ data for a five-mile area on both sides of the highway extending from Pearland to Angleton. This population is referred to in this report as County Other Future Districts. In order to capture the growth in the County (area located outside of the cities, MUDs and WUGs, referred to as County Other Domestic in this report), population projections listed in the *Harris County Toll Road Authority and TxDOT: Investment Grade Traffic and Revenue (T&R) Study* were used. These projections were chosen since the T&R study focuses on developing projections for areas even smaller than Traffic Analysis Zones (TAZs) in order to accurately forecast the growth for the repayment of bonds for proposed transportation projects. A summary of the population projections for Brazoria County, including the project participants and all other county entities, is presented in **Table 4-3**.

Table 4-3 Population Projections - Brazoria County

	Population Projections						
	2010	2015	2020	2025	2030	2035	2040
Total project participants plus (6) TDCJ units (based on participant data)	237,236	262,496	291,553	323,423	357,376	395,747	438,066
Small Systems and WUGs (County Other WUGs) (based on Region H data)	40,491	42,717	44,991	47,250	49,567	51,923	54,562
New MUDs and Districts (County Other Future Districts) (located along 288)	0	0	10,000	25,000	45,000	65,000	85,000
County Other Domestic (based on T&R data)	81,022	105,785	160,758	223,312	276,020	324,172	360,189
TOTAL	358,749	410,998	507,303	618,984	727,963	836,842	937,816

Figure 4-4 represents a comparison of data sources for population projections for the 10 participating cities and six TDCJ prison units located in Brazoria County; projections for the County Other Future Districts, County Other WUGs, new small systems and County Other Domestic are not included in the figure. The population shown for the Participant Data (the series labeled Cities in Figure 4-4) is approximately 140,000 greater than the TWDB data for 2040, and the T&R data forecasts the population to be approximately 200,000 greater than the TWDB data for 2040.

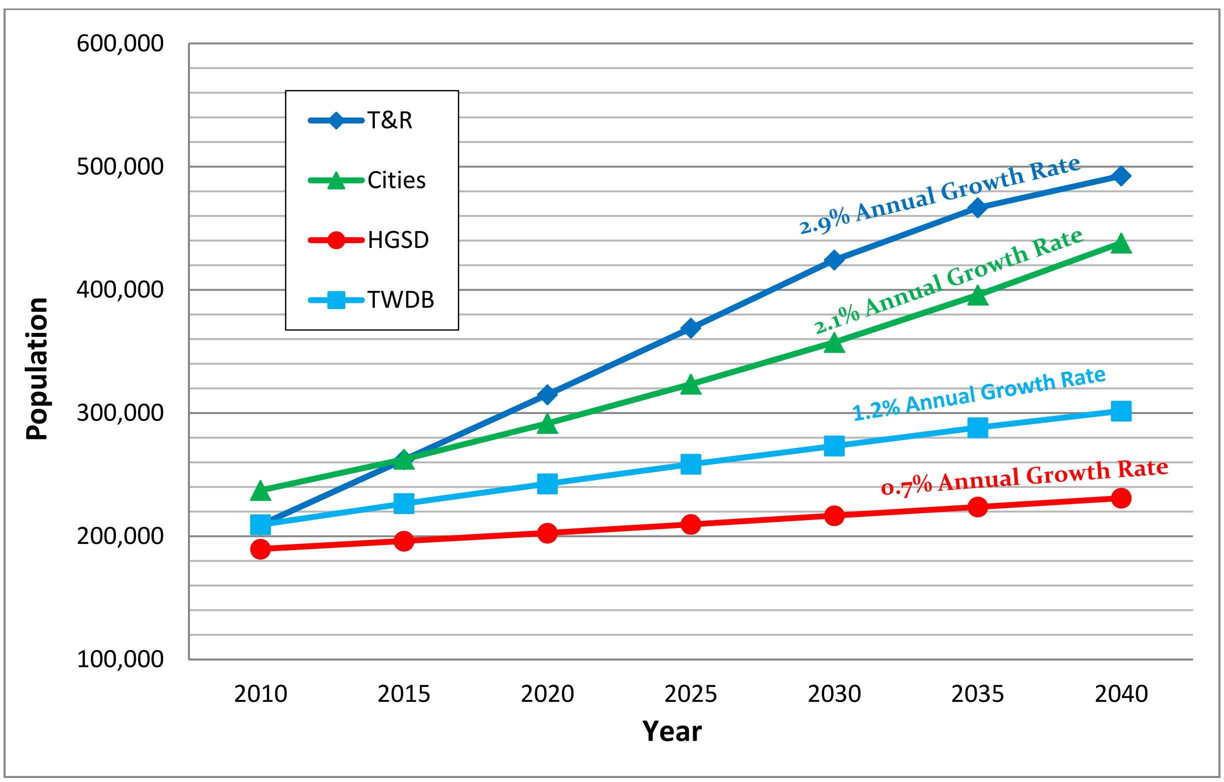


Figure 4-4
Population Projections – Comparison of T&R, City, TWDB and HGSD Data

Since each entity was able to justify the increase or decrease in population data and growth rate for its area, the data provided by the entities was used instead of the TWDB data to size the proposed regional water infrastructure. This methodology used by the project team was approved by TWDB staff on December 20, 2012. The population projections for each of the entities were used to calculate water demands for the study area.

4.2 Planning and Design Criteria

Primary design criteria used for planning and evaluating water supply systems are listed below, along with a description of how these criteria are used in the sizing of the various water system components:

- *Average yearly water demand:* Used for estimating long-term surface water and groundwater withdrawal rates and for estimating yearly operational costs.
- *Maximum daily demand:* Used for sizing wells, raw water intakes, treatment plants, and major transmission mains (for example, between treatment plants and storage facilities).
- *Peak hour demand*:* Used for sizing pumps and hydro-pneumatic tanks that supply water directly into the distribution system, and for distribution piping. Peak hour demands are also involved in sizing elevated water storage tanks.
- *Minimum and maximum pressures*:* Dictate the elevations of elevated storage tanks, pipe sizing, service areas for each elevated or hydro-pneumatic tank, and pumping heads.
- *Minimum water storage requirements*:* Used to size clearwells, ground storage tanks and elevated tanks.

As presented below, not all of the above criteria are applicable when planning a regional water system as most apply only or primarily to the planning of the local storage and distribution system. (Criteria marked with "*" were not applicable to this study). This is especially true if the regional system primarily provides wholesale treated water to the participating entities.

The Texas Commission on Environmental Quality (TCEQ) has established minimum values for most of the criteria listed above and 30 TAC 290 Subchapter D requires that a system be designed to meet the minimum criteria or better, unless the system can provide data that its water usage is consistently lower than the TCEQ minimum criteria.

4.2.1 Average Yearly Water Demand

The average yearly water demand is used to determine the long-term water needs of a community. This demand is used as a basis for acquiring surface water contracts, or determining long-term impacts on an aquifer. Average yearly demands are seldom used for sizing the infrastructure of a water system but they are used for estimating yearly operational costs, such as the cost of chemicals, energy, and solids hauling and disposal.

4.2.2 Maximum Day Water Demand

The maximum day water demand is the most important criterion in an infrastructure planning study because it is used to determine the required capacities of wells, intakes, water treatment plants, transmission mains, and most of the pumping stations found in a regional water system. The TCEQ minimum design standard is 0.6 GPM per connection for maximum day water demands.

This design standard was used to size the infrastructure in each of the alternatives considered in this study. Although a few of the participants have experienced maximum day demands greater than 0.6 GPM per connection, these will not have a significant impact on the overall sizing of the regional facilities for each alternative. If a regional system is implemented, the demands specific to each part of the regional system will need to be used in the final engineering design.

4.2.3 Peak Hour Demand

Peak hour demands dictate the size and layout of the distribution network within a water system and the size of the pumps and hydro-pneumatic tanks that supply water directly into a distribution system. Peak hour demands are also involved in sizing both ground and elevated storage tanks.

Most water systems do not monitor peak hour demands due to the difficulty of measuring these water demands. For this reason, the TCEQ minimum design criterion of 2.0 GPM per connection is typically used when planning and designing new infrastructure.

Peak hour demands are not applicable to a regional water system whose purpose is to provide treated water to existing entities that already have their local water distribution systems in place, or to future entities that will be constructing their own local water distribution infrastructure.

4.2.4 Maximum and Minimum Pressures

Maximum and minimum pressures impact pipeline sizes, storage tank elevations and booster pump locations regarding the planning and design of regional water facilities. According to TCEQ design criteria, the minimum pressure to use in laying out regional alternatives is 35 pounds per square inch (psi). Transmission main pressures are typically designed for operating pressures not to exceed 200 psi; but in some cases, higher pressures may be allowed in order to avoid the additional costs of installing a booster pumping station for example.

4.2.5 Minimum Water Storage Volume

TCEQ's water storage requirements vary with source water type and system size. Systems with surface water sources must have a clearwell(s) with a volume of at least 50 gallons per connection or a volume equal to 5 percent of the daily plant capacity, whichever is greater. TCEQ requires all water systems to provide a total storage of no less than 200 gallons per connection. At a minimum, 100 gallons of elevated storage must be provided for larger groundwater systems and surface water systems. For smaller systems, pressure (hydro-pneumatic) tanks may be used in lieu of elevated storage tanks, but the total storage must equal 200 gallons per connection.

Regional storage facilities are usually provided where booster pumping stations are required due to the length of a regional transmission main or where significant elevation increases occur along the main. These tanks are either ground storage or elevated storage tanks depending on the topography along the transmission main.

4.2.6 Recommended Criteria for Projecting Regional Water Demands

In summary, a maximum day demand of 0.6 GPM per connection was selected for sizing future facilities in this study. As previously mentioned, the maximum day demand has the largest impact on the sizing and cost of regional water facilities. In addition to TCEQ requirements, design criteria used are as follows:

- *Minimum transmission main pressure:* 35 pound per square inch (psi)
- *Maximum transmission main pressure:* 200 psi

- *Maximum velocity in water transmission mains:* 5.0 feet per second (fps)
- *Water storage for booster pumping stations:* 30 minutes of storage at the design pumping rate of the booster station

4.3 Water Demand Projections

The first step in defining water treatment alternatives is to determine future demands for the study area. The assessment of water demands for the participating cities included evaluating their historical water usage characteristics (average day, maximum day and peak hour demands), as well as projected population growth and water consumption data. A summary of each of the project participating cities' water consumption data based on gallons per capita per day (GPCD) is provided below in **Table 4-4.** Each city reported its per capita water usage data to TWDB during its annual water usage survey and/or provided the data specifically for this study. The participant's per capita water demand reported in the 2009 TWDB Survey ranged from 71 to 166 GPCD. Based on discussions with TWDB, the larger reported value of the two (bolded) was used to represent a conservative water consumption scenario. Some participating entities provided 2012 per capita water consumption values during the study period; however, these values were lower than the values reported by the TWDB and were not used in these water demand projections.

The per capita water demand goal for TWDB is 140 GPCD. For those entities with water consumption amounts exceeding 140 GPCD, a reduction goal was identified incrementally through 2030 in order to reach TWDB's water consumption goal. Entities with per capita water demands less than or equal to 140 GPCD were not changed.

Table 4-4 Per Capita Water Usage - Project Participating Cities

Entity	Per Capita Water Usage Data** (GPCD)					
	2009 TWDB Survey	Entity Data	2015 Reduction Goal	2020 Reduction Goal	2025 Reduction Goal	2030 Reduction Goal
City of Alvin	102	**109**	--	--	--	--
City of Angleton	79	NA*	--	--	--	--
City of Brazoria	71	**102**	--	--	--	--
City of Clute	111	NA*	--	--	--	--
City of Freeport	91	**130**	--	--	--	--
City of Lake Jackson	NR*	193	180	167	153	140
City of Manvel	113	NA*	--	--	--	--
City of Oyster Creek	166	NA*	160	153	147	140
City of Pearland	NR*	141	--	--	--	--
City of Richwood	**88**	85	--	--	--	--

*NR represents 'not reported'; NA represents 'not available'
**Bolded values are the larger of the two reported to TWDB or provided by the city. Values shown in red are those used to calculate the water demand projections.

Average day water demand projections for each of the cities were calculated using their population projections in Table 4-2 and their per capita water usage listed above in Table 4-4 (values highlighted in red). Maximum day water demand projections, converted to million gallons per day (MGD), were then calculated by applying a peaking factor to the each entity's projected average day demands through 2040. This methodology, used by the project team, was also approved by TWDB staff. **Table 4-5** below summarizes the maximum day water demand projections for the participating cities and TDCJ prison units; reference **Appendix D** for a complete summary of water demand projections for the project participants.

Table 4-5 Water Demand Projections - Project Participants

Entity	Peaking Factor	Maximum Day Water Demands (MGD)						
		2010	2015	2020	2025	2030	2035	2040
City of Alvin	1.68	4.44	4.72	4.99	5.27	5.54	5.82	6.09
City of Angleton	2.51	3.73	4.33	5.02	5.82	6.74	7.82	9.06
City of Brazoria	1.87	0.58	0.61	0.64	0.67	0.70	0.74	0.78
City of Clute	1.61	2.00	2.08	2.17	2.25	2.35	2.44	2.54
City of Freeport	1.21	1.90	1.85	1.81	1.76	1.72	1.68	1.63
City of Lake Jackson	1.64	8.50	8.85	9.68	10.70	11.42	12.31	12.62
City of Manvel	1.33	0.78	1.13	1.65	2.40	3.50	5.09	7.41
City of Oyster Creek	1.67	0.33	0.34	0.35	0.36	0.36	0.37	0.38
City of Pearland	1.86	23.03	26.30	30.70	40.30	47.70	52.50	58.10
City of Richwood	2.67	0.83	0.94	1.10	1.26	1.43	1.56	1.70
TDCJ Clemens Unit	1.0	0.46	0.46	0.46	0.46	0.46	0.46	0.46
TDCJ Wayne Scott Unit	1.0	0.39	0.39	0.39	0.39	0.39	0.39	0.39
TDCJ Darrington Unit	1.0	0.76	0.76	0.76	0.76	0.76	0.76	0.76
TDCJ Ramsey Unit, Stringfellow Unit, and Terell Unit	1.0	1.52	1.52	1.52	1.52	1.52	1.52	1.52

The comparison of maximum day water demands in both 2010 and 2040 versus the existing water production capacity for the participating cities is provided in **Figure 4-5**. As shown in the figure, the Cities of Alvin, Clute, Freeport and Oyster Creek have sufficient water production capacity to meet their maximum day demands in 2040. For the City of Freeport, the water demand projections continue to decline due to Dow Chemical and other adjacent industries purchasing homes located within a certain distance from their industrial plants and leaving them vacant in order to provide a safety buffer. The Cities of Angleton, Lake Jackson, Manvel, Pearland, and Richwood all need additional water production capacity to meet 2040 maximum day demands. The City of Brazoria needs additional water production capacity to meet current maximum day demands.

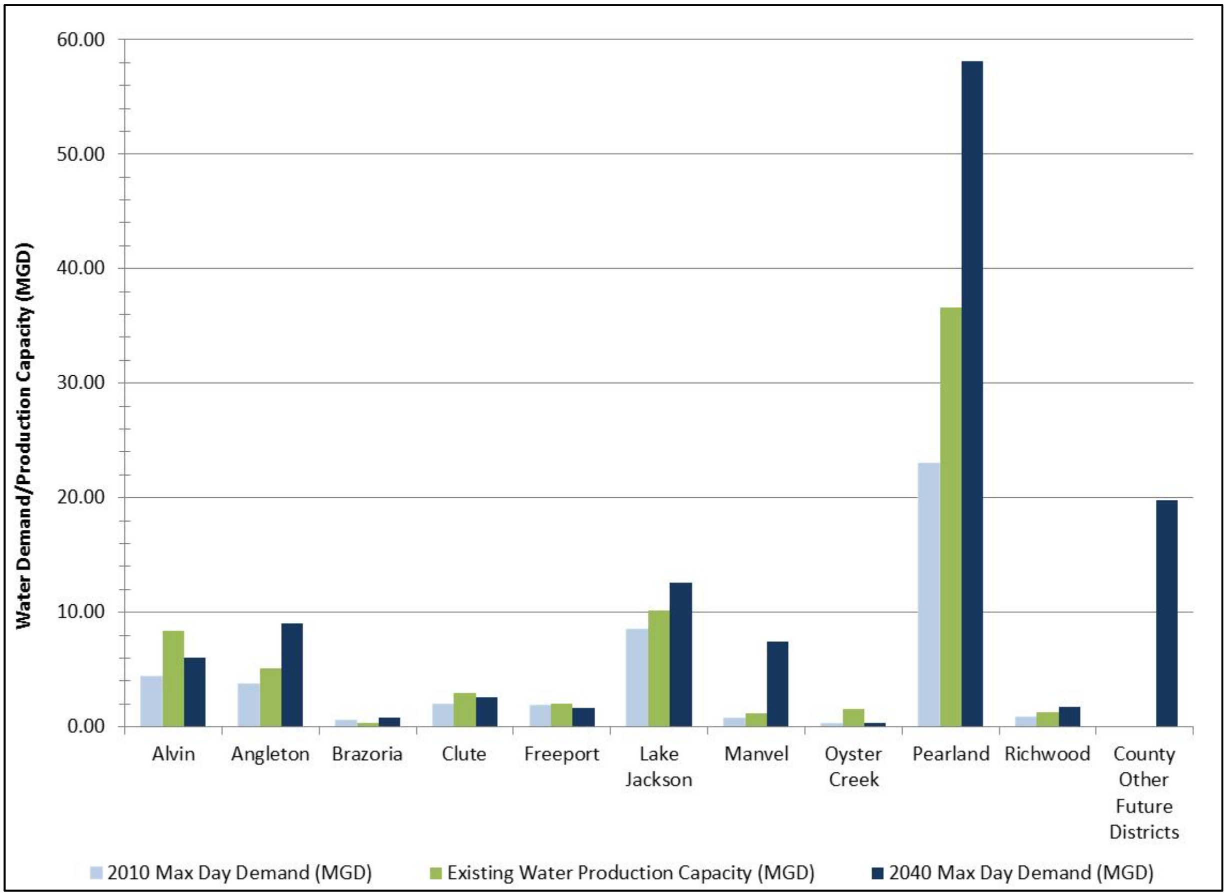


Figure 4-5
Maximum Day Demands vs. Water Capacity

Section 5
Description of Existing Water Systems

The levels of projected growth presented in Section 4 may have an impact on the participating cities' existing water systems. Prior to making alternative recommendations needed to meet future demands, CDM Smith evaluated the water systems within the study area to determine their existing capabilities. This section of the report describes these systems.

5.1 Existing Water Systems by Participant

There are several cities in Brazoria County with independent water systems. Many of the cities in Brazoria County are participants in this master plan. There are also many small utilities, in Brazoria County referred to as Water User Groups (WUGs) by the TWDB that serve a small number of residents. In this master plan, these water users are referred to as County Other WUGs. Examples of County Other WUGs would be the systems operated by Orbit Systems, independent utilities like Varner Creek and small communities like West Columbia. There are also hundreds of residential properties that have individual wells to meet their domestic water needs. In this master plan, the domestic water users in the County are referred to as County Other Domestic users. Below are short descriptions of the participating cities' water systems and a listing of some of the WUGs in Brazoria County.

5.1.1 City of Pearland

The City of Pearland water system has a Superior rating by the TCEQ. Pearland's water supply consists of groundwater and surface water sources. The City has numerous groundwater wells with a combined capacity of 15.5 MGD. The City also has surface water supply it obtains through the City of Houston in two ways. First, the City of Pearland is an equity owner in the City of Houston's Southeast Water Purification Plant. This supplies the City of Pearland with 10 MGD of capacity. The City of Pearland also purchases water directly from the City of Houston. This wholesale water contract is for a capacity of 6 MGD. The City of Pearland also has a surface water contract with GCWA for 10,000 acre-feet per year. The City of Pearland plans to build a surface water treatment plant to treat this water when demand justifies the construction. The City of Pearland recently completed a Water Master Plan and excerpts from that master plan are located in **Appendix E**. In 2010, the City of Pearland's average daily demand was 12.38 MGD (based on a 1.86 peaking factor) and its max day demand was 23.03 MGD.

5.1.2 Cities of Manvel and Alvin

The Cities of Manvel and Alvin both obtain their water supply from groundwater. The City of Manvel has four wells with a combined capacity of 1.15 MGD. In 2010, the City of Manvel's average day demand was 0.59 MGD and its max day demand was 0.78 MGD.

The City of Alvin water system has a Superior rating by the TCEQ. The City of Alvin has five wells with a combined capacity of 8.424 MGD. In 2010, the City of Alvin's average day demand was 2.64 MGD and its max day demand was 4.44 MGD.

5.1.3 Brazosport Water Authority Participating Cities

The Brazosport Water Authority (BWA) has water supply contracts with the following cities. The contract amount is shown in parenthesis.

- City of Angleton (1.8 MGD)
- City of Brazoria (0.3 MGD)
- City of Clute (1.0 MGD)
- City of Freeport (2.0 MGD)
- City of Lake Jackson (2.0 MGD)
- City of Oyster Creek (0.095 MGD)
- City of Richwood (0.235 MGD)`

The 2010 average and maximum day demands for each of these Cities are presented in **Table 5-1**.

Table 5-1 BWA Participating Cities 2010 Average and Max Day Demands

Entity	Average Day Demand (MGD)	Max Day Demand (MGD)
Angleton	1.49	3.73
Brazoria	0.31	0.58
Clute	1.24	2.00
Freeport	1.57	1.90
Lake Jackson	5.19	8.50
Oyster Creek	0.20	0.33
Richwood	0.31	0.83

In addition to the seven participating cities, BWA also has wholesale water supply contracts with the Texas Department of Criminal Justice (TDCJ) to serve the Clemens and Wayne Scott Units with up to 0.75 MGD (0.45 MGD to Clemens and 0.30 MGD to Wayne Scott); and with Dow Chemical to serve up to 1.0 MGD.

The City of Angleton has a Superior rating by the TCEQ. In addition to the water supplied through the BWA contract, the City of Angleton has three wells with a combined capacity of 3.34 MGD.

The City of Brazoria has a Superior rating by the TCEQ. The City of Brazoria receives all of its water supply through its BWA contract.

The City of Clute has a Superior rating by the TCEQ. In addition to the water supplied through the BWA contract, the City of Clute has three wells with a combined capacity of 1.83 MGD. The City of Clute has been discussing purchase of additional water from BWA.

The City of Freeport receives all of its water through its BWA contract.

The City of Lake Jackson has a Superior rating by the TCEQ. In addition to the water supplied through the BWA contract, the City of Lake Jackson has 12 wells with a combined capacity of 8.198 MGD. The City of Lake Jackson has been in discussions with BWA to purchase additional water.

In addition to the water supplied through the BWA contract, the City of Oyster Creek has two wells with a combined capacity of 1.5 MGD. At the current time, Oyster Creek is only using water supplied by its groundwater wells.

In addition to the water supplied through the BWA contract, the City of Richwood has three wells with a combined capacity of 1.008 MGD.

Table 5-2 presents a summary of each City's water sources, system storage and pumping capacities. This information was either provided by the individual cities or obtained from TCEQ.

5.1.4 County Other Water User Groups

The TWDB defines a Water User Group (WUG) as a city with a population of more than 500 people or a utility that uses more than 250,000 gallons per day. A list of WUGs from the Region H study for Brazoria County and others obtained from the Brazoria County Groundwater Conservation District is shown in **Table 5-3**. Some of the WUGs are served by the water system operators Aqua Texas, Orbit Systems and Trent Water Works. The WUGs listed in Table 5-1 are grouped by system operator. All of the listed WUGs obtain their water supply from groundwater wells.

In addition to population in water user groups, there is significant population in Brazoria County using individual domestic water wells. The population using individual domestic water wells is referred to in this master plan as County Other Domestic.

5.2 Study Area Overview and Regional Issues

The study area is expected to experience significant growth along the SH 288 corridor as population from Houston expands southward along this transportation corridor. The Grand Parkway will also bring development pressure along its alignment north of Angleton and south of Manvel and Alvin. For developments along these transportation corridors to have water, the only source currently available is groundwater. As stated in Section 3, groundwater usage is nearing or already exceeding the MAG for Brazoria County. If the additional population expected to reside in Brazoria County over the next 30 years all use groundwater, the groundwater demand will grow so that it is 30,000 acre-feet per year in excess of the MAG. The water demand growth relative to the MAG is shown in **Figure 5-1**. Alternatives to using the fresh water resource of the Gulf Coast Aquifer System are needed to provide the water supplies to this future population.

Also as described in Section 3, surface water is currently not available for users that need firm water supplies. When BRA obtains its system-wide permit and/or Allens Creek Reservoir is constructed, then firm surface water supplies will be available for future populations. The system wide permit is being reviewed by the TCEQ at this time. Even with this permit, firm water may not be available until Allens Creek Reservoir is complete. The construction and completion of that reservoir will not occur until after 2025 based on the Region H Water Plan.

Table 5-2 Existing System Capacities

Entity	Surface Water (MGD)[1]	Ground Water (No. of wells / Total MGD)	2010 Population	GPM/ connection	Storage Type[2]	Storage (No. of Units / MG)	Pumping (No. of Pumps / GPM per pump)
City of Alvin	0	5 / 8.424	24,236	0.72	GST	2.31	6 / 1800 4 / 2400
					EST	1.75	
City of Angleton[4]	1.80	3 /3.34	18,862	0.57	GST	1 / 0.40 2 / 1.00	8 / 750 1 /900
City of Brazoria	0.30	0 / 0	3,019	0.21	GST	1.2	Data not available[3]
					EST	0.5	
City of Clute	1.00	3 / 1.83	11,211	0.53	GST	1.00	Data not available[3]
					EST	0.75	
City of Freeport	2.00	0 / 0	12,049	0.35	GST	2 / 0.50 1 / 1.00	1 / 1000 4 / 500 1 / 600
					EST	2 / 0.50	
City of Lake Jackson	2.00	12 / 8.198	26,883	0.79	GST	4 / 1.00	7 / 1000
					EST	3 / 0.50 1 / 0.30 1 / 0.75	
City of Manvel	0	4 / 1.15	5,179	0.46	GST	1 / 0.50	3 / NA
City of Oyster Creek	0.095	2 / 1.5	1,192	2.79	GST	1 / 0.20	2 / 500
City of Richwood[5]	0.235	3 / 1.008	3,510	0.74	GST	1 / 0.33	3 / 500
					EST	1 / 0.25 1 / 0.75	

Notes

1 Surface Water is provided through contracts with the BWA.

2 Storage type does not include hydropneumatic/pressure tanks.

3 Storage type and capacity for Cities of Alvin, Brazoria and Clute taken from the TCEQ Water Utility Database. Only total storage volumes were provided, not individual number of units.

4 Storage and pumping includes storage tanks and pumps at Jamison Water Plant, Water Plant #2 and Water Plant #3.

5 Storage and pumping includes storage tanks and pumps at Water Plants 1 and 2.

6 Data not provided by entity during data gathering phase of the project.

Table 5-3 Water User Groups in Brazoria County

WUG Name	Operator	WUG Name	Operator	WUG Name	Operator
BERNARD ACRES	Aqua Texas	COUNTRY ACRES II (2 wells)	Orbit Systems	BRAZORIA COUNTY MUD 21	
CALICO FARMS SUBDIVISION	Aqua Texas	COUNTRY MEADOWS (2 wells)	Orbit Systems	BRAZORIA COUNTY MUD 25	
CENTENNIAL PLACE	Aqua Texas	DEMI JOHN ISL. WTR. SYS. (2 wells)	Orbit Systems	BRAZORIA COUNTY MUD 29	
COUNTRY CREEK ESTATES WTR SYSTM	Aqua Texas	DEMI JOHN PLACE (2 wells)	Orbit Systems	BRAZORIA COUNTY MUD 3	
FLORA 6	Aqua Texas	GRASSLANDS (2 wells)	Orbit Systems	BRAZORIA COUNTY MUD 31	
FLORA 7	Aqua Texas	LARKSPUR	Orbit Systems	BRAZORIA COUNTY MUD 4	
HASTINGS HMWNRS WTR SYSTM	Aqua Texas	LEE RIDGE SUBDIVISION	Orbit Systems	BRAZORIA COUNTY MUD 6	
HEIGHTS COUNTRY I & II (2 wells)	Aqua Texas	MARK V ESTATES (2 wells)	Orbit Systems	BRAZOS RIVER CLUB	
LAS PLAYAS	Aqua Texas	KOUNTRY KORNER	Orbit Systems	BRYAN BEACH WSC	
MEADOWLAND SUBDIVISION	Aqua Texas	MOORLAND S/D	Orbit Systems	CITY OF DANBURY	
MEADOWLARK I & II (2 wells)	Aqua Texas	OAK MEADOWS ESTATES SBDVSN	Orbit Systems	CITY OF FRIENDSWOOD	
MEADOWVIEW I & II (2 wells)	Aqua Texas	PALOMA ACRES SUBDIVISION	Orbit Systems	CITY OF HILLCREST VILLAGE	
MORELAND SUBDIVISION BLOCK 1&2	Aqua Texas	QUAIL VALLEY VI	Orbit Systems	CITY OF HITCHCOCK	
MORELAND SUBDIVISION BLOCK 3&4	Aqua Texas	RIVERSIDE ESTATES	Orbit Systems	CITY OF LIVERPOOL	
OAK BEND ESTATES	Aqua Texas	ROSHARON ROAD ESTATES (3 wells)	Orbit Systems	CITY OF SWEENY	
PALMCREST SUBDIVISION	Aqua Texas	ROSHARON TOWNSHIP	Orbit Systems	CITY OF WEST COLUMBIA	
PALMETTO SUBDIVISION I & 2 (2 wells)	Aqua Texas	RYAN LONG I & II WATER SYSTEM	Orbit Systems	COMMODORE COVE IMPROVEMENT DISTRICT	
PLEASANT MEADOWS SUBDIVISION	Aqua Texas	SAN BERNARD RIVER ESTATES (2 wells)	Orbit Systems	HOLIDAY SHORES	
PLEASANTDALE SUBDIVISION	Aqua Texas	SANDY MEADOWS EST. (2 wells)	Orbit Systems	JONES CREEKWOOD	
QUAIL MEADOWS I & II (2 wells)	Aqua Texas	SNUG HARBOR SUBDIVISION	Orbit Systems	KEY LARGO UTILITIES	
SANDY RIDGE SUBDIVISION	Aqua Texas	STONERIDGE LAKES	Orbit Systems	LINCECUM WATER POWERS ADDITION	
SHARONDALE SUBDIVISION	Aqua Texas	WILCO WATER SYSTEM (2 wells)	Orbit Systems	MALLARD LAKE CLUB	
SOUTH MEADOWS EAST	Aqua Texas	WOLF GLEN WATER SYSTEM (2 wells)	Orbit Systems	MARIA ELENA'S MOBILE HOMES	
SOUTH MEADOWS WEST	Aqua Texas	ANGLECREST SUBDIVISION (Trent #11)	Trent Water Works	MARLIN MARINA WATER SYSTEM	
STERLING ESTATES I & II (2 wells)	Aqua Texas	BERNARD RIVER OAKS (Trent #8)	Trent Water Works	OAK CREST OF MANVEL	
VILLAGE TRACE WATER SYSTEM	Aqua Texas	BLACK'S FERRY WATER CO. (Trent #14)	Trent Water Works	OAK MANOR MUD	
WAGON WHEEL UTILITY CO	Aqua Texas	CHOCTAW S/D (Trent # 1 & 2)	Trent Water Works	OYSTER CREEK ESTATES	
WELLBORN ACRES	Aqua Texas	HOMELAND SUBDIVISION (Trent #7)	Trent Water Works	ROBIN COVE WATER SUBDIVISION	
WESTWOOD SUBDIVISION	Aqua Texas	JONES CREEK TERRACE (Trent #9) 5 wells	Trent Water Works	SAVANNAH PLANTATION SUBDIVISION	
WEYBRIDGE SBDVSN WTR SYSTM	Aqua Texas	PARKLAND (Trent #10)	Trent Water Works	SHADY CREEK SECTION 3 WATER SYSTEM	
WINDSONG SUBDIVISION I & II (2 wells)	Aqua Texas	RIVER OAKS (Trent #5) 2 wells	Trent Water Works	SUNCREEK ESTATES SECTION 1	
ANGLE ACRES WATER SYSTEM (2 wells)	Orbit Systems	RIVER RUN WATER SYSTEM	Trent Water Works	SUNCREEK RANCH SECTION 2	
BEECHWOOD SUBDIVISION (2 wells)	Orbit Systems	RIVERWOOD S/D WTR. SYS (Trent #13)	Trent Water Works	TOWN OF HOLIDAY LAKES	
BERNARD OAKS (2 wells)	Orbit Systems	ROYAL RIDGE (Trent 6 & 6A)	Trent Water Works	TOWN OF QUINTANA	
BLUE SAGE GARDENS SUBDIVISION	Orbit Systems	WOOD OAKS WATER WORKS (Trent #12)	Trent Water Works	TREASURE ISLAND MUD	
BRANDI ESTATES	Orbit Systems	ANCHOR ROAD MOBILE HOME PARK		TURTLE COVE LOT OWNERS ASSOC	
BRIAR MEADOWS	Orbit Systems	BATEMAN WATER WORKS		TWIN LAKES CLUB	
COLONY COVE S/D (2 wells)	Orbit Systems	BAYOU SHADOWS WATER SYSTEM		VARNER CREEK UTILITY DISTRICT	
COLONY TRAILS SUBDIVISION	Orbit Systems	BRAZORIA COUNTY FWSD 1 DAMON		VILLAGE OF SURFSIDE BEACH	
CORONADO COUNTRY I & II	Orbit Systems	BRAZORIA COUNTY MUD 2		WOLFE AIR PARK	

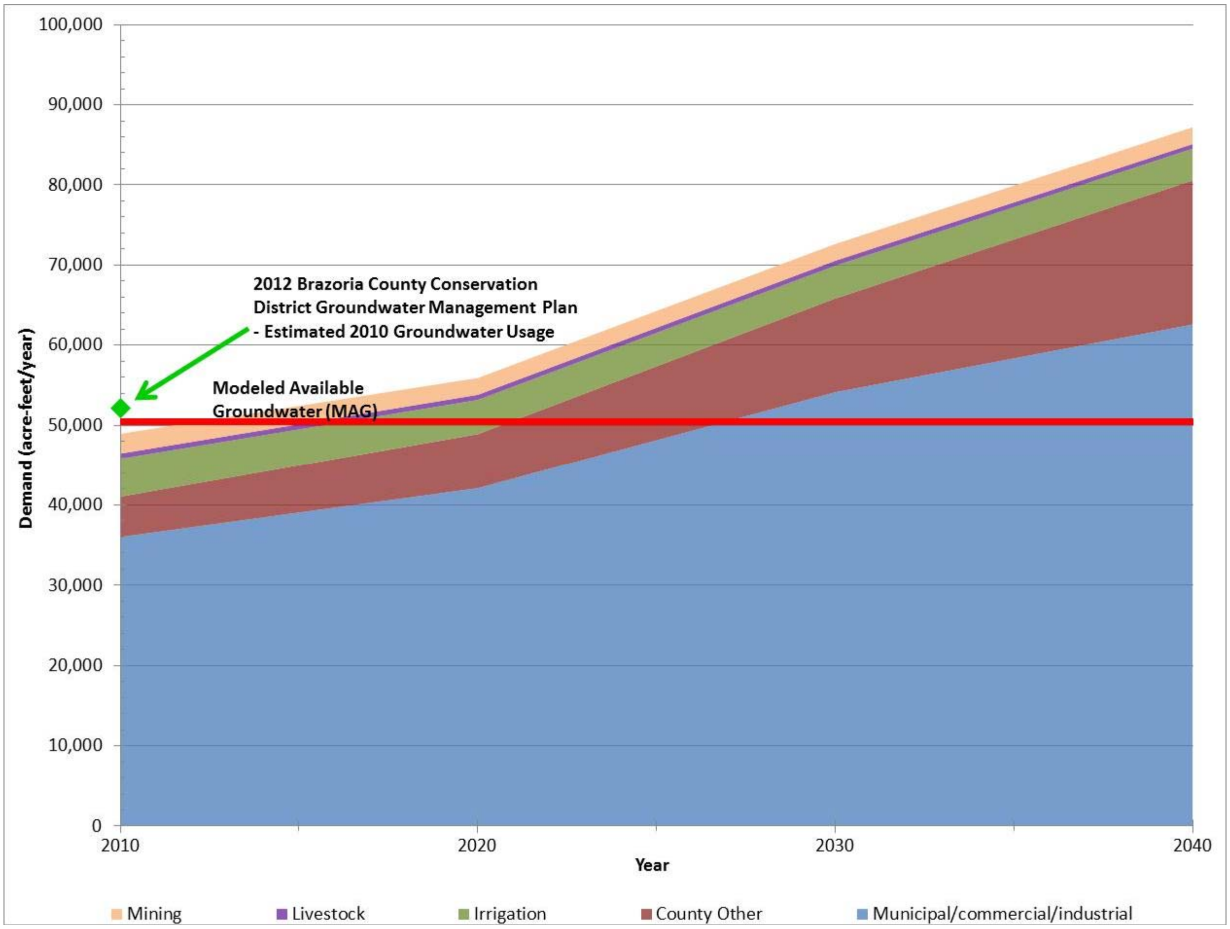


Figure 5-1
Water Demand Growth Relative to MAG

An area of interest for the participating cities is the use of reclaimed water. Water is already being reused within Brazoria County as there are numerous wastewater outfalls throughout the study area. **Figure 5-2** shows the locations and relative sizes of the wastewater outfalls in Brazoria County. Many of the outfalls drain to Oyster Creek or the Brazos River where it is used as a source of industrial water.

5.3 Potential Regional Infrastructure Assets

Brazoria County has two existing regional water providers, BWA and GCWA. BWA is primarily focused on the delivery of treated water and GCWA, although it provides treated water in Galveston County, is primarily focused on the delivery of raw water in Brazoria County. The BWA has available capacity in its treatment and transmission systems to serve additional demands from its existing participating customers and serve regional demands in other parts of the County.

The existing water treatment plant has water supply contracts with participating customers and wholesale customers that total 9.18 MGD. The rated capacity of the plant is 17.97 MGD. Therefore, there is 8.79 MGD of treated water capacity that could be contracted to other entities. The BWA pipeline system is shown on **Figure 5-3**. This figure also shows the diameters of the pipes in the system, the nominal capacities of each pipe, and the current contracted amounts moved through the system. There is available capacity in all the lines; however, of special interest is the 20-inch pipeline that travels from the BWA WTP to Angleton. This pipeline has a nominal capacity of 7.05 MGD and currently provides the City of Angleton and the TDCJ Wayne Scott Unit with their contracted supplies of 1.8 MGD and 0.3 MGD, respectively. There is approximately 5 MGD of capacity in this pipeline that could be used to move water from the BWA WTP to new customers north of Angleton.

BWA is a regional water provider created by HB 650 that has been serving its seven participating cities, a state agency, and private industry with wholesale water since 1989. The creation of the authority does not limit its scope to providing water to its current participating cities. BWA has the governance, management, and operations staff to be the regional provider for the growth areas in Brazoria County.

5.4 Water Conservation and Drought Contingency Plans

Senate Bill 1 (SB-1), passed by the Texas Legislature in 1997, increased the number of entities required to submit water conservation and drought contingency plans. As part of a regionalization strategy, all involved entities would need to draft and adopt Water Conservation and Drought Contingency Plans under the conditions of SB-1. In addition, the TWDB requires project participants receiving grant funding through the Regional Water and Wastewater Facilities Planning Grant Program to prepare and implement water conservation and drought contingency plans. These plans must meet all minimum requirements outlined by the Texas Commission on Environmental Quality (TCEQ).

Many of the project participants using treated surface water already have water conservation and drought contingency plans in place; copies of these plans for each of the participating cities are provided in **Appendix A** for reference.

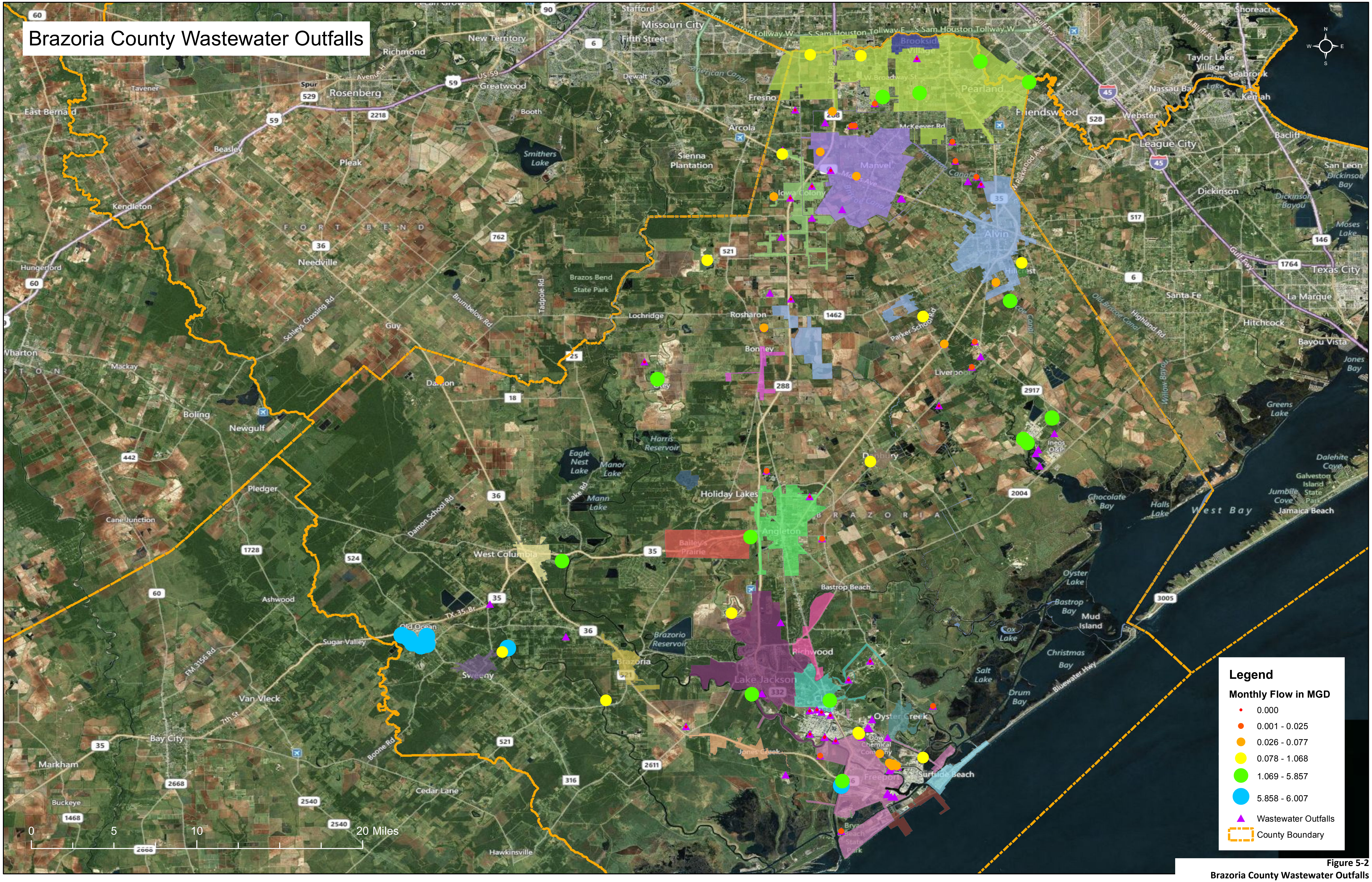
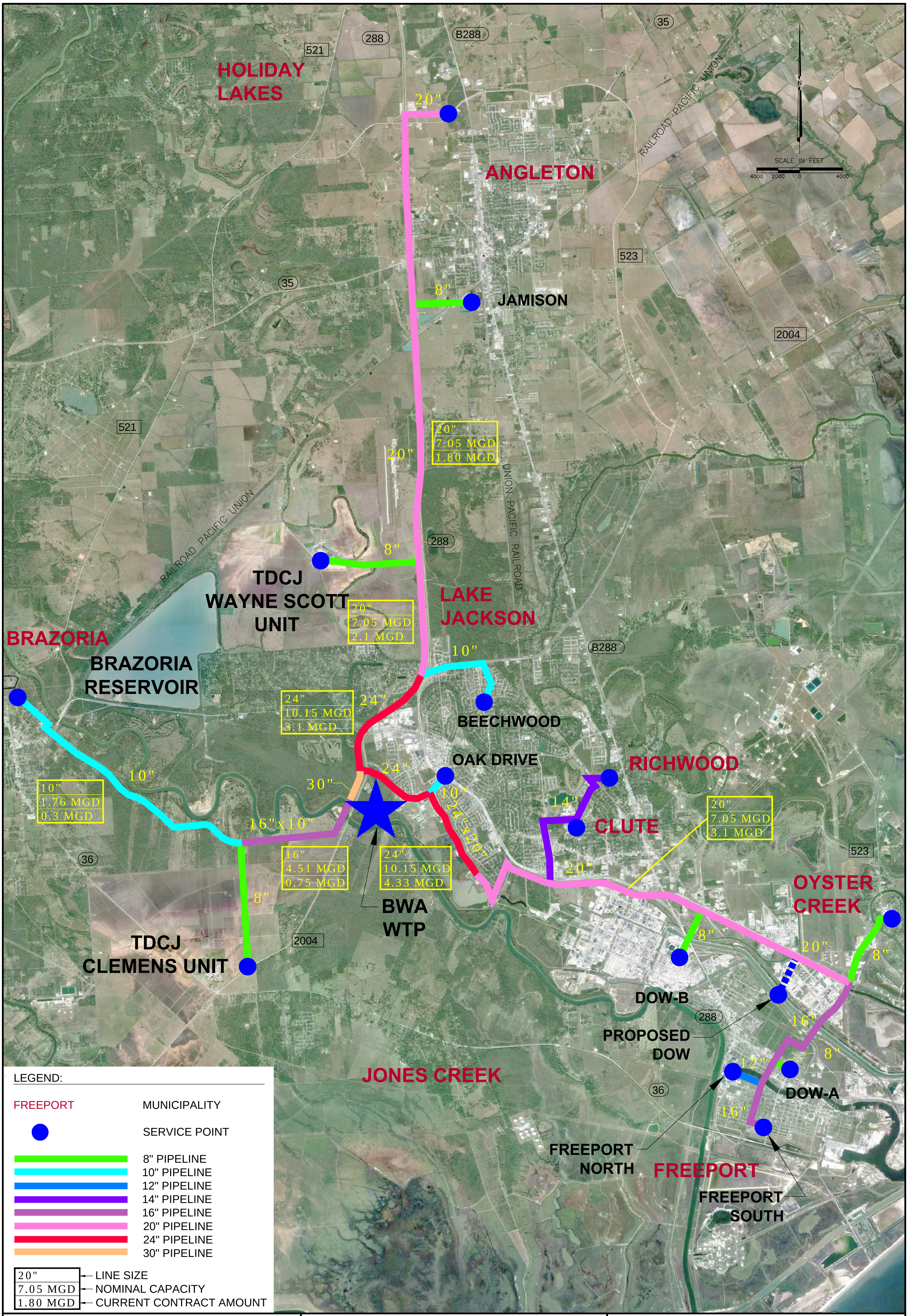


Figure 5-2
Brazoria County Wastewater Outfalls



CDM Smith Riata Corporate Park, 12357-A Riata Trace Parkway, Suite 210 Austin, TX 78727 Tel: (512) 346-1100 Texas Registration Number F-3043	BRAZOSPORT WATER AUTHORITY BRAZORIA COUNTY REGIONAL WATER FACILITY MASTER PLAN	BRAZORIA COUNTY WATER TRANSMISSION PIPELINES

Figure 5-3
BWA Water Transmission Pipelines

Section 6
Development of Alternatives

6.1 Introduction

As presented in previous sections, several drivers have led to the need for Brazoria County to evaluate its water facilities, some of which include a groundwater demands in excess of the MAG, growth in water demands and unreliability in surface water systems.

This section of the report focuses on the development of regional water treatment and transmission alternatives for Brazoria County, to include the methodology, determination and screening of initial and final alternatives.

6.2 Methodology

The first part to developing possible regional water treatment and transmission alternatives for Brazoria County was to gather information from all the project participants on their current water treatment strategies, projected growth and issues they were facing. Electronic questionnaires and/or one-on-one interviews were conducted with each entity. (Descriptions of growth projections and existing systems can be found in Sections 4 and 5, respectively). Taking into account this information that was obtained, the following steps show how CDM Smith developed the regional alternatives:

- ***Step 1: Determine initial alternatives.*** Based on engineering judgment and inputs provided by the project participants, six initial alternatives were developed and presented.
- ***Step 2: Screen initial alternatives.*** Discussions were held and comments collected from the project participants concerning the six initial alternatives with the goal of selecting the top three alternatives for further evaluation.
- ***Step 3: Select regional alternatives for further evaluation.*** Based on the comments during the screening phase, three of the six alternatives were modified and chosen for further evaluation.

The sections below describe these steps.

6.3 Description of Initial Alternatives

6.3.1 Alternative 1

For Alternative 1, Pearland would construct a WTP to meet its future needs and serve Alvin and Manvel; and BWA would expand its existing WTP to meet the 2040 max day demands of its current customers. All other project participants and WUGs in Brazoria County would remain on groundwater. For the transmission system, approximately 78,000 ft of pipeline would need to be constructed from the Pearland WTP to Manvel and Alvin. A water supply contract would need to be negotiated with the Gulf Coast Water Authority (GCWA) to provide the additional raw water supply. **Figure 6-1** at the end of Section 6.3 shows an overview of Alternative 1.

6.3.2 Alternative 2

For Alternative 2, a new BWA WTP would be constructed on the Harris Reservoir to serve Alvin and Manvel; BWA would expand its existing WTP to meet the 2040 max day demands of its current customers; and Pearland would construct a new WTP to serve its customers. All other project participants and WUGs in Brazoria County would remain on groundwater. For the water transmission system, 176,000 feet of pipeline would need to be constructed from the new WTP to Manvel and Alvin. **Figure 6-2** at the end of Section 6.3 shows an overview of Alternative 2.

6.3.3 Alternative 3

For Alternative 3, a new BWA WTP would be constructed in the northern portion of the county to serve Alvin, Manvel and Ineos O&P; BWA would expand its existing WTP to meet the 2040 demands of its current customers; and Pearland would construct a new WTP to serve its customers. All other project participants and WUGs in Brazoria County would remain on groundwater. For the water transmission system, 194,000 feet of pipeline would need to be constructed. A water supply contract would need to be negotiated with GCWA to provide the additional raw water supply. **Figure 6-3** at the end of Section 6.3 shows an overview of Alternative 3.

6.3.4 Alternative 4

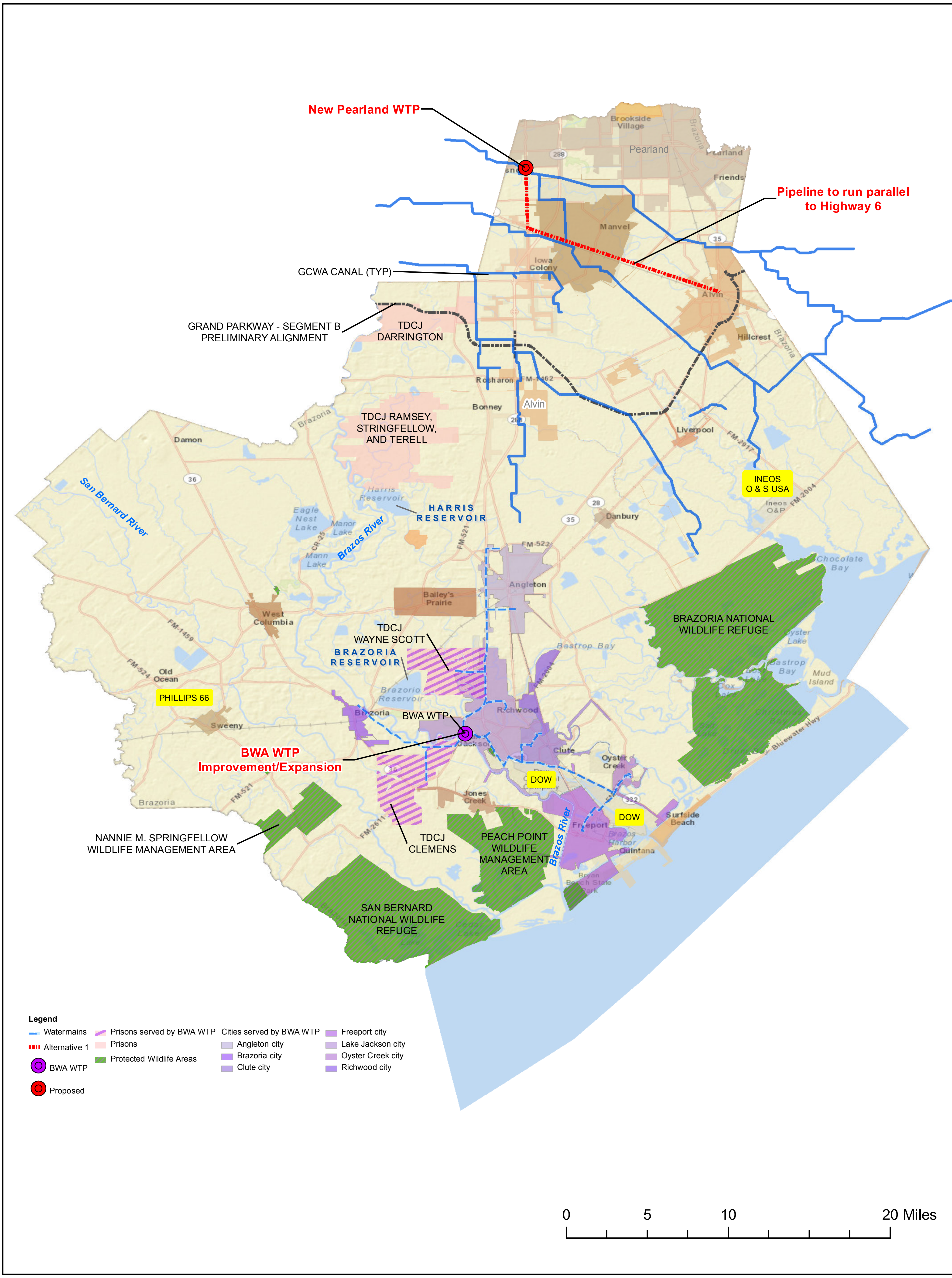
For Alternative 4, a new BWA reverse osmosis (RO) WTP to treat brackish surface water would be constructed at the Ineos O&P site to serve Ineos, Alvin and Manvel; BWA would expand its existing WTP to meet the 2040 demands of its current customers; and Pearland would construct a new WTP to serve its customers. All other project participants and WUGs in Brazoria County would remain on groundwater. For the water transmission system, 122,000 feet of pipeline would need to be constructed from the new RO WTP to Manvel and Alvin. **Figure 6-4** at the end of Section 6.3 shows an overview of Alternative 4.

6.3.5 Alternative 5

For Alternative 5, the existing BWA WTP would be expanded to meet the 2040 demands of its current customers, plus Alvin and Manvel; and Pearland would construct a new WTP to serve its customers. All other project participants and WUGs in Brazoria County would remain on groundwater. A ground storage tank farm and pump station would be constructed near Angleton to help with the transmission of water to the northern regions of the county, and 155,000 feet of pipeline would need to be constructed from the tank farm to Manvel and Alvin. **Figure 6-5** at the end of Section 6.3 shows an overview of Alternative 5.

6.3.6 Alternative 6

For Alternative 6, a new BWA WTP would be constructed on Harris Reservoir to serve Alvin, Manvel, Holiday Lakes, Varner Creek, Oak Manor and West Columbia; BWA would expand its existing WTP to meet the 2040 demands of its current customers, plus Surfside Beach, Jones Creek, Sweeny, and Phillips 66; and Pearland would construct a new WTP to serve its customers. All other project participants and WUGs in Brazoria County would remain on groundwater. With this alternative, more entities are included and removed from groundwater reliance, which can be a long-term option for Brazoria County to alleviate some of the groundwater usage in the future. For the water transmission system, 368,000 feet would need to be constructed. **Figure 6-6** at the end of Section 6.3 shows an overview of Alternative 6.



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Brazoria County Water Distribution Alternatives

- Alternative One -

Brazosport Water Authority

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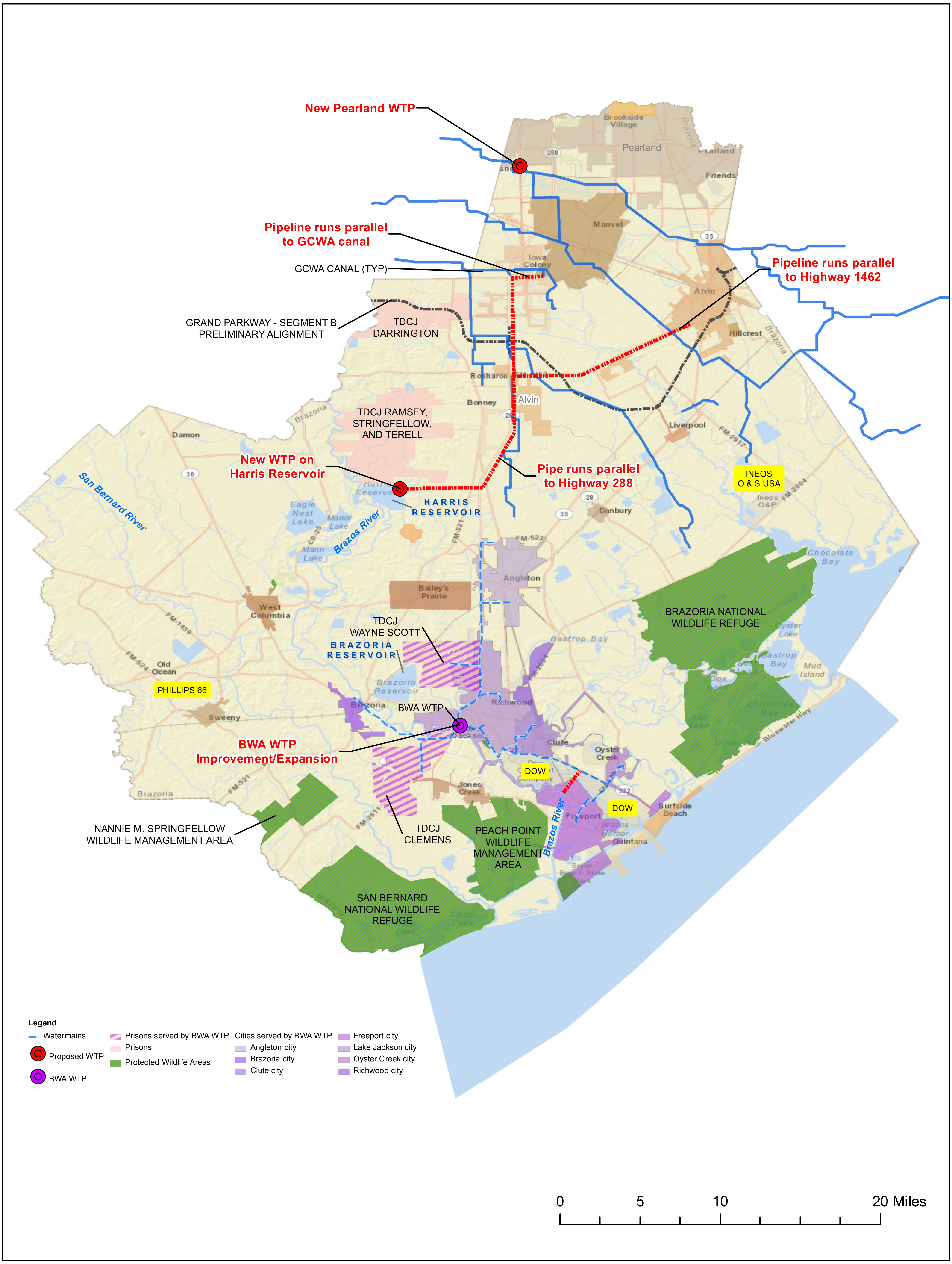
Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

Figure 6-1
Overview of Initial Alternative 1



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Brazoria County Water Distribution Alternatives

- Initial Alternative Two -

Brazosport Water Authority

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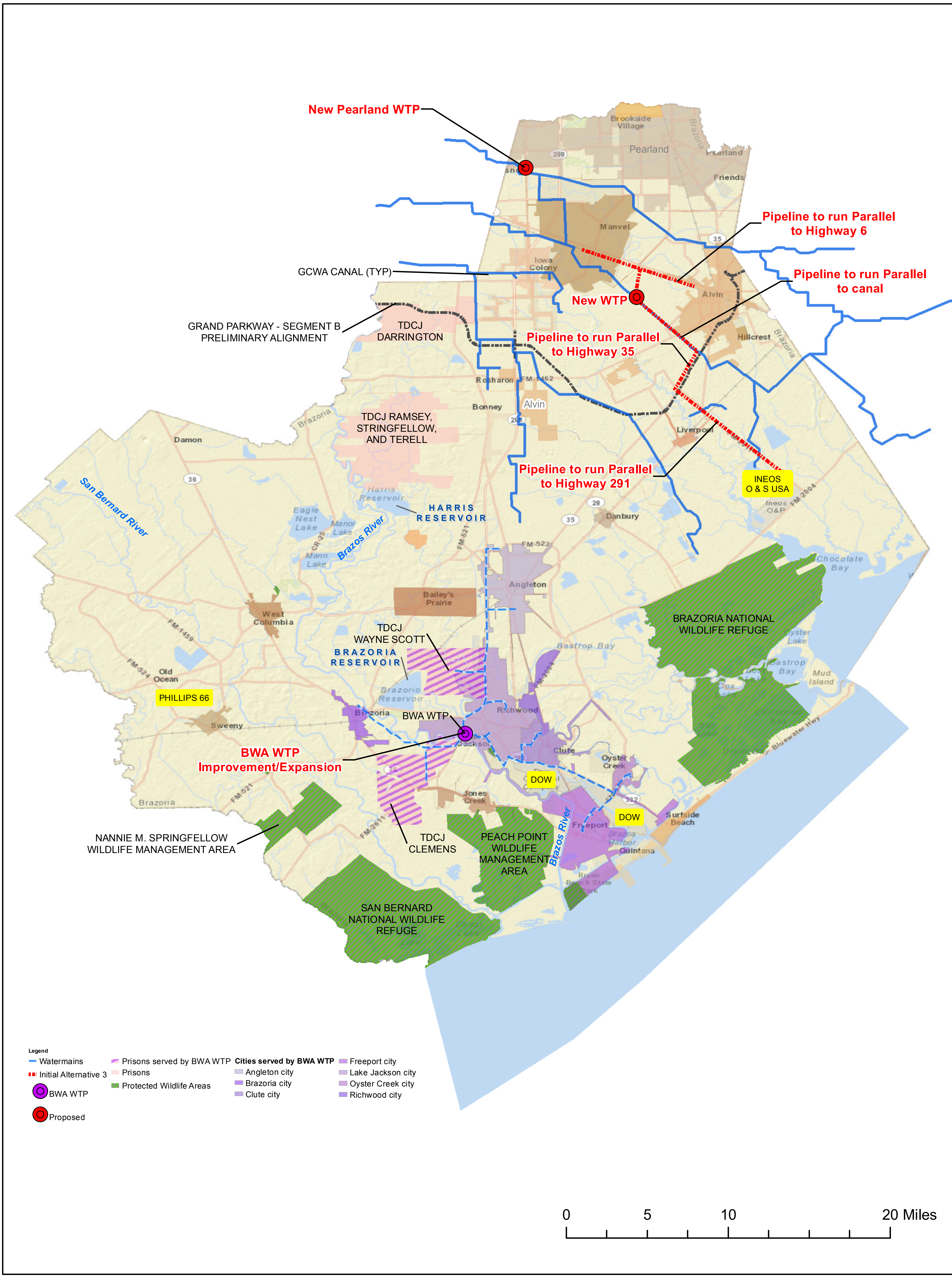
Figure 6-2
Overview of Initial Alternative 2



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Brazoria County Water Distribution Alternatives

- Initial Alternative Three -

Brazosport Water Authority

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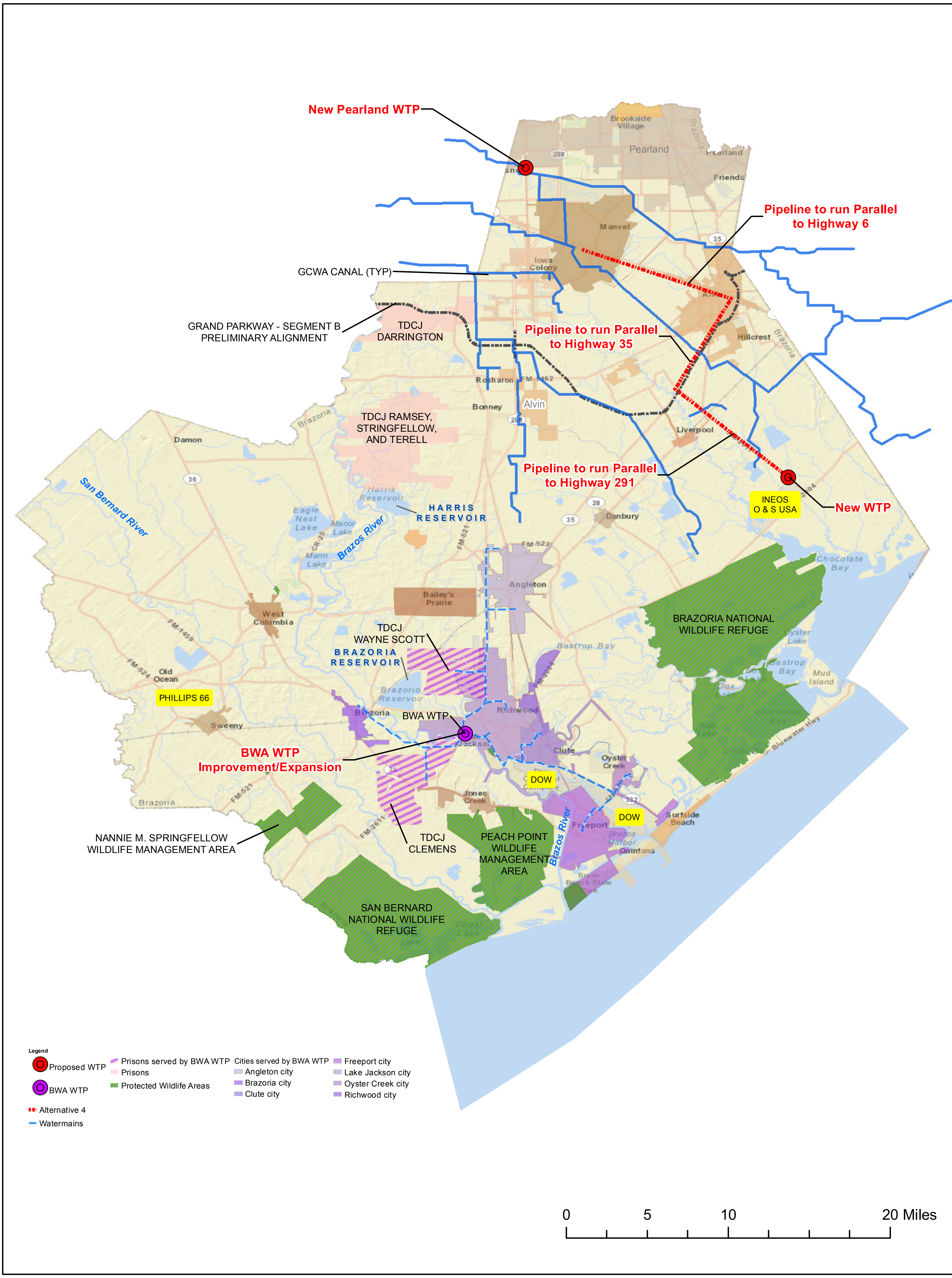
Figure 6-3
Overview of Initial Alternative 3



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Brazoria County Water Distribution Alternatives

- Alternative Four -

Brazosport Water Authority

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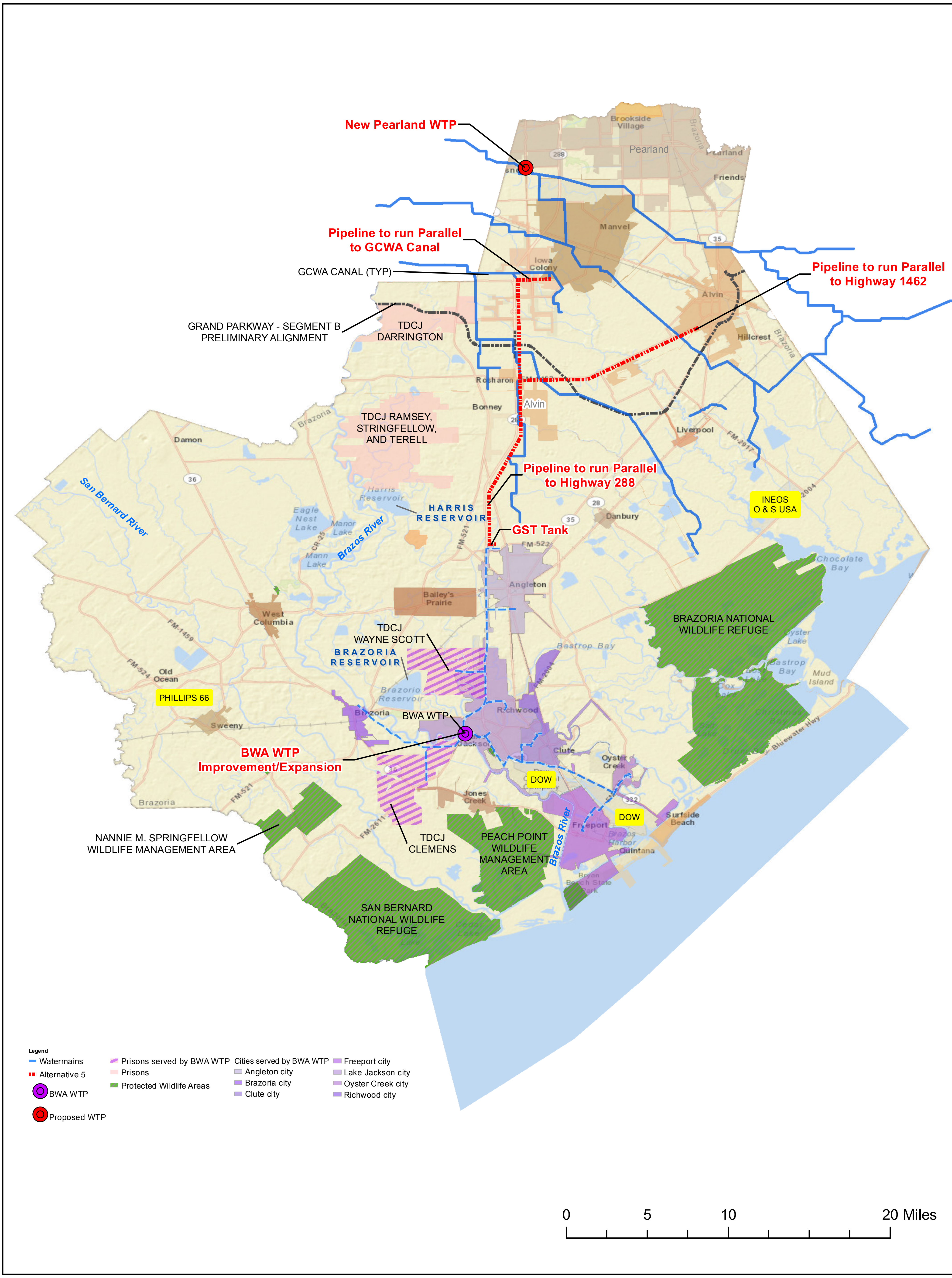
Figure 6-4
Overview of Initial Alternative 4



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Brazoria County Water Distribution Alternatives

- Alternative Five -

Brazosport Water Authority

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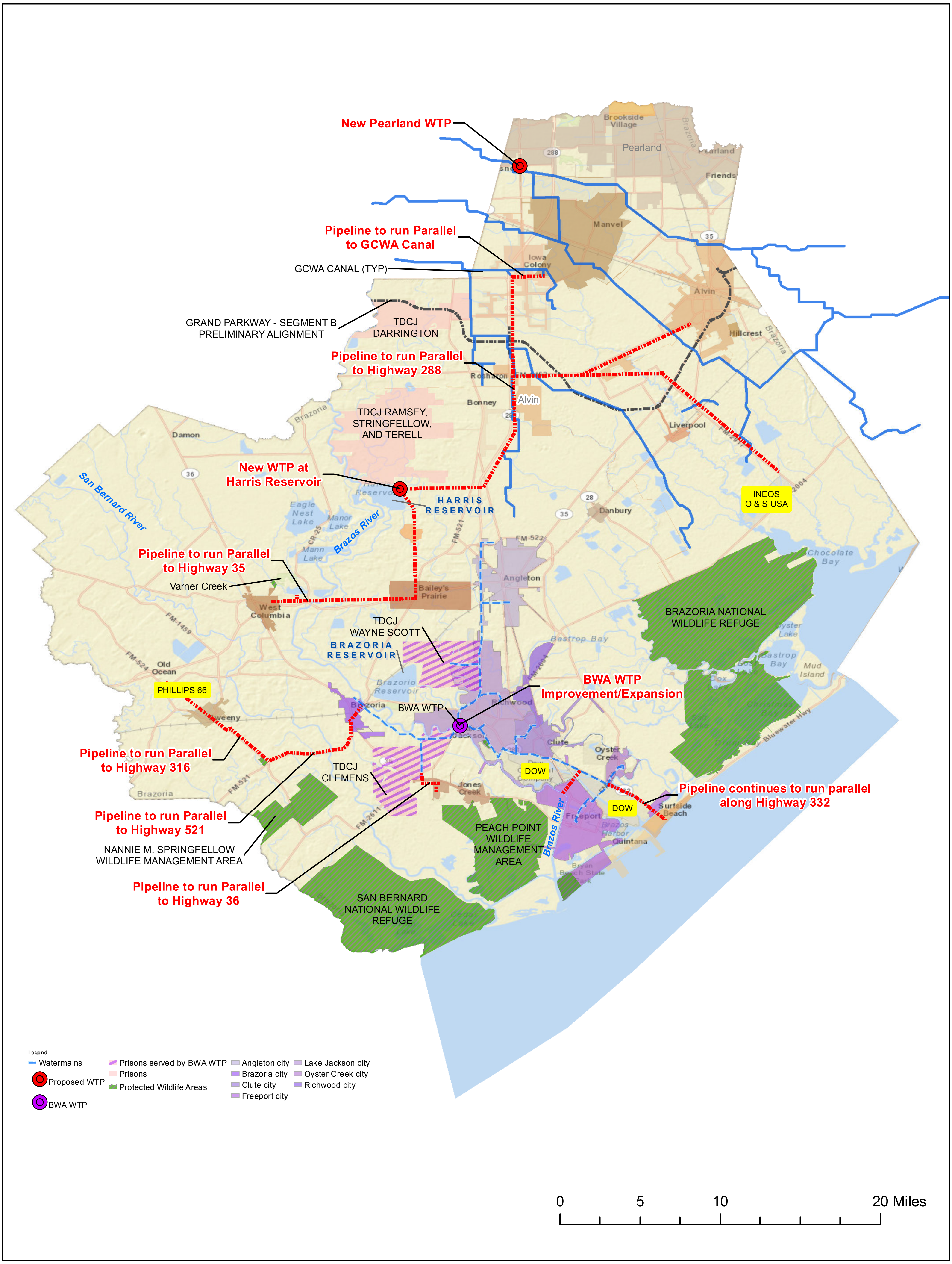
Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

Figure 6-5
Overview of Initial Alternative 5



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Brazoria County Water Distribution Alternatives

- Initial Alternative Six -

Brazosport Water Authority

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Figure 6-6
Overview of Initial Alternative 6

6.4 Screening of Initial Alternatives

The six initial alternatives were presented to the project participants and the screening process initiated. The objective of the screening process was to consolidate and reduce the total number of final alternatives for further evaluation. During a project meeting held in September 2012, participants were given three votes each to pick their top three alternatives. Following the meeting, a second round of voting was accomplished through e-mail in which each participating entity received one more vote. This allowed for those who were not present at the meeting to have an input and to allow each participating entity to have a single vote. Additionally, during this screening period, changes were made to the initial alternatives. Some of these improvements include:

- Gulf Coast Water Authority (GCWA) stated it does not have firm water to sell. In light of this information, all options assuming the use of GCWA water were revised to include the purchase of water from the Brazos River Authority (BRA).
- Upon further evaluation, it was determine Alvin had sufficient groundwater to meet its 2040 max day demands, so it could be removed from consideration in the options. Therefore, the location of the northern plant in Alternative 3 was moved to Manvel.
- Based on the expected population increase in Brazoria County and the potential for population growth along the SH 288 corridor and the Grand Parkway (as shown in the alternative figures), it was assumed that there would be municipal utility districts formed to serve this potential population. Using GIS tools, the population growth between 2015 and 2040 was determined in the area between Angleton and Manvel. This population is assumed to be located in districts and is referred to as County Other Future Districts.
- It was assumed that TDCJ Darrington Unit and TDCJ Ramsey Unit, Stringfellow Unit, and Terell Unit would go from groundwater supply to a treated surface water supply, so they were added to the demands of all chosen alternatives.
- Due to location, Ineos O&P was removed from the alternatives.
- Since Ineos O&P and Alvin were removed from the options, Oak Manor MUD was also removed, as it was only included based on proximity to the transmission main proposed.
- For the chosen alternatives, two options were considered based on surface water availability: 1) 10 percent annual interruptible water supply purchase and 2) 67 percent (eight months) of 2040 average day demand firm water supply purchase. Surface water in the Brazos River for run-of-the-river rights is available approximately 90 percent of the time based on monthly modeling using WAM Run 8. WAM Run 8 does not include the hydrologic data for 2011. Surface water in the Brazos River for run-of-the-river rights would not have been available for up to eight months based on daily modeling of the 2011 flows. Detailed analysis considered both the monthly modeling using WAM Run 8 and the daily modeling using 2011 flows.

6.5 Regional Alternatives Selected for Detailed Evaluation

Following the screening of the initial alternatives, Alternative 2, Alternative 3 and Alternative 6 were chosen for further evaluation, For each alternative, expansions to BWA WTP and/or construction of a new WTP are described. Parameters used consistently throughout all alternatives are as follows:

- It is assumed Pearland will continue to use its current water supplies, with an additional 10 MGD needed by 2020 and another 10 MGD by 2035. This additional treatment capacity will be from a new city water treatment plant using raw water contracts that the City of Pearland has with GCWA.
- Per TCEQ regulations, once the water demand meets 85 percent of the plant capacity, preparations to expand the capacity must begin. This requirement was taken into consideration when determining expansion timeframes.
- Incremental expansion sizes were determined based on demands and economy of scales. CDM Smith assumed all expansions were greater than 5 million gallons per day (MGD), where applicable, and that there would be no more than three expansions during the 30-year planning period.
- CDM Smith assumed that current BWA customers and Manvel would continue to use their current groundwater capacities but would not increase their groundwater withdrawals to meet future demands. All future demands would be met by one of the proposed treatment alternatives. **Table 6-1** presents each entities groundwater capacity.
- For BWA customers, the BWA contract water would be utilized first, and then their groundwater supply, as needed, to meet their demands.
- All other entities included in this evaluation (Sweeney, Jones Creek, Surfside Beach, Phillips 66, TDCJ Wayne Scott Unit, TDCJ Clemens Unit, TDCJ Darrington Unit, TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit, Bailey's Prairie, Holiday Lakes, West Columbia, Varner Creek and County Other Future Districts) would discontinue the use of groundwater if connected to a treated surface water supply.
- Current BWA surface water contracts would continue to remain in effect and additional contracts executed as necessary. **Table 6-1** presents each contract amount.

Table 6-1 Groundwater Capacity and BWA Contracts

Entity	Groundwater Capacity (MGD)	Current Contract with BWA (MGD)
Angleton	3.34	1.80
Brazoria	0	0.30
Clute	1.83	1.00
Freeport	0	2.00
Lake Jackson	8.20	2.00
Oyster Creek	1.50	0.10
Richwood	1.01	0.24
TDCJ Clemens Unit	0	0.45
TDCJ Wayne Scott Unit	0	0.30
Dow	0	1.00
Alvin	8.42	0
Manvel	1.15	0

6.5.1 Alternative 2: BWA WTP Expands to Meet Current Customer Demands (10% Water Shortage Purchase), New Plant on Harris Reservoir

In this alternative, the existing BWA WTP would be expanded to meet the future demands of Angleton, Brazoria, Clute, Freeport, Lake Jackson, Oyster Creek, Richwood, TDCJ Clemens Unit, TDCJ Wayne Scott Unit and Dow. A new WTP will be constructed on the north side of Harris Reservoir to serve Manvel, TDCJ

Darrington Unit, TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit, and the County Other Future District population growth that is projected to occur along Highway 288. This alternative assumes that a suitable location could be found on Harris Reservoir for a new WTP, and that the water supply would be available. **Figure 6-7** at the end of this Section shows an overview of final Alternative 2. The components of this alternative are described below.

BWA Plant Expansion

The existing BWA WTP would be expanded to meet the 2040 max day demands of Angleton, Brazoria, Clute, Freeport, Lake Jackson, Oyster Creek, Richwood, TDCJ Clemens Unit, TDCJ Wayne Scott Unit and Dow. Under this alternative, Angleton, Brazoria, Clute, Freeport, Lake Jackson, Oyster Creek and Richwood would continue to utilize their current groundwater supplies but would meet future water demands in excess of their groundwater capacity with treated surface water from the BWA WTP (additional groundwater supplies were not considered in this analysis). Each entity would first use its water supply from BWA and then its groundwater supply, as needed. **Table 6-2** shows the total water demand, groundwater capacity and expansions for this alternative. (The development of these water demands is explained in detail in Section 4).

Table 6-2 Demand and Supply Summary for Alternative 2 BWA WTP

Year	2010	2015	2020	2025	2030	2035	2040
Total Average Day Demand (MGD)	12.15	13.68	14.55	15.59	16.52	17.59	18.38
Groundwater Supply Used (MGD)	3.44	3.76	4.58	5.64	6.58	7.67	8.47
WTP Average Day Demand (MGD)	9.45	10.47	10.48	10.50	10.52	10.54	10.56
Total Max Day Demand (MGD)	19.71	21.85	23.59	25.66	27.58	29.77	31.57
Groundwater Supply Used (MGD)	10.10	11.25	13.01	13.90	14.00	14.11	14.22
WTP Max Day Demand (MGD)	9.72	10.75	10.78	12.00	13.80	15.99	17.72
Plant Capacity (MGD)	17.97	17.97	17.97	17.97	17.97	17.97	20.97
Expansion Required (MGD)	0	0	0	0	0	3	0

Notes:
1) Expansions required take into account the TCEQ regulation of planning requirements when the plant is at 85-percent capacity.
2) Total groundwater capacity is 15.88 MGD; however, Oyster Creek only uses 0.29 MGD of 1.50 MGD groundwater capacity and Clute uses 1.38 MGD of 1.83 MGD groundwater capacity in 2040.
3) Since BWA is required to fulfill the existing contracts, total contract amounts for Angleton (1.80 MGD) and Freeport (2.00 MGD) are included in the WTP demands, even if complete amount not utilized.

After taking into consideration the groundwater supply available, to meet the 2040 max day demands of this alternative, the existing BWA WTP would be expanded by 3 MGD in 2035. This alternative assumes that the expansion would be a conventional water filtration plant as BWA currently operates.

The high service pump station at the BWA WTP that pumps finished water from the water treatment plant through the distribution system would be expanded incrementally with the water treatment plant. This pump station would be expanded to a firm capacity of 21.8 MGD in 2035. The raw water pump station/intake on the fresh water canal would also be expanded to 21.8 MGD in 2035.

The system's current transmission pipelines would continue to be utilized as long as the velocity through the pipeline is less than 5 feet per second (fps). Additional pipeline capacity will be added where needed, such as for Lake Jackson and Dow. The new transmission pipelines required will be sized to transport the additional capacity needed to meet the year 2040 max day water demand and will be constructed in 2035. **Table 6-3** presents the required transmission piping size and length.

Table 6-3 Transmission Pipelines Required for Alternative 2 BWA WTP Expansion

Pipe Diameter (in)	Length (ft)
6	21,700

In addition to planned expansions, upgrades to the current BWA WTP would need to be completed in 2015 to keep the plant running at its maximum efficiency. A 10 million gallon (MG) clearwell and additional high service pump station will need to be constructed, and some of the WTP's electrical systems and instrumentation and controls will need to be upgraded. A detailed description of the WTP's current condition and recommended upgrades can be found in **Appendix F**.

Based on the water supply study detailed in Section 3, this alternative assumes that BWA would experience a water shortage 10 percent of the time. Therefore, an annual stipend equating to the cost of 10 percent of the year's average day demand would be set aside for use if a water shortage occurs. It is assumed that BRA would have the necessary interruptible water for sale, and that the cost of the raw water would range from $62.50 per acre-foot in 2013 to $150 per acre-foot in 2040, based on the BRA long-term planning strategy. **Figure 6-8** shows the projected raw water costs.

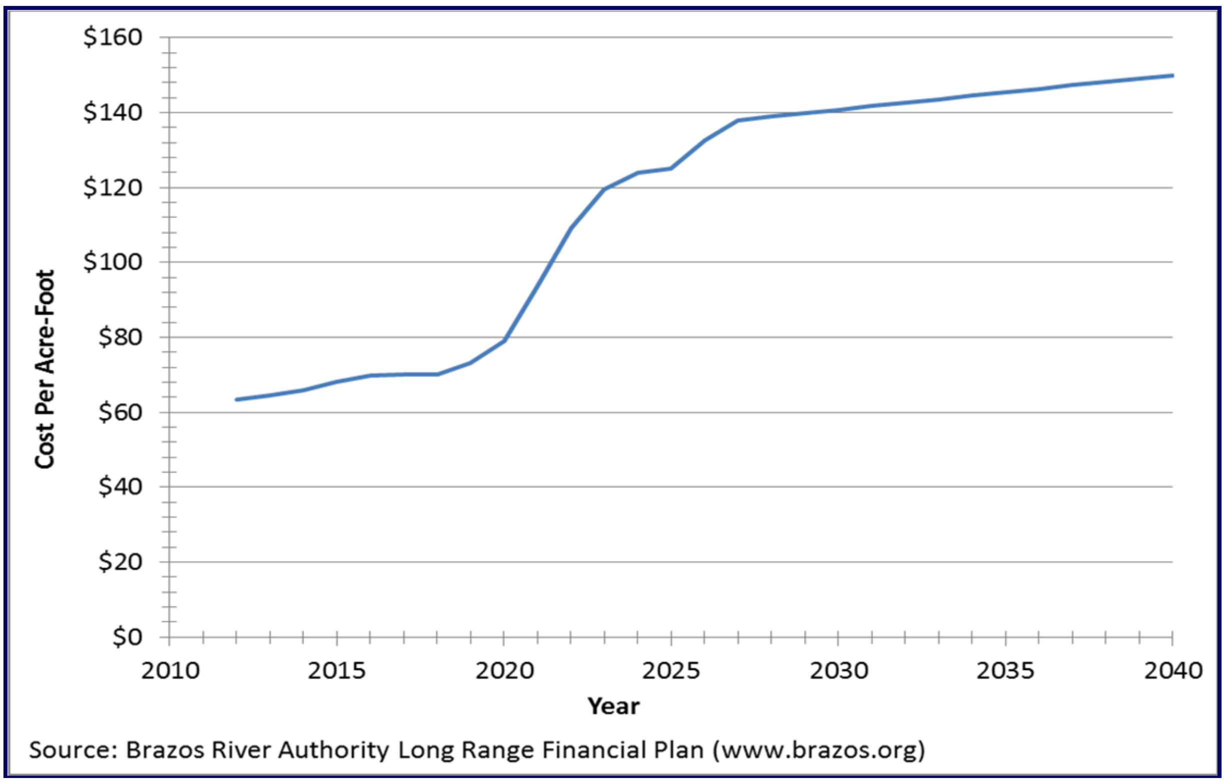


Figure 6-8
Projected Brazos River Authority Raw Water Costs

<u>New Northern Brazoria Regional WTP at Harris Reservoir</u>

The new Northern Brazoria Regional WTP will be constructed on the north side of Harris Reservoir and serve Manvel, TDCJ Darrington Unit, TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit, and the County Other Future District population growth that is projected to occur along Highway 288. Under this alternative, Manvel would continue to utilize its current groundwater supplies but would meet future water demands in excess of its groundwater capacity with treated surface water from the new WTP (additional groundwater supplies were not considered in this analysis). The demands from TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit, TDCJ Darrington Unit and the County Other Future Districts would be met solely by treated surface water from the new WTP. **Table 6-4** shows the total water demand, groundwater capacity and expansions for this alternative. (The development of these water demands is explained in detail in Section 4).

Table 6-4 Demand and Supply Summary for Alternative 2 New WTP

Year	2010	2015	2020	2025	2030	2035	2040
Total Average Day Demand (MGD)	2.87	3.14	4.92	7.59	11.21	15.21	19.75
Groundwater Supply Used (MGD)	2.87	0.85	1.15	1.15	1.15	1.15	1.15
WTP Average Day Demand (MGD)	0.00	2.29	3.77	6.44	10.06	14.06	18.60
Total Max Day Demand (MGD)	3.07	3.42	6.26	10.49	16.24	22.48	29.45
Groundwater Supply Used (MGD)	3.07	1.13	1.15	1.15	1.15	1.15	1.15
WTP Max Day Demand (MGD)	0.00	2.29	5.11	9.34	15.09	21.33	28.30
Plant Capacity (MGD)	0	0	11	11	26	26	34
Expansion Required (MGD)	0	11	0	15	0	8	0

Notes:
1) Expansions required take into account the TCEQ regulation of planning requirements when the plant is at 85-percent capacity.
2) Groundwater supply decreases in 2015 due to the fact that the prison units will no longer use their groundwater supplies once the new WTP is operational.

After taking into consideration the groundwater supply available, to meet the 2040 max day demands for this alternative, the new WTP would be constructed in 2015 at an initial capacity of 11 MGD, with an expansion of 15 MGD in 2025 and 8 MGD expansion in 2035. This alternative assumes that the new plant would be a conventional water filtration plant as BWA currently operates.

The high service pump station at the new WTP that pumps finished water from the WTP through the transmission system would be expanded incrementally with the WTP. This pump station would be expanded to a firm capacity of 34 MGD by 2035. The raw water pump station/intake constructed on the Harris Reservoir would also expand incrementally to 34 MGD by 2035.

New water transmission pipelines will be sized to meet the year 2040 max day water demand while maintaining a pipeline velocity of approximately 5 fps and would be constructed in 2015. A 36-inch regional transmission main would be constructed leaving the new WTP to the east. For TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit, and TDCJ Darrington Unit, a 10-inch and 6-inch transmission line, respectively, would be required. To serve the County Other Future Districts population, CDM Smith assumed three main 20-inch pipelines in the areas of projected growth would come off of the main transmission line. From these pipelines, any entities that wish to be connected in the future could be added. **Table 6-5** presents the required transmission piping sizes and lengths.

Table 6-5 Transmission Pipelines Required for Alternative 2 New WTP

Pipe Diameter (in)	Length (ft)
36	45,700
24	12,000
20	52,200
16	10,000
10	18,000
6	12,200

Any additional piping or storage tanks required for proper operation of the distribution system would be the responsibility of the individual entity and were not included in this evaluation.

Based on the water supply study detailed in Section 3, this alternative assumes that BWA would experience a water shortage 10 percent of the time. Therefore, an annual stipend equating to the cost of 10 percent of the year's average day demand would be set aside for use if a water shortage occurs. It is assumed that BRA would have the necessary water for sale, and that the cost of the raw water would range from $62.50 per acre-foot in 2013 to $150 per acre-foot in 2040, based on the BRA long-term planning strategy.

6.5.2 Alternative 2: BWA WTP Expands to Meet Current Customer Demands (67% Water Shortage Purchase), New Plant on Harris Reservoir

This alternative is the same as Alternative 2, with the exception of the water shortage planning. In the water supply study detailed in Section 3, looking at year 2011, the data showed that BWA could be without water for as long as eight months out of the year. To increase the reliability of the system during periods of drought, this alternative assumed that BWA would negotiate a contract with BRA for firm water equivalent to eight months, or 67 percent, of the given WTP's 2040 average day water demand. (For this alternative, the BWA WTP 2040 average day demand is 10.56 MGD and the new WTP 2040 average day demand is 18.60 MGD). As such, this evaluation assumed that beginning immediately, BWA would purchase 7,885 acre-feet of water for the BWA Plant and 13,893 acre-feet of water for the new WTP, and that the cost of the raw water would range from $62.50 per acre-foot in 2013 to $150 per acre-foot in 2040, based on the BRA long-term planning strategy.

6.5.3 Alternative 3: BWA WTP Expansion (10% Water Shortage Purchase), New Plant in Manvel

In this alternative, the BWA WTP would continue to meet the demands of Angleton, Brazoria, Clute, Freeport, Lake Jackson, Oyster Creek, Richwood, TDCJ Clemens Unit, TDCJ Wayne Scott Unit and Dow, plus added service to TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit and half of the County Other Future Districts. A new North Brazoria Regional WTP will be constructed in northwestern Manvel to serve Manvel, TDCJ Darrington Unit and half the additional County Other Future Districts population growth that is projected to occur along Highway 288. This alternative assumes the water supply would be available from BRA for the new WTP raw water supply. **Figure 6-9** at the end of this Section shows an overview of final Alternative 3. The components of this alternative are described below.

BWA Plant Expansion

The BWA WTP would expand to meet the 2040 max day demands of Angleton, Brazoria, Clute, Freeport, Lake Jackson, Oyster Creek, Richwood, TDCJ Clemens Unit, TDCJ Wayne Scott Unit, Dow, TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit, and half of the County Other Future Districts population. Under this alternative, Angleton, Brazoria, Clute, Freeport, Lake Jackson, Oyster Creek and Richwood would continue to utilize their current groundwater supplies but would meet future water demands in excess of their groundwater capacity with treated surface water from the BWA WTP (additional groundwater supplies were not considered in this analysis). The current treated water contracts would continue to be utilized and additional contracts executed as necessary. **Table 6-6** shows the total water demand, groundwater capacity and expansions for this alternative. (The development of these water demands is explained in detail in Section 4).

Table 6-6 Demand and Supply Summary for Alternative 3 BWA WTP

Year	2010	2015	2020	2025	2030	2035	2040
Total Average Day Demand	13.67	15.20	16.78	18.87	21.19	23.66	25.85
Groundwater Supply Used (MGD)	3.60	3.92	4.74	5.80	6.74	7.83	8.63
WTP Average Day Demand (MGD)	10.81	11.83	12.55	13.61	15.03	16.45	17.87
Total Max Day Demand (MGD)	21.24	23.37	26.28	30.09	34.33	38.85	42.97
Groundwater Supply Used (MGD)	10.26	11.41	13.17	14.06	14.16	14.27	14.38
WTP Max Day Demand (MGD)	11.08	12.11	13.30	16.27	20.45	24.90	28.96
Plant Capacity (MGD)	17. 97	17. 97	17. 97	17. 97	27. 97	27. 97	34. 97
Expansion Required (MGD)	0	0	0	10	0	7	0

Notes:
1) Expansions required take into account the TCEQ regulation of planning requirements when the plant is at 85-percent capacity.
2) Total groundwater capacity is 14.22 MGD; however, Oyster Creek only uses 0.29 MGD of 1.50 MGD groundwater capacity and Clute uses 1.38 MGD of 1.83 MGD groundwater capacity in 2040.
3) Since BWA is required to fulfill the existing contracts, total contract amounts for Angleton (1.80 MGD) and Freeport (2.00 MGD) are included in the WTP demands, even if complete amount not utilized.

After taking into consideration the groundwater supply available, in order to meet the 2040 max day demands of this alternative, the existing BWA WTP will be expanded incrementally, starting with a 10 MGD expansion in 2025, followed by a 7 MGD expansion in 2035. This alternative assumes that the expansions would be a conventional water filtration plant as BWA currently operates.

The high service pump station at the BWA WTP that pumps finished water from the WTP through the distribution system would be expanded incrementally with the WTP. This pump station would be expanded to a firm capacity of 34.8 MGD by 2035. The raw water pump station/intake on the fresh water canal would also be expanded incrementally to 34.8 MGD.

To reach the County Other Future Districts and TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit, a tank farm and booster pump station would be constructed just north of Angleton. From here, water will be distributed to half the County Other Future Districts and the TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit. The tank farm will start with an initial 4 MG ground storage tank (GST) and 6 MGD booster pumping capacity in 2015. Additional 2 MG GSTs will be added in 2025 and 2035, along with an additional 3 MGD of booster pumping capacity in 2025 and 2035.

Transmission piping from the tank farm to TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit will need to be constructed in 2015, but based on the capacity of the current pipeline from the BWA WTP to Angleton, construction of an additional transmission line to the tank farm can be postponed until 2025. A connection from the current Angleton transmission main to the tank farm will need to be installed.

The system's current transmission pipelines would continue to be utilized as long as the velocity through the pipeline is less than 5 fps. Additional pipeline capacity would be added where needed. The new distribution pipelines required would be sized to transport the additional capacity needed to meet the year 2040 max day water demand and would be constructed in 2035. **Table 6-7** presents the required transmission piping sizes and lengths.

Table 6-7 Transmission Pipelines Required for Alternative 3 BWA WTP Expansion

Pipe Diameter (in)	Length (ft)
24	29,900
16	5,000
10	19,200

Any additional piping or storage tanks required for proper operation of the distribution system would be the responsibility of the individual entity and were not included in this evaluation.

In addition to planned expansions, upgrades to the current WTP would need to be completed in 2015 to keep the plant running at its maximum efficiency. A 10 MG clearwell and additional high service pump station will need to constructed, and some of the WTP's electrical systems and instrumentation and controls need to be upgraded. A detailed description of the WTP's current condition and recommended upgrades can be found in Appendix F.

Based on the water supply study detailed in Section 3, this alternative assumes that BWA would experience a water shortage 10 percent of the time. Therefore, an annual stipend equating to the cost of 10 percent of the year's average day demand would be set aside for use if a water shortage occurs. It is assumed that BRA would have the necessary water for sale, and that the cost of the raw water would range from $62.50 per acre-foot in 2013 to $150 per acre-foot in 2040, based on the BRA long-term planning strategy.

New North Brazoria Regional WTP in Manvel

The new North Brazoria Regional WTP will be constructed in northwestern Manvel to serve Manvel, TDCJ Darrington Unit and half the County Other Future District population growth that is projected to occur along Highway 288. Only half of the additional County Other Future District population is included due to the extent of the required transmission line. Under this alternative, Manvel would continue to utilize its current groundwater supplies but would meet future water demands in excess of their groundwater capacity with treated surface water from the new WTP (additional groundwater supplies were not considered in this analysis). The demands from TDCJ Darrington Unit and half the County Other Future District would be met solely by treated surface water from the new WTP. **Table 6-8** shows the total water demand, groundwater capacity and expansions for this alternative. (The development of these water demands were explained in detail in Section 4).

Table 6-8 Demand and Supply Summary for Alternative 3 New WTP

Year	2010	2015	2020	2025	2030	2035	2040
Total Average Day Demand (MGD)	1.35	1.61	2.70	4.31	6.54	9.14	12.28
Groundwater Supply Used (MGD)	1.35	0.85	1.15	1.15	1.15	1.15	1.15
WTP Average Day Demand (MGD)	0.00	0.76	1.55	3.16	5.39	7.99	11.13
Total Max Day Demand (MGD)	1.54	1.89	3.57	6.07	9.49	13.40	18.05
Groundwater Supply Used (MGD)	1.54	1.13	1.15	1.15	1.15	1.15	1.15
WTP Max Day Demand (MGD)	0.00	0.76	2.42	4.92	8.34	12.25	16.90
Plant Capacity (MGD)	0	0	6	6	15	15	20
Expansion Required (MGD)	0	6	0	9	0	5	0

Notes:
1) Expansions required take into account the TCEQ regulation of planning requirements when the plant is at 85-percent capacity.

To meet the 2040 max day demands of this alternative, the new WTP would be constructed in 2015 at an initial capacity of 6 MGD, with an expansion of 9 MGD in 2025 and 5 MGD in 2035. This alternative assumes that the new WTP would be a conventional water filtration plant as BWA currently operates.

The high service pump station at the WTP that pumps finished water from the WTP through the transmission system will be expanded incrementally with the WTP. This pump station will be expanded to a firm capacity of 20 MGD by 2035. The raw water pump station/intake will also be expanded incrementally to 20 MGD.

During the alternative screening phase, it was discovered that GCWA would not have the raw water supply available for a new northern WTP, so the evaluation was completed assuming the water would be available from BRA. For this alternative, a raw water pipeline would be needed from the Brazos River to the new WTP location. If the intake structure can be located anywhere along the river, the length of this pipeline was assumed to be the shortest route from the river to the plant. Based on the average day flow and a velocity in the pipeline of 5 fps, the raw water pipeline would be 24 inches and approximately 10 miles long.

New transmission pipelines will be sized to meet the year 2040 max day water demand while maintaining a pipeline velocity of approximately 5 fps and will be constructed in 2015. A 16-inch transmission main would be constructed leaving the new WTP to the south to service Manvel. A 24-inch transmission main will leave the plant to the south to serve TDCJ Darrington Unit and the County Other District population. To serve half the County Other District population, CDM Smith assumed two 16-inch pipelines in the areas of projected growth would come off of the main transmission line. From these pipelines, any entities that wish to be connected in the future could be added. **Table 6-9** presents the required transmission piping sizes and lengths.

Table 6-9 Transmission Pipelines Required for Alternative 3 New WTP

Pipe Diameter (in)	Length (ft)
24	25,000
16	28,000
6	12,200

Any additional piping or storage tanks required for proper operation of the distribution system within the City would be the responsibility of the individual entity and were not included in this evaluation.

Based on the water supply study detailed in Section 3, this alternative assumes that BWA would experience a water shortage 10 percent of the time. Therefore, an annual stipend equating to the cost of 10 percent of the year's average day demand would be set aside for use if a water shortage occurs. It is assumed that BRA would have the necessary water for sale, and that the cost of the raw water would range from $62.50 per acre-foot in 2013 to $150 per acre-foot in 2040, based on the BRA long-term planning strategy.

6.5.4 Alternative 3: BWA WTP Expansion (67% Water Shortage Purchase), New Plant in Manvel

This alternative is the same as Alternative 3, with the exception of the water shortage planning. In the water supply study detailed in Section 3, looking at year 2011, the data showed that BWA could be without firm water for as long as eight months out of the year. To increase the reliability of the system during periods of drought, this alternative assumed that BWA would negotiate a contract with BRA for firm water equivalent to eight months, or 67 percent, of the given WTP's 2040 average day water demand. (For this alternative, the BWA WTP 2040 average day demand is 18.03 MGD and the new WTP 2040 average day demand is 11.13 MGD). As such, this evaluation assumed that beginning immediately, BWA would purchase

13,466 acre-feet of water for the existing BWA Plant and 12,500 acre-feet of water for the new WTP, and that the cost of the raw water would range from $62.50 per acre-foot in 2013 to $150 per acre-foot in 2040, based on the BRA long-term planning strategy.

6.5.5 Alternative 6: BWA WTP Expands to Meet Existing plus New Customer Demands (10% Water Shortage Purchase), New WTP on Harris Reservoir

In this alternative, the existing BWA WTP would expand to meet the 2040 max day demands of Angleton, Brazoria, Clute, Freeport, Lake Jackson, Oyster Creek, Richwood, TDCJ Clemens Unit, TDCJ Wayne Scott Unit and Dow and would add service to Sweeny, Jones Creek, Surfside Beach and Phillips 66. A new WTP will be constructed on the north side of Harris Reservoir to serve Manvel, TDCJ Darrington Unit, TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit, Bailey's Prairie, Holiday Lakes, West Columbia, Varner Creek, and the County Other Future Districts population growth that is projected to occur along Highway 288. **Figure 6-10** at the end of this Section shows an overview of final Alternative 6. The components of this alternative are described below.

BWA Plant Expansion

The BWA WTP would expand to meet the demands of Angleton, Brazoria, Clute, Freeport, Lake Jackson, Oyster Creek, Richwood, TDCJ Clemens Unit, TDCJ Wayne Scott Unit and Dow and would add service to Sweeny, Jones Creek, Surfside Beach and Phillips 66. Under this alternative, Angleton, Brazoria, Clute, Freeport, Lake Jackson, Oyster Creek and Richwood would continue to utilize their current groundwater supplies but would meet future water demands in excess of their groundwater capacity with treated surface water from the existing BWA WTP (additional groundwater supplies were not be considered in this analysis). **Table 6-10** shows the total water demand, groundwater capacity and expansions for this alternative. (The development of these water demands is explained in detail in Section 4).

Table 6-10 Demand and Supply Summary for Alternative 6 BWA WTP

Year	2010	2015	2020	2025	2030	2035	2040
Total Average Day Demand (MGD)	13.32	14.86	15.76	16.82	17.76	18.85	19.66
Groundwater Supply Used (MGD)	3.60	3.92	4.74	5.80	6.74	7.83	8.63
WTP Average Day Demand (MGD)	10.45	11.49	11.53	11.56	11.60	11.64	11.68
Total Max Day Demand (MGD)	21.81	23.98	25.77	27.87	29.82	32.05	33.89
Groundwater Supply Used (MGD)	10.26	11.41	13.17	14.06	14.16	14.27	14.38
WTP Max Day Demand (MGD)	11.65	12.72	12.79	14.04	15.94	18.11	19.88
Plant Capacity (MGD)	17. 97	17. 97	17. 97	17. 97	17. 97	23.97	23.97
Expansion Required (MGD)	0	0	0	0	6	0	0

Notes:
1) Expansions required take into account the TCEQ regulation of planning requirements when the plant is at 85-percent capacity.
2) Total groundwater capacity is 14.22 MGD; however, Oyster Creek only uses 0.29 MGD of 1.50 MGD groundwater capacity and Clute uses 1.38 MGD of 1.83 MGD groundwater capacity in 2040.
3) Since BWA is required to fulfill the existing contracts, total contract amounts for Angleton (1.80 MGD) and Freeport (2.00 MGD) are included in the WTP demands, even if complete amount not utilized.

After taking into consideration the groundwater supply available, in order to meet the 2040 max day demands of this alternative, the existing BWA WTP would be expanded by 6 MGD in 2030. This alternative assumes that the expansion would be a conventional water filtration plant as BWA currently operates.

The high service pump station at the BWA WTP that pumps finished water from the WTP through the transmission system would be expanded incrementally with the WTP. This pump station would be expanded to a firm capacity of 24 MGD in 2030. The raw water pump station/intake on the fresh water canal would also be expanded in 2030 to 24 MGD.

The system's current transmission pipelines would continue to be utilized as long as the velocity through the pipeline is less than 5 fps. Additional pipeline capacity will be added where needed. The new distribution pipelines required will be sized to transport the additional capacity needed to meet the year 2040 max day water demand and will be constructed in 2030. **Table 6-11** presents the required transmission piping sizes and lengths.

Table 6-11 Transmission Pipelines Required for Alternative 6 BWA WTP Expansion

Pipe Diameter (in)	Length (ft)
12	14,700
10	65,700
6	59,700
4	35,000

In addition to planned expansions, upgrades to the current WTP would need to be completed in 2015 to keep the plant running at its maximum efficiency. A 10 MG clearwell and additional high service pump station will need to constructed, and the WTP's electrical systems and instrumentation and controls need to be upgraded. A detailed description of the WTP's current condition and recommended upgrades can be found in Appendix F.

Based on the water supply study detailed in Section 3, this alternative assumes that BWA would experience a water shortage 10 percent of the time. Therefore, an annual stipend equating to the cost of 10 percent of the year's average day demand would be set aside for use if a water shortage occurs. It is assumed that BRA would have the necessary water for sale, and that the cost of the raw water would range from $62.50 per acre-foot in 2013 to $150 per acre-foot in 2040, based on the BRA long-term planning strategy.

New Northern Brazoria Regional WTP at Harris Reservoir

The new Northern Brazoria Regional WTP will be constructed on the north side of Harris Reservoir to serve Manvel, TDCJ Darrington Unit, TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit, Bailey's Prairie, Holiday Lakes, West Columbia, Varner Creek, and the County Other Future District population growth that is projected to occur along Highway 288. **Table 6-12** shows the maximum and average day demands for all the entities to be served by the new WTP on Harris Reservoir. (The development of these water demands is explained in detail in Section 4).

Under this alternative, Manvel would continue to utilize its current groundwater supplies but would meet future water demands in excess of their groundwater capacity with treated surface water from the new WTP (additional groundwater supplies were not considered in this analysis). The demands from Bailey's Prairie, Holiday Lakes, West Columbia, Varner Creek, TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit, TDCJ Darrington Unit and the County Other Future Districts would be met solely by treated surface water from the new WTP. **Table 6-18** shows the demand, groundwater capacity and expansions for this alternative.

Table 6-12 Demand and Supply Summary for Alternative 6 New WTP

Year	2010	2015	2020	2025	2030	2035	2040
Total Average Day Demand (MGD)	3.59	3.87	5.66	8.33	11.95	15.95	20.49
Groundwater Supply Used (MGD)	3.59	0.85	1.15	1.15	1.15	1.15	1.15
WTP Average Day Demand (MGD)	0.00	3.02	4.51	7.18	10.80	14.80	19.34
Total Max Day Demand (MGD)	4.41	4.79	7.65	11.88	17.63	23.87	30.83
Groundwater Supply Used (MGD)	4.41	1.13	1.15	1.15	1.15	1.15	1.15
WTP Max Day Demand (MGD)	0.00	3.66	6.50	10.73	16.48	22.72	29.68
Plant Capacity (MGD)	0	0	13	13	27	27	35
Expansion Required (MGD)	0	13	0	14	0	8	0

Notes:
1) Expansions required take into account the TCEQ regulation of planning requirements when the plant is at 85-percent capacity.

After taking into consideration the groundwater supply, to meet the 2040 max day demands of this alternative, the new WTP would be constructed in 2015 at an initial capacity of 13 MGD, with an expansion of 14 MGD in 2025 and 8 MGD in 2035. This alternative assumes that the new plant would be a conventional water filtration plant as BWA currently operates.

The high service pump station at the WTP that pumps finished water from the WTP through the transmission system would be expanded incrementally with the WTP. This pump station would be expanded to a firm capacity of 35 MGD by 2035. The raw water pump station/intake would also be expanded incrementally to 35 MGD.

New transmission pipelines will be sized to meet the year 2040 max day water demand while maintaining a pipeline velocity of approximately 5 fps and will be constructed in 2015. A 36-inch regional transmission main would be constructed leaving the new WTP to the east and an 8-inch regional transmission main would be leaving to the south. For TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit, and TDCJ Darrington Unit a 10-inch and 6-inch transmission line, respectively, would be required. To serve the County Other District population, CDM Smith assumed three 20-inch pipelines in the areas of projected growth would come off of the main transmission line. From these lines, any entities that wish to be connected in the future could be added. **Table 6-13** presents the required transmission piping sizes and lengths.

Table 6-13 Transmission Pipelines Required for Alternative 6 New WTP

Pipe Diameter (in)	Length (ft)
36	45,700
30	37,200
24	12,000
20	15,000
16	10,000
10	18,000
8	71,500
6	21,600

Any additional piping or storage tanks required for proper operation of the distribution system would be the responsibility of the individual entity and were not included in this evaluation.

Based on the water supply study detailed in Section 3, this alternative assumes that BWA would experience a water shortage 10 percent of the time. Therefore, an annual stipend equating to the cost of 10 percent of the year's average day demand would be set aside for use if a water shortage occurs. It is assumed that BRA would have the necessary water for sale, and that the cost of the raw water would range from $62.50 per acre-foot in 2013 to $150 per acre-foot in 2040, based on the BRA long-term planning strategy.

6.5.6 Alternative 6: BWA WTP Expands to Meet Existing plus New Customer Demands (67% Water Shortage Purchase), New WTP on Harris Reservoir

This alternative is the same as Alternative 6, with the exception of the water shortage planning. In the water supply study detailed in Section 3, looking at year 2011, the data showed that BWA could be without water for as long as eight months out of the year. To increase the reliability of the system during periods of drought, this alternative assumed that BWA would negotiate a contract with BRA for the rights to eight months, or 67 percent, of the given WTP's 2040 average day water demand. (For this alternative, the BWA WTP 2040 average day demand is 11.84 MGD and the new WTP 2040 average day demand is 19.34 MGD). As such, this evaluation assumed that beginning immediately, BWA would purchase 8,843 acre-feet of water for the existing BWA Plant and 14,446 acre-feet of water for the new WTP, and that the cost of the raw water would range from $62.50 per acre-foot in 2013 to $150 per acre-foot in 2040, based on the BRA long-term planning strategy.

6.5.7 Alternative 3 – Brackish: BWA WTP Expands/Brackish Groundwater RO Plant to Meet Current Customer Demands, New Plant in Manvel

This alternative is the same as Alternative 3, except the initial 10 MGD expansion in 2015 would be the construction of a reverse osmosis (RO) plant treating brackish groundwater at the existing BWA WTP site. The second expansion of 7 MGD in 2030 would be an expansion to the current BWA conventional filtration treatment process.

In addition to the RO Plant, wells would need to be drilled near the existing BWA WTP site. Based on the study completed by INTERA (see **Appendix B**), the wells should be no larger than 3 MGD each. For this alternative, CDM Smith assumed four 3-MGD wells would be needed. They would be approximately 1,200 to 1,500 feet deep and 2,500 feet apart. Each well would have a 12-inch riser, connecting to a header that increased in size, culminating in a 24-inch collection pipeline to the RO Plant.

With brackish groundwater being readily available, this alternative does not include a provision for buying water during periods of drought.

6.5.8 Alternative 3 – Seawater: BWA WTP Expands/Seawater RO Plant to Meet Current Customer Demands, New Plant in Manvel

This alternative is the same as Alternative 3, except the initial 10 MGD expansion in 2015 would be the construction of a reverse osmosis (RO) plant treating seawater at the existing BWA WTP site. The second expansion of 7 MGD in 2030 would be an expansion to the current BWA conventional filtration treatment process. With seawater being readily available, this alternative does not include a provision for buying water during periods of drought.

6.5.9 Alternative 3 BWA – Brackish: Brackish Groundwater RO Plant at BWA WTP Site

In this alternative, an RO Plant treating brackish groundwater would be constructed at the site of the existing BWA WTP to meet the 2040 max day demands from Angleton, Brazoria, Clute, Freeport, Lake Jackson, Oyster Creek, Richwood, TDCJ Clemens Unit, TDCJ Wayne Scott Unit, TDCJ Darrington Unit, TDCJ

Ramsey Unit, Stringfellow Unit and Terell Unit, Manvel, Dow and County Other Future Districts. The existing BWA WTP would continue to operate at its rated capacity. No new WTP would be constructed in Manvel. **Figure 6-11** at the end of this Section shows an overview of final Alternative 3 BWA – Brackish.

Under this alternative, Angleton, Brazoria, Clute, Freeport, Lake Jackson, Oyster Creek, Richwood and Manvel would continue to utilize their current groundwater supplies but would meet future water demands in excess of their groundwater capacity with treated water from the BWA WTP and the RO Plant (additional groundwater supplies were not considered in this analysis). **Table 6-14** shows the total water demand, groundwater capacity and expansions for this alternative. (The development of these water demands is explained in detail in Section 4).

Table 6-14 Demand and Supply Summary for Alternative 3 BWA – Brackish BWA WTP

Year	2010	2015	2020	2025	2030	2035	2040
Total Average Day Demand (MGD)	15.02	16.82	19.48	23.19	27.73	32.80	38.13
Groundwater Supply Used (MGD)	4.03	4.61	5.73	6.80	7.74	8.82	9.63
WTP Average Day Demand (MGD)	11.73	12.75	14.25	16.94	20.58	24.60	29.16
Total Max Day Demand (MGD)	22.78	25.27	29.85	36.16	43.82	52.25	61.02
Groundwater Supply Used (MGD)	10.87	12.38	14.16	15.05	15.16	15.26	15.37
WTP Max Day Demand (MGD)	12.00	13.03	15.88	21.34	28.95	37.31	46.01
Plant Capacity (MGD)	17.97	17.97	27.97	27.97	44.97	44.97	54.97
Expansion Required (MGD)	0	10	0	17	0	10	0

Notes:
1) Expansions required take into account the TCEQ regulation of planning requirements when the plant is at 85-percent capacity.
2) Total groundwater capacity is 14.22 MGD; however, Oyster Creek only uses 0.29 MGD of 1.50 MGD groundwater capacity and Clute uses 1.38 MGD of 1.83 MGD groundwater capacity in 2040.
3) Since BWA is required to fulfill the existing contracts, total contract amounts for Angleton (1.80 MGD) and Freeport (2.00 MGD) are included in the WTP demands, even if complete amount not utilized.

After taking into consideration the groundwater supply, to meet the 2040 max day demands for this alternative, the RO Plant would be expanded incrementally, starting with an initial 10 MGD construction in 2015, followed by a 17 MGD expansion in 2025 and a 10 MGD expansion in 2035.

In addition to the RO Plant, wells would need to be drilled near the existing BWA WTP site. Based on the study completed by INTERA (see Appendix B), the wells should be no larger than 3 MGD. For this alternative, CDM Smith assumed ten 3-MGD wells would be needed. They would be approximately 1,200 to 1,500 feet deep and 2,500 feet apart. Each well would have a 12-inch riser, connecting to a header that increased in size, culminating in a 42-inch influent pipeline to the RO Plant.

The high service pump station at the BWA WTP that pumps finished water from the WTP through the transmission system would be expanded incrementally with the WTP. This pump station would be expanded to a firm capacity of 54.8 MGD by 2035.

In order to reach Manvel, TDCJ Darrington Unit, TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit and the County Other Future Districts, a tank farm and booster pump station were assumed to be constructed just north of Angleton. The tank farm will start with an initial 6 MG GST and 9 MGD pumping capacity in 2015. An additional 6 MG GST and 10 MGD pumping capacity will be added in 2025 and an additional 4 MG GST and 6 MGD of pumping capacity in 2035.

Transmission piping from the tank farm to Manvel, TDCJ Darrington Unit, TDCJ Ramsey Unit, Stringfellow Unit and Terell Unit, and the County Other Future Districts will need to be constructed in 2015, but based on the capacity of the current pipeline from the BWA WTP to Angleton, construction of an additional transmission line from the existing BWA WTP to the tank farm can be postponed until 2020. A connection from the current Angleton transmission main to the tank farm will need to be installed. Any additional piping or storage tanks required for proper operation of the distribution system would be the responsibility of the individual entity and were not included in this evaluation.

The system's current transmission pipelines would continue to be utilized as long as the velocity through the pipeline is at 5 fps. Additional pipeline capacity will be added where needed. New transmission pipelines will be sized to meet the year 2040 max day water demand while maintaining a pipeline velocity of approximately 5 fps and will be constructed in 2020. **Table 6-15** presents the required transmission piping sizes and lengths.

Table 6-15 Transmission Pipelines Required for Alternative 3 BWA WTP Expansion

Pipe Diameter (in)	Length (ft)
42	64,900
30	21,000
20	20,000
16	9,600
10	19,200
6	33,900

In addition to planned expansions, upgrades to the current WTP would need to be completed in 2015 to keep the plant running at its maximum efficiency. A 10 MG clearwell and high service pump station will need to constructed, and the WTP's electrical systems and instrumentation and controls need to be upgraded. A detailed description of the WTP's current condition and recommended upgrades can be found in Appendix F.

With brackish groundwater being readily available, this alternative does not include a provision for buying surface water during periods of drought.

6.5.10 Alternative 3 BWA – Seawater: Seawater RO Plant at BWA WTP Site

This alternative is the same as Alternative 3 BWA – Brackish, except the water supply would be seawater as opposed to brackish groundwater.

6.6 Summary

Each of the regional options has been described in detail in this section including the types and sizes of the regional facilities. **Figures 6-12** and **6-13** show the different WTP sizes for the BWA Regional Facility at Lake Jackson and the New WTP at Harris Reservoir or Manvel, respectively. In Section 7.0, the costs for constructing and operating the facilities associated with each option are presented, along with cost comparisons for each alternative.

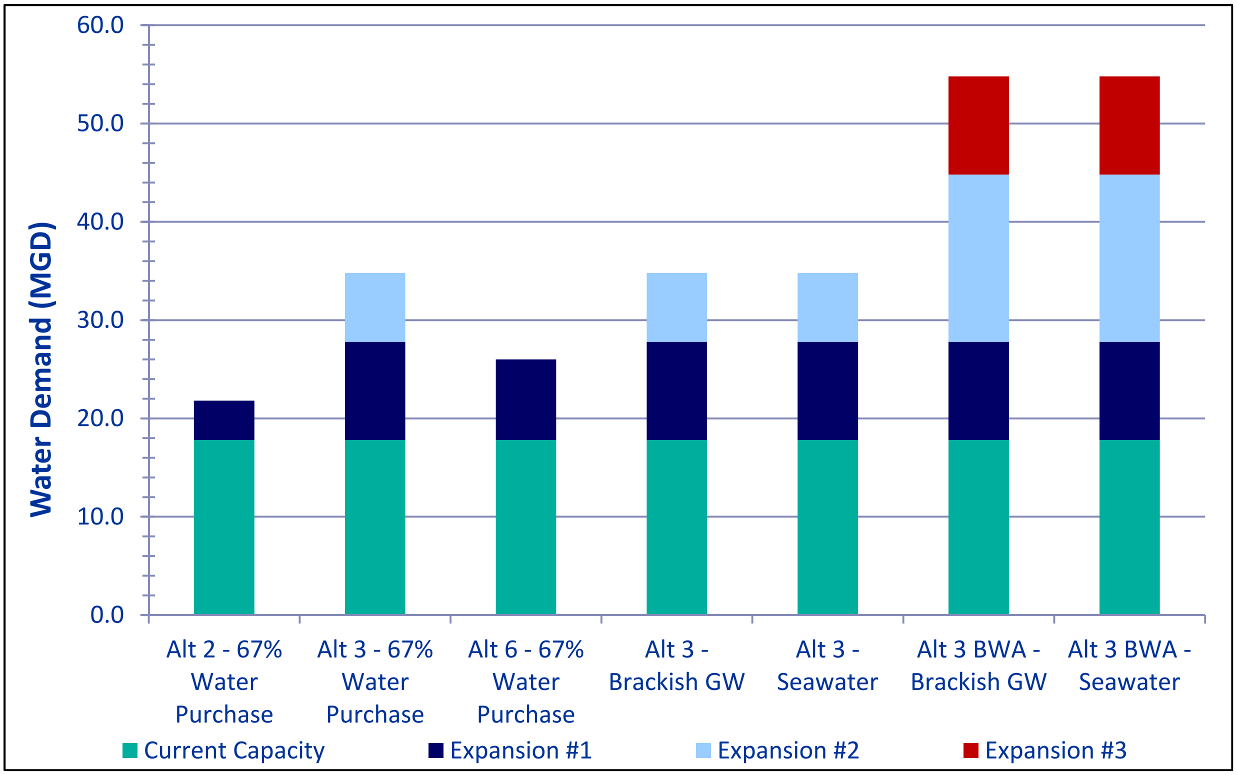


Figure 6-12
Plant Capacity per Alternative at BWA Regional Facility at Lake Jackson

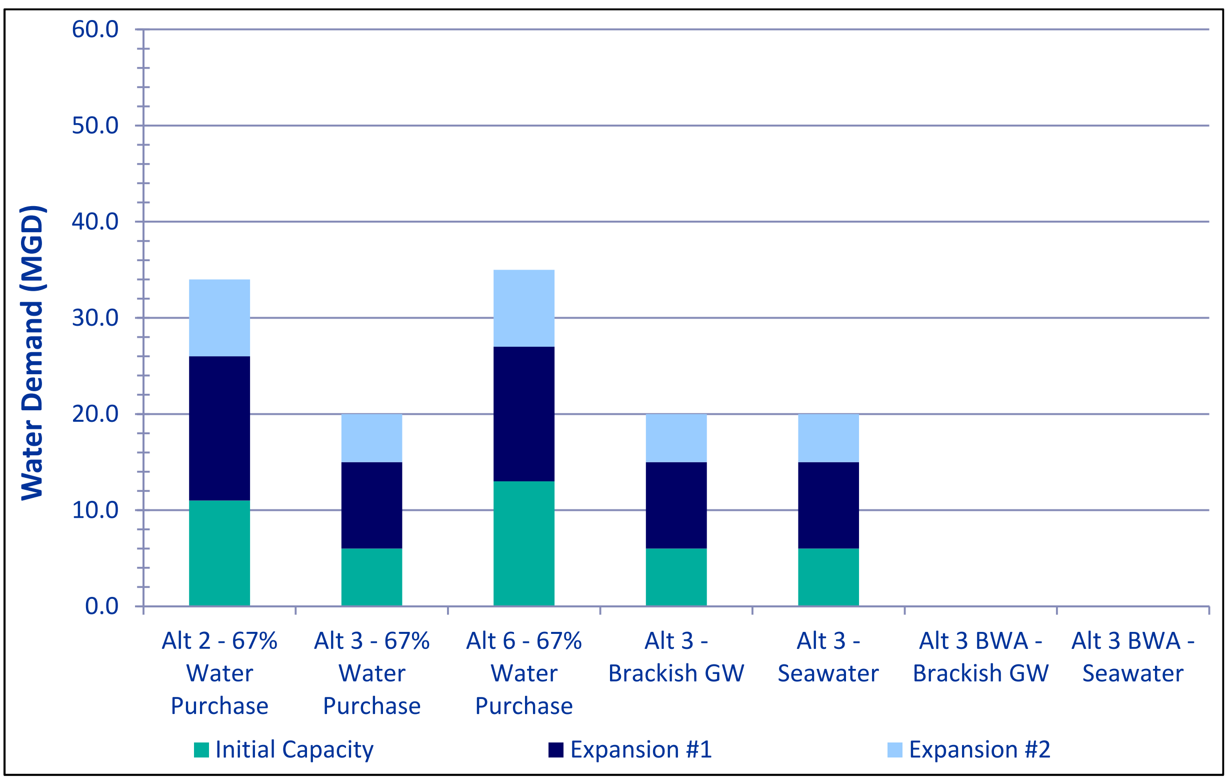
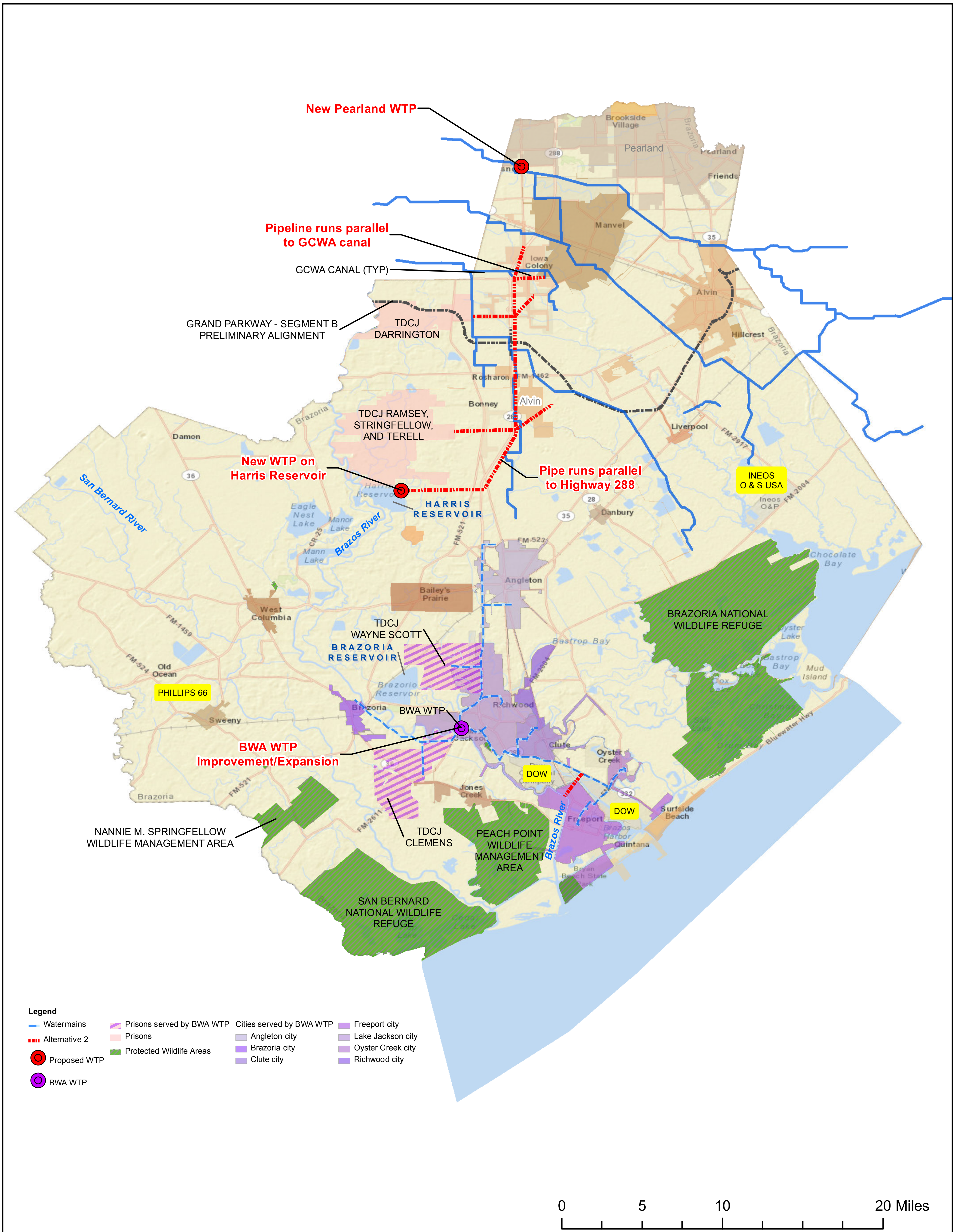


Figure 6-13
Plant Capacity per Alternative at New WTP at Harris Reservoir or Manvel



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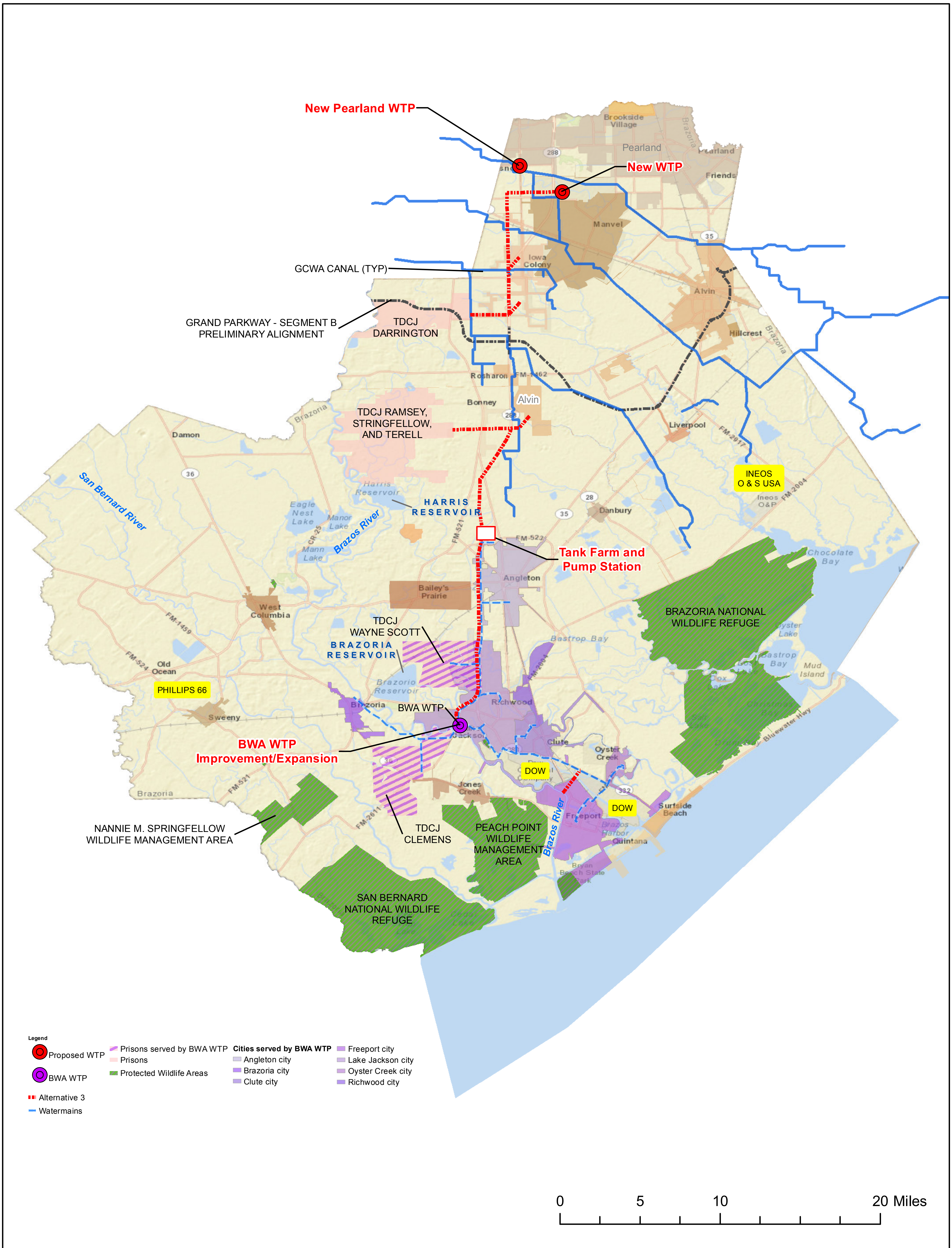
Brazoria County Water Distribution Alternatives

- Alternative Two -

Brazosport Water Authority

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

Figure 6-7
Overview of Final Alternative 2



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Brazoria County Water Distribution Alternatives

- Alternative Three -

Brazosport Water Authority

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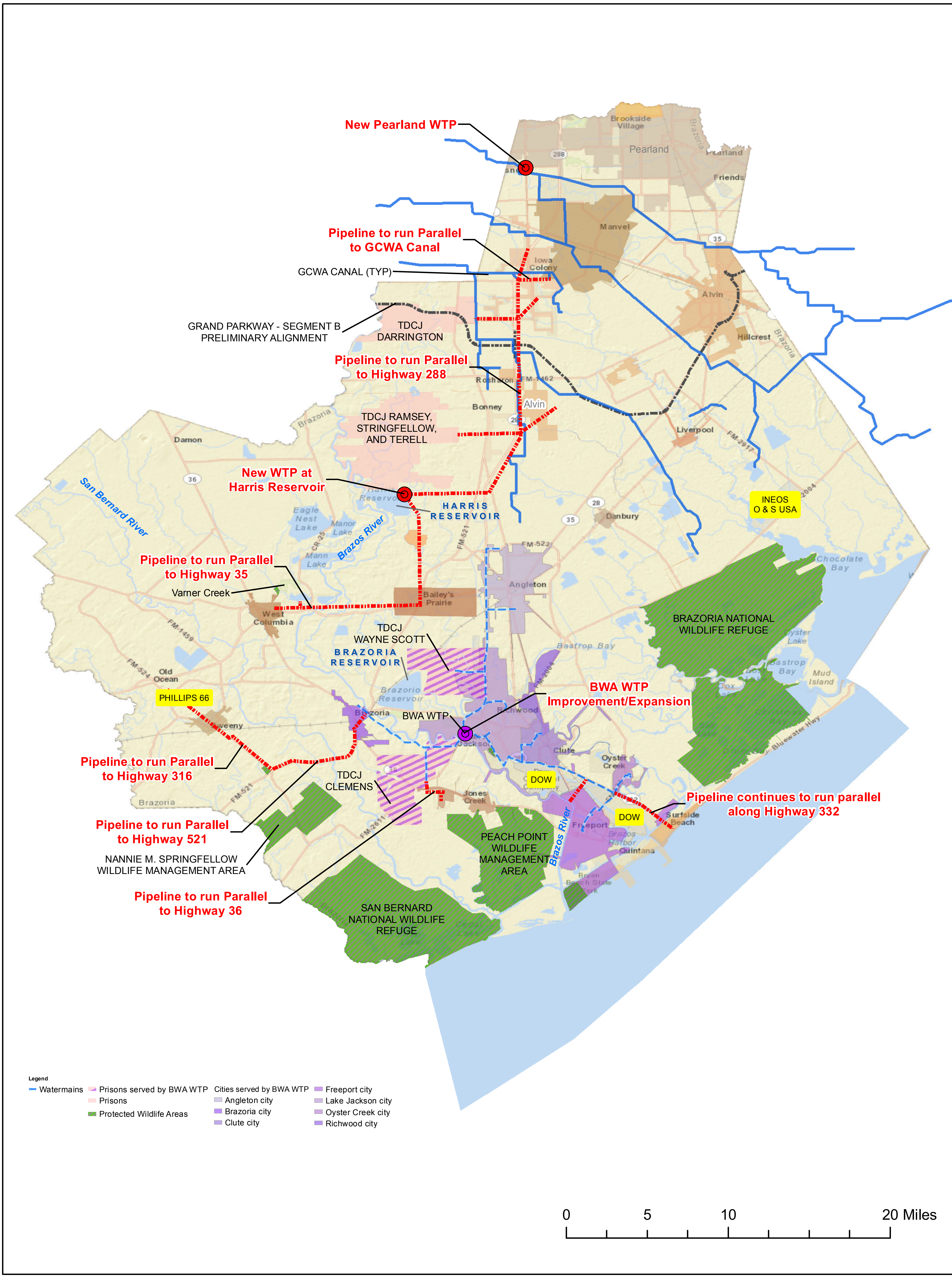
Figure 6-9
Overview of Final Alternative 3



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Brazoria County Water Distribution Alternatives

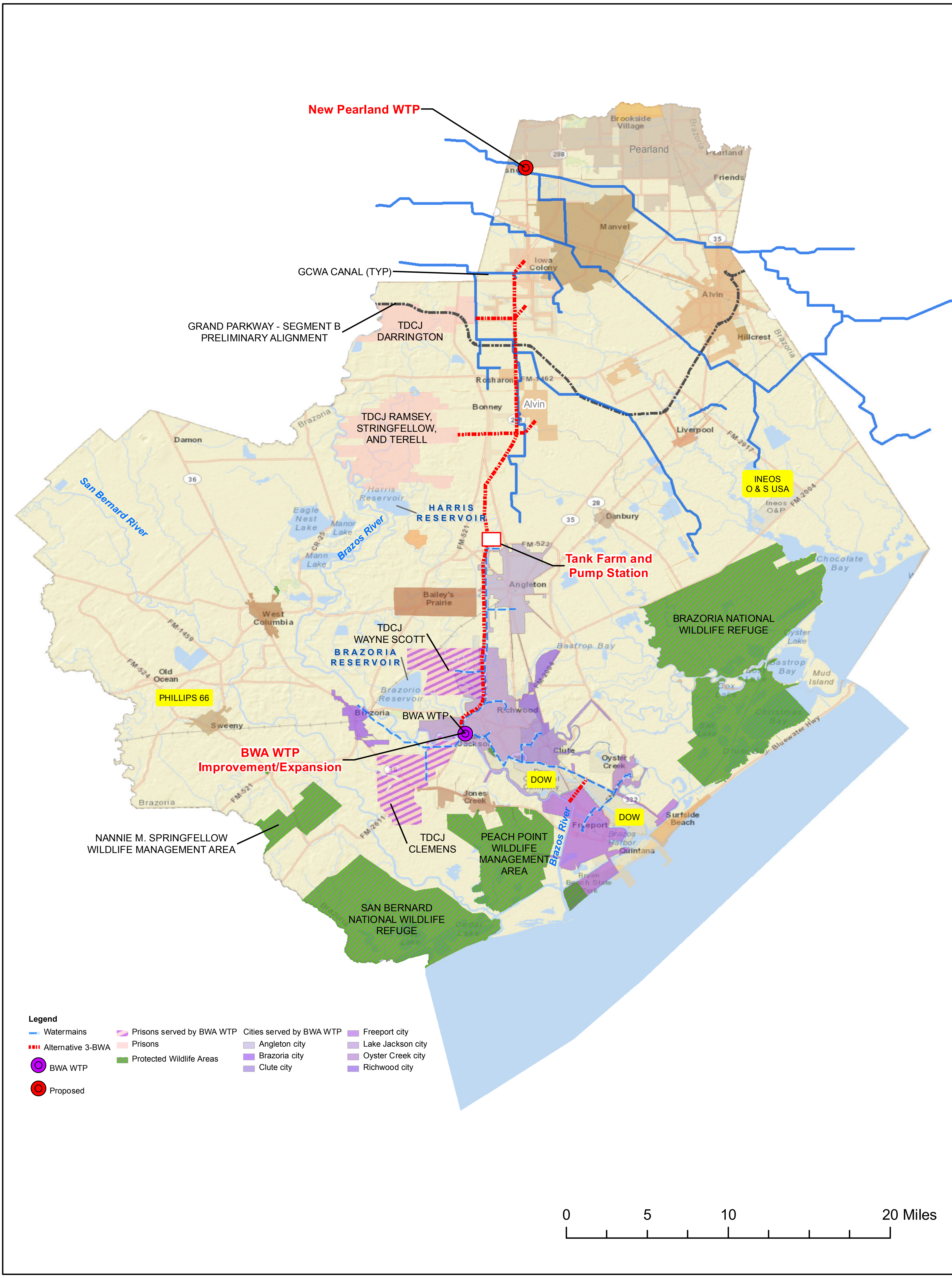
- Alternative Six -

Brazosport Water Authority

N W E S

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

Figure 6-10
Overview of Final Alternative 6



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Brazoria County Water Distribution Alternatives

- Alternative Three-BWA -

Brazosport Water Authority

N
W
E
S

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

Figure 6-11
Overview of Final Alternative 3 BWA - Brackish

Section 7
Cost Estimates

7.1 Introduction

CDM Smith performed an economic analysis on each of the alternatives described in Section 6. This economic analysis allowed the alternatives to be ranked and the least-cost option for the project participants to be determined. After the project participants select a regional system to pursue, CDM Smith recommends a complete financial analysis be performed by a financial analyst before securing funds for the project(s).

CDM Smith considered two categories for each option's cost analysis: capital costs for water treatment and transmission pipelines and annual operations and maintenance (O&M) costs for the entire system. The water treatment cost analysis includes costs for the raw water intake expansion/construction, piping and pumps, and water treatment options, and consists of both capital costs and O&M costs combined and calculated to provide a present worth cost per acre-foot of treated water. Additionally, a financial evaluation was completed to determine a cost per 1,000 gallons of treated water. The steps to this process for each option included the following:

- Step 1: Determine the water demand required for each five-year increment or phase for each alternative.
- Step 2: Compare the water demands to the capacity available. The incremental cost estimate is based on the additional capacity needed to meet the demand.
- Step 3: Determine what upgrades are needed at the existing BWA plant to maintain efficient operations.
- Step 4: Calculate capital costs and determine in which phase these costs will be incurred.
- Step 5: Complete a present worth analysis of the capital costs based on 2013 dollars.
- Step 6: Calculate annual O&M costs.
- Step 7: Complete a present worth analysis of the O&M costs based on 2013 dollars.
- Step 8: Using the combined present worth values for the capital and O&M costs and the total water supplied from 2013 to 2040, calculate a cost per acre-foot of treated water. This unit cost will offer a cost basis on which to compare all options.
- Step 9: Using the capital costs, inflated O&M costs and current debt service, complete a financial evaluation to determine a cost per 1,000 gallons of treated water.

7.2 Demand Determinations

Prior to beginning the cost analysis, CDM Smith compared the water demands versus the current treated water supply for each entity. Using the maximum daily demands for each option, and taking into account the systems that would continue to use their current groundwater supply and existing surface water contracts, the new WTP construction needs were determined. (See this discussion in the alternative description Section 6). **Table 7-1** shows the expansions/construction required at the existing BWA WTP for each alternative from 2015 thru 2040.

Table 7-1 Water Demands for BWA WTP by Alternative

Year	2010	2015	2020	2025	2030	2035	2040
BWA WTP Alternative 2							
Existing Capacity (MGD)	17.97	17. 97	17. 97	17. 97	17. 97	17. 97	20.97
Expansion Required (MGD)	0	0	0	0	0	3	0
New Capacity (MGD)	17. 97	17. 97	17. 97	17. 97	17. 97	20.97	20.97
BWA WTP Alternative 3							
Existing Capacity (MGD)	17. 97	17. 97	17. 97	17. 97	27.97	27.97	34.97
Expansion Required (MGD)	0	0	0	10	0	7	0
New Capacity (MGD)	17. 97	17. 97	17. 97	27.97	27.97	34.97	34.97
BWA WTP Alternative 6							
Existing Capacity (MGD)	17. 97	17. 97	17. 97	17. 97	17. 97	23.97	23.97
Expansion Required (MGD)	0	0	0	0	6	0	0
New Capacity (MGD)	17. 97	17. 97	17. 97	17. 97	23.97	23.97	23.97
BWA WTP Alternative 3 – Brackish: BWA WTP Expands/Brackish Groundwater RO Plant							
Existing Capacity (MGD)	17. 97	17. 97	17. 97	17. 97	27.97	27.97	34.97
Expansion Required (MGD)	0	10	0	0	7	0	0
New Capacity (MGD)	17. 97	27. 97	27. 97	27.97	34.97	34.97	34.97
BWA WTP Alternative 3 – Seawater: BWA WTP Expands/Seawater RO Plant							
Existing Capacity (MGD)	17. 97	17. 97	17. 97	17. 97	27.97	27.97	34.97
Expansion Required (MGD)	0	10	0	0	7	0	0
New Capacity (MGD)	17. 97	27. 97	27. 97	27.97	34.97	34.97	34.97
BWA WTP Alternative 3 BWA – Brackish: Brackish Groundwater RO Plant at BWA WTP Site							
Existing Capacity (MGD)	17. 97	17. 97	27.97	27.97	44.97	44.97	54.97
Expansion Required (MGD)	0	10	0	17	0	10	0
New Capacity (MGD)	17. 97	27.97	27.97	44.97	44.97	54.97	54.97
BWA WTP Alternative 3 BWA – Seawater: Seawater RO Plant at BWA WTP Site							
Existing Capacity (MGD)	17. 97	17. 97	27.97	27.97	44.97	44.97	54.97
Expansion Required (MGD)	0	10	0	17	0	10	0
New Capacity (MGD)	17. 97	27.97	27.97	44.97	44.97	54.97	54.97

Note: For Alternatives 2, 3 and 6, demands for both the 10% water shortage purchase option and the 67% water shortage purchase option are the same.

Table 7-2 shows the initial construction and expansions required at the new WTP for each alternative from 2015 thru 2040.

Table 7-2 Water Demands for New WTP by Alternative

Year	2010	2015	2020	2025	2030	2035	2040
New WTP Alternative 2							
Existing Capacity (MGD)	0	0	11	11	26	26	34
Expansion Required (MGD)	0	11	0	15	0	8	0
New Capacity (MGD)	0	11	11	26	26	34	34
New WTP Alternative 3							
Existing Capacity (MGD)	0	0	6	6	15	15	20
Expansion Required (MGD)	0	6	0	9	0	5	0
New Capacity (MGD)	0	6	6	15	15	20	20
New WTP Alternative 6							
Existing Capacity (MGD)	0	0	13	13	27	27	35
Expansion Required (MGD)	0	13	0	14	0	8	0
New Capacity (MGD)	0	13	13	27	27	35	35

Note: For Alternatives 2, 3 and 6, demands for both the 10% water shortage purchase option and the 67% water shortage purchase option are the same.

Pearland will continue to use its current water supplies, with an additional 10 MGD needed by 2020 and another 10 MGD by 2035.

7.3 Current Plant Upgrades

CDM Smith completed an assessment of the current BWA WTP and held subsequent discussions with Plant staff to determine what improvements would be required now to keep the plant running efficiently. Based on this assessment, CDM Smith recommends the installation of a 10 MG clearwell, high service pump station improvements, yard piping improvements, and upgrades to the electrical systems and instrumentation and controls. The costs of these upgrades were included in all alternatives in the year 2015. **Table 7-3** presents these costs. A complete description of the Plant's current condition and recommended improvements can be found in **Appendix F**.

Table 7-3 Proposed Probable Costs for Current BWA WTP Upgrades

Item	Description	Quantity	Unit	Unit Cost	Total
1.0 Process Mechanical Equipment					
	Clearwell, 10 MG	1	EA	$3,120,000	$3,120,000
	High Service Pump Station	17,500,000	GPD	$0.20	$3,500,000
	30" Yard Piping	1	LS	$366,000	$366,000
	Instrumentation (5%)	1	LS	$156,000	$156,000
	Electrical (20%)	1	LS	$624,000	$624,000
	Ancillary equipment and piping	1	LS	$312,000	$312,000
	Clearwell Foundation	1	LS	$1,000,000	$1,000,000
	Site Preparation	1	LS	$100,000	$100,000
				Subtotal:	***$9,178,000***
2.0 Electrical					
	Demolition of existing 4160V switchgears, 4160V MCC, and appurtenances	1	LS	$20,000	$20,000
	New 4160V MCC	1	LS	$380,000	$380,000
	Cables, conduits, and miscellaneous	1	LS	$110,000	$110,000
	Perform coordination, short circuit, arc flash study, arc flash labels, and training	1	LS	$20,000	$20,000
				Subtotal:	***$530,000***

3.0 Instrumentation and Control				
Remote Sites	14	EA	$32,100	$450,000
High Service DCU	1	LS	$40,000	$40,000
Raw Water DCU	1	LS	$40,000	$40,000
Filter DCU	1	LS	$40,000	$40,000
Master DCU	1	LS	$40,000	$40,000
Computers and Software	1	LS	$50,000	$50,000
			Subtotal:	***$660,000***
			Construction Cost Total:	***$10,368,000***
Contingency (20%)	1	LS	$2,074,000	$2,074,000
Professional Services (15%)	1	LS	$1,556,000	$1,556,000
			Total:	**$13,998,000**

7.4 Unit Capital Costs for Water Treatment

The capital cost analysis for water treatment included the following cost categories for each of the options:

- Current plant upgrades;
- Raw water intake and raw water pump station (RWPS);
- Water treatment plant;
- High service pump station (HSPS);
- Transmission system piping;
- Brackish groundwater wells, where applicable; and
- Tank farm, where applicable.

As it was not within the scope of this project to determine the exact treatment process, raw water pump station or piping design required for each option, planning level unit costs were based on industry standards and experience in lieu of a more specific engineering design. Capital cost analysis also incorporated when the costs would be incurred (i.e., whether it was through a phased cost outlay approach or in one lump sum at the beginning of the project) and included the following cost factors in addition to the unit costs:

- 20 percent contingency
- 15 percent professional services fee, which can include costs for surveying, legal services, engineering services, financial advisors, etc.

Water treatment cost analysis did not incorporate the following elements as these would be determined in subsequent phases of a future project upon selection of an option:

- Any non-capacity increasing upgrades (such as regulatory driven upgrades) required on project participant's existing systems water treatment facilities (i.e., existing treatment plants, raw water pump stations, pipelines, and high service pump stations, etc.); and
- Land acquisition or easement costs.

The methodology used to determine the capital costs is described in the sections below.

7.4.1 Raw Water Intake/Pump Station

Capital costs for the raw water intake and pump station were based on a planning level unit cost per gallon of water pumped. Based on experience and industry standards, CDM Smith used $0.20 per gallon per day (GPD) of capacity for all sizes. This cost is for additional pumps as needed, as well as appurtenances, intake repairs or electrical and instrumentation upgrades needed to handle the additional flows. As an example, for the new Northern Brazoria Regional WTP in Alternative 2, an 11 MGD construction would be planned for 2015, which has a capital cost for the raw water pump station and intake of $2.2 million. Raw water intake and pump station expansions would be incurred incrementally at the same rate as the WTP expansions. Alternatives using brackish groundwater did not include a raw water intake and pump station costs for this water supply.

7.4.2 Water Treatment Plant

Similar to the raw water intake and pump station, estimated planning, design, and construction costs of the new plant expansions of the regional options were based on how much additional capacity would be needed at each phased interval. Incremental expansion sizes were determined based on demands and economy of scales. CDM Smith assumed all expansions were greater than five million gallons per day (MGD), where applicable, and that there are no more than three expansions during the 30-year planning period.

As discussed above, CDM Smith used planning level unit costs that were based on industry standards and experience. **Table 7-4** shows the conventional treatment initial and expansion costs based on a cost per gallon per day of treated water.

Table 7-4 Conventional Water Treatment Plant Planning Level Capital Cost Basis

Capacity	Cost per GPD of Capacity
Plant Expansion	$1.50
New Plant Construction	
3 to 6 MGD	$2.75
6 MGD or larger	$2.50

Based on the required plant expansion and the unit costs contained in Table 7-4, CDM Smith determined a capital cost for water treatment for each expansion required. In the previous example, Northern Brazoria Regional WTP in Alternative 2 needed an initial capacity of 11 MGD in 2015 at $2.50 per GPD of capacity for a total of $27.5 million. In 2025, an expansion of 15 MGD would be needed at $1.50 per GPD for a total of $22.5 million.

For alternatives using brackish groundwater or seawater, **Table 7-5** shows the treatment costs based on a cost per GPD of treated water.

Table 7-5 Brackish Groundwater and Seawater RO Plant Planning Level Capital Cost Basis

Capacity	Cost per GPD of Capacity
Brackish Groundwater	
Less than 7.5 MGD	$2.73
7.5 MGD or larger	$1.79
Seawater	
Less than 7.5 MGD	$7.65
7.5 MGD or larger	$5.81

7.4.3 High Service Pump Station

Similar to the raw water intake and pump station, capital costs for the high service pump station (HSPS) were based on a planning level unit cost per gallon of water pumped. Based on experience and industry standards, CDM Smith used $0.20 per GPD of capacity for all sizes. HSPS expansions were incurred incrementally at the same rate as the WTP expansions. As an example, for the new Northern Brazoria Regional WTP in Alternative 2, an 11 MGD construction is planned for 2015, which has a capital cost for the HSPS of $2.2 million.

7.4.4 Water Transmission System

The costs for the treated water transmission pipeline included the costs of installing the pipeline to convey treated water from the WTP to individual customers but did not include the costs for transmission through the individual systems. For this analysis, CDM Smith assumed that the new pipeline would be sized to accommodate the additional capacity needed only, as the current transmission pipelines would also remain in service. Unlike the WTP and pump stations, the installation of the pipelines would not be phased. Instead, CDM Smith assumed that the cost to accommodate any future flows would be incurred at the earliest phase in which additional capacity was needed. The new pipelines for this analysis were based on the following assumptions:

- Pipeline diameter was based on a maximum velocity of 5.0 feet per second (fps) and designed to meet 2040 max day demand.
- Pipelines to expand existing transmission capacity would follow the alignment of the existing pipelines, where applicable. The additional parallel distribution pipelines required would be sized to transport the additional capacity needed to meet the year 2040 max day water demand.
- Pipeline alignments were not based on a detailed study of the topography and soil conditions as this was not part of the scope. Alignments were assumed to follow major highways within the area.

Based on experience and industry standards, as well as research of pipe prices in the area, planning level unit costs used are presented in **Table 7-6**.

Table 7-6 Pipeline Unit Costs

Diameter	$/in-ft
4	$8.15
6	$8.00
8	$7.15
10	$6.70
12	$5.50
16	$5.50
20	$5.50
24	$5.50
30	$5.85
36	$6.15
42	$6.50
48	$6.90
60	$6.90

For the expansion of BWA WTP, transmission piping was constructed concurrently with the first expansion of the WTP or as needed. For the new WTP, construction of all transmission piping was completed in 2015.

7.4.5 Brackish Groundwater Wells

For alternatives using a brackish groundwater RO Plant, groundwater wells would need to be drilled. Based on experience and industry standards, the unit costs for drilling the wells and adding pumps used in this evaluation are $0.84/gal for wells less than 7.5 MGD and $0.76/gal for wells 7.5 MGD or larger. Based on the groundwater study completed by INTERA, the maximum size of each well is 3 MGD.

7.4.6 Tank Farm

For alternatives utilizing a tank farm and booster pump station, it was assumed that ground storage tanks (GST) would be utilized and constructed in phases as needed. Unit capital costs used for this evaluation were $1.50 per gallon for GSTs less than 5 MG and $1 per gallon for GSTs 5 MG or larger.

7.5 Operations and Maintenance Costs

CDM Smith also considered operation and maintenance (O&M) costs in the economic cost analysis, which are important elements to consider when determining which regional option would be the least cost for the entities. The O&M costs included:

- Operations,
- Quality control, maintenance and administration,
- High service pump station operations,
- Contract water purchase,
- Tank farm operations,
- Raw water purchase (new WTP only), and
- Well operations (brackish groundwater options only).

All calculations are based on the total average daily flows of the existing WTPs plus the additional flows needed to meet the water demands for each option. The methodology used to determine each of these O&M costs is discussed in the subsequent sections.

7.5.1 Operations

Operations costs were based on the current BWA WTP annual expenditures provided for the last five years. This data included:

- Labor,
- Power,
- Chemical,
- Sludge Disposal, and
- Raw Water.

For this same time period, BWA provided the average annual water demand for all its customers. From these values, a cost per 1,000 gallons of treated water was calculated. This cost was then used for the annual operating costs for the BWA WTP through 2040. The annual operating cost used for BWA WTP was

$1.08 per 1,000 gallons. This is the unit O&M cost for operating the entire plant including the additional upgrades. The O&M cost per year was calculated based on average day demands.

For the new WTP, it was assumed a contract for the purchase of raw water from BRA would have to be executed outside of BWA's current water rights. As such, the raw water costs included in the unit cost for BWA WTP operations were removed for the operations unit cost of the new WTP, and an additional raw water cost was added at BRA rates. Raw water costs will be discussed in a subsequent section. The resulting annual operating cost used for the new WTP was $0.88 per 1,000 gallons. This is the unit O&M cost for operating the entire plant including the additional upgrades. The O&M cost per year was calculated based on average day demands.

7.5.2 Quality Control, Maintenance and Administration

While annual quality control, maintenance and administration costs may increase with a larger capacity plant, based on experience, it was assumed that these costs will not rise currently with the unit costs. Instead, the increase was determined to be proportional to the current BWA WTP expenditures provided by BWA. Current annual costs are:

- Quality control – $40,800
- Maintenance – $256,900
- Administration – $160,000

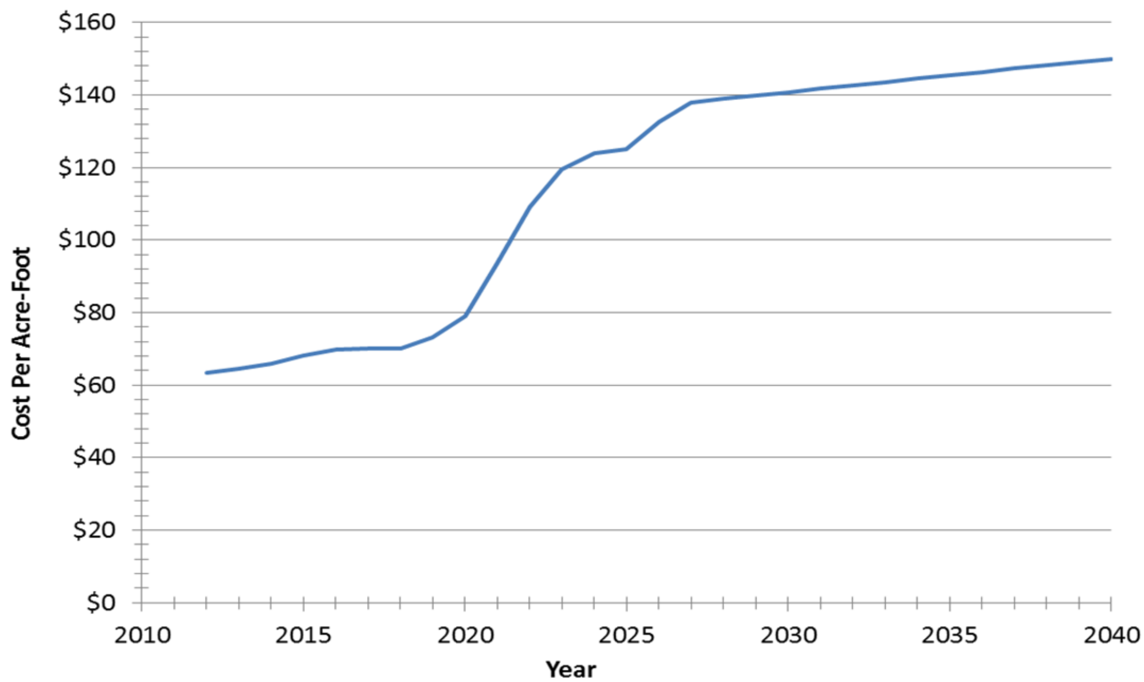
These costs are for a plant operating at an average day flow of 8.0 MGD, based on historic data. For the evaluation, each cost was adjusted proportionally based on the capacity of the WTP being analyzed. For example, a plant with an average day flow of 12.0 MGD would have an annual maintenance cost of $385,350, and a plant with an average day flow of 4.0 MGD would have an annual administration cost of $80,000. The costs used in the evaluation are for operating the entire plant including the additional upgrades. This methodology was used for both the BWA WTP expansions and the new WTP operations.

7.5.3 High Service Pump Station

The greatest source of power consumption comes from the electricity needed for pumping operations. Based on experience, CDM Smith estimated high service pump station operations at a unit cost of $0.05 per 1,000 gallons pumped.

7.5.4 Water Shortage Purchase

As described in Section 6, each alternative took into account planning for water shortages using one of two methods resulting in purchase of 10 percent of annual average daily demand or 67 percent of 2040 average daily demand. This evaluation assumes the raw water will be available for purchase from BRA, and based on the BRA long-term plan, the cost would rise from $62.50 per acre-foot in 2013 to $150 per acre-foot in 2040. **Figure 7-1** presents these costs.



Source: Brazos River Authority Long Range Financial Plan (www.brazos.org)

Figure 7-1
Projected Brazos River Authority Raw Water Costs

7.5.5 Raw Water Purchase

For the new WTP requiring new raw water purchase contracts, CDM Smith assumed an agreement would be executed with BRA for the purchase of the water. For this evaluation, it was also assumed BWA would purchase 100 percent of the 2040 average day demand at the given WTP to ensure the water availability through the study period. Based on the BRA long-term plan, the cost would rise from $62.50 per acre-foot in 2013 to $150 per acre-foot in 2040, as shown in Figure 7-1 above.

7.5.6 Well Operations

For options including the use of brackish groundwater, wells would need to be drilled and operated to meet the demands of the plant. Based on experience, industry standards, and prior CDM Smith work in the operations of brackish groundwater plants, the cost of operation for a brackish groundwater well used in this analysis was $0.05 per 1,000 gallons pumped.

7.6 Economic Analysis Methodology

The economic analysis is used as a way of comparing each alternative on an even level, based on capital and operations and maintenance (O&M) costs. The economic analysis included capital costs for: current plant upgrade, new and expanded water treatment capacity, raw water intake, raw water and high service pump stations and transmission pipelines. O&M costs were included from 2013 through 2040. An effective interest rate of 3.5 percent and a period of 2013 through 2040 were used.

For the economic analysis, the following steps were taken:

- Step 1: Present worth capital costs and O&M costs were calculated as previously described.
- Step 2: Calculate the total volume of water treated for a given WTP based on the average annual water demands from 2013 through 2040 and convert to acre-feet.

- Step 3: Convert each of the phased capital costs of construction to a present worth (PW) value based on 2013 dollars.
- Step 4: Convert the annual O&M costs for each year to a PW value to determine a total O&M cost for each regional option (not assuming the options to be implemented prior to 2013) from 2013 through 2040.
- Step 5: Using the total present worth value (capital and O&M costs) and the total water demand, a cost per acre-foot of treated water, referred to as the economical value, was determined. This unit cost was calculated for each alternative for the BWA WTP and the new WTP.
- Step 6: Using the unit costs for the BWA WTP, the new WTP and the Pearland WTP, a total unit cost for each alternative was determined.

7.7 Cost Comparison of Alternatives

Below are the results of the economic analysis for each alternative.

7.7.1 Alternative 2: BWA WTP Expands to Meet Current Customer Demands (10% Water Shortage Purchase), New Plant on Harris Reservoir

For the BWA WTP for this alternative, the PW of the capital costs is $17.3 million and the PW for the O&M costs from 2013 to 2040 is approximately $102 million, which is a total of approximately $121 million. The total volume of water treated from 2013 through 2040 is 328,865 acre-feet. The economic value for this alternative is $368 per acre-foot. **Table 7-7** summarizes the assessment for this alternative.

Table 7-7 Cost Summary for BWA WTP

Year	2010	2015	2020	2025	2030	2035	2040	Total
RWPS/Intake Expansions	$0	$0	$0	$0	$0	$600,000	$0	$600,000
Transmission System Piping	$0	$0	$0	$0	$0	$1,042,000	$0	$1,042,000
WTP Capital Cost	$0	$0	$0	$0	$0	$4,500,000	$0	$4,500,000
High Service Pump Station Expansions	$0	$0	$0	$0	$0	$600,000	$0	$600,000
Current Plant Upgrades	$0	$10,368,000	$0	$0	$0	$0	$0	$10,368,000
Professional Services (15%)	$0	$1,555,200	$0	$0	$0	$1,011,300	$0	$2,566,500
Contingency (20%)	$0	$2,073,600	$0	$0	$0	$1,348,400	$0	$3,422,000
Phase Capital Cost Totals	$0	$13,996,800	$0	$0	$0	$9,101,700	$0	$23,098,500
2013 Present Worth of Capital Costs	$0	$13,066,163	$0	$0	$0	$4,270,068	$0	$17,336,231
2013 Present Worth of O&M Costs *(Annual Costs Shown in Appendix G)*								$101,695,843
Total 2013 Present Worth Cost								**$119,032,074**
Total Average Day Water Demand from 2013-2040 (acre-feet)								**323,846**
Total Present Worth Cost per Acre-Foot								**$367.56**

For the New WTP for this alternative, the PW of the capital costs is $101 million and the PW for the O&M costs from 2013 to 2040 is approximately $72.5 million, which is a total of approximately $173 million. The total volume of water treated from 2013 through 2040 is 262,472 acre-feet. The economic value for this alternative is $660 per acre-foot. **Table 7-8** summarizes the assessment for this alternative.

Table 7-8 Cost Summary for New WTP

Year	2010	2015	2020	2025	2030	2035	2040	Total
RWPS/Intake Expansions	$0	$2,200,000	$0	$3,000,000	$0	$1,600,000	$0	$6,800,000
Transmission System Piping	$0	$20,116,000	$0	$0	$0	$0	$0	$20,116,000
WTP Capital Cost	$0	$27,500,000	$0	$22,500,000	$0	$12,000,000	$0	$62,000,000
High Service Pump Station Construction Expansions	$0	$2,200,000	$0	$3,000,000	$0	$1,600,000	$0	$6,800,000
Professional Services (15%)	$0	$7,802,400	$0	$4,275,000	$0	$2,280,000	$0	$14,357,400
Contingency (20%)	$0	$10,403,200	$0	$5,700,000	$0	$3,040,000	$0	$19,143,200
Phase Capital Cost Totals	$0	$70,221,600	$0	$38,475,000	$0	$20,520,000	$0	$129,216,600
2013 Present Worth of Capital Costs	$0	$65,552,700	$0	$25,462,200	$0	$9,627,000	$0	$100,641,900
2013 Present Worth of O&M Costs *(Annual Costs Shown in Appendix G)*								$72,533,079
Total 2013 Present Worth Cost								**$173,174,979**
Total Average Day Water Demand from 2013-2040 (acre-feet)								**262,472**
Total Present Worth Cost per Acre-Foot								**$659.79**

7.7.2 Alternative 2: BWA WTP Expands to Meet Current Customer Demands (67% Water Shortage Purchase), New Plant on Harris Reservoir

For the BWA WTP for this alternative, the PW of the capital costs is $17.3 million and the PW for the O&M costs from 2013 to 2040 is approximately $117 million, which is a total of approximately $136 million. The total volume of water treated 2013 through 2040 is 323,846 acre-feet. The economic value for this alternative is $414 per acre-foot. **Table 7-9** summarizes the assessment for this alternative.

Table 7-9 Cost Summary for BWA WTP

Year	2010	2015	2020	2025	2030	2035	2040	Total
RWPS/Intake Expansions	$0	$0	$0	$0	$0	$600,000	$0	$600,000
Transmission System Piping	$0	$0	$0	$0	$0	$1,042,000	$0	$1,042,000
WTP Capital Cost	$0	$0	$0	$0	$0	$4,500,000	$0	$4,500,000
High Service Pump Station Expansions	$0	$0	$0	$0	$0	$600,000	$0	$600,000
Current Plant Upgrades	$0	$10,368,000	$0	$0	$0	$0	$0	$10,368,000
Professional Services (15%)	$0	$1,555,200	$0	$0	$0	$1,011,300	$0	$2,566,500
Contingency (20%)	$0	$2,073,600	$0	$0	$0	$1,348,400	$0	$3,422,000
Phase Capital Cost Totals	$0	$13,996,800	$0	$0	$0	$9,101,700	$0	$23,098,500
2013 Present Worth of Capital Costs	$0	$13,066,163	$0	$0	$0	$4,270,068	$0	$17,336,231
2013 Present Worth of O&M Costs *(Annual Costs Shown in Appendix G)*								$116,708,154
Total 2013 Present Worth Cost								**$134,044,385**
Total Average Day Water Demand from 2013-2040 (acre-feet)								**323,846**
Total Present Worth Cost per Acre-Foot								**$413.91**

For the New WTP for this alternative, the PW of the capital costs is $101 million and the PW for the O&M costs from 2013 to 2040 is approximately $100 million, which is a total of approximately $201 million. The total volume of water treated from 2013 through 2040 is 262,472 acre-feet. The economic value for this alternative is $765 per acre-foot. **Table 7-10** summarizes the assessment for this alternative.

Table 7-10 Cost Summary for New WTP

Year	2010	2015	2020	2025	2030	2035	2040	Total
RWPS/Intake Expansions	$0	$2,200,000	$0	$3,000,000	$0	$1,600,000	$0	$6,800,000
Transmission System Piping	$0	$20,116,000	$0	$0	$0	$0	$0	$20,116,000
WTP Capital Cost	$0	$27,500,000	$0	$22,500,000	$0	$12,000,000	$0	$62,000,000
High Service Pump Station Construction/ Expansions	$0	$2,200,000	$0	$3,000,000	$0	$1,600,000	$0	$6,800,000
Professional Services (15%)	$0	$7,802,400	$0	$4,275,000	$0	$2,280,000	$0	$14,357,400
Contingency (20%)	$0	$10,403,200	$0	$5,700,000	$0	$3,040,000	$0	$19,143,200
Phase Capital Cost Totals	$0	$70,221,600	$0	$38,475,000	$0	$20,520,000	$0	$129,216,600
2013 Present Worth of Capital Costs	$0	$65,552,700	$0	$25,462,200	$0	$9,627,000	$0	$100,641,900
2013 Present Worth of O&M Costs *(Annual Costs Shown in Appendix G)*								$100,088,870
Total 2013 Present Worth Cost								**$200,730,770**
Total Average Day Water Demand from 2013-2040 (acre-feet)								**262,472**
Total Present Worth Cost per Acre-Foot								**$764.77**

7.7.3 Alternative 3: BWA WTP Expansion (10% Water Shortage Purchase), New Plant in Manvel

For the BWA WTP for this alternative, the PW of the capital costs is $68.6 million and the PW for the O&M costs from 2013 to 2040 is approximately $123 million, which is a total of approximately $191 million. The total volume of water treated from 2013 through 2040 is 448,474 acre-feet. The economic value for this alternative is $426 per acre-foot. **Table 7-11** summarizes the assessment for this alternative.

Table 7-11 Cost Summary for BWA WTP

Year	2010	2015	2020	2025	2030	2035	2040	Total
RWPS/Intake Expansions	$0	$0	$0	$2,000,000	$0	$1,400,000	$0	$3,400,000
Tank Farm/Pumps	$0	$8,640,000	$0	$4,320,000	$0	$4,320,000	$0	$17,280,000
Transmission System Piping	$0	$5,234,000	$0	$6,749,000	$0	$0	$0	$11,983,000
WTP Capital Cost	$0	$0	$0	$15,000,000	$0	$10,500,000	$0	$25,500,000
High Service Pump Station Expansions	$0	$0	$0	$2,000,000	$0	$1,400,000	$0	$3,400,000
Current Plant Upgrades	$0	$10,368,000	$0	$0	$0	$0	$0	$10,368,000
Professional Services (15%)	$0	$3,636,300	$0	$4,510,350	$0	$2,643,000	$0	$10,789,650
Contingency (20%)	$0	$4,848,400	$0	$6,013,800	$0	$3,524,000	$0	$14,386,200
Phase Capital Cost Totals	$0	$32,726,700	$0	$40,593,150	$0	$23,787,000	$0	$97,106,850
2013 Present Worth of Capital Costs	$0	$30,550,725	$0	$26,863,900	$0	$11,159,686	$0	$68,574,311
2013 Present Worth of O&M Costs *(Annual Costs Shown in Appendix G)*								$122,525,475
Total 2013 Present Worth Cost								**$191,099,786**
Total Average Day Water Demand from 2013-2040 (acre-feet)								**448,474**
Total Present Worth Cost per Acre-Foot								**$426.11**

For the New WTP for this alternative, the PW of the capital costs is $60 million and the PW for the O&M costs from 2013 to 2040 is approximately $50 million, which is a total of approximately $110 million. The total volume of water treated from 2013 through 2040 is 141,256 acre-feet. The economic value for this alternative is $775 per acre-foot. **Table 7-12** summarizes the assessment for this alternative.

Table 7-12 Cost Summary for New WTP

Year	2010	2015	2020	2025	2030	2035	2040	Total
RWPS/Intake Expansions	$0	$1,200,000	$0	$1,800,000	$0	$1,000,000	$0	$4,000,000
Transmission System Piping	$0	$13,366,000	$0	$0	$0	$0	$0	$13,366,000
WTP Capital Cost	$0	$15,000,000	$0	$13,500,000	$0	$7,500,000	$0	$36,000,000
High Service Pump Station Construction/Expansions	$0	$1,200,000	$0	$1,800,000	$0	$1,000,000	$0	$4,000,000
Professional Services (15%)	$0	$4,614,900	$0	$2,565,000	$0	$1,425,000	$0	$8,604,900
Contingency (20%)	$0	$6,153,200	$0	$3,420,000	$0	$1,900,000	$0	$11,473,200
Phase Capital Cost Totals	$0	$41,534,100	$0	$23,085,000	$0	$12,825,000	$0	$77,444,100
2013 Present Worth of Capital Costs	$0	$38,772,600	$0	$15,277,300	$0	$6,016,900	$0	$60,066,800
2013 Present Worth of O&M Costs *(Annual Costs Shown in Appendix G)*								$49,414,903
Total 2013 Present Worth Cost								**$109,481,703**
Total Average Day Water Demand from 2013-2040 (acre-feet)								**141,256**
Total Present Worth Cost per Acre-Foot								**$775.06**

7.7.4 Alternative 3: BWA WTP Expansion (67% Water Shortage Purchase), New Plant in Manvel

For the BWA WTP for this alternative, the PW of the capital costs is $68.6 million and the PW for the O&M costs from 2013 to 2040 is approximately $146 million, which is a total of approximately $215 million. The total volume of water treated from 2013 through 2040 is 448,474 acre-feet. The economic value for this alternative is $478 per acre-foot. **Table 7-13** summarizes the assessment for this alternative.

Table 7-13 Cost Summary for BWA WTP

Year	2010	2015	2020	2025	2030	2035	2040	Total
RWPS/Intake Expansions	$0	$0	$0	$2,000,000	$0	$1,400,000	$0	$3,400,000
Tank Farm/Pumps	$0	$8,640,000	$0	$4,320,000	$0	$4,320,000	$0	$17,280,000
Transmission System Piping	$0	$5,234,000	$0	$6,749,000	$0	$0	$0	$11,983,000
WTP Capital Cost	$0	$0	$0	$15,000,000	$0	$10,500,000	$0	$25,500,000
High Service Pump Station Expansions	$0	$0	$0	$2,000,000	$0	$1,400,000	$0	$3,400,000
Current Plant Upgrades	$0	$10,368,000	$0	$0	$0	$0	$0	$10,368,000
Professional Services (15%)	$0	$3,636,300	$0	$4,510,350	$0	$2,643,000	$0	$10,789,650
Contingency (20%)	$0	$4,848,400	$0	$6,013,800	$0	$3,524,000	$0	$14,386,200
Phase Capital Cost Totals	$0	$32,726,700	$0	$40,593,150	$0	$23,787,000	$0	$97,106,850
2013 Present Worth of Capital Costs	$0	$30,550,725	$0	$26,863,900	$0	$11,159,686	$0	$68,574,311
2013 Present Worth of O&M Costs *(Annual Costs Shown in Appendix G)*								$145,850,207
Total 2013 Present Worth Cost								**$214,424,518**
Total Average Day Water Demand from 2013-2040 (acre-feet)								**448,474**
Total Present Worth Cost per Acre-Foot								**$478.12**

For the New WTP for this alternative, the PW of the capital costs is $60 million and the PW for the total O&M costs from 2013 to 2040 is approximately $50 million, which is a total of approximately $110 million. The total volume of water treated from 2013 through 2040 is 141,256 acre-feet. The economic value for this alternative is $775 per acre-foot. **Table 7-14** summarizes the assessment for this alternative.

Table 7-14 Cost Summary for New WTP

Year	2010	2015	2020	2025	2030	2035	2040	Total
RWPS/Intake Expansions	$0	$1,200,000	$0	$1,800,000	$0	$1,000,000	$0	$4,000,000
Transmission System Piping	$0	$13,366,000	$0	$0	$0	$0	$0	$13,366,000
WTP Capital Cost	$0	$15,000,000	$0	$13,500,000	$0	$7,500,000	$0	$36,000,000
High Service Pump Station Construction/ Expansions	$0	$1,200,000	$0	$1,800,000	$0	$1,000,000	$0	$4,000,000
Professional Services (15%)	$0	$4,614,900	$0	$2,565,000	$0	$1,425,000	$0	$8,604,900
Contingency (20%)	$0	$6,153,200	$0	$3,420,000	$0	$1,900,000	$0	$11,473,200
Phase Capital Cost Totals	$0	$41,534,100	$0	$23,085,000	$0	$12,825,000	$0	$77,444,100
2013 Present Worth of Capital Costs	$0	$38,772,600	$0	$15,277,300	$0	$6,016,900	$0	$60,066,800
2013 Present Worth of O&M Costs *(Annual Costs Shown in Appendix G)*								$49,414,903
Total 2013 Present Worth Cost								**$109,481,703**
Total Average Day Water Demand from 2013-2040 (acre-feet)								**141,256**
Total Present Worth Cost per Acre-Foot								**$775.06**

7.7.5 Alternative 6: BWA WTP Expands to Meet Existing plus New Customer Demands (10% Water Shortage Purchase), New WTP on Harris Reservoir

For the BWA WTP for this alternative, the PW of the capital costs is $28.6 million and the PW for the O&M costs from 2013 to 2040 is approximately $102 million, which is a total of approximately $131 million. The total volume of water treated from 2013 through 2040 is 362,146 acre-feet. The economic value for this alternative is $359 per acre-foot. **Table 7-15** summarizes the assessment for this alternative.

Table 7-15 Cost Summary for BWA WTP

Year	2010	2015	2020	2025	2030	2035	2040	Total
RWPS/Intake Expansions	$0	$0	$0	$0	$1,200,000	$0	$0	$1,200,000
Transmission System Piping	$0	$0	$0	$0	$9,285,000	$0	$0	$9,285,000
WTP Capital Cost	$0	$0	$0	$0	$9,000,000	$0	$0	$9,000,000
High Service Pump Station Expansions	$0	$0	$0	$0	$1,200,000	$0	$0	$1,200,000
Current Plant Upgrades	$0	$10,368,000	$0	$0	$0	$0	$0	$10,368,000
Professional Services (15%)	$0	$1,555,200	$0	$0	$3,102,750	$0	$0	$4,657,950
Contingency (20%)	$0	$2,073,600	$0	$0	$4,137,000	$0	$0	$6,210,600
Phase Capital Cost Totals	$0	$13,996,800	$0	$0	$27,924,750	$0	$0	$41,921,550
2013 Present Worth of Capital Costs	$0	$13,066,163	$0	$0	$15,559,776	$0	$0	$28,625,939
2013 Present Worth of O&M Costs *(Annual Costs Shown in Appendix G)*								$101,525,366
Total 2013 Present Worth Cost								**$130,151,305**
Total Average Day Water Demand from 2013-2040 (acre-feet)								**362,416**
Total Present Worth Cost per Acre-Foot								**$359.12**

For the New WTP for this alternative, the PW of the capital costs is $115 million and the PW for the O&M costs from 2013 to 2040 is approximately $67 million, which is a total of approximately $182 million. The total volume of water treated from 2013 through 2040 is 284,014 acre-feet. The economic value for this alternative is $641 per acre-foot. **Table 7-16** summarizes the assessment for this alternative.

Table 7-16 Cost Summary for New WTP

Year	2010	2015	2020	2025	2030	2035	2040	Total
RWPS/Intake Expansions	$0	$2,600,000	$0	$2,800,000	$0	$1,600,000	$0	$7,000,000
Transmission System Piping	$0	$27,097,000	$0	$0	$0	$0	$0	$27,097,000
WTP Capital Cost	$0	$32,500,000	$0	$21,000,000	$0	$12,000,000	$0	$65,500,000
High Service Pump Station Construction/Expansions	$0	$2,600,000	$0	$2,800,000	$0	$1,600,000	$0	$7,000,000
Professional Services (15%)	$0	$9,719,550	$0	$3,990,000	$0	$2,280,000	$0	$15,989,550
Contingency (20%)	$0	$12,959,400	$0	$5,320,000	$0	$3,040,000	$0	$21,319,400
Phase Capital Cost Totals	$0	$87,475,950	$0	$35,910,000	$0	$20,520,000	$0	$143,905,950
2013 Present Worth of Capital Costs	$0	$81,659,800	$0	$23,764,700	$0	$9,627,000	$0	$115,051,500
2013 Present Worth of O&M Costs *(Annual Costs Shown in Appendix G)*								$67,099,72
Total 2013 Present Worth Cost								**$182,151,227**
Total Average Day Water Demand from 2013-2040 (acre-feet)								**284,014**
Total Present Worth Cost per Acre-Foot								**$641.34**

7.7.6 Alternative 6: BWA WTP Expands to Meet Existing plus New Customer Demands (67% Water Shortage Purchase), New WTP on Harris Reservoir

For the BWA WTP for this alternative, the PW of the capital costs is $28.6 million and the PW for the O&M costs from 2013 to 2040 is approximately $116 million, which is a total of approximately $145 million. The total volume of water treated from 2013 through 2040 is 362,416 acre-feet. The economic value for this alternative is $399 per acre-foot. **Table 7-17** summarizes the assessment for this alternative.

Table 7-17 Cost Summary for BWA WTP

Year	2010	2015	2020	2025	2030	2035	2040	Total
RWPS/Intake Expansions	$0	$0	$0	$0	$1,200,000	$0	$0	$1,200,000
Transmission System Piping	$0	$0	$0	$0	$9,285,000	$0	$0	$9,285,000
WTP Capital Cost	$0	$0	$0	$0	$9,000,000	$0	$0	$9,000,000
High Service Pump Station Expansions	$0	$0	$0	$0	$1,200,000	$0	$0	$1,200,000
Current Plant Upgrades	$0	$10,368,000	$0	$0	$0	$0	$0	$10,368,000
Professional Services (15%)	$0	$1,555,200	$0	$0	$3,102,750	$0	$0	$4,657,950
Contingency (20%)	$0	$2,073,600	$0	$0	$4,137,000	$0	$0	$6,210,600
Phase Capital Cost Totals	$0	$13,996,800	$0	$0	$27,924,750	$0	$0	$41,921,550
2013 Present Worth of Capital Costs	$0	$13,066,163	$0	$0	$15,559,776	$0	$0	$28,625,939
2013 Present Worth of O&M Costs *(Annual Costs Shown in Appendix G)*								$116,279,688
Total 2013 Present Worth Cost								**$144,905,627**
Total Average Day Water Demand from 2013-2040 (acre-feet)								**362,416**
Total Present Worth Cost per Acre-Foot								**$399.83**

For the New WTP for this alternative, the PW of the capital costs is $115 million and the PW for the O&M costs from 2013 to 2040 is approximately $92 million, which is a total of approximately $207 million. The total volume of water treated from 2013 through 2040 is 284,014 acre-feet. The economic value for this alternative is $729 per acre-foot. **Table 7-18** summarizes the assessment for this alternative.

Table 7-18 Cost Summary for New WTP

Year	2010	2015	2020	2025	2030	2035	2040	Total
RWPS/Intake Expansions	$0	$2,600,000	$0	$2,800,000	$0	$1,600,000	$0	$7,000,000
Transmission System Piping	$0	$27,097,000	$0	$0	$0	$0	$0	$27,097,000
WTP Capital Cost	$0	$32,500,000	$0	$21,000,000	$0	$12,000,000	$0	$65,500,000
High Service Pump Station Construction/Expansions	$0	$2,600,000	$0	$2,800,000	$0	$1,600,000	$0	$7,000,000
Professional Services (15%)	$0	$9,719,550	$0	$3,990,000	$0	$2,280,000	$0	$15,989,550
Contingency (20%)	$0	$12,959,400	$0	$5,320,000	$0	$3,040,000	$0	$21,319,400
Phase Capital Cost Totals	$0	$87,475,950	$0	$35,910,000	$0	$20,520,000	$0	$143,905,950
2013 Present Worth of Capital Costs	$0	$81,659,800	$0	$23,764,700	$0	$9,627,000	$0	$115,051,500
2013 Present Worth of O&M Costs *(Annual Costs Shown in Appendix G)*								$91,927,560
Total 2013 Present Worth Cost								**$206,979,060**
Total Average Day Water Demand from 2013-2040 (acre-feet)								**284,014**
Total Present Worth Cost per Acre-Foot								**$728.76**

7.7.7 Alternative 3 – Brackish: BWA WTP Expands/Brackish Groundwater RO Plant to Meet Current Customer Demands, New Plant in Manvel

For the BWA WTP for this alternative, the PW of the capital costs is $90.1 million and the PW for the total O&M costs from 2013 to 2040 is approximately $120 million, which is a total of approximately $211 million. The total volume of water treated from 2013 through 2040 is 453,493 acre-feet. The economic value for this alternative is $469 per acre-foot. **Table 7-19** summarizes the assessment for this alternative.

Table 7-19 Cost Summary for BWA WTP

Year	2010	2015	2020	2025	2030	2035	2040	Total
Groundwater Wells	$0	$7,605,000	$0	$0	$0	$0	$0	$7,605,000
RWPS/Intake Expansions	$0	$0	$0	$0	$1,400,000	$0	$0	$1,400,000
Tank Farm/Pumps	$0	$8,640,000	$0	$4,320,000	$0	$4,320,000	$0	$17,280,000
Well Piping	$0	$903,000	$0	$0	$0	$0	$0	$903,000
Transmission System Piping	$0	$5,234,000	$6,749,000	$0	$0	$0	$0	$11,983,000
WTP Capital Cost	$0	$17,890,181	$0	$0	$10,500,000	$0	$0	$28,390,181
High Service Pump Station Expansions	$0	$2,000,000	$0	$0	$1,400,000	$0	$0	$3,400,000
Current Plant Upgrades	$0	$10,368,000	$0	$0	$0	$0	$0	$10,368,000
Professional Services (15%)	$0	$7,896,027	$1,012,350	$648,000	$1,995,000	$648,000	$0	$12,199,377
Contingency (20%)	$0	$10,528,036	$1,349,800	$864,000	$2,660,000	$864,000	$0	$16,265,836
Phase Capital Cost Totals	$0	$71,064,244	$9,111,150	$5,832,000	$17,955,000	$5,832,000	$0	$108,891,394

2013 Present Worth of Capital Costs	$0	$66,339,232	$7,161,282	$3,859,600	$10,004,594	$2,736,086	$0	$90,100,794
2013 Present Worth of O&M Costs *(Annual Costs Shown in Appendix G)*								$120,200,166
Total 2013 Present Worth Cost								**$210,300,960**
Total Average Day Water Demand from 2013-2040 (acre-feet)								**448,474**
Total Present Worth Cost per Acre-Foot								**$468.93**

For the New WTP for this alternative, the PW of the capital costs is $60 million and the PW for the total O&M costs from 2013 to 2040 is approximately $50 million, which is a total of approximately $110 million. The total volume of water treated from 2013 through 2040 is 141,256 acre-feet. The economic value for this alternative is $775 per acre-foot. **Table 7-20** summarizes the assessment for this alternative.

Table 7-20 Cost Summary for New WTP

Year	2010	2015	2020	2025	2030	2035	2040	Total
RWPS/Intake Expansions	$0	$1,200,000	$0	$1,800,000	$0	$1,000,000	$0	$4,000,000
Transmission System Piping	$0	$13,366,000	$0	$0	$0	$0	$0	$13,366,000
WTP Capital Cost	$0	$15,000,000	$0	$13,500,000	$0	$7,500,000	$0	$36,000,000
High Service Pump Station Construction/Expansions	$0	$1,200,000	$0	$1,800,000	$0	$1,000,000	$0	$4,000,000
Professional Services (15%)	$0	$4,614,900	$0	$2,565,000	$0	$1,425,000	$0	$8,604,900
Contingency (20%)	$0	$6,153,200	$0	$3,420,000	$0	$1,900,000	$0	$11,473,200
Phase Capital Cost Totals	$0	$41,534,100	$0	$23,085,000	$0	$12,825,000	$0	$77,444,100
2013 Present Worth of Capital Costs	$0	$38,772,600	$0	$15,277,300	$0	$6,016,900	$0	$60,066,800
2013 Present Worth of O&M Costs *(Annual Costs Shown in Appendix G)*								$49,414,903
Total 2013 Present Worth Cost								**$109,481,703**
Total Average Day Water Demand from 2013-2040 (acre-feet)								**141,256**
Total Present Worth Cost per Acre-Foot								**$775.06**

7.7.8 Alternative 3 – Seawater: BWA WTP Expands/Seawater RO Plant to Meet Current Customer Demands, New Plant in Manvel

For the BWA WTP for this alternative, the PW of the capital costs is $132 million and the PW for the O&M costs from 2013 to 2040 is approximately $138 million, which is a total of approximately $270 million. The total volume of water treated from 2013 through 2040 is 453,493 acre-feet. The economic value for this alternative is $602 per acre-foot. **Table 7-21** summarizes the assessment for this alternative.

Table 7-21 Cost Summary for BWA WTP

Year	2010	2015	2020	2025	2030	2035	2040	Total
RWPS/Intake Expansions	$0	$2,000,000	$0	$0	$1,400,000	$0	$0	$3,400,000
Tank Farm/Pumps	$0	$8,640,000	$0	$4,320,000	$0	$4,320,000	$0	$17,280,000
Transmission System Piping	$0	$5,234,000	$6,749,000	$0	$0	$0	$0	$11,983,000
WTP Capital Cost	$0	$58,102,089	$0	$0	$10,500,000	$0	$0	$68,602,089
High Service Pump Station Expansions	$0	$2,000,000	$0	$0	$1,400,000	$0	$0	$3,400,000
Current Plant Upgrades	$0	$10,368,000	$0	$0	$0	$0	$0	$10,368,000
Professional Services (15%)	$0	$12,951,613	$1,012,350	$648,000	$1,995,000	$648,000	$0	$17,254,963
Contingency (20%)	$0	$17,268,818	$1,349,800	$864,000	$2,660,000	$864,000	$0	$23,006,618
Phase Capital Cost Totals	$0	$116,564,521	$9,111,150	$5,832,000	$17,955,000	$5,832,000	$0	$155,294,671
2013 Present Worth of Capital Costs	$0	$108,814,227	$7,161,282	$3,859,600	$10,004,594	$2,736,086	$0	$132,575,789
2013 Present Worth of O&M Costs *(Annual Costs Shown in Appendix G)*								$137,507,708
Total 2013 Present Worth Cost								**$270,083,497**
Total Average Day Water Demand from 2013-2040 (acre-feet)								**448,474**
Total Present Worth Cost per Acre-Foot								**$602.23**

For the New WTP for this alternative, the PW of the capital costs is $60 million and the PW for the total O&M costs from 2013 to 2040 is approximately $50 million, which is a total of approximately $110 million. The total volume of water treated from 2013 through 2040 is 141,256 acre-feet. The economic value for this alternative is $775 per acre-foot. **Table 7-22** summarizes the assessment for this alternative.

Table 7-22 Cost Summary for New WTP

Year	2010	2015	2020	2025	2030	2035	2040	Total
RWPS/Intake Expansions	$0	$1,200,000	$0	$1,800,000	$0	$1,000,000	$0	$4,000,000
Transmission System Piping	$0	$13,366,000	$0	$0	$0	$0	$0	$13,366,000
WTP Capital Cost	$0	$15,000,000	$0	$13,500,000	$0	$7,500,000	$0	$36,000,000
High Service Pump Station Construction/Expansions	$0	$1,200,000	$0	$1,800,000	$0	$1,000,000	$0	$4,000,000
Professional Services (15%)	$0	$4,614,900	$0	$2,565,000	$0	$1,425,000	$0	$8,604,900
Contingency (20%)	$0	$6,153,200	$0	$3,420,000	$0	$1,900,000	$0	$11,473,200
Phase Capital Cost Totals	$0	$41,534,100	$0	$23,085,000	$0	$12,825,000	$0	$77,444,100
2013 Present Worth of Capital Costs	$0	$38,772,600	$0	$15,277,300	$0	$6,016,900	$0	$60,066,800
2013 Present Worth of O&M Costs *(Annual Costs Shown in Appendix G)*								$49,414,903
Total 2013 Present Worth Cost								**$109,481,703**
Total Average Day Water Demand from 2013-2040 (acre-feet)								**141,256**
Total Present Worth Cost per Acre-Foot								**$775.06**

7.7.9 Alternative 3 BWA – Brackish: Brackish Groundwater RO Plant at BWA WTP Site

For the BWA WTP for this alternative, the PW of the capital costs is $169 million and the PW for the total O&M costs from 2013 to 2040 is approximately $156 million, which is a total of approximately $325 million. The total volume of water treated from 2013 through 2040 is 596,456 acre-feet. The economic value for this alternative is $544 per acre-foot. **Table 7-23** summarizes the assessment for this alternative.

Table 7-23 Cost Summary for BWA WTP

Year	2010	2015	2020	2025	2030	2035	2040	Total
Groundwater Wells	$0	$7,605,000	$0	$12,928,500	$0	$7,605,000	$0	$28,138,500
Tank Farm/Pumps	$0	$9,360,000	$0	$9,600,000	$0	$8,640,000	$0	$27,600,000
Well Piping	$0	$4,127,000	$0	$0	$0	$0	$0	$4,127,000
Transmission System Piping	$0	$8,112,000	$19,252,000	$0	$0	$0	$0	$27,364,000
WTP Capital Cost	$0	$17,890,181	$0	$30,413,308	$0	$17,890,181	$0	$66,193,669
High Service Pump Station Expansions	$0	$2,000,000	$0	$3,400,000	$0	$2,000,000	$0	$7,400,000
Current Plant Upgrades	$0	$10,368,000	$0	$0	$0	$0	$0	$10,368,000
Professional Services (15%)	$0	$8,919,327	$2,887,800	$8,451,271	$0	$5,420,277	$0	$25,678,675
Contingency (20%)	$0	$11,892,436	$3,850,400	$11,268,362	$0	$7,227,036	$0	$34,238,234
Phase Capital Cost Totals	$0	$80,273,944	$25,990,200	$76,061,440	$0	$48,782,494	$0	$231,108,079
2013 Present Worth of Capital Costs	$0	$74,936,586	$20,428,062	$50,336,200	$0	$22,886,338	$0	$168,587,186
2013 Present Worth of O&M Costs *(Annual Costs Shown in Appendix G)*								$155,648,422
Total 2013 Present Worth Cost								**$324,235,608**
Total Average Day Water Demand from 2013-2040 (acre-feet)								**596,456**
Total Present Worth Cost per Acre-Foot								**$543.60**

7.7.10 Alternative 3 – Seawater: Seawater RO Plant at BWA WTP Site

For the BWA WTP for this alternative, the PW of the capital costs is $282 million and the PW for the O&M costs from 2013 to 2040 is approximately $156 million, which is a total of approximately $437 million. The total volume of water treated from 2013 through 2040 is 596,456 acre-feet. The economic value for this alternative is $733 per acre-foot. **Table 7-24** summarizes the assessment for this alternative.

Table 7-24 Cost Summary for BWA WTP

Year	2010	2015	2020	2025	2030	2035	2040	Total
RWPS/Intake Construction/ Expansions	$0	$2,000,000	$0	$3,400,000	$0	$2,000,000	$0	$7,400,000
Tank Farm/Pumps	$0	$9,360,000	$0	$9,600,000	$0	$8,640,000	$0	$27,600,000
Transmission System Piping	$0	$8,112,000	$19,468,000	$0	$0	$0	$0	$27,580,000
WTP Capital Cost	$0	$58,102,089	$0	$98,773,552	$0	$58,102,089	$0	$214,977,731
High Service Pump Station Expansions	$0	$2,000,000	$0	$3,400,000	$0	$2,000,000	$0	$7,400,000
Current Plant Upgrades	$0	$10,368,000	$0	$0	$0	$0	$0	$10,368,000
Professional Services (15%)	$0	$13,491,313	$2,920,200	$17,276,033	$0	$10,611,313	$0	$44,298,860
Contingency (20%)	$0	$17,988,418	$3,893,600	$23,034,710	$0	$14,148,418	$0	$59,065,146

Phase Capital Cost Totals	$0	$121,421,821	$26,281,800	$155,484,295	$0	$95,501,821	$0	$391,289,736
2013 Present Worth of Capital Costs	$0	$113,348,569	$20,657,257	$102,897,000	$0	$44,804,739	$0	$281,707,565
2013 Present Worth of O&M Costs *(Annual Costs Shown in Appendix G)*								$155,648,422
Total 2013 Present Worth Cost								**$437,355,987**
Total Average Day Water Demand from 2013-2040 (acre-feet)								**596,456**
Total Present Worth Cost per Acre-Foot								**$733.26**

7.7.11 Pearland

For the Pearland WTP, the PW of the capital costs is $58 million and the PW for the O&M costs from 2013 to 2040 is approximately $49 million, which is a total of approximately $107 million. The total volume of water treated from 2013 through 2040 is 175,062 acre-feet. The economic value for this alternative was $614 per acre-foot. **Table 7-25** summarizes the assessment for this alternative.

Table 7-25 Cost Summary for Pearland WTP

Year	2010	2015	2020	2025	2030	2035	2040	Total
RWPS/Intake Construction/Expansion	$0	$0	$0	$0	$0	$2,000,000	$0	$2,000,000
Transmission System Piping	$0	$0	$0	$0	$0	$0	$0	$0
WTP Capital Cost	$0	$0	$0	$0	$0	$15,000,000	$0	$15,000,000
High Service Pump Station Expansions	$0	$0	$2,000,000	$0	$0	$2,000,000	$0	$4,000,000
Professional Services (15%)	$0	$0	$0	$0	$0	$2,550,000	$0	$2,550,000
Contingency (20%)	$0	$0	$0	$0	$0	$3,400,000	$0	$3,400,000
Phase Capital Cost Totals	$0	$0	$59,000,000	$0	$0	$24,950,000	$0	$83,950,000
2013 Present Worth of Capital Costs	$0	$0	$46,373,467	$0	$0	$11,705,308	$0	$58,078,775
2013 Present Worth of O&M Costs *(Annual Costs Shown in Appendix G)*								$49,411,770
Total 2013 Present Worth Cost								**$107,490,545**
Total Average Day Water Demand from 2013-2040 (acre-feet)								**175,062**
Total Present Worth Cost per Acre-Foot								**$614.02**

7.7.12 Summary

Figures 7-2, 7-3 and 7-4 summarize the present worth analysis for all the alternatives. Values shown in Figure 7-2 are lower than those presented in Figure 7-3, but alternatives with 10 percent water purchase do not offer the reliability needed within the system. Alternative 3 – 67 percent water purchased and Alternative 6 – 67 percent water purchased have similar present worth values. However, Alternative 6 – 67 percent water purchased may be more difficult to implement as it incorporates smaller entities within Brazoria County, and getting buy in of these entities may be challenging. However, implementing a variation of Alternative 3 would be simpler, and the option to add the smaller entities in Brazoria County in the future would remain a possibility. Alternative 3 – 67 percent water purchased, Alternative 3 – Brackish and Alternative 3 BWA – Brackish are comparable in present worth cost, but Alternative 3 – Brackish and Alternative 3 BWA – Brackish have the added benefit of diversifying BWA's water sources and are not relying on future water supplies to provide firm surface water.

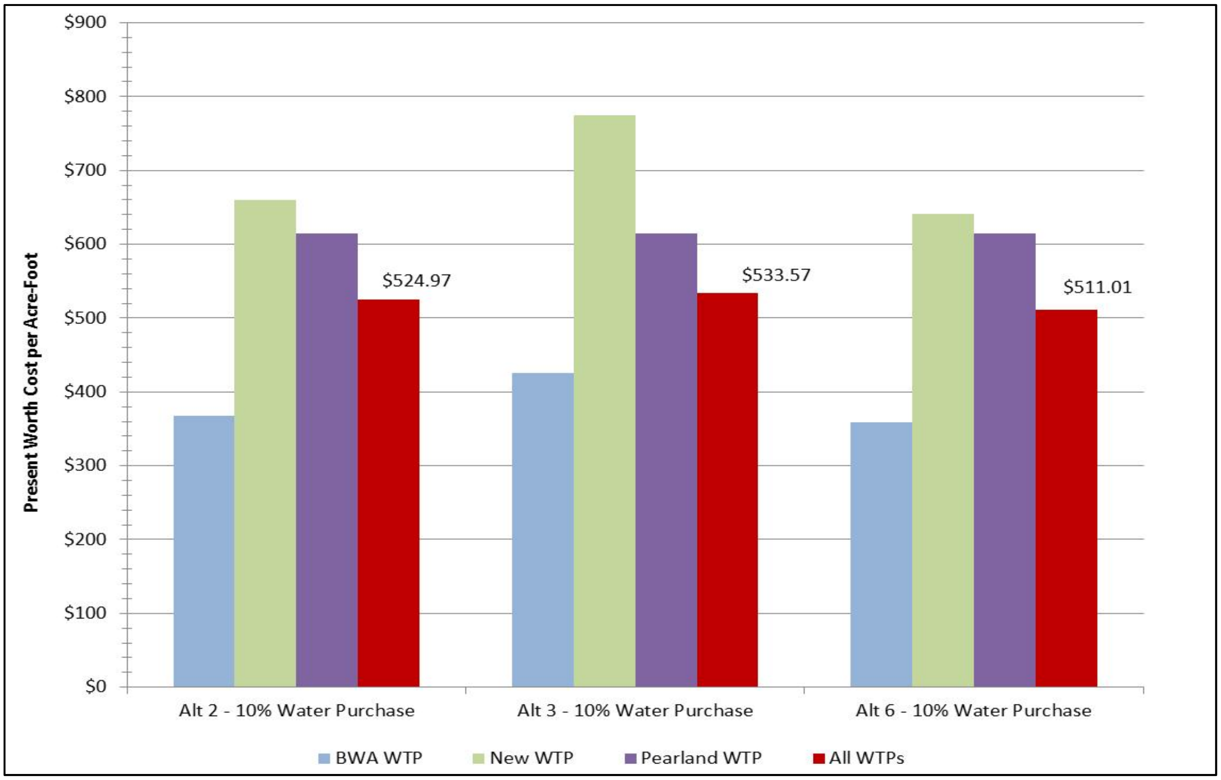


Figure 7-2
Summary of Present Worth Analysis for 10 Percent Water Purchase Alternatives

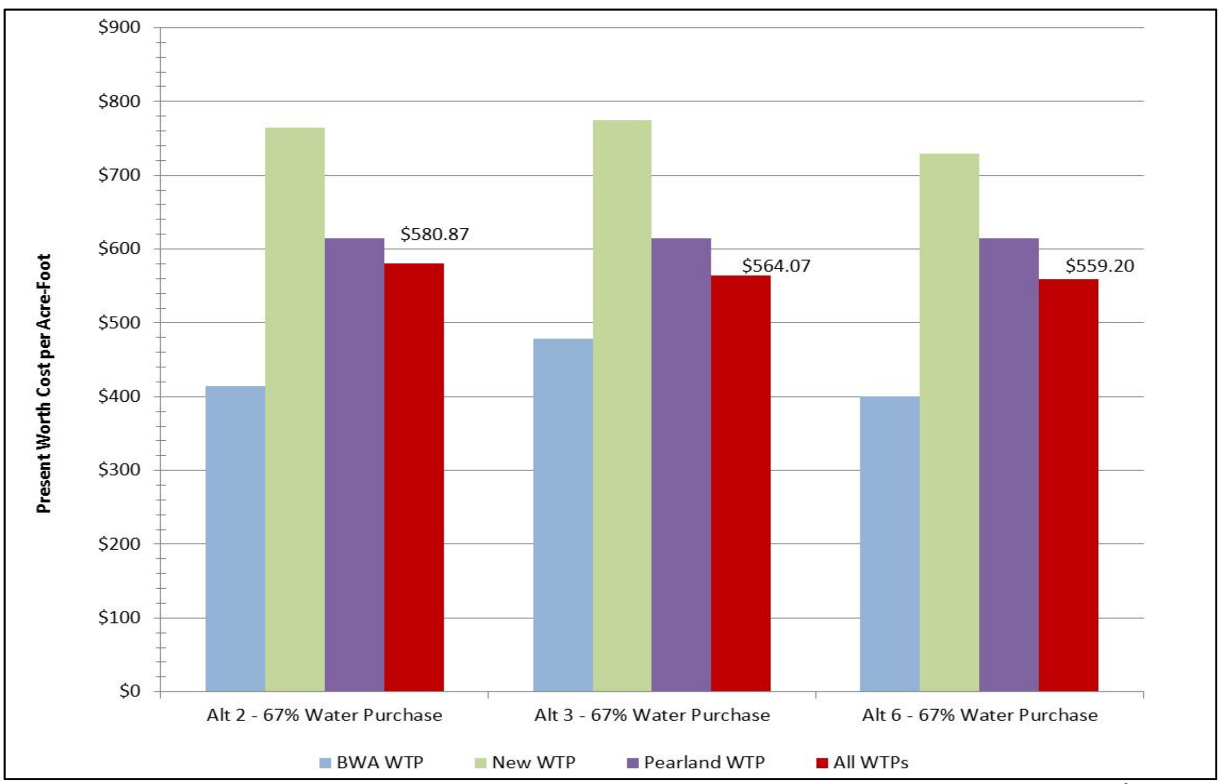


Figure 7-3
Summary of Present Worth Analysis for 67 Percent Water Purchase Alternatives

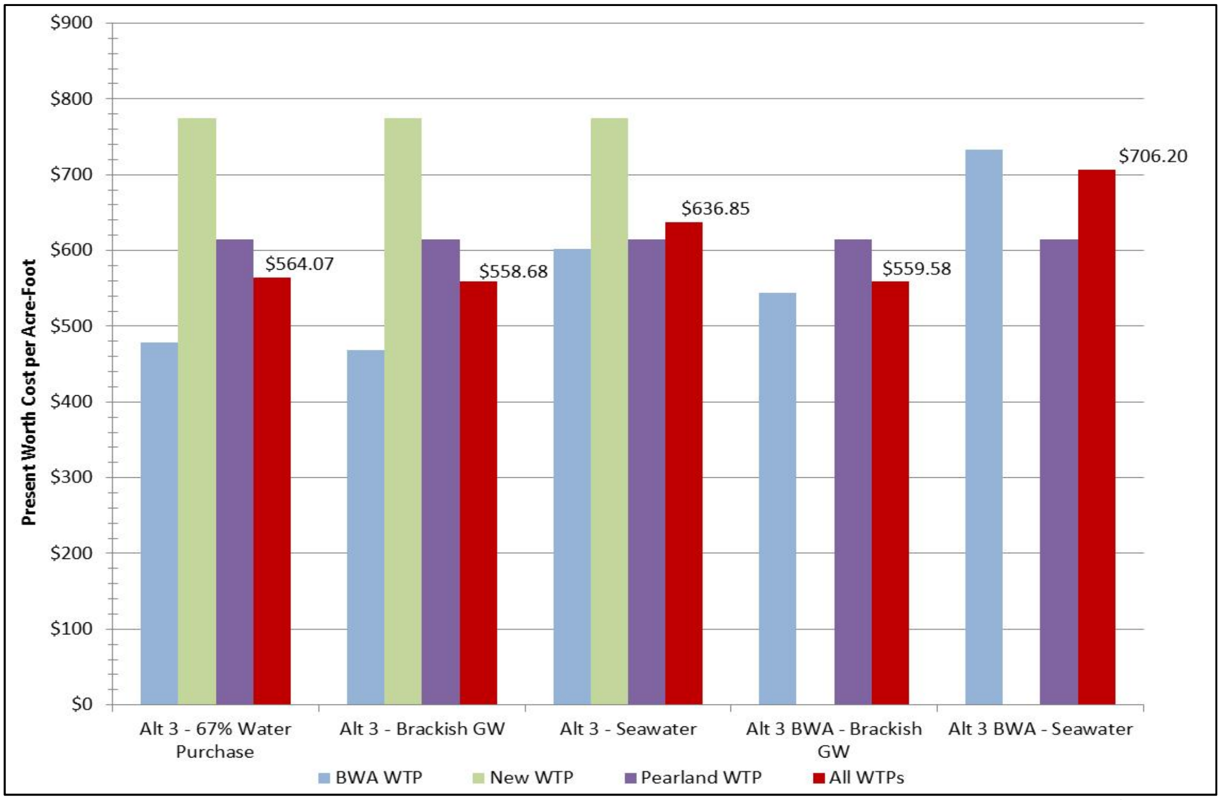


Figure 7-4
Summary of Present Worth Analysis for Alternative 3 Options

7.8 Financial Evaluation

For this evaluation, CDM Smith took a closer look at the variations of Alternative 3. A review of the alternatives shows that the variations of Alternative 3 are fairly similar in their economic analysis, so a financial analysis is another way of differentiating the alternatives. Additionally, for added safety and reliability within the system, from this point forward, CDM Smith only considered options that had 67 percent water shortage planning.

For the financial evaluation, the following methodology was applied:

- Step 1: Using the previously calculated O&M costs, determine an inflated O&M cost for each year from 2013 through 2040. The inflation rate used for this evaluation is 2.5 percent.
- Step 2: Using the previously calculated capital costs, determine a debt service payment for each capital expenditure.
- Step 3: Based on the annual expenditures and average annual water sold, determine a cost per 1,000 gallons.

Calculating the annual payment uses similar factors as the present worth calculations previously discussed. For this evaluation, the following factors were used.

- BWA currently has an annual payment of $1,697,820. This will continued to be paid through 2017.
- The interest rate used was 4.5 percent.
- For this evaluation, the payment period was 20 years.

Figure 7-5 shows the financial comparison for the different components of Alternative 3: BWA WTP Expansion (67 percent Water Shortage Purchase), New WTP in Manvel. **Figure 7-6** shows the financial comparison of Alternative 3: BWA WTP Expansion (67 percent Water Shortage Purchase), New WTP in Manvel, Alternative 3 BWA – Brackish and Alternative 3 BWA – Seawater.

As shown in Figure 7-5, the initial cost of a New WTP to serve the northern part of the county is high in comparison to the BWA WTP expansions due to large capital investments and small initial customer base. However, at the end of the study period, the costs for the northern part of the county end up being similar to the BWA costs. To balance out the initial spike in costs, a fully regional approach may be considered to lessen the initial burden of construction costs and to provide a consistent rate for alternative water supplies across the county. (See Section 8.0 for more information on funding options). This approach would have to be approved by all participants.

Looking at Alternative 3 variations in Figure 7-6, while the implementation of a seawater desalination plant is noticeably higher, the rates of the brackish groundwater desalination plant and the surface water plant with purchase of 67 percent firm supply water are comparable.

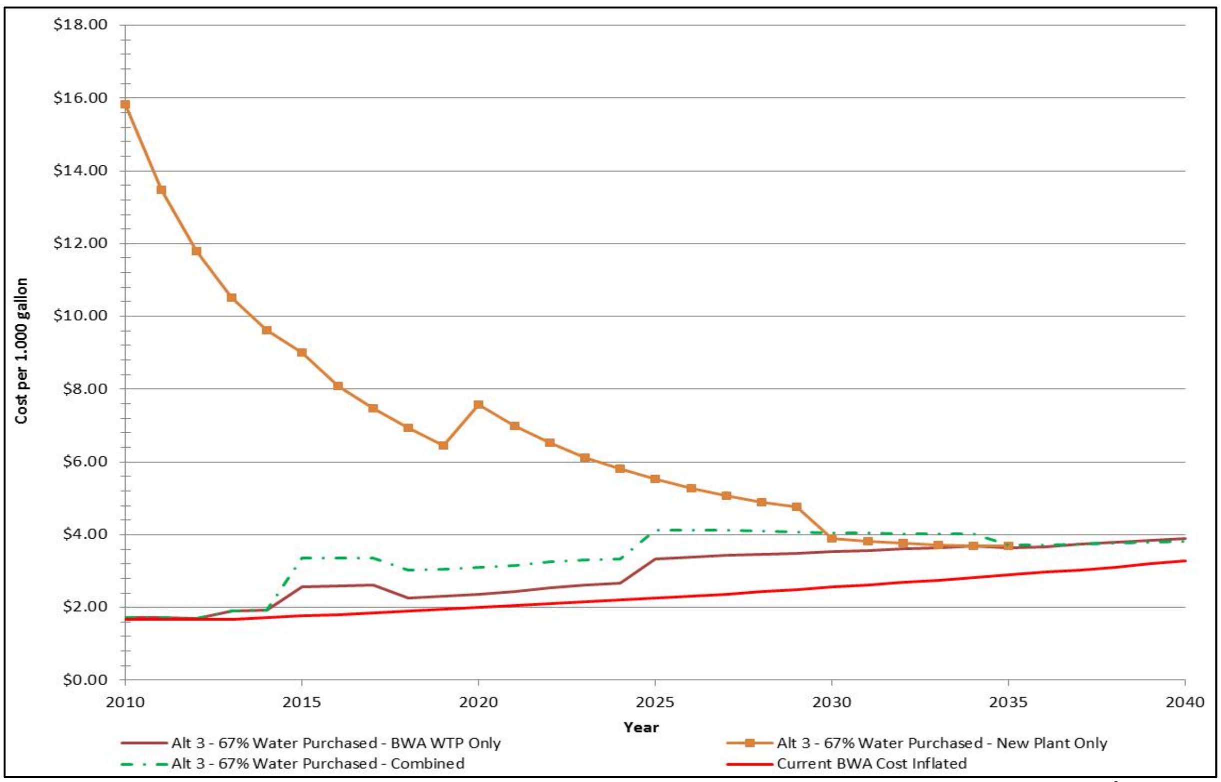


Figure 7-5
Financial Evaluation of Alternative 3 with 67 Percent Water Shortage Purchase

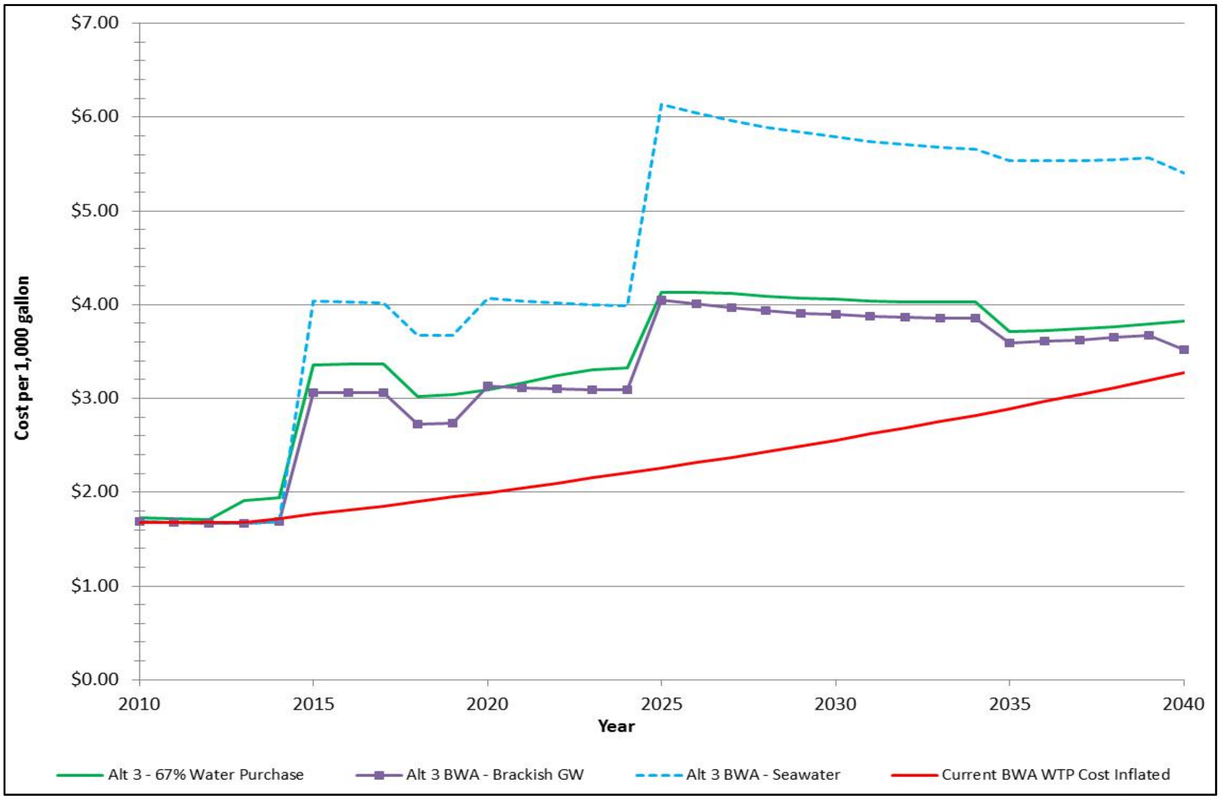


Figure 7-6
Financial Evaluation of Alternative 3 with 67 Percent Water Shortage Purchase and Alternative 3 BWA

Section 8
Potential Funding Sources

Funding sources for the Brazoria County Regional Water System are dependent on the selected alternative and financial viability of each political entity within the study area. Also, the type of funding source selected to finance the engineering design and construction costs will depend on the organizational structure of the entity that owns and operates the regional system.

A number of potential funding sources exist for rural utilities, which typically provide service to less than 50,000 people. Both state and federal agencies offer grant and loan programs to assist rural communities in meeting their infrastructure needs. Most are available to "political subdivisions" such as counties, municipalities, school districts, special districts, or authorities of the state with some programs providing access to private individuals.

Grant funds are typically available to those entities that demonstrate financial need based on a median household income (MHI) value below 75 to 80 percent of the State's MHI value. The funds may be used for planning, design, and construction of water infrastructure projects. Some funds may be used to finance the consolidation or regionalization of neighboring water utilities. Three Texas agencies that offer financial assistance for water infrastructure are described below:

- **Texas Water Development Board (TWDB)** has several programs that offer loans at interest rates lower than the market offers to finance projects for public water systems that facilitate compliance with state and federal regulations. Additional subsidies may be available for disadvantaged communities. Low interest rate loans with short- and long-term finance options at tax exempt rates for water projects give an added benefit by making construction purchases qualify for a sales tax exemption. Generally, the program targets customers with eligible water projects for all political subdivisions of the state (at tax exempt rates).

- **Texas Department of Agriculture (TDA, formerly TDRA and ORCA)** is a Texas state agency with a focus on rural Texas by making state and federal resources accessible to rural communities. Funds from the U.S. Department of Housing and Urban Development Community Development Block Grants (CDBG) are administered by TDA for small, rural communities with populations less than 50,000 that cannot directly receive federal grants. These communities are known as non-entitlement areas. One of the program objectives is to meet a need having a particular urgency, which represents an immediate threat to the health and safety of residents, principally for low- and moderate-income persons.

- **U.S. Department of Agriculture Rural Development (USDA Rural Development)** coordinates federal assistance to rural Texas to help rural Americans improve their quality of life. The Rural Utilities Service (RUS) programs provide funding for water systems. The application process, eligibility requirements, and funding structure vary for each of these programs. There are many conditions that must be considered by each agency to determine eligibility and ranking of projects. The principal factors that affect this choice are population, percent of the population under the State MHI, health concerns, compliance with standards, Colonia status, and compatibility with regional and state plans.

In addition to Federal and State water programs, funding sources may also originate from revenue bonds and developer participation towards the regional infrastructure of the system. An overview of all of these financing mechanisms is presented below.

8.1 Federal and State Infrastructure Programs

There are a variety of funding programs available to entities through Federal and State infrastructure programs. Depending on the type of organization that owns the proposed regional water facilities, funding is most likely to be obtained from programs administered by the TWDB, TDA and/or USDA Rural Development. Information required by these agencies for initial applications may include financial analyses, records demonstrating health concerns, failing infrastructure, and financial need.

8.1.1 TWDB Funding Options

The programs offered by the TWDB include the Drinking Water State Revolving Fund (DWSRF), State Loan Program (Development Fund II), State Participation Fund, and Economically Distressed Areas Program (EDAP).

Drinking Water State Revolving Fund

The Drinking Water State Revolving Fund (DWSRF) provides loans at interest rates lower than the market to political subdivisions with the authority to own and operate a water system. The DWSRF also includes Disadvantaged Communities funds that provide even lower interest rates for those meeting the respective criteria.

The DWSRF offers fixed and variable rate loans at subsidized interest rates. The maximum repayment period for a DWSRF loan is 20 years from the completion of project construction. A cost-recovery loan origination charge of 1.85 percent is imposed to cover administrative costs of operating the DWSRF; however, there is no additional interest rate subsidy for those financing the origination charge.

TWDB accepts Project Information Forms (PIFs) from prospective loan applicants to be included on the DWSRF Intended Use Plan (IUP) during the early part of each year. The Project Information Form describes the applicant's existing water facilities, facility needs, the nature of the project being considered and project cost estimates. This information is used to rate each proposed project and place them in priority order on the IUP. Applicants eligible for funding through the DWSRF program are notified during the summer to attend a pre-application meeting and submit an application for financial assistance. TWDB will typically take 60 to 90 days to review a complete application and to present the funding request formally to the Board for approval. Once approved, the applicant could then proceed with closing on the funding.

State Loan Program (Development Fund II)

The State Loan Program is a diverse lending program directly from state funding sources. As it does not receive federal subsidies, it is more streamlined. The loans can incorporate more than one project under the umbrella of one loan. Political subdivisions of the state are eligible for tax exempt rates. Projects can include purchase of treatment plants, pump stations, storage tanks, distribution lines, and land acquisitions. The loan requires that the applicant pledge revenue or taxes. The maximum financing life is 50 years, and the average financing period is approximately 20 years. The lending rate scale varies according to several factors, but is set by the TWDB based on cost of funds to the board, risk factors of managing the board loan portfolio, and market rate scales.

The application materials must include an engineering feasibility report, environmental information, rates and customer base, operating budgets, financial statements, and project information. The TWDB considers the needs of the area; benefits of the project; the relationship of the project to the overall state water needs and the State Water Plan; and the availability of all sources of revenue to the rural utility for the ultimate repayment of the loan. TWDB will typically take 60 to 90 days to review a complete application and to present the funding request formally to the Board for approval. Once approved, the applicant could then proceed with closing on the funding.

State Water Plan Funding: State Participation Fund

The State Participation Fund encourages the optimum regional development of projects by funding excess infrastructure capacity for consideration of future needs. This program allows the TWDB to provide funding and assume temporary ownership interest in a regional water project when the local sponsors (i.e. political subdivision of the state, including a water supply corporation) are unable to assume debt for an optimally sized facility.

State Participation Funding can only be used to finance the portion of water infrastructure projects that is designated as 'excess capacity'. For new water supply and state water plan projects, TWDB can fund as much as 80 percent of project costs, as long as the local sponsor finances at least 20 percent of the total project cost; the total capacity of the proposed project also must serve at least 20 percent of existing needs.

For other State Participation projects, the TWDB can fund as much as 50 percent of costs, provided that the local sponsor finances at least 50 percent of the total project cost; the total capacity of the proposed project also must serve at least 50 percent of existing needs.

State Water Plan Funding: Water Infrastructure Fund (WIF)

Special financial assistance for planning, design, and construction of State Water Plan and regional water plan projects may be obtained from the Water Infrastructure Fund. Projects must be recommended water management strategies in the most recent TWDB-approved regional water plan and approved State Water Plan. Funds may not be used to maintain a system or to develop a retail distribution system.

To apply for financial assistance, the applicant must be a political subdivision of the state. All loans through this fund are offered at a subsidized interest rate that currently is one percent blow the TWDB's cost of funds during FY12 and FY13. The maximum repayment period is 20 years. TWDB will typically take 60 to 90 days to review a complete application and to present the funding request formally to the Board for approval. Once approved, the applicant could then proceed with closing on the funding.

Economically Distressed Areas Program

The EDAP Program was originally designed to assist areas along the U.S./Mexico border in areas that were economically distressed. In 2008, this program was extended to apply to the entire state as long as specific requirements are satisfied. This program provides financial assistance through the provision of grants and loans to communities where present facilities are inadequate to meet resident's minimal needs. Eligible communities are those that have median household incomes less than 75 percent of the state median household income.

The county where the project is located must adopt model rules for the regulation of subdivisions prior to application for financial assistance. If the applicant is a city, the city must also adopt Model Subdivision Rules of TWDB (31 TAC Chapter 364). The program funds design, construction, improvements, and acquisition, and includes measures to prevent future substandard development. The TWDB works with the applicant to find ways to leverage other state and federal financial resources. The loan requires that the applicant pledge revenue or taxes. The maximum financing life is 50 years, and the average financing period is approximately 20 years. The lending rate scale varies according to several factors, but it is set by the TWDB based on cost of funds to the board, risk factors of managing the board loan portfolio, and market rate scales. The TWDB seeks to make reasonable loans with minimal loss to the state. Most projects have a financial package with the majority of the project financed with grants; many recipients have received 100 percent grant funds.

8.1.2 TDA Funding Options

The Texas Department of Agriculture (TDA, previously TDRA and ORCA) seeks to strengthen rural communities and assist them with community and economic development and healthcare by providing a variety of rural programs, services, and activities. Of their many programs and funds, the most appropriate programs related to drinking water are the Community Development (CD) Fund and Texas Small Towns Environment Program (STEP). These programs offer attractive funding packages to help make improvements to water systems to mitigate potential health concerns.

Community Development Fund

The CD Fund is a competitive grant program for water and wastewater system improvements. Funds are distributed between 24 state planning regions where funds are allocated to address each region's utility priorities. Funds can be used for various types of public works projects, including water system improvements. Cities with a population of less than 50,000 that are not eligible for direct CDBG funding from the U.S. Department of Housing and Urban Development are eligible. Funds are awarded on a competitive basis decided twice a year by regional review committees. Awards are no less than $75,000 and cannot exceed $800,000.

Texas Small Towns Environment Program

Under special occasions some communities are invited to participate in grant programs when self-help is a feasible method for completing a water project, the community is committed to self-help, and the community has the capacity to complete the project. The purpose is to significantly reduce the cost of the project by using the communities' own human, material, and financial capital. Projects typically are repair, rehabilitation, improvements, service connections, and yard services. Reasonable associated administration and engineering costs can be funded. A letter of interest is first submitted, and after CDBG staff determines eligibility, an application may be submitted. Awards are only given twice per year on a priority basis so long as the project can be fully funded ($350,000 maximum award). Ranking criteria are project impact, local effort, past performance, percent of savings, and benefit to low-to-medium-income persons.

8.1.3 USDA Rural Development Funding Options

USDA Rural Development established a Revolving Fund Program (RFP) administered by the staff of the Water and Environment Program (WEP) to assist communities with water and wastewater systems. The purpose is to fund technical assistance and projects to help communities bring safe drinking water and sanitary, environmentally sound, waste disposal facilities to rural Americans in greatest need.

WEP provides loans, grants, and loan guarantees for drinking water, sanitary sewer, solid waste, and storm drainage facilities in rural areas and cities and towns with a population of 10,000 or less. Recipients must be public entities such as municipalities, counties, special purpose districts, Native American Indian tribes, and corporations not operated for profit. Projects include all forms of infrastructure improvement, acquisition of land and water rights, and design fees. A request for a combination of grants and loans vary on a case by case basis, and some communities may have to wait through several funding cycles until funds become available.

Water and Wastewater Disposal Program

The major components of the RFP are loans, loan guarantees, and grant funding for water and waste disposal systems. Entities must demonstrate that they cannot obtain reasonable loans at market rates, but have the capacity to repay loans, pledge security, and operate the facilities. Grants can be up to 75 percent of the project costs, and loan guarantees can be up to 90 percent of eligible loss. Loans are not to exceed a 40-year repayment period, require tax or revenue pledges, and are offered at three rates:

- ***Poverty Rate*** - The lowest rate is the poverty interest rate of 4.5 percent. Loans must be used to upgrade or construct new facilities to meet health standards, and the MHI in the service area must be below the poverty line for a family of four or below 80 percent of the statewide MHI for non-metropolitan communities.

- ***Market Rate*** – Where the MHI in the service exceeds the state MHI, the rate is based on the average of the "Bond Buyer" 11-Bond Index over a four week period.

- ***Intermediate Rate*** – the average of the Poverty Rate and the Market Rate, but not to exceed seven percent.

8.2 Revenue Bonds

In addition to Federal and State water programs, a water utility may pledge future earnings to fund improvements to the water system through the issuance of revenue bonds. A revenue bond is a special type of municipal bond, and the income generated by the improvement or expansion of the water project would be used for repayment. Unlike general obligation (G.O.) bonds, only the revenues specified in the legal contract between the bond holder and bond issuer are required to be used for repayment of the principal and interest of the revenue bonds. Since the pledge of security is not as great as that of G.O. bonds, revenue bonds may carry a slightly higher interest rate than G.O. bonds.

8.3 Developer Participation

Developer participation typically occurs through two means: upfront capital contributions and/or payment of impact fees for a water/wastewater infrastructure project. Under a regional system where several political subdivisions are participating, a single independent organization or entity is recommended to manage and/or operate the regional system, such as a river authority or regional utility authority. River authorities, a regional utility authority, or other similar entities may require a developer to completely finance the entire cost of an infrastructure project and then turn it over to the utility to own and operate on their behalf. A utility may also require a developer to pledge capital towards an infrastructure project through an upfront cash payment or a letter of credit for the utility to drawdown on if needed to reduce the level of risk on the project.

The utility may also require that developers contribute toward the cost of new water/wastewater infrastructure through the payment of impact fees. The intent of this funding source is that the cost of new infrastructure serving new utility customers will not be subsidized by the existing utility rate payers. In essence, growth pays for growth.

Section 9
Conclusions and Recommendations

The recommended facility plans for Brazoria County are based on several factors: the overall economics based on a present worth analysis, a financial analysis of the impact on the cost of water to participating customers, and the availability of groundwater and surface water. The recommended facility plan is also based on an implementation plan that allows the recommended plan to be permitted, constructed and operational in a reasonable amount of time and a facility plan that has adequate operations, management and governance. The recommended facility plan for each entity is provided below.

9.1 City of Pearland

The City of Pearland has recently completed a Water Master Plan, and the City has identified their path forward with its water supply and facilities. The City will continue to use groundwater from the Gulf Coast Aquifer System to meet a portion of its needs. The City is currently an equity partner in the City of Houston's Southeast Water Purification Plant and has a contract to buy additional wholesale water from the City of Houston. Finally, The City of Pearland has a contract with GCWA for 10,000 acre-feet per year of raw water. The City plans to build a surface water treatment plant that will eventually be 20 MGD to meet the buildout needs of its water service area defined by their Certificate of Convenience and Necessity (CCN).

9.2 City of Alvin

The future maximum day water demands in Alvin are projected to be 6.1 MGD in 2040. The City has 8.4 MGD in wells currently in service in the Gulf Coast Aquifer System. These wells are sufficient to meet the water needs of the City of Alvin during the period of this master plan. No regional water facilities are needed or recommended for the City of Alvin through the study period.

9.3 Brazosport Water Authority Participating Customers

The seven cities that are BWA participating customers will continue to use the contract water purchased from BWA. The participating customers will also continue to use their groundwater wells to the extent they are already constructed and operational. The drilling of additional wells is not recommended to meet the water facility needs of these participants. With groundwater usage in the County already exceeding the MAG, it is recommended that the BWA customers rely on their existing and future contracts with BWA to meet their water supply needs.

The following participating customers will need the following additional water supply amounts contracted from BWA by the end of the study period in 2040.

- City of Angleton 3.92 MGD
- City of Brazoria 0.48 MGD

- City of Lake Jackson 2.42 MGD
- City of Richwood 0.45 MGD

The existing BWA water treatment facilities, pumping facilities and transmission mains have the capacity to meet the future demands of these participants. Specific needs for improvements to the existing water treatment plant to meet the demands of other participants and future districts are presented later in this section.

9.4 City of Manvel

Growth in the City of Manvel will increase its max day water demands from less than 1 MGD to over 7.4 MGD. The City's existing groundwater wells can only meet slightly more than 1 MGD. The future water demands of the City of Manvel if not met by additional groundwater wells in the Gulf Coast Aquifer System, will have to be met by other means.

The City of Manvel recently purchased a site for raw water storage and a water treatment plant. Long term this site could be used for surface water storage and a water treatment plant, but until there is firm surface water available, either through the BRA system wide permit and/or Allens Creek Reservoir, this approach to meet the water demands in the City will not provide firm water.

It is recommended that the City of Manvel meet its future water demands by regional Alternative 3 BWA – Brackish. BWA has excess capacity in its existing water treatment and transmission system and can deliver up to 5 MGD to the north side of the City of Angleton. With the addition of ground storage, booster pumping and a water transmission line from Angleton to Manvel, BWA could have additional water service to the City of Manvel in only a couple of years.

9.5 County Other Existing WUGs

County Other existing water user groups (WUGs) will continue to meet their water needs through the continued use of their existing wells in service in the Gulf Coast Aquifer System. If a County Other WUG is near an existing or future BWA transmission line, they could apply to BWA for wholesale water service to reduce their reliance on groundwater. This extension of regional service to County Other WUGs is similar to Alternative 6.

9.6 County Other Domestic

There is a substantial population in Brazoria County that has individual wells in service in the Gulf Coast Aquifer System that serve the domestic needs of individual households. These domestic demands will continue to be met by the Gulf Coast Aquifer System. Regional water service to County Other Domestic will be difficult because there are no rural water systems in place to distribute regional water to individual domestic customers. The lack of rural water systems in Brazoria County is a result of the historically available groundwater from the Gulf Coast Aquifer System. The lack of reasonable alternatives for the County Other Domestic is why entities such as cities and future developments should not rely only on groundwater from the Gulf Coast Aquifer System to meet their future needs.

9.7 County Other Future Districts

It has been assumed that there will be substantial population growth in future municipal utility districts or similar districts in the SH 288 corridor between the City of Manvel and the City of Angleton. It is recommended that BWA expand its water treatment, pumping and transmission system to serve the population in these future districts. The continued growth of population in these districts and their reliance on groundwater from the Gulf Coast Aquifer System will significantly increase the withdrawal of water from the aquifer resulting in a drop in aquifer water levels. The drop in water levels will affect the levels in the wells used by County Other WUGs and County Other Domestic. These organizations and individuals may not have the resources to deepen their wells and reset their pumps due to falling aquifer levels. The new districts will have financing and could arrange with BWA for the extension of transmission mains from Angleton to their development. This approach to providing water to County Other Future Districts is included in Alternative 3 BWA – Brackish.

9.8 Alternative 3 BWA – Brackish

Alternative 3 BWA – Brackish, which includes Brackish Groundwater Desalination (BGD), is the recommended alternative for Brazoria County. Alternative 3 BWA –Brackish takes advantage of available treatment and transmission capacity in the existing BWA system to provide water to the County Other Future Districts, the City of Manvel and the TDCJ Darrington and Ramsey prison units. As Angleton and areas north of Angleton grow, additional transmission facilities from the BWA WTP to Angleton will be necessary. As noted in Section 7, present worth costs for the alternatives are fairly similar; however, Alternative 3 BWA – Brackish would be simpler to implement than other regional options, and the option to add the smaller entities in Brazoria County in the future would remain a possibility. Additionally, this alternative has the added benefit of diversifying BWA's water sources and is not relying on future water supplies to provide firm surface water.

Although there is excess treatment capacity at the BWA WTP, the availability of raw water is dependent on the BWA's run-of-the-river rights. To firm up this water supply, it is recommended that the BWA start pursuing the construction of brackish groundwater wells, a well collection system, and a brackish groundwater desalination plant using reverse osmosis (RO) membranes. The capacity of the RO plant needed to firm up the existing BWA surface WTP is 10 MGD. The total treatment capacity of the brackish groundwater and surface water treatment plants would eventually be expanded to 54.8 MGD. This WTP capacity plus the existing groundwater capacity would meet the 2040 water demands of Alternative 3 BWA – Brackish. It is recommended that BWA initiate design and construction of improvements to their existing plant that includes a new 10 MG clearwell, high service pump station, yard piping improvements, electrical improvements and SCADA improvements. The cost of the proposed improvements to the BWA WTP total approximately $14 million. It is also recommended that BWA conduct a pilot of the brackish groundwater desalination plant using RO. A pilot is not required by TCEQ for this process, but there are potential water quality issues including iron and manganese, organics and biologic fouling, and silt production that could negatively impact a desalination facility. A pilot would provide an opportunity for these potential issues to be discovered and addressed.

It is also recommended that BWA secure property on the north side of Angleton for the construction of the tank farm and booster pump station that will allow for regional water service north of Angleton. The first customers of this system would be the Ramsey and Darrington Prison Units. Having the storage and booster facility near Angleton also provides the potential of regional water service to future districts and developments along SH 288 between Angleton and Manvel. The construction of the first ground storage tank and booster pump station is estimated to cost $11.7 million (including contingencies and professional services). The construction of this facility is not required until contracts for water service north of Angleton have been secured.

9.9 Use of Brackish Groundwater in Brazoria County

As stated in Section 3, groundwater usage is nearing or already exceeding the MAG for Brazoria County. As an alternative to further fresh water pumping in the Chicot Aquifer, it is recommended that development of brackish groundwater in the Chicot Aquifer be pursued. There may seem to be a conflict between recommending against further development of fresh groundwater and recommending the development of brackish groundwater. However, there are a number of factors to consider when developing groundwater resource projects in Texas today. One of those factors is a relatively new consideration referred to in Texas Water Code §36.001 (a)(25) as Modeled Available Groundwater (MAG). Modeled available groundwater is defined as "the amount of water that the executive administrator determines may be produced on an annual basis to achieve a desired future condition established under Section 36.108." The term modeled available groundwater was added to the statute with the passage of Senate Bill 660 by the 2011 Texas Legislature. Although the acronym MAG has remained the same, the term and definition changed significantly from the original term "managed available groundwater" that was originally codified in Texas Water Code by the 2005 Texas Legislature and was defined as "the amount of water that may be permitted by a district for beneficial use in accordance with the desired future condition established (of the aquifer as determined) under Section 36.108."

Two major differences between the original term managed available groundwater and modeled available groundwater are most relevant to the BWA brackish groundwater desalination project. First, while the original concept or use of managed available groundwater estimates were viewed as a ceiling or cap on permitting inside a Groundwater Conservation District (GCD), clearly in the amended definition for modeled available groundwater, the ceiling or cap concept was deliberately removed from statute by Senate Bill 660. Instead, the relevant phrases are "may be produced on an annual basis to achieve a desired future condition..." Thus, the actions of a GCD relative to permitting and estimates of modeled available groundwater are permissive. Also, it is important to remember the terms of the currently adopted desired future conditions for the Chicot and Evangeline Aquifers in Brazoria County. In both cases, the adopted desired future conditions are based on 50-year goals. There are no identified metrics in the adopted desired future condition based on annual targets. As noted in review comments on the draft Brazosport Water Authority Regional Facility Plan, groundwater pumping in Brazoria County drops significantly below the current MAG during periods of normal or above normal precipitation. These fluctuations in precipitation-driven variability in groundwater pumping are not built into the current groundwater availability models. Periods of recovery in aquifers that occur during wetter periods are not accounted for in the estimates of modeled available groundwater. This is one of the reasons why several GCDs have issued permits for non-exempt wells significantly in excess of the estimates of MAG for adopted desired future conditions (in some cases, more than twice the estimates of modeled available groundwater).

From 2005 – 2010 during the first round of joint planning in which desired future conditions were originally developed and adopted, it was generally the stated intent of most district representatives to adopt desired future conditions that would adequately encompass both currently permitted and exempt groundwater production plus anticipated new projects within individual GCDs. To date, this trend is continuing during the second round of joint planning. Therefore, as new groundwater resources projects are contemplated to meet current and future local water supply needs and to sustain local economies, and as part of the adaptive management process now integral to joint planning in Texas Water Code Chapter 36, GCD representatives will be afforded the opportunity to revise desired future condition statements to reflect both current and anticipated future conditions. GMA 14 is currently in the process of reevaluating the future desired conditions in all the counties in that groundwater management area.

The desired future conditions are set in part to protect existing users of groundwater and in the counties along the coast to protect against land surface subsidence. BWA received comments at the last public meeting expressing concerns regarding additional development of groundwater resources and the impact on land surface subsidence. As a result, BWA contracted with INTERA to evaluate the impact on land surface subsidence from the development of brackish groundwater near the existing water treatment plant. Unfortunately, the model used by GMA 14, the HAGM model, does not differentiate between fresh water and brackish water layers in the Chicot aquifer. Therefore, when this model was run the land surface subsidence predicted would be for either brackish water development or fresh water development. INTERA also used the Lower Colorado River Basin (LCRB) model to determine the impact of brackish water development on land surface subsidence. Unlike the HAGM, which represents the Chicot Aquifer using one model layer, the LCRB model represents the Chicot Aquifer using four model layers. As a result, the LCRB model contains sufficient vertical resolution to differentiate the impacts of pumping fresh or brackish water in the Chicot Aquifer. In addition, the LCRB offers the benefit of substantially smaller-sized grid cells so that well placement is more accurately depicted. The report prepared by INTERA can be found in **Appendix H**. The results of the modeling shows that for the well capacities and the well spacing recommended that there will potentially be land surface subsidence near the wells, but that it is considered minor. The land surface subsidence predicted by the LCRB model is less than predicted by the HAGM – one of the reasons for these differences is the model layering and size of the grid cells discussed above. After 50 years of pumping, the HAGM Model predicts 1.07 feet of net subsidence at the well field and the LCRB model predicts 0.43 feet of net subsidence at the well field.

There are many aspects of the regulatory management of brackish groundwater desalination in Texas for which clear legislative guidance is needed. To that end, the Texas Water Conservation Association, at the request of the legislative leadership, has initiated a Groundwater Panel made up of both GCDs and cities and water providers to develop draft legislation to address these issues in the 2015 Texas Legislature. At the request of Senator Troy Frasier, Chairman of the Texas Senate Committee on Natural Resources, these confusing and unresolved issues regarding the regulatory approach to brackish groundwater resources have been put at the top of the policy issues for the Groundwater Panel to resolve.