CITY OF SUGAR LAND

INTEGRATED WATER RESOURCE PLAN

FINAL REPORT

March 2019

CDM Smith

In association with KIT Professionals, Inc.

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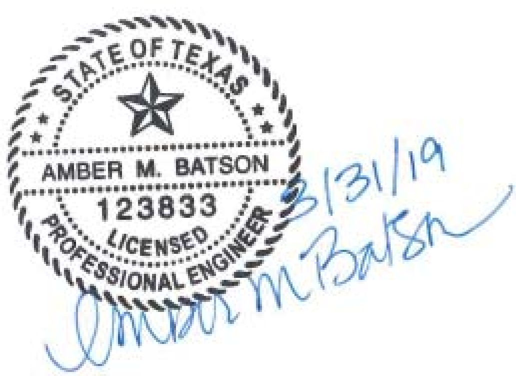

Prepared by:

CDM Smith

TBPE Firm No. F-3043
11490 Westheimer Road, Suite 700
Houston, TX 77077

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List of Acronyms

AADF	annual average daily flow
AF	acre-feet
AFY	acre-feet per year
AMI	advanced metering infrastructure
ASR	aquifer storage and recovery
BRA	Brazos River Authority
BWA	Brazosport Water Authority
CAI	Community Association Incorporated
CDP	Criterium Decision Plus
DPR	direct potable reuse
DSM	decision support model
ESFC	equivalent single-family connection
ETJ	extra-territorial jurisdiction
FBSD	Fort Bend Subsidence District
GCWA	Gulf Coast Water Authority
GRP	groundwater reduction plan
HOA	homeowners' association
IPR	indirect potable reuse
IWRP	integrated water resource plan
LID	Levee Improvement District
MG	million gallons
MGD	millions of gallons per day
MGY	million gallons per year
MUD	Municipal Utility District
NRW	nonrevenue water
OCR	off-channel reservoir
O&M	operation and maintenance
POA	property owners' association
STELLA	Systems Thinking Experimental Learning Laboratory with Animation
SWTP	surface water treatment plant
TxDOT	Texas Department of Transportation
WW	wastewater
WWTP	wastewater treatment plant

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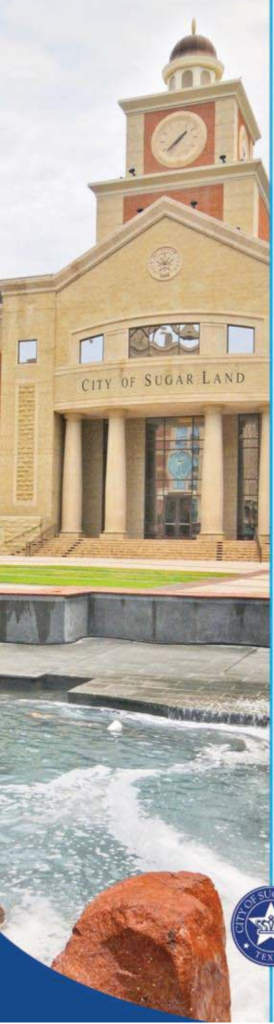
SECTION 1 | INTRODUCTION

The City of Sugar Land (City) is a vibrant community located in Fort Bend County about twenty miles southwest of Houston. The area was initially sugar plantations in the mid-1800s, incorporated in 1959 and has become an award-winning suburban community with a population nearing 120,000 residents and a strong, sustainable local economy.

Historically, water supply needs for the City have been met by groundwater from the Gulf Coast aquifer system, similar to other municipalities across Fort Bend, Harris and Galveston counties. Groundwater withdrawals from the Gulf Coast aquifer system throughout the region, combined with the underlying geologic structure in the southeast Texas coast, have resulted in a phenomenon called subsidence. Subsidence is the settling of the land surface due to groundwater production and consolidation of clays in the subsurface, a geologic process that is for the most part not reversible. This can result in increased potential for localized flooding and damage to infrastructure including buildings, highways, and pipelines. To date, as much as ten feet of land subsidence has occurred in these counties. Because of this, the Fort Bend Subsidence District (FBSD) was established by the Texas Legislature in 1989 to regulate groundwater withdrawals to prevent further land subsidence in Fort Bend County. Beginning in 2014, the City had to meet FBSD regulations requiring the City to supply 30 percent of its water demand from alternative (non-groundwater) sources. In 2025, this water supply requirement will increase to 60 percent alternative sources.

The City recognizes the need to have a clear vision and strategic direction for water supplies to meet future water demands and the FBSD regulatory requirements. To provide this direction, the City initiated a planning process to develop an integrated water resource plan (IWRP), which is a comprehensive planning process to evaluate a wide mix of water supply and demand management options while building consensus and support from decision makers and other stakeholders that will be affected by the recommendations. The plan will provide a roadmap for future water supply strategies, outlining a combination of management strategies, policies, and capital projects that, when implemented, will be both cost-effective and sustainable to meet future water needs for the City.



1.1 Overview of the City of Sugar Land

The following sub-sections provide an overview of the City's planning areas and background on the FBSD groundwater reduction targets.

1.1.1 Planning Area

The IWRP encompasses an approximately 55-square-mile area, including the city limits and the City's extra-territorial jurisdiction (ETJ), as shown in **Figure 1-1**. The IWRP planning area was subdivided based upon pre-established planning areas from previous City planning efforts, which are shown in **Figure 2-1**. The city limits recently expanded considerably as the New Territory and Greatwood planning areas were officially annexed by the City in December 2017. At the time of annexation, the City's population grew by more than 30 percent (from an estimated 88,000 residents to approximately 120,000 residents) and the City took over responsibility for utility services in those areas. The planning areas that remain as part of the ETJ include Tara Plantation, Royal Lake Estates, Riverstone, and the largely undeveloped area known as Brazos South.

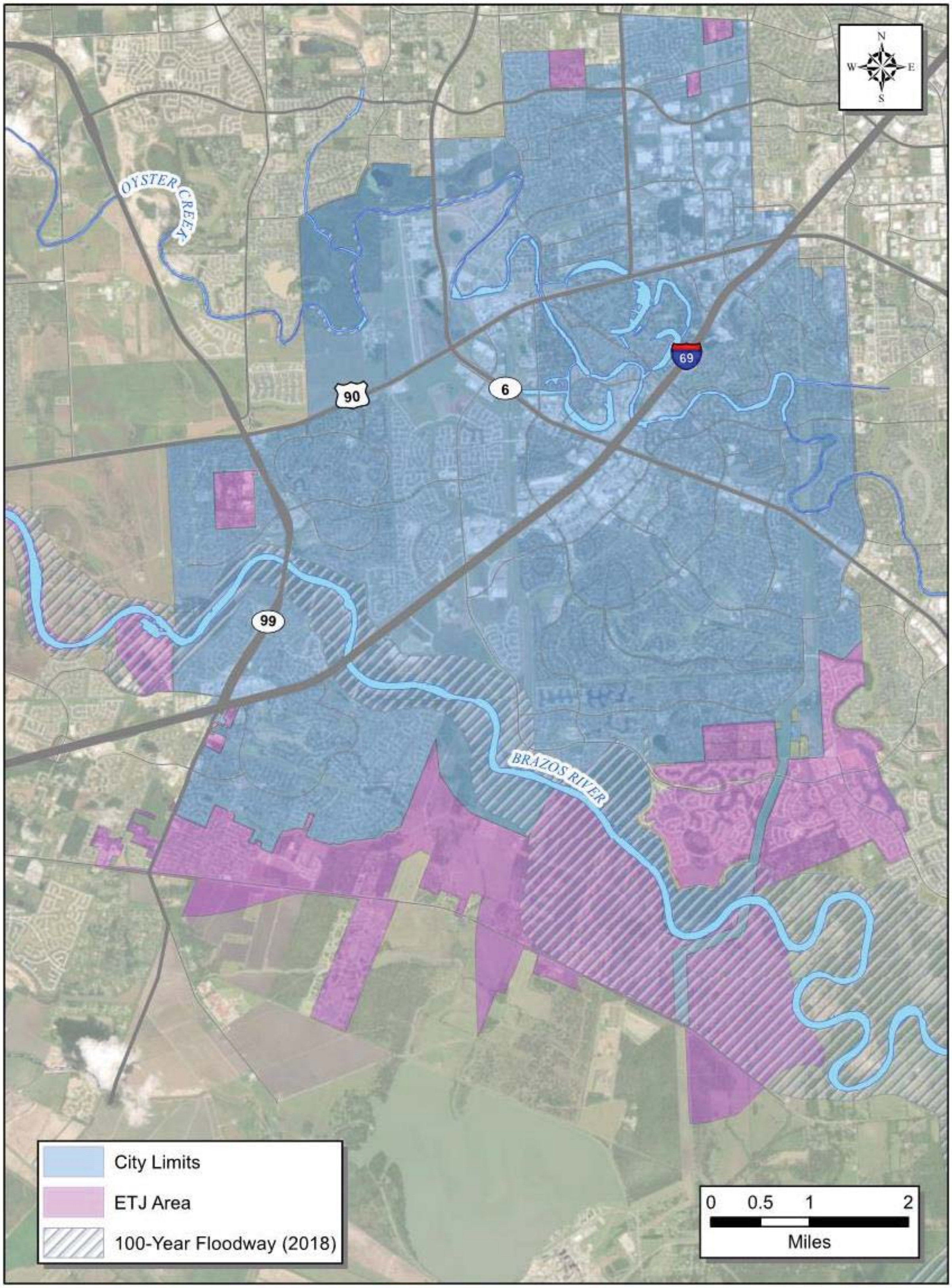


Figure 1-1. Map of City Limits and ETJ

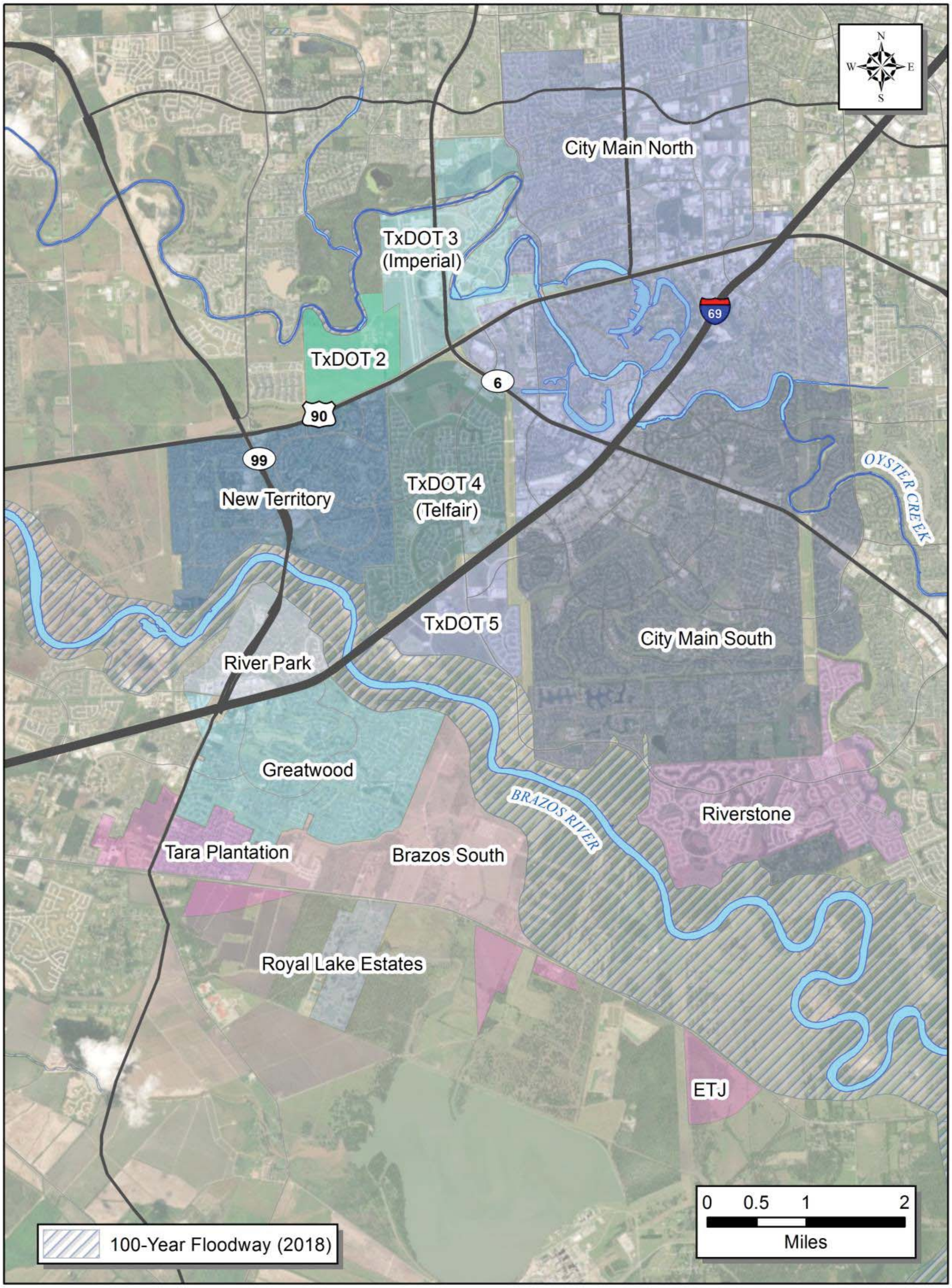


Figure 1-2. Map of IWRP Planning Areas

1.1.2 Groundwater Reduction Plan

The FBSD is divided into Area A (which includes the City), the Richmond Rosenberg subarea, and Area B as shown in **Figure 1-3**. As part of the FBSD regulations, permittees with a total water demand over 10 million gallons per year are required to develop or participate in a regional groundwater reduction plan (GRP). The City approved their first GRP in 2008 (Resolution 07-12). The GRP includes the City and 18 other partner entities. The partner entities include communities and private well owners – such as property owner associations, levee districts, or businesses – in the city limits and ETJ. The City acts as the manager of the GRP and handles reporting to FBSD on behalf of all participants to demonstrate the group's compliance with the regulations.

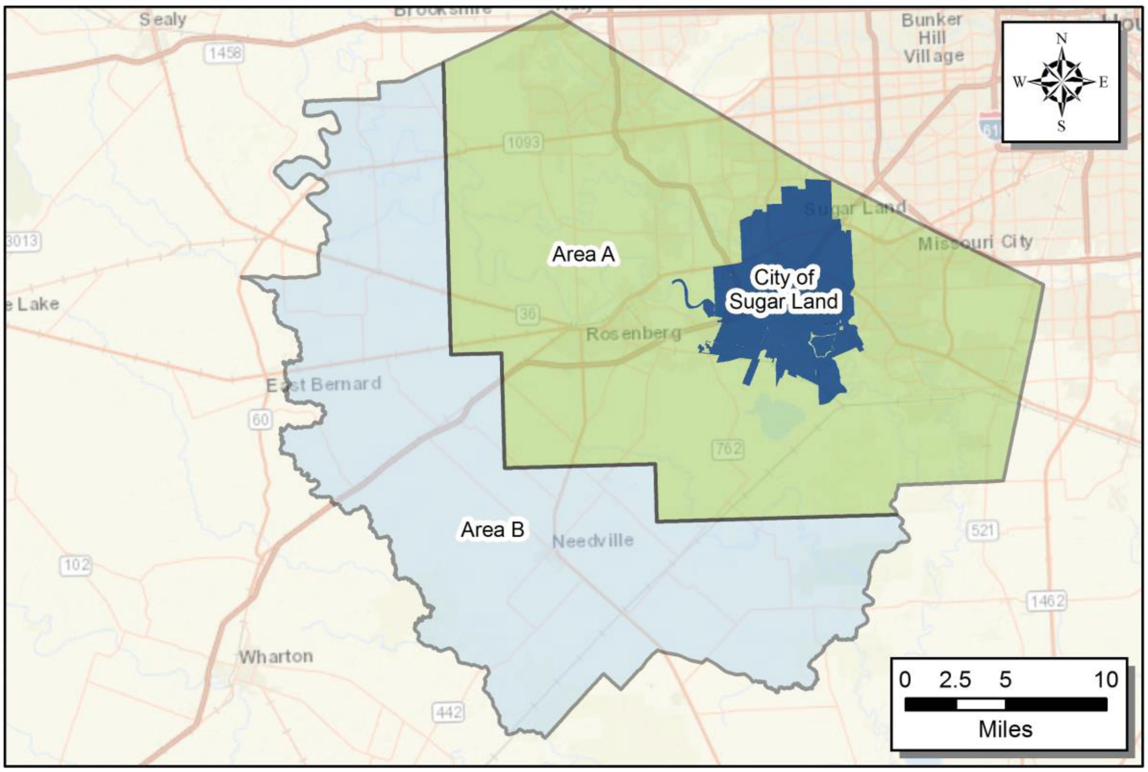


Figure 1-3. Fort Bend Subsidence District Regulatory Areas

If the City and its GRP participants do not meet the minimum 30 percent use of alternative water supplies, there is a financial penalty called a disincentive fee. The 2018 disincentive fee was $6.50 per 1,000 gallons of excess groundwater withdrawals. This fee is higher than the rate that the City charges its customers for water. If the City chooses to be non-compliant and pay the fee, water rates throughout the City and the ETJ would need to increase significantly.

The City's GRP outlined the strategies to achieve reduced groundwater withdrawals. These included:

- Pooling the groundwater and alternative water reporting for all participants.
- Securing surface water supply agreements.
- Constructing the City's first and only surface water treatment plant (SWTP) to produce and deliver alternative water to the most densely populated areas.

Figure 1-4. Photograph of the Surface Water Treatment Plant

All these initial steps were successfully implemented by the City and the GRP participants, leading to exceeding the initial requirement for supply of 30 percent alternative water. The FBSD incentivizes additional use of alternative water by awarding credits, in the form of certificates, to the GRP if the GRP "over converts" by using alternative water sources for more supply than required.

The City has continued to exceed the 30 percent alternative water requirement and built up over 6 billion gallons of over-conversion credits as of the publication of this report. These credits can be redeemed in the future to meet alternative water requirements in years when alternative water use may fall short of regulatory requirements. The City has also earned 1.4 billion additional credits through participation in the WaterWise educational program. The program teaches fourth or fifth grade students the importance of conservation and provides each student with a water conservation kit including water-efficient technologies that can be installed at home. Under this program, FBSD provides 84,000 gallons of credits for each student supported through the program.

1.2 Need for the IWRP

In 2015, the City began to develop a comprehensive plan to meet the 2025 deadline for 60 percent alternative water supply. The traditional method for water supply planning has focused on the cost to develop additional water supplies and the available yield of the newly developed water supply. The City developed a list of over three dozen specific questions that needed to be answered prior to making a long-term investment in additional water resources, some of which are:

- Do we have enough water? Do we have excess water?
- How reliable are our surface water contracts?
- How important is reliability to our community?
- How willing is our community to accept risk?
- What is the future of wastewater reuse?

- How should we prioritize our supply options?
- Are we using the right water for the right use?
- Are we maximizing system efficiency?
- Are we being fair and equitable to all customers?
- What are the drivers for future supply decision?

The City recognized the need to develop an alternative approach to the traditional planning process. This approach needed to allow for capital projects but also needed to include potential policy and procedure recommendations. Staff also felt it was critical to involve the City Council as well as members of the public when formulating the proposed path forward for our community. The City selected the Integrated Water Resources Plan (IWRP) process as the best tool for completing this program. The IWRP allows the City to evaluate policies, management strategies and capital improvement projects while building consensus and support from City staff, citizens, and council members impacted by the final IWRP recommendations.

1.3 Complementary Work

This IWRP is built upon a mix of previous and simultaneous planning studies as detailed below:

- **Groundwater Reduction Plan (Resolution 07-12):** The 2008 GRP lays out the City's originally planned strategies for meeting the FBSD regulatory targets. The plan covers projected demands, design considerations for the SWTP, availability of raw water sources, project funding, and conservation programs.
- **Water master plan:** The City's water master plan is updated every five years, with the last update occurring from 2012 to 2014. The water master plan was reviewed as part of the IWRP as background for the current water system and previously planned future initiatives, and also provides the basis for the planning areas used in this study. The projected water demands from the water master plan were also the starting point for the water demands refined in the IWRP. The water master plan also includes a stand-alone white paper with updated analysis on meeting the FBSD regulatory targets via the GRP.
- **Wastewater master plan:** The City's wastewater master plan is also updated every five years, with the last update in 2012. The most recent update reflected the growth and development projections and evaluated needed improvements to the wastewater collection and treatment systems that service the City and the ETJ. The wastewater master plan was reviewed as part of the IWRP as background on the current wastewater system and previously planned future initiatives. The City will update the wastewater master plan upon conclusion of the IWRP to include recommendations from this report.
- **Reclaimed water supply study:** A reclaimed water study occurred concurrently with the IWRP. Options and costs developed in the reclaimed water supply study are being used directly in the IWRP.

1.4 Purpose and Structure of the IWRP

The IWRP is being executed to provide both continued compliance with FBSD requirements and efficient use of the City's water resources. The IWRP process aims to identify the preferred combination of management strategies, policies, and capital projects that will sustainably and cost-effectively meet the City's future water needs.

The remainder of this report includes:

- **Section 2:** Structure of the IWRP process utilized to arrive at the preferred strategy for meeting the FBSD regulatory requirements.
- **Section 3:** Relevant components of the existing water, wastewater, and reclaimed water systems.
- **Section 4:** Overview of the water demand projections from 2018 through the end of the IWRP planning period in 2040.
- **Section 5:** Development of a decision support model.
- **Section 6:** Needs assessment of how much additional non-groundwater alternative water sources are required.
- **Section 7:** Future water supply options considered in meeting the FBSD regulatory requirements.
- **Section 8:** Evaluation of portfolios, or groups of options, in meeting the IWRP objectives.
- **Section 9:** Final recommended strategy.

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SECTION 2 | IWRP PROCESS

The IWRP process is a comprehensive planning process used to evaluate a wide mix of water supply and demand management options while building consensus and support from decision makers and other stakeholders that will be affected by the recommendations. The development of the IWRP, as detailed in this report and appendices, followed a defined set of steps. Each of the following steps is listed below and then described further in this section:

- Establishing the Council and Citizen Task Forces to provide input into the IWRP process;
- Defining and quantifying the City's existing water system infrastructure;
- Quantifying and projecting the City's current and future water supply demand;
- Developing IWRP planning objectives and performance measures;
- Developing a decision support model (DSM) that represents the current system and in which different water supply strategies could be included and compared against each other;
- Quantifying and analyzing future water supply deficiencies, referred to as needs or gaps, throughout the City;
- Developing 15 future water supply options representing a mix of management strategies and infrastructure options;
- Evaluating varying portfolios composed of different water supply options using the DSM; and
- Developing and advancing a preferred water supply strategy and related policies for the City based on the results of the best scoring set of portfolios.

Key terminology that is used in the development of an IWRP evaluation is provided in **Figure 2-1**. **Figure 2-2** shows the overview of the IWRP process and how each step informs the others.

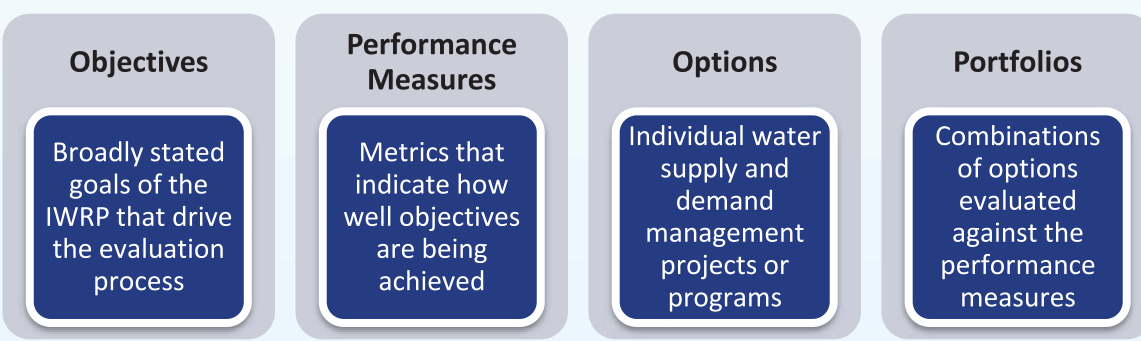

Figure 2-1. Integrated Water Resource Planning Terminology

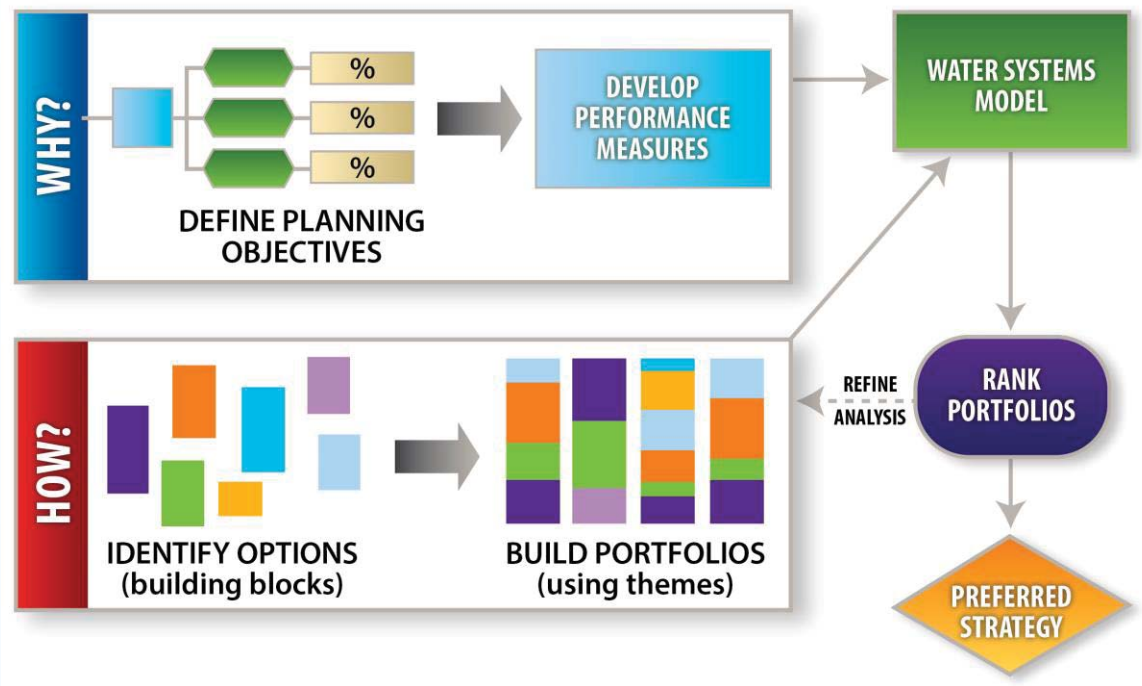

Figure 2-2. IWRP Planning Process

2.1 Stakeholder Involvement

The City established two task forces to guide and provide input to the IWRP process: the Council Task Force and the Citizen Task Force. The Council Task Force was composed of Council members Himesh Gandhi representing At-Large Position One and Council Member Steve R. Porter representing District One. The Council Task Force was responsible for providing input on the plan objectives, providing feedback on Citizen Task Force governance and providing feedback on the questions to be answered by the IWRP. The 14-member Citizen Task Force was appointed by the City Council and represented a range of interests and backgrounds to guide the development of the IWRP. The Citizen Task Force was responsible for developing objective weights, providing feedback on options and providing feedback on the final IWRP framework. Each task force met separately, typically on a monthly basis over a period of approximately 24 months. A list of the task force members is provided in **Table 2-1**.

Table 2-1. Task Force Members

Council Task Force	
Himesh Gandhi	Steve R. Porter
Harish Jajoo (retired)	
Citizen Task Force	
Ruth Barrett	Bruce Lowrie
Elizabeth Bryson	Poonam Mathur
Ann De Stefano	Showri Nandagiri
Trisha Frederick, P.E. - Chairperson	Megan Ortiz (Alternate)
James Goldman – Vice-Chairperson	Baseer Pirzada
Chuck Hewell, P.E.	Leo Weinberg, P.E.
Michaela Lim	Enayat Zareian

2.2 Existing System

The City's existing water supply and wastewater infrastructure was analyzed and defined to lay the groundwork for future evaluations during the project. The system definition was developed from a variety of data sources, including the City's various master plans, mapping database, water supply and wastewater data, treatment plant and pumping data, and other sources. Additional information regarding the existing system is given in **Section 3**.

2.3 Water Demands

An analysis of water demands was performed to quantify the volume of water that must to be delivered to each of the IWRP planning areas. This analysis reviewed the current water demands and projected future water demand, by IWRP planning area, through ultimate build-out conditions (assumed to be 2040 for the purposes of this study). The results of this analysis were then used in the DSM to inform the needs assessment and aid in the development of water supply options. Additional information regarding the water supply demand analysis is given in **Section 4**.

2.4 IWRP Planning Objectives and Performance Measures

The IWRP planning objectives and performance measures provide the evaluation criteria for which the IWRP portfolios will be scored. The City's management developed the IWRP planning objectives and presented them to both the Council Task Force and the Citizen Task Force. For each objective, performance measures were then developed to score how well a potential portfolio would meet each objective. The following subsections detail how planning objectives and performance measures were developed.

2.4.1 Planning Objectives

To serve as the framework for how the IWRP is developed, objectives should have the following attributes:

- **Distinctive:** to distinguish between one portfolio and another.
- **Measurable:** to determine if they are being achieved, either through quantitative or qualitative metrics.
- **Nonredundant:** to avoid overlap and avoid bias in ranking the portfolios.
- **Understandable:** to be easily explainable and clear.
- **Concise:** to focus on what is most important in decision-making.

The objectives and performance measures were developed through a series of workshops with city staff. The final list of seven IWRP objectives is provided in **Table 2-2**.

Table 2-2. IWRP Objectives

Objective No.	Objective	Description
1	Optimize Water Resources	Maximize the City's water supplies to meet current and future demands, including using the "right" type of water for the "right use of water (e.g., non-potable water for irrigation demands).
2	Provide Reliable Water Supply	Maintain reliable water supplies for the City with an acceptable amount of risk, accounting for droughts, subsidence, facility failures, and regulatory uncertainties.
3	Develop Cost-Effective Solutions	Manage the financial impacts associated with meeting customer expectations for service and water quality.
4	Promote System Efficiency	Maximize efficiency and effectiveness for water use and value of water resources, including water loss and operational management (e.g., improved water age and distribution system water quality).
5	Promote Equity	Promote fairness and equity among all water users, both potable and non-potable.
6	Protect Environment	Protect the natural environment of the community, including impacts to receiving water (e.g., discharges to creeks and rivers) and land subsidence.
7	Maintain Quality of Life	Acknowledge the value water resources have on the economic, cultural, and recreational health of the City and its residents.

2.4.2 Objective Weighting

One of the key inputs of the Citizen Task Force was weighting the objectives. In any decision-making process, objectives are generally not all equally important. Thus, developing a set of weights is necessary to better reflect the difference in preferences among the various objectives.

To develop objective weights, the Citizen Task Force conducted two different weighting exercises: forced pair comparison and dot voting. Dot voting provided an opportunity to compare all of the objectives wholisticlly, while the forced pair comparison evaluated each option relative to the others. For the dot voting exercise, each task force member was given a sheet of 24 adhesive circle-shaped stickers. The seven objectives were printed on poster board and placed on tables around the room. Each task force member was asked to place as many or as few stickers on an objective as they desired. The only condition was that one dot (at a minimum) had to be placed on each objective. An example of what an objective sheet looked like after the exercise is shown in **Figure 2-3**. The number of dots on each objective was then tallied, and the objectives were ranked based on the number of dots each one received.

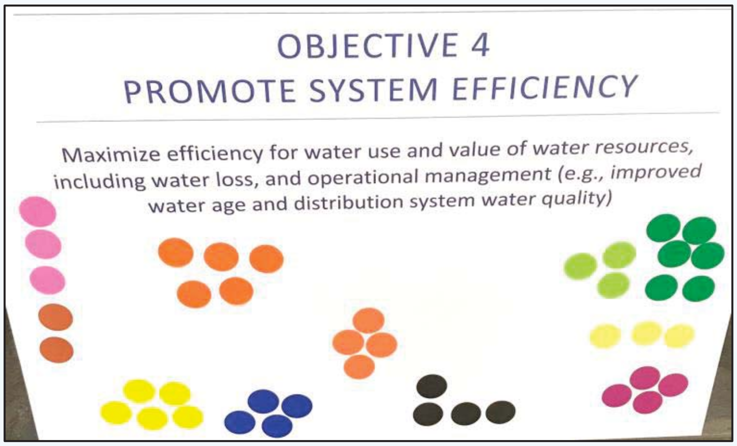

Figure 2-3. Sample Dot Voting Exercise Score Card from Citizen Task Force Meeting

For the forced pair comparison, each task force member was given a worksheet that compared two of the seven objectives against each other and required the member to decide which objective was more important to them. This was done for each possible pair of objectives, which resulted in a total of 21 decisions being made by each task force member. The number of instances where one objective was chosen over the other was tallied and then displayed as a percentage of all the votes cast.

The results of the forced pair comparison and dot voting exercise provided similar results as shown in **Table 2-3**. The average between the two exercises was voted on and approved by the Citizen Task Force as the objective weights to be carried forward into the IWRP process. The final weightings for each objective are shown in **Figure 2-4**. More detail on the results of the objective weighting exercises is available in **Appendix A – Citizen Task Force Objective Weighting Exercises**.

Table 2-3. IWRP Objective Weighting Results

Objective	Dot Exercise	Forced Pair	Average
Optimize Water Resources	19%	17%	18%
Provide Reliable Water Supply	22%	27%	25%
Develop Cost-Effective Solutions	13%	17%	15%
Promote System Efficiency	17%	19%	18%
Promote Equity	9%	4%	6%
Protect Environment	12%	10%	11%
Maintain Quality of Life	8%	6%	7%

2.4.3 Performance Measures

For each objective, at least one performance measure is required. The performance measures are used to indicate how well an objective is being achieved. Where possible, quantitative performance measures were established. In certain instances, a qualitative score is the most suitable performance measure. **Table 2-4** lists the performance measure for each objective along with the measurement unit and subweight for the performance measure. The performance measure subweight shows how the overall objective weight is split between the performance measures. An equal-weighing split between performance measures was utilized. More detail on performance measures and how they are calculated can be found in **Section 8 – Portfolio Evaluation** and **Appendix B – Decision Support Model Documentation.**

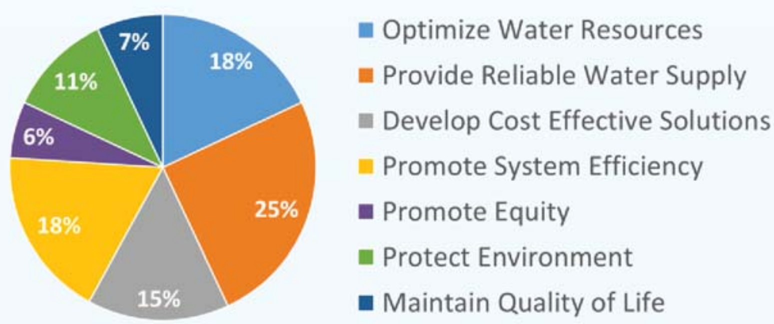

Figure 2-4. Objective Weights

Table 2-4. Performance Measures and Subweights

Objective	Objective Weight	Performance Measure	Subweight	Measurement Unit
Optimize Water Resources	18%	Percent of non-potable demands met with non-potable supply	50%	%
		Percent utilization of surface water contracts	50%	%
Provide Reliable Water Supply	25%	New non-groundwater yield incorporated	33%	MGD
		Non-groundwater usage during extreme summer drought	34%	%
		Yield from options with high implementation challenges	33%	MGD
Develop Cost-Effective Solutions	15%	Levelized cost of delivered water	50%	$/1,000 gallon
		Total capital cost (present value)	50%	$ (millions)
Promote System Efficiency	18%	Average percent savings from demand-side management options.	50%	%
		Qualitative score for operational complexity	50%	Qualitative
Promote Equity	6%	Qualitative equity impact score	50%	Qualitative
		Demands with access only to groundwater	50%	%
Protect Environment	11%	Additional energy cost of options	34%	$/year (millions)
		Qualitative subsidence score	33%	Qualitative
		Qualitative environmental scores	33%	Qualitative
Maintain Quality of Life	7%	Qualitative score for benefiting economy	50%	Qualitative
		Unmet annual amenity lake raw water demand during drought	50%	AFY

AFY – acre-feet per year, MGD – millions of gallons per day.

2.5 Decision Support Model and Analysis

A decision support model (DSM) was developed to test the ability of project option combinations to achieve the IWRP objectives while meeting the FBSD regulatory targets. The DSM represents the backbone of the water, wastewater and reclaimed water systems. Additional information regarding the DSM is given in **Section 5 – Decision Support Model** and **Appendix B – Decision Support Model Documentation**.

The DSM also produces raw output for a number of the quantitative performance measures. A Microsoft Excel spreadsheet scoring tool is used to calculate some qualitative performance measures as well as organize the individual performance metric scores for each portfolio of interest.

Once all portfolios were analyzed with the DSM and scoring tool, the raw performance measure scores were input into Criterium Decision Plus (CDP), a software program that normalizes the scores and applies the relative weightings. This process is described further in **Section 8 – Portfolio Evaluation**. The final output is a composite score for each portfolio.

2.6 Needs Assessment

Performing a needs assessment allowed the City to predict potential water supply shortages and FBSD out-of-compliance water deliveries that could result in a financial penalty to the City. The needs assessment was done by analyzing the existing system infrastructure in conjunction with the current and future water supply demands for the City. The results of this analysis informed the development of water supply options and portfolios. Additional information regarding the needs assessment is given in **Section 6 – Needs Assessment**.

2.7 Water Supply Options

For the IWRP, 15 water supply options were developed. These options could consider construction of physical infrastructure, such as an expanded reclaimed water system, or a management strategy, such as conservation. A planning level analysis was performed to establish the option's potential water supply yield, costs, and implementation challenges. The results of this analysis were input into the DSM. The City then assembled portfolios of different options to evaluate and score based on the objectives and performance measures. Additional information regarding the water supply options is given in **Section 7 – Future Water Supply Options**.

2.8 Portfolio Evaluation

The development of portfolios to meet water supply needs is a critical component of the IWRP analysis. As previously mentioned, portfolios are a mix of water supply options. To begin, the City outlined a set of themed portfolios, such as lowest cost or highest reliability using water supply options focused on that single goal. These initial themed portfolios informed the City of what was possible but not necessarily practical. Using this information, hybrid portfolios were developed using a mix of water supply options that could meet the required future water supply needs. The best scoring of the revised hybrid portfolios then informed the final recommended strategy. Additional information regarding the evaluation of portfolios is given in **Section 8 – Portfolio Evaluation**.

2.9 Identification of the Recommended Strategy

The final composite scores provide an easy way to compare portfolios and identify which best meet the multiple objectives of the IWRP. Tradeoffs between portfolios can also be seen by how each total score is built up by the various objectives and performance measures. Sensitivity of the scoring to different weightings and assumptions was explored. The City staff, along with the Council and Citizen Task Forces, considered the results and the underlying assumptions in building the final recommended strategy outlined in **Section 9 – Recommendations.**

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SECTION 3 | EXISTING SYSTEM

The City and its ETJ area are served by several distinct water systems: potable water systems, wastewater treatment systems, a reclaimed water system, and other non-potable water supplies. This section describes each of these systems as understanding the current capabilities and infrastructure is important for laying the groundwork for future supply evaluations.

3.1 Potable Water

Figure 3-1. Photograph of the First Colony Groundwater Plant

Historically, the majority of the City's drinking water supply has been from groundwater. There are twelve existing city-owned and operated groundwater treatment plants within the city limits and three non-city groundwater plants in the ETJ area. The locations of the plants are shown in **Figure 3-1**; production capacities and firm pump capacity for each groundwater plant is listed in **Table 3-1**. Finished surface water from the SWTP can be conveyed through surface water transmission lines, as shown in **Figure 3-1**, to the First Colony, Lakeview, and Riverstone groundwater plants, where it enters ground storage tanks and blends with treated groundwater before being delivered to the distribution system**.** Overall, the City's water system includes approximately 625 miles of transmission and distribution waterlines of diameters ranging from 1 inch to 36 inches.

The City operates four distinct potable water systems: City Main, New Territory, River Park and Greatwood. Additionally, the Riverstone planning area (Municipal Utility District (MUD) 128) is supplied with wholesale water from the City Main distribution system. Similarly, Greatwood Lakes (MUD 192), a subarea within Brazos South, receives water wholesale from the Greatwood distribution system. Within the ETJ, Tara Plantation receives water from Plantation MUD and Royal Lake Estates receives water from Royal Valley Utilities. These areas are all highlighted in **Figure 3-2.**

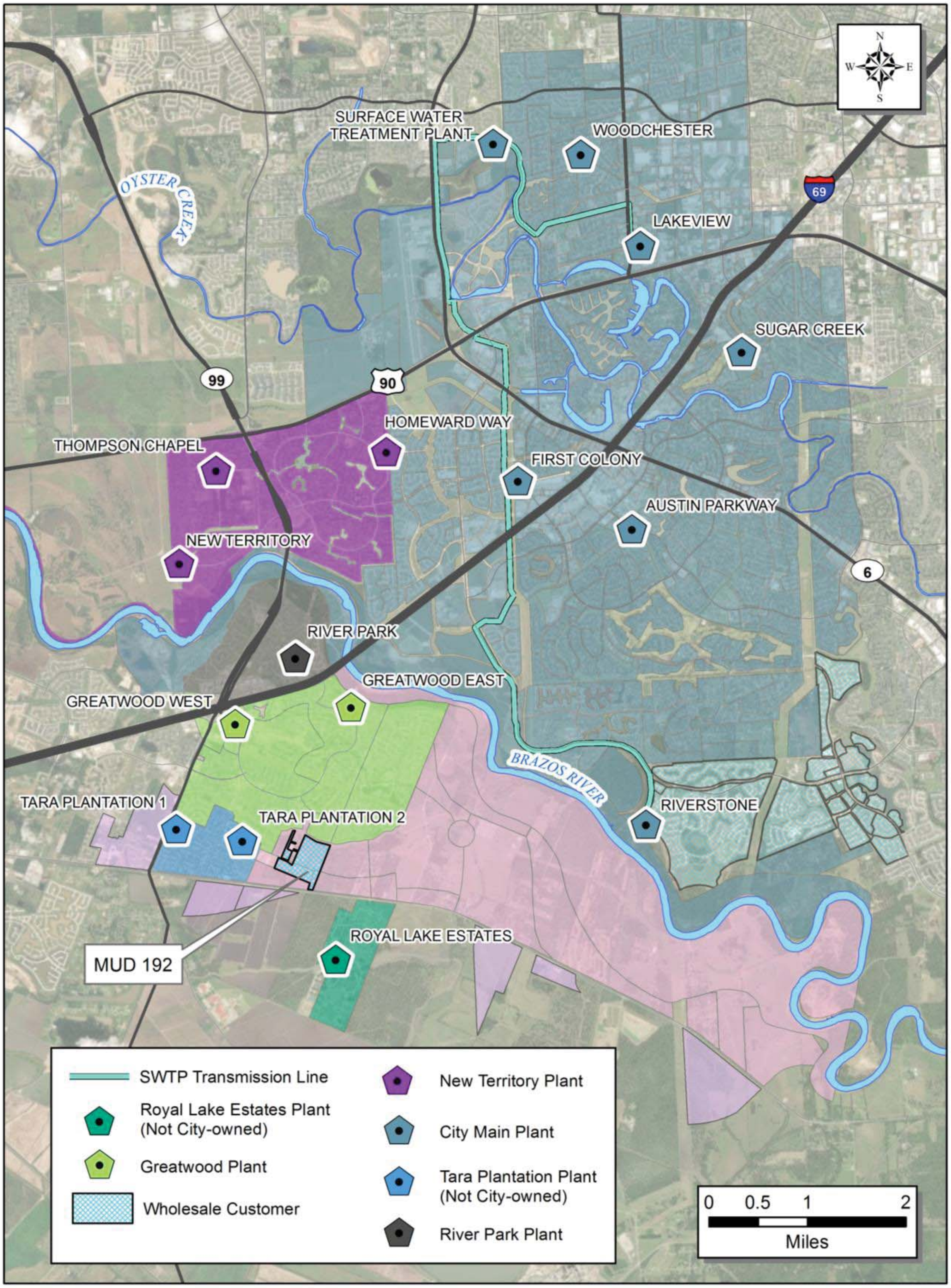

Figure 3-2. Map of Key Potable Water Infrastructure

Table 3-1. Groundwater Production and Firm Pumping Capacity Constraints (MGD)

Groundwater Plant	Production Capacity (MGD)	Pump Firm Capacity (MGD)[a]	Potable Distribution System
Austin Parkway	9.92	11.16	City Main
First Colony[b]	12.07	14.40	City Main
Lakeview[b]	10.05	12.24	City Main
Sugar Creek	8.35	5.04	City Main
Woodchester	6.98	4.61	City Main
Riverstone[b]	4.26	5.76	City Main
River Park	4.03	5.04	River Park
Thompson Chapel	3.05	3.6	New Territory
Homeward Way	4.03	6.48	New Territory
New Territory	3.99	9.36	New Territory
Greatwood West	4.44	7.92	Greatwood
Greatwood East	4.78	3.24	Greatwood
Tara Planation 1	1.15	-[c]	Plantation (ETJ)
Tara Planation 2	1.15	-[c]	Plantation (ETJ)
Royal Valley	-[c]	-[c]	Royal Lake Estates (ETJ)

[a] Firm capacity determined with largest pump out of service.
[b] Groundwater plants that receive water from the SWTP.
[c] For non-City-owned systems without data, enough production and pump capacity was assumed to meet demands.

The City has secured three surface water supply sources to supply the SWTP. The City holds a water right on Oyster Creek, allowing the City to withdraw 18,000 AFY (equivalent to 16.1 MGD on an average annual basis) with no explicit restriction on pumping rate; however, the City has agreed to limit diversions during extreme drought. The combined diversions for this water right and an additional, smaller (159 AFY) water right on Oyster Creek held by the City for industrial and irrigation purposes are authorized at a maximum rate of 32,200 gallons per minute (46 MGD).

In addition to natural streamflow, Oyster Creek receives raw water pumped from the Brazos River by the Gulf Coast Water Authority (GCWA), a wholesale water provider. The City has a water supply agreement with GCWA for 10 MGD of raw water. This is a "take or pay" contract where the City pays for the full 10 MGD of supply whether they utilize it or not. The City has another 10 MGD reserved in the contract with GCWA (called option water). The City pays a reduced amount to hold the option to purchase this water at a later date.

Finally, the City has a contract with the Brazos River Authority (BRA) for 6,388 AFY (equivalent to 5.7 MGD on an average annual basis) of raw water. The BRA contract has no restriction on daily pumpage. However, neither BRA nor the City has a way to deliver the Brazos River water to Oyster Creek. If the City wishes to access this water in Oyster Creek, either a pump station must be constructed, or the City can contract with GCWA to pump the water via their existing infrastructure. For comparison purposes, surface water supply volumes are shown on both a daily and an annual basis in **Table 3-2**.

Table 3-2. Surface Water Supplies

Surface Water Supply	Raw Water Flow[a]		Uses
	(MGD)	(AFY)	
GCWA Agreement	10.0[b]	11,201	Municipal and noncommercial irrigation
GCWA Agreement – Option	10.0[b]	11,201	Municipal and noncommercial irrigation
BRA Agreement	5.7[c]	6,388	Unspecified
Oyster Creek Water Right (1914)	0.1[c]	159.27	Industrial and irrigation
Oyster Creek Water Right (1948)	16.1[c]	18,000	Municipal, industrial, irrigation, and agriculture
Total Surface Water Supply	---	**46,949**	

[a] Listed flow reflects contractually available water and/or water rights that have been granted by the State of Texas. Water availability is not guaranteed.

[b] Agreement specifies a "take or pay" of 10 MGD with an option to purchase additional water up to 10 MGD. Withdrawal rate for each is limited to 10 MGD.

[c] Agreement/Water right flow is on an AFY basis.

N/A – not applicable

3.2 Wastewater

The following sections provide an overview of the collection system (**Section 3.2.1**) and the wastewater treatment plants (WWTPs) (**Section 3.2.2**).

3.2.1 Collection System

The City's existing wastewater collection system consists of four distinct sewersheds within the city limits: North WWTP, South WWTP, West WWTP, and Greatwood WWTP, as shown in **Figure 3-3**. The Tara Plantation WWTP facility is located within the city limits immediately adjacent to the Greatwood WWTP, but its sewershed is entirely in the ETJ area and it is not operated by the City. Each plant's collection system is independent, with one exception. The North WWTP has existing pumping facilities that are capable of diverting a portion of the plant's inflows to the South WWTP sewershed. While the North WWTP's treatment capacity is sufficient for current inflows, flow diversion may be utilized in the future to maintain WWTP process flows below levels that would trigger regulatory expansion requirements. WWTP capacities are discussed in greater detail in **Section 3.2.2**.

In addition to the WWTPs, wastewater infrastructure includes over 500 miles of gravity mains ranging from 4 to 60 inches in diameter and 40 miles of force mains up to 24 inches in diameter. The collection system also includes approximately 140 lift stations within city limits.

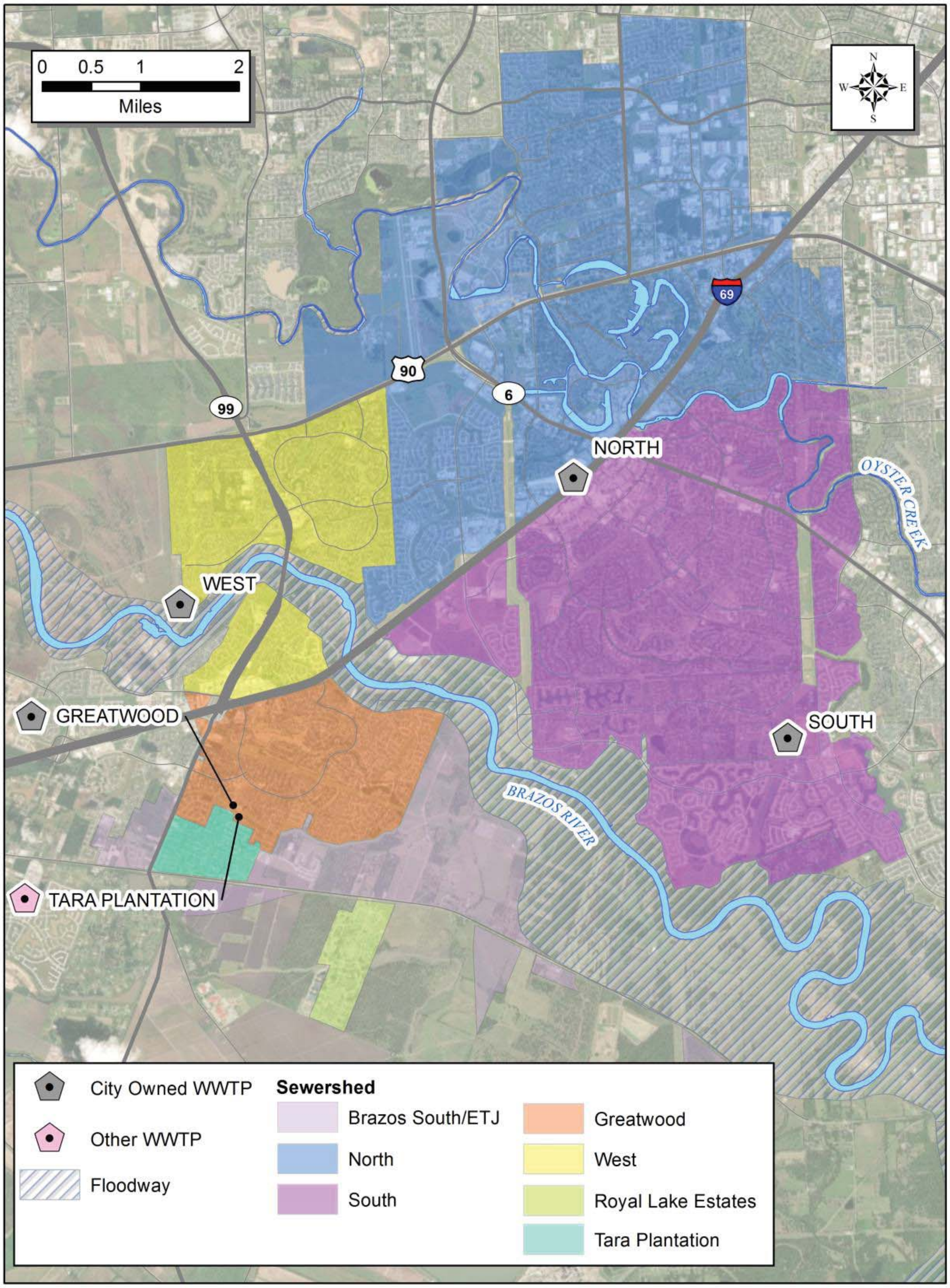

Figure 3-3. Map of WWTP Service Areas

3.2.2 Wastewater Treatment Plants

Treatment capacities for the WWTPs are summarized in **Table 3-3** in average annual daily flow (AADF). Existing infrastructure allows the diversion of 0.75 MGD of North WWTP flows to the South WWTP service area. This diversion is intended to delay the plant reaching 75 percent of design capacity, which triggers a Texas Commission on Environmental Quality requirement to begin WWTP expansion planning.

Table 3-3. WWTP Capacities

Wastewater Treatment Plant	Design Capacity (MGD AADF)
North WWTP	6.00
South WWTP	7.50
West WWTP	2.20
Greatwood WWTP	1.35
Tara Plantation WWTP (ETJ)	0.44
Total Design Capacity	**17.49**

The 7.5-MGD South WWTP has the highest capacity of the City's existing WWTPs. While the South WWTP currently has excess capacity to accept diverted inflows from the North WWTP sewershed, it is anticipated that continued growth in the South WWTP sewershed will reduce the WWTP's excess capacity and eventually preclude these diversions.

The City's 2.2-MGD West WWTP serves New Territory and River Park planning areas. The wastewater master plan identified the expansion of the West WWTP from 2.2 to 4.5 MGD to accommodate future growth and diversions from the North WWTP, with the ultimate buildout capacity of the West WWTP projected at 10 MGD.

The Greatwood WWTP sewershed is fully developed, and the plant's 1.35-MGD design capacity is sufficient for current inflows. However, the plant does not have excess capacity to accept inflows from other sewersheds (i.e., regionalization), and space constraints at this facility currently prevent plant expansion.

Figure 3-4. Photograph of Greatwood WWTP

The Tara Plantation WWTP's sewershed, located in the ETJ area, is also fully developed. The plant's relatively small size (0.44 MGD) and space constraints do not allow for regionalization at this facility. However, both the Greatwood WWTP (as shown in **Figure 3-4**) and Tara Plantation WWTP could potentially be bypassed if a larger, regional WWTP is constructed (e.g., in the Brazos South area).

In total, the current design capacity of the existing WWTPs, including the Tara Plantation WWTP, is approximately 17.5 MGD. In areas without a WWTP, such as Royal Lakes Estate and Brazos South, septic systems are utilized.

3.3 Reclaimed and Non-Potable Water

Within the City's water planning area, non-potable water demands are supplied with either reclaimed water, raw (untreated) surface water, or untreated groundwater.

3.3.1 Reclaimed Water Supply

Each of the WWTPs provides secondary treatment and could potentially contribute to the City's reclaimed water supply system. The South WWTP has existing infrastructure capable of producing and delivering Type I reclaimed water suitable for irrigation, filling amenity lakes, and other non-potable uses. The extent of this current system is shown in **Figure 3-5**. The West WWTP does not produce reclaimed water, but the City has an agreement to supply WWTP effluent to Fort Bend County Levee Improvement District (LID) 7, which owns and operates reclaimed water treatment facilities to produce Type I reclaimed water. This reclaimed water is used for refilling amenity lakes, irrigation, and other non-potable uses by New Territory Residential Community Association.

The North and South WWTPs also utilize reclaimed water for plant washdown at the facilities.

3.3.2 Raw Surface Water Supply

The City supplies raw (untreated) surface water to five entities for neighborhood landscape irrigation and amenity lake filling (**Table 3-4**). Each entity has entered into a water supply agreement specifying terms for water use. Actual demand fluctuates seasonally, and based on historical data from 2015 through 2017, averaged 0.6 MGD (670 AFY).

Table 3-4. Existing Non-Potable Surface Water Supply Agreements

Raw Water Purchaser	Demand Type
Lakepointe First Colony Community Association (FCCA)	Irrigation
LID 17 / Telfair	Lake filling/irrigation
Orchard Pump Station	Irrigation
Sugar Lakes HOA	Lake filling
Venetian Estates Property Owners Association (POA)	Lake filling/irrigation

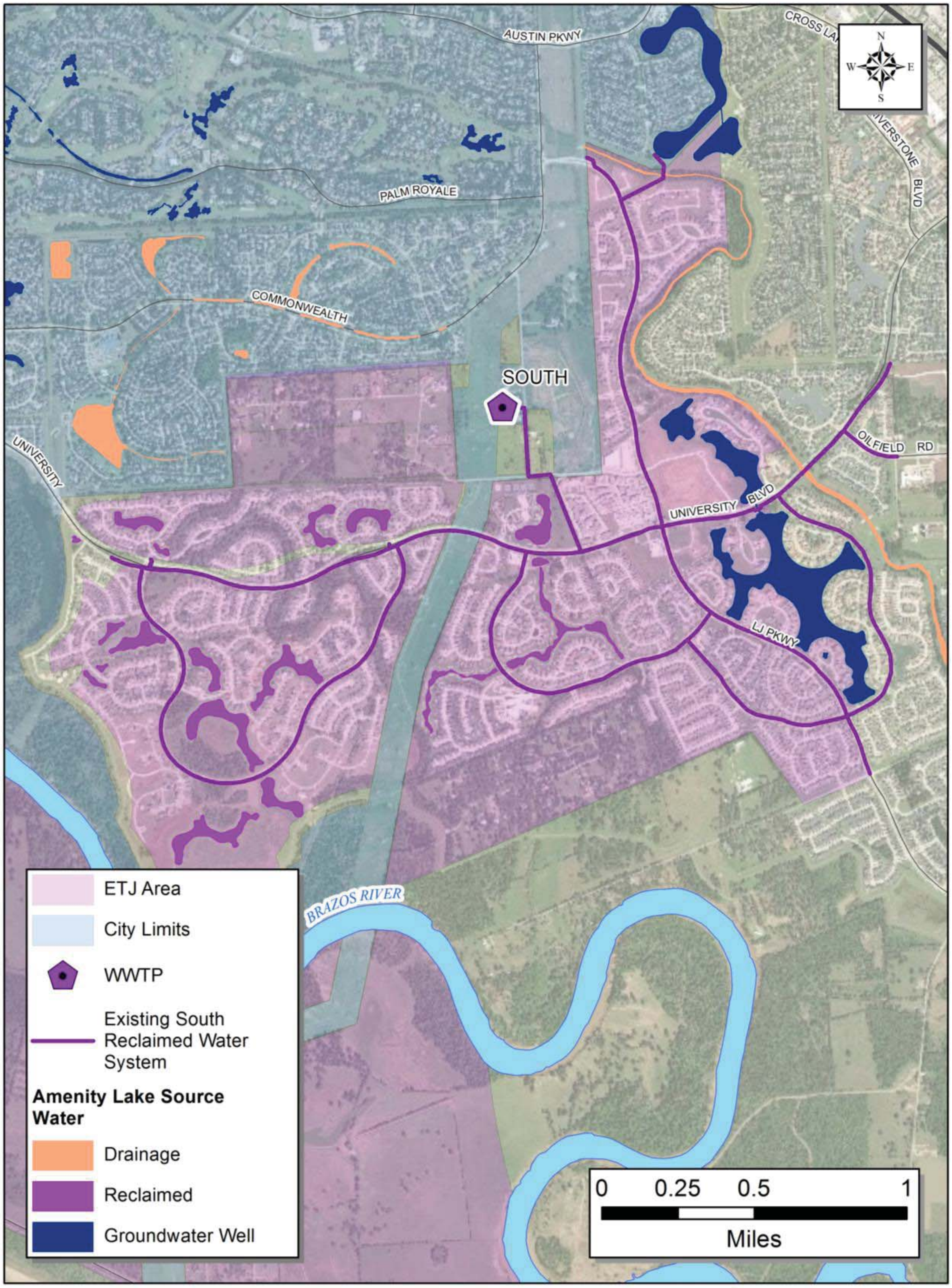

Figure 3-5. Map of the Current Reclaimed Water System

3.3.3 Non-Potable Groundwater

The GRP participants (property owner associations, LIDs, or businesses) who are private well owners who use the wells to irrigate landscapes and fill amenity lakes include the following:

- Avalon Community Association
- City of Sugar Land – Parks and Recreation
- First Colony Community Association
- First Colony Property Association
- Fort Bend County LID 17 / Telfair
- Fort Bend County MUD 192 / Greatwood Lakes
- New Territory Residential Community Association
- River Park Homeowners' Association (HOA)
- River Pointe Golf Course
- Royal Lakes Estates HOA
- Schlumberger Technology Center
- Sugar Lakes HOA
- Sugar Land Business Park
- Sugar Mill Community Association Incorporated (CAI)
- Sweetwater Country Club Golf Course
- Texas Par Golf Academy

In addition, Riverstone and Venetian Estates POA are not part of the City's GRP but the City receives credits for their alternative water usage.

Annual average water use for all the private well owners from 2015 to 2017 was 0.47 MGD. This water is accounted for as groundwater within GRP reporting to FBSD.

3.3.4 Amenity Lakes

Many communities within the City have amenity lakes (**Figure 3-6**) that can provide recreational opportunities and, in some cases, flood control benefits. Maintenance of amenity lake levels is a major use of non-potable water. A map of the major amenity lakes and the source water used for supplemental filling is shown in **Figure 3-7.**

Figure 3-6. Example Amenity Lake

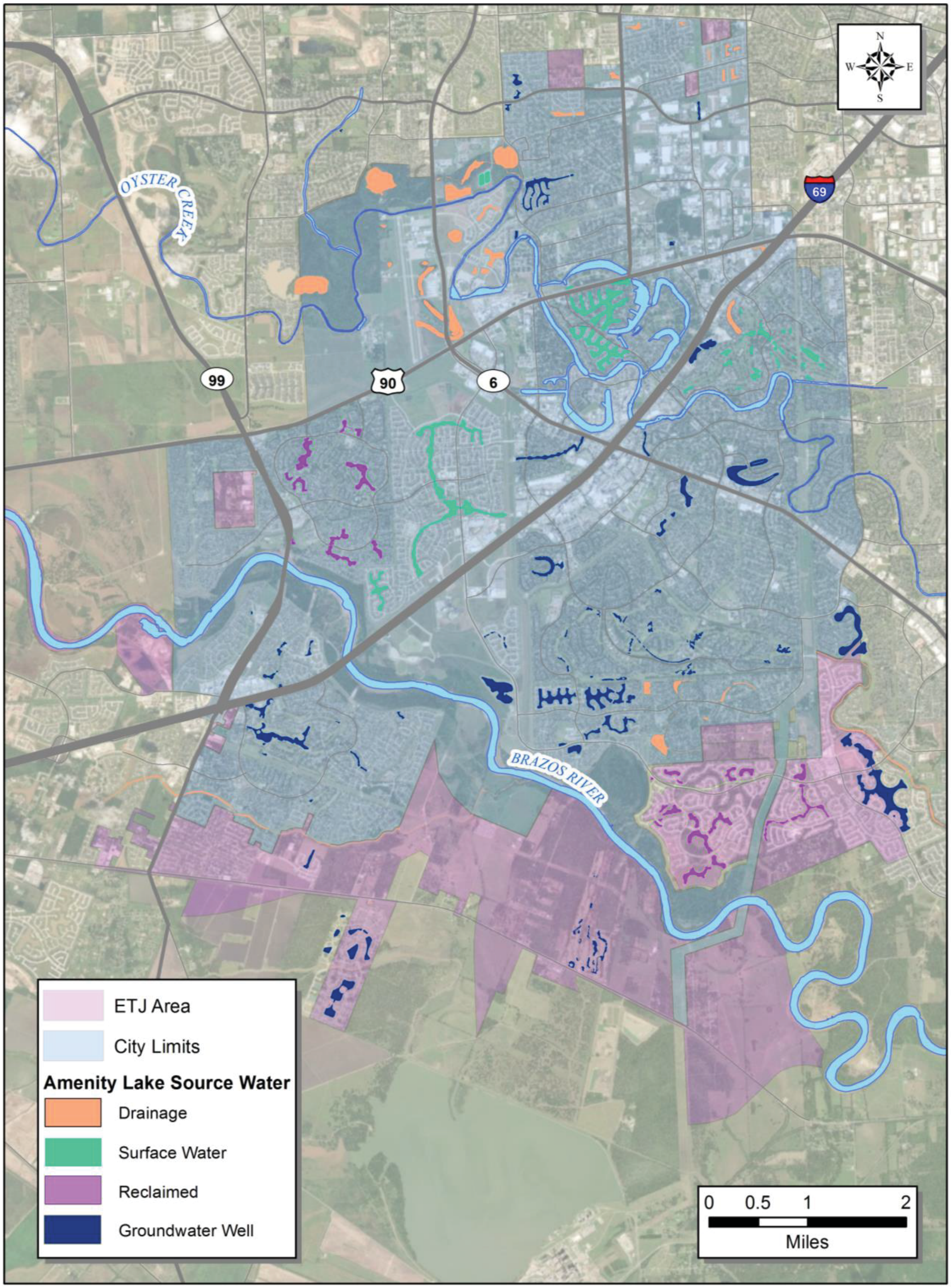

Figure 3-7. Map of Water Supplies for Amenity Lakes

SECTION 4| WATER DEMANDS

To properly plan for future use of the City's water resources, it is critical to understand how and where water is currently used in the city as well as estimate how much water will be needed in the future. The overall goal of the demand analysis was to identify demands by water use sector, determine the indoor versus outdoor portions of the demands, and generate seasonal patterns. This section provides an overview of the water demand totals and patterns utilized in the IWRP. Additional detail on the demand analysis can be found in **Appendix C – Potable Demand Analysis Technical Memorandum**.

4.1 Potable Water Demand

As a starting point for potable water demands, the City provided the projected water demand data utilized in the 2012 Water Master Plan update for the years 2018, 2025 and 2040. The values for 2040 are considered to be the ultimate buildout condition. The data were organized as estimated equivalent single-family connections (ESFCs), which represents the average daily water demand for a Sugar Land single-family dwelling. ESFCs are converted to demand utilizing average demand factors. For the water master plan, a factor of 525 gallons per day per ESFC was assumed for the Greatwood and New Territory service areas, whereas a factor of 400 gallons per day per ESFC was assumed for the rest of the City and ETJ area. These flows represent dry year conditions, which was appropriate for the water master plan; however, the IWRP is focused on both average year and dry year conditions. Based on historical data, the demand factors were adjusted to 404 gallons per ESFC for the Greatwood and New Territory areas and 308 gallons per ESFC for the rest of the planning areas to represent average year demands. **Appendix C – Potable Demand Analysis Technical Memorandum** provides additional details on this analysis.

A few minor adjustments were also made to the ESFC totals as compared to the water master plan data. The Riverstone planning area developed faster than projected, and connections for 2018 were adjusted up, whereas the Brazos South planning area developed slower than projected, and 2018 and 2025 connections were adjusted down. The average demand by planning area is shown in **Figure 4-1** for 2040. A full summary of the total demand under both average weather and dry weather conditions per planning area is provided in **Table 4-1**.

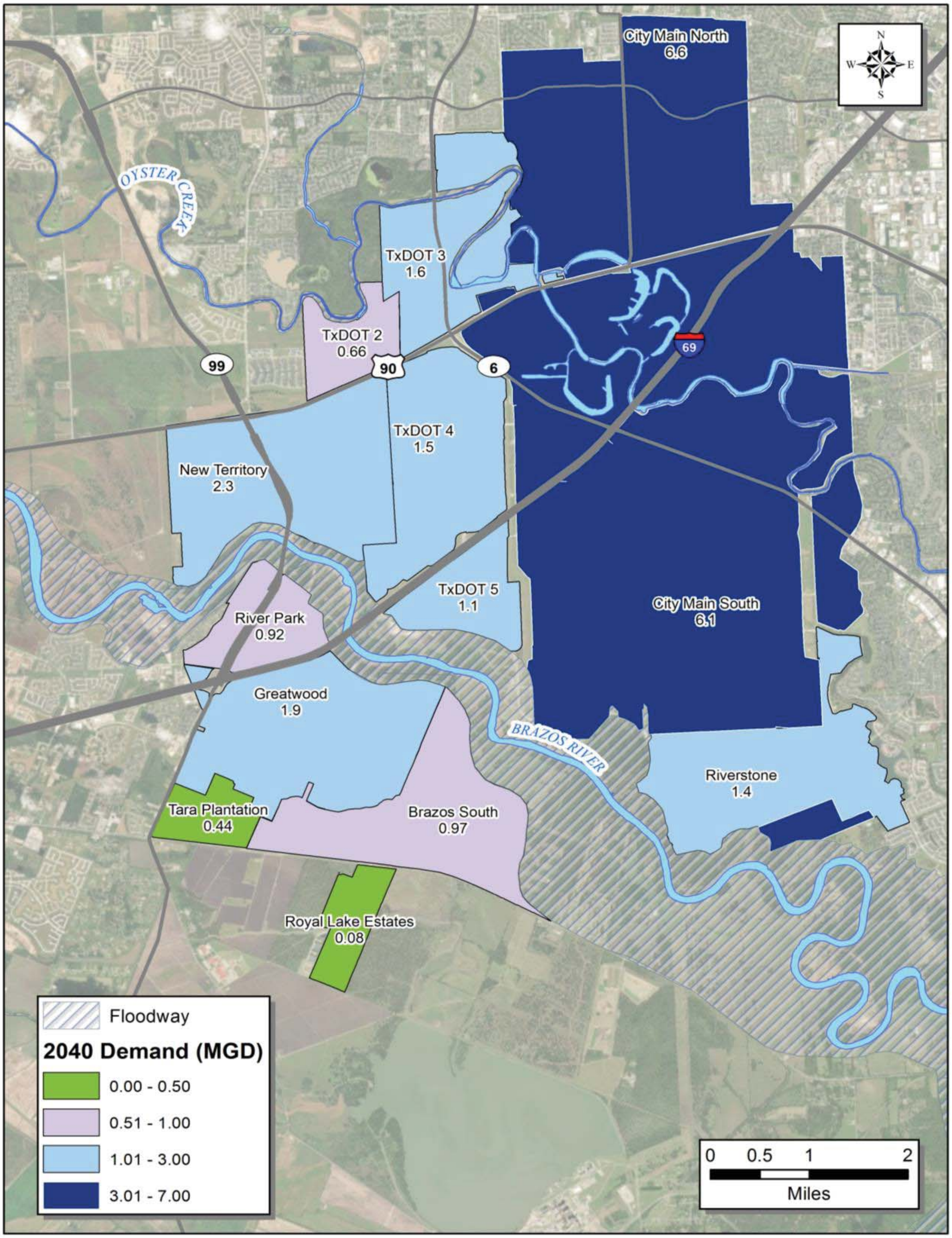

Figure 4-1. Map of 2040 Average Potable Demand by Planning Sector

Table 4-1. Projected Potable Demands per Planning Area (MGD)

Planning Area	Dry Year Demand Flows			Average Year Demand Flows		
	2018	2025	2040	2018	2025	2040
City Main North	8.00	8.33	8.60	6.15	6.41	6.61
City Main South	7.63	7.72	7.93	5.87	5.94	6.10
Greatwood	2.41	2.41	2.41	1.86	1.86	1.86
New Territory	2.94	2.94	2.95	2.26	2.26	2.27
Plantation	0.58	0.58	0.58	0.44	0.44	0.44
River Park	0.82	1.03	1.19	0.63	0.79	0.92
Riverstone	1.18	1.77	1.77	0.91	1.36	1.36
Royal Lake Estates	0.10	0.10	0.10	0.08	0.08	0.08
South Brazos	0.01	0.33	0.97	0.01	0.26	0.75
MUD 192	0.04	0.22	0.30	0.03	0.17	0.23
Texas Department of Transportation (TxDOT) Tract 2	0.20	0.53	0.86	0.15	0.41	0.66
TxDOT Tract 3	1.15	1.73	2.08	0.89	1.33	1.60
TxDOT Tract 4	1.64	2.01	2.01	1.26	1.54	1.54
TxDOT Tract 5	0.86	1.32	1.42	0.66	1.01	1.09
Total	**27.56**	**31.02**	**33.17**	**21.20**	**23.86**	**25.51**

The total potable water demand was also divided between nonrevenue water (NRW), indoor use, and outdoor use in **Table 4-2** for average weather and **Table 4-3** for dry weather. NRW is water that is produced but lost before reaching the customer. This can be from physical water loss via leaks or breaks or apparent losses due to metering inaccuracies. A 2015 water audit estimated NRW as 11 percent of the total use for the main Sugar Land system. Estimates from the recently annexed areas showed 17 percent NRW in Greatwood and 8 percent NRW in New Territory. The estimated percentage split between indoor and outdoor usage varies by planning area based on the land use and ranges between 34 percent to 50 percent indoor water usage during average weather. During dry weather, outdoor usage is assumed to increase while indoor usage is held constant, as indoor usage is assumed to be independent from the weather. Detail on the method used for these calculations is available in **Appendix C – Potable Demand Analysis Technical Memorandum**.

Table 4-2. Average Weather Indoor, Outdoor, and NRW Potable Demand per Planning Area (MGD)

Planning Area	2018			2025			2040		
	Indoor	Outdoor	NRW	Indoor	Outdoor	NRW	Indoor	Outdoor	NRW
City Main North	3.35	2.16	0.64	3.48	2.25	0.67	3.60	2.32	0.69
City Main South	3.14	2.11	0.61	3.18	2.14	0.62	3.26	2.19	0.64
Greatwood	0.74	0.81	0.31	0.74	0.81	0.31	0.74	0.81	0.31
New Territory	0.91	1.16	0.19	0.91	1.16	0.19	0.92	1.16	0.19
Plantation	0.23	0.17	0.05	0.23	0.17	0.05	0.23	0.17	0.05
River Park	0.34	0.22	0.07	0.44	0.27	0.08	0.51	0.31	0.10
Riverstone	0.49	0.33	0.09	0.73	0.49	0.14	0.73	0.49	0.14
Royal Lake Estates	0.04	0.03	0.01	0.04	0.03	0.01	0.04	0.03	0.01
South Brazos	0.003	0.002	0.001	0.15	0.08	0.03	0.42	0.25	0.08
MUD 192	0.02	0.01	0.004	0.09	0.06	0.02	0.12	0.09	0.02
TR2	0.09	0.05	0.02	0.23	0.13	0.04	0.37	0.21	0.07
TR3	0.51	0.29	0.09	0.75	0.44	0.14	0.90	0.53	0.17
TR4	0.68	0.45	0.13	0.84	0.54	0.16	0.84	0.54	0.16
TR5	0.38	0.21	0.07	0.59	0.32	0.11	0.63	0.35	0.11
Total	**10.92**	**8.00**	**2.29**	**12.40**	**8.89**	**2.57**	**13.31**	**9.45**	**2.74**

Table 4-3. Dry Weather Indoor/Outdoor/NRW Demand per Planning Area (MGD)

Planning Area	2018			2025			2040		
	Indoor	Outdoor	NRW	Indoor	Outdoor	NRW	Indoor	Outdoor	NRW
City Main North	3.35	3.81	0.84	3.48	3.97	0.87	3.60	4.10	0.90
City Main South	3.14	3.69	0.80	3.18	3.73	0.81	3.26	3.83	0.83
Greatwood	0.74	1.27	0.40	0.74	1.27	0.40	0.74	1.27	0.40
New Territory	0.91	1.78	0.24	0.91	1.78	0.24	0.92	1.79	0.25
Plantation	0.23	0.29	0.06	0.23	0.29	0.06	0.23	0.28	0.06
River Park	0.34	0.39	0.09	0.44	0.49	0.11	0.51	0.56	0.13
Riverstone	0.49	0.57	0.12	0.73	0.86	0.19	0.73	0.86	0.19
Royal Lake Estates	0.04	0.05	0.01	0.04	0.05	0.01	0.04	0.05	0.01
South Brazos	0.003	0.003	0.001	0.15	0.15	0.04	0.42	0.45	0.10
MUD 192	0.02	0.02	0.005	0.09	0.11	0.02	0.12	0.15	0.03
TR2	0.09	0.09	0.02	0.23	0.24	0.06	0.37	0.39	0.09
TR3	0.51	0.53	0.12	0.75	0.80	0.18	0.90	0.96	0.22
TR4	0.68	0.79	0.17	0.84	0.95	0.21	0.84	0.95	0.21
TR5	0.38	0.38	0.09	0.59	0.59	0.14	0.63	0.64	0.15
Total	**10.92**	**13.66**	**2.97**	**12.40**	**15.28**	**3.34**	**13.31**	**16.28**	**3.57**

4.2 Non-Potable Water Demands

Table 4-4 lists the non-potable demands used in the IWRP for GRP participants and other water customers (e.g., Venetian Estates POA and Riverstone) along with the water sources utilized to meet the demand and the typical water use. While the non-potable demands can vary year to year, the values used represent conservative assumptions based on the participants' projected demands and average water usage from 2009 to 2017 with a focus on the last three years. GRP participant demands are assumed to increase by 65 percent under dry weather conditions which is consistent with the projected increase in potable outdoor demands between average and dry weather conditions. **Appendix F – Reclaimed Study Final Report** provides additional details on these demands.

Table 4-4. Non-Potable Average Weather GRP Participant and Other Customer Demands

GRP Participants	Annual Average Weather Demand (MGY)*	Water Source	Water Usage
Avalon Community Association	15	Private Well	Lake Fill and Irrigation
City of Sugar Land – Parks	10	Private Well	Lake Fill and Irrigation
First Colony Community Association – Lakepointe	25	Raw Surface Water	Lake Fill and Irrigation
First Colony Community Association	40	Private Well	Lake Fill and Irrigation
First Colony Property Association	10	Private Well	Lake Fill and Irrigation
Fort Bend County LID 17 Backup Well	3	Private Well	Lake Fill and Irrigation
Fort Bend County LID 17 / Telfair	250	Raw Surface Water	Lake Fill and Irrigation
Fort Bend MUD 192	10	Private Well	Lake Fill and Irrigation
New Territory Residential Community Association	25	Reclaimed	Lake Fill and Irrigation
River Park HOA	15	Private Well	Lake Fill and Irrigation
River Pointe Golf Course	5	Private Well	Golf Course Irrigation
Riverstone	135	Reclaimed	Lake Fill and Irrigation
Royal Lakes Estates HOA	20	Private Well	Lake Fill and Irrigation
Schlumberger	2	Private Well	Lake Fill and Irrigation
Sugar Lakes HOA	25	Raw Surface Water	Lake Fill and Irrigation
Sugar Land Business Park	2	Private Well	Lake Fill and Irrigation
Sugar Mill CAI	15	Private Well	Lake Fill and Irrigation
Sweetwater Golf	75	Private Well	Golf Course Irrigation
Texas Par Golf Academy	20	Private Well	Golf Course Irrigation
Venetian Estates POA	50	Raw Surface Water	Lake Fill and Irrigation
Total	**727 (2.0 MGD)**		

MGY – million gallons per year

*These values are meant to represent assumed average weather demands and not the maximum allowable contract volumes.

Besides the non-potable demand from GRP participants, there is also additional reclaimed water use for plant washdown at the City WWTPs. The amount of washdown water was estimated per plant and is provided in **Table 4-5** based on recent usage.

Table 4-5. WWTP Reclaimed Usage for Plant Washdown

Wastewater Treatment Plant	Assumed Plant Washdown (MGD)
North WWTP	0.140
South WWTP	0.280
West WWTP	0.049
Greatwood WWTP	0.027
Tara Plantation WWTP (ETJ)	0.000
Total	**0.496**

4.3 Seasonal Analysis

The projected annual water demands are converted into monthly demands using seasonal peaking factors developed from historical data. The seasonal demand patterns for potable water, non-potable lake fill and irrigation, and non-potable golf course irrigation are shown in **Figure 4-2**. Potable demands show a gradual pattern of rising through the spring and early summer, peaking in August, and then gradually decreasing through the fall and winter to a low point in February. The seasonal pattern for golf course irrigation shows little usage December through March; some usage in the spring and early summer; and a steep increase in water use for July, August, and October. The lake fill and irrigation seasonal pattern is similar to the golf course pattern but not as dramatic, with more water use during the winter months.

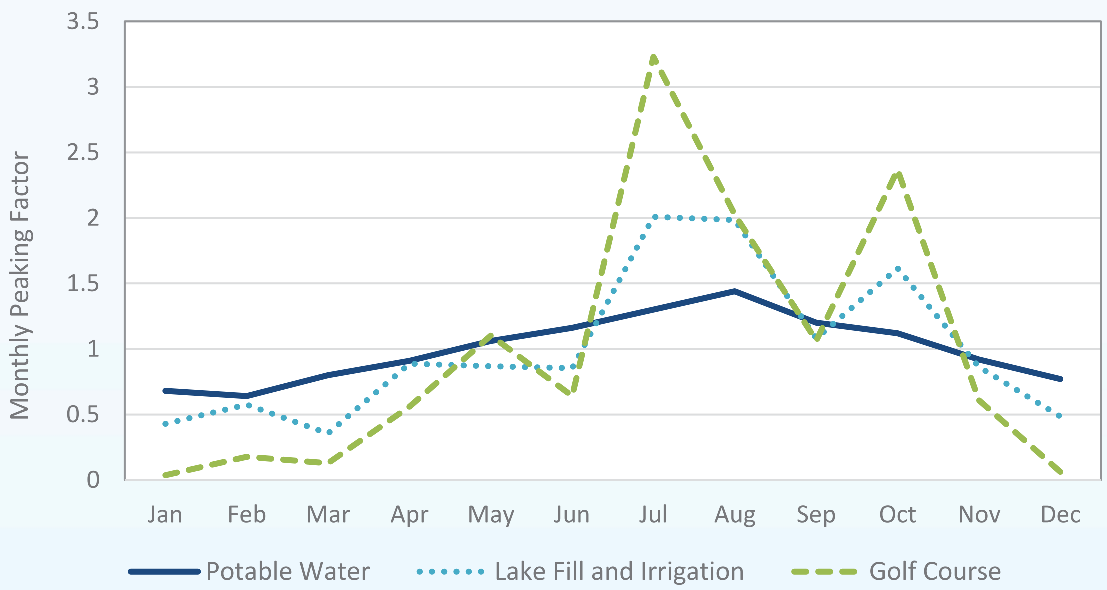

Figure 4-2. Seasonal Demand Patterns

4.4 Water Demand Summary

Figure 4-3 and **Figure 4-4** show a summary of the total water demand for average weather and dry weather conditions compared to historical deliveries for all GRP participants. The figures split the projected demand into indoor potable, outdoor potable, NRW, raw surface water, GRP wells, and reclaimed water. Figure 4-3 also shows that the 2018 projected demands under average weather are comparable to deliveries seen in recent years while Figure 4-4 shows the 2018 projected demand under dry weather is similar to deliveries seen in the most recent drought year of 2011.

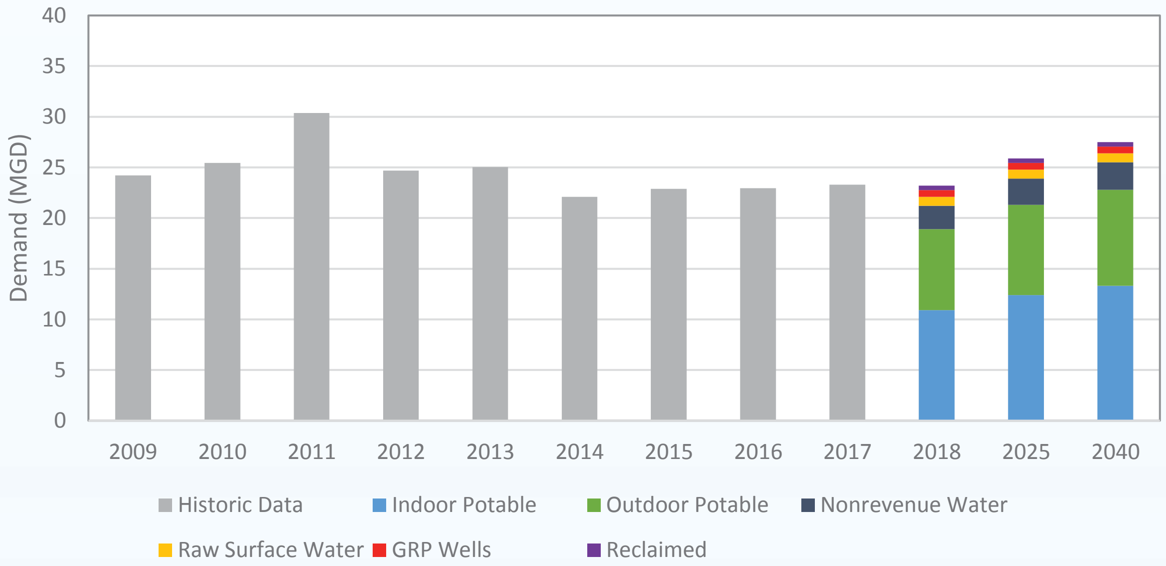

Figure 4-3. Total Water Demand Projections under Average Weather Conditions Compared to Historic Data

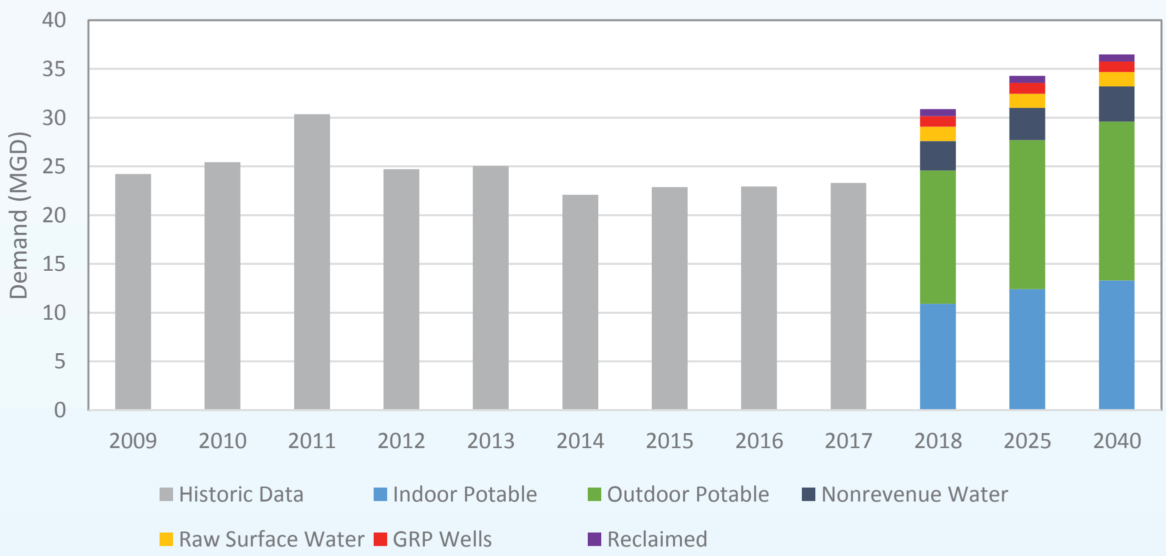

Figure 4-4. Total Water Demand Projections under Dry Weather Conditions Compared to Historic Data

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SECTION 5 | DECISION SUPPORT MODEL

An important aspect of the IWRP is the ability to analyze the current system and future options in an integrated, interconnected manner. While numerous models and tools can be used for evaluation, the decision support model developed has the following advantages:

- Customizable, allowing for all the most pertinent systems or parts of systems to be accounted for;
- Ability to simulate demands, supplies, major system constraints, as well as aggregate costs, and other metrics in a comprehensive manner;
- Highly visual, with built-in graphics and performance indicators; and
- Quick run time, allowing on-the-fly analysis and exploration.

5.1 Software

The DSM was developed in STELLA software (Systems Thinking Experimental Learning Laboratory with Animation, created by isee systems, inc.). STELLA is a graphical system simulation package that allows users to model physical flow systems with operational- or planning-level resolution. The software allows users to develop on-screen control interfaces that facilitate rapid adjustments of system variables for alternatives and sensitivity analyses. Dozens of alternatives are feasible (e.g., alternate water sources, use and reuse guidelines, operational triggers); STELLA can rapidly help city planners and decision makers screen information, identify key drivers, and understand the causal relationships throughout the big picture of a complex system.

Fundamentally, the DSM was designed to screen options and alternatives, providing numeric scores for performance measures identified as quantitative. In this context, STELLA does not make decisions, but it can be used to generate information and promote more informed and balanced decisions via rapid comparison of the performance of alternatives using physical, environmental, and economic metrics. Its ability to include multi-sectoral interests in an analytical framework is what distinguishes it from more traditional hydraulic or hydrologic models, which evaluate systems in a purely physical setting. STELLA models do not simulate finely discretized river basins, groundwater aquifers, channels, or pipes but include key system elements and their interdependencies in a lower-resolution network framework in which physical, environmental, and economic response patterns can be effectively examined. The model results are used to judge the influence of projects and policies on IWRP performance metrics. Fast model run times allow for small, or incremental, changes to be made to arrive at solutions that achieve important objectives without compromising other needs.

The DSM was developed to be operated through user-friendly interface management panels. From these panels, all options can be turned on or off to build the portfolios for investigation. The management panels also easily allow changes and updates to any of the project data or assumptions included in the model structure.

5.2 Existing System Model Development

The DSM runs on a monthly calculation time step, projecting demand from 2018 to 2040. All the key infrastructure for the existing water, wastewater, and reclaimed water systems have been included in the DSM to evaluate impacts on the system. A conceptual schematic of the interconnected elements considered in the model is shown in **Figure 5-1**. This section describes the key components and assumptions in the DSM. Additional detail can be found in **Appendix B – Decision Support Model Documentation**.

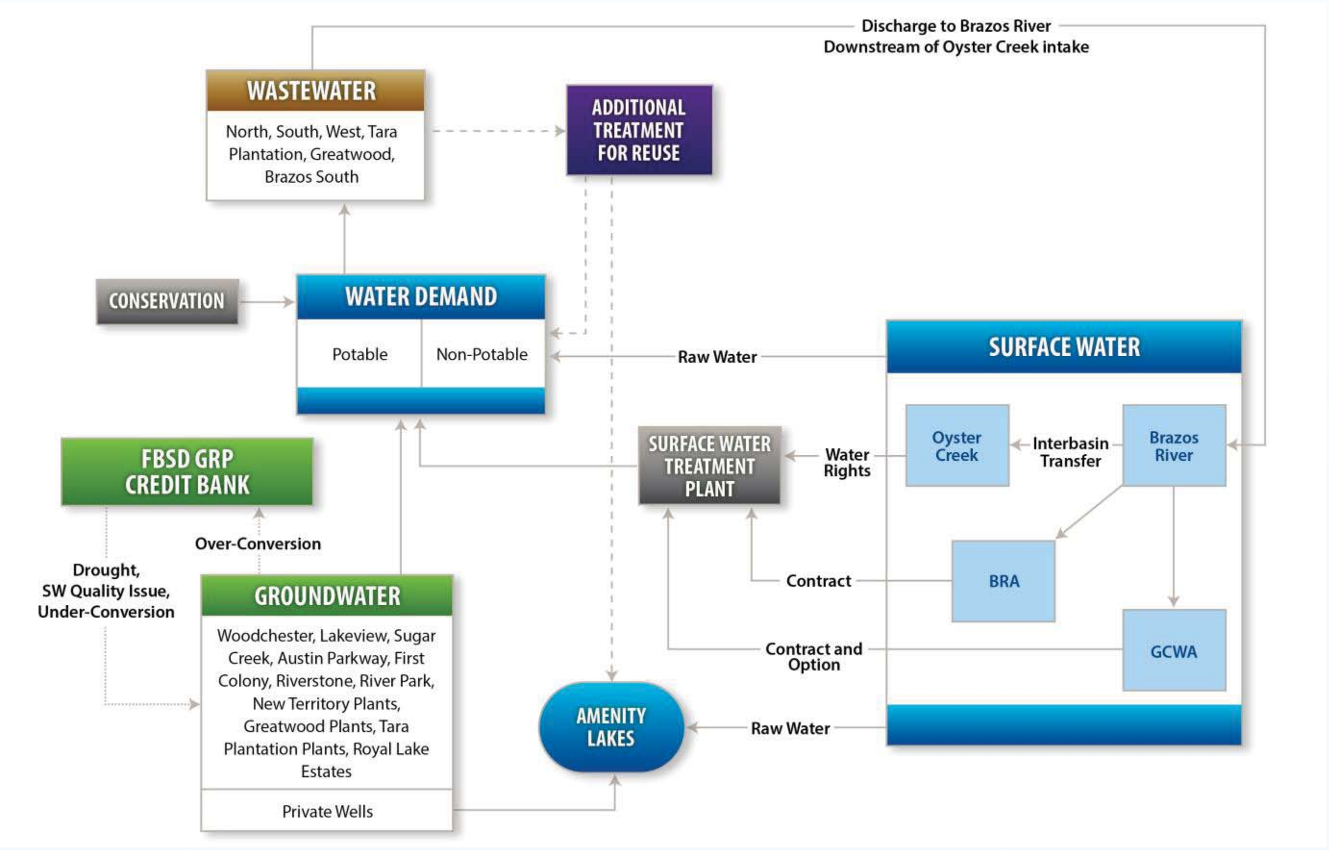

Figure 5-1. Conceptual System Schematic

5.2.1 Capacity Constraints

The DSM aims to meet the projected demands while staying within the designated system capacity constraints. This section provides an overview of key capacity constraints within the model for the water plants, raw water supplies, wastewater plants, and reclaimed water supplies.

5.2.1.1 SURFACE WATER TREATMENT PLANT

The SWTP is currently rated for 10.85 MGD, but average production is typically 9 MGD, which was assumed as the baseline in the model. Of this 9 MGD, it is assumed that 5.5 MGD is sent through the First Colony pump station, 1.5 MGD is sent through the Lakeview pump station, and 2 MGD is sent through the Riverstone pump station and into the City Main distribution system. With surface water transmission lines to these three pump stations, it is assumed that surface water can serve up to a maximum of 70 percent of the total demand within the City Main distribution system. The DSM calculates losses at the treatment plant of 8.5 percent per the 2012 water master plan; thus, 9.8 MGD of raw water is required to produce the 9 MGD of treated water at the plant.

5.2.1.2 GROUNDWATER PLANTS

The groundwater production capacity and firm pump capacity of each groundwater plant, as documented in **Section 3**, is included in the model. When considering how much demand can be met by each plant, the DSM compares the well production capacity and the firm pump capacity and uses whichever value is lower. At groundwater plants where SWTP water is blended before being pumped into the distribution system, the pump capacity remaining for groundwater is taken as the firm pump capacity of the plant minus the delivered surface water. This reduced pump capacity is then compared to the well production capacity to determine which is more limiting in providing supply from the groundwater plant.

For non-city-owned plants in the ETJ area, if capacity data are not available, it is assumed in the DSM that there is sufficient groundwater production capacity and firm pump capacity to meet current and future demands.

5.2.1.3 SURFACE WATER SUPPLIES

The following surface water contracts and rights are included in the existing system model as raw water supply sources:

- Oyster Creek water right
- GCWA contract
- GCWA contract option
- BRA contract

Although the City has a contract with BRA, there is currently no City-owned infrastructure available to physically deliver the water; therefore, the amount is not considered available under existing system model runs.

During a model run, there are two types of droughts that were considered for this project. The first represents a long-term 5-year drought, and the second represents a shorter-term (4 month) extreme and intense summer drought. These two droughts can be simulated individually or combined to produce a longer-term drought with a short, intense drought in a single summer. During either drought, the outdoor demands are increased by 65 percent, and the availability of surface water is decreased. The reliability assumed for each surface water supply under the different drought conditions is provided in **Table 5-1**.

Table 5-1. Surface Water Contracts and Rights with Assumed Drought Conditions

Surface Water Contract or Rights	Total Value	5-yr Drought Available Volume After Curtailment	Extreme Summer Drought Assumed Curtailment [d]
Oyster Creek Water Right (AFY)	18,159	3,660[a]	0
Oyster Creek Max Withdrawals (MGD)	46	3.27[a]	0
GCWA Contract (MGD)	10	8 (80%)[b]	40% of what is currently under contract
GCWA Option (MGD)	10	8 (80%)[b]	Additional option water not currently under contract assumed unavailable
BRA Contract (AFY)*	6,388	4,471 (70%)[c]	2,236 (35%)

*BRA Contract water is not able to be delivered without construction of a pump station or pumping agreement with GCWA.

[a] Firm yield with consideration of modified impoundment volume from the 2017 City of Sugar Land Surface Water and Groundwater Evaluation.

[b] The 2016 GCWA Drought Contingency Plan set a goal for 20% reduction in water use under Stage 3 Response conditions.

[c] The 2012 BRA Drought Contingency Plan requires a minimum 30% pro-rata curtailment upon Stage 4 Drought conditions.

[d] The assumption was made under the extreme short-term drought that GCWA and BRA supplies would be curtailed by an additional 50% while Oyster Creek Water would be unavailable.

5.2.1.4 WASTEWATER PLANTS

Under the existing system model conditions, all WWTPs are set at their current capacities. If flow to the North WWTP exceeds the 6 MGD capacity, up to 0.75 MGD is diverted to the South WWTP through the current North WWTP to South WWTP interconnection. Under existing conditions, the North WWTP reaches its current permitted capacity in the model in 2031, thus diversion to the South WWTP is necessary. In 2031, the diversion is 0.02 MGD which increases to 0.3 MGD by the end of the simulation (in 2040).

5.2.1.5 RECLAIMED WATER SUPPLIES

For the existing system, the model represents the current reclaimed water capabilities, including up to 2 MGD of capacity to provide reclaimed water from the South WWTP to the Riverstone planning area and 2 MGD of capacity to provide reclaimed water from the West WWTP to the New Territory planning area.

As noted in **Section 3.3.1**, the City provides effluent from the West WWTP to Fort Bend County LID 7, which produces reclaimed water at their treatment facility. Fort Bend County LID 7 then provides the reclaimed water to the New Territory Residential Community Association for their use. For the purposes of the IWRP analysis, this is simplified in the model as reclaimed water from the West WWTP directly serving demands.

Besides the capacity of the reclaimed water systems, the model also constrains the water available for reclaimed deliveries by the available flow through the treatment plants.

5.2.2 Modeled Demands

This section provides an overview of the demands included in the model. The model tracks both potable and non-potable demands, converting annual demands to monthly values based on seasonal patterns.

5.2.2.1 POTABLE DEMANDS

The annual potable demands outlined in **Section 4.1** are input into the model per planning area and split between indoor demand, outdoor demand, and NRW. Demands are entered for 2018, 2025, and 2040. The model uses straight line interpolation for the demands in intermediate years. The average weather demands that are input into the model, and these are increased to produce the dry weather demands during a simulated drought.

5.2.2.2 NON-POTABLE DEMANDS

The non-potable demands outlined in **Section 4.2** are also included in the model. There is an interface screen where the average weather water demands per GRP participant and the water source and demand pattern are input. The model then increases the outdoor non-potable demands during a simulated drought.

5.2.2.3 PEAKING FACTORS

The potable and non-potable demands are entered into the model as annual averages. The model then uses the seasonal peaking factors described in **Section 4.3** to convert the annual demands into monthly demands.

The model runs on a monthly time step; however, peak daily demands are more critical for some capacity considerations. Based on measured data for 2011 to 2017, August was established to be the peak demand month. A maximum day peaking factor was calculated by comparing the historical average August daily water usage to the maximum August daily water usage for each year as shown in **Table 5-2**. This was based on combined groundwater and surface water deliveries to the main city center area. Observations from the data include:

- The drought year of 2011 shows the highest average flows, but flows stayed consistently high throughout the month leading to a lower peaking factor.
- The highest maximum daily flow of 36.7 MGD occurred in 2015 giving a 1.54 peaking factor.
- The highest peaking factor of 1.81 occurred in 2017. Average flows were relatively low, and there was one single high day that dramatically increased the peaking factor. If this single high day is considered an outlier, the next highest day in that month had a peaking factor of 1.42.

Overall, a maximum day August peak of 1.55 was selected to utilize in the model for daily peak flow checks to be conservative compared to the historical data.

Table 5-2. Analysis of August Daily Peaking

Year	Average Daily August Flow (MGD)	Maximum Daily August Flow (MGD)	Maximum Day Peaking Factor
2011	28.9	31.6	1.09
2012	21.4	26.1	1.22
2013	23.4	29.9	1.28
2014	19.9	24.6	1.24
2015	23.9	36.7	1.54
2016	19.1	29.1	1.52
2017	18.0	32.5	1.81[a]

[a] Average flows were relatively low for the month of August 2017, and there was one single high flow day that dramatically increased the peaking factor for the month. If this single high day is considered an outlier, the next highest day in that month had a peaking factor of 1.42.

5.2.3 Regulatory Compliance Tracking

The FBSD has mandated that total water demand for permittees in Area A must be supplied by 30 percent non-groundwater sources by 2014 and 60 percent non-groundwater sources by 2025. If these regulations are not met, the FBSD has a financial penalty that was set at $6.50 per 1,000 gallons in 2018. GRP participants and well owners in FBSD regulatory areas who use more alternative water supply than required (i.e., those who exceed the regulatory requirements) may request over-conversion credits for the amount of alternative water supply utilized in excess of the FBSD regulatory plan's requirement (over-conversion). Over-conversion credits for gallons of additional alternative water supply are issued by the FBSD in the form of certificates. Because the City, through its GRP, is currently exceeding the conversion requirements, over-conversion credits are being earned that are held by the City on behalf of all GRP participants. These credits do not expire and can be redeemed to meet alternative water requirements in years when alternative water use falls short of regulatory requirements (under-conversion). Use of reclaimed water is incentivized by the ability to earn 1.5 credits for every gallon utilized; whereas, other alternative water supplies only earn credits on a 1:1 basis.

The model starts the simulation with a baseline of 6.3 billion gallons of over-conversion credits that were previously accumulated through 2017 as a result of the City surpassing the current 30 percent conversion target. The model also includes 1.4 billion gallons of credits from supporting educational conservation programs. Moving forward, the achieved percent conversion to non-groundwater sources is calculated annually in the model, with an April to April time frame to match the City's compliance reporting with FBSD. The annual percent conversion is then compared to the regulatory target. If the City surpasses the regulatory target through over-conversion, the model adds credits to the City's credit bank. If the annual percent conversion is lower than the regulatory target, the model removes credits from the credit bank and redeems them to meet the regulatory requirements. If the credit bank runs out of credits, the model tracks out-of-compliance deliveries and incurs the $6.50 per 1,000 gallons disincentive fee in the financial calculations.

5.2.4 Financial Calculations

Baseline operating costs for the key water and wastewater infrastructure are included in the model. Operating costs are divided into annual fixed costs, which occur each year, and variable costs (such as energy and chemicals), which depend on the amount of flow through the facilities. **Table 5-3** summarizes operating cost assumptions utilized in the model for the different treatment plants. As the model simulation moves into the future, costs are escalated at a 3 percent annual rate.

Table 5-3. Baseline Operating Costs for Key Water and Wastewater Infrastructure (in 2018 $$)

Infrastructure Type	Annual Fixed Cost ($M)	Variable Cost ($/1,000 gallons)	Variable Cost at 2018 Flows ($M)	Total 2018 Modeled Plant Operation and Maintenance ($M)
Surface Water Treatment Plant	$10.9	$0.79	$2.5	$13.4
Groundwater Plants	$18.7	$0.31	$1.3	$20.0
Wastewater Plants	$16.1	$0.41	$1.6	$17.7
			Total	**$51.1**

The cost for the raw water contracts is also tracked in the model at the rates provided in **Table 5-4**. The annual escalation rate for the contracts is based on extending out near-term planned rate increases.

Table 5-4. Model Cost Assumptions for Contract Water

Contract	Starting Cost	2018 Total	Annual Escalation[a]
GCWA Contract Water	$221.22/MG	$808,000	6%
GCWA Option Water	$44.24/MG	$161,000	6%
BRA Contract	$74/AF	$473,000	3%
Total	-	**$1,442,000**	-

AF – acre-feet, MG – million gallons

[a] Escalation rates are based on near-term planned rate increases

5.3 Model Validation

Because the DSM looks out into the future, it is difficult to calibrate in the classical sense by comparing to historical data. However, a comparison of model output to expected values was conducted, providing validation that the model produces reasonable results.

5.3.1 Potable Water Demands

The projected annual water demands for average weather conditions are an input into the model. These are then converted into monthly demands using seasonal peaking factors. Dry weather conditions are represented in the model by multiplying outdoor water demands by a demand factor of 1.65. **Figure 5-2** shows the modeled 2018 water demands compared to historical production data for average years within the city center distribution system. This includes the planning areas City Main North, City Main South, Riverstone, and all the TxDOT tracts. **Figure 5-3** compares the model versus the production data for the same area under dry conditions as represented by the 2011 drought. The figures show that the model is able to produce demands which align with historic data for the planning area.

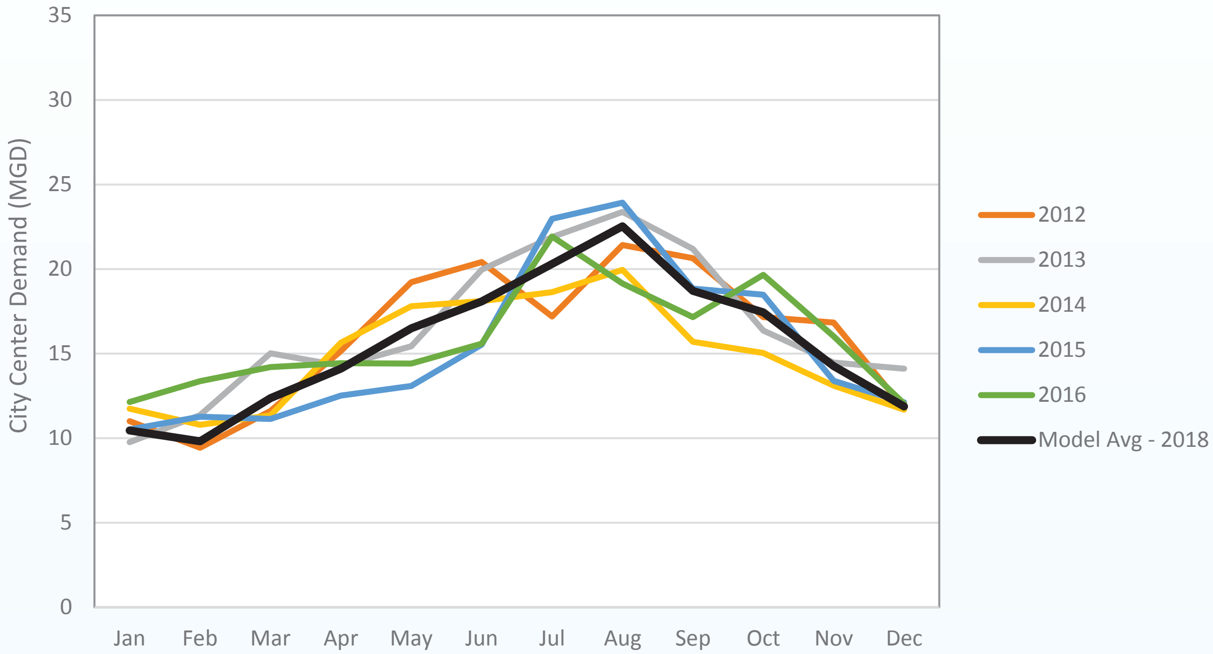

Figure 5-2. Modeled City Center Average Weather Demand Compared to Historical Data

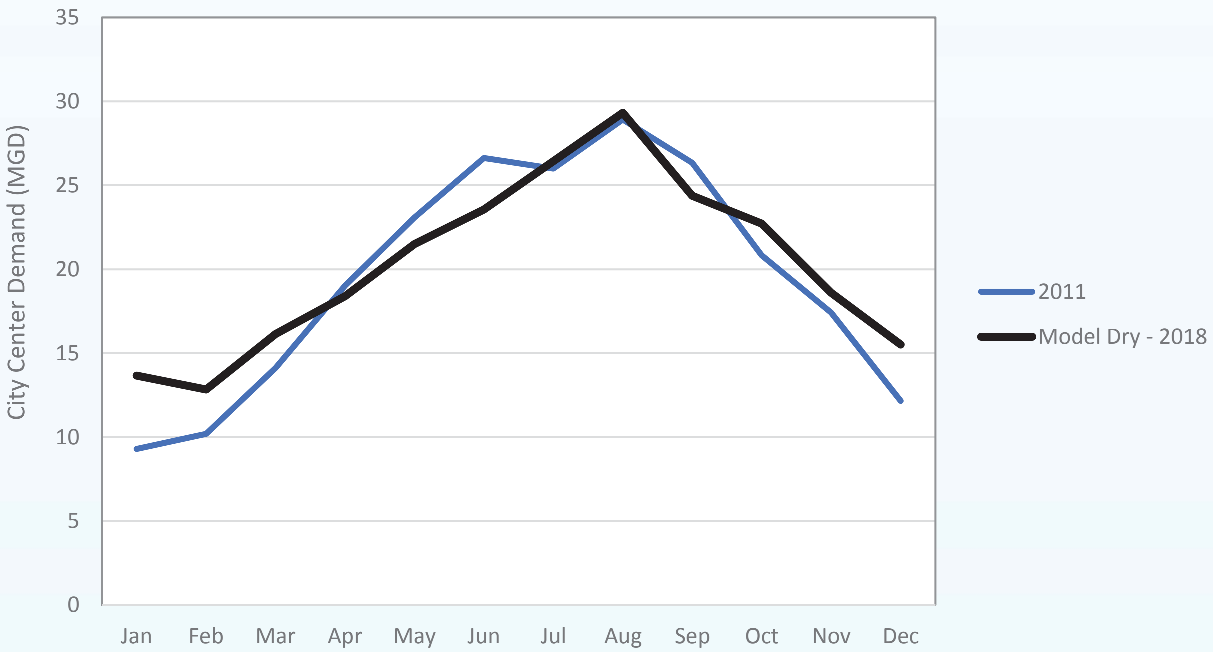

Figure 5-3. Modeled City Center Dry Weather Demand Compared to Historical Data

5.3.2 Wastewater Treatment Plant Flows

Indoor potable water demand from the planning areas is routed to the WWTPs in the model. An additional flow percentage representing inflow and infiltration is then added and validated against the measured average flow to each plant (December 2016 through November 2017), with data influenced by Hurricane Harvey (September 2017) removed from the average. **Table 5-5** shows the final validated values for each WWTP. The Plantation WWTP is included in the model but is not operated by the City; thus, data for calibration were not available. The table shows that the model produces wastewater flows which are representative of measured historic flows.

Table 5-5. Wastewater Treatment Plant Model Validation

Metric	North WWTP	South WWTP	West WWTP	Greatwood WWTP	Tara Plantation WWTP**
Contributing Planning Areas	City Main North, TxDOT Tract 2, TxDOT Tract 3, TxDOT Tract 4	City Main South, TxDOT Tract 5, Riverstone	New Territory, River Park	Greatwood, MUD 192	Tara Plantation
Projected 2018 Indoor Demand (MGD)	4.62	4.01	1.25	0.76	0.23
Assumed Infiltration Percent	10%	15%	10%	20%	15%
Modeled 2018 Wastewater Inflow (MGD)	5.08	4.61	1.38	0.91	0.26
Measured Average 2017 Wastewater Inflow (MGD)	4.91	4.73*	1.36	1.00	-
Modeled Percentage	103%	97%	101%	91%	-

*The South WWTP does not monitor influent flows; rather, they only measure effluent. Inflow was calculated assuming a 10% loss during treatment.

**The Tara Plantation WWTP is not operated by the City, and measured wastewater flows were not available.

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SECTION 6| NEEDS ASSESSMENT

A needs assessment was performed to characterize the limitations and potential opportunities for serving the City's existing and future water demands. This analysis considers the amount of additional non-groundwater sources required to meet FBSD regulatory targets as well as any potential water supply shortages in meeting future demands.

The existing system DSM was used to conduct the needs assessment. When the existing infrastructure falls short, the unmet need is then identified as the "gap" or a "need." The type and volume of the needs are then utilized in the development of supply options and portfolios to ensure continued compliance with FBSD regulations and service provision.

This section first looks at the potential volume of out-of-compliance water deliveries in **Section 6.1**, which could result in a financial penalty to the City for not achieving regulatory targets under both average weather and dry weather conditions. In **Section 6.2**, the capacity constraints in delivering future water demands and treating future wastewater flows are explored.

6.1 Out-of-Compliance Water Deliveries

Out-of-compliance water deliveries were assessed by evaluating the baseline compliance with the FBSD requirement to obtain 30 percent then 60 percent of the City's water demand from alternative (i.e., non-groundwater) sources.

Using the DSM, the baseline conditions were evaluated using the existing system model. The City is already complying with the 30 percent target, averaging around 45 percent use of alternative sources. Although the City has a selection of options that can be used to achieve the 60 percent target, the needs assessment assumed that no additional projects take place. Thus, once the 60 percent target takes effect, current existing alternative water supplies are utilized along with banked over-conversion credits. Groundwater will need to be utilized to meet any demands in excess of the current alternative water supplies. Groundwater use above the 40 percent allowable by FBSD is tracked as out-of-compliance incurring financial disincentive fees once the credits are exhausted.

Figure 6-1 shows the needs assessment under average year conditions. The graph provides the calculated percentage of total water demand met by alternative water supply (gray dotted line) and the required alternative water supply percentage (black line). In addition, the figure shows the bank of over-conversion credits accumulating and then declining (blue bar chart), followed by tracking out-of-compliance deliveries (gold bar chart).

Under these conditions, the City continues to earn over-conversion credits until the 60 percent requirement goes into effect. With the assumption of no new projects to help meet this requirement, the banked over-conversion credits are utilized to make up the difference for an estimated period of nine years under average weather and demand conditions. At this point, the out-of-compliance deliveries begin building to a total of 11,300 MG by the end of the simulation. The maximum out-of-compliance deliveries in one year is 1,900 MG, which equates to needing about 5.3 MGD of additional non-groundwater sources. Without additional alternative water sources, the City would end up paying as much as $70 million over the simulation in disincentives fees under average weather conditions.

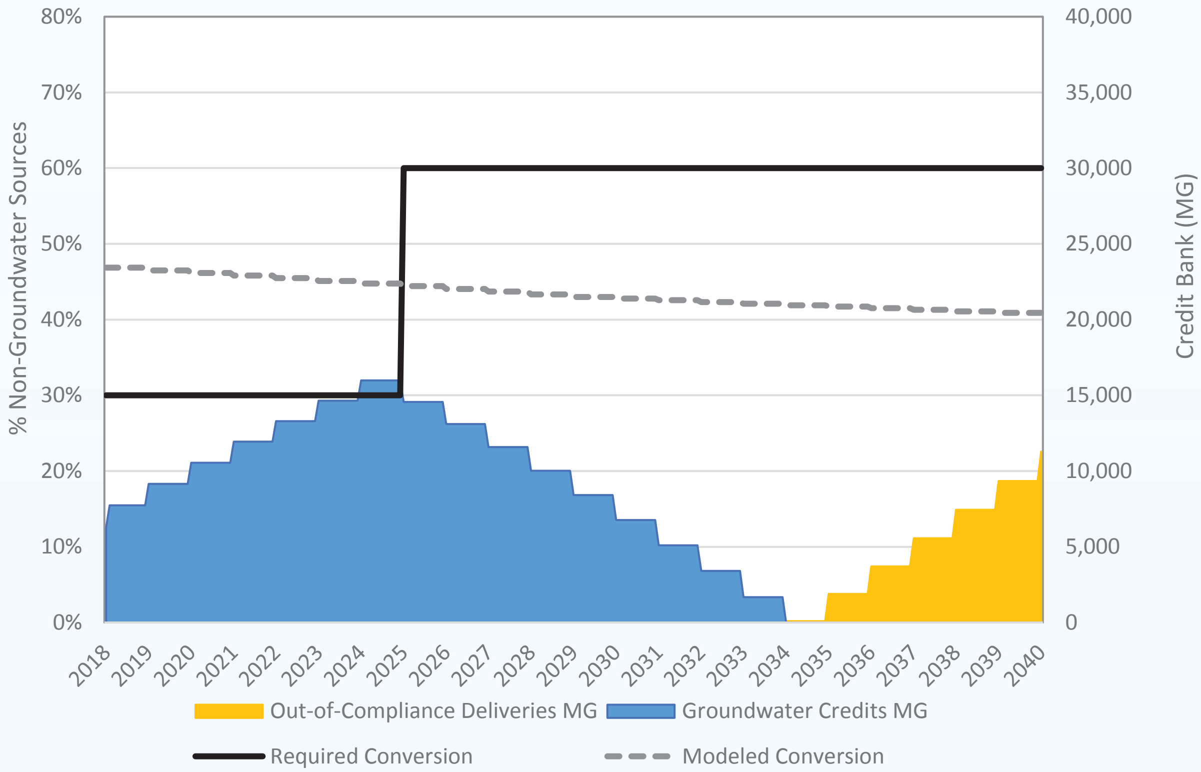

Figure 6-1. Average Year Conditions Needs Assessment: Comparison of Delivered Water to Required GRP Targets

Running a similar analysis under dry weather conditions gives the results presented in **Figure 6-2**. Under these conditions, fewer over-conversion credits can be banked because higher demands reduce the percentage of alternative supplies making up the total water demand. In addition, the over-conversion credits only last an estimated four years following enactment of the 60 percent requirement. Total out-of-compliance deliveries reach 37,400 MG, with the maximum year equating to the need for 9.5 MGD of additional non-groundwater sources. Disincentive fees could reach as high as $230 million over the simulation under dry weather conditions.

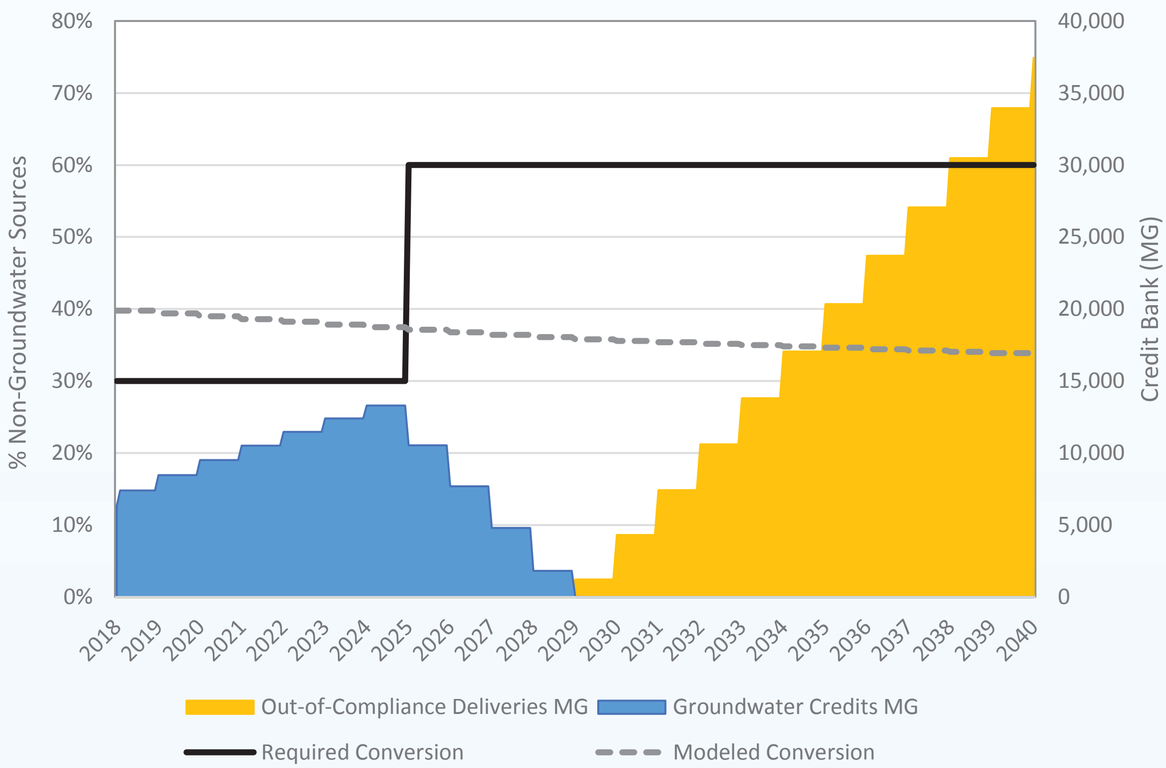

Figure 6-2. Dry Year Conditions Needs Assessment: Comparison of Delivered Water to Required GRP Targets

6.2 Infrastructure Needs Assessment

The DSM is programmed to meet the projected demands while staying within the City's existing infrastructure constraints. To determine any future infrastructure gaps in meeting demands, the existing system DSM was run with increased future demands so that future infrastructure needs can be identified. Water production capacity is analyzed first as compared to demand for the various service areas in **Section 6.2.1**. Next, the ability of current surface water contracts to serve the SWTP under normal and drought conditions is explored in **Section 6.2.2**, followed by an analysis of the current permit capacity of the WWTPs to treat future projected wastewater flows in **Section 6.2.3**.

6.2.1 Total Production Capacity

The water production capacity needs assessment was conducted by comparing the 2040 water demands to the current water production capacity. Based on that evaluation, the City is projected to be able to meet future demands with the existing infrastructure. The only area where demands are projected to approach but not exceed the production capacity is in the city center during dry weather peak days as shown in **Figure 6-3**. In this figure, the modeled 2040 annual demand, peak monthly demand, and peak daily demand are shown by the colored bars for each planning area, and the production capacity of a planning area is shown as the black line.

While the existing infrastructure is sufficient to deliver the projected future water demands, there is not enough alternative (non-groundwater) supply to meet the regulatory requirements established by FBSD as discussed in the previous section.

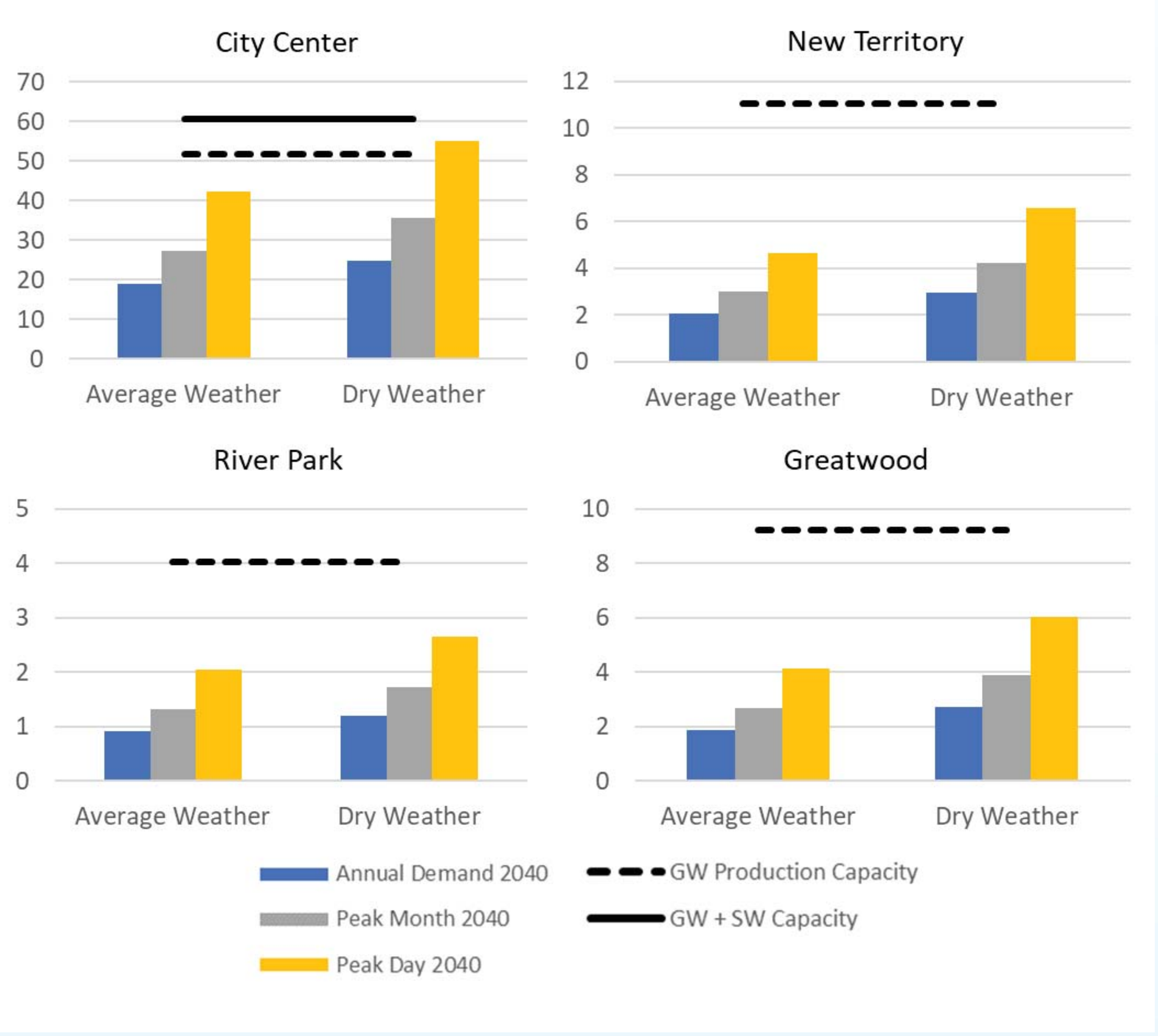

Figure 6-3. Planning Area Total Production Capacity Compared to 2040 Demands

6.2.2 Surface Water Contract Needs

During the baseline model run, the DSM utilizes GCWA contract water to serve the surface water treatment plant; Oyster Creek water rights are used for non-potable raw water needs and any additional needs for the surface water plant beyond the GCWA contract. BRA contract water is not available during the baseline model run since there is no current City-owned infrastructure to access the water or agreement with a third party (such as GCWA) to pump the water to Oyster Creek.

Table 6-1 shows the percentage of the surface water contracts and water rights utilized under different demand and drought conditions. Under average conditions, there is sufficient surface water supply to serve the needs of the SWTP at its current capacity. Under dry weather conditions, when the reliability of some of the surface water supplies are assumed to be limited based on drought contingency plans, there is adequate supply to meet the needs of the plant as currently sized and non-potable raw water needs. If the plant is expanded in the future, the additional supplies of the BRA contract or GCWA option water would need to be utilized to serve the plant.

Table 6-1. Surface Water Contract Utilization under Baseline (Current) Conditions

Contract Utilization	Average Weather		Drought Conditions[a]	
	(MGD)	(AFY)	(MGD)	(AFY)
GCWA Contract Available	10	11,201	8	8,961
Max GCWA Contract Utilized	9.8	10,978	8	8,961
Percent Utilization	98%		100%	
Oyster Creek Water Rights Available	16.2	18,159	3.3	3,660
Oyster Creek Water Rights Utilized	0.9	998	2.9	3,288
Percent Utilization	5.5%		90%	
GCWA Option Available	10	11,201	8	8,961
GCWA Option Utilized	0	0	0	0
Percent Utilization	0%		0%	
BRA Contract Available [b]	5.7	6,388	5.7	6,388
BRA Contract Utilized	0	0	0	0
Percent Utilization	0%		0%	

[a] See Table 5-1 for additional information on drought assumptions.

[b] BRA Contract water is not currently available to utilize due to lack of City-owned infrastructure or pumping agreements to access the water

6.2.3 Wastewater Treatment Plant Capacity

Wastewater is produced in the DSM based on the indoor water demands plus an additional factor to represent groundwater infiltration which enters the wastewater collection system as flow travels to the WWTP. Additional inflow and infiltration which occurs during wet weather events are not captured in the model; thus, the capacity comparison is for average annual flows and not peak wet weather events. The baseline model used for the infrastructure needs assessment assumed the WWTPs remain at their current permitted capacity. This capacity and the projected flows in the model for 2040 are provided in **Table 6-2**.

The permitted treatment capacity at the North WWTP is projected to be exceeded by 2040. Excess flow from the North WWTP can currently be bypassed to the South WWTP to stay within permitted limits. In addition, the City is considering additional interconnections between the North WWTP and West WWTP to transfer North WWTP flows prior to reaching capacity. Additionally, the City is considering expanding the capacity of the West WWTP first to 4.5 MGD and then to 10 MGD as per the 2012 Wastewater Master Plan.

Table 6-2. Average Annual Utilization by WWTP

WWTP	Permitted Capacity (MGD)	Projected 2040 WWTP Flow (MGD)	Projected WWTP Flow in 2040 as Percent of Permitted WWTP Capacity
North WWTP	6.0	6.29	105%
South WWTP	7.5	5.31	71%
West WWTP	2.2	1.57	71%
Greatwood WWTP	1.35	1.03	76%

SECTION 7 | FUTURE WATER SUPPLY OPTIONS

In support of the IWRP, future water supply options were evaluated to help the City meet their long-term water supply needs. Fifteen future water supply options were defined through a collaborative process with city staff and various stakeholders. Of these options, three were focused on demand management, four on reclaimed water, four on infrastructure and storage, three on alternative water supplies and one on groundwater credit banking. The future water supply options are summarized in **Table 7-1** and discussed in more detail in the following section.

Table 7-1. Future Water Supply Options

Option Type	Option Name	2040 Yield (MGD)
Demand Management	Advanced Metering Infrastructure	0.94
	Water Loss Control	0.24
	Conservation – Basic (Rebates)	0.86
	Conservation – Advanced (Ordinances)	2.19
Reclaimed Water	Expanded Reclaimed Water System (North System)	1.10
	Expanded Reclaimed Water System (South System)	0.40
	Direct Potable Reuse	1.80[b]
	Collection System Wastewater Scalping (West Airport)	0.17
	Collection System Wastewater Scalping (Harmon LS)	0.17
	On-site Reuse	0.04
Infrastructure and Storage	Surface Water Treatment Plant Expansion (5.5 MGD)	5.50
	Surface Water Treatment Plant Expansion (11 MGD)	11.00
	Access to Brazos River Water w/ Pump Station (to Oyster Creek)	5.70[b]
	Access to Brazos River Water w/ Pump Station (to Reservoir)	5.70[b]
	Access to Brazos River Water w/ Agreement to Pump BRA Water through GCWA	5.70[b]
	Aquifer Storage and Recovery (Airport)	6.60[a]
	Aquifer Storage and Recovery (Retrofit)	6.60[a]
	Aquifer Storage and Recovery (SWTP)	6.60[a]
	Off-channel Reservoir	6.00[ab]
Alternative Water Supplies	Seawater Desalination (New Pipeline)	5.00
	Seawater Desalination (BWA Northern Line)	5.00
	Brackish Groundwater Desalination (2 MGD)	2.00
	Brackish Groundwater Desalination (4 MGD)	4.00
	Expanded Water Supply Contracts	3.57[b]
Groundwater Credit Banking	Groundwater Credit Banking	Not Applicable

[a] Yield for storage options is the maximum flow available to be withdrawn from storage when needed.

[b] These options are treated at the SWTP; the listed 2040 yield should not be counted in addition to the SWTP yield.

7.1 Future Water Supply Option Descriptions

This section provides more detail for each of the possible future water supply options that were considered in this IWRP with a summary of yield and cost. A comprehensive summary for each option, providing the projected yield, cost, and assumptions made in developing each of the final water supply options, can be found in **Appendix D – Option Fact Sheets** and **Appendix E – Option Costing Summary Technical Memorandum.**

7.1.1 Demand Management Options

7.1.1.1 ADVANCED METERING INFRASTRUCTURE

Advanced metering infrastructure (AMI) is an integrated system of customer water meters, communication networks, and data management systems that provides real time water use information to the City and its residents. Implementation of AMI would reduce water losses in the City's water distribution system and improve billing data by:

- Improving customer meter accuracy.
- Reducing unauthorized consumption.
- Reducing data transfer/archive errors.
- Reducing data billing errors.
- Reducing customer-side leaks by identifying uncharacteristic water use.
- Improving main break response time.

A feasibility study was performed in 2016 and recommended initial implementation of AMI through the replacement of 57 percent of current water meters over a 2-year deployment period and incremental replacement of remaining meters as they reach the end of their useful life. Meters not being initially replaced can still be retrofitted with meter interface units to allow for immediate data collection into the meter communication network.

Residential customers with AMI typically experience a 6 percent reduction in indoor water use, and nonresidential customers with AMI typically experience a 5 percent reduction in indoor water use through increased attention to water use efficiency and quicker identification of leaks within customer piping. In addition, an estimated 1-percent of total demand can be saved through rapid response to main breaks due to the data analysis support offered by AMI. **Table 7-2** shows the expected demand savings from AMI as the project is rolled out over the planning horizon.

Table 7-2. AMI Yield through 2040

Year	Indoor Savings (MGD)	Rapid Response Savings (MGD)	Total Water Conserved via AMI (MGD)
2020	0.20	0.07	0.27
2030	0.66	0.23	0.89
2040	0.70	0.24	0.94

7.1.1.2 WATER LOSS CONTROL

This option builds upon the City's current water loss control program. Water loss control can be achieved in two forms, real and apparent. Real water loss is typically a result of leaks in the distribution system or unmetered water use, whereas apparent losses are typically due to meter and billing inaccuracies. In 2015, the City reported a real water loss of 461 MG, approximately 8 percent of the total water supplied for that year. This option focuses on implementing measures to reduce real water losses that were developed during the City's 2015 American Water Works Association/International Water Association water audit. The measures considered for this option are as follows:

- Conduct a strategic leak detection pilot program.
- Conduct a district metering area feasibility study.
- Develop a large meter assessment and testing program.
- Develop a demand profile for 2-inch and larger meters.
- Conduct a real loss component analysis.

After implementation of the measures outlined above, annual real water loss reduction is expected to be approximately 1 percent of the total demand for a total savings of 0.24 MGD in 2040.

7.1.1.3 CONSERVATION

This option outlines the development of two conservation programs: basic and advanced. The basic program is incentive-focused, whereas the advanced program considers ordinances for reducing outdoor water use. These two programs were developed based on review of conservation practices implemented by cities with characteristics similar to Sugar Land.

The basic program is composed of the following initiatives: continuing distribution of WaterWise kits to local schools; continuing free residential and nonresidential irrigation system evaluations; improving conservation awareness through education and outreach; and offering rebates for rain barrels, irrigation "smart" controllers, and water-efficient household fixtures. WaterWise kit distribution is a partnership with the FBSD that provides students with take-home conservation kits containing items that will improve conservation practices inside their home. The water efficient household fixture rebate program would be a new program made available by the City to all residential customers. The program would reimburse residents, up to a certain percentage of the cost, for purchasing and installing items that reduce overall water use. The irrigation "smart" controller program would provide financial incentives for customers to invest in irrigation controllers that are optimized based on local weather, such as rainfall amount. For the irrigation system evaluations, a licensed professional will evaluate a customer's irrigation system and suggest water efficiency improvements.

The advanced program is composed of the following initiatives: twice-weekly irrigation ordinance and landscape transformation ordinance and incentives. A twice-weekly irrigation ordinance would limit all customer outdoor irrigation to twice per week, which will conserve water use by reducing extraneous irrigation. A landscape transformation ordinance would require all new residential development to use native, low-water using plants in the development, thereby reducing the amount of irrigation required. This ordinance would be coupled with an incentive program developed by the City and HOAs for current residential customers who want to lower their own irrigation needs by replacing at least 500 square feet of their existing landscaping with native, low-water using plants. A percentage of the cost of this landscape transformation would be reimbursed by the City if certain requirements are met.

The potential demand reductions for each individual initiative under the conservation programs is provided in **Table 7-3**.

Table 7-3. Conservation Yield through 2040

Conservation Initiatives	Estimated Savings in Year 2040 (MGD)
Basic Plan	
WaterWise kits	0.025
Irrigation evaluation	0.003
Rain barrels	0.002
Irrigation "smart" controllers	0.069
Accelerated plumbing rebates	
Showerheads	0.27
Faucets	0.25
Washing machines	0.24
Total Estimated Savings for Basic Plan	**0.86**
Advanced Plan	
Twice-weekly irrigation	1.87
Landscape transformation ordinance and incentives	0.32
Total Estimated Savings for Advanced Plan	**2.19**

7.1.2 Reclaimed Water Options

7.1.2.1 EXPANDED RECLAIMED WATER SYSTEM

Reclaimed water is highly treated wastewater that can be distributed to customers for non-potable uses such as irrigation, amenity lake filling, cooling towers, and industrial water use. This option would expand the City's reclaimed water system to incorporate additional customers and increase reclaimed water use. This option considers two sub-options: expansion of the existing 2-MGD reclaimed water treatment facilities at the City's South WWTP and construction of reclaimed water facilities at the City's North WWTP. **Figure 7-1** displays the current system and the potential expanded system.

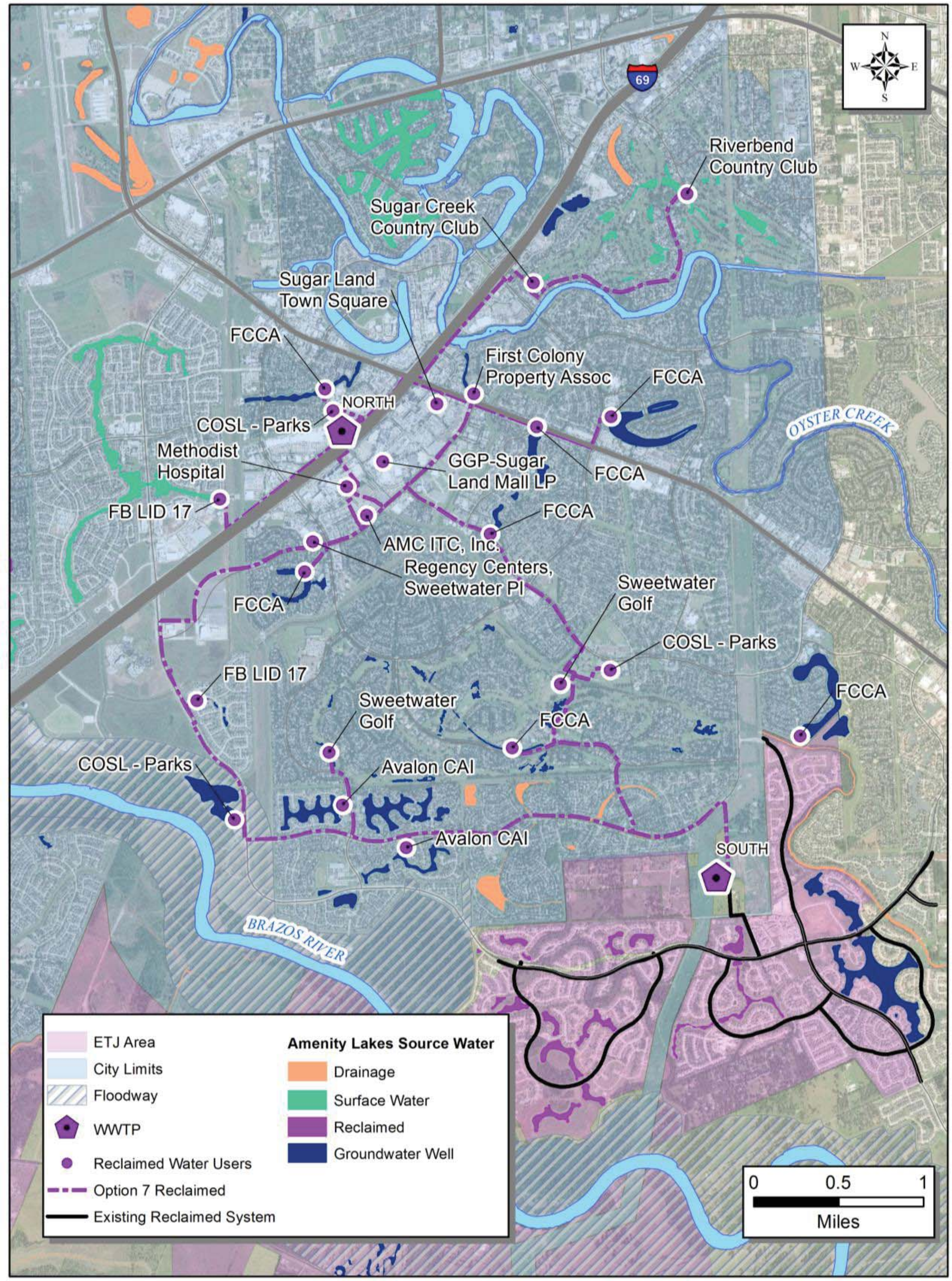

Figure 7-1. Map of Current and Future Expanded Reclaimed System

The locations and capacities of additional facilities are contingent upon customer interest, potential reclaimed water usage, and proximity to the City's WWTPs. It is envisioned that reclaimed water would be delivered directly to ponds, lakes, or storage tanks at customer receiving stations.

Capacity for the expanded reclaimed water system is based on anticipated non-potable water demand. Contingent upon customer interest, the expanded South reclaimed system is projected to provide an additional 0.4 MGD annual average of reclaimed water supply for amenity lake filling and irrigation. The North reclaimed water system is tentatively estimated to provide 1.1 MGD annual average of reclaimed supply.

Additional detail is provided in **Appendix F – Reclaimed Study Final Report.**

7.1.2.2 DIRECT POTABLE REUSE/INDIRECT POTABLE REUSE

In general, there are two forms of potable reuse: direct potable reuse (DPR) and indirect potable reuse (IPR). DPR would send highly treated WWTP effluent directly to the SWTP where it would be blended with other water sources for treatment and distribution. IPR would introduce highly treated WWTP effluent into an environmental buffer such as groundwater or a surface reservoir. The treated effluent would be extracted from the environmental buffer and sent for further treatment at the SWTP. The Texas Commission on Environmental Quality has guidelines and requirements for implementation of DPR/IPR projects based on protection of public health, natural resources, and lessons learned from previous projects in Texas and across the country.

Treated effluent from the North and/or West WWTP would provide source water for the DPR and IPR options. Regulatory constraints can limit potential implementation of IPR for the City. Discharging treated water into Oyster Creek will require a bed-and-banks permit and may result in transfer of water rights to the GCWA per the existing contract terms. Although aquifer storage and recovery (ASR) is a viable strategy for storing reclaimed water, there may be significant regulatory challenges presented by the FBSD for implementing such a strategy in the near term. Therefore, DPR is the representative option being considered for potable reuse at this time.

The proportion of blended water for DPR supply at the SWTP will be kept within 10 to 20 percent of the total water supply. The initial capacity of advanced water treatment facility is proposed to be 1.8 MGD and could be expanded to 3 to 4 MGD in the future. The West WWTP and North WWTP reliably produce more than enough effluent for the proposed DPR/IPR facilities.

Additional detail is provided in **Appendix F – Reclaimed Study Final Report.**

7.1.2.3 COLLECTION SYSTEM WASTEWATER SCALPING

Collection system wastewater scalping, also known as decentralized or satellite wastewater treatment, is a process in which a WWTP withdraws wastewater directly from the collection system to produce reclaimed water. The biosolids and non-reclaimed wastewater are returned to the trunk sewer for treatment at the centralized WWTP downstream. These facilities are typically upstream of WWTPs and located close to the end-users of reclaimed water.

This option considers integration of possible scalping plants at both the Harmon and West Airport lift stations in the North WWTP service area. These were considered optimal sites because they are near City-owned parks or amenity lakes. The anticipated yield for scalping facilities is 0.17 MGD per lift station location but depends on irrigation demands variations due to seasonal rainfall patterns.

Additional detail is provided in **Appendix F – Reclaimed Study Final Report.**

7.1.2.4 COMMERCIAL/INDUSTRIAL CONSERVATION AND ON-SITE REUSE

This option is focused on use of on-site reclaimed water treatment to meet non-potable demands at commercial and industrial facilities located in the North WWTP service area. By treating wastewater on-site, these facilities reduce flows to the City's collection system and WWTPs. Additionally, the use of reclaimed water reduces demands on the City's potable water system. Implementation of conservation measures at commercial/industrial facilities can further reduce their demands on the potable water system.

Capacity of on-site reuse facilities is based on anticipated non-potable water demand. The yield for a typical commercial/industrial facility is expected to be approximately 0.01 to 0.04 MGD. The IWRP assumes an initial on-site reuse facility, which would be prioritized based on the amount of water used. The total yield for the initial implementation of this option is tentatively estimated at 0.04 MGD but would be dependent on potential customer interest and demands, the latter of which may vary seasonally. The assumption is currently made that the commercial/industrial demand being served is a consistent year-round demand.

Additional detail is provided in **Appendix F – Reclaimed Study Final Report.**

7.1.3 Infrastructure and Storage Options

7.1.3.1 SURFACE WATER TREATMENT PLANT EXPANSION

This option would expand the City's existing SWTP, increasing its treatment capacity from approximately 11 MGD to an ultimate capacity of 22 MGD. This expansion would enable the City to increase the use of existing surface water rights and contracts and would increase surface water utilization to comply with the FBSD requirements.

The SWTP site is master planned for 22 MGD of ultimate production, which includes the 11-MGD expansion. **Figure 7-2** provides an aerial view of the SWTP where planned space for the expansion can be seen. The expansion could potentially be phased with an initial installation of 5.5 MGD. A two-phase expansion would allow ramping up of production to meet FBSD groundwater reduction requirements. Both the 5.5-MGD partial expansion and the full 11-MGD expansion are considered as part of the IWRP.

Figure 7-2. Photograph of SWTP (Aerial View)

Besides the expansion of the plant itself, this option includes expansion of the surface water transmission system to three additional groundwater plants as follows: Woodchester, Austin Parkway, and Homeward Way. By expanding the surface water transmission system, there is more demand that can be served by the treated surface water.

7.1.3.2 ACCESS TO BRAZOS RIVER WATER

This option considers ways to access the Brazos River water that the City currently has under contract with BRA. Two sub-options were evaluated: construction of a new City-owned and operated pump station or contracting with GCWA to use their existing infrastructure to convey the BRA water to Oyster Creek.

Yield would average 5.7 MGD annually based on the City's agreement with BRA. However, the City's agreement with BRA specifies only annual withdrawals, not daily pumping rates. The initial capacity of the pump station would be approximately 12 MGD to provide the City greater flexibility regarding the timing of withdrawals (e.g., increased pumping during warm summer months). Additionally, if the City wishes to construct the OCR, a pump station would be required to convey flow to the OCR.

7.1.3.3 AQUIFER STORAGE AND RECOVERY

ASR is a strategy in which treated surface water, untreated or treated groundwater or reclaimed water is stored underground in an aquifer during periods when water supply is plentiful and recovered for use during periods when water supply is needed. Storing water underground can improve drought preparedness and reduces the amount of water that evaporates compared to water storage in open aboveground reservoirs. As considered in this IWRP, an ASR project would be implemented near the SWTP transmission lines and include infrastructure required to take surplus treated surface water from the transmission system and use it to recharge an aquifer below the City. Three different locations are currently considered, as shown in **Figure 7-3**, with ASR implemented directly on-site at the SWTP selected as the representative option for modeling.

ASR is not currently considered an alternative water supply by the FBSD. However, the Harris-Galveston Subsidence District is nearing completion of a study focusing on the potential for land subsidence impacts due to ASR implementation. This option assumes that ASR will ultimately be deemed an alternative supply by the FBSD, and their determination will strongly impact this option's viability.

For analysis, the storage capacity of the ASR option is assumed to be 7,500 AF (2,444 MG) with an extraction rate is 2,300 gallons per minute (6.6 MGD). It is assumed that only 80 percent of the water stored in the ASR system is available for extraction due to anticipated regulatory constraints necessary to prevent subsidence.

7.1.3.4 OFF-CHANNEL RESERVOIR

This option includes the construction of an off-channel reservoir (OCR) to store raw surface water for later use at the SWTP. An OCR would allow the City to maximize existing contracts for Brazos River water and/or water rights on Oyster Creek by providing storage. Depending on the location, the OCR could also be designed to capture rainwater and stormwater runoff, provided that the necessary water right permit is obtained. The raw surface water from the OCR would be sent to the SWTP via Oyster Creek.

The reservoir will be sized to reliably supply surface water during the high demand periods and extended drought periods. It is anticipated that the OCR would store enough surface water to fully supply the existing 11-MGD SWTP for 60 days (660 MG). If the SWTP is expanded to 22 MGD, the OCR would store enough water to fully supply the expanded SWTP for 30 days.

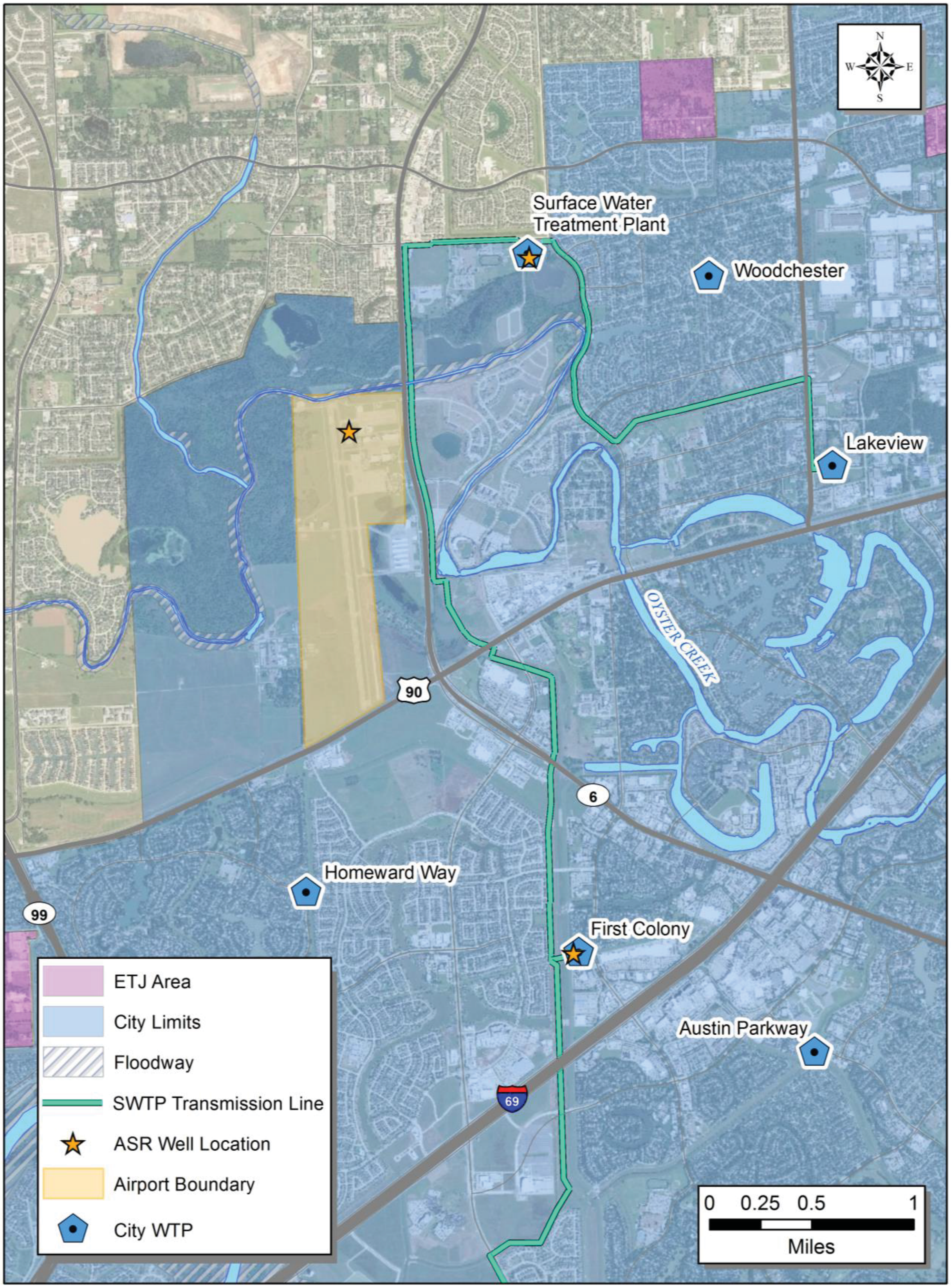

Figure 7-3. Map of Potential ASR Sites

7.1.4 Alternative Water Supply Options

7.1.4.1 SEAWATER DESALINATION

Seawater desalination is the treatment of seawater using energy-intensive reverse osmosis. This option considers two potential sub-options. One option considers installation of a 5-MGD seawater desalination plant in Freeport, Texas. The treated water would then be pumped approximately 55 miles through a new city-owned pipeline from Freeport to the City's Riverstone and Austin Parkway plants as shown in **Figure 7-4**.

Another option considers that the seawater desalination facility could be owned and operated by a suitable third-party water provider. This could be accomplished by using the Brazosport Water Authority (BWA) Northern Transmission pipeline to convey the water to BWA's water plant in Angleton. A new pipeline would be required to convey the desalinated seawater from Angleton to the Riverstone, and Austin Parkway water plants through which the desalinated water could enter the distribution system.

In either option, once the desalinated seawater is delivered, it can be blended with treated surface water or disinfected groundwater at the Austin Parkway and Riverstone plants prior to being pumped into the distribution system. This will allow seamless integration of the new water supply with reduced corrosion implications.

There is no limit on the supply available from this option. Yield is based on the infrastructure investment. The initial reverse osmosis treatment plant could be sized for 5 MGD, with the option to expand the facility in the future.

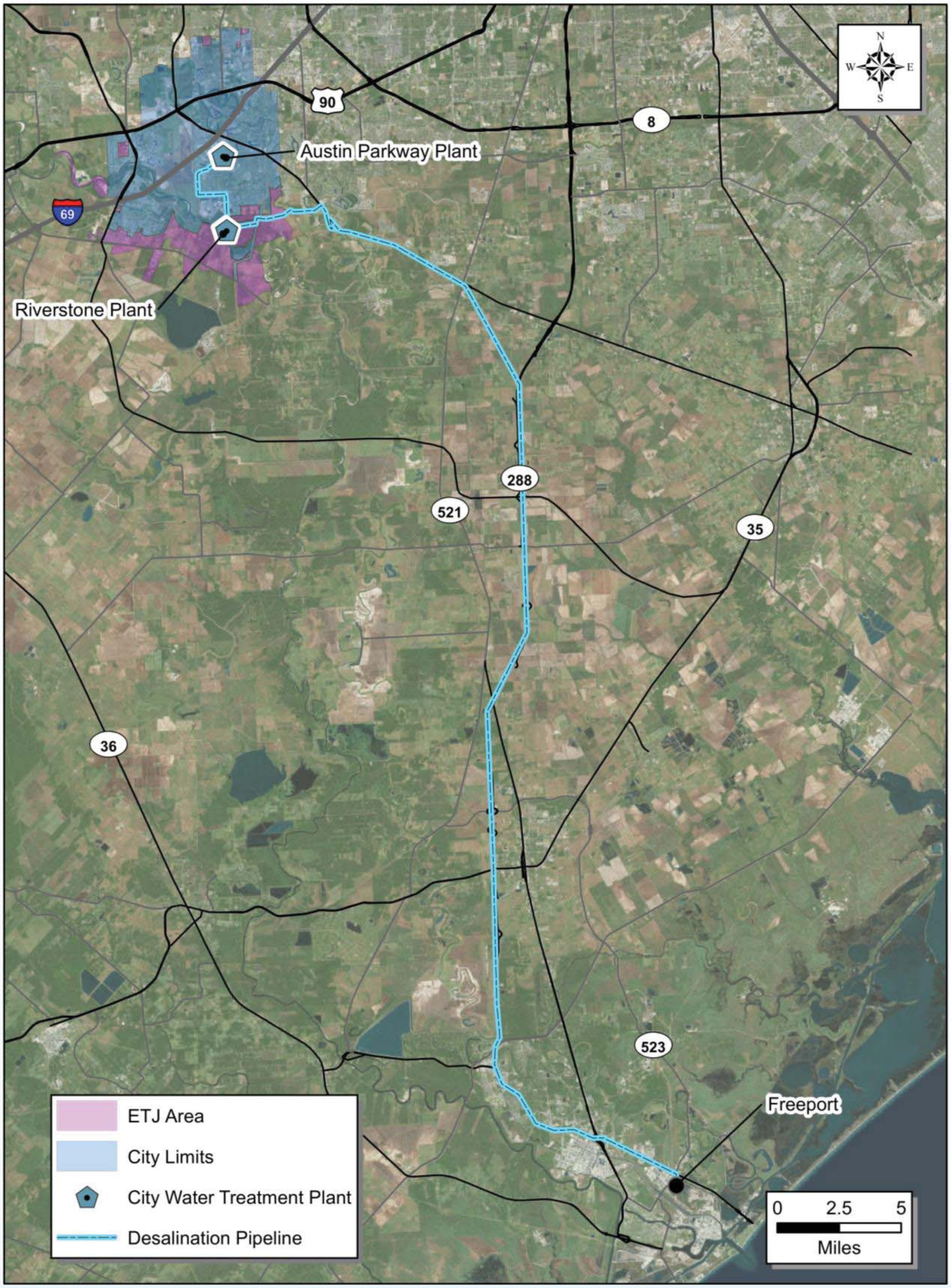

Figure 7-4. Map of Seawater Desalination Potential Transmission Route

7.1.4.2 BRACKISH GROUNDWATER DESALINATION

Brackish water is water with salinity in the range of 1,000 to 8,000 milligrams per liter as compared to seawater which typically has a salinity of around 35,000 milligrams per liter. There are several Gulf Coast aquifers that can supply brackish water. The target aquifers from which to extract brackish water would be the Jasper and lower Evangeline formations, which are approximately 2,000 to 3,000 feet below the surface. Salinity from brackish groundwater can be removed using reverse osmosis treatment. This option assumes that a brackish groundwater treatment facility with several wells would be constructed at the City's SWTP site.

During option development, FBSD in conjunction with the Harris-Galveston Subsidence District was nearing completion of a study focusing on the potential for land subsidence impacts due to pumping brackish water from the Jasper Aquifer. As part of this study, information from an ongoing pilot study (Cinco Ranch MUD 1) has served as an important data set. Brackish water from the Jasper Aquifer is not currently considered an alternative supply by the FBSD. Results of the brackish water study will serve to inform the FBSD as they consider possible revisions to the rules, permitting requirements and regulatory plan for the utilization of brackish groundwater as an alternative water supply within Fort Bend County. This option assumes that the Jasper Aquifer will ultimately be deemed an alternative supply by the FBSD, and their determination will strongly impact this option's viability.

Brackish water wells in the Jasper Aquifer can produce between 1 and 2 MGD. The net yield for this option will depend on the number of brackish water wells installed. The SWTP site has adequate land available to integrate a 2- to 4-MGD brackish water desalination facility.

7.1.4.3 EXPANDED WATER SUPPLY CONTRACTS

The City has long-term water supply contracts in place with GCWA and BRA. This option involves pursuing additional contracts. Below is a summary of some potential opportunities:

- Expanded contracts from BRA; expected to be available during the spring of 2019.
- Water rights on Rabbs Bayou and Middle Bayou, with diversion amounts from 100 to 2,000 AFY and reliabilities ranging from 65 to 73 percent without any additional storage.
- Purchase of wastewater effluent from upstream WWTPs that is discharged to the Brazos River and conveyed through bed and banks permits.

For the IWRP, purchase of expanded contracts from BRA is considered the most feasible opportunity; however, similar to the current contract, neither BRA nor the City has infrastructure in place to convey this water from the Brazos River to Oyster Creek. To access this water, the City must either construct a new Brazos River pump station or contract with GCWA to pump BRA water on behalf of the City.

Yield is dependent on available contracts and contract conditions, but an additional 4,000 AFY (3.57 MGD) was assumed for this option.

7.1.5 Groundwater Credit Banking

The FBSD allows the City to earn over-conversion credits that can be accumulated over time if they utilize more alternative water supplies than the required 30 percent volume. Over-conversion of surface water offers a one-to-one credit, whereas conversion to reclaimed water offers a credit of 1.5 gallons for every gallon of over-conversion.

As part of their GRP compliance strategy, the City constructed the SWTP in 2014. When running at full capacity, this plant exceeds the current 30 percent conversion requirement, which provides the City an opportunity to gain over-conversion credits. The City has been accumulating these credits into an "over-conversion credit bank" that can be used by the City in the event that additional groundwater pumpage is needed in a given year (i.e. drought or delayed implementation of new alternative water strategies).

Besides over-conversion credits, the City has also earned educational credits through support of the WaterWise educational program. While over-conversion credits never expire, educational credits expire after 20 years and are tracked separately within the model.

Groundwater credit banking does not directly yield new water. However, it does enable the city to legally access groundwater supplies that would otherwise be prohibited based on FBSD regulations.

7.2 Future Water Supply Option Costing

For each future water supply option, capital and operation and maintenance (O&M) costs were developed. These costs are intended for use as a screening level evaluation for conceptual projects and are commensurate with Association for the Advancement of Cost Engineering Level 5 estimates. The developed costs rely on comparable feasibility studies or construction costs. When not available, cost estimates were determined in a manner consistent with planning level order-of-magnitude cost estimates based on cost curves, the Texas Water Development Board Unified Costing Model, professional judgement, and other resources. Baseline assumptions for option cost develop are shown in **Table 7-4.**

Table 7-4. Option Costing Assumptions

Cost Component	Cost Assumptions
Contractors Overhead and Profit	15% of direct project costs
Mobilization and Demobilization	5% of direct project costs
Permits, Bonds, and Insurance	13% of direct project costs
Engineering and Design	10% of direct project costs
Contingency	25% of direct project costs
Land Cost	$500,000 per acre inside the City $20,000 per acre outside of the City
Labor	$60,000 per year for each full-time employee
Electrical Power	$0.10 per kilowatt hour
Supplies and General Maintenance	2% of capital costs
Miscellaneous Cost	10% of option yearly O&M costs

Other assumptions also were made to develop costs for each option. Debt service assumptions include a 20-year payment period and a 5 percent interest rate. Avoided costs represent savings from water no longer needing to be produced at the groundwater treatment plants or treated at the WWTPs for certain options. Lost revenue is an accounting of revenue no longer earned on sold water and is a factor for AMI, conservation, and the expanded reclaimed water system.

Table 7-5 provides a summary of the option costs. Additional information, including detailed costing sheets for each option, can be found in **Appendix E – Option Costing Summary Technical Memorandum.**

Table 7-5. Option Costing Summary

Option Name	Total Capital Costs ($)	Annualized Debt Service Payment ($/yr)	Annual O&M Costs ($/yr)	Cost Adjustments for Avoided Costs and Lost Revenue	Total Annual Cost ($/yr)	Provided Yield (MGD)	Unit Cost ($/1,000 gallons)
Advanced Metering Infrastructure	$12,504,000	$1,003,000	$75,000	$1,243,000	$2,321,000	0.94	$6.77
Water Loss Control	$360,000	$29,000	$132,000	-$63,000	$98,000	0.24	$1.12
Conservation - Basic (Rebates)	$0	$0	$489,000	$1,524,000	$2,013,000	0.86	$6.41
Conservation - Advanced (Ordinances)	$0	$0	$1,091,000	$1,774,000	$2,865,000	2.19	$3.58
Expanded Reclaimed Water System (North System)	$17,707,000	$1,421,000	$370,000	$153,000	$1,944,000	1.10	$4.84
Expanded Reclaimed Water System (South System)	$9,817,000	$788,000	$203,000	$210,000	$1,201,000	0.40	$8.23
Direct Potable Reuse	$80,634,000	$6,470,000	$2,845,000	$0	$9,315,000	4.00	$6.38
Collection System WW Scalping (West Airport)	$9,676,000	$776,000	$299,000	-$45,000	$1,031,000	0.17	$16.61
Collection System WW Scalping (Harmon LS)	$8,048,000	$646,000	$271,000	-$45,000	$872,000	0.17	$14.06
Commercial/Industrial On-site Reuse	$3,675,000	$295,000	$123,000	-$11,000	$407,000	0.04	$27.90
Surface Water Treatment Plant Expansion (5.5 MGD)	$50,019,000	$4,014,000	$2,594,000	-$622,000	$5,985,000	5.50	$2.98
Surface Water Treatment Plant Expansion (11 MGD)	$66,325,000	$5,322,000	$5,188,000	-$1,245,000	$9,265,000	11.00	$2.31
Access to Brazos River Water (Pump Station to Oyster Creek)	$22,713,000	$1,823,000	$834,000	$0	$2,657,000	5.70	$1.28
Access to Brazos River Water (Pump Station to Reservoir)	$19,891,000	$1,596,000	$778,000	$0	$2,374,000	5.70	$1.14
Aquifer Storage and Recovery (Airport)*	$7,123,000	$572,000	$559,000	$0	$1,131,000	6.60	$0.47
Aquifer Storage and Recovery (Retrofit)*	$2,373,000	$190,000	$559,000	$0	$749,000	6.60	$0.31
Aquifer Storage and Recovery (SWTP)	$6,260,000	$502,000	$559,000	$0	$1,061,000	6.60	$0.44
Off-channel Reservoir	$51,804,000	$4,157,000	$644,000	$0	$4,801,000	6.00	$2.19
Seawater Desalination (New Pipeline)	$139,595,000	$11,201,000	$5,206,000	-$566,000	$15,842,000	5.00	$8.68
Seawater Desalination (BWA Northern Line)*	$108,549,000	$8,710,000	$5,607,000	-$566,000	$13,752,000	5.00	$7.54
Brackish Groundwater Desalination (2MGD)	$26,364,000	$2,116,000	$1,320,000	-$226,000	$3,209,000	2.00	$4.40
Brackish Groundwater Desalination (4MGD)	$43,409,000	$3,483,000	$2,182,000	-$453,000	$5,213,000	4.00	$3.57
Expanded Water Supply Contracts (Purchase from BRA)	$0	$0	$296,000	$0	$296,000	3.57	$0.23

Options indicated with an asterisk are considered representative options and carried forward for further analysis in portfolios.

7.3 Future Water Supply Option Modeling

Each of the future water supply options are included in the DSM and can be turned on and off through the model interface. How each option specifically is incorporated into the DSM is described in the option fact sheets in **Appendix D – Option Fact Sheets**.

As new water supply sources are activated, the DSM has a hierarchy of how supplies are utilized in meeting demand. This modeled hierarchy is outlined below and mainly applies to serving potable water within the City Main distribution system. River Park and Greatwood water systems will continue to have groundwater as their only available source water. New Territory could receive some surface water if the SWTP expansion option is selected.

- **Minimum groundwater flows:** To keep groundwater wells active and in service, it is assumed that each well is operated a minimum of 1 hour every 3 days.
- **SWTP:** The model looks to utilize as many non-groundwater supply sources as possible in meeting demand. It first prioritizes use of the SWTP. The plant has its own hierarchy for the raw water supply sources utilized at the plant. While the model utilizes one raw water supply source before moving to the next, the City would have more flexibility in how water sources are mixed to supply the plant.
  - **Direct potable reuse:** If the DPR option is turned on in the model, it provides up to 20 percent (with a maximum of 1.8 MGD) of the raw water flow to the plant.
  - **Current contracts**: The model utilizes raw water from the GCWA contract, then the Oyster Creek water rights, then the BRA contract if an option has been selected to access this water.
  - **Additional contracts:** If additional contracts have been turned on in the model, these new contracts are utilized following usage of the current contracts.
  - **OCR:** If the OCR option has been selected, the model utilizes water from the reservoir to supply the SWTP next.
  - **ASR:** When water is recovered from the ASR system in the model, it does not go back through the SWTP, but it does utilize the surface water transmission system to be transported to groundwater plants for blending and pumping into the distribution system. If this option is selected and there is additional demand that could be serviced by the SWTP, the model looks next to stored ASR supplies to supplement SWTP deliveries.
  - **GCWA option water:** If there is additional demand that the plant can serve but no other source of raw water or ASR water, the model utilizes the GCWA option water. This water is used last because once GCWA option water is utilized the first time, it becomes part of the GCWA contract and is charged at the higher rate.
- **Brackish desalination:** After serving demand with the SWTP, the model next looks to water provided via brackish groundwater desalination if this option is active.
- **Seawater desalination:** Water provided from seawater desalination is utilized next in the model if this option is active.
- **Groundwater:** Once all the active non-groundwater supply sources are utilized to the maximum extent possible for a given month, any remaining demand is met via groundwater.

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SECTION 8| PORTFOLIO EVALUATION

Portfolios are combinations of future water supply options that are evaluated against the performance measures. Options are combined into portfolios with enough new non-groundwater supply and demand management to meet the FBSD regulations through at least 2040 under average weather conditions. Based on the needs assessment, at least 6 MGD of new supply and/or demand management was set as the lower boundary to include in each portfolio to meet the FBSD regulations. Under dry weather conditions, the portfolios can rely on banked credits to achieve regulatory targets. Each portfolio is modeled from the year 2018 through 2040, with a 5-year drought in the middle of the simulation.

8.1 Scoring Overview

The first step in evaluating portfolios is determining the raw performance scores for each IWRP performance measure. The planning objectives are used to guide the comparison of portfolios, and performance measures associated with each objective describe how well the portfolios perform to meet the ideals set forth by the City residents, council, and staff. **Table 8-1** provides a list of the planning objectives for the IWRP along with associated performance measures and weights of relative importance as identified by the Citizen Task Force. Also shown in **Table 8-1** are the measurement units for each performance measure, the range of raw scores from the modeling and analysis, and an indication as to whether a higher or lower score is better. Finally, the location where the score is calculated for each of the performance measure is shown on the table. The majority of the quantitative performance measures are calculated within the DSM, while the qualitative performance metrics and a few straightforward quantitative calculations are performed within an Excel-based scorecard tool.

A description of the qualitative scores is provided in this section. Additional detail for exactly how each quantitative performance measure is calculated in the model can be found in **Appendix B – Decision Support Model Documentation**.

Table 8-1. Objectives, Performance Measures, Units, Ranges, and Data Sources

Objective	Objective Weight	Performance Measure	Subweight	Measurement Unit	Range of Performance	Better Score	Scoring Location
Optimize Water Resources	18%	Percent of non-potable demands met with non-potable supply	50%	%	33–72	higher	Model
		Percent utilization of surface water contracts	50%	%	49–69	higher	Model
Provide Reliable Water Supply	25%	New non-groundwater yield incorporated	33%	MGD	6–11	higher	Scorecard
		Non-groundwater usage during extreme summer drought	34%	%	12–34	higher	Model
		Yield from options with high implementation challenges	33%	MGD	0–11	lower	Scorecard
Develop Cost-Effective Solutions	15%	Levelized cost of delivered water	50%	$/1,000 gallon	4.81–6.00	lower	Model
		Total capital cost (Present Value)	50%	$ (millions)	0–227	lower	Model
Promote System Efficiency	18%	Average percent savings from demand-side management options	50%	%	0–15	higher	Model
		Qualitative score for operational complexity	50%	Qualitative	1–5	higher	Scorecard
Promote Equity	6%	Qualitative equity impact score	50%	Qualitative	1–5	higher	Scorecard
		Demands with access only to groundwater	50%	%	17–23	lower	Model
Protect Environment	11%	Additional energy cost of options	34%	$/year (millions)	0–5	lower	Scorecard
		Qualitative subsidence score	33%	Qualitative	1–5	higher	Scorecard
		Qualitative environmental scores	33%	Qualitative	1–5	higher	Scorecard
Maintain Quality of Life	7%	Qualitative score for benefiting economy	50%	Qualitative	1–5	higher	Scorecard
		Unmet annual amenity lake raw water demand during drought	50%	AFY	0–1650	lower	Model

8.1.1 Qualitative Scoring of Options

As part of the IWRP process, qualitative performance measures were assessed for each of the options based on input from city staff and other experts. Initial qualitative scores were developed by the consultant team and refined during a workshop with city staff. All qualitative performance metrics were scored on a scale of 1 to 5, with a higher score being better. The scoring criteria utilized to guide the scoring for each metric are provided in **Table 8-2**, and the final scores for each option are provided in **Table 8-3**. A single qualitative score was determined for each portfolio by calculating the average option score, weighted based on maximum yield.

Table 8-2. Qualitative Performance Measure Scoring Criteria

Qualitative Metric	Scoring Criteria
Implementation Challenges	1=multiple challenges 5=minimal challenges
Operational Improvements/Complexity	1=expands on current infrastructure, adds operational complexity 5=improves current infrastructure or operations
Equity	1=narrow/independent benefit 5=widest benefit value
Subsidence	1=increased subsidence impacts 5=no subsidence impact
Environmental Impact	1=potential detrimental impacts 5=potential beneficial impacts
Economic Benefits	1=minimal job creation 5=sustained local job creation

Table 8-3. Qualitative Scores per Option

Category	Options	Implementation Challenges	Operational Improvements/ Complexity	Equity	Subsidence	Environmental Impact	Economic Benefits
Conservation	AMI	3	5	5	4	4	4
	Water Loss Control	4	5	5	4	4	4
	Conservation – Basic (Rebates)	3	3	5	3	4	3
	Conservation – Advanced (Ordinances)	2	3	5	4	5	2
Reclaimed Water Supply	On-Site Reuse	2	2	1	3	4	4
	Direct Potable Reuse	1	1	4	4	3	5
	Expanded Reclaimed Water System (South)	4	4	3	4	4	4
	Expanded Reclaimed Water System (North)	3	3	3	4	4	4
	Collection System Wastewater Scalping	3	2	2	3	4	4
New Supply Sources	Brackish Desalination	2	1	3	2	2	4
	Seawater Desalination	1	1	3	5	1	1
	Expanded Contracts	4	4	4	4	3	1
Infrastructure	SWTP Expansion	4	3	4	4	3	5
	Agreement to Pump BRA Water through GCWA	4	4	4	4	3	1
	Brazos River Pump Station	3	2	4	4	2	3
Storage	OCR	2	1	4	4	3	3
	ASR	2	2	4	2	2	4
Other	Groundwater Credit Banking	5	5	5	1	5	1

8.1.2 Portfolio Scoring

Once the portfolio has a value for each performance measure, CDP is used to rank the portfolios against each other. CDP is a software tool converts the raw performance measures for each sub-objective--often with different measurement units--into standardized scores so that each portfolio of options can be ranked using all the quantitative and qualitative metrics. **Figure 8-1** presents an overview of the multi-attribute rating technique used in CDP for each of the portfolios.

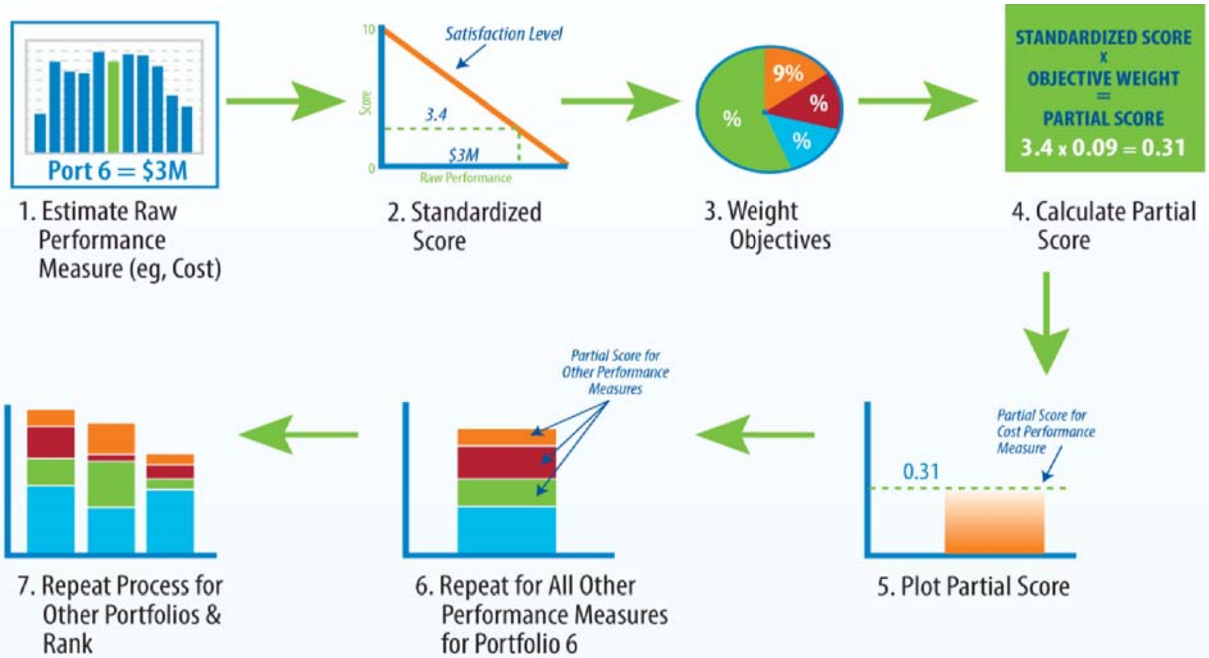


Figure 8-1. Multi-attribute Rating Technique Used by CDP Software to Score Portfolios

Multi-attribute rating uses seven steps to score and rank portfolios:

- **Step 1** compares the raw performance for all the portfolios for a given metric (for example, cost).
- **Step 2** standardizes the performance into a score from 0 to 10. In the above example, Portfolio 6's cost performance is fairly expensive, so its standardized score is fairly low (e.g., 3.4 out of 10). This step is important because performance can be measured in different units for each metric (i.e., cost in dollars, energy in kWh).
- **Step 3** assigns weights to the metrics.
- **Step 4** calculates a partial score for a given portfolio based on the multiplication of the standardized score (Step 2) and weight (Step 3).
- **Step 5** plots the partial score.
- **Step 6** repeats the process for all the other performance measures. This creates a total score for the portfolio.
- **Step 7** repeats all the previous steps for any other portfolios, so they can be compared and ranked.

8.2 First Pass Portfolio Analysis

A set of six initial portfolios were developed around objective-based themes to test outcomes when focused on a specific project type or objective. The initial portfolios are not meant to be the final solution but to push boundaries to see what can be achieved with a singular focus. Descriptions of the first pass portfolios are below:

- **Low cost:** Selection of options with the lowest unit cost.
- **Non-potable supply:** Options focused on meeting non-potable demand with non-potable supply while conserving the current potable supply.
- **Surface water focused (5.5-MGD expansion):** Options focused on utilizing the current surface water contracts through a smaller SWTP expansion.
- **Surface water focused (11-MGD expansion):** Options focused on utilizing the current surface water contracts through a larger SWTP expansion.
- **Maximum reliability:** Options which utilize hydrologically independent supplies and thus perform well under drought conditions.
- **Local control:** Selection of options where the water source is under the control of the City.

The options included in each of the first pass portfolios are shown in **Table 8-4** while the yield composition of each portfolio is shown in **Figure 8-2.**

Table 8-4. Options per Initial Portfolios

Option Type	Options	Low Cost	Non-Potable Supply	Surface Water Focused (5.5 MGD)	Surface Water Focused (11 MGD)	Max Reliability	Local Control
Conservation	AMI		X	X		X	X
	Water Loss Control		X			X	X
	Conservation – Basic (Rebates)		X				
	Conservation – Advanced (Ordinances)		X				X
Reclaimed Water Supply	Expanded Reclaimed Water System (North System)	X	X				
	Expanded Reclaimed Water System (South System)		X			X	X
	Direct Potable Reuse		X			X	
	Collection System Wastewater Scalping		X			X	X
	On-Site Reuse		X			X	
Infrastructure and Storage	SWTP Expansion	X (5.5 MGD)		X (5.5 MGD)	X (11 MGD)		
	Agreement to Pump BRA Water through GCWA	X		X			
	Brazos River Pump Station (to OCR)				X		
	ASR			X			
	OCR				X		
Alternative Water Supply	Brackish Groundwater Desalination					X (2 MGD)	X (4 MGD)
	Seawater Desalination (New Pipeline)					X	
	Expanded Contracts				X		
Other	Groundwater Credit Banking	X	X	X			X
	New Non-Groundwater Yield (MGD)	6.6	7.9	6.4	11.0	10.8	8.1

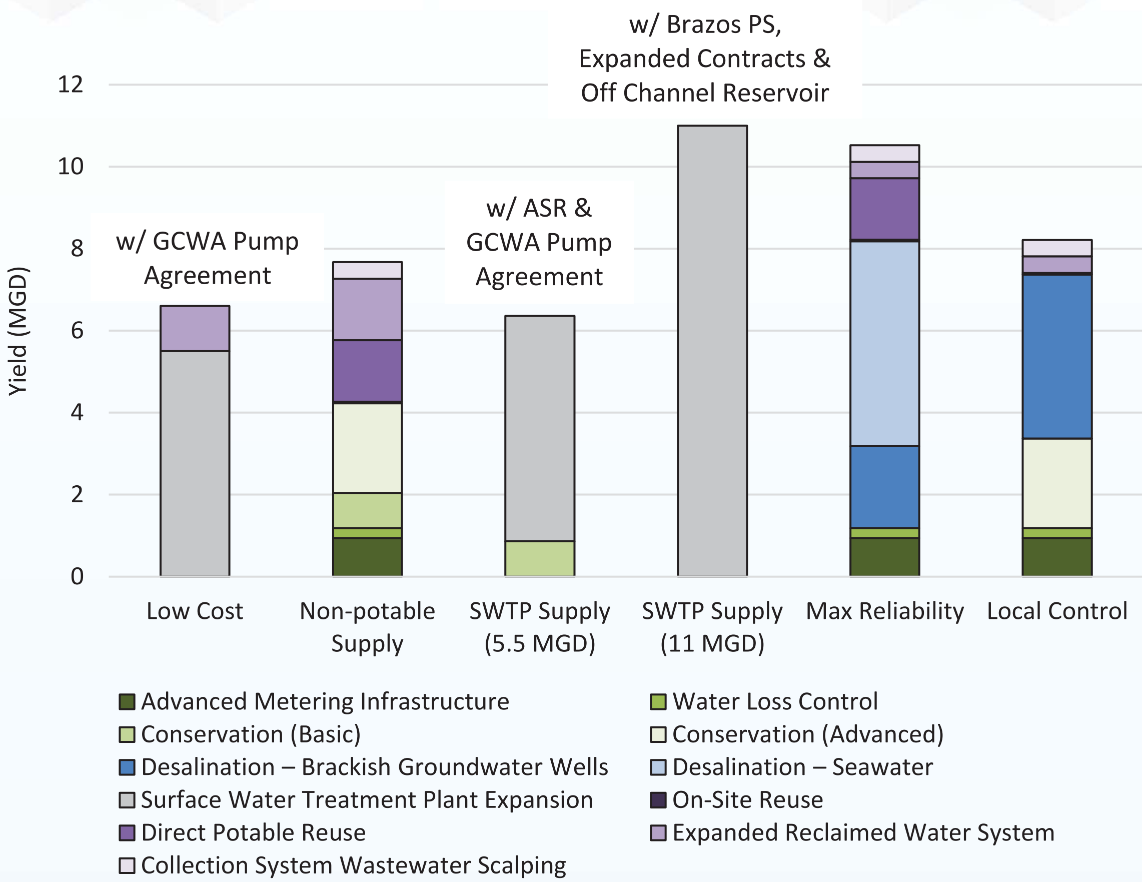


Figure 8-2. New Non-Groundwater Yield per Initial Portfolios

Using the raw performance scores, the portfolios were ranked with the multi-attribute rating method using the CDP software package. The portfolios were ranked based on the relative importance of each objective and sub-objective. **Figure 8-3** shows the ranking of portfolios. The figure not only shows which portfolios ranked the highest but also which objectives contributed to the scoring. The larger the color bar segment, the better the portfolio did in achieving that particular objective. Along with the six initial portfolios a "no action" portfolio was also scored, which included implementing no project options and instead paying disincentive fees for not achieving the regulatory targets.

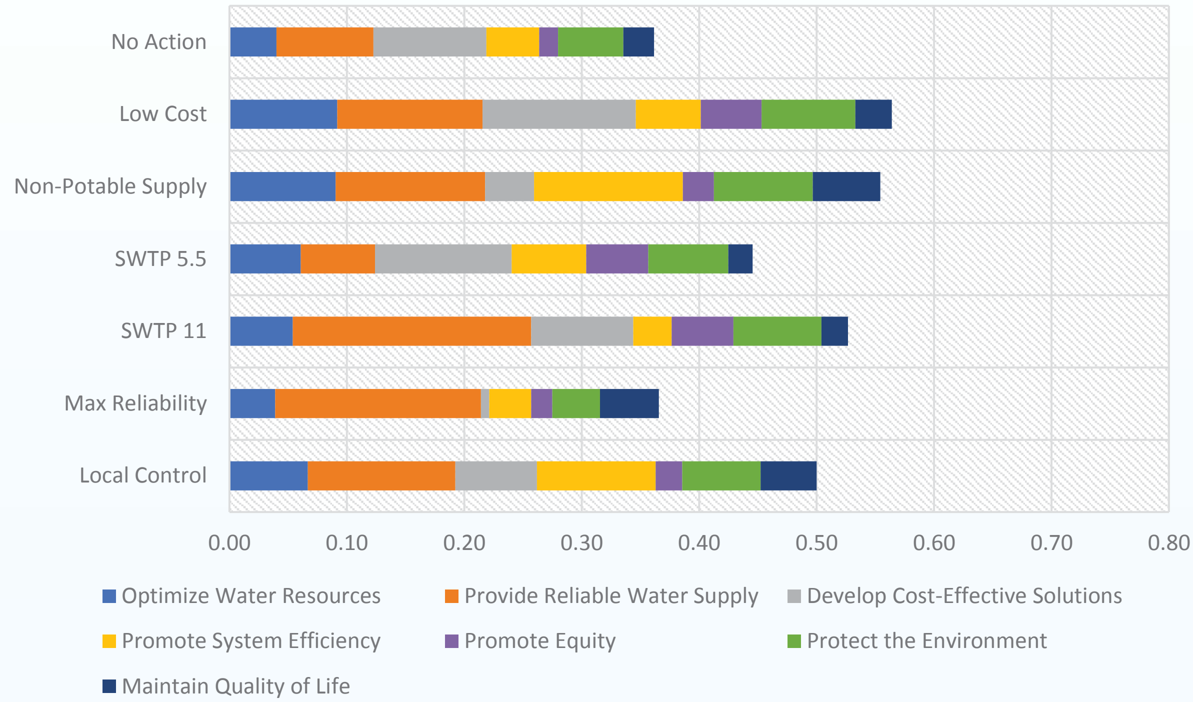


Figure 8-3. First Pass Portfolio Rankings

The low-cost portfolio containing the 5.5-MGD expansion of the SWTP along with an expanded reclaimed system at the North WWTP is the best scoring of the initial portfolios. A very close second is the non-potable supply portfolio focused exclusively on demand management and reclaimed options. The no action portfolio performed the worst, with the reliability-focused portfolio built around the desalination options also performing poorly compared to the other initial portfolios.

8.3 Second Pass Portfolio Analysis

Informed by the results of the first pass portfolio analysis, second pass portfolios, also called hybrid portfolios, were developed to improve portfolio performance. Hybrid portfolios are not constrained by themes but instead can contain any mix of project options. City staff submitted nine initial hybrid portfolios for scoring. Two of those initial hybrids achieved a higher score than the initial portfolios and were carried forward for further analysis. The options included in the two hybrids are shown in **Table 8-5**. Both Hybrid A and Hybrid B contain a mix of demand management, expanded reclaimed water systems and expansion of the SWTP by 5.5 MGD. The difference between the two is that Hybrid B contains more options and provides 9.0 MGD of new alternative water supply while Hybrid A provides 6.8 MGD of new supply.

Table 8-5. Options Included in Second Pass Portfolios

Category	Options	Low Cost	SWTP 11 Only (original plan per Water Master Plan)	Hybrid A	Hybrid B
Demand Management	AMI				X
	Water Loss Control			X	X
	Conservation – Basic (Rebates)				X
	Conservation – Advanced (Ordinances)				
Reclaimed Water Supply	Expanded Reclaimed Water System (North System)	X		X	X
	Expanded Reclaimed Water System (South System)				X
	DPR				
	Collection System Wastewater Scalping				
	On-Site Reuse				
Infrastructure and Storage	SWTP Expansion	X (5.5 MGD)	X (11 MGD)	X (5.5 MGD)	X (5.5 MGD)
	Agreement to Pump BRA Water through GCWA	X	X	X	X
	Brazos River Pump Station				
	ASR				
	OCR				
Alternative Water Supply	Brackish Desalination				
	Seawater Desalination				
	Expanded Contracts				
Other	Credit Banking	X		X	X
	New Yield (MGD)	6.6	11	6.8	9.0

The rankings for the second pass portfolios are shown in **Figure 8-4**. The hybrid portfolios are compared to the low-cost portfolio from the first pass analysis for reference as well as a portfolio containing only the 11-MGD SWTP expansion, which was the original plan outlined in the 2012 Water Master Plan. The current SWTP 11 Only portfolio is different from the previous first pass SWTP Supply (SWTP 11) portfolio as it does not include the Brazos River pump station and OCR. As can be seen from the figure, the two top performing portfolios from this second pass analysis are SWTP 11 Only and Hybrid B.

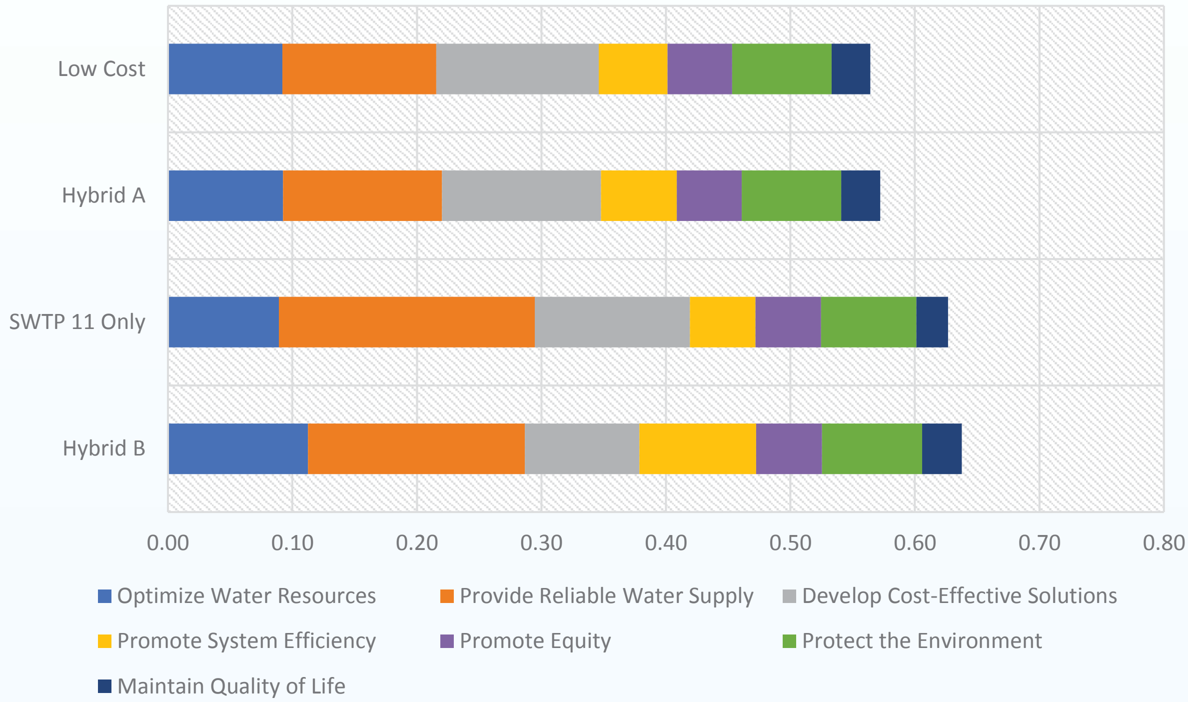


Figure 8-4. Hybrid Portfolio Rankings

8.4 Third Pass Portfolio Analysis

Sensitivity analyses were performed as a third pass for the hybrid portfolios. Options were added and removed from the best scoring portfolio (Hybrid B) to evaluate if the score could be further improved. It was determined that no significant improvements could be made to the composition of Hybrid B.

8.4.1 Demand Management

To test the scoring impact of demand management options, a starting portfolio with both expanded reclaimed projects and a 5.5-MGD SWTP expansion had various combinations of demand management options added to it. Results are shown in **Figure 8-5.** Including demand management options improves the total score, largely through improved reliability and system efficiency. Including all demand management options produces the best score, while including advanced conservation via ordinances has the greatest impact for a single option. This is because there is the most potential for water savings from the enforced ordinances. However, implementation of conservation ordinances could present customer acceptance concerns. At this time, the City Council and staff are not interested in pursuing conservation ordinances for the community; thus, advanced conservation is not considered further past this analysis. The recommended Hybrid B portfolio includes all the other demand management options.

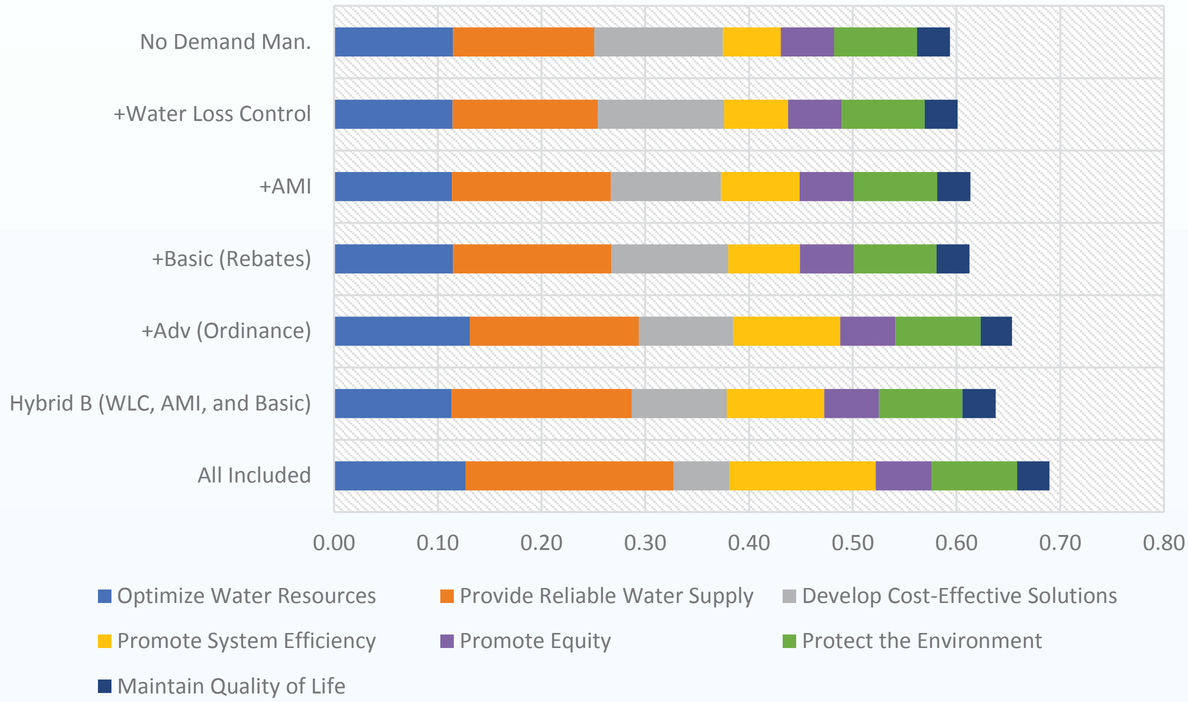


Figure 8-5. Scoring Sensitivity to Inclusion of Demand Management Options

8.4.2 Desalination

Within the Hybrid B portfolio, the 5.5-MGD SWTP expansion was replaced by either 4 MGD of desalinated brackish groundwater or 5 MGD of desalinated seawater. **Figure 8-6** shows the scoring sensitivity to these changes. Neither desalination option is able to achieve the objectives as well as the surface water treatment expansion. While the desalinated supplies score well for drought reliability, there are significant costs and implementation challenges. Potential challenges include permitting, blending issues with current water supplies, brine disposal, and uncertainty of whether brackish groundwater will be considered by FBSD as an alternative non-groundwater supply. Thus, the recommended portfolio will continue to focus on surface water instead of desalinated water as the main non-groundwater source for regulatory compliance.

8.4.3 Surface Water Supply Sources

Hybrid B includes BRA contract water provided through GCWA. A sensitivity analysis was performed to instead include BRA contract water provided through a new pump station or not using BRA water and instead relying on GCWA option water to serve the SWTP expansion. **Figure 8-7** shows the result of this sensitivity analysis. The results show that accessing BRA water through GCWA scores better than building a pump station. The drawbacks to the pump station include increased costs, adding operational complexity, and the environmental impacts of building additional infrastructure. However, utilizing BRA water via GCWA or utilizing GCWA option water scores similarly, and either option or a mix of strategies could be utilized as additional raw water supply.

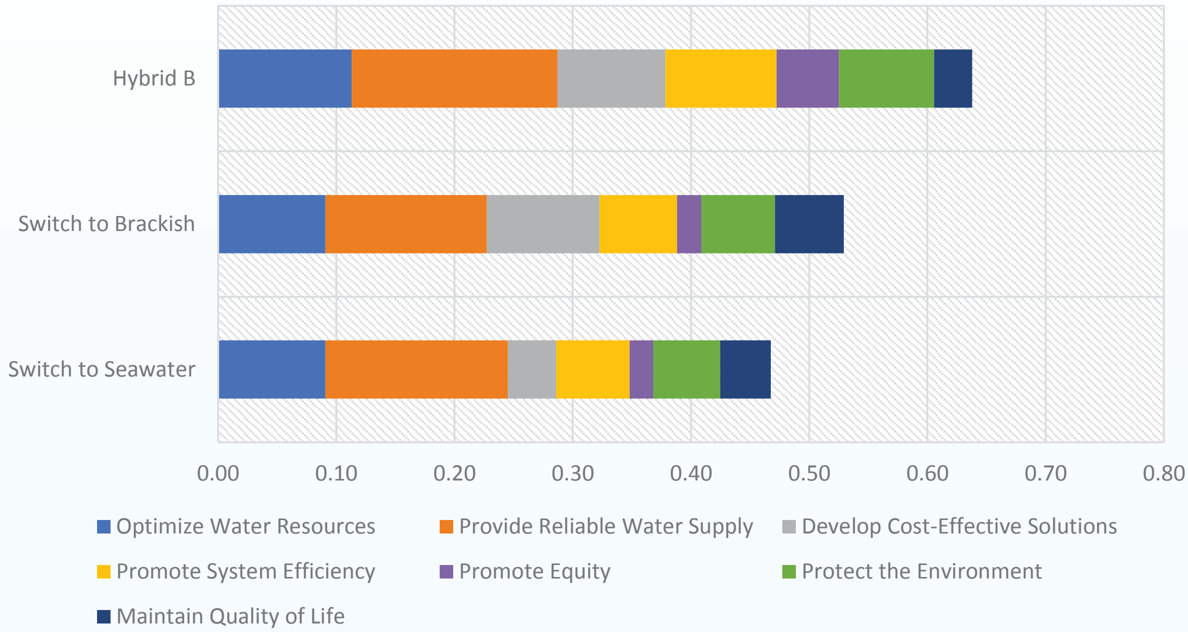


Figure 8-6. Scoring Sensitivity to Inclusion of Desalination Options

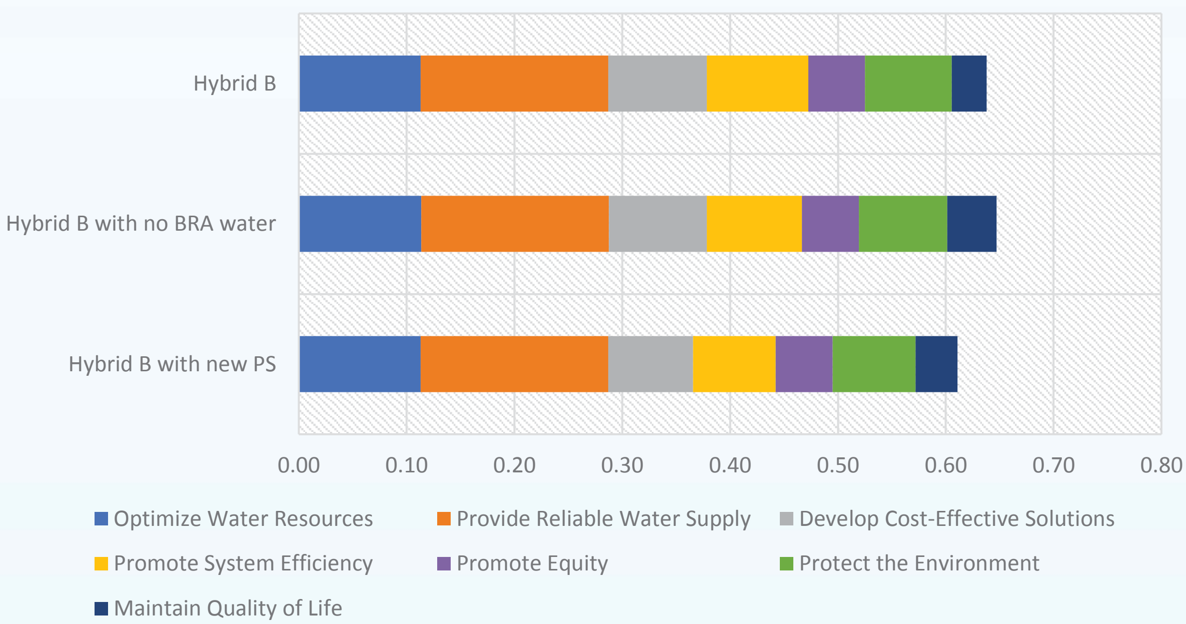


Figure 8-7. Scoring Sensitivity to Raw Water Supply Source

8.4.4 Reclaimed Water Options

Hybrid B includes expanded reclaimed water from the North WWTP and from the South WWTP. A sensitivity analysis was performed to also include the other reclaimed water options in the portfolio. This is shown in **Figure 8-8**. Inclusion of DPR decreases the total score, mainly due to cost consideration and implementation challenges. Inclusion of on-site reuse improves the score slightly while inclusion of wastewater scalping keeps the score nearly the same. However, the provided yield from on-site reuse of 0.04 MGD is so small that its role in achieving the regulatory targets is minimal. Thus, it is recommended to pursue on-site reuse as opportunities become available but not as a core component of the recommended portfolio. The same strategy of considering wastewater scalping as opportunities become available is also recommended.

Another sensitivity analysis was performed to include only one of the expanded reclaimed options instead of both. The result of this analysis is shown in **Figure 8-9**. Removing either of the expanded reclaimed options decreases the overall score. If only one expanded reclaimed option is prioritized for inclusion, expanding the system at the North WWTP scores better than inclusion of only the expansion at the South WWTP. There is more potential demand expanding the reclaimed system at the North WWTP since there is not a reclaimed water distribution system currently in place.

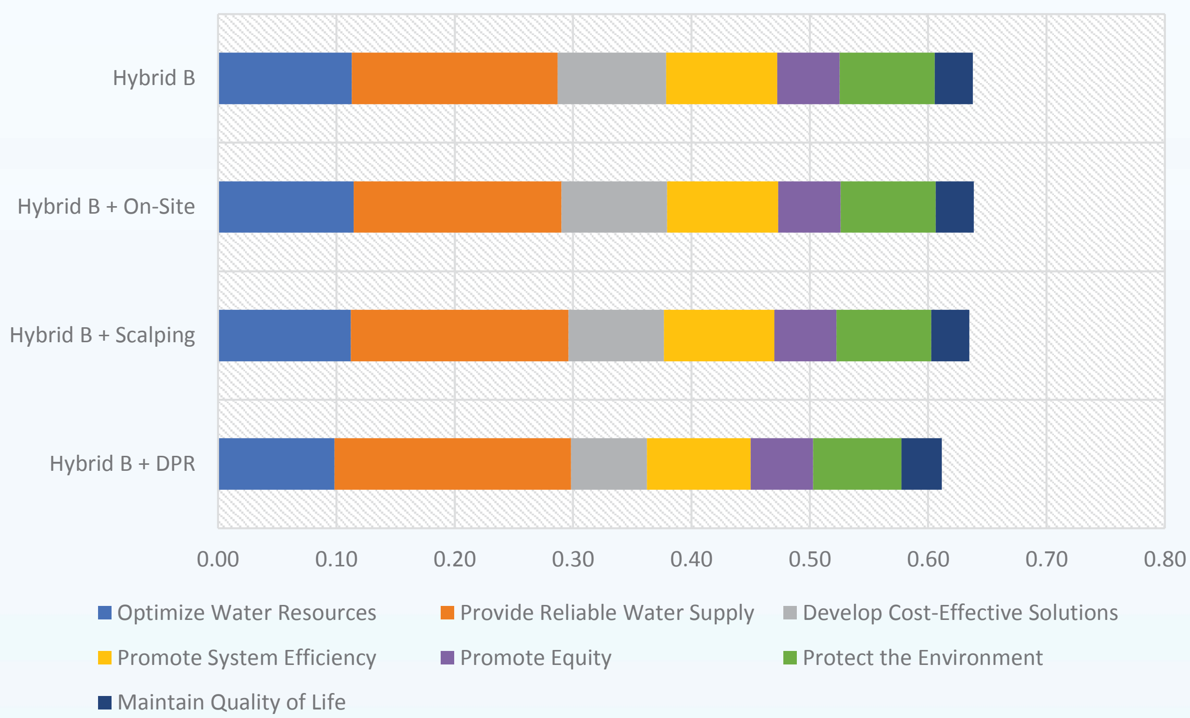


Figure 8-8. Scoring Sensitivity to Additional Reclaimed Options

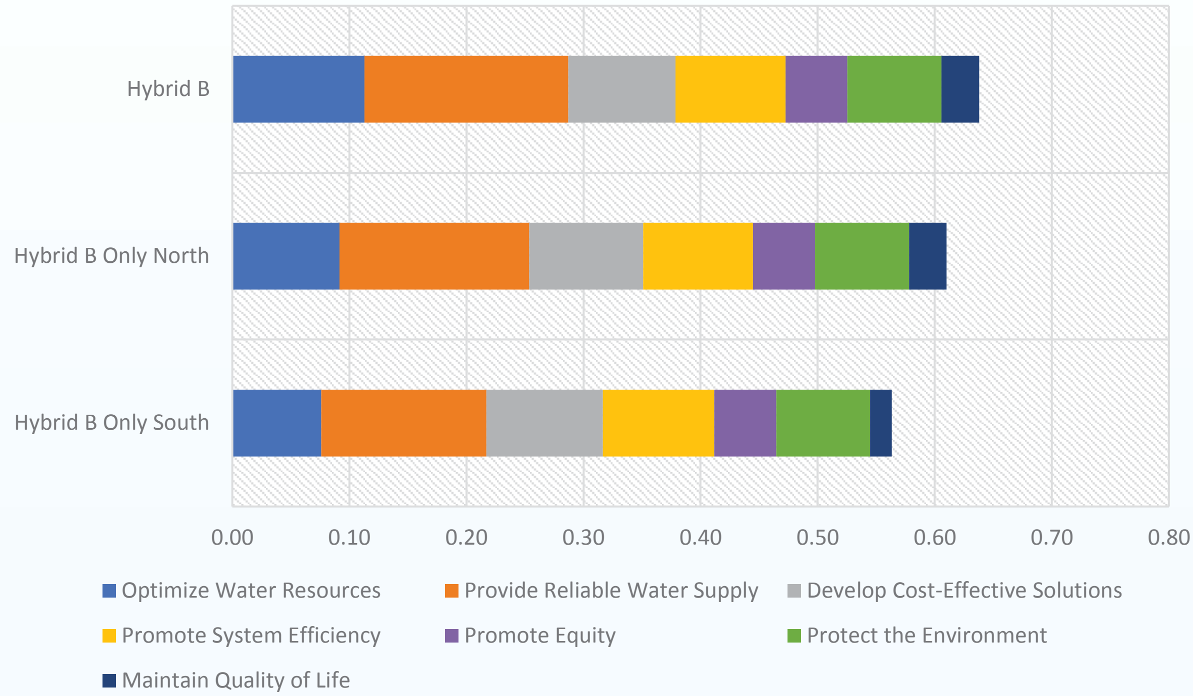


Figure 8-9. Scoring Sensitivity to Removing Expanded Reclaimed Options

8.4.5 Storage Options

Hybrid B does not include either of the storage options. A sensitivity analysis was performed adding these options to the portfolio. Results of the analysis are presented in **Figure 8-10**. Both storage options currently do not improve the scoring. The storage options allow better optimization of the current surface water contracts and provide increased drought reliability. However, this is balanced by implementation challenges, operational complexity, and potential environmental impacts. ASR may need to be reconsidered based on outcomes of ongoing studies by the Harris Galveston Subsidence District, which could clear up implementation challenges for FBSD as well thus improving the subsidence scoring metric for the option.

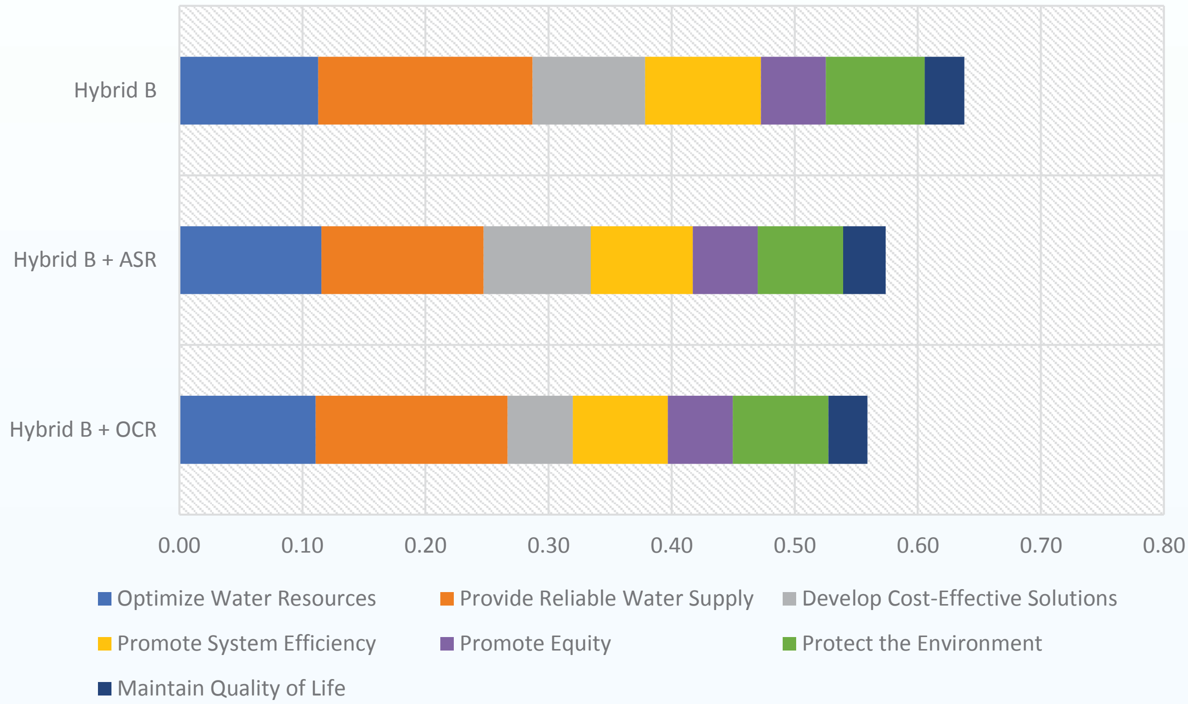


Figure 8-10. Scoring Sensitivity to Including Storage Options

8.4.6 Hybrid Sensitivity to Objective Weights

The weights of the objectives were varied to study the sensitivity of the analysis to the importance placed on each objective. The following alternative weights were investigated:

- **Cost weight doubled**: Under the current weighting, cost is 15 percent of the score. The weight of cost was increased to 30 percent while the other objectives were re-weighted proportionally.
- **Equal weights**: Each of the seven objectives was given an equal weight of 14.3 percent.
- **Only top four objectives**: Only the top four weighted objectives of optimize water resources, provide reliable water supply, develop cost-effective solutions, and promote system efficiency were included in the scoring, each at 25 percent weight.

Results are shown in **Table 8-6** and indicate that the ranking of the portfolios is robust against alternative weightings of the objectives. However, the top-ranked portfolio is sensitive to the weighting of cost, and this was further explored as recommendations were developed.

Table 8-6. Portfolio Total Scores and Rankings Under Different Objective Weights

Portfolio	Current Weighting	Cost Weight Doubled	Equal Weights	Only Top 4 Objectives
Low Cost	0.53 (5th)	0.58 (4th)	0.56 (5th)	0.51 (4th)
Non-Potable	0.56 (4th)	0.51 (5th)	0.58 (4th)	0.50 (5th)
SWTP 11 Only	0.63 (2nd)	**0.67 (1st)**	0.63 (2nd)	0.61 (2nd)
Hybrid A	0.57 (3rd)	0.62 (3rd)	0.61 (3rd)	0.56 (3rd)
Hybrid B	**0.64 (1st)**	0.64 (2nd)	**0.65 (1st)**	**0.62 (1st)**

8.5 Leading Portfolios

Based on the hybrid and sensitivity analyses, two leading portfolios were identified—Hybrid B and SWTP 11 Only. These portfolios are described in more detail in the following section.

8.5.1 Beneficial Options

The hybrid analysis determined a group of options that generally improve scores and aid the City in meeting their multiple IWRP objectives. On a purely scoring basis, the more options included in a portfolio, the better the total composite score. However, to meet the FBSD regulations, only a subset of these options is required. The two leading hybrids both contain a different subset of these recommended options (see **Table 8-7**) while scoring similarly.

Table 8-7. Beneficial Options and Inclusion in Leading Portfolios

Options Shown to Improve a Portfolio in Meeting the IWRP Objectives	Options in Hybrid B	Options in SWTP 11 Only
AMI	Yes	No
Water Loss Control	Yes	No
Conservation (Basic and Advanced)	Yes (Basic)	No
Expanded Reclaimed (North and South)	Yes (North and South)	No
SWTP Expansion (5.5 or 11 MGD)	Yes (5.5 MGD)	Yes (11 MGD)
Agreement to Pump BRA Water through GCWA	Yes	Yes
Credit Banking	Yes	Yes

8.5.2 Tradeoffs of the Leading Portfolios

The City staff and both task forces took a closer look at the assumptions, uncertainties, and risk inherent in both portfolios. As part of this process, a dashboard was created to compare not just the overall scores of each portfolio but some of the key performance metrics and supporting data. The dashboard for Hybrid B is shown in **Figure 8-11**, and the dashboard for SWTP 11 Only is shown in **Figure 8-12**.

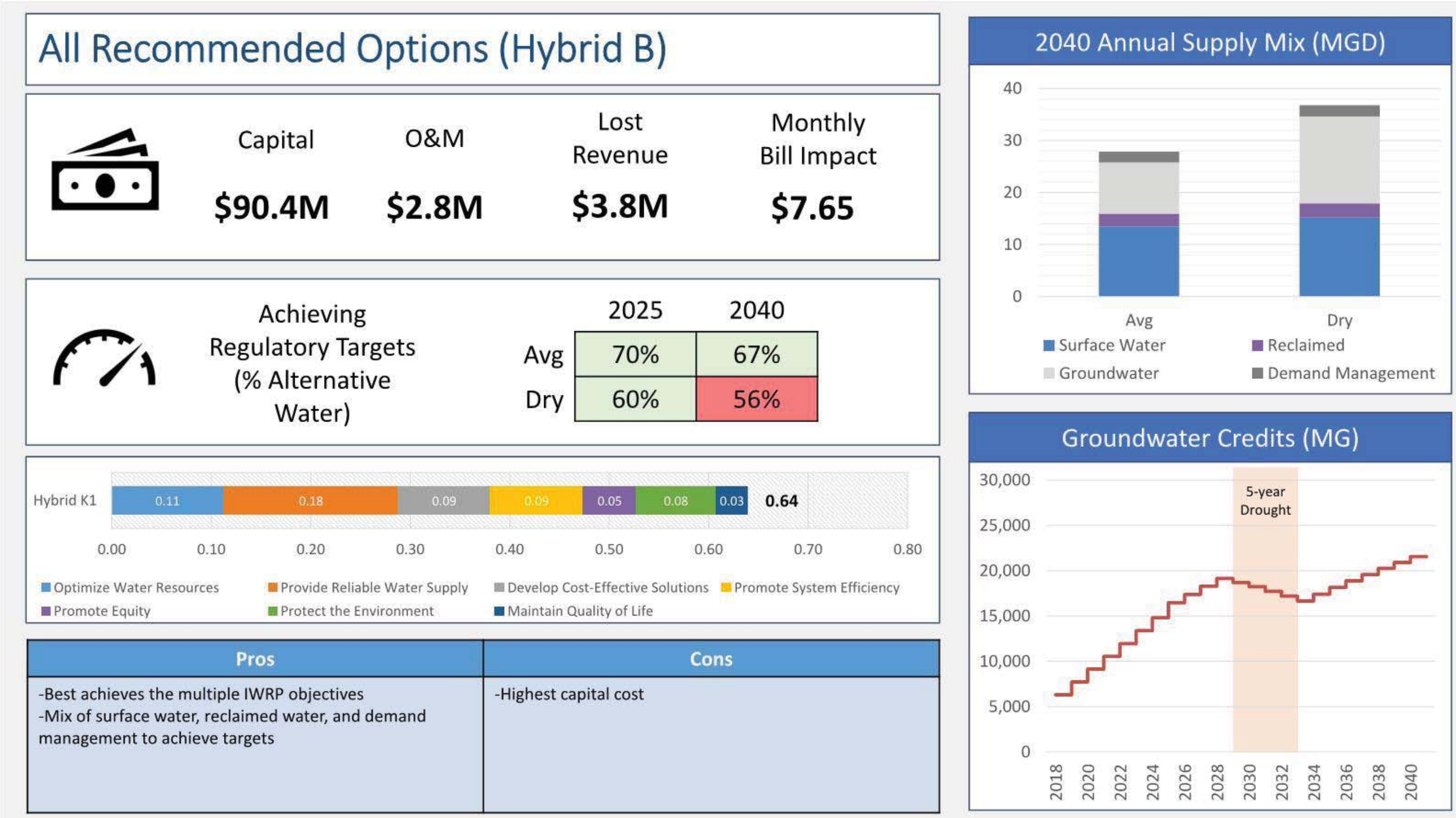


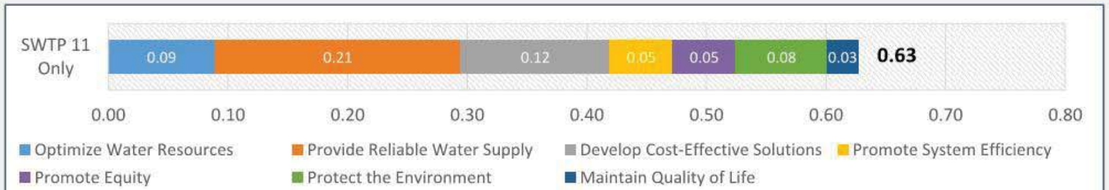
Figure 8-11. Dashboard for Hybrid B Portfolio

SWTP 11 Only

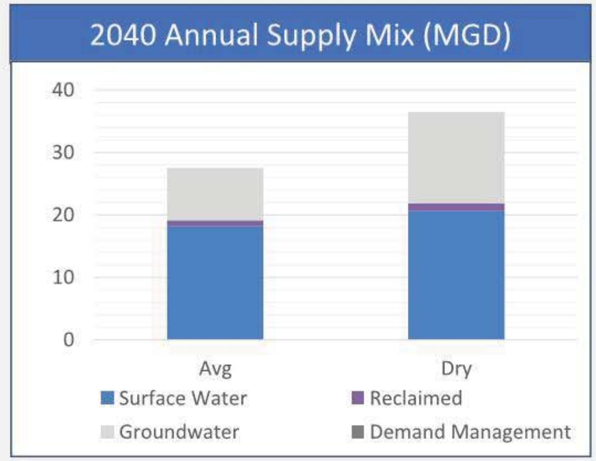
Capital	O&M	Lost Revenue	Monthly Bill Impact
$66.3M	$4.2M	$0M	$7.38

Achieving Regulatory Targets (% Alternative Water)

	2025	2040
Avg	75%	71%
Dry	66%	62%



Pros	Cons
-Meets regulatory requirement independent of weather	-No conservation initiatives to balance rate impacts -No increased use of non-potable water -Higher O&M costs -Full plant capacity only utilized during summers -Over-converted past regulatory target



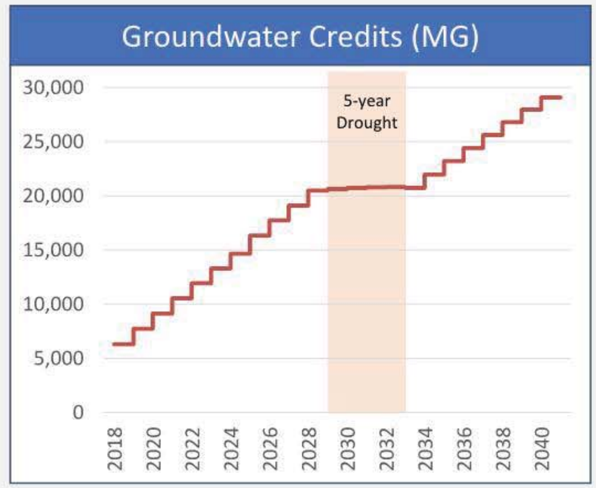


Figure 8-12. Dashboard for SWTP 11 Only Portfolio

While the two portfolios scored similarly, City staff along with both the Council and Citizen Task Force preferred the Hybrid B portfolio due to its increased diversity of supply sources. Moving forward with only the expansion of the SWTP would make the City solely reliant on the availability of surface water to meet the regulatory targets. The Hybrid B portfolio however balances continued reliance on surface water with an expanding role for reclaimed water use within the City as well as promotion of demand management options. Including reclaimed water as an alternative water supply strategy gives the City control over this new supply source and brings a new drought-resistant water supply to future customers. The diversified portfolio also has the advantage of focusing on improving system efficiency through AMI and water loss control initiatives. Overall, these benefits lead to the selection of Hybrid B as the preferred portfolio.

Figure 8-13 shows the projected new non-groundwater yield of options within the portfolio. In total, the recommended portfolio provides 9 MGD of yield through a mix of demand management and water supply options.

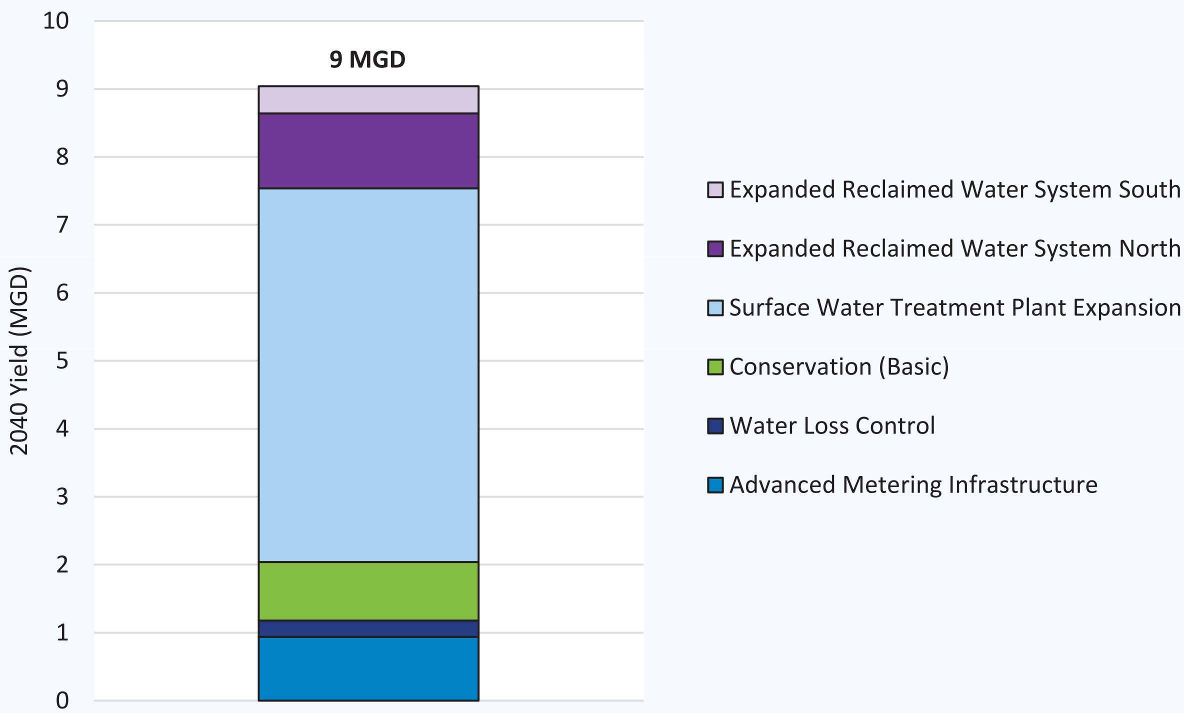


Figure 8-13. Recommended Portfolio (Hybrid B) New Non-Groundwater Yield

SECTION 9| RECOMMENDATIONS

The purpose of the IWRP was to identify the preferred combination of management strategies, policies, and capital projects that will provide both continued compliance with FBSD regulations and efficient use of the City's water resources. This section overviews the options included within the final recommended strategy and lays out a course for implementation.

9.1 Overview of Recommended Water Supply Strategy

The recommended IWRP strategy is based on the Hybrid B portfolio composition which was found to best meet the City's IWRP objectives based on both scoring and consultation with the Citizen and Council Task Forces. This portfolio includes a diverse mix of strategies for achieving regulatory compliance including increased use of surface water through a 5.5-MGD SWTP expansion, expanding the reclaimed water system, installing AMI, continuing to aggressively pursue water loss control, enacting multiple new conservation initiatives, negotiating an agreement with GCWA to pump BRA water, and continued use of credit banking (see **Figure 9-1**). Costs have been established for implementation of each of these recommended options; however, it is noted that this was completed on a planning level based on current cost of service and contractual and regulatory requirements.

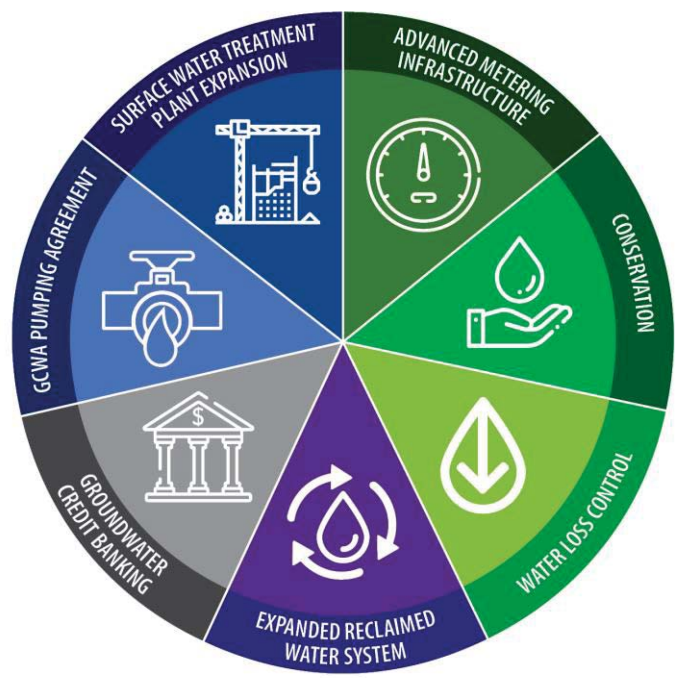


Figure 9-1. Recommended IWRP Options

Now that the recommended portfolio of projects has been identified, the next step of this process must be the completion of a rate study. This study should identify how these projects can be capitalized, provide an understanding of associated rate impacts, and establish final phasing so that the City may achieve their goals and objectives in a timely manner before the next FBSD regulatory deadline. During this rate study, the City may need to refine the anticipated phased project costs and timing to meet their community financial objectives. The rate study should consider groundwater pumpage, GRP fees, potential disincentive fees for delayed projects, and raw water rates. Additionally, the rate study should provide recommendations for the expanded reclaimed water system including potential connection fees and usage rates to allow the City to recover costs associated with implementing, operating and maintaining the expanded reclaimed water system.

Additional details on each of the recommended options has been provided in the following subsections. Each option includes a text box highlighting its expected yield as well as the annual cost. The annual cost includes annualized debt payments on the capital costs, annual O&M, as well as New proposed infrastructure for the 5.5-MGD SWTP expansion and expanded reclaimed systems is shown in **Figure 9-2** as well as the areas to be targeted for AMI installations and conservation initiatives.

9.2 Implementing the Recommended Options

9.2.1 AMI

Implementation of AMI requires multiple pieces of infrastructure including new meters, meter communication networks, AMI software, data management system and an analytics portal.. The AMI network should be integrated into the City's utility billing system in order to take full advantage of the benefits rendered by AMI.

AMI

Yield	0.94 MGD
Annual Cost	$2,321,000

It is recommended that AMI be implemented across the entire City service area to maximize benefit to the community and capitalize on the data analysis capabilities for more efficient utility operations. There are two infrastructure components to the AMI project: the replacement of old meters and the installation of a meter communication network. The City can phase the program to maximize data collection capabilities and defray large capital expenditures for full meter replacement across the City. This could be accomplished via (1) prioritizing meters to be replaced in a phased approach across the City, (2) completing the initial phase of meter replacement as budget allows focused on older or problematic meters, the (3) retrofitting any remaining existing meters with meter interface units to allow for immediate data collection until those meters are scheduled to be replaced in the future.

9.2.2 Water Loss Control

Before beginning the IWRP process, the City already had an aggressive water loss control strategy including audits every three years and implementing recommendations from those audits. The IWRP water loss control strategy builds upon the City's current efforts, providing a cost-effective strategy for reducing water demand and improving efficiency of available water resources. The IWRP recommends several water loss control steps in addition to the continued program in the five- to ten-year time frame. The first step is to develop metered areas of 1,000 to 3,000 customers to improve water loss tracking between the City's water treatment plants and the City's customers. Secondly, the IWRP recommends developing a large-user meter assessment program and demand profile for these meters. Finally, it is recommended that the City conduct a strategic leak detection program. These steps will synergize with the continued roll out of the AMI program and the City's current water loss control strategies being performed in the interim.

Water Loss Control

Yield	0.24 MGD
Annual Cost	$98,000

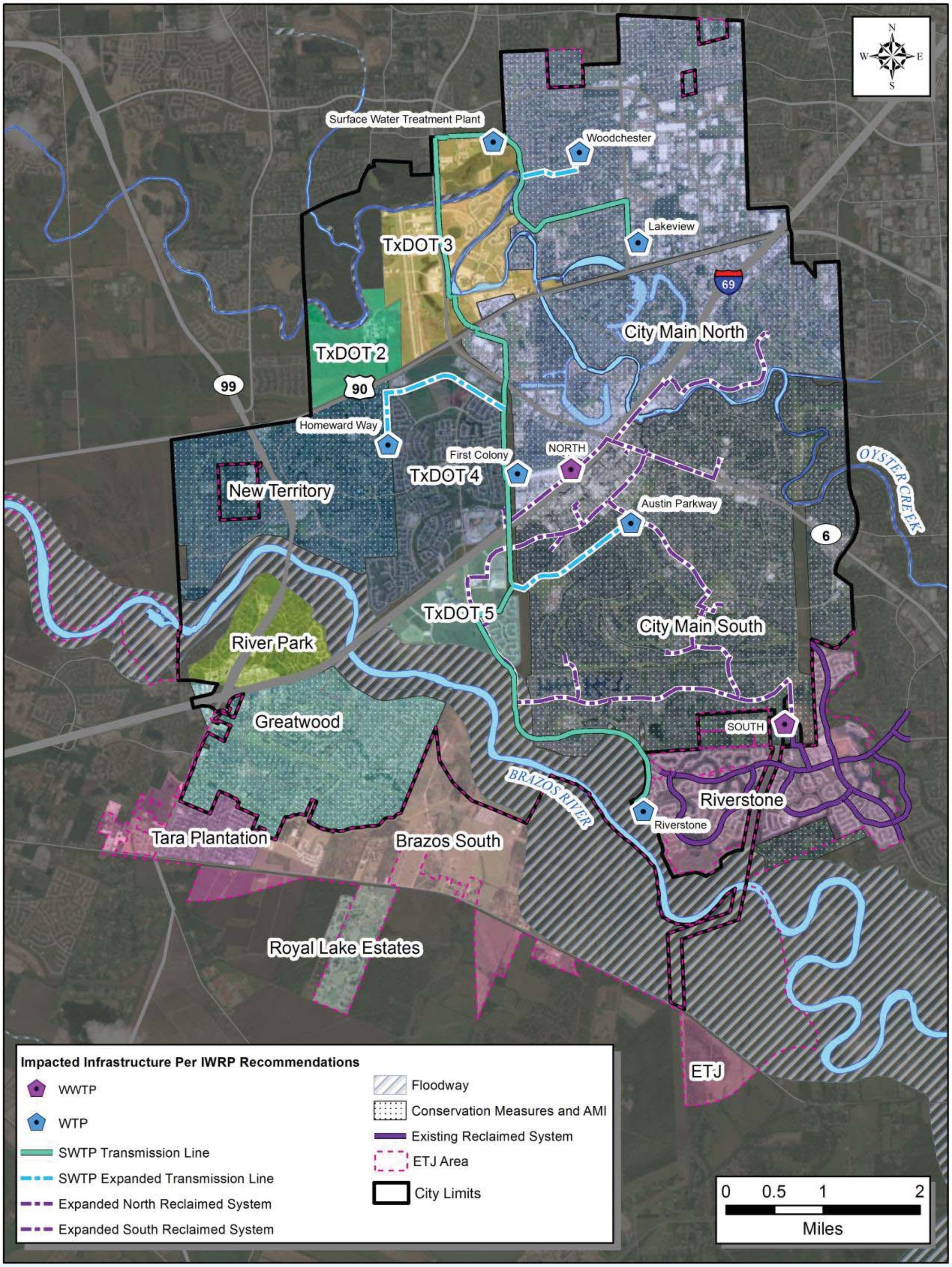


Figure 9-2. Locations of Recommended IWRP Options

9.2.3 Conservation Rebates (Basic)

Conservation Rebates	
Yield	0.86 MGD
Annual Cost	$2,013,000

The recommended basic conservation program builds on measures the City is already doing, such as WaterWise education kits and irrigation audits, while developing a new rebate program that would reimburse customers for implementing certain conservation practices such as purchasing and installing low flow water fixtures or high efficiency (low water usage) appliances. The basic conservation program pairs well with AMI implementation as it allows customers the opportunity to track their water use in real time and see how conservation practices can help save overall water use and lower their monthly bills.

The benefits of conservation are highly dependent on customer participation. WaterWise kits are only effective if their contents are installed inside the home. A rebate program is successful if customers choose to purchase water efficient household fixtures. It will take time for promotion of the new conservation initiatives and starting earlier will allow participation to ramp up prior to the 2025 regulatory deadline.

9.2.4 Expanded Reclaimed System (North and South)

Expanded Reclaimed North	
Yield	1.1 MGD
Annual Cost	$1,944,000

The Reclaimed Water Supply Study identified several large potential reclaimed water customers in the US-59/I-69 highway corridor. Servicing these customers would require expansion of the City's reclaimed water system with additional treatment and distribution from the North WWTP. The proposed conceptual layout includes reclaimed water trunk lines extending from the North WWTP in opposite directions along US-59/I-69 and branching out to customers. The exact locations and capacities of facilities are contingent upon customer interest and potential reclaimed water usage. As the City invest in an expanded reclaimed water system, development of reclaimed water policies and guidelines is necessary. Policies on requesting service, requiring service for large users within a certain distance of the reclaimed water distribution system, reclaimed customer contract provisions, cross-connection control requirements, and requirements for reclaimed water usage in new development areas should be established.

Expanded Reclaimed South	
Yield	0.4 MGD
Annual Cost	$1,201,000

The South WWTP has an existing 2-MGD reclaimed water system which supplies reclaimed water to the Riverstone area. It is recommended that the capacity of the system be expanded to serve additional customers. This option is prioritized lower than expansion of the north system due to fewer opportunities for additional reclaimed water demand.

Depending on the constructed extent of the reclaimed water system in the north, an interconnection between the two systems can also be considered during the south system expansion. Having an interconnect would increase the reliability of reclaimed water by allowing either plant to serve a portion of the demands

9.2.5 Expansion of the SWTP by 5.5 MG

SWTP Expansion	
Yield	5.5 MGD
Annual Cost	$5,985,000

The expansion of the SWTP by 5.5 MGD provides the majority of the yield required to achieve the 60 percent non-groundwater supply goal, and therefore, the City should strive to make this expanded facility operational by 2025 to meet FBSD's increased regulatory requirements. The recommended 5.5-MGD expansion would increase the plant capacity to 16.5 MGD and, if required, still allow for a final expansion to the full 22-MGD capacity at a later date.

To utilize the expanded water production at the SWTP, an expansion of the surface water transmission system is also required. The initial plan includes an expansion of the transmission system to Austin Parkway, Woodchester and Homeward Way groundwater plants for blending with treated groundwater and delivery into the distribution system; however, this will be subject to confirmation in a future routing study.

9.2.6 Access to Brazos River Water

In order to expand the SWTP and have sufficient water during times of drought, the City needs additional surface water to be available in Oyster Creek. The recommended method to obtain this surface water is to negotiate a long-term pumping agreement with GCWA to deliver the City's BRA contract water from the Brazos River to Oyster Creek through the existing GCWA infrastructure. An agreement must be reached prior to the 5.5-MGD SWTP expansion in order to achieve full benefits of the expansion.

9.2.7 Credit Banking

The IWRP showed that over-conversion credits can provide a significant value to the City; and this plan recommends that the City develop a policy on accrual of credits to a defined amount to hold or "bank" for risk mitigation purposes. While the policy is being developed, it is recommended that the City continue to operate the SWTP and reclaimed water system with a focus on gaining over-conversion credits, as well as WaterWise education credits, prior to the regulatory targets increasing in 2025. After regulatory targets increase in 2025, it is recommended that the City consider prioritizing use of non-groundwater sources when they are available, even if this causes over-conversion above the required targets up to the targeted credit amount per the City's policy. Credits can be redeemed in the future to meet alternative water requirements in years when alternative water use may fall short of the regulatory targets. The City may also wish to establish provisions for the potential sale of excess credits in the new credit policy.

9.3 Implementation Timeframes

Implementation of the recommended IWRP Strategy has been divided into three planning horizons; near-term (less than five years), medium-term (five to ten years), and long-term (ten years and beyond). Proposed phasing has been presented on the following pages in **Figure 9-3** and **Table 9-1**.

Figure 9-3. Proposed Implementation Schedule

Table 9-1. Option Implementation Actions per Planning Horizon

Planning Horizon	Task	Start Year	Completion Year	Applicable Option
Near Term	Conduct a detailed rate study for City utility customers, GRP participants, and potential reclaimed water customers.	2019	2020	All
	Update current Capital Improvement Plan and Water and Wastewater Master Plans to include recommended IWRP strategies.	2019	2020	All
	Continue current water loss control program and address deficiencies identified via the existing program.	2019	Continual	Water Loss Control
	Continue current conservation education and audit programs.	2019	Continual	Conservation
	Negotiate pumpage of BRA contract water from Brazos River with GCWA.	2019	2020	SWTP Expansion/Access Brazos River Water
	Evaluate current and potential contracted water supplies (i.e. expiration of GCWA option water and new water available from BRA)	2019	2020	All
	Develop groundwater credit policy including establishing a defined amount to hold for risk mitigation purposes	2019	2020	Credit Banking
	Develop reclaimed water policy for new service, connection fees, usage rates, contract provisions, service areas, etc.	2019	2020	Expanded Reclaimed North and South
	Complete routing study to confirm feasibility of recommended expansion of the surface water transmission system to additional groundwater plants.	2020	2020	SWTP Expansion
	Develop and roll-out new conservation initiatives including enhanced education and outreach as well as rebate program for rain barrels, smart irrigation controllers, water efficient household fixtures, and high efficiency washing appliances.	2020	2025	Conservation
	Initiate pilots/studies for additional water loss control measures such as developing a large meter user assessment program and piloting a strategic leak detection program.	2020	2025	Water Loss Control
	Complete preliminary design, final design, and construction of the SWTP expansion and associated transmission system improvements.	2020	2025	SWTP Expansion
	Procure and install AMI system including system design, installation of necessary new meters, and installation of meter interface units.	2023	2025	AMI
	Outreach to potential reclaimed water users for both the North and South systems to garner interest in program and establish project start dates.	2020	2030	Expanded Reclaimed North and South

Table 9-1. Option Implementation Actions per Planning Horizon (Cont.)

Planning Horizon		Task	Start Year	Completion Year	Applicable Option
Medium Term		Continue AMI meter replacement and gather AMI data for informed utility operations and maintenance.	2026	Continual	AMI
		Incorporate AMI data into the City's water loss control strategy.	2026	Continual	AMI/Water Loss Control
		Complete preliminary design, final design, and construction of the Reclaimed North System expansion.	2026	2030	Expanded Reclaimed North
		Initiate a formal IWRP update based upon latest regulatory plan update and what conversion has been achieved as of the 2025 deadline.	2026	2027	IWRP Progress Tracking
Long Term		Complete preliminary design, final design, and construction of the Reclaimed South System expansion.	2031	2034	Expanded Reclaimed South
		Complete a formal IWRP update	2036	2037	IWRP Progress Tracking

The recommended implementation strategy is able to achieve the regulatory targets under average weather conditions. **Figure 9-4** shows model results for the percentage of water demand the City can meet with alternative water supplies based on the outlined implementation strategy.

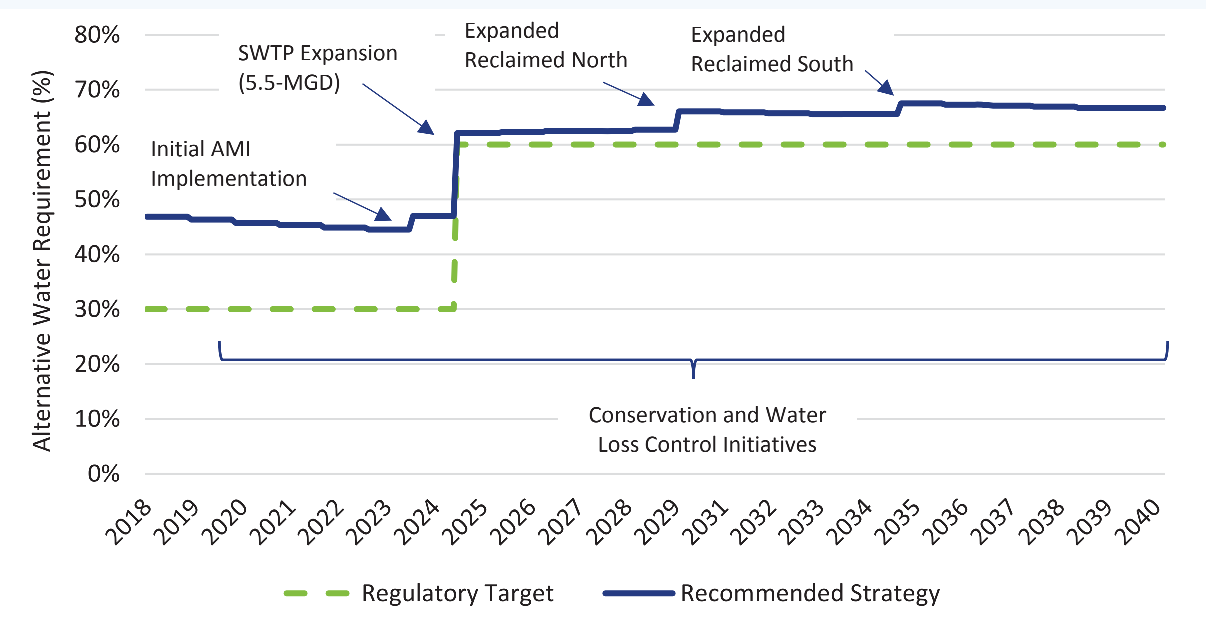


Figure 9-4. Achieving the Regulatory Targets with the Recommended Strategy

9.4 Adaptive Management

While recommendations for the timing of various infrastructure is provided above, it is recognized that the implementation strategy should be adaptive and flexible to future changes. Potential disrupters to the plan should be monitored such as changes to the assumptions utilized in the analysis, regulatory drivers, changes in water demands, development/growth, and other factors so that the plan can be adapted as needed. If disrupters are encountered, the IWRP allows for an incremental and flexible approach to overcoming these disrupters, such as having projects be sped up or slowed down. Additionally, credits can be redeemed to meet the regulatory requirements if projects are delayed or the availability of alternative water supply sources is temporarily reduced. If conditions change dramatically, the City also has the other analyzed water supply options at their disposal. A list of some current uncertainties and potential adaptation strategies are presented in **Figure 9-5**.

UNCERTAINTIES

- Increased or decreased predicted rate of development
- Adding or losing GRP participants
- Reduced or accelerated reclaimed water demand from anticipated users
- Interest in reclaimed water from potential neighboring communities or industries
- Increased or reduced rate of assumed conservation participation
- Adjustments to regulatory requirements
- Occurrence of prolonged drought
- Changes to pricing assumptions

STRATEGIES

- Fast track or pause expanded reclaimed water supply projects
- Use banked credits
- Expand the SWTP to full 22-MGD capacity
- Implement conservation ordinances
- Reconsider on-site reuse as opportunities arise
- Reconsider ASR and brackish groundwater desalination based on additional FBSD guidance
- Utilize DSM for analysis of other potential options

Figure 9-5. Adaptive Management Techniques

9.5 Moving Forward

To proactively plan for future FBSD regulations and continue to invest in the City's water resource management, the City initiated the development of the IWRP. Shown on **Figure 9-6** is the year 2040 modeled water use with status quo conditions and the preferred strategy. By 2040, the worst-case scenario out-of-compliance deliveries reach 9.5 MGD during a dry year. With the current FBSD disincentive fee considered, this equates to a financial penalty of up to $22 million per year. However, because of the City's goal to maintain a financially and environmentally responsible community, this financial penalty can be avoided. Instead, a robust preferred strategy will be used moving forward enabling the City to honor its commitment to excellence in the delivery of public service.

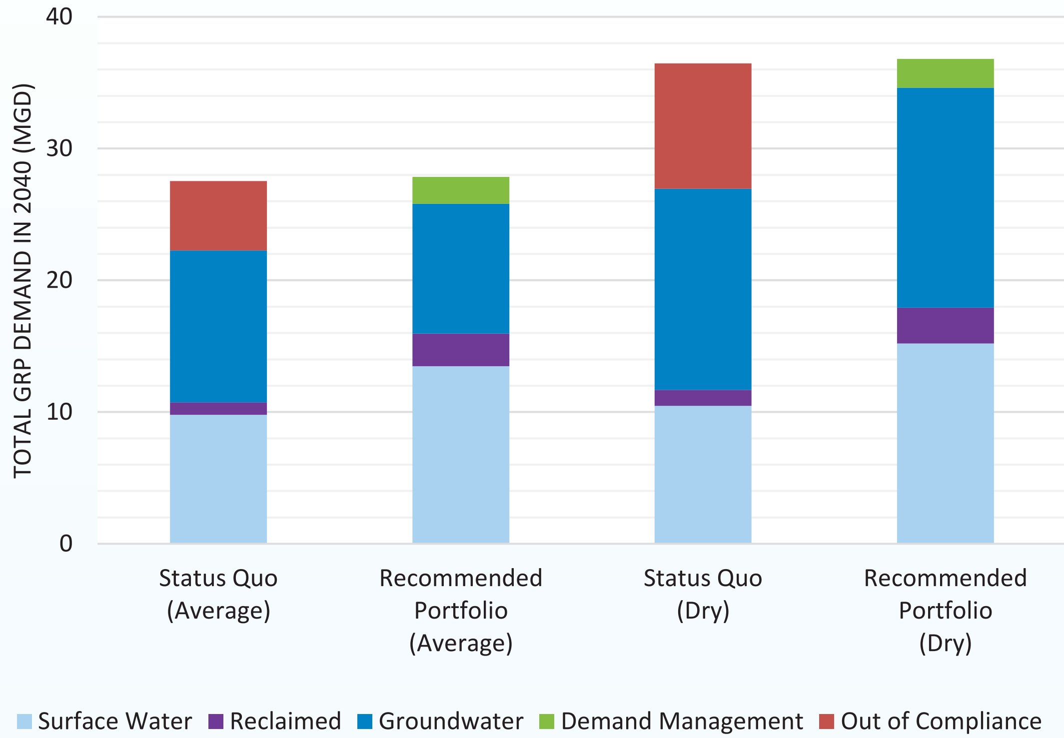


Figure 9-6. Status Quo versus Preferred Strategy in 2040

By undergoing the IWRP process, the City is building upon a history of proactive water resource management for its citizens. The City staff, the Citizen and City Council Task Forces, and the consultant team rigorously worked for over two years to cast and develop a cohesive vision for the Sugar Land community. From start to finish, the IWRP characterized the City's entire water infrastructure, formulated and weighted guiding objectives, conceptualized fifteen water supply options with several sub options, created a DSM with thousands of pieces of programming logic, quantified the City's future water supply needs, developed and evaluated over 35 unique portfolios, and laid a solid foundation for the City and its citizens to advance into the future with confidence.