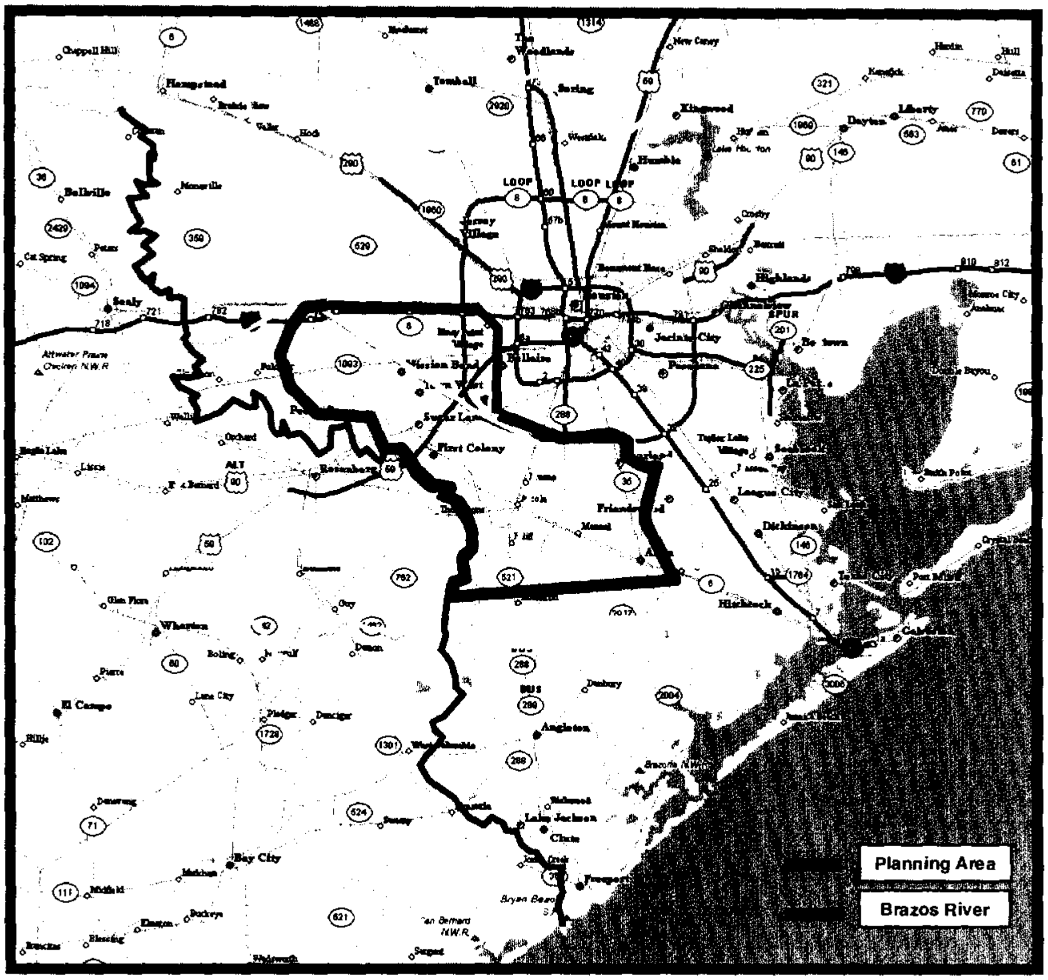


Regional Surface Water Plant Feasibility Study
for
Brazoria, Fort Bend, and West Harris Counties

Fort Bend WCID No. 2

Friendswood

Pearland

Alvin

Arcola

Missouri City

Houston

Manvel

Sugar Land

2000-483-329, FINAL

November 2000

GULF C
WATER AU

TEXAS WATER
DEVELOPMENT BOARD

Acknowledgements

The preparation of this report would not have been possible without the assistance and full cooperation of the Gulf Coast Water Authority, Texas Water Development Board, and the Participating Utilities. Special thanks are extended to the Gordon Myers, Robert Istre, Nancy Matthews, and David Sauer of the GCWA and Ernest Rebuck of the TWDB for coordinating this project and spearheading the planning effort for surface water conversion in Fort Bend, Brazoria, and West Harris County.

Additional, each participating team member deserves special thanks for providing information and guidance over the direction of the planning efforts and for thinking regionally and acting locally.

<u>Participating Utility Team Members</u>

Dick Carter, City of Alvin

Jun Chang, City of Houston

Howard Christian, City of Sugar Land

Lee Dorger, City of Missouri City

Kaz Hamidian, City of Friendswood

Owen Matherne, Fort Bend WCID No. 2

Melvin Meinecke, City of Friendswood

Michael Ross, City of Pearland

Dale Rudick, City of Sugar Land

Wayne Sabo, City of Manvel

Chuck Settle, City of Houston

Tommy Haynes, City of Sugar Land

SuEllan Staggs, City of Sugar Land

Montgomery Watson Americas, Inc. is responsible for the completion of this report. Team members include Todd Larson P. E., John D'antoni P.E., Bob Higgins P.E., Gary Rabalais P.E., Chris Canonico, and Mari Garza.

Regional Surface Water Plant Feasibility Study
for
Brazoria, Fort Bend, and West Harris Counties

Fort Bend WCID No. 2

Friendswood

Pearland

Alvin

Missouri City

Houston

Sugar Land

Manvel

Arcola

November 2000

Gulf Coast Water Authority

Montgomery Watson

Texas Water Development Board

Table of Contents

Table of Contents

Tables

Figures

Behind or on Page

Faced with a growing potable water demand and the regulations limiting pumping from the underlying groundwater aquifer, nine water utilities in the Brazoria, Fort Bend, and Harris County region have formed a partnership with the State of Texas and Gulf Coast Water Authority to evaluate the feasibility of constructing and operating a regional surface water treatment facility. This study reports on the findings of the constructability, feasibility, and preliminary cost of a proposed regional surface facility and associated raw and finished water delivery improvements.

The primary water supply for residents of western Harris County, Fort Bend County, and northern Brazoria County continues to be the Evangeline and Chicot aquifers. Subsidence due to extensive groundwater pumping will eventually result in flooding and property damage in these areas unless restrictions are placed on groundwater use. Additionally, the extensive pumping of water from the aquifers has also led to a decrease in level of the water table. As the level drops, many well owners have been forced to lower their wells or find alternative sources of water. In addition, decreases in piezometric heads are often associated with a decrease in water quality. As the water level drops, the salinity and TDS levels in the aquifer increase.

As a result of these problems, the Harris-Galveston Coastal Subsidence District (HGCSD) and Fort Bend Subsidence District (FBSD) were created by the Texas Legislature. Both districts have the authority to regulate the withdrawal of groundwater to mitigate subsidence and falling water table levels. The HGCSD has adopted three regulatory plans beginning in 1976. The initial plan focused on having an immediate impact in the area where the most subsidence had taken place and where surface water was available as an alternative to groundwater. Subsequent plans have focused an overall goal of changing primary water usage from groundwater to surface water in a series of steps. In April of 1999, the HGCSD issued a revised District Regulatory Plan (DRP) with an overall goal to reduce groundwater withdrawal to no more than 20% of total water demand. In December of 1999, the HGCSD established a disincentive fee for not complying with the DRP. The FBSD is in the process of developing a DRP and should release a draft rule by the end of the year 2000. This plan may have a disincentive fee structure to reduce the groundwater withdrawal in Fort Bend County. It is anticipated that the rules promulgated for Fort Bend County will be similar to those for Harris and Galveston Counties.

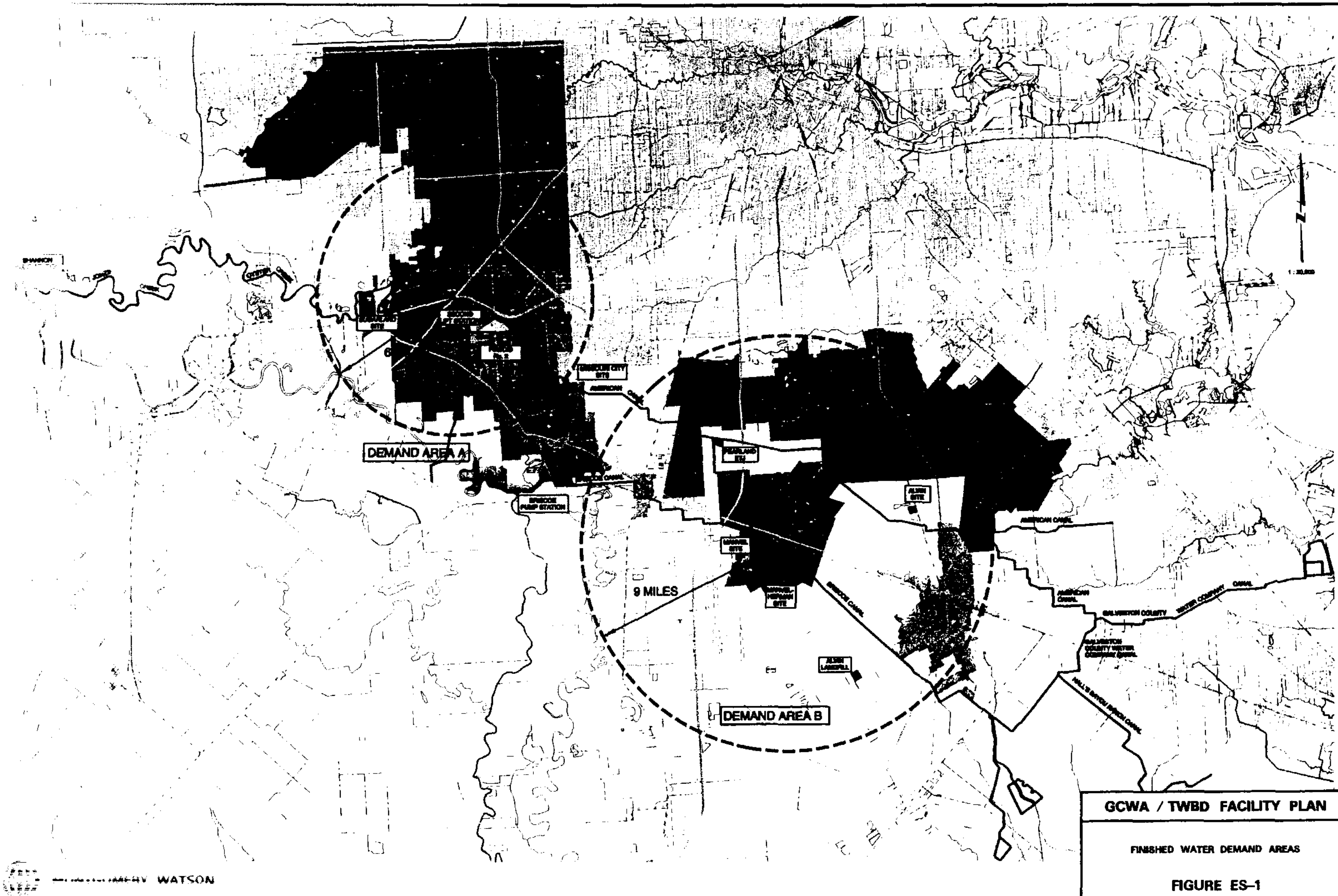
To comply with these rules, the municipalities and industries currently using groundwater will be required to use surface water as their primary supply. The costs of this conversion to surface water will be significant and every Municipal Utility District (MUD), Water Control and Improvement District (WCID), or municipality in western Harris County and Fort Bend County will have to share in this expense regardless of the size of their utility. A regional surface water plant may be a viable and economically attractive alternative to supply water to this region.

SCOPE

This study was authorized to investigate the feasibility of constructing a regional surface water plant, including an analysis of the surface water treatment alternatives and site locations. Through this study, the estimated cost to plan, design, construct, operate and maintain a regional surface water treatment plant, complete with raw water delivery and finished water transmission, was determined. This study started with the development of the projected water demand for nine Participating Utilities and culminates with a facility plan of the proposed facilities necessary to satisfy this water demand through the year 2050 through a mix of groundwater and treated surface water.

BACKGROUND

The planning area, shown on **Figure ES-1**, for this study encompasses portions of Harris County, Fort Bend County, and Brazoria County. Water utilities located in the planning area were contacted regarding



GCWA / TWBD FACILITY PLAN

FINISHED WATER DEMAND AREAS

FIGURE ES-1

MONTGOMERY WATSON

their interest in participating in a regional surface water plan and nine utilities elected to be part of this regional planning effort. The Participating Utilities are:

- City of Alvin
- City of Arcola
- City of Friendswood
- City of Houston
- City of Manvel
- City of Missouri City
- City of Pearland
- City of Sugar Land
- Ft. Bend WCID No. 2 (FBWCID No.2)

The closest raw surface water source to this region is the Brazos River, which traverses much of Fort Bend and Brazoria County. The State of Texas, through the Brazos River Authority (BRA), currently allocates water from the Brazos River for agricultural, industrial, and municipal needs through water permits. The Gulf Coast Water Authority (GCWA), a political subdivision of the State of Texas has legal authority to plan, develop, and operate regional water facilities, currently holds the most senior water permits in the Lower Brazos Basin and operates raw water canals which carry Brazos River water through the planning area. The GCWA can draw on these permits to provide raw water for the regional water plant. The GCWA currently operates two raw water canals from the Brazos River to Galveston County to serve existing industrial, municipal, and agricultural customers. The GCWA canal system is shown on **Figure ES-1**. The American Canal is supplied with water from the Brazos River at the Shannon Lift Station that flows through Jones and Oyster Creek before the 2nd Lift Station in Sugar Land lifts water to the manmade portion of the American Canal. The Canal meanders from Sugar Land through Brazoria County until it reaches the Galveston County Reservoir. The Briscoe Canal is supplied water from the Brazos River at the Briscoe Lift Station and transports the water by gravity through Brazoria County to the Galveston County Reservoir. Lateral 10 connects the two canals at State Highway 288.

SURFACE WATER CONVERSION

Conversion to surface water from groundwater is driven by increasing regulations aimed at reducing groundwater production to mitigate subsidence and an ever-present increasing water demand. As subsidence rules are promulgated and implemented and demand grows, the availability of groundwater will become limited. Mitigation of this limitation may be achieved through the use of surface water as the raw water source. A review of the surface water conversion drivers is as follows:

Subsidence Regulations

Many of the Participating Utilities involved in the planning study fall under the jurisdiction of the Harris-Galveston Coastal Subsidence District (HGCSD) and Fort Bend Subsidence District (FBSD). The HGCSD has issued regulations limiting the withdrawal of groundwater from the aquifer based on the geography of the district. The HGCSD is broken into three regions, of which the planning area for this project falls into HGCSD Region 2 and 3. The rules for HGCSD Region 2 mandate conversion of 80 percent of the water demand to surface water by the year 2010 and in HGCSD Region 3 groundwater pumping must be reduced to 70 percent by 2010, 30 percent by 2020, and 20 percent by 2030. The FBSD is scheduled to promulgate rules in the fall of 2000. These rules are expected to be similar to the HGCSD rules.

Water Demand

The Participating Utilities estimate that the portion of their utilities in the planning area have a current population of 603,000 and an average daily water demand of 74.9MGD. Over the next 50 years, the population of the Participating Utilities in the planning area and water demand are projected to grow to 807,000 and 187.9 MGD. This represents a 240 percent increase in water demand and will require a significant conversion to surface water.

FACILITY DEMAND

To serve this growing demand and meet projected groundwater withdrawal regulations, the Participating Utilities will need to provide 80 percent of the average annual water demand with surface water. The remaining 20 percent of the water demand will be met through groundwater facilities at each of the Participating Utilities. The phasing of the conversion to surface water is dependent of the shape of the FBSD regulations and the overall regional groundwater management plan for HGCSD Region 2 and 3. For the purposes of this study, it was assumed that the surface water conversion would be required by the year 2010 and groundwater production would be limited to 20 percent of total demand.

The Participating Utilities agreed to develop this facility plan based on a plant that delivers a fairly constant supply of surface water and to augment this supply with groundwater from their wells during high demand periods. The Participating Utilities will activate their wells during times when the water demand exceeds 80 percent of their average annual demand. Peak hour demands will be met through use of the Participating Utilities individual storage capacity. Each participating utility noted that they would expand their existing well and storage facilities to meet future peak flow demands in lieu of drawing additional water from the surface water plant.

Given these assumptions, the Planning Area surface water treatment demands are as follows:

TABLE ES-1
PLANNING AREA SURFACE WATER DEMAND

Year	Surface Water Demand (MGD)
2010	83
2020	102
2030	118
2040	135
2050	150

The majority (75 percent) of the total Participating Utility water demand is for the City of Houston, City of Sugar Land, FBWCID No. 2, and City of Missouri City. The demand for these four utilities is located within a 6 mile radius of the intersection of Beltway 8 and Interstate 59 in Sugar Land, Texas. This area is called Demand Area A. The remaining 25 percent of the water demand for the City of Arcola, City of Pearland, City of Friendswood, City of Alvin, and the City of Manvel is located within a 9 miles radius of the intersection of Hwy 6 and Masters Road in Manvel and is called Demand Area B. The two demand areas are located approximately 18 miles apart and are shown on **Figure ES-1**.

Strategic locations for regional surface water treatment facilities were investigated in Demand Area A and B. Locations in Manvel and Alvin were investigated to serve Demand Area B and locations in Sugar Land and Missouri City were investigated to serve Demand Area A. The locations within Demand Area A were also evaluated to serve the entire study area with a single regional water treatment facility.

TAKE POINTS

As a wholesale provider of raw and potable water, GCWA will contract with each participating utility to deliver water at specified "take points". Take points are defined as the end point at which the GCWA will transport potable water to the Participating Utilities. At each of these take points, a flow meter will be installed to record and monitor the total flow delivered to each participating utility. From this point on, the participating utility will be responsible for operation and maintenance of the water distribution system.

Each participating utility provided the physical address, desired water pressure, and expected water demand at each preferred "take point". The City of Houston, City of Missouri City, and the City of Sugar Land requested GCWA to deliver water to existing ground storage tanks. These utilities will boost the water from the ground storage in to the distribution system. The remaining six Participating Utilities requested finished water at a minimum system pressure in order to directly pressurize the system from the regional water treatment plant high service pump station.

The take points with pressure requirements and flow demands are tabulated in **Table ES-2**.

TABLE ES-2
REQUESTED FLOW AND PRESSURE AT UTILITY TAKE POINTS

Utility	Take Point Name	Average Water Demand (mgd)	Pressure Requirement (psi)	Ground Elevation At Take Point (ft)	Tank Height (ft)
City of Houston	Bellaire Braes PS	59.20	Fill Tank	80	25
City of Sugar Land	First Colony	17.47	Fill Tank	80	23.5
	Lakeview	11.65	Fill Tank	68	23.5
City of Missouri City	Quail Valley	8.46	Fill Tank	65	25
	Sienna Plantation	8.46	Fill Tank	60	25
FBWCID No. 2	Site B	5.00	60	80	-
	Avenue E	5.00	60	75	-
City of Pearland	SH 288	7.19	50	60	32
	SH 35	7.19	50	40	32
City of Manvel	Site E	3.52	50	55	-
City of Arcola	Town Center	0.13	Fill Tank	63	16
City of Alvin	Bypass 35	5.60	65	35	-
City of Friendswood	West Friendswood	5.71	65	35	-
	SW Friendswood	5.71	65	35	-

Preliminary Water Plant Locations

The Participating Utility Team reviewed the planning area in search of alternative treatment plant locations that met established minimum acreage requirements. In sum, eight preliminary sites were identified. After careful evaluation by the Participating Utility Team, several potential water plant sites were eliminated from consideration based on the following criteria: proximity of the proposed plant site to the demand, proximity of the proposed plant site to the raw water source, and acreage of the proposed plant parcel. The Participating Utility Team selected sites that were adjacent to a GCWA raw water canal minimizing raw water conveyance pipelines, centered to a demand area to minimize finished water pipelines, and with sufficient acreage to support a regional water treatment plant.

After this preliminary screening, the following four potential water treatment sites remained:

- Sugar Land – Hwy 90 and Hwy 6 in Sugar Land,
- FBWCID No. 2 – Lexington Blvd and 5th Avenue in Missouri City,
- Manvel – Hwy 6 and Iowa Lane in Manvel, and
- Alvin - CR 285 and CR 144 west of Friendswood in Alvin ETJ.

The elevation of the planning area ranges from 80 feet mean sea level in the western area near Sugar Land and Missouri City to around 20 feet in the southeastern edge of the planning area near Alvin and Friendswood. A water plant placed in Demand Area B to serve the entire planning area, would require finished water pumps designed to pump water uphill (60 feet) to the western part of the service area. A water plant located in the Sugar Land or FBWCID No. 2 site can take advantage of the elevation difference in the planning area. This reduced finished water design head attained by locating the plant at the Sugar Land or FBWICD NO. 2 site, over the Manvel or Alvin site, results in significant O&M cost savings.

The Participating Utility team also realized that if the regional water plant is located in Demand Area A, a large diameter 18-mile long finished water pipeline is required to convey water to Demand Area B. Considering these factors, the Team agreed to evaluate the following two water treatment plant scenarios:

1) One large water treatment plant located at the Sugar Land or FBWCID No.2 site and a large transmission main connecting the plant site to all the Participating Utilities, or
2) Two water treatment plants
    - One pant located at the Sugar Land or FBWCID No.2 site with finished water pipelines to serve the demand for the City of Houston, City of Sugar Land, FBWCID No. 2, and City of Missouri City, and
    - One plant located at the Manvel or Alvin site with finished water pipelines to serve the demand for the City of Arcola, City of Pearland, City of Friendswood, City of Alvin, and the City of Manvel.

Raw Water Canals

Raw water for the regional water plant must be taken from the Brazos River by direct pumping from the river or through the GCWA Canal System. As the screened alternative sites are adjacent to the GCWA canal, the canal serves as the most economical location for a raw water intake. The study reviewed the capacity in the canal to determine if projects are required to upgrade the canal capacity to handle the flow necessary to feed the regional water plant demand and the demand associated with the existing GCWA customers. The required facility upgrades for each plant site scenario were identified.

Redundant Raw Water Supply

In terms of raw water reliability, the GCWA Canal System is a single continuous delivery system from the Brazos River to the regional water treatment plant. The reliability of this raw water delivery system is limited as a single point of failure exists. If the Shannon Pump Station or 2nd Lift Station experiences an outage, raw water delivery to the regional water plant would stop and treated water production would be limited to stored water in the American Canal and the water plant forebay.

The GCWA has experienced isolated three week outages at the Shannon plant as a result of lightening strikes. In addition, the GCWA has experienced canal outages of up to a week for repair a ruptured siphon. To ensure continued water delivery customers in the planning area during a temporary raw water outage, the Participating Utilities can either have sufficient groundwater capacity or the regional facility can have improved reliability or a combination of the two solutions. An evaluation of these methods was conducted.

Groundwater Supply

Since the Participating Utilities have selected to meet peak day and peak hour demands through groundwater wells and storage volumes, this infrastructure will have the capacity to provide all or a significant portion the average water demand of the customers. During a temporary outage of the water plant, the Participating Utilities can draw on this existing infrastructure to meet the needs of the customers while repairs are made to GCWA raw water delivery system. This method requires no new infrastructure over and above what the Participating Utilities will provide to supply peak day and hour demands.

Alternative Raw Water Supply

The following three alternate methods for improving the reliability of the raw water supply were evaluated:

- Construct alternate power or fuel-driven motors at Shannon and 2nd Lift Station as needed. The capacity of the raw water pump stations would be increased to minimize the risk of failure at the pump station. This option will not eliminate a risk to canal failure, but will reduce to overall risk of raw water outages due to the mechanical failure or power outages.

- Construct new pump station and pipeline from the Brazos River to the American canal. This option would minimize risk of a Shannon or 2nd Lift Station failure and a simultaneous canal failure by offering a completely independent raw water transmission system from the Brazos the regional water authority.

- Construct an on-line storage reservoir on the American Canal upstream of the 2nd Lift Station. This terminal storage reservoir would be located near the regional water treatment facility and would contain enough storage to maintain flow to the water plant in the event of a temporary raw water pump station or canal failure.

Raw Water Redundancy Recommendation

Each of these alternatives was evaluated in terms of non-economic factors and economic present worth. The option of utilizing Participating Utilities groundwater wells to meet the potable water demand during a temporary outage in the raw water delivery system was selected as the preferred alternative. This alternative maximizes use of the Participating Utilities existing infrastructure and minimizes capital expenditures for a redundant system that will only be utilized during infrequent emergencies.

Finished Water Transmission

For each water treatment plant alternative, the finished water transmission system that presents the lowest overall capital and O & M costs was developed. The pipeline alignment was based on the preferred pipeline corridors identified in a pipeline corridor analysis. The analysis reviewed alternative pipeline corridors between the various treatment plants alternatives and the participating utility take points. The preferred pipeline corridors were identified based on the following criteria:

- Minimize overall length of finished water pipelines,
- Minimize construction in urban areas,
- Minimize construction in corridors with numerous existing utilities, wetlands, and private lands requiring easements.

To develop the cost effective sizing of the finished water transmission system components, a hydraulic model was utilized to size pipeline components based on the take point requirements and the preferred pipeline alignments. The goal of the model was determine the minimum sized pipelines and booster pump station pressure that could adequately meet the take point requirements. The results of the model runs for each of the alternatives are provided in **Section 6.**

Economic Evaluation

An economic evaluation was performed for six different siting alternatives. Two alternatives consisted of a single plant located at either the Sugar Land site or the FBWCID No. 2 site. The other four alternatives combined a plant at these two sites with a second plant at either Alvin or Manvel.

Capital Cost

The capital costs for each plant site alternative includes costs associated with the finished water pipeline, high service pump station, booster pump stations, easements, raw water pump station upgrades, raw water canal improvements, and treatment plant facilities. The capital costs also includes engineering construction administration and contingency.

Construction projects have certain unpredictable expenses. To cover the costs of these unpredictable expenses, an allowance for various contingencies is designed to reduce project risk. The contingency will vary according to the type of project, complexity of design, and geographical location. This allowance can be reduced as the design progresses from concept through final construction documents, but some contingency must remain throughout the life of the project as a reserve for events that experience shows will likely occur. Contingency is applied to total construction cost which includes the construction estimate with engineering and construction administration.

The capital costs associated with the identified raw water improvements, finished water transmission systems, and water treatment process for each of the identified plant site alternatives are shown in **Table ES-3.**

TABLE ES-3
CAPITAL EXPENDITURE (YR 2000 $)

Alternative	Phase I Year 2008	Expansion Year 2028
Sugar Land	$ 317,290,000	$ 40,970,000
FBWCID No. 2	$ 294,660,000	$ 39,830,000
Sugar Land / Manvel	$ 331,250,000	$ 51,250,000
Sugar Land /Alvin	$ 310,750,000	$ 48,980,000
FBWCID No. 2 / Manvel	$ 312,190,000	$ 49,380,000
FBWCID No. 2 / Alvin	$ 291,730,000	$ 49,380,000

Operation and Maintenance Costs

O & M costs for the facility include the costs associated with producing and delivering the water demand to the Participating Utilities. O & M costs include the following items:

- Electricity,
- Maintenance,
- Chemicals,
- Labor,
- Sludge disposal, and
- Administration

The annual O&M costs for the alternative plant site scenarios are summarized in **Table ES-4**

TABLE ES-4
ANNUAL O&M ($ PER YR, YR 2000 $)

Alternative	Phase 1 2010-2030	Phase 2 2030-2050
Sugar Land	$ 19,320,000	$ 23,540,000
FBWCID No. 2	$ 19,350,000	$ 23,540,000
Sugar Land / Manvel	$ 20,780,000	$ 24,910,000
Sugar Land / Alvin	$ 20,750,000	$ 24,880,000
FBWCID No. 2 / Manvel	$ 21,170,000	$ 25,250,000
FBWCID No. 2 / Alvin	$ 21,140,000	$ 25,320,000

Present Worth Analysis

A present worth analysis was prepared for the purposes of evaluating the identified alternatives. The present worth of an alternative represents the investment required today to construct and operate the recommended raw water improvements, water treatment plant, and finished water transmission system. The present worth analysis of each of the alternatives evaluated utilizing the low cost treatment process is provided in **Table ES-5**.

TABLE ES-5
PLANT SITE ALTERNATIVES PRESENT WORTH SUMMARY

Alternative	Present Worth Cost ($M)
150 MGD Plant at FBWCID No.2 Site	$597
150 MGD Plant at Sugar Land Site	$615
115 MGD Plant at FBWCID No. 2 Site and 35 MGD Plant at Alvin Site	$628
115 MGD Plant at Sugar Land Site and 35 MGD Plant at Alvin Site	$636
115 MGD Plant at FBWCID No. 2 Site and 35 MGD Plant at Manvel Site	$644
115 MGD Plant at Sugar Land Site and 35 MGD Plant at Manvel Site	$654

The analysis indicates that the scenario of one treatment plant serving the entire planning area is less expensive than the two regional water plant scenario.

Non-Economic Evaluation

The Participating Utility Team met to discuss the non-economic factors involved in site selection and developed the following list of general criteria: Public Acceptance, Expandability, Reliability, Environmental Impacts, and Permitting. An analysis was completed to review this criteria.

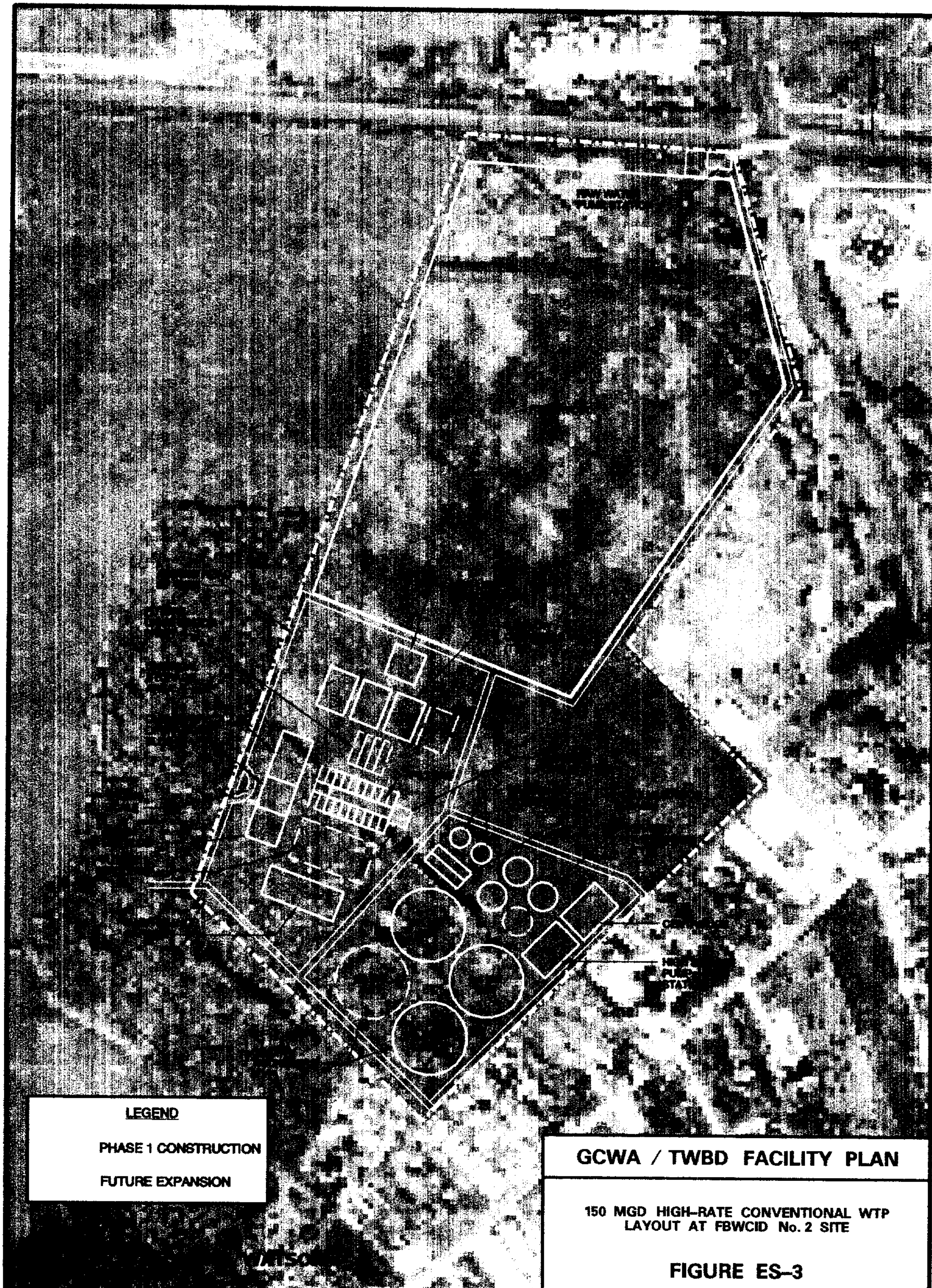
The analysis compared the Sugar Land site against the FBWCID No.2 site and showed that no significant difference existed between the two sites based on non-economic impacts to the community. Each site has drawbacks and benefits, but no one criteria outweighed another. The analysis also compared the Manvel site versus the Alvin site. In this comparison, the Manvel site scored slightly higher than the Alvin site based on the Manvel sites ability to be fed by a redundant raw water canals, increasing the reliability of the raw water supply.

FACILITY PLAN

The single plant alternative at the FBWCID No. 2 site offers the lowest present worth cost and will serve as the basis for the recommended facility plan. However, there is less than a 10% cost difference between all of the siting alternatives. The other alternatives may offer siting options as the project matures.

The facility plan is based on the development of a single 150 mgd high-rate conventional surface water treatment plant at the FBWCID No. 2 site, as shown in **Figure ES-3**. The plant would be developed in two phases. The initial phase would provide 120 mgd to meet the regional surface water conversion requirements for the year 2010. Regional surface water demands, from the City of Houston or other participants may modify the timing and phasing of the initial plant project. A 30 mgd expansion would be accomplished in year 2030 to satisfy future growth requirements.

The facility plan also includes improvements to the raw water delivery system and the associated finished water transmission systems required to deliver water to the individual participants. A summary of the probable capital costs for the facility plan are presented in **Table ES-6**.



GCWA / TWBD FACILITY PLAN

150 MGD HIGH-RATE CONVENTIONAL WTP
LAYOUT AT FBWCID No. 2 SITE

FIGURE ES-3

TABLE ES-6
FACILITY PLAN CAPITAL COSTS

ITEMS	COST ($1000, YR 2000)	
	120 MGD Initial Phase	30 MGD Expansion
Water Treatment Plant	$131,2000	$26,140
Finished Water Transmission	$82,910	$2,460
Raw Water Improvements	$4,150	$910
Capital Subtotal	**$218,260**	**$29,510**
Contingency	$76,390	$10,330
Total Capital	**$294,650**	**$39,840**

CONCLUSIONS

- Mandates by the HGCSD and the FBSD will require participating utilities in western Harris and Fort Bend Counties to convert to surface water as their primary water supply.
- Ground water quality and localized drainage and flooding issues may require surface water conversion in Brazoria County
- GCWA is the logical developer of regional surface water facilities to serve the planning area and has extensive experience in successfully treating lower Brazos river water.
- While GCWA does hold senior rights on the Brazos, it currently does not have sufficient water rights to meet the projected demand for the facility plan.
- The alternative analysis developed in this study provides a number of sties and plant configurations that are technically and economically feasible.
- The single 150 mgd high-rate conventional plant at the FBWCID No. 2 site, with associated raw and finished water improvements provides the lowest present worth option for the surface water facility plan

RECOMMENDATIONS

- GCWA should prepare a preliminary rate analysis based on the facility plan. Initial project sizing and phasing alternatives may be considered as part of the rate analysis to improve project feasibility. The larger the system is, the more cost-effective it will be to the participants. Therefore GCWA should begin negotiations with the Participating Utilities for their inclusion in the project.
- Investigate Federal and State grants and other available funding sources to help offset project development costs.
- Confirm the timing and quantity of the City of Houston's water needs within the planning area
- GCWA should continue to explore alternative water resources within the region to meet the projected demands associated with the facility plan

Section 1
Introduction

BACKGROUND

Surface Water Conversion

The primary water supply for the residents of western Harris County, Fort Bend County, and northern Brazoria County continues to be the Evangeline and Chicot aquifers which are a part of the Gulf Coast Aquifer. Continuous groundwater pumping in these areas has led to significant ground subsidence, which has resulted in localized flooding and property damage. The extensive pumping of water from the aquifers has also led to a decrease in piezometric level of the water table. As the piezometric level drops, many well owners have been forced to lower their wells or find alternative sources of water. In addition, the piezometric head in the aquifers serves as a barrier to salt water intrusion from the Gulf of Mexico. As the piezometric head falls, the barrier to salt water intrusion is diminished and the water quality of the aquifer may be compromised.

As a result of these problems, the Harris-Galveston Coastal Subsidence District (HGCSD) and Fort Bend Subsidence District (FBSD) were created by the Texas Legislature. Both districts have the authority to regulate the withdrawal of groundwater to mitigate subsidence and falling water table levels. In April of 1999, the HGCSD issued a revised District Regulatory Plan (DRP) with an overall goal to reduce groundwater withdrawal to no more than 20% of total water demand. In December of 1999, the District established a disincentive fee for not complying with the DRP. The FBSD is in the process of developing a new DRP and should release a draft rule by the end of the year 2000. This plan may have a disincentive fee structure to reduce the groundwater withdrawal in Fort Bend County. It is anticipated that the rules promulgated for Fort Bend County will be similar to those for Harris and Galveston County.

To comply with these rules, the municipalities and industries currently using groundwater water will be required to convert to surface water. In lieu of each Municipal Utility District (MUD), Water Control and Improvement District (WCID), or municipality in western Harris County, Fort Bend County, or northern Brazoria County designing and constructing numerous individual water plants to serve their customers, a regional surface water plant may be a viable and economically attractive alternative to supply surface water to this region.

STUDY PURPOSE

The purpose of this **Regional Surface Water Plant Feasibility Study** is to evaluate alternatives for regional water treatment facilities and transmission piping system to serve Participating Utilities in Brazoria, Fort Bend and Harris Counties. This feasibility study will estimate the capital cost to construct a regional water treatment facility inclusive of the cost of raw water pumping and treatment process facilities, potable water pump stations, and potable water pipelines. Operating and maintenance costs for the facility will also be estimated. The study planning horizons in the year 2050.

SCOPE OF FACILITY PLAN

Montgomery Watson has been retained by Gulf Coast Water Authority (GCWA) to evaluate the feasibility of constructing a new regional surface water treatment plant to serve the Participating Utilities. This study includes the following tasks:

- An evaluation of the water treatment plant capacity,
- An evaluation of alternative water treatment technologies,
- An evaluation of alternative water treatment plant site locations,
- Pipeline corridor study,

- The single 150 mgd high-rate conventional plant at the FBWCID No. 2 site, with associated raw finished water improvements should serve as the basis for the development of regional surface water facilities in the planning area.

BACKGROUND

Surface Water Conversion

The primary water supply for the residents of western Harris County, Fort Bend County, and northern Brazoria County continues to be the Evangeline and Chicot aquifers which are a part of the Gulf Coast Aquifer. Continuous groundwater pumping in these areas has led to significant ground subsidence, which has resulted in localized flooding and property damage. The extensive pumping of water from the aquifers has also led to a decrease in piezometric level of the water table. As the piezometric level drops, many well owners have been forced to lower their wells or find alternative sources of water. In addition, the piezometric head in the aquifers serves as a barrier to salt water intrusion from the Gulf of Mexico. As the piezometric head falls, the barrier to salt water intrusion is diminished and the water quality of the aquifer may be compromised.

As a result of these problems, the Harris-Galveston Coastal Subsidence District (HGCSD) and Fort Bend Subsidence District (FBSD) were created by the Texas Legislature. Both districts have the authority to regulate the withdrawal of groundwater to mitigate subsidence and falling water table levels. In April of 1999, the HGCSD issued a revised District Regulatory Plan (DRP) with an overall goal to reduce groundwater withdrawal to no more than 20% of total water demand. In December of 1999, the District established a disincentive fee for not complying with the DRP. The FBSD is in the process of developing a new DRP and should release a draft rule by the end of the year 2000. This plan may have a disincentive fee structure to reduce the groundwater withdrawal in Fort Bend County. It is anticipated that the rules promulgated for Fort Bend County will be similar to those for Harris and Galveston County.

To comply with these rules, the municipalities and industries currently using groundwater water will be required to convert to surface water. In lieu of each Municipal Utility District (MUD), Water Control and Improvement District (WCID), or municipality in western Harris County, Fort Bend County, or northern Brazoria County designing and constructing numerous individual water plants to serve their customers, a regional surface water plant may be a viable and economically attractive alternative to supply surface water to this region.

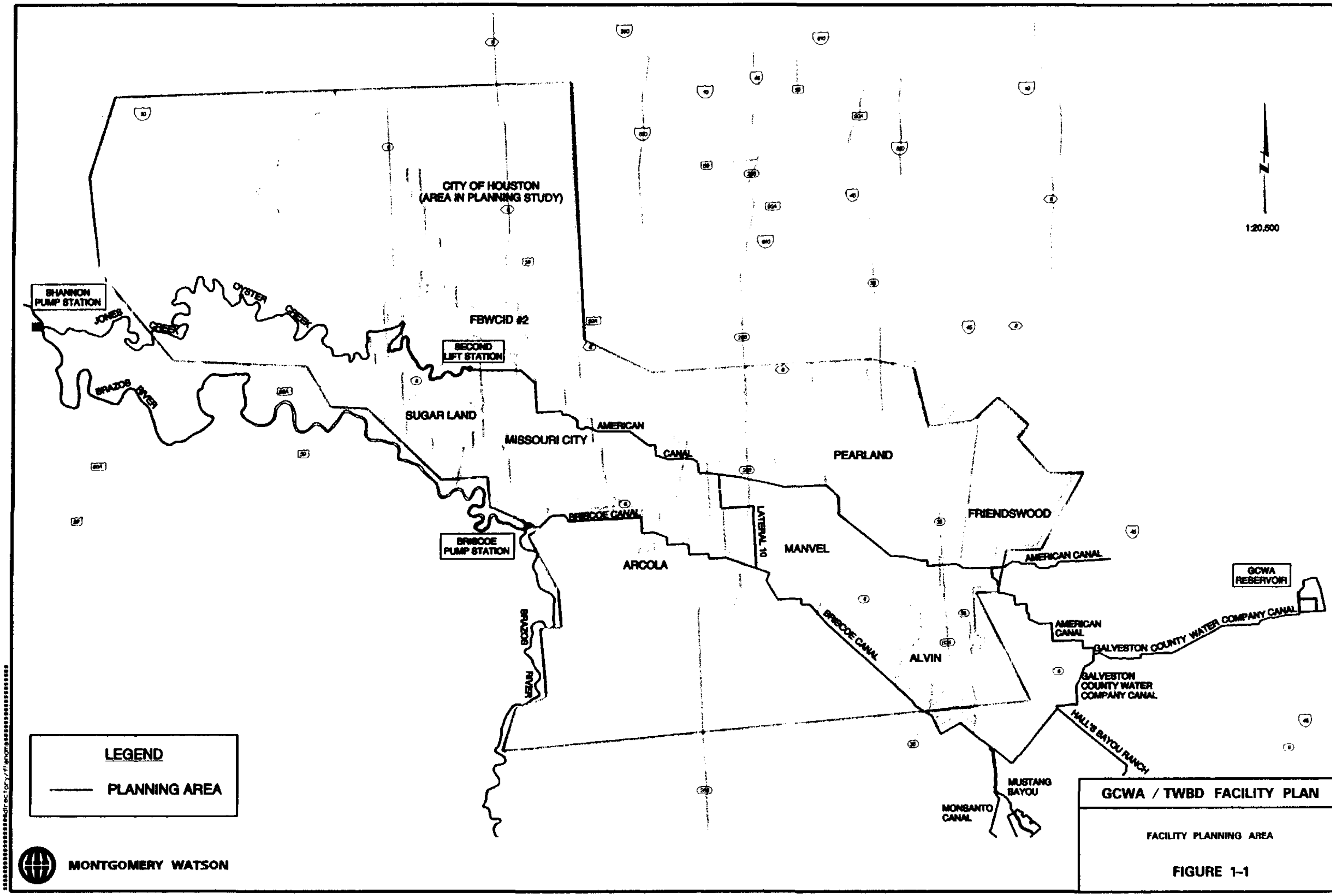
STUDY PURPOSE

The purpose of this **Regional Surface Water Plant Feasibility Study** is to evaluate alternatives for regional water treatment facilities and transmission piping system to serve Participating Utilities in Brazoria, Fort Bend and Harris Counties. This feasibility study will estimate the capital cost to construct a regional water treatment facility inclusive of the cost of raw water pumping and treatment process facilities, potable water pump stations, and potable water pipelines. Operating and maintenance costs for the facility will also be estimated. The study planning horizons in the year 2050.

SCOPE OF FACILITY PLAN

Montgomery Watson has been retained by Gulf Coast Water Authority (GCWA) to evaluate the feasibility of constructing a new regional surface water treatment plant to serve the Participating Utilities. This study includes the following tasks:

- An evaluation of the water treatment plant capacity,
- An evaluation of alternative water treatment technologies,
- An evaluation of alternative water treatment plant site locations,
- Pipeline corridor study,



GCWA / TWBD FACILITY PLAN

FACILITY PLANNING AREA

FIGURE 1-1

- Schematic water treatment plant design,
- Overall capital and operating costs, and
- Facility plan for recommended alternative.

In addition, a cultural resources survey and public information program were included in this study. References used in the preparation of this report are included in Appendix A.

PLANNING AREA

The planning area is located in the Texas Water Development Board Regional Water Planning Area H in southeast Texas. It contains West Harris County, the north part of Brazoria County, and the southern part of Fort Bend County to the east of Brazos River. The area includes many major cities and population centers. Utilities electing to be included in this study are:

- City of Alvin
- City of Arcola
- Ft. Bend WCID No. 2
- City of Friendswood
- City of Houston
- City of Manvel
- City of Missouri City
- City of Pearland
- City of Sugar Land

A map of the planning area is shown in **Figure 1-1**. The Participating Utilities estimates that the portion of their utilities in the planning area have a current population of 630,000 and an average daily water demand of 74.9 mgd.

The Fort Bend Subsidence District and the Harris-Galveston Coastal Subsidence District cover significant portions of the planning area. River basins within the planning are: the lower portion of the Brazos River Basin, the northeast portion of the San Jacinto-Brazos Coastal Basin and the southwest portion of the San Jacinto Coastal Basin.

AVAILABLE SURFACE WATER

The major surface water feature in this area is the Brazos River. The Brazos River flows diagonally through Fort Bend County from the northwest to the southeast and then serves as the border between Brazoria and Fort Bend Counties until the Brazos turns towards the south and flows through Brazoria County before discharging into the Gulf of Mexico. The Brazos River is shown on **Figure 1-1**.

The State of Texas, through the Texas Natural Resources Conservation Commission (TNRCC), currently allocates water from the Brazos River for agricultural, industrial, and municipal needs through water permits. The GCWA currently holds the most senior water permits in the Lower Brazos Basin. GCWA is thus a logical supplier for the surface water for a regional plant.

Gulf Coast Water Authority

Gulf Coast Water Authority was created by the 59th Texas Legislature in 1965 under Chapter 712 and was given legal authority to plan, develop, and operate regional water facilities. The GCWA operates an extensive canal and reservoir system that conveys water from the Brazos River to industrial, agricultural, and municipal customers in Fort Bend, Brazoria and Galveston Counties. Gulf Coast Water Authority has over twenty years experience in operating a regional water treatment facility in Texas City, Texas serving municipal and industrial customers in Galveston County.

Section 2
Planning Area Existing Envirostructure

As the planning area utilities plan for the conversion from ground water to surface water, the Participating Utilities plan to maximize use of their existing envirostructure to minimize the cost of improvements for surface water conversion. This section reviews the planning area and identifies the existing envirostructure in the planning area and highlights the capacity of the surface water availability and conveyance in the planning area.

SURFACE WATER SOURCE AND SUPPLY

The City of Houston and the GCWA are well suited to serve as the prime purveyors of treated surface water. The City of Houston currently has two surface water plants with expected total capacity exceeding 470 mgd located on the east side of Houston. The plants treat water from the Trinity and San Jacinto rivers. The Gulf Coast Water Authority currently has one surface water treatment plant located in Texas City that treats surface water from the Brazos River. The GCWA plant is currently expanding the capacity of the plant to 50 mgd.

Due to the proximity of the Brazos River to the planning area and the existing GCWA and City of Houston water rights on the Brazos, it is likely that a new regional surface water plant for the planning area would utilize the Brazos River as the raw water source.

Water Source

The Gulf Coast Water Authority currently draws surface water from the Brazos River. The Brazos River transverses Texas from Lubbock through Waco to Richmond before discharging into the Gulf of Mexico at Freeport. For the period between 1973 and 1995, the Brazos River had an average daily flow at the Richmond – Rosenberg USGS monitoring station of 8,200 mgd. During this same monitoring period, the minimum recorded flow at the station was 148 mgd. Water quality for the Brazos River is presented in **Section 4** of this report.

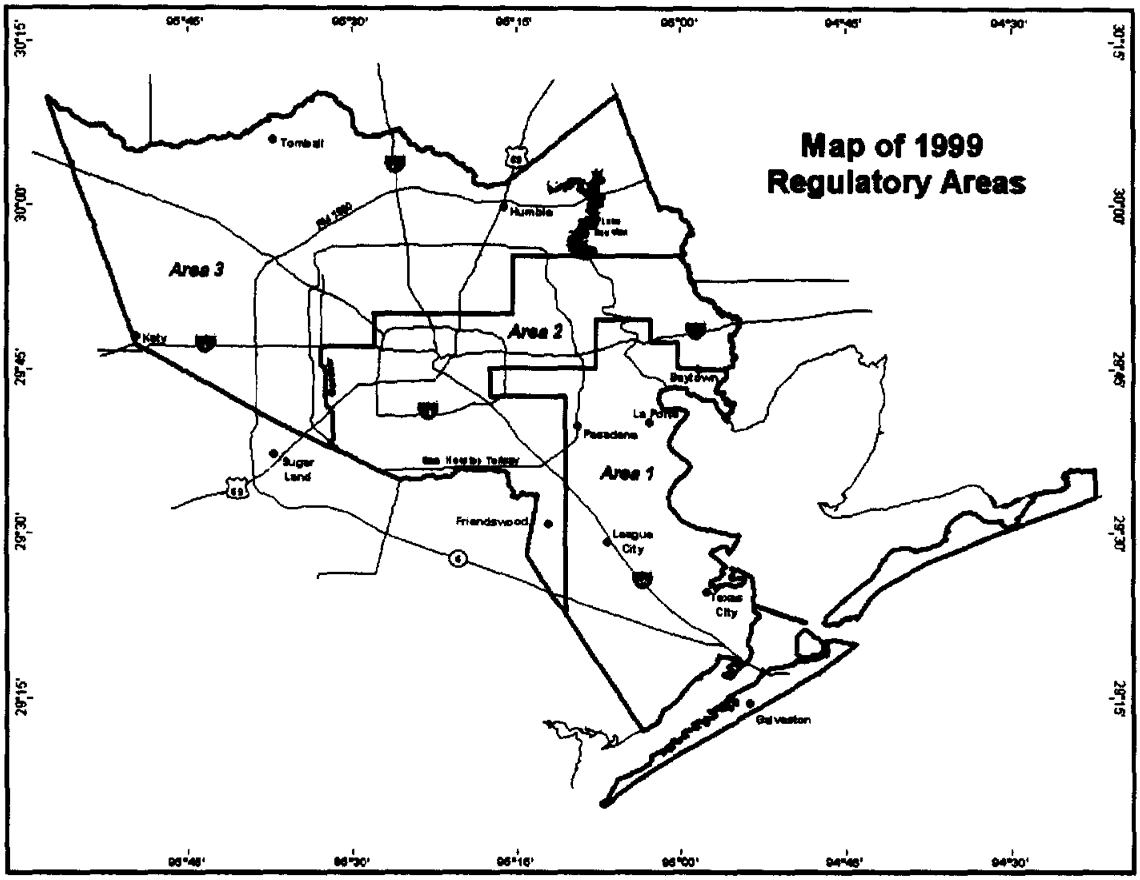
Water Rights

The right to take water from the Brazos is based on the permit allocation from the State of Texas and the date of the permit. Holders of the oldest water permits have first right to take available water from the Brazos River. Junior water rights must wait until all holders of senior water rights have had the chance to receive their allocated water rights. Gulf Coast Water Authority currently holds 3 water permits for diversion of water from the run of the Brazos River and one permit for diversion of water that falls in the Oyster Creek watershed. A summary of these permits and allocations are shown in the following table:

TABLE 2-1
GULF COAST WATER AUTHORITY EXISTING WATER PERMITS

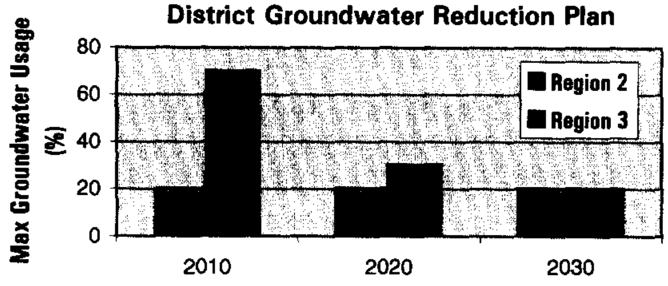
CA Number (Permit #)	Year	Total Withdrawal		Maximum Withdrawal Rate	
		ac-ft / yr	mgd	cfs	mgd
5168 (10401) - GCWA Shannon Pumping Plant	1926	99,932	89.20	685.00	442.74
5171 (1299D) - GCWA Briscoe Pumping Plant	1939 / 1950	125,000	111.57	600.00	387.80
5169 (1467D) - Oyster Creek Withdrawal	1930	12,000	10.71	60.10	38.84
Total	Total	236,932	211.48	1,345.10	869.38

FIGURE 2-2
HARRIS GALVESTON COASTAL SUBSIDENCE DISTRICT REGULATORY BOUNDARIES



Area 1 must limit groundwater production to 10 percent of total water demand. In Area 2, the region must reduce groundwater pumping to 20 percent of the total water use or have a certified groundwater reduction plan in place to attain the 20 percent rule by year 2010. In Area 3, groundwater pumping must be reduced to 70 percent by 2010, 30 percent by 2020, and 20 percent by 2030. Construction of the facilities necessary to meet these reductions must be started by January 1, 2005. A chart of the groundwater reduction plan is shown in **Figure 2-3**:

Figure 2-3
Harris-Galveston Subsidence
District Groundwater Reduction Plan



The rules for Fort Bend County are not expected to be promulgated until the fall of 2000, but it is expected that the rules will be similar in form to the rules for Harris and Galveston Counties. Brazoria County is not currently under any mandate for groundwater reduction.

GULF COAST WATER AUTHORITY EXISTING FACILITIES AND DEMAND

Raw Water Conveyance System

Canal System

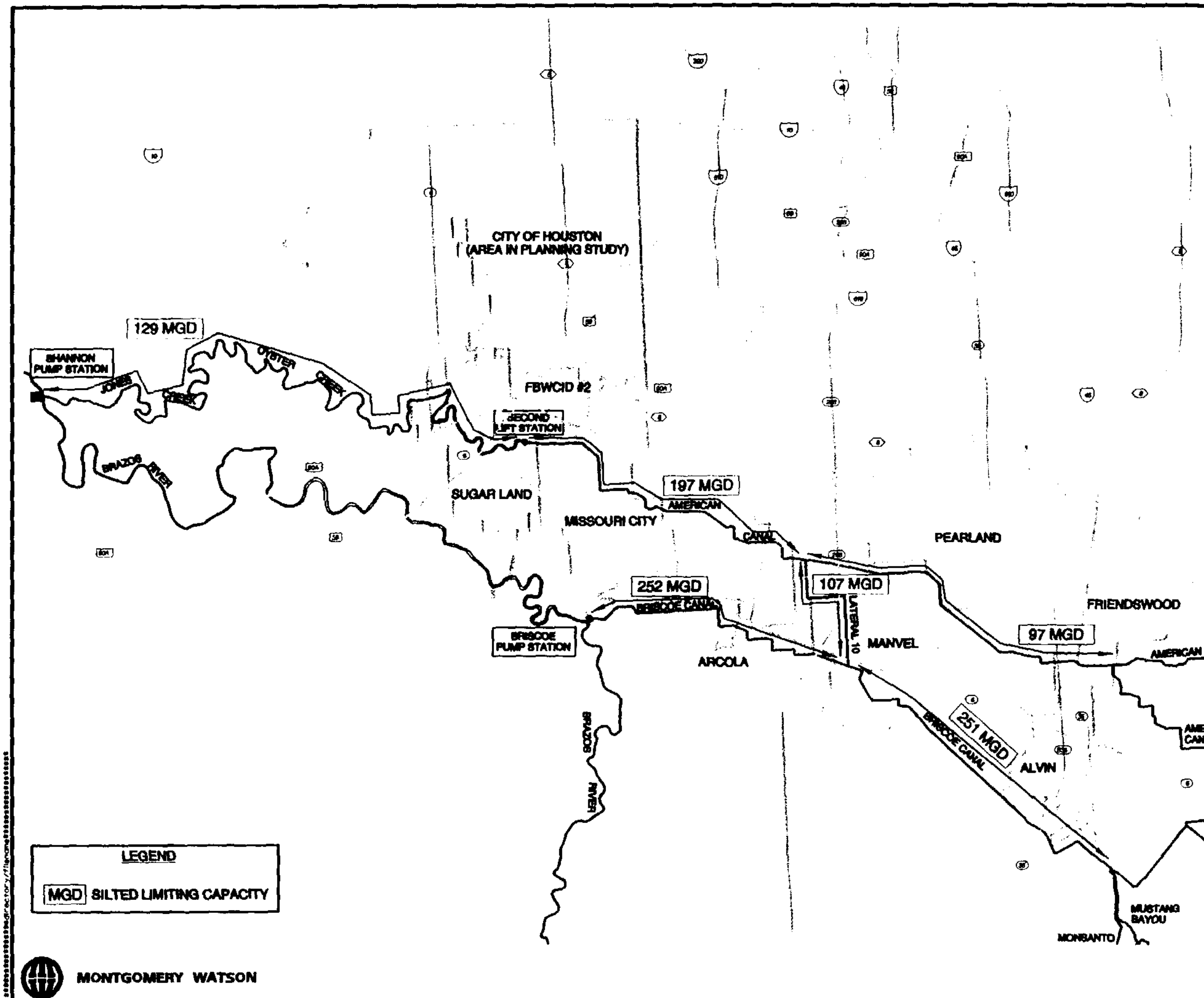
The GCWA operates two canals from the Brazos River to serve customers in Brazoria and Galveston Counties. These canals are designated System A or the American Canal and System B or the Briscoe Canal. They are shown on **Figure 1-1.** If the new water plant were to utilize Brazos River water as the raw water source, the GCWA canal system could be utilized to convey raw water to the new plant.

The American Canal transverses approximately 72 miles from the Shannon Pump Station near Fulshear, Texas to the Galveston County Reservoir which is located north of Texas City, Texas. The Shannon Pump Station has 4 pumps and has a rated capacity of 330 mgd, but field tests indicate that actual installed capacity is in the range of 260 mgd. The American canal system consists of both natural and man made sections. Once the flow is lifted from the Brazos River to the American Canal, Jones Creek carries the flow to Oyster Creek in Sugar Land, Texas. The 2nd lift Station then lifts flow from Oyster Creek to the man-made portion of the American Canal. After the 2nd lift Station, the American Canal flows through Missouri City and adjacent to Manvel, Alvin, and Friendswood before finally discharging to the GCWA Reservoir. The 2nd Lift Station has 4 pumps with an installed capacity of 220 mgd.

The Briscoe Canal starts at the Briscoe Pump Station, which is located on the Brazos River south of Missouri City. The Briscoe Pump Station has 3 pumps with an installed capacity of 300 mgd. Once the water is lifted from the Brazos to the man-made canal, the water flows 51 miles to the Monsanto and Chocolate Bayou Reservoirs. Lateral 10 connects the American and Briscoe Canal near Manvel and is primarily used to convey water from the American Canal to the Briscoe Canal. Flow in Lateral 10 can be reversed, but the hydraulic grade line of the Briscoe Canal must be raised to drive water to the American Canal.

Canal Capacity

The GCWA has recently completed a report entitled "Gulf Coast Water Authority Water Audit Summary". This report reviews the canal system and calculated the theoretical capacity of the canal, and



GCWA / TWBD FACILITY PLAN

GCWA CANAL LIMITING CAPABILITIES

FIGURE 2-4

recommends improvements to the Canal to minimize restrictions in flow. The report findings in regards to the capacity of the System A and B canal system are shown in **Table 2-2**. The limiting capacities along the Canal are shown in **Figure 2-4**.

TABLE 2-2
GCWA CANAL CAPACITY

Canal Segment	Clean Capacity (1) (mgd)	Silted (1') Capacity (1) (mgd)
Jones and Oyster Creek	175	129
American Canal: 2nd Lift Station to Lateral 10	220	197
American Canal: Lateral 10 to New Extension	129	97
Briscoe Canal: Briscoe Pump Station to Lateral 10	265	252
Briscoe Canal: Briscoe Pump Station to B-4 Canal	291	291
Lateral 10	107	107

(1): With 1 foot of freeboard

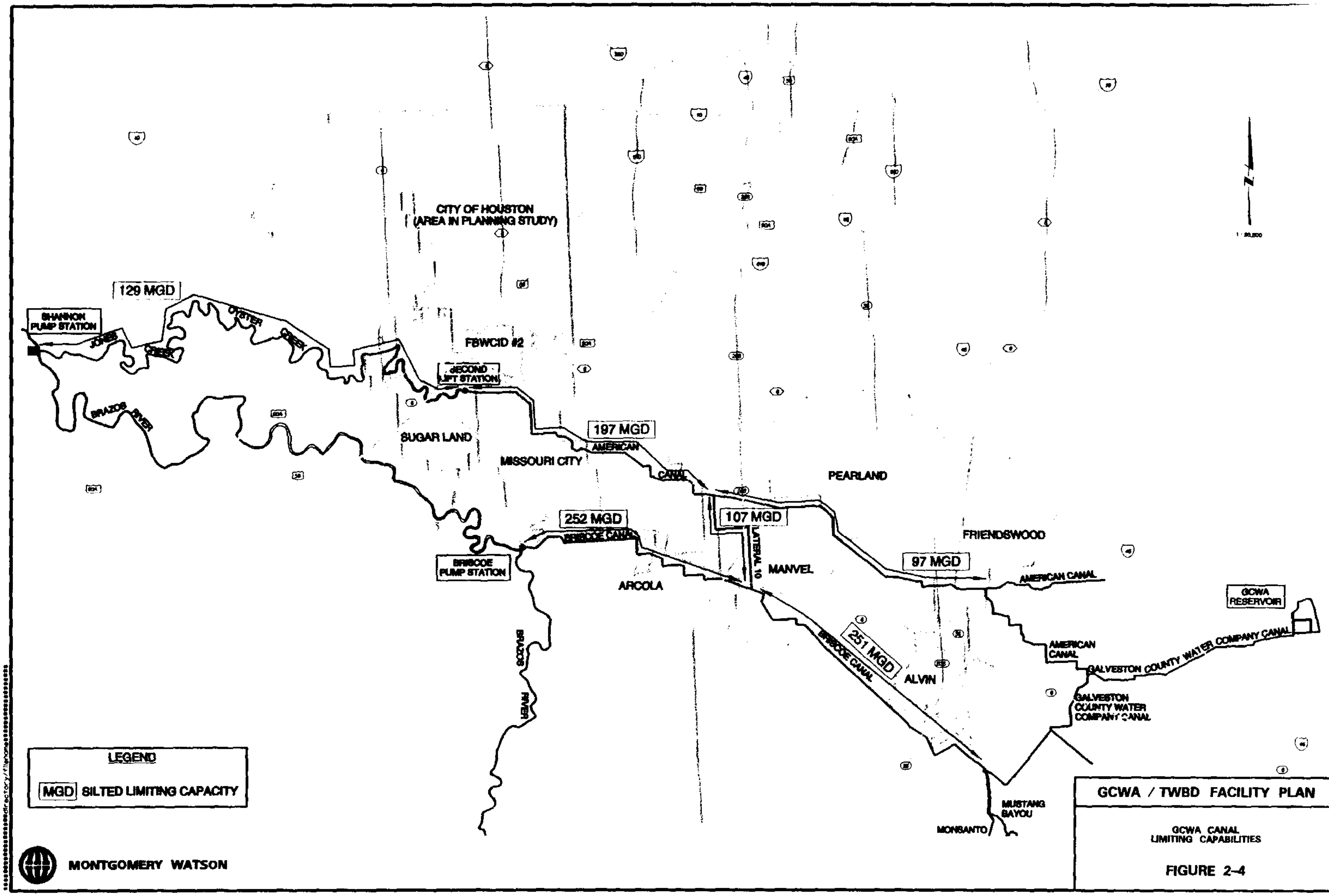
With a clean canal, the limiting capacity of the American Canal above Lateral 10 is 175 mgd, while the limiting capacity of the American Canal below Lateral 10 drops to 129 mgd. With several modifications noted in the consultant's report, the capacity of the Jones and Oyster Creek section could be upgraded to approximately 1,200 mgd. If these improvements were constructed, the limiting silted capacity of the American Canal System above Lateral 10 would be 197 mgd.

Dr. Thomas Mackey Water Treatment Plant

GCWA currently owns and operates the Dr. Thomas Mackey WTP in Texas City, Texas. The plant is being expanded to 50 mgd from an original capacity of 25 mgd. Construction of this expansion should be complete by the summer of 2000. The 50 mgd plant provides potable water to the majority of the residents of Galveston County, including the citizens of Texas City, La Marque, Galveston, Tiki Island, League City, and various other Galveston County communities.

The conventional filtration plant has a highly flexible operations plan. The Authority can feed powdered activated carbon and chlorine dioxide at the head of the plant for raw water taste and odor control. The plant currently feeds cationic polymer primary coagulant with ferric sulfate and non-ionic polymer as coagulant aids. Flocculation and primary clarification occur in the upflow solids contact reactors from which the settled water passes through dual-media filters. The existing dual media filters contain granular activated carbon over sand. The plant adds chlorine and chlorine dioxide as post-filtration primary disinfectants. Ammonia is added downstream of the clearwells to form chloramines for secondary disinfection. The Authority also adds zinc polyphosphate and sodium fluoride for corrosion control and consumer dental hygiene. The Authority also land-applies the sludge from the plant on land adjacent to the site. The plant has the capability to provide lime softening to remove heavy metals and hardness.

GCWA is a wholesaler supplier and the plant distributes water from the distribution pump station through a series of transmission mains to the ground storage tanks of customers. The plant currently operates the high service pumps at approximately 90 psi.



GCWA / TWBD FACILITY PLAN

GCWA CANAL LIMITING CAPABILITIES

FIGURE 2-4

GCWA Existing Customer Demand

GCWA currently serves numerous municipalities, industries, and agricultural customers in Fort Bend, Brazoria, and Galveston Counties. The customers obtain raw water directly from the GCWA canals or treated water via the Dr. Thomas Mackey WTP. The customers have contracted with the GCWA for delivery of a total of approximately 154 mgd. The distribution of water among the existing GCWA customers is shown in **Table 2-3**

TABLE 2-3
EXISTING GULF COAST WATER AUTHORITY CUSTOMER WATER DEMAND

Customer	Existing Demand	Existing Water Contract	Projected Increase in Water Demand	Projected Year 2050 Water Demand
Raw Water (mgd)	95.7	104.2	15.3	119.5
Treated Water (mgd)	18	49.7	4.8	54.5
Total Water Demand (mgd)	113.7	153.9	20.1	174.0

It should be noted that only 1.9 mgd of the existing raw water demand is withdrawn along the upper reaches of the American Canal and customers along the Briscoe Canal use 26.9 mgd. The upstream demands are not projected to increase over the next 50 years. Therefore, of the projected water demand for GCWA's existing customers in the year 2050, the demand at the Galveston County Reservoir will be 145.2 mgd (total GCWA demand minus the upstream raw water demand). The Galveston County Reservoir is replenished by water conveyed through the American and Briscoe Canals. Detailed descriptions of the existing GCWA customers with individual projects for water use can be found in the **Appendix B - GCWA Existing Customer Water Demand.**

PARTICIPATING UTILITY EXISTING FACILITIES DESCRIPTION

The planning area contains many small Municipal Utility Districts (MUDs) and Water Conservation and Improvement Districts (WCIDs), in addition to municipally owned water systems that deliver potable water to customers. These entities have constructed the infrastructure to withdraw, store, and treat water for delivery and consumption by their customers. Participating Utility water customers in the planning area are served either via water pumped from the Gulf Coast Aquifer or treated surface water from the City of Houston.

The Cities of Friendswood, Houston, and Pearland use treated surface water for some or all of their potable water supplies. The other Participating Utilities serve their customers entirely with groundwater. A summary of the Participating Utilities in this study and their water infrastructure are provided below. Unless otherwise noted, population estimates for each utility are summarized from Appendix C – TWDB Population and Water Used Projections.

City of Sugar Land

The City of Sugar Land extraterritorial jurisdiction (ETJ) limits comprises a geographic area of approximately 45 square miles, including the existing Sugar Land city limits, the undeveloped areas west of the city, Riverpark, New Territory, and Greatwood. The City of Sugar Land currently has approximately 79,758 residents. The city serves its residents through a total of 14 wells with a total capacity of 35.5 mgd.

The city's water distribution system is divided into two separate divisions: North and South. The South system contains one elevated storage tank with a 2 mg capacity and 4 ground storage tanks with a combined capacity of 3.84 mg. The North system contains 4 elevated storage tanks with a combined capacity of 4 tanks and 8 ground storage tanks with a total capacity of 5.83 mg.

City of Missouri City

The City of Missouri City's ETJ comprises approximately 60 square miles and includes the existing city limits and the Sierra Plantation area. The City's population is currently estimated at 63,458 residents. The City of Missouri City currently does not provide potable water to the residents of the city, instead the residents of Missouri City are provided water by one of 16 MUDs. The MUDs range in size from less than 600 to 5,000 connections. Each MUD has it's own water source, storage tanks, and distribution system. Southwest Harris County MUD 1 and Harris County WCID (HCMUD)– Fondren Road purchase treated water from the City of Houston for use during peak flow conditions. HCMUD 122 receives all of its potable water from the City of Houston at the City of Houston system pressure. The rest of the MUDs rely on their own wells to supply the daily water demand. The MUDs have a combined well capacity of 31.5 mgd. Each MUD except HCMUD 122 has at least one ground storage tank. The total ground storage capacity of the MUDs in Missouri City is 9.084 mg. Two MUDs have elevated storage tanks with a total storage volume of 1 mg.

For the purposes of providing residents of Missouri City with potable surface water, the City of Missouri City will serve as a local water wholesaler to each of the 16 MUDs.

City of Friendswood

The City of Friendswood is located in Galveston and Harris Counties. The City's ETJ covers an approximate area of 22 square miles. The city's current population is estimated at 32,416 residents. The city currently serves it's customers with potable water purchased from the Southeast Water Purification Plant (SEWPP) located near Ellington Field in Houston Texas and several groundwater wells. The city currently has a contract to purchase 6 mgd from the SEWPP and has a groundwater capacity of 7.85 mgd.

The city water infrastructure includes one elevated storage tank with a capacity of 1.0 mg and 8 ground storage tanks with a combined storage volume of 2.3 mg.

Ft. Bend WCID No. 2

Ft. Bend WCID No. 2 provides Stafford and portions of Missouri City with water and wastewater services. The District's service area is 6.1 square miles. The District reports that the current population in the service area is 17,900 residents. The city has 5 water plants with seven wells totaling a capacity of 10.4 mgd and has plans to increase groundwater capacity to 17.3 mgd over the next few years. The District owns 6 ground storage tanks with a combined storage volume of 6.0 mg and has one elevated storage tank with a volume of 0.5 mg.

City of Arcola

The City of Arcola serves approximately an area of 1.58 square miles and has a current population of 988 residents. The population projections were obtained as part of the "Recommended Population and Water Use Projections for GCWA Customers" Residents of the City of Arcola have private groundwater wells.

City of Manvel

The City of Manvel is located in Brazoria County and serves an area bordered by Lewis Lane to the North, SH 288 to the west, Taylor Lane to the south, and Lewis Lane to the east. The City of Manvel's ETJ is approximately 23.3 square miles. The city currently has approximately 4,686 residents with extensive expansion expected in the future.

The city operates one groundwater plant with 2 wells and one ground storage tank. The primary well has a capacity of 175 gpm and the ground storage tank is designed to hold 125,000 gallons.

City of Alvin

The City of Alvin, located in Brazoria County, serves a geographic area of 14.8 square miles with a current population of approximately 24,075 residents. The city receives all of its potable water from wells drilled in the Gulf Coast Aquifer. The City of Alvin has one elevated storage tank with a capacity of 1 mg and a total ground storage capacity of 2.8 mg.

City of Pearland

The City of Pearland, located in Harris and Brazoria County, has an ETJ of approximately 75 square miles in the planning area. The City of Pearland serves its customers through numerous ground water wells and connections with the City of Houston distribution system. The City of Pearland existing population is estimated at 45,000 residents. The city has several ground storage tanks and an elevated storage tank.

City of Houston

The portion of the City of Houston within the study area covers approximately 12 percent of the existing residents of the city. This portion of the City of Houston receives potable water from numerous ground water wells in the area. The City of Houston already serves a large portion of its customers with surface water, but this area of this study is primarily served with groundwater. The City of Houston anticipates that the western portion of the city will receive water from a new regional surface water plant described as part of this study.

It is anticipated that the city would use the Bellaire Braes Pump Station as a booster station for any surface water from a new water plant. The Bellaire Braes Pump Station currently has a ground storage capacity of 10 mg.

PROJECTED POTABLE WATER DEMAND

The size of the regional water plant depends on the potable water requirements of the Participating Utilities to the year 2050. Water and population projections for the Participating Utilities were evaluated and summarized to obtain the projected ultimate capacity for the water plant in the year 2050. The size of the water plant will be governed by the projected average and peak potable water demand for the planning area, the subsidence district rules and regulations, and the service area of the plant.

Current Population and Water Usage

Data for current population and water usage were taken from the Texas Water Development Board Population & Water Demand Projections: Board Approved Regional Projections to be Used in the 2002 State Water Plan. For the Participating Utilities in this study, **Table 3-1** provides the year 2000 population and water use as reported by TWDB through the Region H Board or the Utility itself, where Board projections for the portion of the utility in the planning area were not provided.

TABLE 3-1
YEAR 2000 POPULATION AND AVERAGE WATER DEMAND

Participating Utility	Year 2000 Planning Area Population	Year 2000 Average Day Water Demand (mgd)
Alvin	24,075	2.94
Arcola	988	0.11
Manvel	5,152	0.63
Pearland	31,983	4.32
Missouri City	63,458	10.66
FBWCID No. 2	17,033	2.01
Sugar Land	79,758	12.44
Friendswood	32,416	4.21
Houston	376,000	37.6
Total for Study Area	630,863	74.93

Projected Population and Water Usage

Data regarding projected population and water use for the planning were collected from the TWDB, the GCWA, and questionnaires delivered to the Participating Utilities.

The TWDB population and water use projections will serve as a basis for the State's Year 2002 Water Plan. Although the State of Texas has adopted these numbers for their future projections, the Participating Utilities felt that the projections underestimate the future population for the planning area. Detailed breakdowns of the TWDB population and water use projections can be found in **Appendix C – TWDB Population and Water Use Projections**.

The Participating Utilities felt that the projections contained in the GCWA report entitled "Recommended Population and Water Use Projections for GCWA Customers" dated December 1999 better reflected realistic projections of regional population and water demand. These projections were

Figure 3-1
Water Use and Population Projections for Planning Area

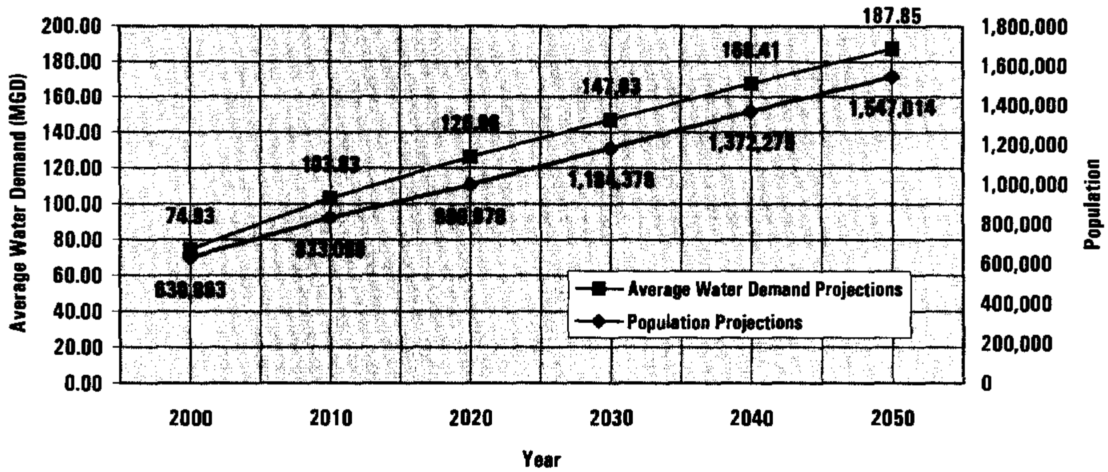
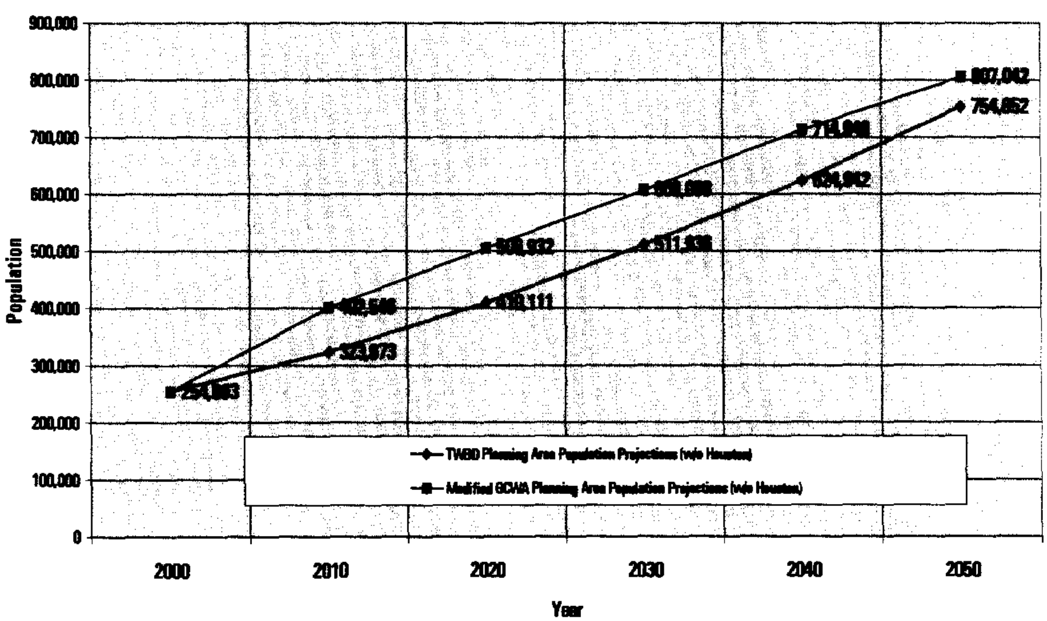


Figure 3-2
Population Projections Comparison



then modified by the Participating Utilities with data obtained from recent questionnaires. Therefore, this study will use the GCWA projections, as modified by the Participating Utility's questionnaires, as the official projected population and water use for the planning area. These projections will be labeled as the "GCWA modified" projections.

Participating Utility Projected Population

The GCWA modified population projections for the Participating Utilities are reported in the **Table 3-2**. The data lists projected water use and population in 10-year increments to the year 2050. **Figure 3-1** shows the relative difference in these projections versus the TWDB Region H water planning group population projections.

TABLE 3-2
PROJECTED POPULATION FOR PARTICIPATING UTILITIES IN PLANNING AREA

Participating Utility	2010	2020	2030	2040	2050
Alvin	39,048	48,922	64,615	80,307	96,000
Arcola	1,037	1,089	1,144	1,201	1,261
Manvel	16,522	27,000	28,000	29,000	30,000
Pearland	97,000	117,000	143,000	174,000	212,000
Missouri City	72,588	87,979	115,994	137,739	137,739
Stafford (FBWCID 2)	33,000	40,400	45,267	50,133	55,000
Sugar Land	98,651	122,975	129,642	136,310	142,977
Friendswood	44,700	61,567	81,427	105,959	132,065
Houston	430,520	492,945	575,288	657,630	739,972
Total for Planning Area	833,066	999,878	1,184,376	1,372,279	1,547,014

Population Projection Comparison

A comparison of the GCWA modified population projections to the Region H water planning group numbers is shown in **Figure 3-2**. This figure indicates that the modified GCWA projections are more conservative than the TWDB projections with an additional increase in population projection of approximately 50,000 residents by the year 2050. It is also noted that the modified GCWA projections shown a more accelerated growth pattern throughout the planning horizon than the Region H water planning group projections. This reflects the data that shows that Participating Utilities expected growth in the planning area is occurring faster than the growth schedule presented by Region H water planning group.

The City of Houston population projections are not included in this comparison. The Region H water planning group projections are listed for an entire city. Region H water planning group population estimates for the portion of the City of Houston in the study planning area were not available.

Water Demand Projection

Given the Participating Utilities approved population projections, the corresponding water use projections are shown in **Table 3-3**. These water use projections represent the expected annual water use reported as average daily demand in mgd.

Figure 3-1
Water Use and Population Projections for Planning Area

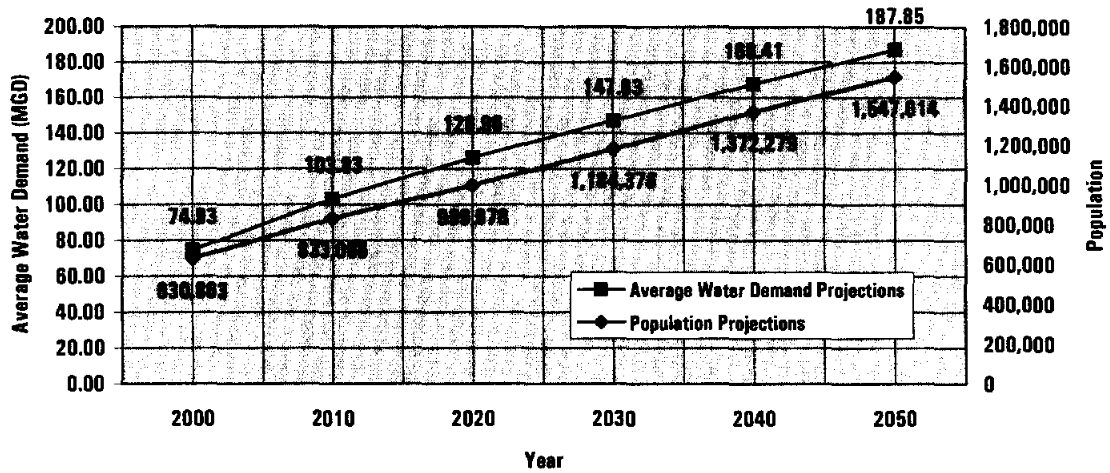
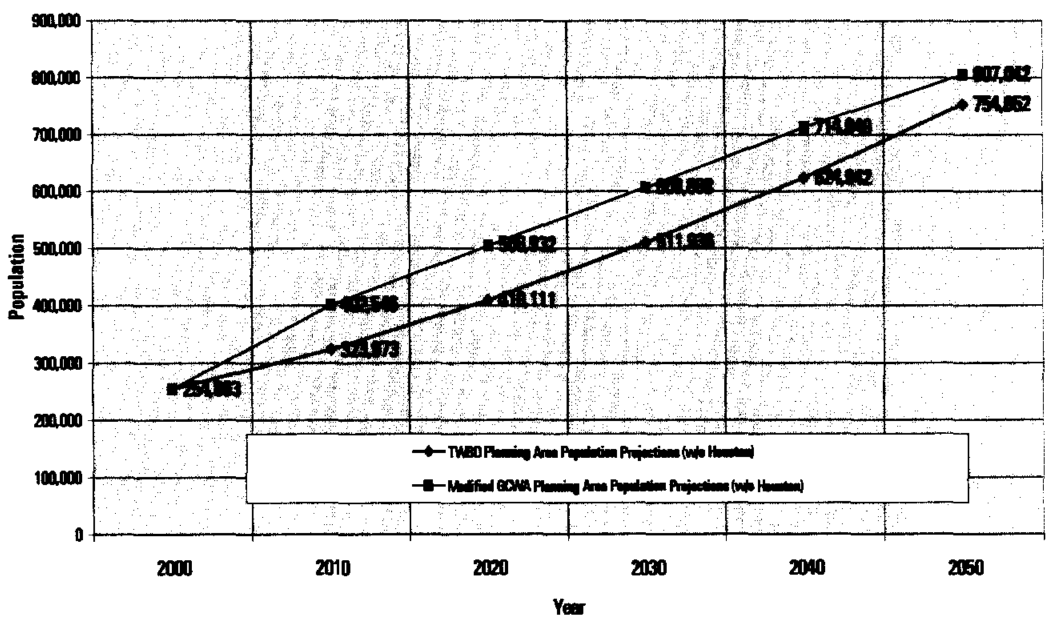


Figure 3-2
Population Projections Comparison



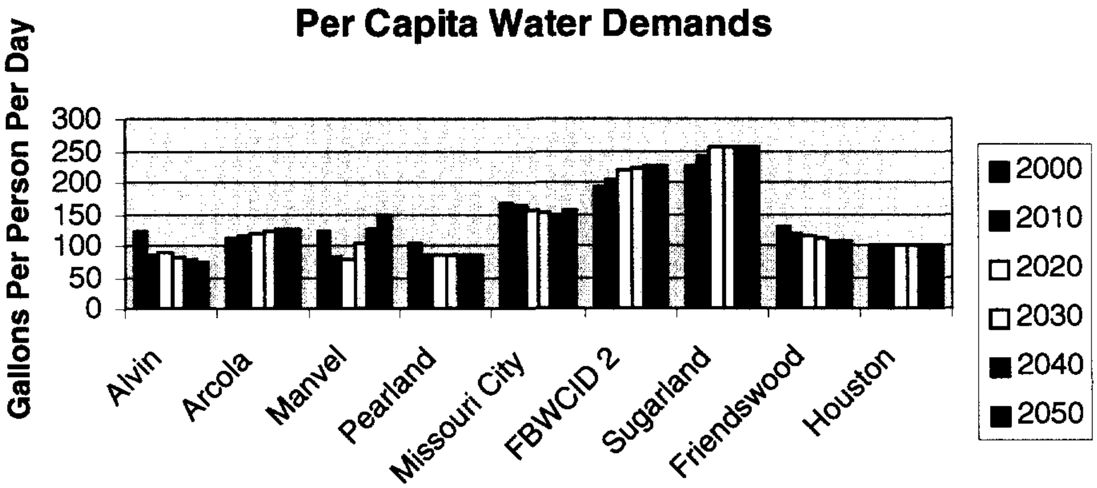
Each participating utility developed their water use projections based on the past water use data and future projections of growth.

TABLE 3-3
PROJECTED AVERAGE WATER DEMAND (MGD)
FOR PARTICIPATING UTILITIES IN PLANNING AREA

Participating Utility	2000	2010	2020	2030	2040	2050
Alvin	2.94	3.30	4.30	5.20	6.10	7.00
Arcola	0.11	0.12	0.13	0.14	0.15	0.16
Manvel	0.63	1.37	2.13	2.89	3.64	4.40
Pearland	4.32	8.23	9.92	12.13	14.76	17.98
Missouri City	10.66	11.82	13.85	17.57	20.50	21.15
Stafford (FBWCID 2)	2.01	6.70	8.80	10.03	11.27	12.50
Sugar Land	12.44	23.87	31.58	33.19	34.79	36.40
Friendswood	4.21	5.37	6.96	8.96	11.44	14.26
Houston	37.60	43.05	49.29	57.53	65.76	74.00
Total for Planning Area	74.93	103.83	126.96	147.63	168.41	187.85

By the year 2050, the Participating Utilities expect the average daily water use for the nine utilities to be approximately 188 mgd, which represents an increase of 113 mgd over the water demand in the year 2000. The per capita water use figures for each participating utility will vary as several utilities have diverse commercial and industrial centers with differing water use projections and can be seen in the **Figure 3-3**.

Figure 3-3
Per Capita Water Demands



Average and Peak Day Demand

The water use projections reported in **Table 3-3** are for average daily demand. In addition to the average daily water demand, each utility also reported their expected peak water demand to average water demand ratio. The peaking factor for each utility are shown in **Table 3-4**. The peaking factor is influenced by the distribution of residential, commercial, and industrial customers throughout the utility.

TABLE 3-4
PEAK DAILY TO AVERAGE DAILY FLOW PEAKING FACTORS AND PEAK DEMANDS

Participating Utility	Peaking Factor	Peak Daily Flow in the Year 2050 (mgd)
Alvin	1.64	11.50
Arcola	1.50	0.30
Manvel	1.50	6.60
Pearland	2.00	36.00
Missouri City	1.81	38.30
FBWCID No. 2	2.24	28.00
Sugar Land	2.40	87.40
Friendswood	2.13	30.40
Houston	1.25	92.50
Total for Planning Area		330.80

For the overall planning area, the peak daily flow to average daily flow ratio is 1.76. If the water treatment plant were to be sized to meet 100 percent of the water demand at each of the utilities, the plant would be required to deliver at least 331 mgd to meet the peak daily demand for the planning area.

Water Plant Capacity

The HGCSD currently limits groundwater production to a percentage of annual average water use. The FBSD is in the process of issuing a District Regulatory Plan (DRP). It is anticipated that the FBSD DRP will use the current HGCSD rules as a guide. For the purposes of this study, it is anticipated that the HGCSD and FBSD rules governing the planning area will limit the maximum groundwater pumpage from the underlying Gulf Coast Aquifer to no more than 20 percent of their annual water use.

It is the intention of the Participating Utilities to maximize the use of their existing infrastructure in providing water to their customers; therefore the Participating Utilities desire to pump as much water from the underlying aquifer as permissible by the Subsidence District. Given an expected 80 / 20 rule from the Subsidence District, the Participating Utilities would pump 20 percent of their average annual demand from the aquifer and obtain 80 percent of their water from the new surface water plant.

It is the desire of the Participating Utilities to receive a fairly constant supply of surface water and to augment this supply with groundwater from their wells. The Participating Utilities will activate their wells during times when the daily water demand exceeds 80 percent of their average annual demand. During winter months, when water demand is typically lower, the Participating Utilities may not need to operate their wells as the constant flow of the surface water may meet the daily demand in and of itself. During the summer months, the Participating Utilities will be required to utilize their groundwater wells to meet the daily water demand.

The Participating Utilities will also use their existing infrastructure to meet peak daily fluctuations in the water demand. The Participating Utilities can draw on their elevated and ground storage tanks to meet peak hour flows. Each participating utility noted that they plan on expanding their existing well and storage facilities to meet future peak flow demands in lieu of drawing additional water from the surface water plant.

The following bullets summarize the assumptions used by the Participating Utilities to determine the required capacity of the new surface water plant and provide their customers with a reliable supply of water in accordance with Subsidence District regulations are summarized below.

- Use GCWA Modified Population and Water Use Projections
- Maximize allowable groundwater production
- Meet 80 percent of Average Annual Water Demand with Surface Water, Use Existing or Future Groundwater Infrastructure to meet 20 percent of Average Annual Water Demand
- Use water stored in elevated and ground storage tanks to meet maximum day and peak hour demands

Given these assumptions, the required capacity of the water treatment plant are shown in **Table 3-5**:

TABLE 3-5
SURFACE WATER TREATMENT PLANT DEMAND

Year	Surface Water Demand (mgd)
2010	83
2020	102
2030	118
2040	135
2050	150

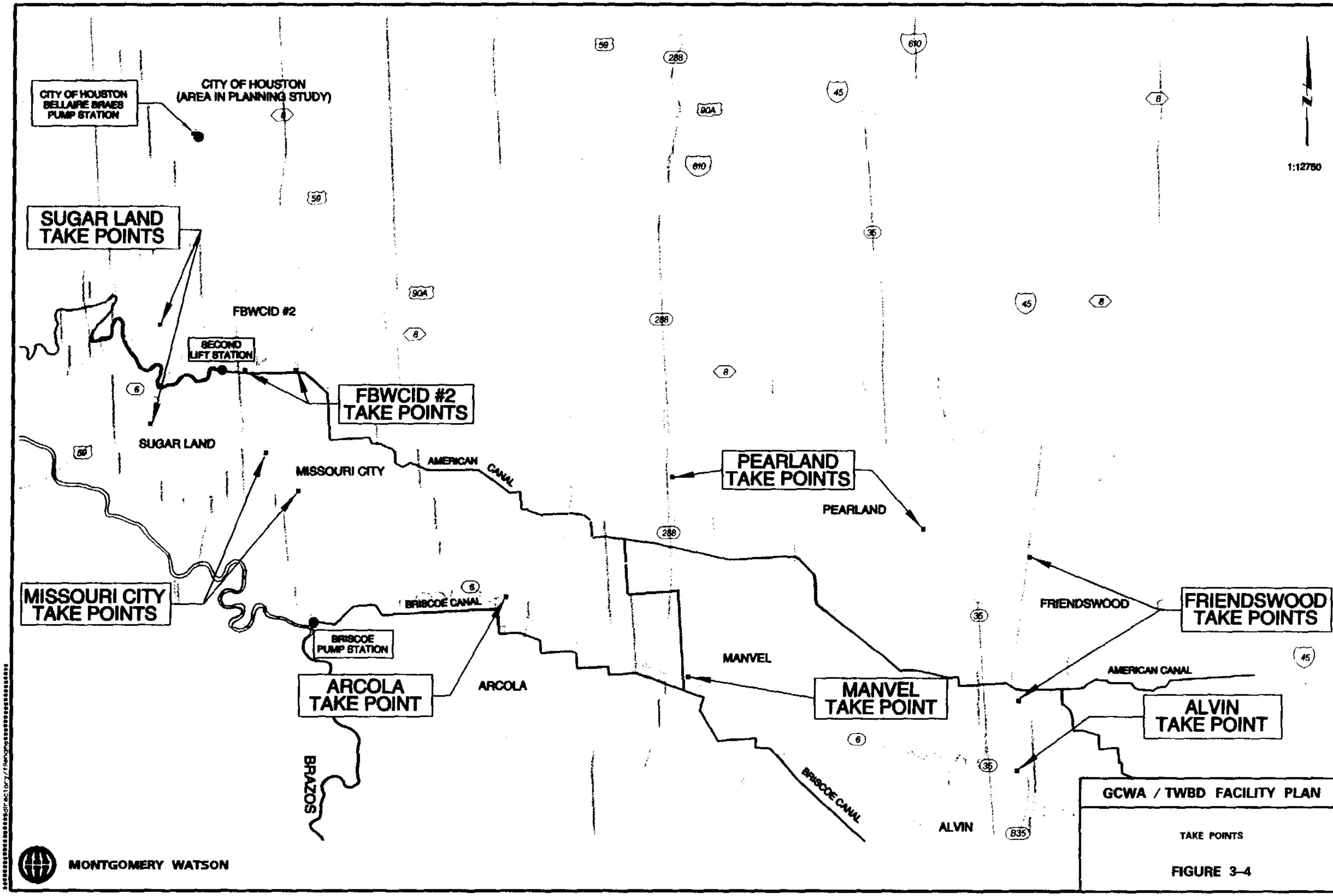
TAKE POINT OPERATING PLAN

Take points are defined as the end point at which the GCWA will transport potable water to the Participating Utilities. At each of these take points, a flow meter will be installed to record and monitor the total flow delivered to each participating utility. From this point on, the participating utility will be responsible for operation and maintenance of the water system.

Each participating utility provided the physical address, desired water pressure, and expected water demand at each preferred "take point". The take points can be viewed on **Figure 3-4** and are summarized on **Table 3-6** by Participating Utility.

The Participating Utilities were presented with the following two delivery options:

- At System Pressure: Water will be delivered at a preset pressure requested by the participating utility. Water will be feed directly into the Participating Utilities distribution system. If necessary, a booster pump station will be added.



GCWA / TWBD FACILITY PLAN

TAKE POINTS

FIGURE 3–4

TABLE 3-6
PARTICIPATING UTILITY TAKE POINT INFORMATION

Utility	Take Point Name	Address	Average Water Demand (mgd)	Take Point Pressure Requirement	Ground Elevation at Take Point (ft)	Tank Height (ft)
City of Houston	Bellaire Braes Pump Station	12423 Bellaire Blvd, Houston TX	59.20	Fill Tank	80	25
City of Sugar Land	First Colony	1402 Austin Parkway, Sugar Land TX	17.47	Fill Tank	80	23.5
	Lakeview	1101 Lakeview Drive, Sugar Land TX	11.65	Fill Tank	68	23.5
City of Missouri City	Quail Valley	Corner of Hwy 6 and Murphy Road, Missouri City Texas	8.46	Fill Tank	65	25
	Sienna Plantation	Corner of Hwy 6 and Sienna Parkway, Missouri City Texas	8.46	Fill Tank	60	25
FBWCID No. 2	Site B	GCWA Canal, 1700 feet east of Murphy Road	5.00	60 psi	80	-
	Avenue E	GCWA Canal, 4300 feet west of Murphy Road	5.00	60 psi	75	-
City of Pearland	SH 288	SH 288 at 518, Pearland TX	7.19	50 psi	60	32
	SH 35	SH 35 at CR 101, Pearland TX	7.19	50 psi	40	32
City of Manvel	Site E	Iowa Lane and Hwy 6, Manvel TX	3.52	50 psi	55	-
City of Arcola	Town Center	Hwy 521 and the Briscoe Canal	0.13	Fill Tank	63	16
City of Alvin	Bypass 35	Bypass 35 north of Shirley Drive, Alvin TX	5.60	65 psi	35	-
City of Friendswood	West Friendswood	FM 528 at SW city limits, Friendswood TX	5.71	65 psi	35	-
	SW Friendswood	FM 2351 at W city limits, Friendswood TX	5.71	65 psi	35	-

- Fill Tanks: Water will be delivered to the Participating Utilities existing or future ground storage tanks. The participating utility will be responsible for distributing water from these tanks to their customers via a booster pump station.

The City of Houston, City of Missouri City, City of Sugar Land, and the City of Arcola have requested the GCWA to deliver surface water to ground storage tanks. Water will be delivered at such pressure to fill the tank. FBWCID No. 2, the City of Pearland, City of Friendswood, City of Manvel, and the City of Alvin have requested treated surface water at system pressure. System pressure requests ranged from 50 psi to 65 psi.

OTHER DEMAND CONSIDERATIONS

Raw Water Conveyance

The new surface water plant will draw on Brazos River water delivered to the plant via the existing GCWA canal system. The canal system will have to convey not only the flows associated with the new surface water plant, but flows associated with the GCWA existing municipal, industrial, and agricultural customers. The projected demand for GCWA existing municipal, industrial, and agricultural customers are detailed in Section 2 and total 174 mgd in the year 2050. This represents an increase of 61 mgd over the Year 1999 demand of these existing customers.

The raw water demand placed on the GCWA canal by the new surface water plant will be equal to the finished water flow plus the water losses in the treatment process. It is expected that process will lose about 7 percent of the raw water flow in producing the finished water. Therefore, to meet a finished water demand of 150 mgd, the raw water flow entering the plant should be 161 mgd, or 7 percent over the desired finished water capacity.

The required capacity of the American Canal to ensure that raw water is delivered for both the new water plant and to the existing GCWA customers are shown in **Table 3-7**. The GCWA also uses the Briscoe Canal to convey water to its customers, but it is assumed that all raw water demand will be drawn from the American Canal. This is the worst case scenario and will simulate the requirement on the Canal in the event that the Briscoe Canal is out of service for maintenance.

TABLE 3-7
GCWA CANAL REQUIRED CAPACITY

Year	Existing Customer Water Contracts (mgd)	Surface Water Plant Raw Water Demand (mgd)(1)	Total Canal Flow To WTP (mgd)(2)
2000	174	-	191
2010	174	89	289
2020	174	109	311
2030	174	126	313
2040	174	145	350
2050	174	161	368

Note 1: with 7% allowance for wash water and sludge production.

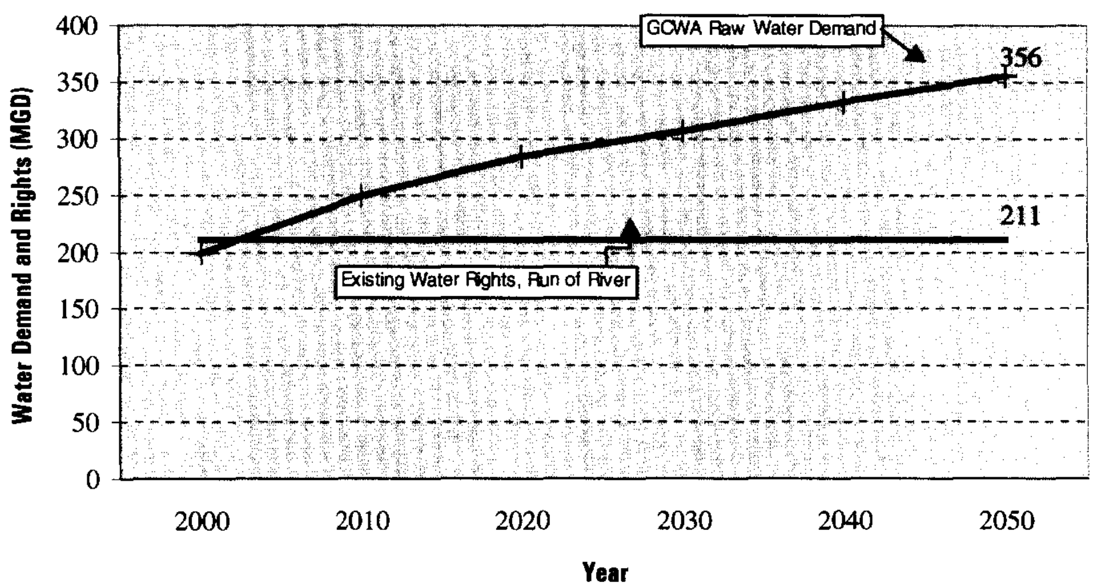
Note 2: with 10% allowance for evaporation and seepage.

To carry these flows to the water treatment plant, the canal will require several modifications to limit constrictions and increase capacity. The GCWA has identified that these modifications are feasible and that the required capacities can be attained. The location and the magnitude of the canal reaches where improvements are required are shown in **Figure 3-5.**

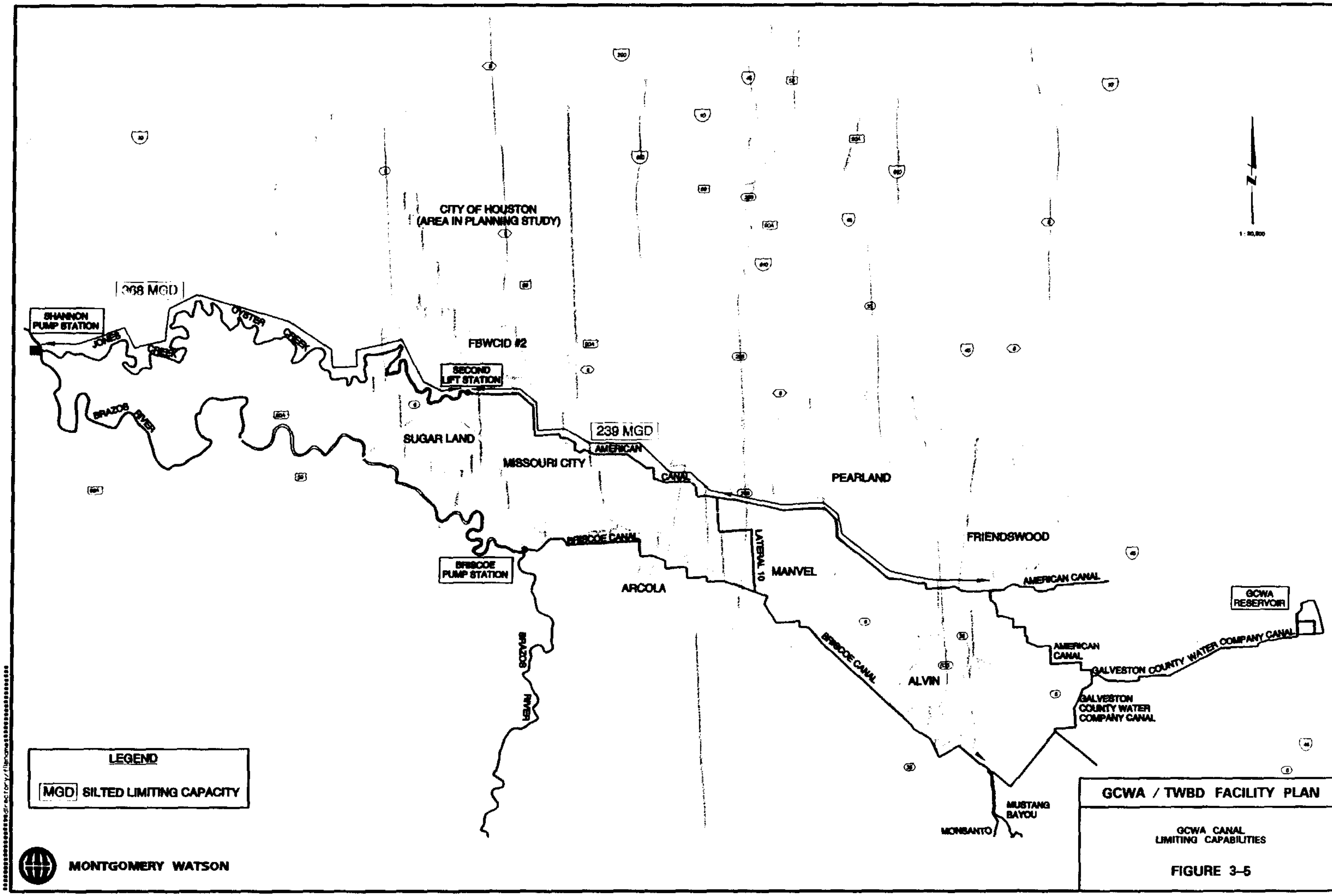
Water Rights

One issue surrounding the construction of a surface water facility is the availability of reliable surface water. The GCWA currently holds senior water rights on the Brazos River and Oyster Creek watersheds to the sum of an average annual withdrawal of 211.48 mgd. The GCWA currently holds contracts with its customers to deliver an average annual flow of 154 mgd, leaving the GCWA with approximately 55 mgd of unallocated water rights. These unallocated rights have been optioned to several Participating Utilities, but will not meet the projected water demand of the new surface water facilities. To meet the required demand of the new surface water plant and serve the existing GCWA customers, an additional 145 mgd of reliable surface water will be required. The need for additional water rights over the planning period is demonstrated in **Figure 3-6.**

Figure 3-6
Water Rights vs. Water Demand



Although the current GCWA water rights fall short of the amount needed for the region through the year 2050, GCWA is actively pursuing additional water rights and it is the expectation of GCWA to secure reliable raw water yield within the next few years. Additionally, the Texas Natural Resource Conservation Commission is currently completing a water availability modeling (WAM) effort to help clarify water rights. The results from this study will show the impacts of current withdrawal during drought conditions and will be used to craft the next version of the State Water Plan.



GCWA / TWBD FACILITY PLAN

GCWA CANAL
LIMITING CAPABILITIES

FIGURE 3-5

Section 4
Development of Treatment Process

This section provides discussion of the quality of water from the Brazos River, along with descriptions of current and potential federal drinking water regulations, which have applicability to treatment of the water. This development of treatment requirements is followed by the development of treatment process alternatives, unit process design criteria, and associated chemical feed criteria.

WATER QUALITY

Historical Raw Water Quality

The proposed treatment facilities will treat raw water from the Brazos River. The water will be conveyed to the sites via the GCWA canals. The canal system effectively serves as a presedimentation process to remove solids and dampen the effects of the variable water quality in the Brazos River.

Water quality data was obtained from two sources: United States Geological Society (USGS) data for the Brazos River at the Richmond – Rosenberg Monitoring Station, and data from the GCWA for the river intake and for the raw water at the existing water treatment plant in Texas City. A summary of the available data is shown in **Table 4-1**.

The raw water quality evaluation showed that the Brazos River contained elevated levels of total dissolved solids, aluminum, manganese, bromide, and total organic carbon, but the observed contaminant levels in the raw water is easily treatable through conventional processes.

FEDERAL AND STATE STANDARDS

Federal standards for drinking water are summarized in **Table 4-2**. Standards for the State of Texas are set by the Texas Natural Resources Conservation Commission. In most cases, Texas standards match federal standards. Some secondary standards are different; Texas has a maximum contaminant level (MCL) of 1,000 mg/l for Total Dissolved Solids, and a chloride MCL of 300 mg/l.

Pending federal regulations must be considered in the evaluation of treatment processes for the proposed plant. The Stage 2 Disinfectants/Disinfection By-Products (D/DBP) Rule is expected to maintain current MCLs for total trihalomethanes (TTHMs) and total haloacetic acids (THAAs) at 80 and 60 ug/l. The rule will become more stringent in that individual monitoring sites will be used to determine compliance, rather than on a system-wide basis. This change will probably have the effect of requiring lower levels of TTHMs and THAAs leaving a treatment plant. The recently promulgated Interim Enhanced Surface Water Treatment Rule (EWSTR) set a goal for disinfection/removal of *Cryptosporidium* of zero, with an MCL of 2-log disinfection/removal. The rule grants 2-logs of disinfection/removal credit to facilities using conventional treatment processes that meet other requirements of the rule. A second Enhanced Surface Water Treatment Rule is expected in the future. This rule is expected to focus on more stringent disinfection/removal requirements for microbiological contaminants, such as *Cryptosporidium*. The Backwash Treatment Rule is in development, and is expected to require all plants to recycle waste washwater from backwashing of filters to the head of the treatment process after equalization. The Backwash Treatment Rule is not expected, at least initially, to set treatment limits.

The Stage 1 D/DBPR and the Interim ESWTR were promulgated in December, 1998. Data related to future changes in these two rules has been collected by utilities, and is now under evaluation by EPA and other agencies and groups. It is estimated that the data evaluation will be completed in 2000. The EPA has formed advisory committees to begin a negotiated process for future regulations. Based on the time required for the negotiations for the most recent two regulations, it is anticipated that the Stage 2 D/DBPR and a future ESWTR may be proposed in the next five to ten years. If proposed in this time

TABLE 4-1
SUMMARY OF RAW WATER QUALITY

Quality Analysis	Unit	BRAZOS RIVER Average [a]	BRAZOS RIVER Range [b]	River Intake [c]	Raw Water at WTP
Algae count	(cells/ml)			14214	
Alkalinity(as CaCO3)	mg/l	136	75 - 234	156.6	141
Aluminium, dissolved	ug/l	51	10 - 390		
Ammonia Nitrogen (as N)	mg/l	0.06	0 - 0.23	0.068	
Apparent Color	ACU				
Arsenic	ug/l	3.0	1 - 7		
Beryllium	ug/l	0.6	0.5 - 2		
Boron, dissolved	ug/l	119	60 - 170		
Bromate	mg/l			0.26	0.07
Bromide	mg/l			0.26	
Cobalt (as Co)	ug/l	2.9	0 - 60		
Cadmium (as Cd)	ug/l	1.4	0 - 3		
Calcium	mg/l	60	28 - 100		53
Chloride	mg/l	114	12 - 370	118	67
Chromium (as Cr)	ug/l	10	0 - 20		
Copper (as Cu)	ug/l	16.8	5 - 47		
Dissolved oxygen	mg/l	8.6	5.4 - 12	6.8	
DOC	mg/l	11	4.2 - 25	4.09	
Fecal coliform, 7um-mf	colonies/100 ml	730	12 - 7,300		
Flouride	mg/L	0.3	0.1 - 0.5		
Glyphosate	ug/l				
H_2S	mg/L				
Iron, Total (as Fe)	ug/l	5500	390 - 22,000	2650	24
Kjeldahl Nitrogen	mg/l	0.9	0.01 - 7.3		
Lead (as Pb), Total	ug/l	24.5	2 - 65		
Lithium (dissolved as Li)	ug/l	14.3	6 - 30		
Magnesium	mg/l	13	3.5 - 71		20
Manganese, Total (as Mn)	ug/l	205	5 - 740		
Mercury (as Hg), Total	ug/l	0.2	0.1 - 0.4		
Molybdenum (dissolved as Mo)	ug/l	10.2	10 - 20		
Nickel (as Ni), Total	ug/l	8.9	2 - 30		
Nitrate	mg/l	0.4	0.01 - 1.5	1.47	1.40
Nitrite	mg/l	0.04	0 - 0.29	0	0.05
Odor					
Organic Nitrogen	mg/l	0.9	0.15 - 4.3	0.86	
Ortho-Phosphate Phosphorus (as	mg/l	0.1	0.01 - 0.13		0.18
pH	units	7.9-8.0	7.4 - 8.5	8.4	8.2
Potassium	mg/l	4.7	1.8 - 7.5		
Selenium (as Se), Total	ug/l	0.5	0 - 1		
Silica	mg/l	8.7	0.3 - 40	8.4	
Silver (as Ag), Total	ug/l	0.6	0 - 1		
Sodium	mg/l	80	9.5 - 240		
Specific Conductance	umho/cm	770	220 - 1,900	700	
Streptococci fecal, membrane	colonies/100 ml	860	20 - 9,100		
Strontium (dissolved as Sr)	ug/l	570	70 - 1,000		
Sulfate (as SO4)	mg/l	76	16 - 200		57
TDS	mg/L	430	50 - 980	440	140
Temperature	oC	20	3.5 - 33.5		
Total Hardness, Non Carbonate	mg/L	70	0 - 190		
Total Hardness, as CaCO3	mg/l	200	90 - 470		189
Total Nitrogen N	mg/l			0.90	
Total Organic Carbon (as C)	mg/l	10	2.7 - 44	4.80	4.8
Total Organic Halogen	ug/l				
Total Phosphorus P	mg/l	0.2	0.04 - 0.95	0.07	
TSS	mg/L	1150	12 - 7,360	280	19.8
Turbidity	NTU	150	0.4 - 890	160	50
UV-254	1/cm			0.10	
Vanadium (dissolved as V)	ug/l	6.1	6 - 8		
Zinc (as Zn), Total	ug/l	60	20 - 120		

a : Average of samples taken from 1970 to 1995. b: Range of samples taken from 1970 to 1995.

c: Year 1990

TABLE 4-2
SUMMARY OF FEDERAL STANDARDS

Volatile Organic Chemicals	Max Contaminant Level (mg/l)
1,1-Dichloroethylene	0.007
1,1,1-Trichloroethane	0.2
1,1,2-Trichloroethane	0.005
1,2-Dichloroethane	0.005
1,2-Dichloropropane	0.005
1,2,4-Trichlorobenzene	0.07
Benzene	0.005
Carbon tetrachloride	0.005
Cis-1,2-Dichloroethylene	0.07
Dichloromethane	0.005
Ethylbenzene	0.7
Monochlorobenzene	0.1
o-Dichlorobenzene	0.6
para-Dichlorobenzene	0.075
Styrene	0.1
Tetrachloroethylene	0.005
Toluene	1
trans-1,2-Dichloroethylene	0.1
Trichloroethylene	0.005
Vinyl chloride	0.002
Xylenes (total)	10
Synthetic Organic Chemicals	**Max Contaminant Level (mg/l)**
2,3,7,8-TCDD (Dioxin)[a]	$3x10^{-8}$
2,4-D	0.07
2,4,5-TP (Silvex)	0.05
Alachlor	0.002
Atrazine	0.003
Benzo(a)pyrene	0.0002
Carbofuran	0.04
Chlordane	0.002
Dalapon	0.2
Di(2-ethylhexyl)adipate	0.4
Di(2-ethylhexyl)phthalate	0.006
Dibromochloro-propane (DBCP)	0.0002
Dinoseb	0.007
Diquat	0.02
Endothall	0.1
Endrin	0.002
Ethylene dibromide	0.00005
Glyphosate	0.7
Heptachlor	0.0004
Heptachlor epoxide	0.0002
Hexachlorobenzene	0.001
Hexachlorocyclo-pentadiene	0.05
Lindane	0.0002
Methoxychlor	0.04
Oxamyl (vydate)	0.2
Pentachlorophenol	0.001
Picloram	0.5
Polychlorinated biphenyl (PCB)	0.0005
Simazine	0.004
Toxaphene	0.003
Acrylamide	TT
Epichlorohydrin	TT

TABLE 4-2 (CONTINUED)
SUMMARY OF FEDERAL AND STATE STANDARDS

Disinfection	Max Contaminant Level (mg/l)
Total Trihalomethanes (TTHMs)	*0.080*
Haloacetic Acids (HAAs)	0.060
Bromate	0.010
Chlorite	1.0
	Maximum Residual Disinfectant
Chlorine	4.0
Chloramines	4.0 as Total Chlorine
Chlorine Dioxide	0.8
Enhanced Coagulation	Treatment Technique
Giardia Lamblia	3-log inactivation/removal
Viruses	4-log inactivation/removal
Cryptosporidium	2-log inactivation/removal
Inorganics	Max Contaminant Level (mg/l)
Antimony	0.006
Arsenic	0.05
Asbestos	7 MFL > 10microns
Barium	2
Beryllium	0.004
Cadmium	0.005
Chromium	0.1
Copper	1.3 action level
Cyanide	0.2
Fluoride	4.0
Lead	*0.015 action level*
Mercury	0.002
Nickel	0.1
Nitrate	10 (as N)
Nitrite	1 (as N)
Total Nitrate and Nitrite	10 (as N)
Selenium	0.05
Thallium	0.002
Secondary Standards	Max Contaminant Level (mg/l)
Aluminum	0.05 to 0.2
Chloride	250
Color	15 color units
Copper	1
Corrosivity, Sat. Index	Non-corrosive
Fluoride	2.0
Foaming Agents	0.5
Iron	0.3
Manganese	0.05
Odor-TON[b]	3
PH	6.5-8.5
Silver	0.1
Sulfate	250
Total Dissolved Solids	500
Zinc	5
Solids	Max Contaminant Level
Turbidity	0.3 ntu
Microbiological	
Total Coliform	Presence/Absence
Radionuclides	Max Contaminant Level (pCi/l)
Combined Radium-226 and	5
Gross Alpha (incl. Radium-228,	15
Tritium	20,000
Strontium-90	8

frame, it is likely that compliance would be required within an additional three to five years after the rules are actually promulgated.

A future ESWTR has not been proposed, nor has EPA suggested what contaminants, nor what levels of treatment may be regulated. It is recommended that the process treatment selection NOT be selected to meet the undefined requirements of the future EWSTR additional disinfection/removal requirements at this time. The federal advisory committee is currently discussing a period of monthly monitoring for *Cryptosporidium*. Based on the monitoring results, action levels would trigger additional inactivation/removal requirements. For example 1.0 to 3.0 oocysts/l of *Cryptosporidium* would trigger an additional 2.0 log inactivation/removal requirement. Multiple approaches for achieving inactivation/removal credit may be allowed, including watershed protection, enhanced turbidity removal, in addition to a mandatory partial disinfection process that is broadly defined as Ultraviolet light, ozone, or membranes).

It is recommended, however, that the treatment process evaluation consider the adaptability of the process to possible changes by this rule. It is recommended that an allocation (both site area and hydraulic head) be set aside for future processes that may be required by this rule.

FINISHED WATER QUALITY GOALS

The key water quality goals for the proposed WTP are listed in **Table 4-3**. The goals are based on federal Primary and Secondary Standards, and TNRCC standards from its draft proposal for Chapter 290, Subchapter F, Drinking Water Standards Governing Drinking Water Quality and Reporting Requirements for Public Water Supply Systems. The new TNRCC standards are for turbidity, TTHMs, THAAs, bromate, chlorite, and enhanced coagulation. .

TABLE 4-3
SUMMARY OF TREATMENT GOALS

Parameter	Units	Treatment Goal	Remarks
Giardia Lamblia	-	0.5-log chemical disinfection	2.5-log removal provided by conventional process
Cryptosporidium	-	No additional treatment	2-log removal provided by conventional process
Viruses	-	2.0-log chemical disinfection	2-log removal provided by conventional process
Turbidity	Ntu	< 0.1	
TOC	Mg/l	Up to 25 percent removal	
Total coliform	-	Not detectable	
Alkalinity, Total	Mg/l	No additional treatment	
Langlier Index	Mg/l	Between 0.1 and 0.4	
Total Hardness	Mg/l	No additional treatment	
pH	-	Between 7.5 and 8.0	
Chlorite	Mg/l	< 1.0	
Total Haloacetic Acids	Ug/l	< 30	Quarterly running average in distribution system
Total Trihalomethanes	Ug/l	< 40	Quarterly running average in distribution system

TREATMENT PROCESS ALTERNATIVES

The treatment process alternatives that were evaluated include:

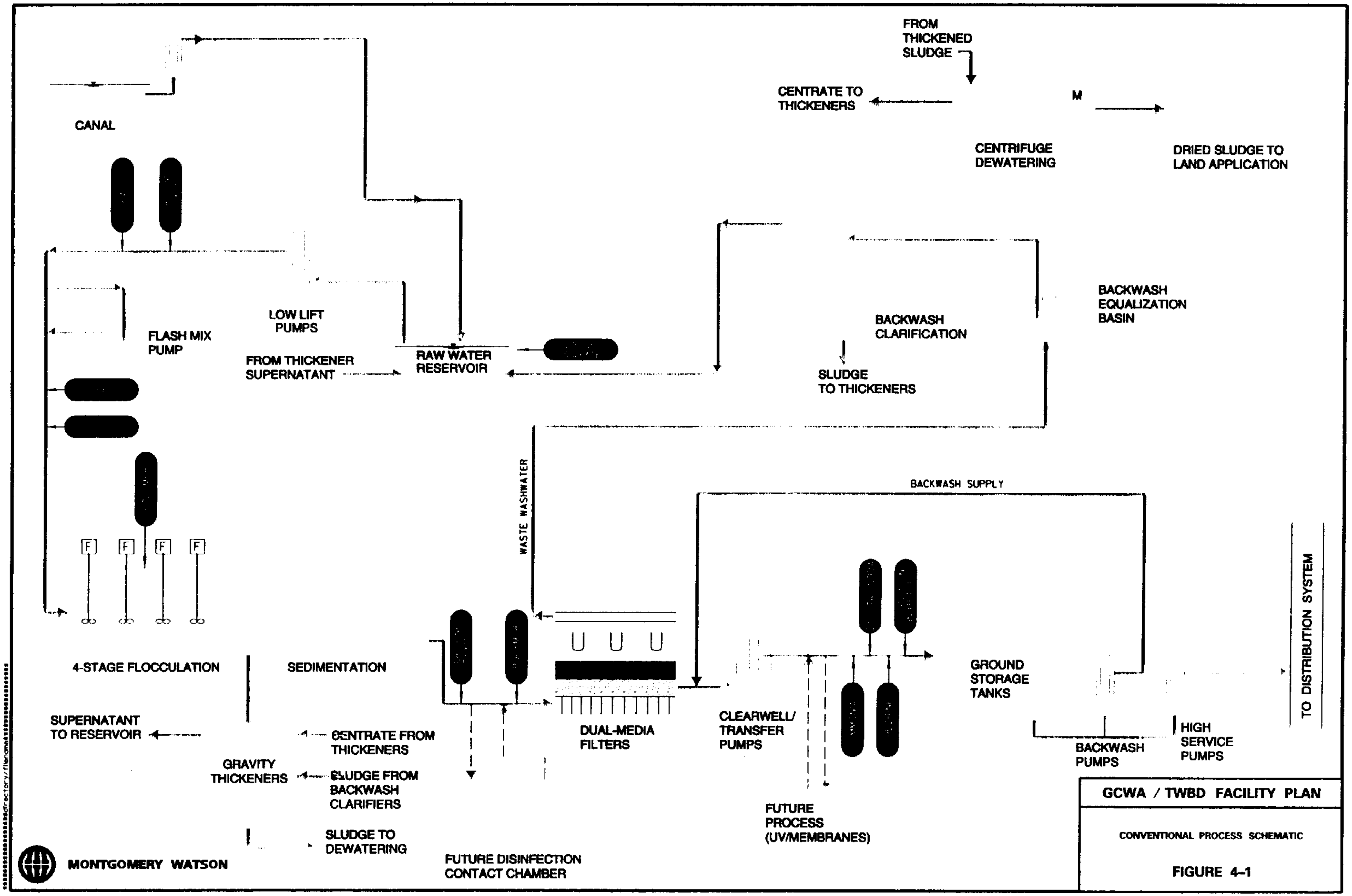
- Conventional process – The conventional process includes standard pretreatment (four stages of flocculation and rectangular plug-flow sedimentation basin) before filtration with granular activated carbon media.
- A high-rate conventional process - The high-rate conventional process assumes that a high-rate pretreatment process (SUPERPULSATOR Type U technology) is used to reduce the space and cost of pretreatment before filtration with granular activated carbon media. The existing Mackey WTP uses high-rate pretreatment (reactor-clarifiers).
- A membrane filtration process - The membrane filtration process is experiencing more widespread use in the United States as the cost of membranes and the cost of pumping associated with the membrane treatment is lowered.

Ozone was considered as a possible treatment alternative at this time due to the elevated levels of bromide in the raw water, average of 0.26 mg/l, as a process with ozone would create bromate as an ozonation by-product. Bromate is regulated at an MCL of 0.010 mg/l with discussions of a lower MCL in the future of 0.005 mg/l. Many studies of ozone and bromate formation have found that bromide levels above 0.10 mg/l typically result is bromate levels in excess of the MCL. Since ozone would likely create bromate at a level that exceeds the MCL for this DBP, it was not considered to be a viable option at this time. Ozone may indeed be a viable option, but an exhaustive treatability study to determine the exact requirements to control DBPs will be required.

Alternative 1- Conventional Process

Oxidation	*Chlorine dioxide*
Pretreatment	*Coagulation, flocculation, sedimentation*
Filtration	*Media filters*
Adsorption	*Powdered and Granular Activated Carbon*
Primary disinfectant	*Chlorine dioxide*
Residual disinfectant	*Chloramine*

A flow diagram of the recommended process units for the conventional treatment alternative is shown in **Figure 4-1**. Pre-oxidation is accomplished with chlorine dioxide. Taste and odor control is accomplished with chlorine dioxide or PAC addition. Pre-treatment is provided by chemical coagulation, rapid mixing, four-stage flocculation, and sedimentation. For this evaluation, flocculation is accomplished with vertical turbine flocculators. The sedimentation basins are assumed to be rectangular basins with chain-and-flight collector mechanisms. Filters are assumed to be deep-bed, constant-level, constant loading filters. Media is assumed to be granular activated carbon (for taste and odor control) with an underlayer of sand. Additional processes that may be required by future regulations include post-sedimentation ozone or chlorine dioxide for inactivation of *Cryptosporidium*, and / or post-filtration membrane filtration or UV disinfection. Circular concrete, above-ground tanks are provided for storage of finished water. Sludge from the pretreatment process is sent to a gravity thickener for preliminary separation of solids and water. Thickened sludge is dewatered on-site with centrifuges. Ultimate disposal is to a permitted disposal site. Dirty filter backwash water is equalized and clarified, and then recycled to the head of the treatment process.



GCWA / TWBD FACILITY PLAN

CONVENTIONAL PROCESS SCHEMATIC

FIGURE 4-1

Alternative 2- Conventional with High-rate Pretreatment

Oxidation	*Chlorine dioxide*
Pretreatment	*High Rate Solids contact (Pulsed Upflow)*
Filtration	*Media filters*
Adsorption	*Powdered and Granular Activated Carbon*
Primary disinfectant	*Chlorine dioxide*
Residual disinfectant	*Chloramine*

A process schematic of Alternative 2 for the conventional process with High-Rate Pretreatment is shown in **Figure 4-2**. This alternative is similar to Alternative 1, except that the pretreatment process is solids-contact type utilizing pulsed upflow clarifiers. These proprietary units can be operated at higher rates than is normally allowed for conventional processes. The high-rate process combines two processes into a single unit. The high rate process results in to space savings because of the smaller basin volume which in-turn results in reduced construction costs. This process is proven with source waters similar to those for this facility. In addition, the clarifiers maintain a sludge blanket, which when used in conjunction with powdered activated carbon, is an efficient process for removing organic material. All other processes will be as described in Alternative 1 above.

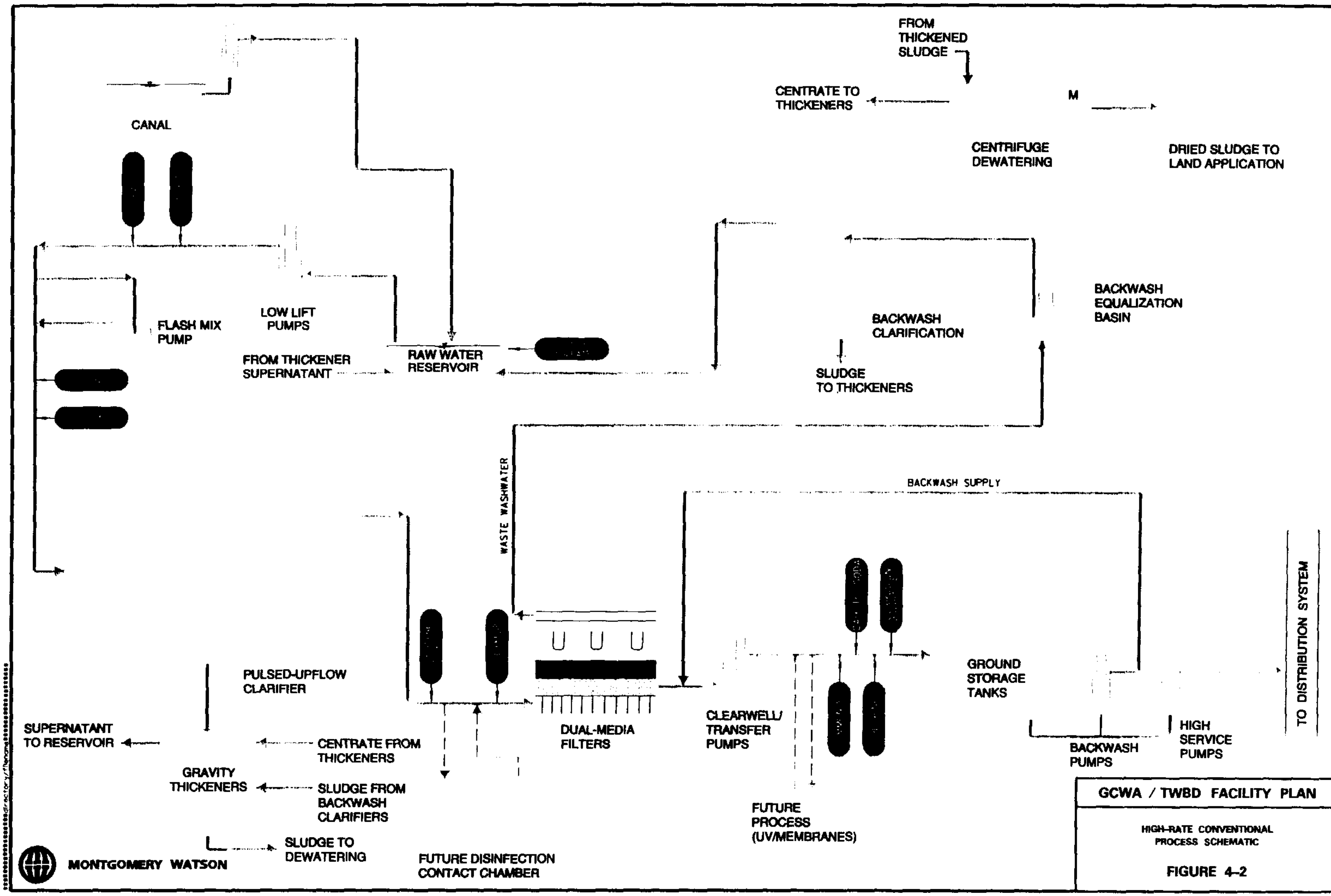
Alternative 3- Membrane Filtration

Oxidation	*Chlorine dioxide*
Pretreatment	*Pulsed-upflow clarifiers*
Filtration	*Ultrafiltration membranes*
Adsorption	*PAC*
Primary disinfectant	*Chlorine dioxide*
Residual disinfectant	*Chloramine*

The quality of the source water will allow the use of membrane filtration when used in conjunction with pretreatment for removal of solids. The sizing of the membranes is optimized with the use of high-rate pretreatment with pulsed upflow clarifiers. Taste and odor control is achieved with chlorine dioxide as a pre-oxidant, and with powdered activated carbon added to the pretreatment process. PAC may also be re-circulated in the membrane system. Reject water from the membranes (up to 10% of the finished water flow) is equalized and clarified prior to return to the head of the plant. Residuals from the clarifiers is thickened in gravity thickeners, and subsequently dewatered with centrifuges. Ultimate disposal is to a permitted disposal site. Waste from chemical cleaning of membranes is discharged to the sludge system after neutralization. A process schematic of this alternative is shown in **Figure 4-3.**

PROCESS CRITERIA

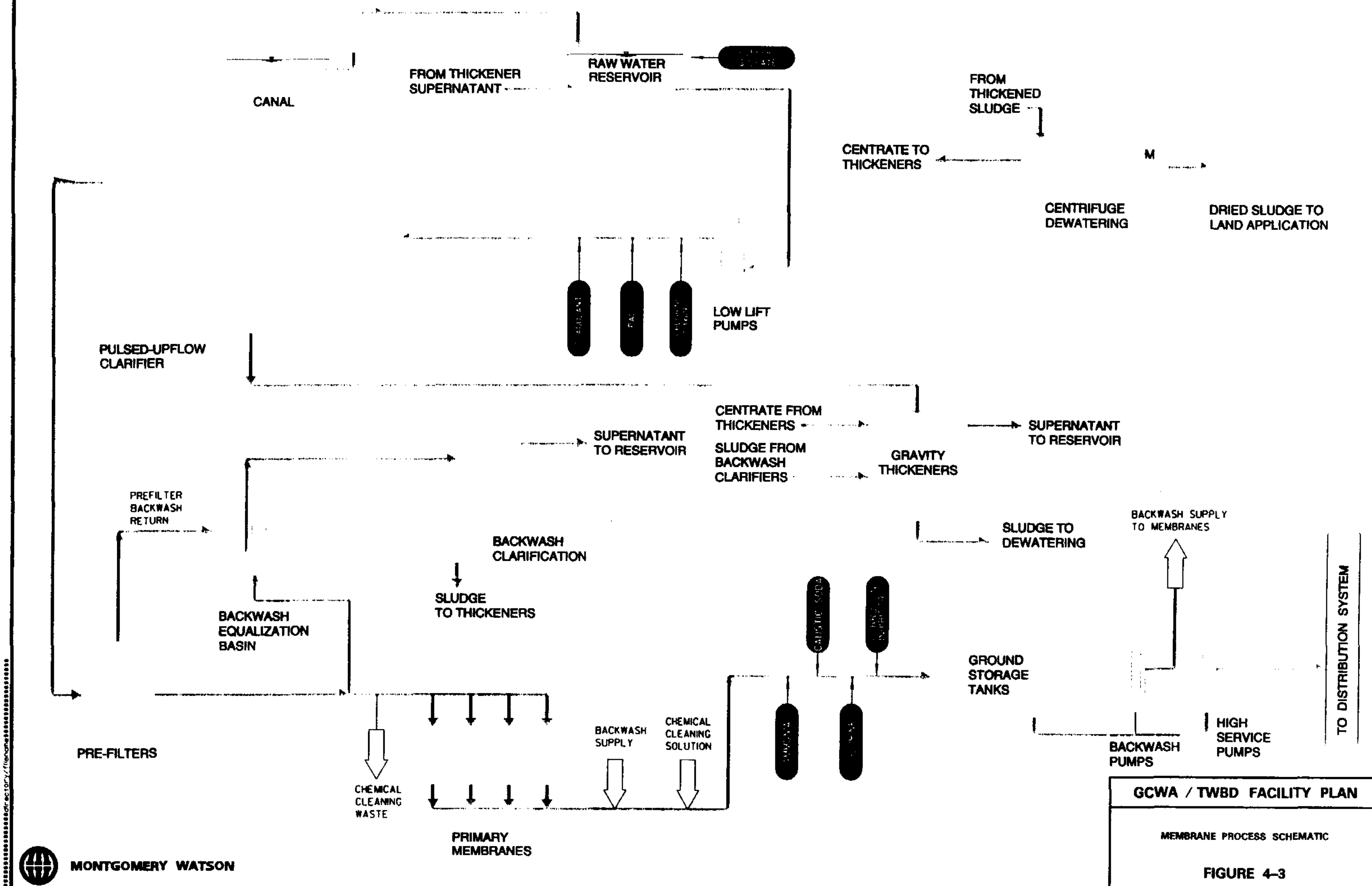
Criteria for unit processes are listed in **Table 4-4.** Where applicable, criteria are based in TNRCC criteria contained in <u>Subchapter D: Rules and Regulations for Public Water Systems, 290.42, Water Treatment.</u> Criteria for proprietary process equipment, such as the pulsed upflow clarifiers and membranes are based on manufacturer's recommendations. Criteria for other unit processes are based on criteria from "Integrated Design of Water Treatment Facilities" by Kawamura. The costs analysis of these three alternatives is presented in **Section 7**.



GCWA / TWBD FACILITY PLAN

HIGH-RATE CONVENTIONAL PROCESS SCHEMATIC

FIGURE 4-2



GCWA / TWBD FACILITY PLAN

MEMBRANE PROCESS SCHEMATIC

FIGURE 4-3

TABLE 4-4
CRITERIA FOR SIZING WATER TREATMENT PROCESSES

Sizing Criteria	Units	Value
Mixing		
Type		Pumped Diffusion
Velocity Gradient	sec^{-1}	2000
Flocculation Basins		
No. Stages	each	4
Velocity Gradient	sec^{-1}	75,60,40,25
Type		Vertical Turbine
Detention Time	minutes	30
Conventional Sedimentation Basins		
Type		Rectangular, Plug Flow
L:W Ratio		> 4:1
Depth	Ft	12
Surface Loading Rate	gpm/ft^2	0.6
Media Filters		
Type		Deep Bed, Dual Media (GAC/Sand)
L/d Ratio		1500
L:W Ratio		2
Loading Rate (one filter off-line)	gpm/ft^2	5
Backwash Rate	gpm/ft^2	22
Average Filter Runtime	hours	72
Auxiliary Wash Type		Air Scour
Auxiliary Wash Rate	scfm/sq ft	3.0
Gravity Thickener		
Solids loading rate	lb/ft^2	9
Hydraulic Loading Rate	gpm/ft^2	0.12
Sludge Lagoon Process		
Loading Rate	lb/ft^2	14
Minimum length	ft	100
Storage Capacity per Unit	months	3
Minimum Number of Units	each	4
Waste Washwater Equalization		
Type		Rectangular, Sloped Bottom
L:W Ratio		4
SWD	ft	16
Storage Volume	# of backwashes	3

TABLE 4-4 (CON'T)
CRITERIA FOR SIZING WATER TREATMENT PROCESSES FEED CRITERIA

Sizing Criteria	Units	Value
Waste Washwater Clarification		
Clarifier Type		Lamella
Clarifier Loading Rate	gpm/ft^2	0.2
Sludge Removal	%	85
Dewatering		
Holding Tank Capacity	days	4
Holding Tank Depth	ft	30
Centrifuge Type		Solid Bowl
Hydraulic Loading Rate	gpm/unit	200
Finished Water Storage		
Operational Volume	hours	4
Type		Above Ground, Pre-stressed Concrete
High-Rate Clarification		
Type		Pulsed-Upflow
Unit Design Application Rate	gpm/ft^2	2.1
Membrane Filtration		
Design Flux	gfd	70
Average Recovery	%	90
Temperature	degrees C	10
Maximum TMP	psi	13
Cleaning Cycle	per year	4 (max)

Chemical feed criteria are shown in **Table 4-5**. Criteria are based on historical chemical data for the Dr. Thomas Mackey WTP. Preliminary jar tests were also conducted on the raw water by GCWA staff to understand the estimated ferric and polymer dose required for coagulation. It should be noted that these chemical doses are preliminary and represent likely chemical doses at the water plant. It would be advantageous to establish a pilot plant to test and optimize chemical doses.

TABLE 4-5
CHEMICAL FEED CRITERIA

Chemical	Purpose	Avg. Dose (mg/l)	Application Point
Ferric	Coagulant	30	Flash Mix Pump
Cationic Polymer	Coagulant Aid	5	Flash Mix Pump
Anionic Polymer	Flocculant / Filter Aid	1	After Flash Mix Pump/ Settled Water Channel
Sodium Chlorite	Form Chlorine Dioxide for Disinfection	0.8	Chlorine Dioxide Generator
Chlorine	Form Chlorine Dioxide for Disinfection	0.8	Following Low Lift Pumps, Following Clarifier
Chlorine -BW	Disinfection	5	Backwash Supply Pipe
Chlorine	Residual Disinfection	3	Following Transfer Pumps
Ammonia	Disinfection	1	Following Transfer Pumps
PAC	Taste and Odor	10	Following Low Lift Pumps
Caustic Soda	pH Adjustments	10	Following Transfer Pumps
Flouride	Aesthetics	0.6	Following Transfer Pumps
Phosphate	Corrosion Inhibitor	0.5	Following Transfer Pumps
Copper Sulfate	Algae Control		Raw Water Reservoir

Each of these three treatment plant alternatives can meet the required finished water goals and are easily adaptable for future regulations. Selection of the preferred treatment process alternative will be based on the overall project cost including capital expenditures and operating and maintenance costs over the lifespan of the project.

DISCUSSION OF ALTERNATIVES

The treatment process alternatives were compared based on the following general criteria.

- Ability to meet all current applicable federal and state water quality standards and achieve treatment goals defined in **Table 4-3**
- Based on commercially available process equipment that have a successful history of application in municipal drinking water industry
- Maximize use of limited raw water supply by high recovery / low wastage or recycle rates
- Fit within the available space of the proposed site
- Ease of operations
- Level of maintenance

Alternative 1 is very similar to the existing Mackey WTP. The one notable difference is the conventional flocculation and sedimentation basins are proposed. These types of units are more economical at the scale of the facility under evaluation as compared to the reactor-clarifiers in use at the Mackey plant. This similarity to the Mackey WTP is a significant advantage in terms of operability, training of staff, and water quality produced. This alternative is capable for meeting current drinking water standards and is adaptable for future regulations. An ozone process can be added after the pretreatment process for additional disinfection, if may be required by the Final Enhanced Surface Water Treatment Rule. An UV irridation can be added after the media filters as another alternative means of disinfection. This alternative is space efficient since multiple trains of flocculator / sedimentation tanks can be constructed with common walls. The level of maintenance for Alternative 1 is higher than Alternative 2 because Alternative 1 requires additional equipment. The type of unit is very resistant to changes in water quality and requires very little operator attention. Filter operations can be automated to allow minimal operator attention. This alternative uses process design criteria that are covered by the TNRCC design criteria in Subchapter D: Rules and Regulations for Public Water Systems, 290.42, Water Treatment.

The advantages and disadvantages for Alternative 2 are very similar to those for Alternative 1. This alternative is capable of meeting current drinking water standard. With the exception of the pulsed-upflow clarifiers, this alternative uses process design criteria that are covered by the TNRCC in Subchapter D: Rules and Regulations for Public Water Systems, 290.42, Water Treatment. Alternative 2 is adaptable for future regulations. An ozone process can be added after the pretreatment process for additional disinfection, if may be required by the Final Enhanced Surface Water Treatment Rule. An UV irridation can be added after the media filters as another alternative means of disinfection. As with Alternative 1, the pulsed-upflow clarifiers are space efficient and allow the use common wall construction. The level of maintenance for Alternative 2 is lower that the conventional alternative because there is less equipment. Pulsed-upflow clarifiers flocculate and settle the raw water in a single basin with a single mechanism, while conventional flocculators and sedimentation basins have multiple flocculators and sludge collectors. This type of unit is more susceptible to changes in water quality, and more operator attention is required. Filter operations can be automated to allow minimal operator oversight.

The membrane process of Alternative 3 will exceed current water quality standards for turbidity and removal of microorganisms. With a membrane process in use at the proposed WTP, and a conventional process in use at the Mackey WTP, public issues about the disparity in the level of treatment will arise. Although both processes will meet all drinking water standards, the perception exists that membranes provide a more aesthetic water that is more safer to drink. A membrane process is expected to yield a 90 percent rate of recovery. Additional processes are needed to capture and treat the high volume of reject water generated by the primary membranes. This process alternative does provide total removal of microorganisms that are currently regulated. Therefore, this process already provides or exceeds the level of treatment that the future regulations are anticipated to require. Membrane filtration is not currently covered by TRNCC's design criteria in Subchapter D: Rules and Regulations for Public Water Systems, 290.42, Water Treatment. Several months of treatability testing would be required by the TNRCC to gain regulatory approval. Pilot testing of new processes is generally advisable in advance of construction of a major treatment plant. Currently there is no membrane facility in the United States of the size being proposed for this facility. While there is no inherent reason why a large scale membrane facility cannot be operated, the economy of scale realized with large concrete structures used in conventional processes does not yet exist with membrane systems. In addition, the water industry is still developing a level of comfort with the potential risks and cost uncertainties associated with larger membrane systems. Alternative 3 has the highest maintenance costs as membrane s will have to be constantly monitored with replacement of the membranes on a frequency of about every seven years. The high number of components (approximately 240 separate membrane modules on each separate unit) requires a high level of maintenance.

Water Treatment Process Costs

Each alternative has a capital cost associated with the construct the facilities and an operating and maintenance (O&M) cost during operation of the plant. For each alternative, the estimated construction costs were developed based on the preliminary process sizing using the aforementioned design criteria and the estimated O&M costs were calculated based on the labor, maintenance, and electrical demands of the plant process based on a capacity of 150 MGD. The summary of the costs appear in **Table 4-6.**

TABLE 4-6
ALTERNATIVE PROCESS CONSTRUCTION COST ESTIMATE (YR 2000$)

Unit	Water Treatment Process		
	Conventional	High Rate	Membranes
Sitework	$6,000,000	$6,000,000	$7,500,000
Yard Piping	$9,000,000	$9,000,000	$9,000,000
Low Lift Pumping	$5,192,000	$5,192,000	$5,192,250
Mixing/Flocculation/Sedimentaiton	$15,525,000	$12,883,000	$ -
Filters	$25,322,000	$25,322,000	$ -
Transfer Pumping	$4,515,000	$4,515,000	$ -
Pretreatment Clarifiers	$ -	$ -	$10,600,000
Membrane Building	$ -	$ -	$9,245,000
Membrane Equipment	$ -	$ -	$33,063,000
PAC System	$750,000	$750,000	$750,000
Backwash Equalization Tank	$3,570,000	$3,570,000	$3,060,000
Backwash Clarification	$480,000	$480,000	$5,200,000
Gravity thickeners/holding tanks	$2,640,000	$2,640,000	$3,510,000
Chemical Systems, Building, Tanks	$6,435,000	$6,435,000	$2,820,000
Centrifuges	$3,360,000	$3,360,000	$3,360,000
Centrifuge Building	$3,230,000	$3,230,000	$3,230,000
Ground Storage Tanks	$13,300,000	$13,300,000	$13,300,000
Subtotal	$99,319,000	$96,677,000	$109,829,000
Electrical, Instrumentation, and Controls	$12,912,000	$12,568,000	$16,474,000
Subtotal	$112,231,000	$109,245,000	$126,304,000
Mobilization	$3,367,000	$3,277,000	$3,789,000
Subtotal	$115,598,000	$112,523,000	$130,093,000
Construction Management, Insurance, Bonds, Profit	$15,028,000	$14,628,000	$16,912,000
Total	$130,625,000	$127,151,000	$147,006,000

The conventional plant has the lowest estimated construction cost at $127.1 M, which equates to $0.85 cents per gallon of capacity. Construction contingency and engineering fees are not included in these calculations as they are percentages of construction and are independent of the process selection.

The O&M costs to operate the plant include the following items:

- Electricity,
- Maintenance,
- Chemicals,
- Labor,
- Sludge disposal, and
- Administration

The costs for the operating and maintenance were based on recent quotes from vendors and current operations at the GCWA Dr. Thomas Mackey Water Treatment Plant. A summary of the O&M costs for the alternative processes appear in the **Table 4-7 though 4-9.**

The high rate conventional O&M costs for a 150 MGD plant is the least expensive at $24.0 M per annum. These O&M costs exclude high service pumping and raw water delivery costs which are a function of plant location and will be considered in the site location study.

These costs and non-economic were evaluated and entered into part of the alternative selection process for the Regional Surface Water as described in **Section 7** of this report.

TABLE 4-7
CONVENTIONAL PROCESS O&M COST ESTIMATE (YR 2000$)

O&M Component	Annual Usage	Units	Unit Cost	Annual Cost
Process Electrical	94,094	KWh	$0.06	$2,061,000
Chemical				
Ferric	7,533	tons	$450	$ 3,390,000
Cationic Polymer	1,256	tons	$1,000	$1,256,000
Anionic Polymer	125	tons	$1,500	$188,000
Sodium Chlorite	203	tons	$1,000	$203,000
Chlorine - ClO2	208	tons	$400	$83,000
Chlorine - BW	58	tons	$400	$23,000
Chlorine - Residual Disinfectant	685	tons	$400	$274,000
Ammonia	229	tons	$350	$80,000
PAC	3,767	tons	$1,100	$4,144,000
Caustic Soda	2,283	tons	$600	$1,370,000
Fluoride	205	tons	$1,000	$137,000
Corrosion Inhibitor, mg/L	114	tons	$5,200	$594,000
Total Chemical				$11,742,000
Sludge Disposal	79,000	Yd^3	$15	$1,185,000
Maintenance	2	% of construction		$2,613,000
GAC Replacement	23,000	Ft^3	$100.00	$2,300,000
Labor	Number at Plant		Burdened Hourly Rate	
Process Operators	9		$25.50	$477,000
Electrician, Instrument Tech	4		$33.75	$281,000
Maintenance	5		$27.00	$281,000
Administration	2		$19.50	$81,000
Superintendent	1		$49.50	$103,000
Total	21		$28.00	$1,223,000
Administration	---		---	$600,000
Cost of Raw Water	165 MGD		$.07 / 1000 gal	$4,220,000
Total Annual O&M for 150 MGD Conventional Plant				$25,940,000

TABLE 4-8
HIGH RATE CONVENTIONAL PROCESS O&M COST ESTIMATE (YR 2000$)

O&M Component	Annual Usage	Units	Unit Cost	Annual Cost
Process Electrical	89,821	KWh	$ 0.06	$ 1,967,000
Chemical				
Ferric	7533	tons	$450	$ 3,390,000
Cationic Polymer	1256	tons	$1,000	$ 1,256,000
Anionic Polymer	125	tons	$1,500	$ 188,000
Sodium Chlorite	203	tons	$1,000	$ 203,000
Chlorine - ClO2	208	tons	$400	$ 83,000
Chlorine - BW	58	tons	$400	$ 23,000
Chlorine - Residual Disinfectant	685	tons	$400	$ 274,000
Ammonia	229	tons	$350	$ 80,000
PAC	2512	tons	$1,100	$ 2,763,000
Caustic Soda	2283	tons	$600	$ 1,370,000
Fluoride	205	tons	$1,000	$ 205,000
Corrosion Inhibitor, mg/L	114	tons	$5,200	$ 594,000
Total Chemical				$ 10,429,000
Sludge Disposal	79,000	Yd^3	$15	$ 1,185,000
Maintenance	1.7	% of construction		$2,162,000
GAC Replacement	23000	Ft^3	$100.00	$2,300,000
Labor	Number at Plant		Burdened Hourly Rate	
Process Operators	9		$25.50	$477,000
Electrician, Instrument Tech	4		$33.75	$281,000
Maintenance	5		$27.00	$281,000
Administration	2		$19.50	$81,000
Superintendent	1		$49.50	$103,000
Total	21		$28.00	$1,223,000
Administration	---		---	$600,000
Cost of Raw Water	165 MGD		$.07 / 1000 gal	$4,220,000
Total Annual O&M for 150 MGD High Rate Conventional Plant				$ 24,090,000

TABLE 4-9
MEMBRANE CONVENTIONAL PROCESS O&M COST ESTIMATE (YR 2000$)

O&M Component	Annual Usage	Units	Unit Cost	Annual Cost
Process Electrical	185,754	KWh	$0.06	$ 4,068,000
Chemical				
Ferric	3938	tons	$450	$ 1,772,000
Sodium Chlorite	213	tons	$1,000	$ 213,000
Chlorine - ClO2	218	tons	$400	$ 87,000
Chlorine - BW	113	tons	$400	$ 45,000
Chlorine - Residual Disinfectant	685	tons	$400	$ 274,000
Ammonia	229	tons	$350	$ 80,000
PAC	2625	tons	$1,100	$ 2,888,000
Caustic Soda	2283	tons	$600	$ 1,370,000
Fluoride	137	tons	$1,500	$ 205,000
Corrosion Inhibitor, mg/L	114	tons	$5,200	$ 594,000
Total Chemical				$ 7,528,000
Sludge Disposal	110,000	Yd^3	$15	$ 1,650,000
Membrane Cleaning	4	Number per Year	$249,250	$ 997,000
Maintenance	2.5%	% of construction		$3,675,000
Membrane Replacement	1	Every Seven Years	$2,008,800	$2,009,000
Labor	Number at Plant		Hourly Rate	
Process Operators	9		$25.50	$477,000
Electrician, Instrument Tech	5		$33.75	$351,000
Maintenance	6		$27.00	$337,000
Administration	2		$19.50	$81,000
Superintendent	1		$49.50	$103,000
Total	23		$42.31	$1,246,000
Administration	---		---	$600,000
Cost of Raw Water	172.5 MGD		$.07 /1000 gal	$4,410,000
Total Annual O&M for 150 MGD Membrane Plant				$26,290,000

Section 5
Water Treatment Plant Site Development

One of the most important steps in this feasibility study is selecting the site for any treatment facilities. The decision to select one site over another is complex and is influenced by many diverse criteria. This chapter will review these criteria with respect to several alternative sites throughout the planning area and summarize the benefits and costs associated with each alternative site.

APPROACH TO SITE SELECTION

One of the first tasks in this study was to identify possible sites of a water treatment facility. In order to evaluate the entire planning area, a selection approach was developed to ensure that all alternatives were considered and that the benefits to each Participating Utility were taken into consideration in the selection of the alternative WTP sites. The approach consisted of the following three steps:

- Establishment of Preliminary Siting Criteria
- Identify Candidate Sites
- Preliminary Screening
- Final Screening

This approach allowed the Participating Utilities to have control over the selection of the water treatment plant site and to offer input at each stage in the process. The following is a detailed description of the process for selecting the site

Establishment of Preliminary Siting Criteria

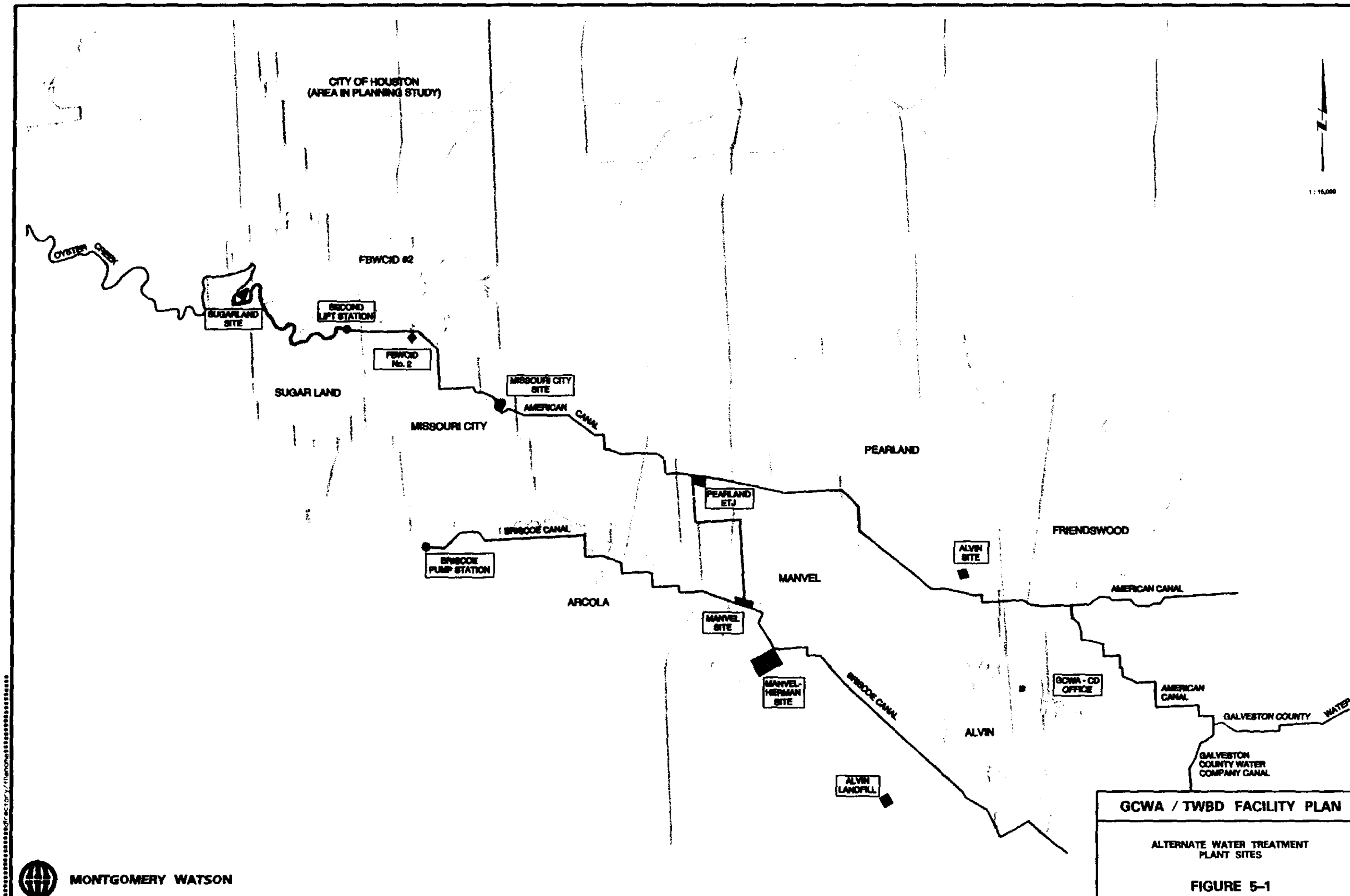
The first step was to identify potential sites for the water treatment plant. The Participating Utility team was tasked with reviewing the planning area to locate sites based on the following three criteria: estimated required acreage for the water plant, the proximity of the plant to the Participating Utilities and the raw water source, and surface features of the site. Each of these criteria is discussed below:

Estimated Minimum Acreage Required For A Water Plant

One of the primary criteria in selecting a site for a water plant is the size of the site. The selected site must have enough acreage to support the requirements of a water plant. The layout of the facilities on the site has a large impact on the total required area. Water treatment plants with high-rate process units and compact, common-wall construction require less space than conservatively sized stand-alone process basins. According to Kawamura in "Integrated Water Treatment Plant Design", the required plant area for the basic process facilities of a conventional treatment plant is $Q^{0.6}$, where Q is the ultimate capacity of the plant. For a design flow of 150 MGD, the minimum plant area would then be 20 acres.

Ideally, the site should also contain ample land for a raw water forebay, sludge disposal, pipeline easements, finished water storage, and future expansion. Based on the data from local water treatment plants, an additional 35 to 80 acres would be required to support these ancillary facilities.

For this preliminary selection of potential water treatment plants, acceptable sites were limited to those with enough acreage to accommodate the basic processes of the water treatment plant. Preference was also given to sites with enough acreage to accommodate the ancillary facilities as well as the basic processes. Therefore the minimum acceptable parcel of land is 20 acres, with a preference for sites with a minimum of 55 acres.



MONTGOMERY WATSON

GCWA / TWBD FACILITY PLAN

ALTERNATE WATER TREATMENT PLANT SITES

FIGURE 5–1

Proximity To the Water Source and Distribution System

Another criteria for selecting the location of water plant facilities is the proximity of the plant to the raw water source and the customer. It is desirable to keep the raw water piping as short as practicable to simplify the maintenance and reduce the cost of the raw water pipeline. The new water plant can either withdrawal water directly from the Brazos River or indirectly from the Brazos through the existing GCWA American and Briscoe Canals. Sites adjacent to or in very close proximity to the Brazos River or to the Canals will be given preference as no raw water pipeline will be required. One advantage of placing the water plant as close to the raw water source is that less energy is expended in pumping water consumed by in-plant needs (backwash, sludge, etc.).

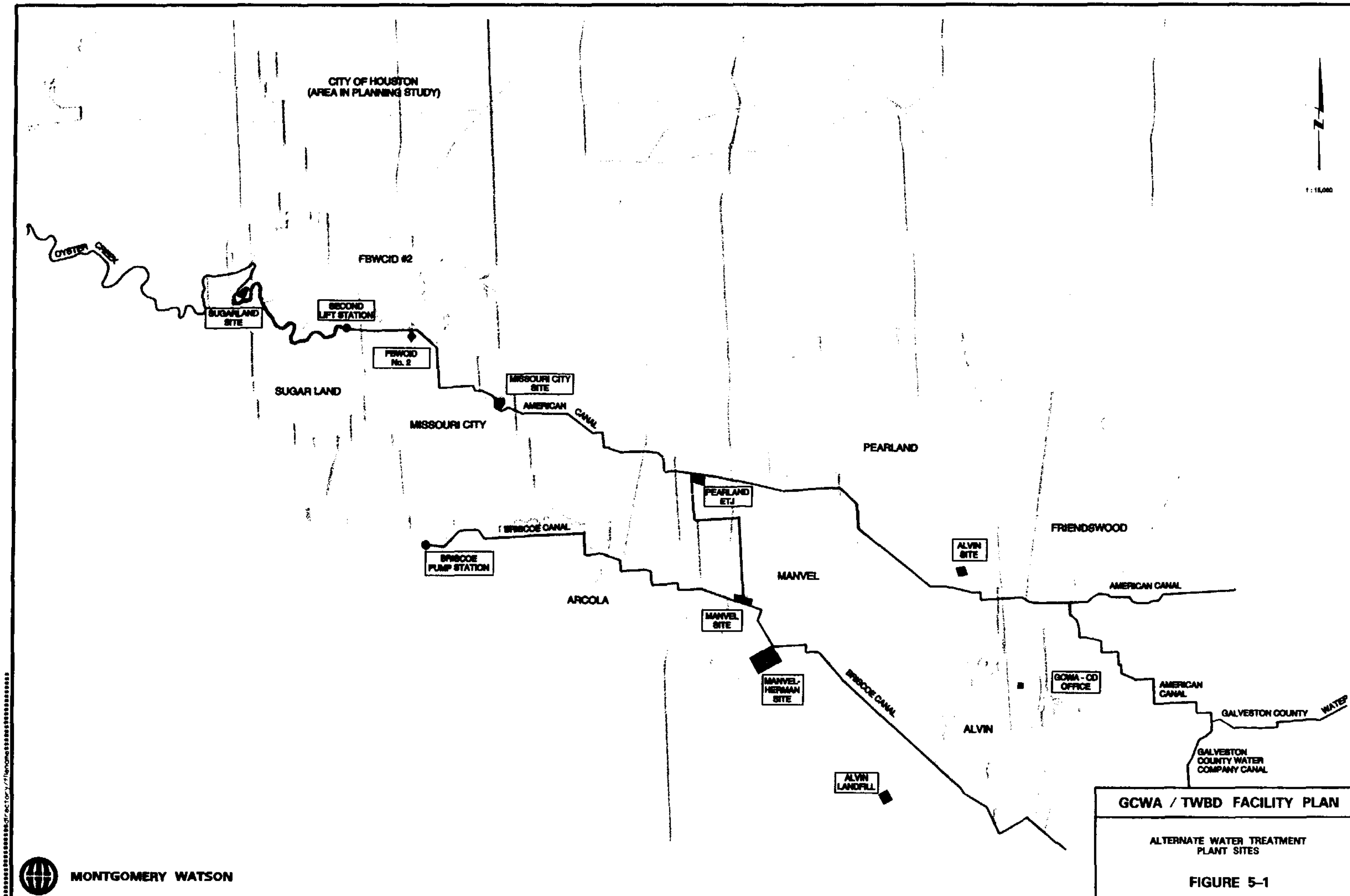
Similarly, the water treatment plant site should be located in close proximity to the distribution system, which in this case is the nine Participating Utilities. This will minimize the size of the finished water transmission pipelines and the cost of pumping the water to the Participating Utilities. Duplication of the raw water and finished water pipelines should also be avoided.

Site Surface Features

A potential site should be relatively flat without any major obstacles, such as fault zones, wetlands, areas prone to flooding, or encumbrances. This cursory review of the planning area for potential sites looked for sites in areas without large areas of known wetlands, utility encumbrances, or flood plains. Although wetlands and utilities can be relocated and levees can be built to protect the facility from flooding, these attributes of a site are not desirable and result in additional site work that increases cost and complicate permitting from regulating bodies. Sites without these surface features were given a higher rating in this preliminary site selection.

Identify Candidate Sites

Based on these criteria, the Participating Utilities team assessed the planning area and developed a list of alternative water treatment sites. The location of the sites that were selected by the Participating Utility team are shown in **Figure 5-1.** The listing of these sites with a brief description appears in **Table 5-1.**



GCWA / TWBD FACILITY PLAN

ALTERNATE WATER TREATMENT PLANT SITES

FIGURE 5-1

TABLE 5-1
POTENTIAL WATER TREATMENT PLANT SITES

Plant Site	Location				Approx. Usable Acreage (AC)
	County	Nearest City	Key Map Location	Description	
Sugar Land	Fort Bend	Sugar Land	567 M / 568 J	Hwy 6 and Hwy 90 in Sugar Land	225
FBWCID No. 2	Fort Bend	Stafford	569 U,V,Y, Z	Lexington Blvd - east of Murphy Road in the city of Stafford	80
Missouri City	Fort Bend	Missouri City	611 M / 612 J	Adjacent to TV Towers, north of American Canal east of Missouri City	150
Pearland ETJ	Brazoria	Arcola	612 Y, Z	Lateral 10 and American Canal west of 288 in Pearland ETJ	80
Manvel	Brazoria	Manvel	653 S, W	SH 6 at Briscoe Canal and Lateral 10 intersection in Manvel	50
Manvel-Herman	Brazoria	Manvel	-	Herman Hospital property south of Manvel	1193
Alvin	Brazoria	Friendswood	615 T	CR 285 and CR 144 west of Friendswood in Alvin ETJ	280
Alvin-Landfill	Brazoria	Alvin	-	City of Alvin land adjacent to existing landfill	100

Preliminary Screening

The next step in the site selection process was to evaluate these eight sites with respect to their preliminary siting criteria. The eight sites contained in the preliminary review represent a geographically diverse selection across the planning area, each with a minimum usable acreage of 50 acres, meeting the minimum criteria established above. The following is a general comparison of the eight sites in relation to the screening criteria.

Evaluation of Minimum Acreage Requirements

All of the identified potential sites have the required minimum acreage meeting the requirements listed above, with several sites having large open expanses of land available for use. These additional lands over and above the minimum required are a valuable attribute of the site as this land could be used for future expansions, sludge disposal, buffer zone, or a raw water reservoir. The FBWCID No. 2, Pearland ETJ, and Manvel sites are the smallest of the eight sites and will yield a constrained site layout. Expansion past 150 MGD at these three sites may not be feasible.

On the basis of available acreage, the Sugar Land, Missouri City, Manvel-Herman, Alvin, and Alvin-landfill sites were the most desirable as the large amount of usable land at each of these sites offers the following advantages:

- Operational flexibility. Layout of plant not scripted by limited site configuration,
- Future Expansion Possibilities, and

- Inclusion of Ancillary WTP options. Sludge Disposal, Raw Water Reservoir, Additional Finished Water Storage

Evaluation of Proximity of Site to Raw Water Source and Finished Water Demand

Proximity of Site to Raw Water Source

Although the eight selected sites are scattered throughout the planning area, the one common thread is that each site, with the exception of the Manvel-Herman site, is located adjacent to a GCWA raw water canal. By locating the water plant as close to the raw water source as possible, the raw water transport costs are minimized or in some cases eliminated. The Alvin-Landfill site will require a one and half mile long pipeline from the GCWA Canal to the plant site to deliver raw water plant. Conversely, the other seven sites can pump directly from the canal and eliminate the raw water pipeline.

The differences among the sites in reference to proximity of the plant to the raw water source are:

- Canal which the plant would be served by,
- Required improvements to the canal pump stations, and
- Operational flexibility

The Sugar Land, FBWCID No. 2, Missouri City, Pearland ETJ, and Alvin sites are located along the American Canal and can only be served by the American Canal. The Manvel, Manvel-Herman, and Alvin-Landfill sites offer the advantage that they can be served from either the American Canal (through Lateral 10) or the Briscoe Canal. This allows the GCWA to take a canal out of service for repairs or maintenance and maintain flow to the water plant via the other canal.

Depending on the water plant location, modifications to the canal and raw water pump stations will be required. A summary of the required improvements are shown in the **Table 5-2**:

TABLE 5-2
REQUIRED RAW WATER CONVEYANCE IMPROVEMENTS

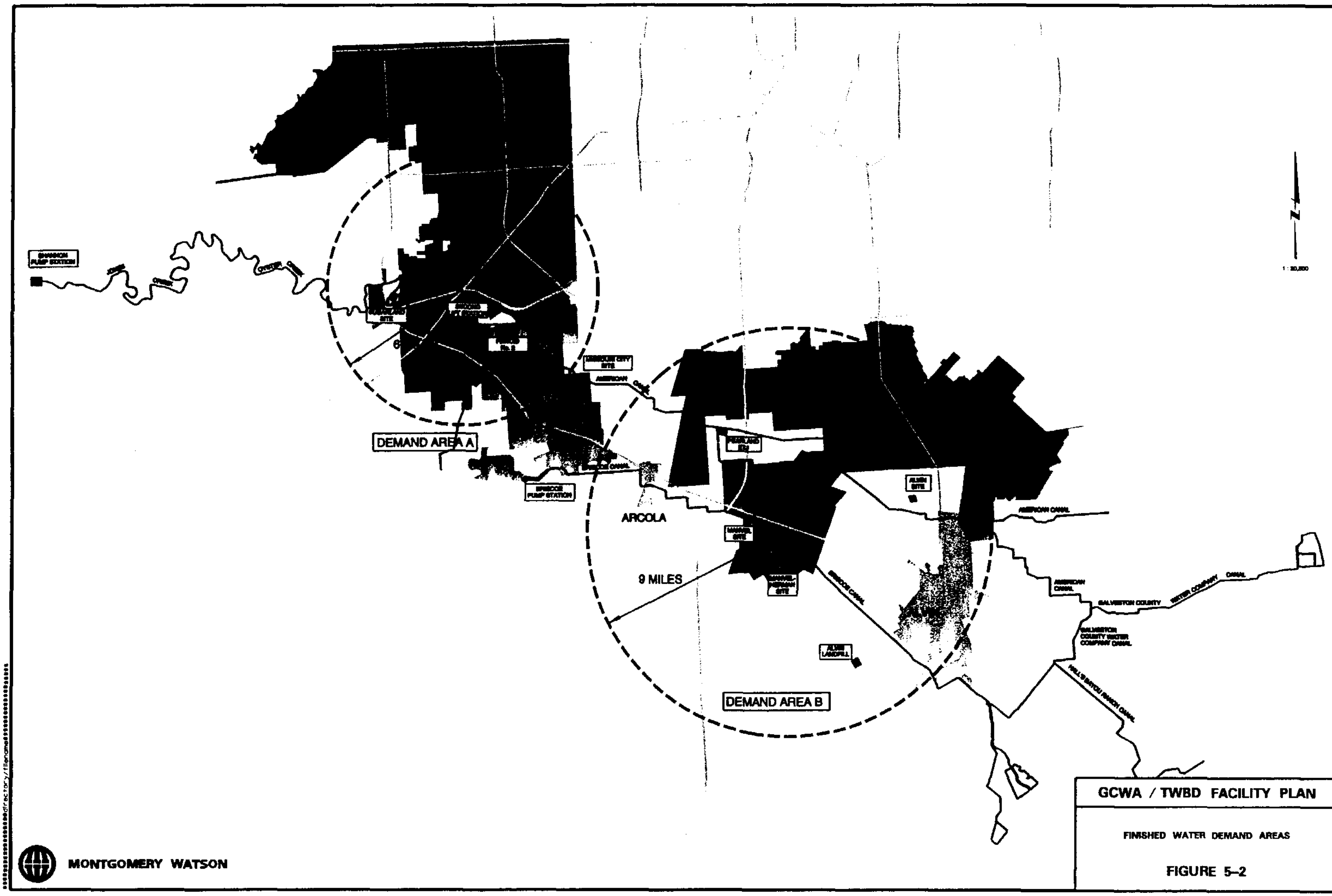
Plant Site	Raw Water Source	Pump Improvements			Canal Improvements		
		Shannon Plant	2nd Lift Station	Briscoe Plant	Oyster Creek	American Canal (System 2)	Briscoe Canal
Sugar Land	Oyster Creek	x	-	-	x	-	-
FBWCID No. 2	American Canal	x	x	-	x	-	-
Missouri City	American Canal	x	x	-	x	x	-
Pearland ETJ	American Canal	x	x	-	x	x	-
Manvel	American or Briscoe Canal	x (1)	x (1)	x (2)	x (1)	x (1)	x (2)
Manvel - Herman	American or Briscoe Canal	x (1)	x (1)	x (2)	x (1)	x (1)	x (2)
Alvin	American Canal	x	x	x	x	x	x
Alvin-Landfill	American or Briscoe Canal	x (1)	x (1)	x (2)	x (1)	x (1)	x (2)

(1)– Improvement required if the American Canal is used
(2)– Improvement required if the Briscoe Canal is used

As seen in the table, the Sugar Land site requires the least improvement and thus is the most desirable from a proximity to the raw water canal point of view. The Manvel, Manvel-Herman, and Alvin-Landfill sites offer the operational flexibility of having two raw water feeds, but will require raw water improvements to both canals to provide this flexibility.

Proximity of Site to Finished Water Demand

The planning area is divided into two distinct areas of potable water demand. The majority, 75 percent, of the demand is located within a 6 mile radius of the intersection of Beltway 8 and Interstate 59 in Sugar Land Texas. The remaining 25 percent of the average water demand is located within a 9 miles radius of the intersection of Hwy 6 and Masters Road in Manvel Texas. These two demand areas are shown on **Figure 5-2** and are located approximately 18 miles apart. The proximity of the proposed plant location to the water demand is shown in **Table 5-3**.



MONTGOMERY WATSON

GCWA / TWBD FACILITY PLAN

FINISHED WATER DEMAND AREAS

FIGURE 5–2

TABLE 5-3
PROXIMITY OF SITE TO FINISHED WATER DEMAND

Plant Site	Water Demand Within (%)				
	5 mi	10 mi	15 mi	27 mi	35 mi
Sugar Land	61	75	75	82	100
FBWCID No. 2	36	75	82	100	100
Missouri City	14	36	82	100	100
Pearland ETJ	7	7	42	100	100
Manvel	2	7	31	100	100
Manvel-Herman	2	14	25	100	100
Alvin	11	25	25	42	100
Alvin-Landfill	0	5	14	39	100

The Sugar Land, FBWCID No. 2, and Missouri City sites are located in and around the Demand Center A, while sites Pearland ETJ, Manvel, Manvel-Herman, Alvin, and Alvin-Landfill sites are located in and around Demand Center B. Since it is desirable to locate the plant as close to the demand to minimize the finished water pumping expense, the distance between the demand area centers creates several issues. If a plant is located near one of the demand center, an extensive piping network will be required to transport the finished water across the planning area to the other demand center, resulting in an increased expenditure for pipelines and pumping costs.

If the water plant is located in Demand Area B, only 25 percent (+/-) of the demand is located within 15 miles. A large finished water transmission main would be required to convey approximately 76 percent of the planning area average water demand, or 115 MGD, 18 miles to the northeast. Not only would this require a large transmission main, but the pumping cost to transport 115 MGD over 18 miles would be substantial.

Conversely, if the plant is located in Demand Area A, a minimum of 75 percent of the water demand is located within 15 miles of a proposed water plant. A transmission main is still required to convey water to Demand Area B, but the pipeline would only have to be sized to transport approximately 24 percent of total finished water demand, or 35 MGD, instead of 115 MGD if the water plant was located in Demand Area B.

This scenario of having the a single water plant in Demand Area A over a single water plant in Demand Area B will result in reduced finished water pipelines capital costs. In addition, the cost of pumping water from one side of the planning area to the other will be substantially less expensive for a single water plant in Demand Area A versus a single water plant in Demand Area B.

Additionally, the general topography of the planning area is a gentle slope from the Sugar Land area to Alvin. The decrease in elevation from the northwest side to the southwest side of the planning area is approximately 60 feet. If the plant is located in Demand Area B, the finished water will have to be pumped uphill to Sugar Land, Missouri City, City of Houston, and FBWCID No. 2 at an increased cost because of pumping against a higher head.

The Participating Utilities reviewed this alternative and decided that a single plant in the eastern section of the planning area serving the entire planning area was not feasible when compared to having a single water plant in the western section of the planning area.

The Participating Utilities realized that the 18-mile difference in demand areas requires a vast transmission network to serve the entire planning area from one plant. One option is to split the planning area into two distinct demand areas and serve each demand area with its own surface water plant. If this alternative is initiated, a large surface water plant located in Demand Area A would serve the City of Houston, FBWCID No. 2, Sugar Land, and the City of Missouri City. This plant would serve 76 percent of the water demand and would have an ultimate capacity of 115 MGD. Secondarily, a small surface water plant with a maximum capacity of 35 MGD would be located at the Alvin, Alvin-Landfill, Manvel, Manvel-Herman, or Pearland ETJ to serve the water needs of Demand Area B. In this alternative, 100 percent of the water demand would be located within 15 miles of a water plant.

Evaluation of Site Surface Features

Cursory reviews of each of the eight sites revealed the following surface features that impact the sites use as a water treatment plant. The following is a list of these potential impacts:

- Site A contains a man-made wetland on the southwest corner, but due to large acreage of available land at this site, it is likely that impact to the wetland can be mitigated.
- All sites adjacent to the Canal have a risk of having sections of their sites located within the 100-year flood plain. In addition, the Sugar Land, Pearland ETJ, Manvel, and Alvin sites are located adjacent to a natural bayou or creek, which is subject to flooding. A cursory review of the 100-year flood plain indicates that each of these sites will be impacted by the flood plain, but mitigating measures can be taken to eliminate the risk due to flooding. It is anticipated that only the Manvel site will require improvements which will impact project costs as the flood plain impacts on this site are extensive while proper site layout on the other sites will mitigated the potential impact of flooding.
- The Manvel site contains an existing encumbrance with regards to an HL&P high voltage electrical transmission main. This easement is located along the southern boundary and does not impact the site's ability to host a 35 MGD plant.

Sites Selected for Further Review

After preliminary review of the alternative water treatment sites, the Participating Utility team narrowed the field of alternative sites to four sites, eliminating sites that they felt were not desirable. The team decided to further analysis the sites based on the following two scenarios.

Scenario A - One Regional Surface Water Plant

In Scenario A, the planning area would be served through one large water treatment plant. This plant would be located in Demand Area A and would serve the entire planning area through an extensive system of transmission mains. The ultimate capacity of this plant by the year 2050 would be 150 MGD.

The Participating Utility team decided that the Sugar Land or FBWCID No.2 sites were the most advantageous sites for the water treatment plant in Demand Area A as sites A and B both offer the following advantages over the other six sites:

- Ample Land for Existing Demand and Future Growth. Both sites have a minimum of acreage required to support a 150 MGD plant and ancillary facilities with provisions for future expansion as required past the year 2050.
- Lowest Water Distribution Costs. The cost of distributing water to the Participating Utilities will be lowest at Site A or B, as these sites are the closest to the demand of any of the eight potential sites. Since the sites are the closest to the demand, the required length and diameter of finished water pipeline and construction cost will be significantly reduced. In addition, the power costs associated with transmitting water will also be significantly trimmed with the decrease in distance between the Participating Utilities and the water plant location.

Scenario B - Two Regional Surface Water Plants

In Scenario B, two surface water plants would serve the planning area. One plant would serve Demand Area A and would be located in the western portion of the planning area. The second plant would serve Demand Area B and would be located in the eastern portion of the planning area. The water plant near Demand Area A will have a year 2050 capacity of 115 MGD to meet the demands of Sugar Land, Missouri City, Houston, and FBWCID No. 2. The water demand at the second water plant serving Arcola, Manvel, Pearland, Friendswood, and Alvin will have a capacity of 35 MGD in the year 2050.

For Alternative B, the Participating Utility team decided that the large plant would be located at the Sugar Land or FBWCID No.2 sites for the same principles as under Alternative A. For the second plant, the Participating Utility team based their decision to site the smaller water plant at the Manvel or Alvin Site on the following screening decisions:

- The Alvin-Landfill site was eliminated from consideration due to the proximity of the site to an existing landfill and its distance from the raw water canal.
- The Manvel-Herman was eliminated as the property was recently sold to a residential development as an entire site, 1192 acres, and purchasing a small allotment of land for the water plant (50 acres) would be difficult. In addition, the parcel of land contains numerous pipeline easements and encumbrances that transverse the site.
- Of the remaining three sites, the following table describes the major differences in the sites. The Alvin Site is the closest of the sites to the Demand Area while Manvel Site has the advantage of being fed from both canals. The Pearland ETJ does not have any site drawbacks other than is the farthest from the demand area and can be only fed from the American Canal.

A summary of the preliminary screening criteria for a 35 mgd water plant in Demand Area B is shown in **Table 5-4.**

TABLE 5-4
REVIEW OF PRELIMINARY SCREENING CRITERIA FOR SMALL WATER PLANT

Site	Proximity to Demand Area B	Raw Water Source
Pearland ETJ	Farthest	American Canal
Manvel	Far	American and Briscoe Canal
Alvin	Close	American Canal

Based on this preliminary screening info, the Participating Utilities eliminated Pearland ETJ and selected the Manvel and Alvin Sites for further review.

Screened Alternatives

The following is the list of alternatives agreed upon by consensus as being the alternatives that most merited additional evaluation:

- 150 MGD WTP at the Sugar Land Site
- 150 MGD WTP at the FBWCID No.2 Site
- 115 MGD WTP at the Sugar Land Site, 35 MGD WTP at Manvel Site
- 115 MGD WTP at the Sugar Land Site, 35 MGD WTP at Alvin Site
- 115 MGD WTP at FBWCID No.2 Site, 35 MGD WTP at Manvel Site
- 115 MGD WTP at FBWCID No.2 Site, 35 MGD WTP at Alvin Site

These 6 alternatives were then subject to final screening criteria based on the economic cost and non-economic factors associated with each alternative. Aerial photos of the 4 screened sites appear as **Figures 5-3 through 5-6**. The discussion of these costs and factors appears in **Section 7**.

GCWA / TWBD FACILITY PLAN

SUGAR LAND WTP SITE

FIGURE 5–3

Based on this preliminary screening info, the Participating Utilities eliminated Pearland ETJ and selected the Manvel and Alvin Sites for further review.

Screened Alternatives

The following is the list of alternatives agreed upon by consensus as being the alternatives that most merited additional evaluation:

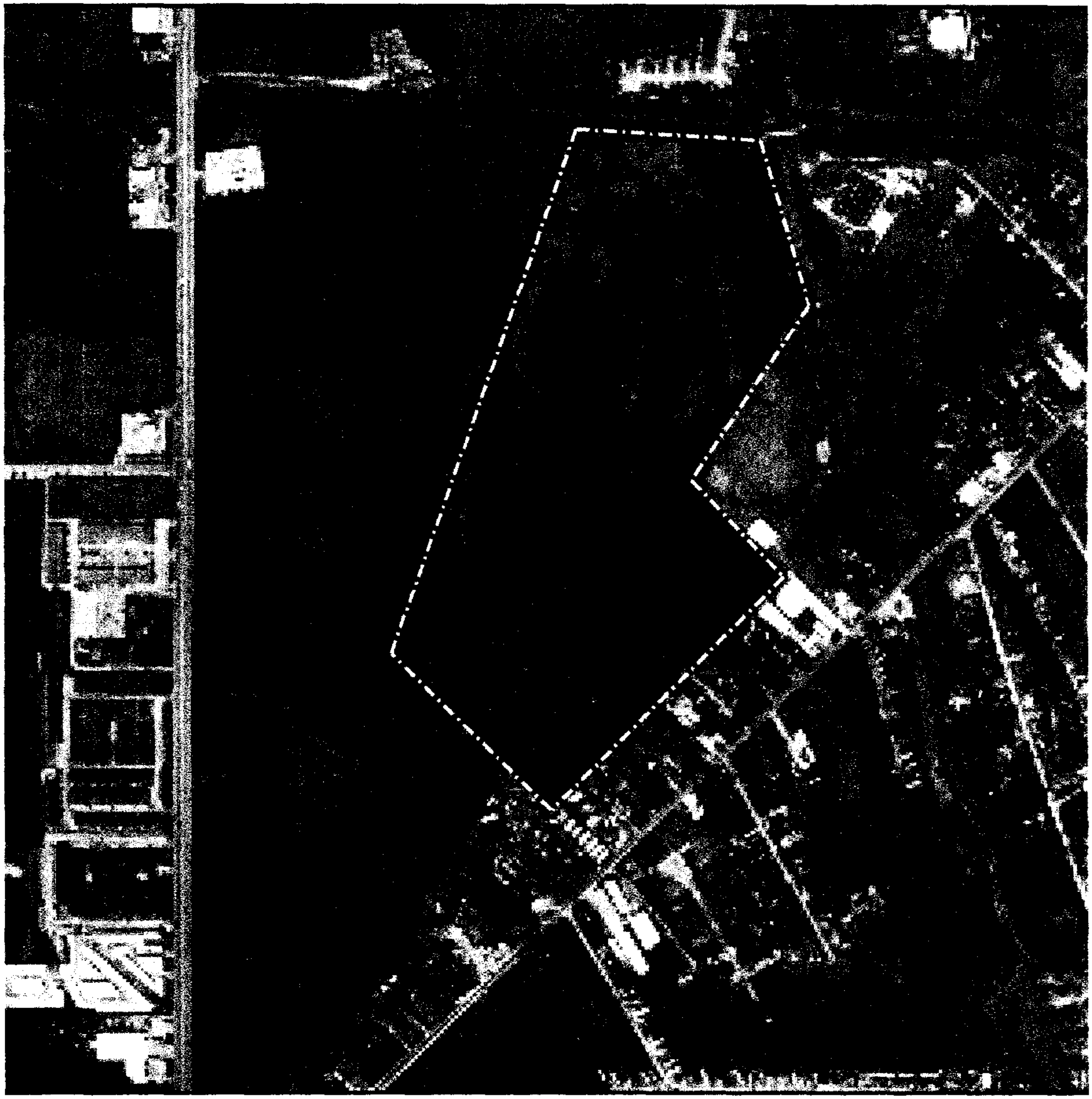
- 150 MGD WTP at the Sugar Land Site
- 150 MGD WTP at the FBWCID No.2 Site
- 115 MGD WTP at the Sugar Land Site, 35 MGD WTP at Manvel Site
- 115 MGD WTP at the Sugar Land Site, 35 MGD WTP at Alvin Site
- 115 MGD WTP at FBWCID No.2 Site, 35 MGD WTP at Manvel Site
- 115 MGD WTP at FBWCID No.2 Site, 35 MGD WTP at Alvin Site

These 6 alternatives were then subject to final screening criteria based on the economic cost and non-economic factors associated with each alternative. Aerial photos of the 4 screened sites appear as **Figures 5-3 through 5-6**. The discussion of these costs and factors appears in **Section 7**.

GCWA / TWBD FACILITY PLAN

SUGAR LAND WTP SITE

FIGURE 5-3

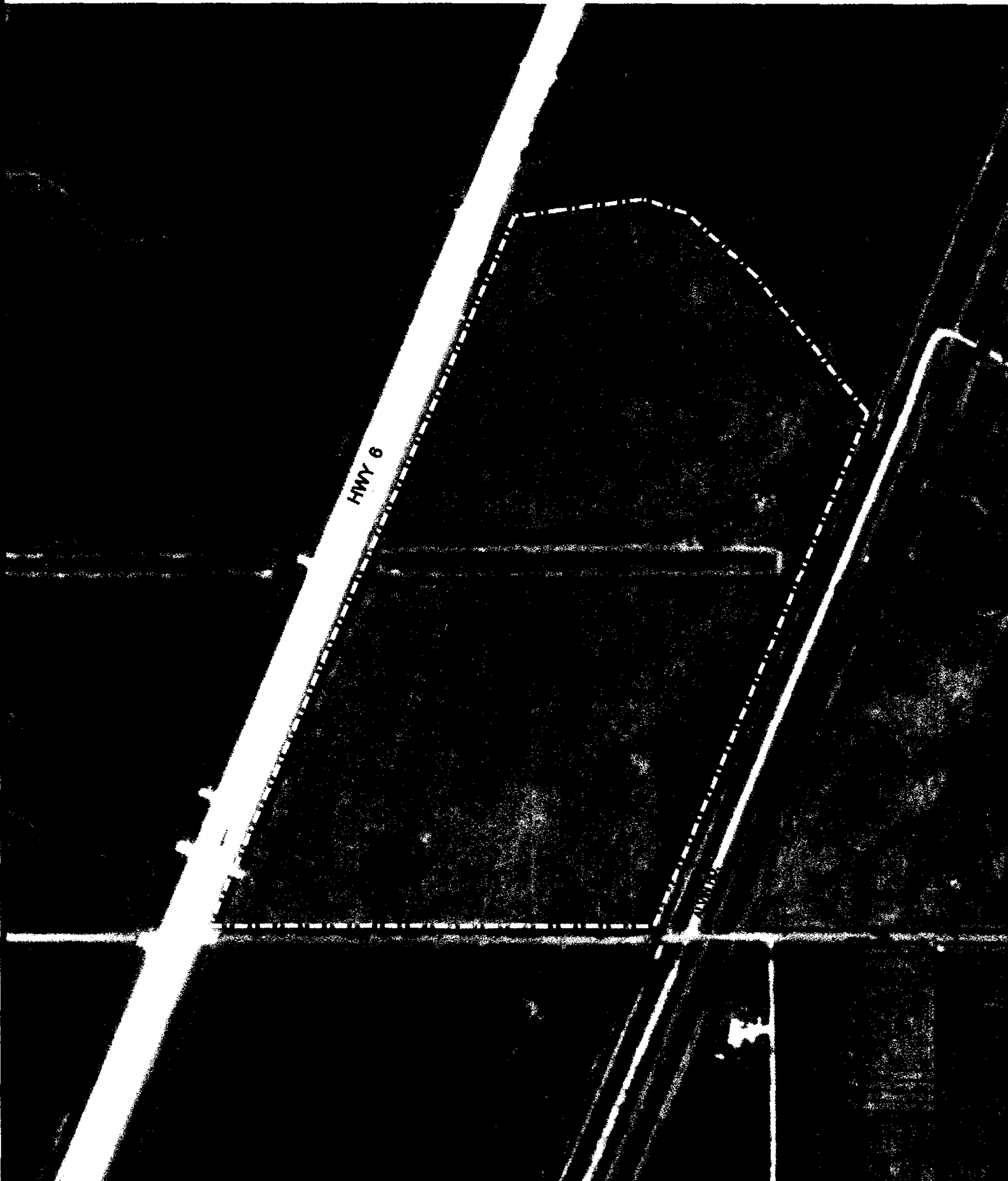


GCWA / TWBD FACILITY PLAN

FBWCID No. 2 WTP SITE

FIGURE 5–4

MONTGOMERY WATSON



MONTGOMERY WATSON

GCWA / TWBD FACILITY PLAN

MANVEL WTP SITE

FIGURE 5–5

MONTGOMERY WATSON

GCWA / TWBD FACILITY PLAN

ALVIN WTP SITE

FIGURE 5-6

$$$$$$$$$$$$$$$$$$$$$directory/filename$$$$$$$$$$$$$$$$$$$$$$$$$$

Section 6
Pipeline Corridor and Raw Water Improvements Study

Surface water must be transported from the Brazos River to the selected plant site and finished water must be transmitted from the plant site to the Participating Utilities take points. As noted in Section 3, the existing capacity of the raw water canals is insufficient to serve the total raw water needs with a regional surface plant. As such, improvements to the raw water conveyance system will be required to upgrade the canal system to carry the increased raw water flow. This section develops facility plans for distributing treated water from the regional water treatment facilities to the Participating Utility take points. Again, as the alternate treatment water treatment plant sites are located throughout the planning area, facility plans for the finished water transmission network with estimated construction costs for each alternate water treatment plant scenario will be developed.

This section also reviews the existing raw water conveyance system and develops a plan and estimated construction costs for bringing the required raw water flow from the Brazos River to the regional surface water treatment facilities. As the alternate water treatment sites are located at widely varied locations along the GCWA canal system, a plan will be developed for each alternate plant site.

FINISHED WATER PIPELINE AND RAW WATER IMPROVEMENT FACILITY PLAN

Finished Water Pipelines

From the high service pumps at the regional water treatment facilities, treated water must be transported through a finished water transmission system to the Participating Utilities. This development of this finished water transmission system plan depends on the following questions:

- Where is the finished water source?
- What is the Participating Utilities water demand?
- What is the Participating Utilities desired water pressure?
- Where will the finished water pipelines be installed?

As responses to these system questions are developed, the finished water transmission system can be developed. The goal of the finished water transmission system is to deliver water at the specified flow and pressure to the Participating Utilities at the lowest overall project cost. To assist in this analysis, a hydraulic model was utilized to optimize the size of the finished water pipelines and pump stations in order to minimize project costs.

The first step in creating and analyzing the finished water transmission system was to locate the finished water source and end-user demand flow and pressure. The following is a review of these items.

Finished Water Source

The location of the finished water depends on the location of the regional surface water plant. In **Section 5,** the Participating Utilities Team developed the following six water plant scenarios.

- 150 MGD WTP at the Sugar Land Site
- 150 MGD WTP at the FBWCID No.2 Site
- 115 MGD WTP at the Sugar Land Site, 35 MGD WTP at Manvel Site
- 115 MGD WTP at the Sugar Land Site, 35 MGD WTP at Alvin Site
- 115 MGD WTP at FBWCID No.2 Site, 35 MGD WTP at Manvel Site
- 115 MGD WTP at FBWCID No.2 Site, 35 MGD WTP at Alvin Site

As the location and capacity of the water plants vary, six separate hydraulic models and finished water transmission system plans are required to evaluate the differences in the water treatment plant location.

Participating Utilities Water Demand

Each Participating Utility has reviewed their water distribution system and has submitted their requirements for water pressure at the take point. Several Participating Utilities have requested water at "system" pressure, while others will utilize existing ground storage tanks and booster pump stations to boost the pressure of the finished water to their customers. The water demand and pressure requirements for each Participating Utility are shown on **Table 6-1.**

TABLE 6-1
REQUESTED FLOW AND PRESSURE AT UTILITY TAKE POINTS

Utility	Take Point Name	Average Water Demand (mgd)	Pressure Requirement (psl)	Ground Elevation At Take Point (ft)	Tank Height (ft)
City of Houston	Bellaire Braes PS	59.20	Fill Tank	80	25
City of Sugar Land	First Colony	17.47	Fill Tank	80	23.5
	Lakeview	11.65	Fill Tank	68	23.5
City of Missouri City	Quail Valley	8.46	Fill Tank	65	25
	Sienna Plantation	8.46	Fill Tank	60	25
FBWCID No. 2	Site B	5.00	60	80	-
	Avenue E	5.00	60	75	-
City of Pearland	SH 288	7.19	50	60	-
	SH 35	7.19	50	40	-
City of Manvel	Site E	3.52	50	55	-
City of Arcola	Town Center	0.13	Fill Tank	63	16
City of Alvin	Bypass 35	5.60	65	35	-
City of Friendswood	West Friendswood	5.71	65	35	-
	SW Friendswood	5.71	65	35	-

The geographic location of these take points can be viewed in **Figure 6-1** and the relation of these take points to the alternate water treatment plant site plays an important decision to developing the pipeline corridors.

Pipeline Corridor Analysis

The corridor analysis focuses on the route the finished water pipelines will take from the water plant to the Participating Utilitytake points. Given the fixed location of the take points and the four alternate water treatment site locations, alternate pipeline corridors were identified to connect the take points with the alternate water plant sites. These alternative corridors were then evaluated on the basis of criteria to determine a preferred routing of the finished water pipelines. Factors considered in the selection of routes include the following:

- Length of corridor
- Known environmental impacts along route
- Land ownership
- Constructability

Each corridor has a general economic costs associated with the construction of a pipeline through the corridor. As the length of the corridor increases, so does the length of the pipeline and the construction costs. Construction cost also increase if the pipeline passes through an environmental sensitive area, such as wetlands since remedial efforts will likely be required. If the corridor is owned by a public agency, right-of-way for the finished water pipeline without expensive surveying and easement agreements. If a corridor traverses private land, pipeline easements will be required. These easements will increase the overall project costs. If the proposed corridor passes through developed areas, the corridor will likely contain existing utilities that will impact the alignment of the pipeline. Construction around these utilities will increase the cost of construction and impact utility services to the surrounding area.

The corridor analysis was focused into three general areas based on the location of the take points. These areas are Demand Area A, the Brazoria County corridor between Demand Area A and Demand Area B, and the eastern half of Demand Area B. Demand Area A includes the City of Houston, Sugar Land, Missouri City, and FBWCID No. 2. These utilities represent approximately 75 percent of the total water demand for the planning area. The corridor analysis for the Demand Area focuses on delivering water from the FBWCID No.2 or Sugar Land alternative site location to these Participating Utilities take points. The Brazoria County Corridor focuses on serving the Arcola, Manvel, and Pearland-SH 288 take points while connecting finished water service from Demand Area A to B. The corridor analysis for this Demand Area focuses on developing potential corridors to deliver water from the Manvel or Alvin water treatment plant to the Participating Utilities take points along this corridor. The Demand Area B corridor analysis forced on the Alvin, Friendswood, and Pearland-SH35 take points.

Demand Area A Corridor Analysis

In Demand Area A, the take points are aligned in two general sections of the demand area. The City of Houston, FBWCID No. 2 , and City of Sugar Land Lakeview take point are generally aligned along Hwy 90 in the northern half of the Demand Area while the Missouri City take points and City of Sugar Land First Colony take point are aligned along Highway 6 in the southern portion of the Demand Area. The corridor analysis evaluates alternative pipeline corridors to serve these two general areas.

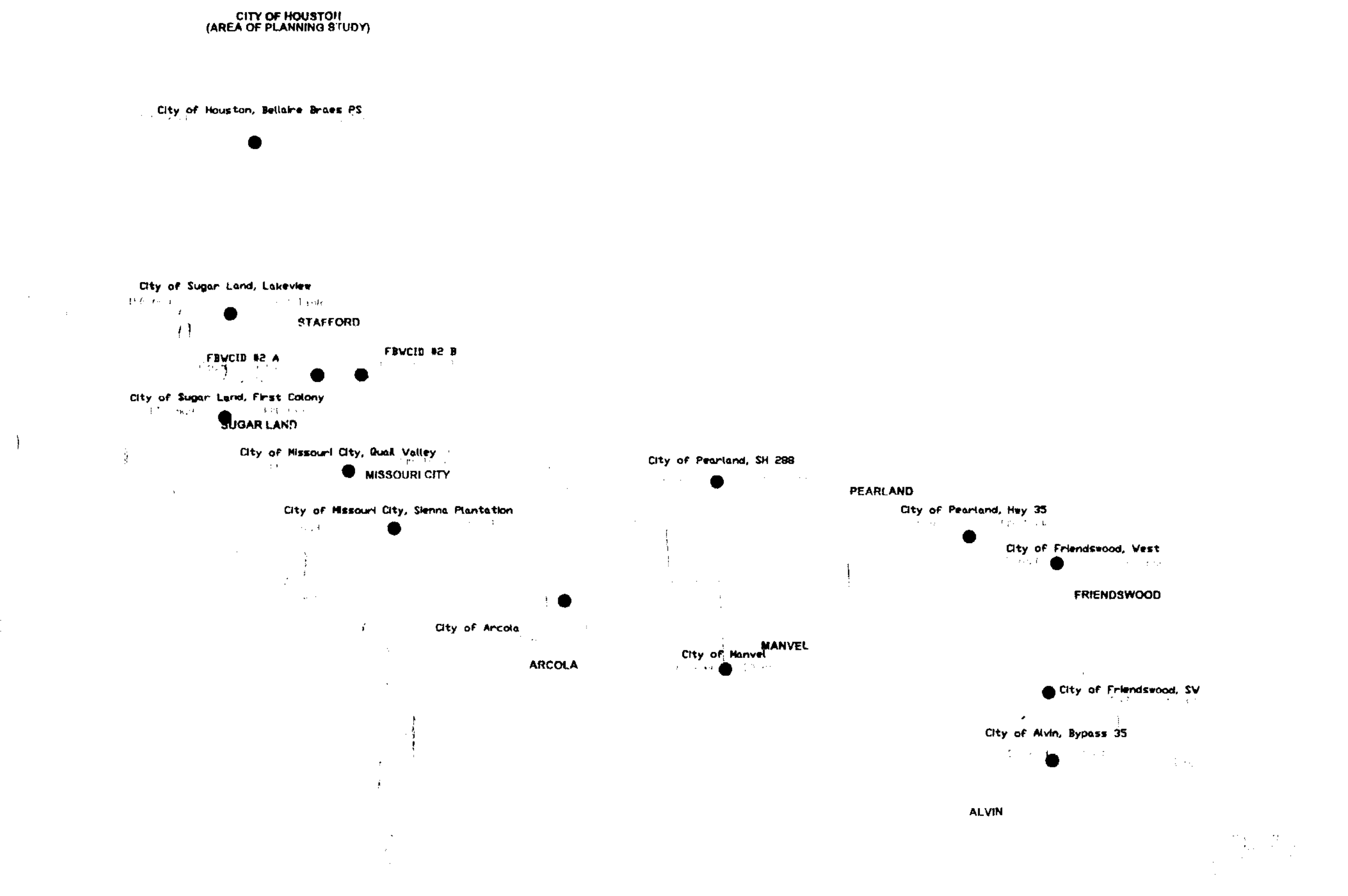
Corridor to City of Houston, FBWCID No. 2, and Sugar Land Lakeview Take Point

Three alternative pipeline corridors between the City of Houston, FBWCID No. 2, and Sugar Land Lakeview take points and the two alternative water treatment plant sites in Demand Area A were developed. These alternatives were the Dairy Ashford corridor, SH 6 corridor, and the Farm-to-Market (FM) Road 1876 corridor. The three alternatives from the Sugar Land water treatment plant site are shown on **Figure 6-2** and the three alternative routes from the FBWCID No.2 water treatment plant site are shown on **Figure 6-3**. Highlights of each of corridor are discussed below.

Each alternative will use the Highway 90 and the American Canal public right-of-way as the east-west corridor between the Sugar Land Lakeview and FBWCID No. 2 take points. This corridor is the shortest distance between the take points and minimizes impact to environmentally sensitive areas and highly congested areas along US 59 and Hwy 90 south of US 59.

Dairy Ashford Corridor

This route would install a pipeline in the Dairy Ashford public right-of-way. Dairy Ashford is designated as an emergency corridor route and has additional right of way over a conventional city street, but this right-of-way is cluttered with existing water, sewer, and storm utilities. Construction along this corridor will require significant traffic control and road repair and construction parallel to US 59.

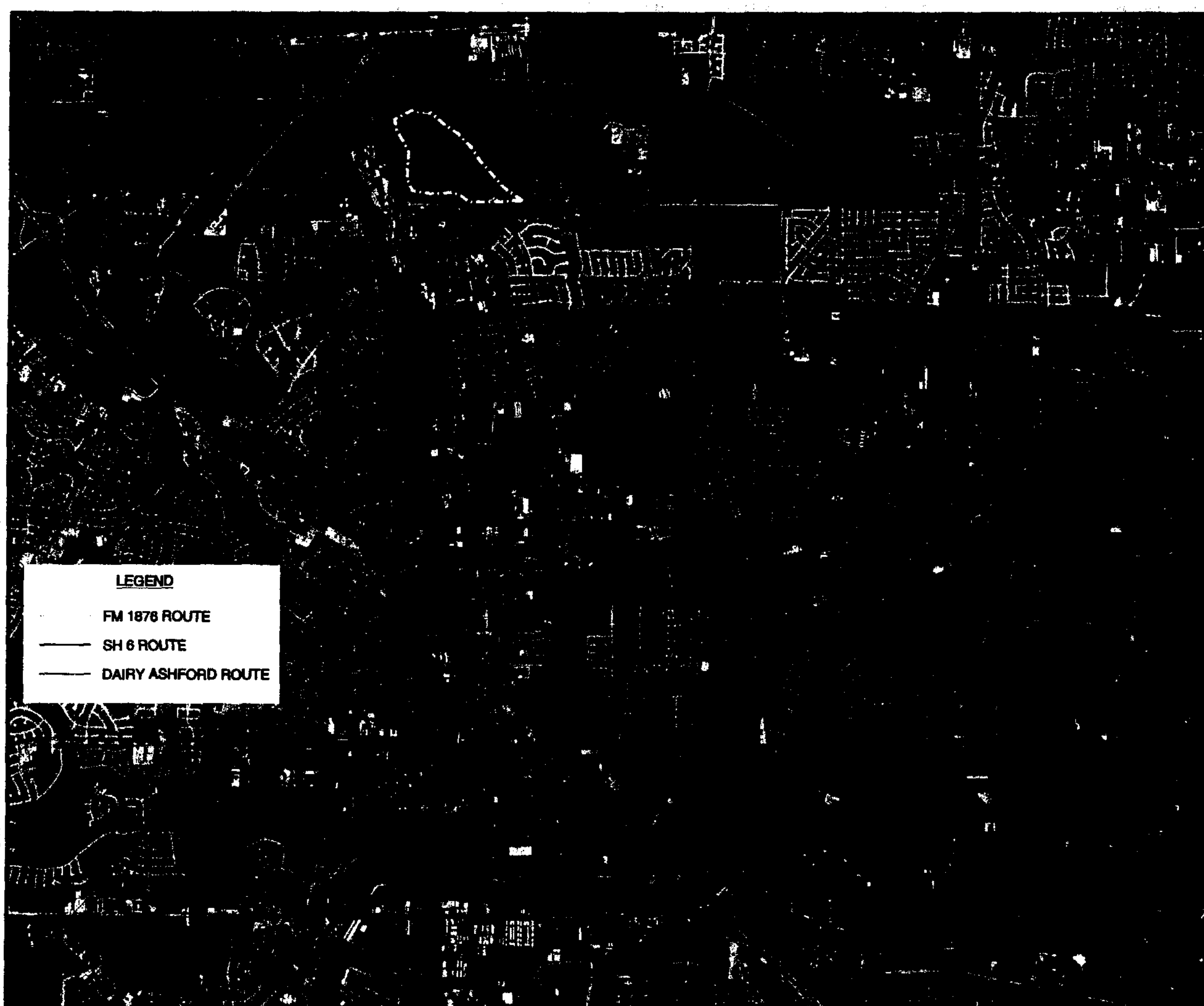


MONTGOMERY WATSON

GCWA / TWBD FACILITY PLAN

TAKE POINTS WITH DEMAND REQUIREMENTS

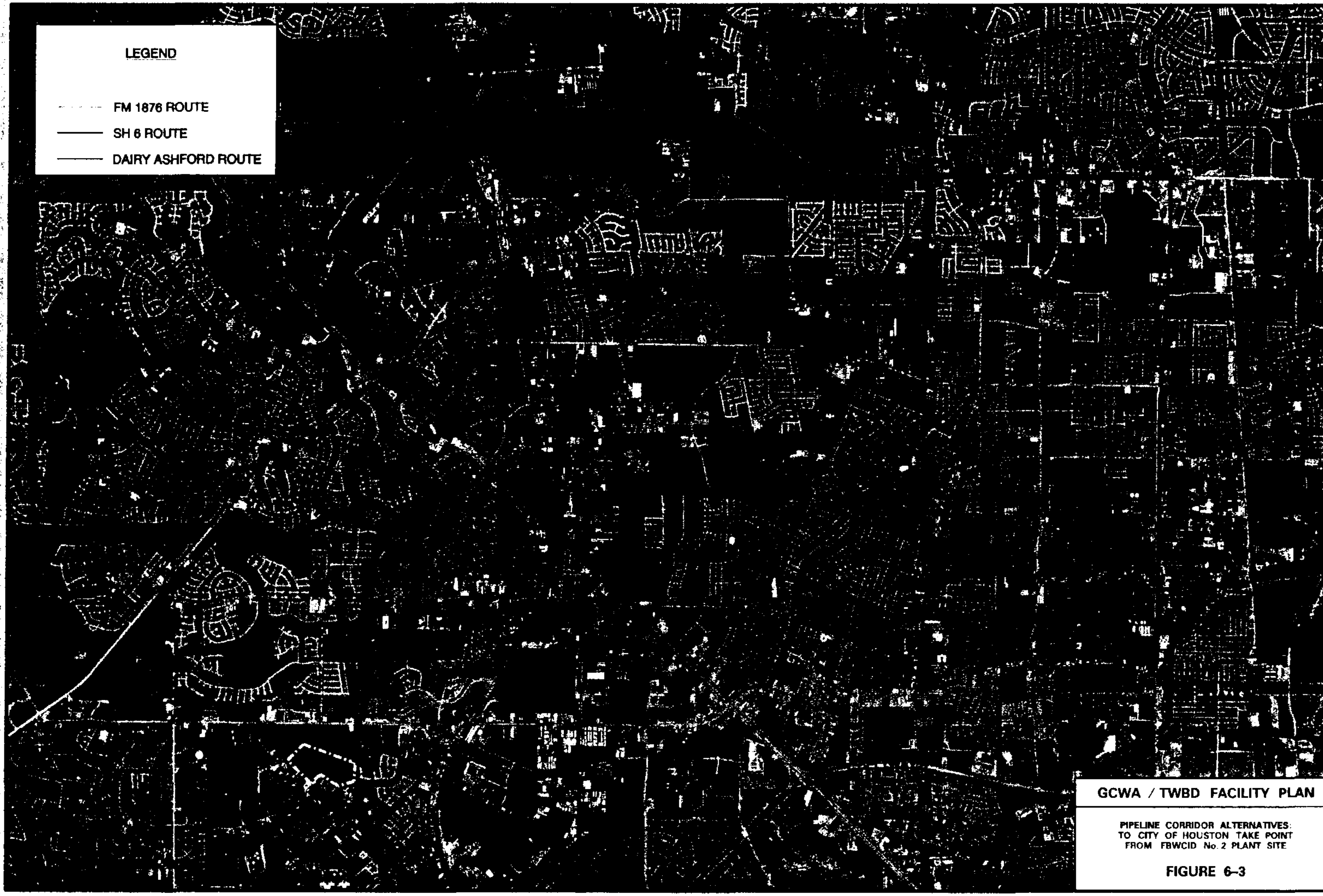
FIGURE 6-1



GCWA / TWBD FACILITY PLA

PIPELINE CORRIDOR ALTERNATIVES:
CITY OF HOUSTON TAKE POINT
FROM SUGAR LAND PLANT SITE

FIGURE 6–2



GCWA / TWBD FACILITY PLAN

PIPELINE CORRIDOR ALTERNATIVES:
TO CITY OF HOUSTON TAKE POINT
FROM FBWCID No. 2 PLANT SITE

FIGURE 6–3

SH 6 Corridor

SH 6 minimized the corridor distance from the Sugar Land site to the City of Houston Bellaire Braes Pump Station and has ample right-of-way for a installation of a large diameter water line. Construction along this route will require coordination around numerous existing utilities and will likely require trenchless construction methods to cross waterways and private utilities. From the FBWCID No. 2 site, the SH 6 corridor is significantly longer than the other options.

FM 1876 Corridor

FM 1876 corridor minimizes the overall length of pipeline required to serve the Houston and Sugar Land-Lakeview take points. FM 1876 has available public right-of-way and will require coordination with existing utilities to minimizes disruption of traffic, sewer, and water during construction.

Summary Evaluation

The advantages and disadvantages of the alternative pipeline corridors are shown in **Table 6-2**. It is anticipated that the FM 1876 corridor will result in the lowest cost alternative for the northern half of Demand Area A as this route is the shortest and contains the least number of known utility conflicts traffic, and environmental hazards.

TABLE 6-2
CITY OF HOUSTON, FBWCID NO. 2 AND SUGAR LAND-LAKEVIEW PIPELINE CORRIDOR ANALYSIS

Alternative	Advantages	Disadvantages
Dairy Ashford	• Minimizes pipeline length between Sugar Land Site and City of Houston Bellaire Braes Take Point • No easements required • Minimizes disturbance to environmentally sensitive areas	• Dairy Ashford is cluttered with existing water, sewer, and storm lines • Dairy Ashford has increased traffic volume and passes through significant developed areas. • Construction in this corridor will require traffic control plan which will detour traffic from a hurricane evacuation route.
SH 6	• Available room in Right-of-way for large diameter water line using open cut methodology	• Increased pipe length to serve both the City of Houston and Sugar Land Lakeview take point • Crossing of Oyster Creek required
FM 1876	• Minimal pipeline length between alternate water plant sites and take points • Limited commercial development	• Construction adjacent to existing utilities

Corridor to the Missouri City and Sugar Land First Colony Take Points

From the Sugar Land Plant, the following two options were identified as possible pipeline corridors to the Missouri City take points: SH 6 and University Boulevard. Both corridors are shown on **Figure 6-4.**

SH 6 Corridor

SH 6 loops around the West Side of Houston from U.S. 290 to SH 288 and then continues Southward. The pipeline would follow this public right of way and minimizes the length of pipeline required to connect the alternate water treatment plant sites and the Missouri City and Sugar Land-First Colony take points. This corridor is highly developed and construction will require numerous street, driveway and existing utility crossings, along with an extensive traffic control program.

University Boulevard Corridor

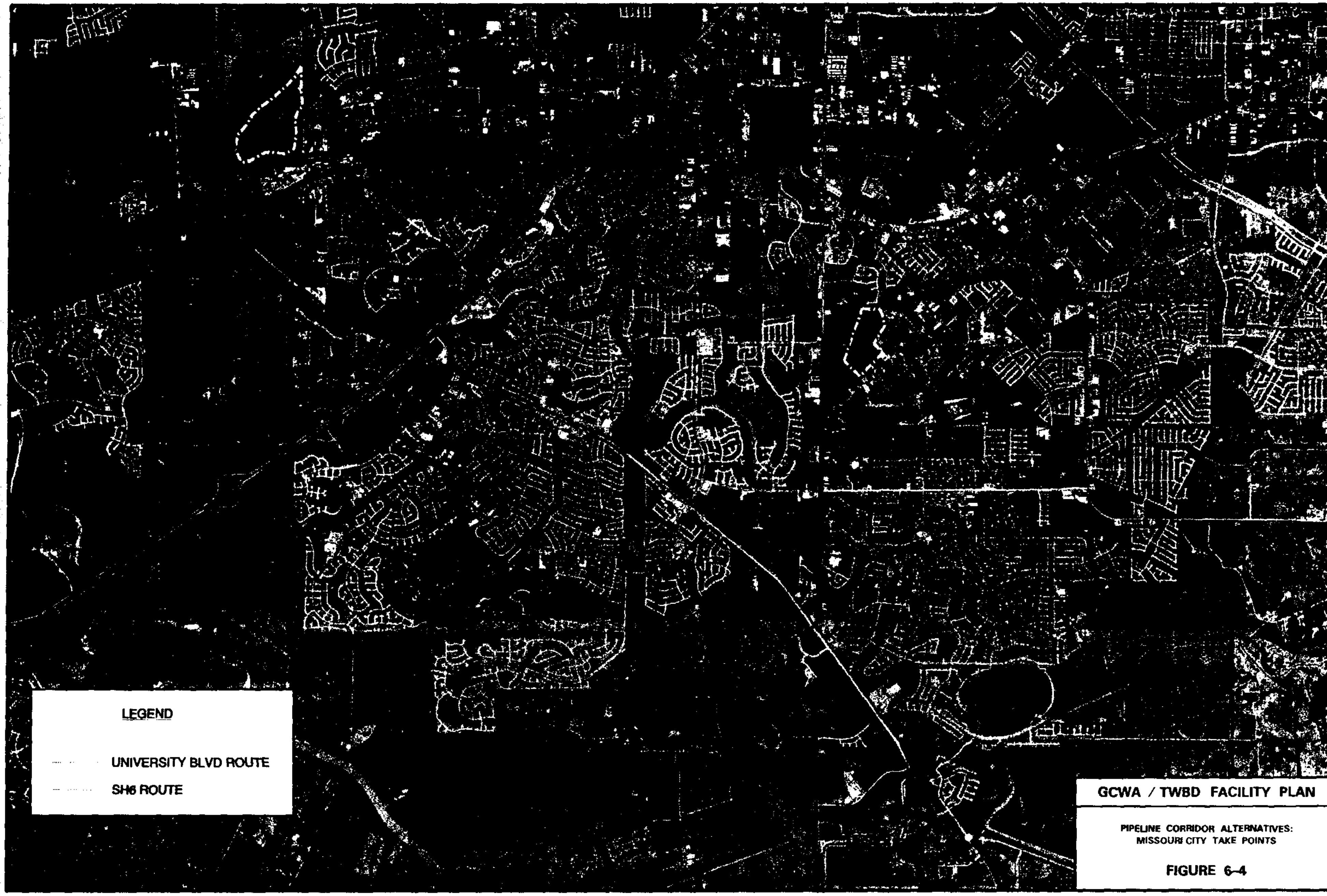
The second alternative is the University Boulevard loop. University Boulevard is a proposed thoroughfare that will connect US 59 and SH 6. The proposed road starts at SH 6 north of US 59 and loops around Sugar Land and finally intersects SH 6 at Oilfield Road. Since the pipeline could be constructed in conjunction with the proposed road, utility crossings and pavement repair would be minimized. The disadvantage of this corridor is that University Boulevard is in the planning stages and the timing of the construction of this road is yet unknown. This corridor significantly increases the length of pipeline from the Sugar Land-First Colony take point to the Missouri City take points.

Summary Evaluation

The advantages and disadvantages of these two alternatives are shown in **Table 6-3**. The constructability of the transmission line along the SH 6 route poses a major difficulties. Not only would this route disrupt traffic flow along a major thoroughfare, but construction along the corridor will not be possible with impacting the road surface of SH 6, which will require Texas Department of Transportation approval and dramatically increase overall project costs. The advantages associated with the constructability, availability of right-of-way and lack of public impact of the University Boulevard route over the SH 6 route outweigh the additional length requirements of the University Boulevard route and the University Boulevard corridor is recommended as the preferred alignment.

TABLE 6-3
MISSOURI CITY AND SUGAR LAND-FIRST COLONY PIPELINE CORRIDOR ANALYSIS

Alternative	Advantages	Disadvantages
SH 6	• Least pipeline length • No easements required	• Construction through a high density area with numerous existing utiliites, minimal public right of way, and heavy traffic volume
University Boulevard	• No conflict with existing utilities • Construction can be implemented along open right-of-way through open cut methods	• University Boulevard is not yet constructed • May have environmental constraints • Longer Pipeline route



GCWA / TWBD FACILITY PLAN

PIPELINE CORRIDOR ALTERNATIVES:
MISSOURI CITY TAKE POINTS

FIGURE 6-4

Brazoria County Corridor Analysis

A corridor analysis was conducted to determine the preferred route between Demand Area A and Demand Area B and to serve the Pearland-SH 288, Manvel and Arcola take points. The following three options were considered for the pipeline corridor to link Demand Area A and Demand Area B: American Canal, Houston Lighting and Power (HL&P) Easement, and SH 6. The various routes are shown on **Figure 6-5 and Figure 6-6**.

American Canal Corridor

The American Canal corridor would lay the transmission pipeline along the banks of the existing GCWA canal from Demand Area A to SH 35. The area along the canal is easily accessible and for the most part is agricultural land, which should support standard open cut construction. The most difficult issue to resolve for the use of this corridor is the easements and right-of-way. It is anticipated that there are well over 100 landowners that will have to grant easements to the GCWA to install and maintain a finished water pipeline on their land. One positive of this easement requirement is that these landowners currently have existing easements and that the pipeline easement will overlap with existing GCWA encumbrances for the American Canal. It is expected that this easement process could require 18 months to identify property owners, survey the easement, locate the landowners, and obtain contracts.

Houston Light and Power Easement Corridor

Another fairly direct corridor between Demand Area A and B is through existing HL&P power transmission easements. The HL&P easements were obtained to route power transmission lines from the W.A. Parrish Power Plant to substations throughout the Houston metropolitan area. Use of these easements would minimize the number of private landowner easements required and would centralize permitting. One disadvantage of using the HL&P corridor is that the easement is considered fee property and HL&P will charge GCWA an annual fee for a pipeline easement. In addition, HL&P has strict construction requirements for work adjacent to overhead power lines. These requirements often require trenchless installation within 40 feet of a power line support. This requirement as well as the requirement of 48" minimum cover over any pipeline will increase the overall project over standard open cut installation.

SH 6 Corridor

The third option for the connection corridor is SH 6. SH 6 is a straight line link between the Missouri City take points and the City of Alvin. The advantage to using this corridor is that it is a relatively direct route between the two demand areas, thus minimizing the overall length of the transmission pipeline. As the SH 6 is public right of way, no easements would be required, but construction along this is anticipated to be difficult through several congested sections requiring expensive installation techniques. In several locations, the pipeline will be required to rout outside of the Texas Department of Transportation easement as no room inside the easement for a large diameter pipeline exists.

Summary Evaluation

The advantages and disadvantages of each alternative for the Brazoria County Corridor are shown in **Table 6-4**. The American Canal route was selected as the preferred corridor because this route is expected to be the least expensive. This corridor will require the least amount of pipe, allow for the most economical pipeline installation (open cut), and minimizes utility crossings and pavement repair. The drawbacks to this alternative are the number of required easements and the potential for environmental impacts. These drawbacks can be mitigated by planning and implementing an easement collection

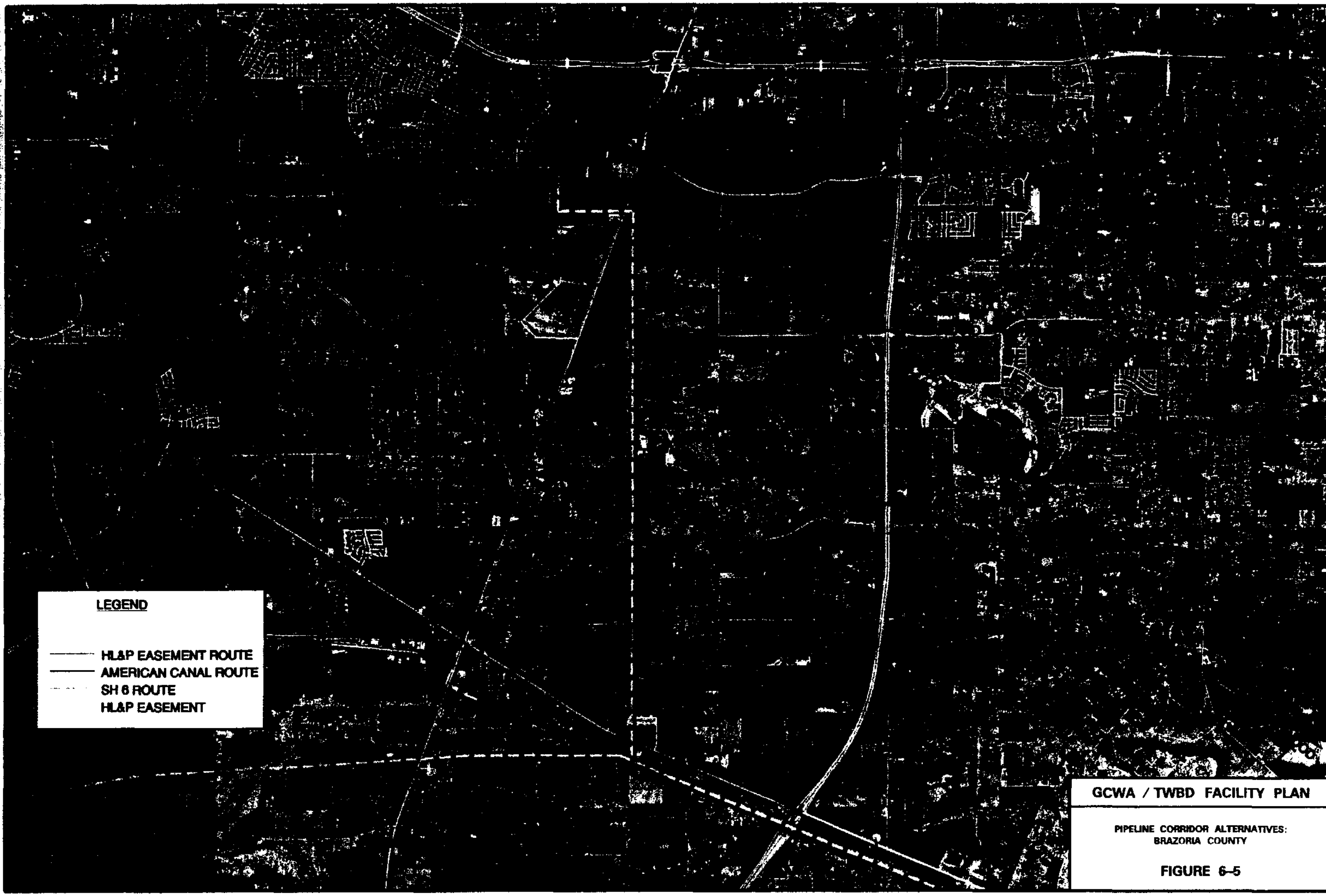

LEGEND
HL&P EASEMENT ROUTE
AMERICAN CANAL ROUTE
SH 6 ROUTE
HL&P EASEMENT
GCWA / TWBD FACILITY PLAN
PIPELINE CORRIDOR ALTERNATIVES:
BRAZORIA COUNTY

FIGURE 6-5


LEGEND
AMERICAN CANAL ROUTE
SH 6 ROUTE
SH 35 ROUTE
HL&P EASEMENT ROUTE
HL&P EASEMENT
GCWA / TWBD FACILITY PLAN
PIPELINE CORRIDOR ALTERNATIVES:
DEMAND AREA B
FIGURE 6-6

program early in the planning process and conducting an environmental assessment to determine the extent of environmental impacts.

TABLE 6-4
BRAZORIA COUNTY CORRIDOR ANALYSIS

Alternative	Advantages	Disadvantages
American Canal	• Minimizes pipeline length between Demand Area A and SH 35 • Construction through rural area, few anticipated utility conflicts	• Pipeline Easements with numerous private landowners will be required • Environmental impacts of construction along a body of water
HL&P Easement	• Minimizes pipeline length between Demand Area A and SH 35	• Pipeline Easement • Construction Methods around HL&P facilities
SH 6	• Minimizes pipeline length between Missouri City Take Points and SH 35 • Public Right-of-way	• Construction through a high density area with numerous existing utiliites, minimal public right of way, and heavy traffic volume • Will have to purchase private easement to bypass areas of SH 6, where available right-of-way is constrained.

Demand Area B Corridor Analysis

This analysis focused on serving the Pearland-SH35, Friendswood and Alvin take points. A preliminary review of the area indicated that SH 35 served as a direct connection between these take points and unless this construction along this route was impossible, this route would be recommended as the preferred alignment. Other potential routes connecting these take points would require construction around the City of Alvin. The length associated with these alternates routes would considerably increase the cost of serving these taking points. The City of Alvin has indicated that SH 35 has sufficient public right-of-way available and installation of a large diameter pipeline within the right-of-way is feasible. The disadvantages are the impact on the public and the typical problems involved with construction on a major thoroughfare, but the costs associated with mitigating these disadvantages do not preclude use of this corridor. The location of the demand points with the preferred pipeline corridor for Demand Area B is shown on **Figure 6-6**.

Summary of Preferred Pipeline Analysis

The corridor analysis identified preferred pipeline routing based on the expected cost to install the pipeline to the planning area take points from the alternate water treatment plants. Preferred alternatives are summarized in the **Table 6-5**:

TABLE 6-5
PREFERRED PIPELINE CORRIDORS

Take Point Corridor	Preferred Alignment
Houston and Sugar Land – Lakeview	FM 1876
FBWCID No.2	Hwy 90 and American Canal
Missouri City and Sugar Land – First Colony	University Boulevard
Arcola, Manvel, and Pearland –SH 288	American Canal
Pearland-SH35, Friendswood, and Alvin	SH 35

With these selected pipeline alternatives, Participating Utility take point demands, and alternative water treatment plant locations, a facility plan for the finished water transmission system can be developed for each water treatment plant scenario.

Modeling and Pipeline Layout Descriptions

To develop the cost effective sizing of the finished water transmission system components, a hydraulic model was utilized to size pipeline components based on the take point requirements and the preferred pipeline alignments. The goal of the model was determine the minimum sized pipelines and booster pump station pressure that could adequately meet the take point requirements. For each of the six alternative water treatment plant scenarios developed in **Section 5**, a hydraulic model was constructed.

Hydraulic Model

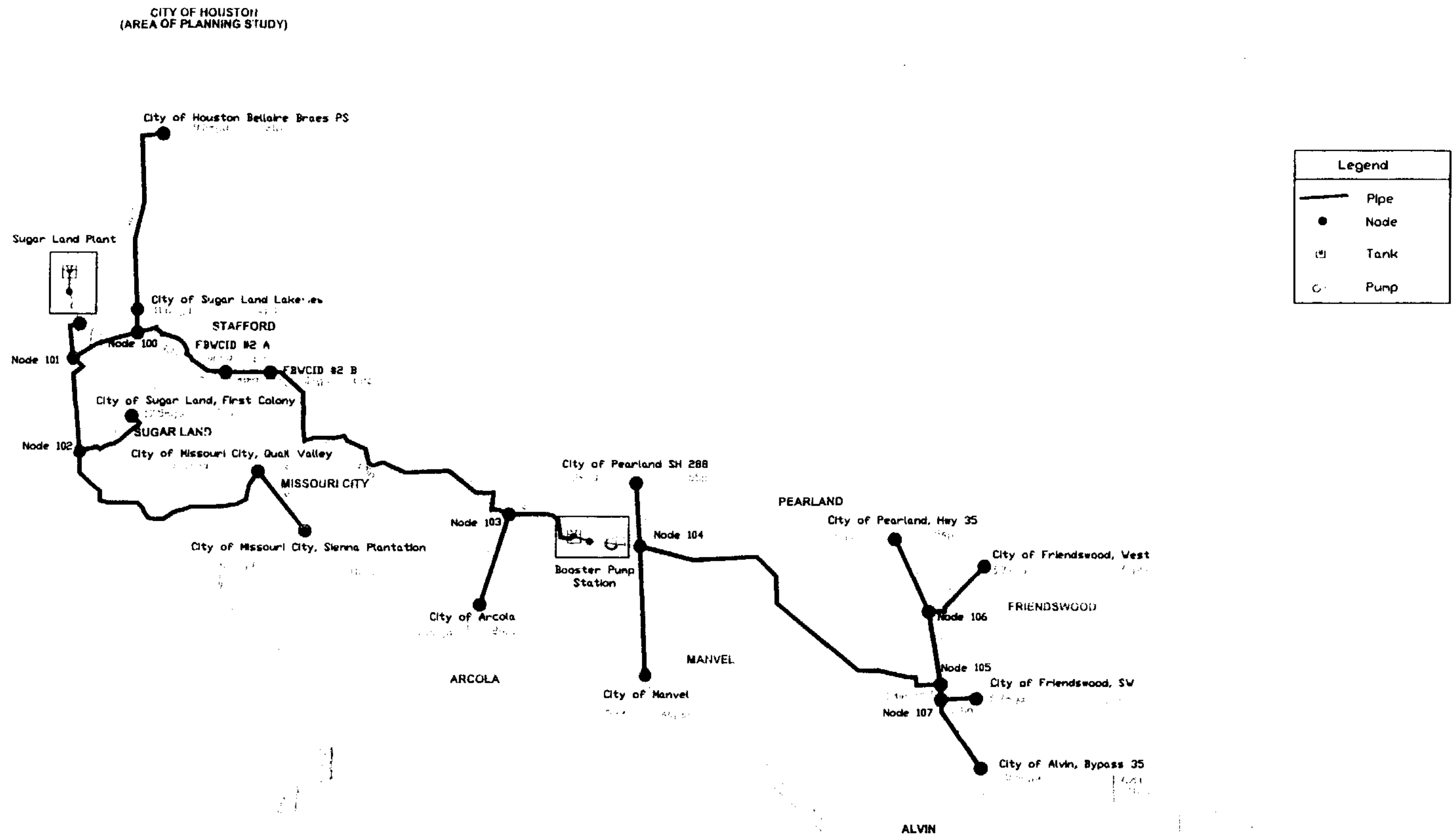
The program used for the hydraulic modeling was H_2ONET Utility Suite, which contains seven subprograms designed to optimize water distribution modeling. The subprogram used for this task was the H_2ONET Analyzer. H_2ONET Analyzer enables the modeler to track the flow and velocity of water in each pipe; the pressure, age of water, and fire flow capacity at each node; the height and volume of water in each tank; the discharge pressure/flow, efficiency and energy cost for each pump; the cost of physical improvements; and the movement and fate of water quality constituents as they travel through the distribution system. For this evaluation, only a portion of these modeling capabilities were utilized.

Model Assumptions and Layout

Several basic parameters and assumptions were used to design the hydraulic model. For this study, the following assumptions were defined:

- Pipeline size based on ultimate demand of Participating Utilities in year 2050
- Maximum velocity in any given pipeline - 8 ft/s
- Hazen and Williams pipe friction coefficient - 130
- Ground storage tank at take points are filled at top of tank
- Ground storage tank at water treatment plant or booster station is empty

Given these assumptions, all hydraulic model scenarios were constructed and the layout of the demand points, plant location, and pipeline sizes can be seen for each model scenario in **Figures 6-7 through 6-12.**



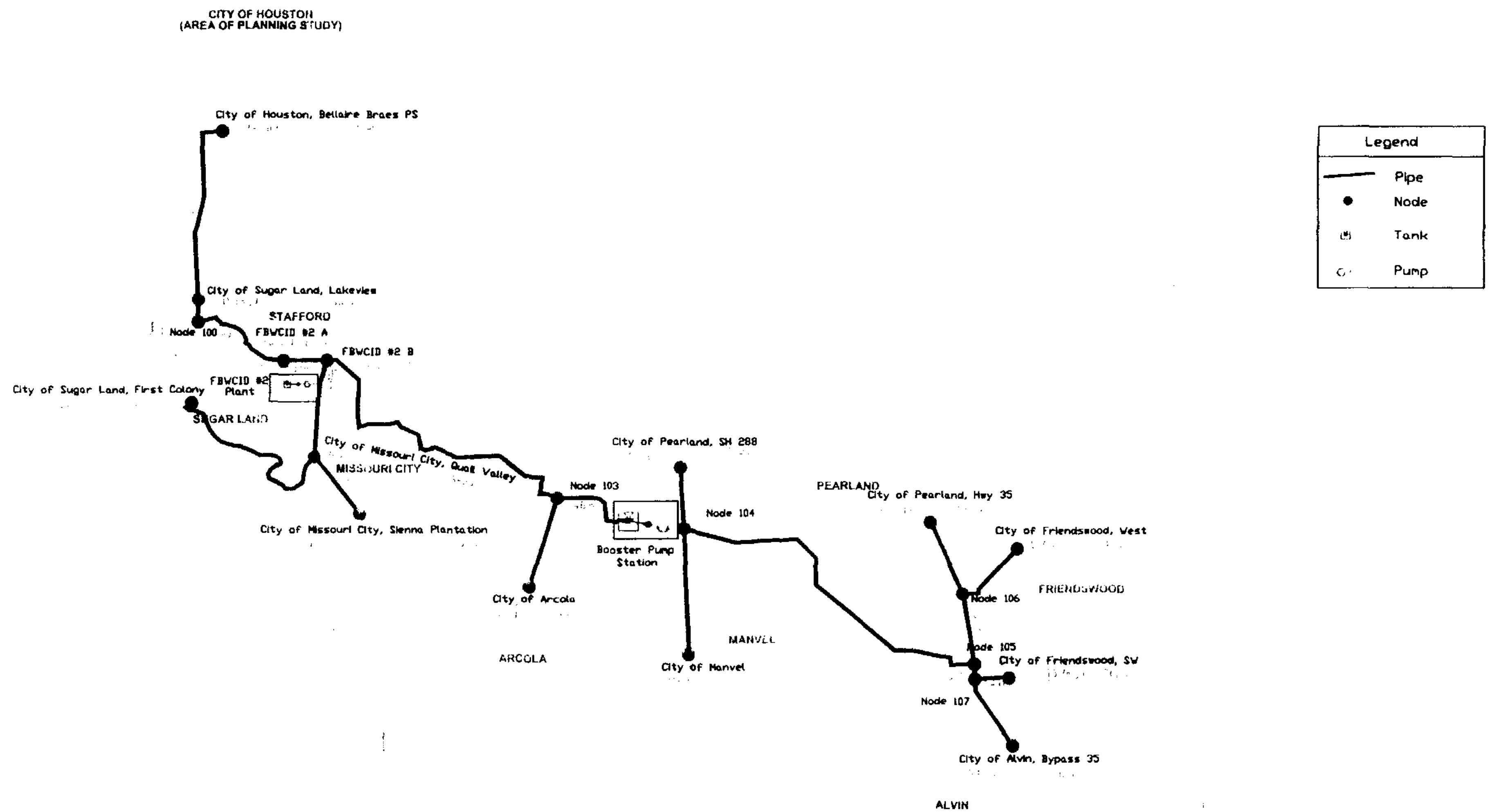
MONTGOMERY WATSON

GCWA / TWBD FACILITY PLAN

MODELING RESULTS

SUGAR LAND SITE

FIGURE 6-7



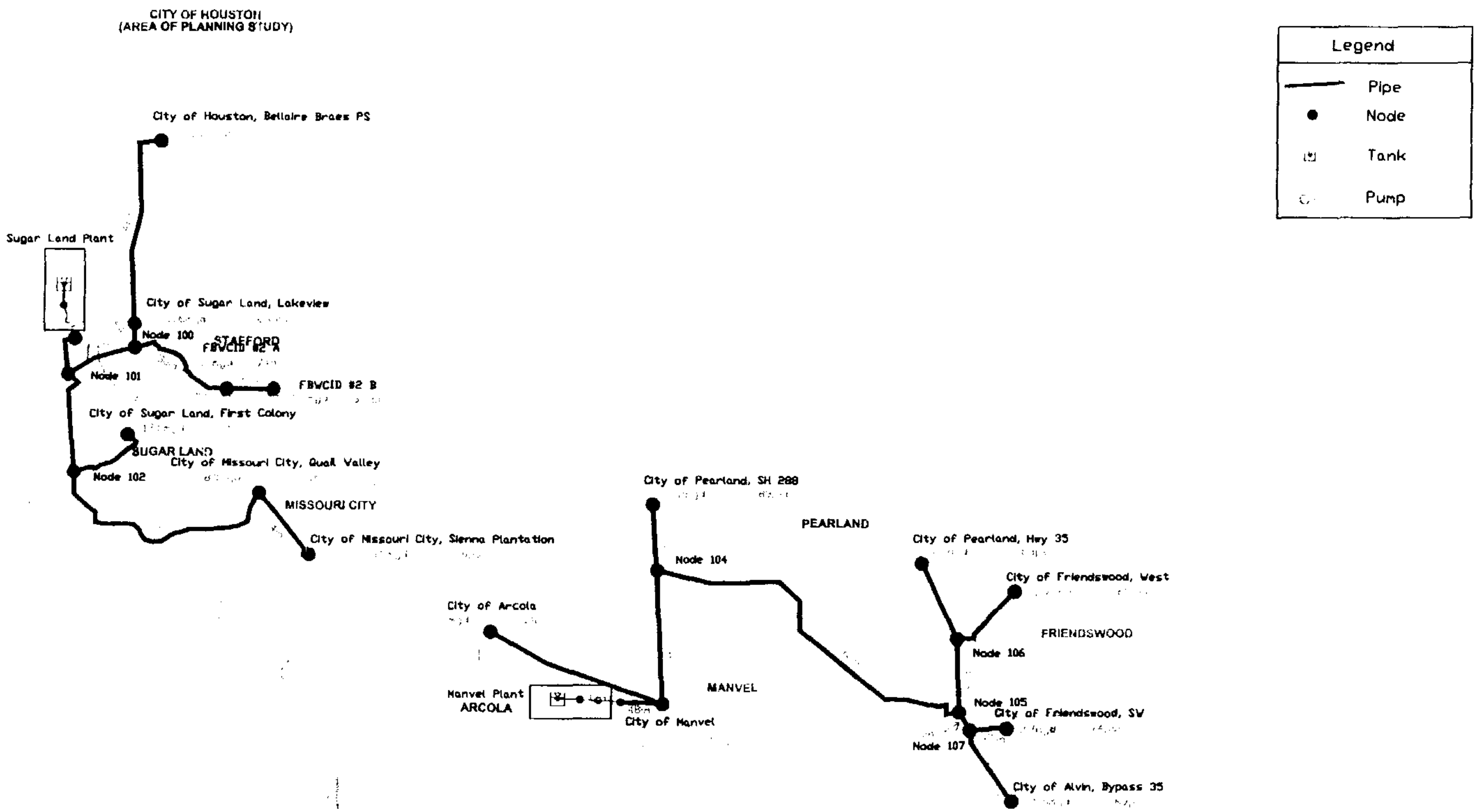
MONTGOMERY WATSON

GCWA / TWBD FACILITY PLAN

MODELING RESULTS

FBWCID#2 PLANT SITE

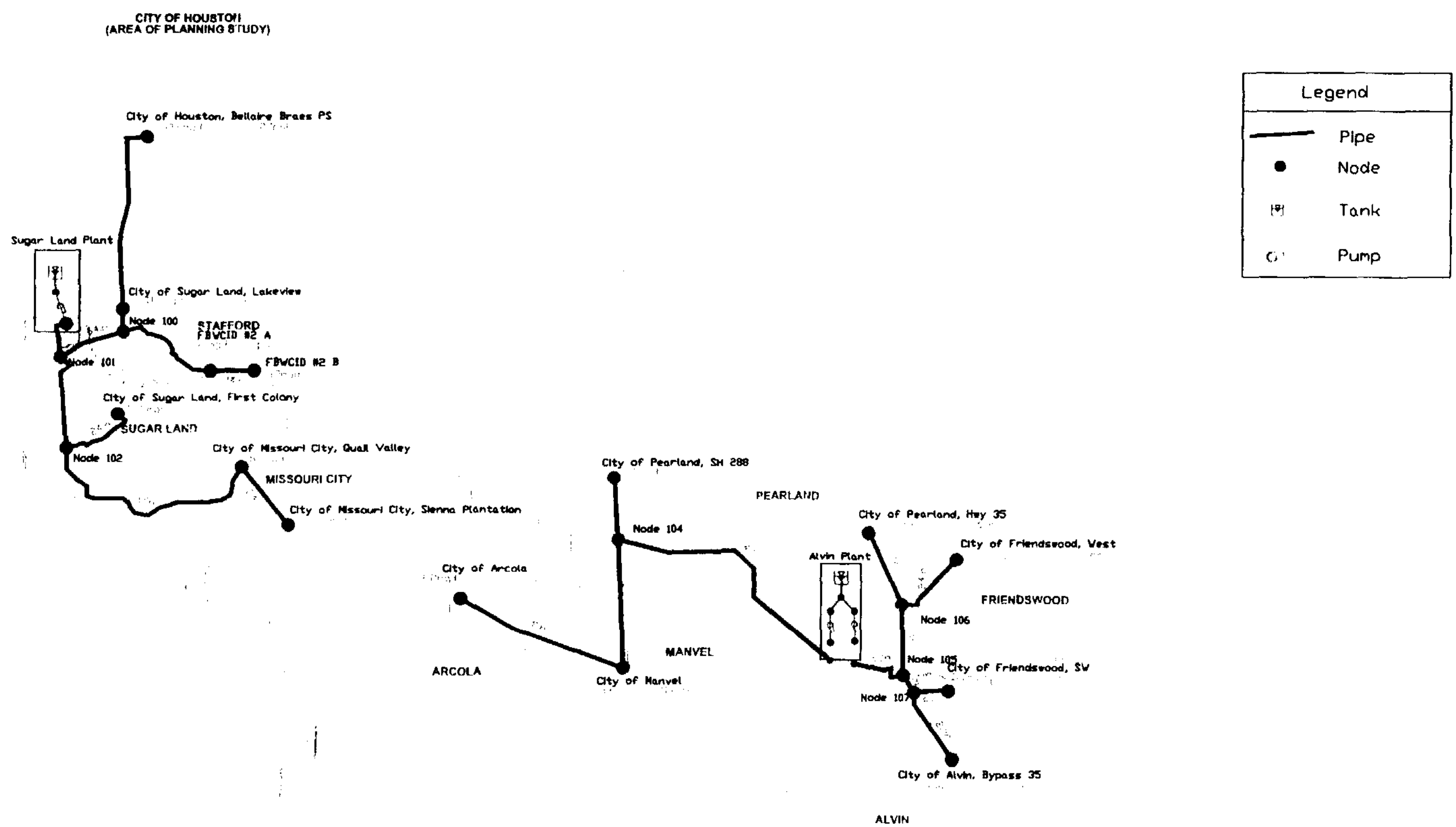
FIGURE 6-8



MONTGOMERY WATSON

GCWA / TWBD FACILITY PLAN

MODELING RESULTS
DUAL PLANT ALTERNATIVE
SUGAR LAND AND MANVEL SITES
FIGURE 6-9

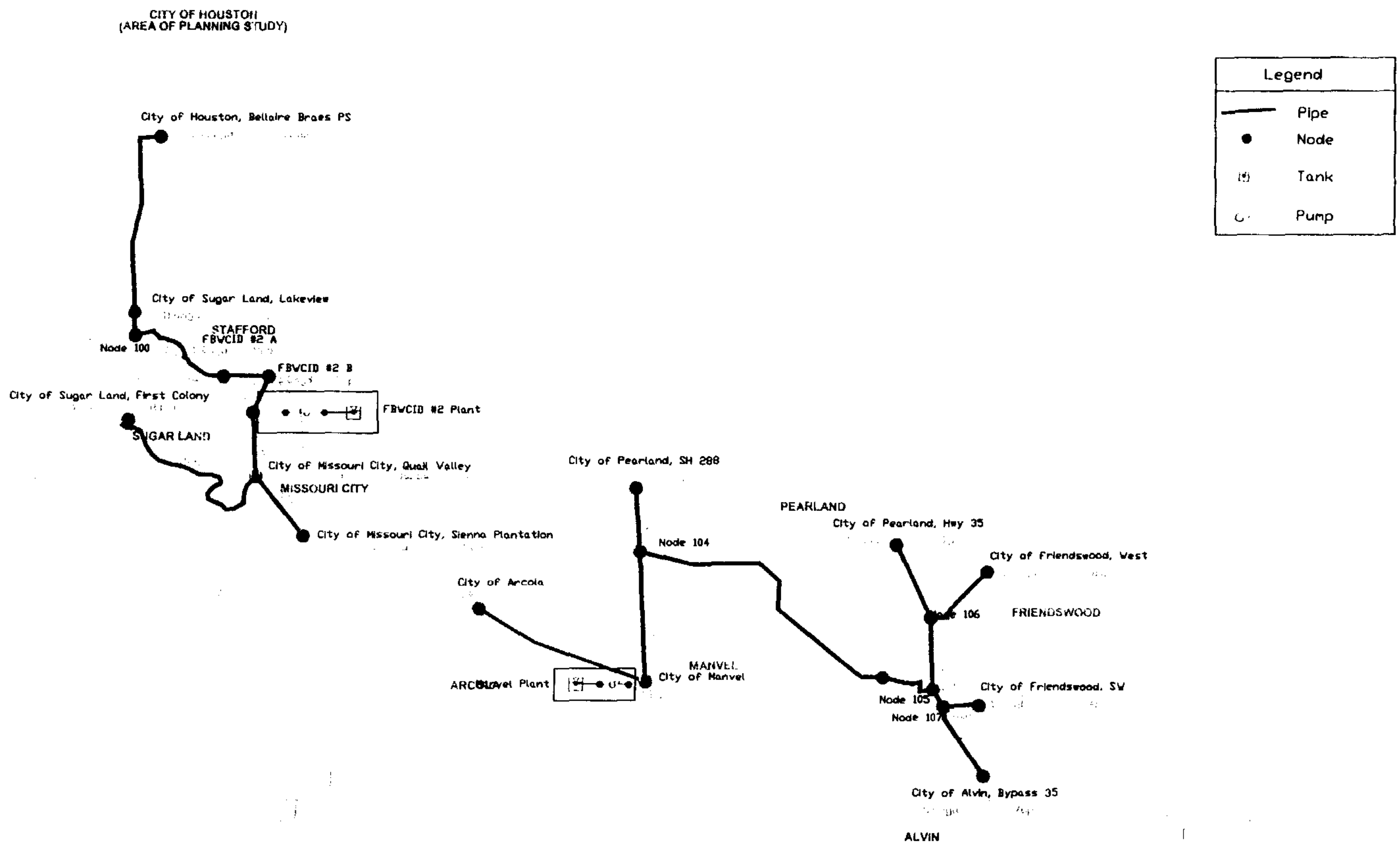


MONTGOMERY WATSON

GCWA / TWBD FACILITY PLAN

MODELING RESULTS
DUAL PLANT ALTERNATIVE
SUGAR LAND AND ALVIN SITES

FIGURE 6-10

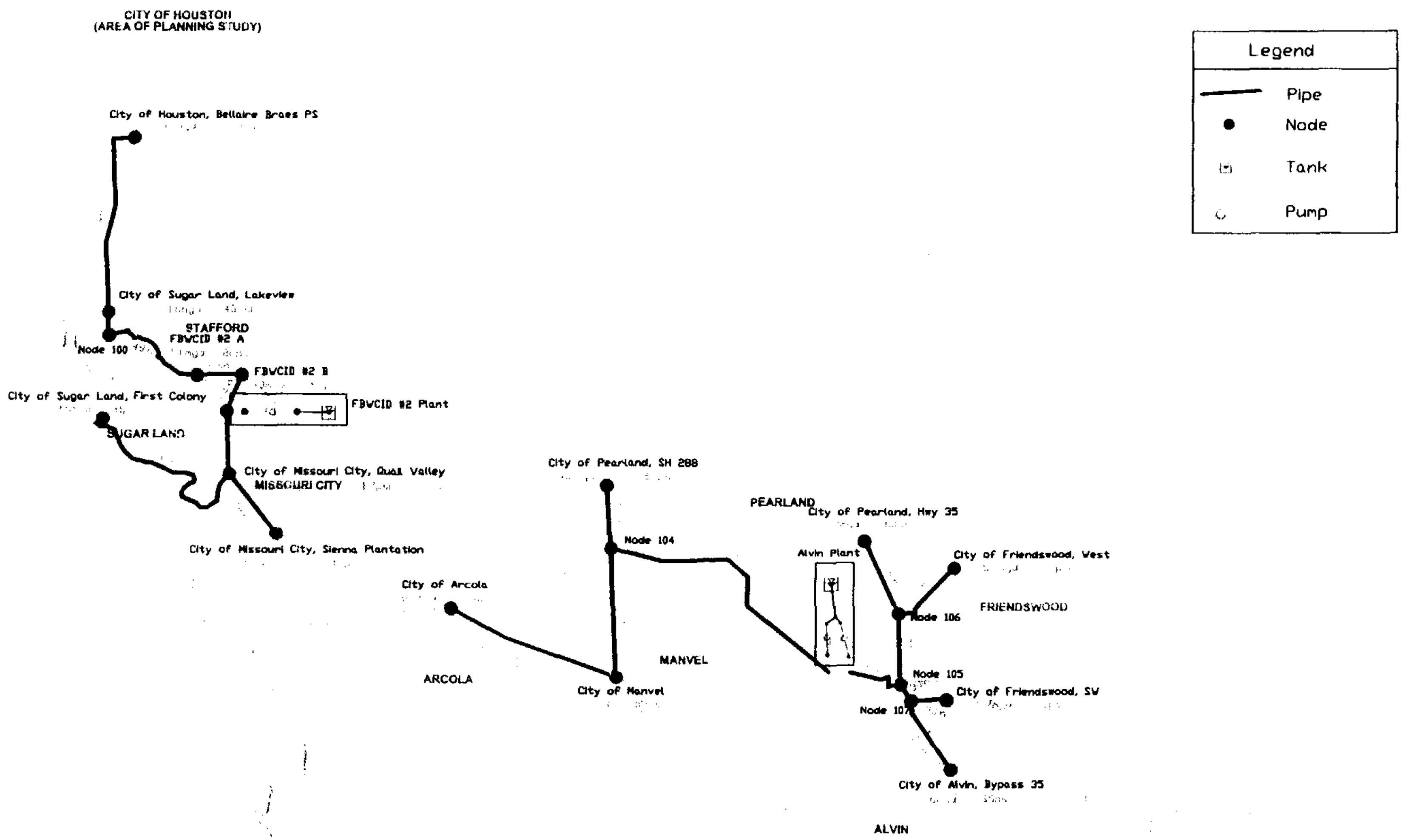


MONTGOMERY WATSON

GCWA / TWBD FACILITY PLAN

MODELING RESULTS
DUAL PLANT ALTERNATIVE
FBWCID #2 AND MANVEL SITES

FIGURE 6-11



MONTGOMERY WATSON

GCWA / TWBD FACILITY PLAN

MODELING RESULTS

DUAL PLANT ALTERNATIVE

FBWCID #2 AND ALVIN SITES

FIGURE 6-12

Model Results

For each alternative, finished water transmission system consists of the pipeline facilities and high service pump stations. The final quantities of finished water pipelines are shown in **Tables 6-6 and 6-7**. These tables report the finished water pipe lengths as either rural or urban, based on the existing site geography. Urban installations are italicized. Rural installations refer to pipelines that will be installed in open cut trenches with minimal utility crossings, pavement repair, and trenchless installations. Conversely, urban installations refer to pipelines installed in developed areas where frequent trenchless installations, pavement repair, utility conflicts, and traffic control will be required. The type of installation, either rural or urban, will be affect the construction cost of the transmission alternatives. The tables also summarize the required length of private landowner easements.

TABLE 6-6
MODEL RESULTS FOR ONE PLANT SCENARIOS

Pipeline Segment	Sugar Land Plant Site		FBWCID No.2 Plant Site	
	Length (ft)	Diameter (in)	Length (ft)	Diameter (in)
Lakeview TP to Bellaire Braes PS	*31,900*	*54*	*31,900*	*48*
Sugar Land Site out of WTP	*6,270*	*70*	-	-
Node 100 to Lakeview TP	*715*	*54*	-	-
Node 100 to Node 101	*10,180*	*66*	-	-
Node 101 to Node 102	*12,270*	*40*	-	-
Node 102 to First Colony TP	*3,300*	*24*	-	-
Node 102 to Missouri City TP	*37,010*	*36*	*35,580*	*30*
Quail Valley TP to Sienna Plantation	*11,300*	*30*	*11,300*	*16*
Node 100 to FBWCID A TP	*17,390*	*66*	*18,105*	*54*
FBWCID A TP to FBWCID B TP	*6,700*	*48*	*6,700*	*54*
FBWCID B to Node 103	50,800	42	50,800	48
Node 103 to Arcola TP	14,100	8	14,100	8
Node 103 to Booster PS	22,366	42	22,366	48
Node 104 to Pearland SH 288 TP	9,350	18	9,350	24
Node 104 to Manvel TP	19,200	14	19,200	16
Node 104 to Node 105	55,400	42	55,400	42
Node 105 to Node 106	*10,000*	*36*	*10,000*	*36*
Node 105 to Node 107	*2,300*	*24*	*2,300*	*24*
Node 107 to Friendswood SW TP	*5,300*	*24*	*5,300*	*24*
Node 107 to Alvin Bypass 35 TP	*10,100*	*20*	*10,100*	*20*
Node 106 to Pearland 35 TP	*11,700*	*24*	*11,700*	*24*
Node 106 to Friendswood West TP	*11,200*	*24*	*11,200*	*24*
FBWCID No.2 Site to FBWCID B TP	-	-	*3,830*	*54*
FBWCID No.2 Site to Quail Valley TP	-	-	*11,100*	*36*
Manvel Site to Arcola TP	-	-	-	-
Manvel Site to Node 104	-	-	-	-
Alvin Site to Node 104	-	-	-	-
Manvel Site to Arcola TP	-	-	-	-
Alvin Site to Node 105	-	-	-	-
Total Pipe in Rural Areas (ft)	171,216		171,216	
Total Pipe in Urban Areas (ft)	187,635		169,115	
Total Pipeline Length (ft)	**358,851**		**340,331**	
Total In-Diameter Foot in Rural		5,949,672		6,483,168
Total In-Diameter Foot in Urban Areas		7,876,690		6,019,290
Total In-Diameter Foot (in-dia ft)		**13,826,362**		**12,502,458**
Private Landowner Easements (ft)	106,200		106,200	

Note: Rural installations are designated in Italic Type

TABLE 6-7
MODEL RESULTS FOR TWO PLANT SCENARIOS

Pipeline Segment	FBWCID No. 2 / Alvin Plant		Sugar Land /Manvel Plant		Sugar Land / Alvin Plant		FBWCID No. 2 / Manvel Plant	
	Length (ft)	Diameter (in)	Length (ft)	Diameter (in)	Length (ft)	Diameter (in)	Length (ft)	Diameter (in)
Lakeview TP to Bellaire Braes PS	*31,900*	*48*	*31,900*	*48*	*31,900*	*48*	*31,900*	*48*
Sugar Land Site out of WTP	*6,300*	*72*	*6,300*	*72*	-	-	-	-
Node 100 to Lakeview TP	*715*	*48*	*715*	*48*	*715*	*48*	*715*	*48*
Node 100 to Node 101	*10,180*	*66*	*10,180*	*66*	-	-	-	-
Node 101 to Node 102	*15,250*	*36*	*15,250*	*36*	-	-	-	-
Node 102 to First Colony TP	*3,300*	*24*	*3,300*	*24*	-	-	-	-
Node 102 to Missouri City TP	*37,010*	*30*	*37,010*	*30*	*35,580*	*30*	*35,580*	*30*
Quail Valley TP to Sienna Plantation	*11,300*	*24*	*11,300*	*24*	*11,300*	*18*	*11,300*	*18*
Node 100 to FBWCID A TP	*18,105*	*30*	*18,105*	*30*	*17,390*	*48*	*17,390*	*48*
FBWCID A TP to FBWCID B TP	*6,700*	*18*	*6,700*	*18*	*6,700*	*48*	*6,700*	*48*
FBWCID B to Node 103	-	-	-	-	-	-	-	-
Node 103 to Arcola TP	-	-	-	-	-	-	-	-
Node 103 to Booster PS	-	-	-	-	-	-	-	-
Node 104 to Pearland SH 288 TP	9,350	24	9,350	20	9,350	24	9,350	20
Node 104 to Manvel TP	-	-	-	-	-	-	-	-
Node 104 to Node 105	55,400	48	-	-	55,400	48	-	-
Node 105 to Node 106	*10,000*	*36*	*10,000*	*30*	*10,000*	*36*	*10,000*	*30*
Node 105 to Node 107	*3,000*	*24*	*3,000*	*30*	*3,000*	*24*	*3,000*	*30*
Node 107 to Friendswood SW TP	*5,300*	*20*	*5,300*	*20*	*5,300*	*20*	*5,300*	*20*
Node 107 to Alvin Bypass 35 TP	*10,100*	*24*	*10,100*	*20*	*10,100*	*24*	*10,100*	*20*
Node 106 to Pearland 35 TP	*11,700*	*30*	*11,700*	*24*	*11,700*	*30*	*11,700*	*24*
Node 106 to Friendswood West TP	*11,200*	*30*	*11,200*	*24*	*11,200*	*30*	*11,200*	*24*
FBWCID No.2 Site to FBWCID B TP	-	-			*3,830*	*54*	*3,830*	*54*
FBWCID No.2 Site to Quail Valley TP	-	-			*11,100*	*36*	*11,100*	*36*
Manvel Site to Arcola TP	26,800	8	-	-	26,800	8	-	-
Manvel Site to Node 104	50,000	48	-	-	50,000	48	-	-
Alvin Site to Node 104	-	-	46,400	42	-	-	46,400	42
Manvel Site to Arcola TP	-	-	27,000	8	-	-	27,000	8
Alvin Site to Node 105	-	-	9,000	30	-	-	9,000	30
Total Pipe in Rural Areas (ft)	141,550		91,750		141,550		91,750	
Total Pipe in Urban Areas (ft)	192,060		192,060		169,815		169,815	
Total Pipeline Length (ft)	333,610		283,810		311,365		261,565	
Total In-Diameter Foot in Rural Areas(in-dia ft)		5,498,000		2,621,800		5,498,000		2,621,800
Total In-Diameter Foot in Urban Areas (in-dia ft)		6,831,850		6,612,050		6,066,460		5,846,660
Total In-Diameter Foot (in-dia ft)		9,715,450		6,799,050		8,950,060		6,033,660
Private Landowner Easements (ft)	55,400		46,400		55,400		46,400	

Note: Rural installations are designated in Italic Type

For each of the scenarios, a high service pump station will be required to deliver water from the water treatment plant to the Participating Utility Take Points. The requirements of the pump station are dependent on the pressure requirements of the Participating Utilities and the headloss associated with flow through the pipelines. To meet the specified pressure and flow requirements at the Participating Utility Take Points, the following pump station pressures will be required. In several cases, a intermediate booster station was required to maintain pressure to the Demand Area B take points. A 2MG ground storage tank was considered in the construction of this booster pump station to increase system storage and mitigate surge pressures at the booster tank.. The pump station requirements are shown in **Table 6-8.**

TABLE 6-8
PUMP STATION MODEL RESULTS

Plant Site Alternative	WTP Pump Station Pressure Setting (psi)	Intermediate 35 MGD Booster Pump Station Pressure Setting (psi)	Chlorine Booster Station Required	Linear Feet of Required Pipeline Easement
Sugar Land	82	89	Yes	106,200
FBWCID No.2	74	89	Yes	106,200
Sugar Land /Manvel	Demand Area A - 89 / Demand Area B - 95	None	No	55,400
Sugar Land / Alvin	Demand Area A - 89 / Demand Area B - 97	None	No	46,400
FBWCID No. 2 / Manvel	Demand Area A - 95 / Demand Area B - 95	None	No	55,400
FBWCID No. 2 / Alvin	Demand Area A - 95 / Demand Area B - 97	None	No	46,400

Raw Water Delivery System Improvements

Requirements

Since each proposed surface water plant is adjacent to a GCWA canal, the regional water treatment plant will utilize the GCWA Canal System to bring raw water from the Brazos River to the water treatment plant intake. The Sugar Land, FBWCID No.2 and Alvin plant sites are adjacent to the American Canal and will utilized the American Canal System as the raw water delivery route. The Manvel site has the distinct advantage of being fed from either the American Canal System or the Briscoe Canal System by the use of Lateral 10.

This section discusses the required improvements to the Canal system to meet the demand of the existing GCWA agricultural, industrial, and municipal users as well as the additional raw water demand required for the new regional water plant facilities. For the purposes of this study, it is assumed that the existing GCWA users will continue to use their full compliment of Brazos River water and that the American Canal will be the primary method of conveyance through the planning area. This scenario simulates a worse case scenario where the Briscoe Canal is out of service for maintenance and water demand is at its peak.

Raw Water Demand

As described in **Section 3**, the GCWA Brazos River water demand in the year 2050 is 368 MGD. As discussed above, this raw water will be conveyed through the American Canal to the GCWA agricultural, industrial, and municipal users. As the canal progresses to Sugar Land from the Brazos River, the required capacity of the American Canal and associated lift stations will depend on the location of the proposed regional water plant. This chapter will discuss the required canal improvements in terms of plant site alternatives described **Section 5.**

Required Raw Water Improvements

For all plant site scenarios, required improvements to the raw water delivery system will include the following three items:

- Shannon Pump Station 2nd Lift Station Upgrade
- Jones/Oyster Creek Capacity Upgrade
- Lower American Canal Capacity Expansion

It should be noted that all reported existing canal capacities and locations of limiting capacities are taken from the GCWA report entitled "Water Audit and Water Use Projections" dated February 1999. Required canal improvements are based on this report and are discussed in general terms only. A summary of the required raw water capacities for the various plant site alternatives appears in **Table 6-9.**

TABLE 6-9
RAW WATER REQUIREMENTS

Area of Improvement	Limiting Capacity (MGD)	Require Capacity (MGD)			
		Sugar Land Site (150 mgd)	FBWCID No. 2 (150 mgd)	Sugar Land (115 mgd) and Alvin or Manvel (35 mgd)	FBWCID No. 2 (115 mgd) and Alvin or Manvel (35 mgd)
Shannon Lift Station	260	368	368	368	368
2nd Lift Station	220	-	368	245	368
Jones / Oyster Creek	129	368	368	368	368
American Canal Below 2nd Lift Station					
2nd Lift Station to Lateral 10	197	-	-	245	245
Below Lateral 10	97	-	-	245	245

Shannon Pump Station and 2nd Lift Station

For the purposes of this study, we anticipate that the demand associated with the regional water treatment plant will consist of new construction and will not utilize any of the existing pumps. Therefore, the required capacity upgrade at each the Shannon Lift Station will be equal to 176 mgd, the raw surface water demand for the regional water plant plus a 10 percent allowance for seepage and evaporation along the canal route. The improvements to the 2nd Lift Station will be dependant on the location of the proposed water facilities. If the Sugar Land plant site is selected, no improvements to the 2nd Lifts will be required. If the FBWCID No.2 site is selected the required improvement to the pump station will be equal to 161 mgd. If a small 35 mgd water plant is constructed at the Manvel or Alvin site and a 115 mgd water treatment plant is built at the Sugar Land site, the required improvements to the 2nd Lift Station will be equal to the raw water demands of the 35 mgd plant, which is 38 MGD.

Canal Capacity Upgrades- Jones/Oyster Creek

The Jones/Oyster Creek portion of the American Canal is required to convey 368 MGD. To achieve this capacity, improvements are required to increase the existing silted capacity from 129 MGD to 368 MGD. According to the "Water Audit and Water Use Projections" report, the limiting restriction in canal capacity is due to the configuration of the canal at transition between the Jones and Oyster creek sections. The report indicates that this canal section can be easily upsized to handle a flow in excess of 1000 MGD.

Estimates of the required improvements to the canal include retrofitting several siphons, dams, and bridges as well as dredging several sections of canal. It was beyond the scope of this study to detail the specific locations of canal channel improvements, but an allocation for the raw water improvements was including in the cost estimate.

American Canal Capacity Upgrades- Lower Canal

The Lower American Canal System between the 2nd Lift Station and Lateral 10 has a reported limited capacity of 197 MGD. The "Water Audit and Water Use Projections" report identified the limited canal capacity is due to constrictions at check dams, siphons, and road bridges. The report indicates that improvements to these constrictions are feasible and the capacity can be increased to handle the required 245 mgd raw water flow.

If a 35 MGD plant is located at the Alvin site, the raw water canal south of Lateral 10 will be utilized to carry flow to the water treatment facility. The limiting capacity of the American Canal south of Lateral 10 is reported as 97 mgd in the Water Audit and Water Use Projections" report. The report indicates that upgrades to this section should be feasible and the limiting capacity of this section of the American Canal can be raised to handle the increased flow required for the 35 MGD water plant. It was beyond the scope of this study to detail the specific locations of canal channel improvements, but an allocation for the raw water improvements was including in the cost estimate.

Capital Costs

The capital costs associated with constructing the raw water conveyance improvements and finished water delivery system for each water treatment plant were calculated based in the unit costs summarized in **Table 6-10**.

TABLE 6-10
RAW WATER CONVEYANCE IMPROVEMENT AND
FINIHSED WATER DELIVERY UNIT CONSTRUCTION COSTS

Category	Unit Cost	Source
Finished Water Pump Station	$56,000 per MGD	Recent Pump Station Bids
Pipeline – Rural Installation	$4.00 per in-dia/ft	Recent Pipeline Bids
Pipeline – Urban Installation	$5.00 per in-dia/ft	Recent Pipeline Bids
Pipeline Easement	$20,000 per Acre	Recent Easement Acquisitions
2 MG Ground Storage Tank	$750,000	Vendor Estimate
Chlorine Booster Station	$450,000	Vendor Estimate
Raw Water Pump Station Expansion	$10,400 per MGD	Recent Pump Station Bids
Jones Creek Expansion	$430,000	Allocation for Canal Dredging and Dam Improvement
Lower American Canal Expansion: 2nd Lift Station to Lateral 10	$150,000	Allocation for Canal Dredging and Dam Improvement
Lower American Canal Expansion: Lateral 10 to Alvin Site	$210,000	Allocation for Canal Dredging and Dam Improvement

The probable cost for installation increases by $1.00 per inch-diameter-foot for urban installation due to constrictions placed upon construction for increased pavement repair, trenchless installation, utility crossings, traffic control, and limited construction work zones. The price of easements includes fees for the cost of the easement plus additional estimates of legal fees, surveying, and abstracting. The allotment for raw water improvements including an estimate for improving several check dams and dredging portions of the canal. Given these unit costs, the summary of the capital costs for the ancillary water delivery items for each plant site alternative is shown in **Table 6-11**. All costs are reported in year 2000 dollars.

TABLE 6-11
CONSTRUCTION EASTIMATE FOR RAW WATER IMPROVEMENTS AND FINISHED WATER TRANSMISSION SYSTEMS (YR 2000 $)

Construction Item	Plant Site Alternative (1000's of $'s)					
	Sugar Land	FBWCID No.2	Sugar Land / Manvel	Sugar Land / Alvin	FBWCID No. 2 / Manvel	FBWCID No. 2 / Alvin
Finished Water Transmission System						
Pipeline: Rural	$23,800	$25,900	$22,000	$10,500	$22,000	$10,500
Pipeline: Urban	$39,400	$30,100	$34,200	$33,100	$30,300	$29,200
Subtotal of Pipelines	$63,200	$56,000	$56,200	$43,600	$52,300	$39,700
High Service Pump Station	$8,400	$8,400	$8,400	$8,400	$8,400	$8,400
35 MGD Booster PS	$2,000	$2,000	NR	NR	NR	NR
Booster PS GST	$750	$750	NR	NR	NR	NR
Easements	$1,800	$1,800	$760	$640	$760	$640
Chlorine Booster PS	$500	$500	NR	NR	NR	NR
Total	$76,650	$69,450	$65,360	$52,640	$61,460	$48,740
Raw Water Delivery Improvements						
Raw Water Pump Stations	$1,835	$3,670	$2,264	$2,264	$3,670	$3,670
Canals	$430	$2,936	$490	$550	$490	$550
Total	$2,265	$6,606	$2,754	$2,814	$4,160	$4,220
Total Construction Estimate	$78,915	$76,056	$68,114	$55,454	$65,620	$52,960

NR: Not Required

The analysis shows the two plant alternative with a 115 mgd plant at the FBWCID No. 2 plant site and a small 35 mgd plant at the Alvin plant site will have the lowest capital costs. The capital costs of the raw water delivery and finished water pipelines for the one plant scenario are approximately $25 million higher than the two plant scenario.

Operating and Maintenance Costs

Major components of the finished water O&M costs include booster pump station operation, chlorine dosing, and maintenance of the pipeline. All costs are reported in Year 2000 dollars and shown in **Table 6-12**. The following assumptions were made regarding the operation of the finished water transmission system:

- The booster pumps at the raw water lift stations will operate 100 percent of the time at a flow rate equal to the capacity of the regional water plant. The cost of electricity was assumed to be $.06 per KWh
- Maintenance of the finished water pipeline system is equal to .25 percent of the pipeline construction.
- A chlorine residual will be maintained in the transmission system for residual disinfection.
- Water Treatment Plant production of 150 MGD

TABLE 6-12
ANNUAL O&M EASTIMATE FOR RAW WATER IMPROVEMENTS AND FINISHED WATER TRANSMISSION SYSTEMS (YR 2000$)

O&M Item	Plant Site Alternative (1000's of $'s)					
	Sugar Land	FBWCID No.2	Sugar Land / Manvel	Sugar Land / Alvin	FBWCID No. 2 / Manvel	FBWCID No. 2 / Alvin
Finished Water Transmission System						
Pump Station Electricity	$ 3,100	$ 2,800	$ 2,700	$ 2,700	$ 2,800	$ 2,900
Maintenance	$ 200	$ 200	$ 100	$ 100	$ 100	$ 100
Total	$ 3,300	$ 3,000	$ 2,800	$ 2,800	$ 2,900	$ 3,000
Raw Water Delivery Improvements						
Pump Station Electricity	$ 300	$ 600	$ 400	$ 400	$ 600	$ 600
Maintenance	$ 90	$ 130	$ 70	$ 70	$ 130	$ 130
Total	$ 390	$ 730	$ 470	$ 470	$ 730	$ 730
Total Construction Estimate	$ 3,690	$ 3,730	$3,270	$ 3,270	$ 3,630	$ 3,730

Alternative Selection

The participating utilities determined that the selection of the plant location would be based on both the economic costs of the alternatives and non-economic factors involved with each plant site alternative. This selection process is discussed in detail in **Section 7** of this report.

REDUNDANT RAW WATER SUPPLY

In terms of raw water reliability, the American Canal is a single continuous delivery system from the Brazos River to the regional water treatment plant. The reliability of this raw water delivery system is limited if a single point of failure exists. If the Shannon plant or 2nd Lift Station experiences an outage, raw water delivery to the regional water plant would stop and treated water production would be limited to stored water in the American Canal and the water plant forebay.

The GCWA has experienced isolated three week outages at the Shannon plant as a result of lightening strikes. In addition, the GCWA has experienced canal outages of up to a week for repair a ruptured siphon. To continue water delivery customers in the planning area during a temporary raw water outage, the Participating Utilities can either utilize the full capability of their groundwater wells to meet water demand or construct an alternative redundant raw water supply.

As the Participating Utilities have selected to meet peak day and peak hour demands through groundwater wells and storage volumes, this infrastructure will have the capacity to provide a significant portion the average water demand of the customers. During a temporary outage of the water plant, the Participating Utilities can draw on this existing infrastructure to meet the needs of the customers while repairs are made to GCWA raw water delivery system.

The other alternative to increase the reliability of the raw water delivery system and provide time for emergency repairs of the raw water conveyance system without interruption to the regional surface water plants is to construct new infrastructure. The following three alternatives were considered.

- Construct alternate power or fuel driven motors at Shannon and 2nd Lift Station
- Construct new pump station and pipeline from the Brazos River to the American canal
- Construct on-line storage reservoir on the American Canal upstream of the 2nd Lift Station.

The three alternatives are shown on **Figure 6-13** and a discussion of these alternatives is as follows:

Alternative 1 – Backup PS at Shannon and 2nd Lift Station

Backup pumps at the Shannon and 2nd lift station would provide reliability to these raw water pump stations. These pumps would have the ability to either be operated from standard electrical feed or from a gas driven generator. As a result, these backup pumps would be able to maintain pumping during power outages and other emergency situations. The capacity of the backup pump station would match the required raw water demand for the regional water plants, as described above.

Alternative 2 – New Brazos River PS and Raw Water Pipeline

In this alternative, a new pump station on the Brazos River with a raw water pipeline to the Sugar Land or FBWCID No. 2 plant site would be constructed. This pipeline would serve as a backup to the Shannon pump station and would deliver water to the regional water plant in the event that the Shannon plant is out of service for maintenance or repair. A review of the planning area indicates that it is feasible to place a pump station on the Brazos in the vicinity of the Greatwood community and the proposed University Boulevard. The raw water pipeline would then follow University Blvd to the north to Hwy 90 and then continue north along SH 6 to Oyster Creek. The approximate length of pipeline to connect the pump station and Oyster Creek is 7.5 miles. The route utilizes the University Blvd corridor to take advantage of the uncongested public right-of-way surrounding the new road.

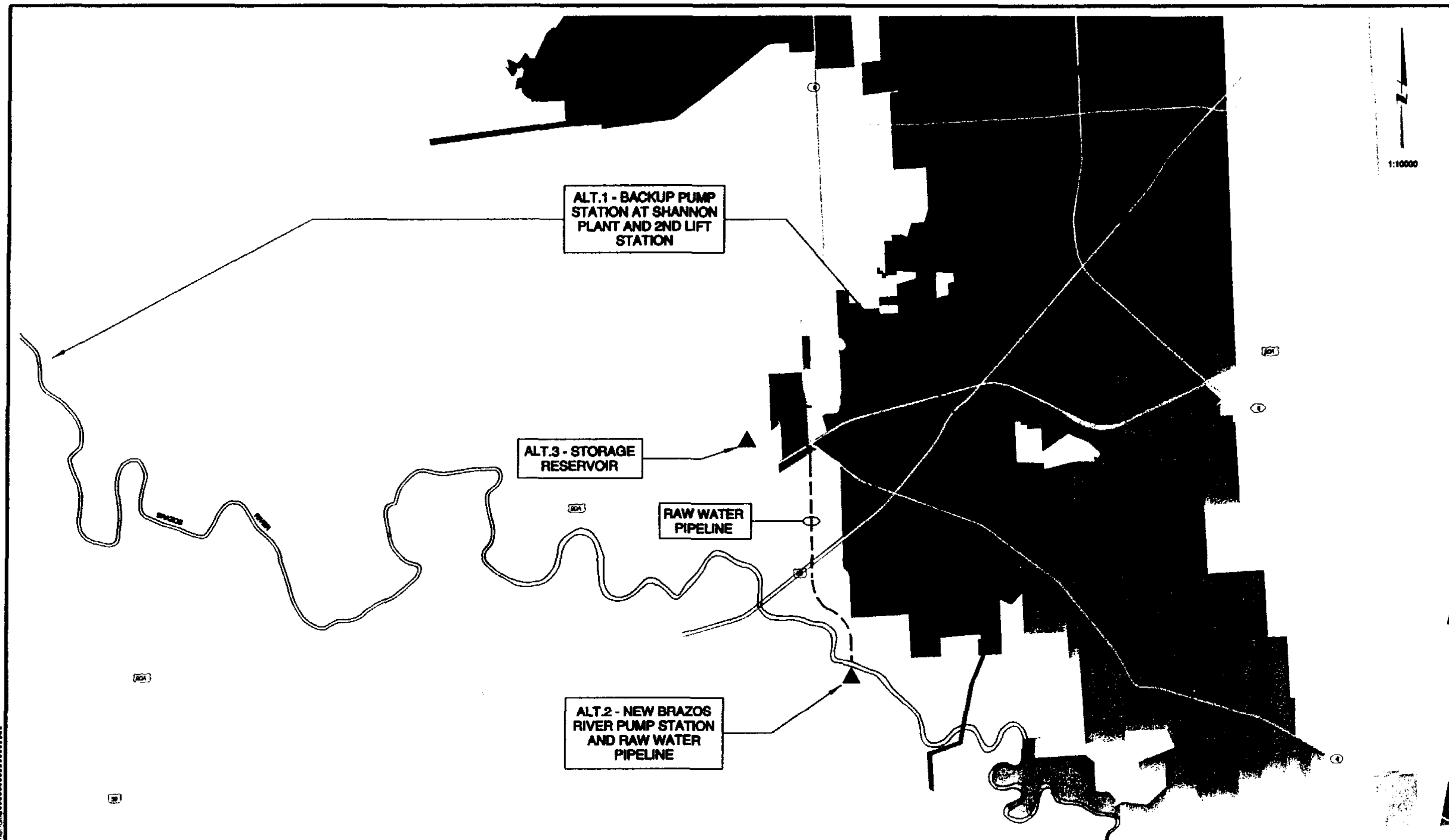
Alternative 3 – Storage Reservoir

The third alternative is to construct a storage reservoir near the intake for the Sugar Land or FBWCID No. 2 plant. This storage reservoir would provide terminal storage that could be used in the event that the Shannon Pump Station or Upper American Canal are out of service. The size of the storage reservoir depends on the desired storage at the plant. The required land area for the reservoir in relation to the storage are shown in **Table 6-13**. The listed size assumes an average water depth in the reservoir of 15 feet.

TABLE 6-13
STORAGE RESERVOIR SIZE

Day Storage	Land Required (Acre) @ 75 MGD	Land Required (Acre) @ 150 MGD
7	112	215
14	215	430
21	322	645
28	430	860

Land in the Sugar Land area is generally developed and large open tract of unimproved land is expensive. The Texas Department of Transportation is actively marketing a piece of property known as Tract 2, which is adjacent to Oyster Creek and the Midway Central Correctional Facilities. The property



GCWA / TWBD FACILITY PLAN

BACKUP RAW WATER SUPPLY ALTERNATIVES

FIGURE 6–13

MONTGOMERY WATSON

encompasses 312 acres. This property is within 2 miles of the Sugar Land site and could serve as a good location for a small 14 day storage reservoir at a discharge rate of 75 MGD.

Alternative Benefits and Costs

The costs for the three redundant water source alternatives were developed based in the cost assumption presented in **Table 6-14**.

TABLE 6-14
UNIT COSTS FOR REDUNDANT RAW WATER SOURCE CONSTRUCTION

Category	Unit Cost	Source
Raw Water Pump Station Expansion	$10,400 per MGD	Recent Pump Station Bids
Raw Water Pipeline Through Urban Area	$5.00 per in-dia-foot	Recent Pipeline Bids
Land Acquisition	$20,000 per acre	Fort Bend Appraisal District
Reservoir Construction	$0.34 per CY	1999 Means Construction Estimating

The estimated raw construction costs for the backup pump station at the Shannon Pump Station and 2nd Lift Station depend on the selected plant alternative and are presented in terms of the selected plant alternative. Given these cost basis numbers, the resulting capital costs to constuct the redundant raw water source improvements are noted in **Table 6-15.**

TABLE 6-15
REDUNDANT RAW WATER ALTERNATIVE CONSTRUCTION COSTS

Alternative	Unit Cost	Estimated Construction Cost (YR 2000$)
Backup Pump Station at Shannon and 2nd Lift Station		
150 MGD Plant - Sugar Land	$10,393 per MGD	$ 1,835,000
150 MGD Plant - FBWCID No. 2	$10,393 per MGD	$ 3,670,000
115 MGD Plant - Sugar Land, 35 MGD Plant - Manvel or Alvin	$10,393 per MGD	$ 2,264,000
115 MGD Plant - FBWCID No. 2, 35 MGD Plant - Manvel or Alvin	$10,393 per MGD	$ 3,670,000
New Brazos River Pump Station and Raw Water Pipeline	Pump Station: $10,393 per MGD Pipeline: $5.00 per in-dia-ft	$ 13,840,000
14-day Storage Reservoir	$0.34 per CY	$ 9,130,000

The analysis shows that a alternatives for constructing a new Brazos River Pump Station or a terminal storage reservoir are 3 to 4 times as expensive than redundant pumps at the existing Shannon and 2nd Lift Station. A summary of the overall benefits and non-economic costs of each of the redundant raw water alternatives are shown in **Table 6-16**.

TABLE 6-16
BENEFITS AND COSTS OF SECONDARY RAW WATER ALTERNATIVES

Alternative	Benefits	Disadvantages
Use Existing Groundwater Wells	• No new facilities or additional required	• Increases annual groundwater pumpage and exceed maximum annual groundwater pumpage threshold set by the Subsidence Districts
Backup Pumps at Shannon and 2nd Lift Station	• Increases Reliability of Pump Stations to Deliver Raw Water During Power Outages, Pump Maintenance, and Pump Failures • No new separate facilities required	• No Protection Against Failure of Raw Water Canal
New Brazos River Pump Station and Raw Water Pipeline	• Increases Reliability of Pump Stations to Deliver Raw Water During Power Outages, Pump Maintenance, and Pump Failure • Protects Against Upper American Canal Failure	• Economics of new backup pump station
Storage Reservoir	• Downstream storage provide for 14 day outage of Upper American Canal or Shannon Pump Station • Allows for Maintenance of Canal Without Interruption of Raw Water Flow	• No Protection against 2nd Lift Station Outage • Land Cost

Raw Water Redundancy Recommendation

Based on the benefits and costs of each redundant raw water supply alternative, it is recommended that the Participating Utilities rely on their existing groundwater infrastructure to provide potable water to their customers during a temporary outage at the water plant. This will maximize the use of the Participating Utilities existing infrastructure and minimizes capital expenditures for a redundant system that will only operate during infrequent emergencies.

Development of the facility plan requires selecting a preferred water treatment technology and selecting the location of the regional surface water plant and associated treated water transmission system. The previous sections have identified and evaluated the various alternatives for treating Brazos River water and delivering this treated water to the Participating Utilities. This section serves to compare the alternatives and makes facility recommendations. Comparison of these alternatives will be based on the overall project cost, after careful consideration of non-economic factors.

ALTERNATIVE SELECTION PROCESS

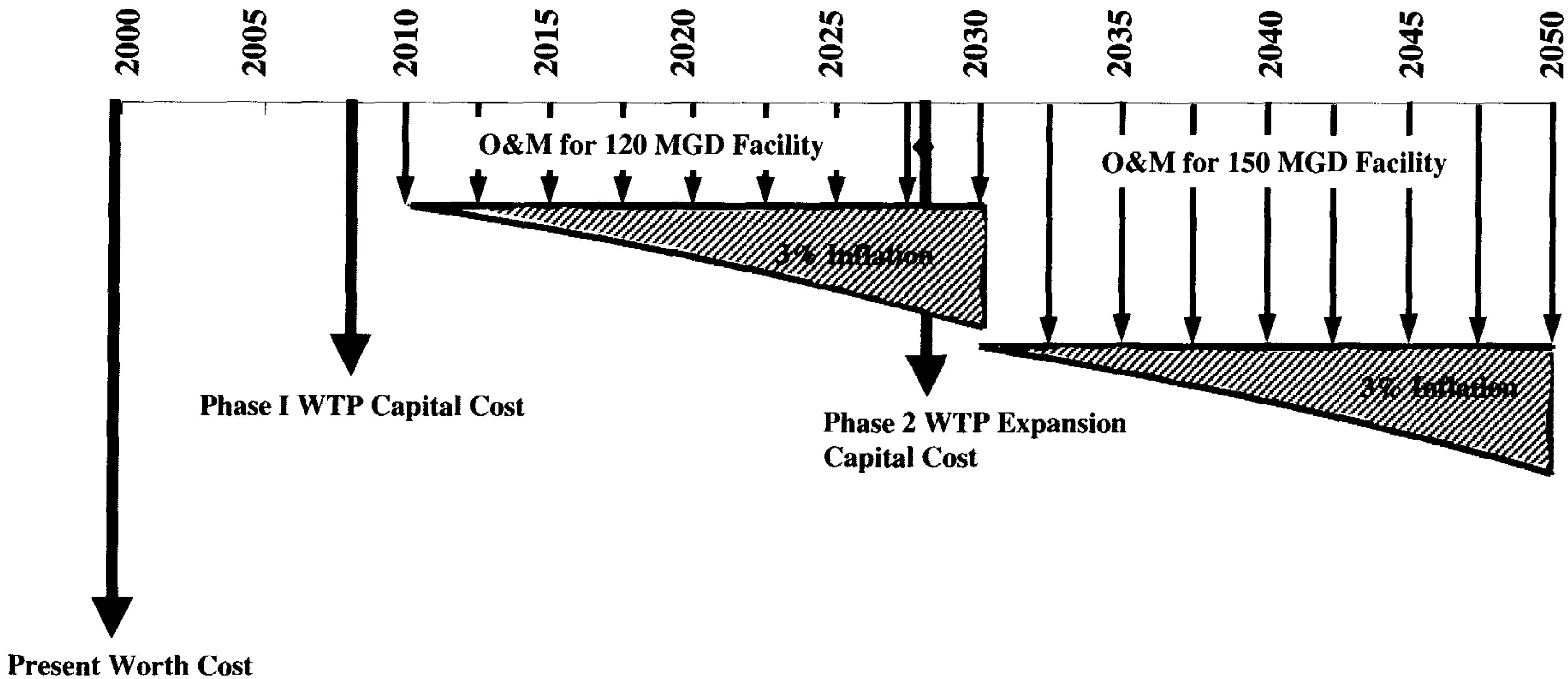
The process for selecting the recommended facility plan includes the development of the lifecycle project costs and the non-economic project impacting each water plant alternative. As these impacts and costs are determined, the alternatives can be compared. Selection of the recommended facility plan will be based on alternatives that offers the greatest flexibility in design, permitting, operations, and public acceptance at the lowest overall project cost. This section is divided into a discussion of the comparison methodology, the project costs of each alternative, and the non-economic impacts of each alternative and culminates in recommended facilities. A discussion of both of the selection criteria follows.

Facility Plan Cost Assumptions and Economic Analysis Methodology

Each alternative has a dollar amount associated with the capital construction of the infrastructure and the operating and maintenance of the facilities. In order to compare these costs, the timing of the expenditures must be considered in the analysis. To account for this time value of money, a present worth analysis will be conducted. The present worth analysis calculates the required investment in the year 2000 to fund the entire project, including capital expenditures and annual operating and maintenance, over the life span of the project.

A synopsis of the analysis is as follows. All economic costs were calculated in terms of year 2000 dollars and then adjusted by the inflation rate to the year that they would be incurred. The timeline of expenditures is shown in **Figure 7-1**. Once these costs are plotted in time, the amount of money required to be invested today to fund each year's capital or O&M cost based on an annual interest rate is calculated. This is known as the present worth of the project and can used to compare all of the alternatives. The following assumptions were used in this analysis:

1) Water treatment plant will begin operation in the year 2010.
2) Plant capacity will be constructed in two phases.
   a) The first construction period will commence in the year 2006 with completion in the year 2010. The first phase of construction will consist of:
      i) 120 MGD water treatment plant
      ii) Raw water improvements to handle 120 MGD flow for new WTP
      iii) All finished water infrastructure with capacity for 150 MGD
   b) The second phase will commence in the year 2026 with completion of a 30 MGD water treatment plant expansion by the year 2030. The raw water pump stations will also be expanded at this time to meet the increased demand.
3) Annual Inflation Rate = 3 Percent
4) Annual Interest Rate = 6 Percent
5) Water Treatment Plant Annual Production
   a) Year 2010-2030 – 120 MGD
   b) Year 2030-2050 – 150 MGD



Present Worth Analysis Timeline

Figure 7-1

The costs included in this analysis fall into two major categories: Capital costs to construct the infrastructure and operating and maintenance costs to produce and deliver treated water to the Participating Utilities. A discussion of each of these costs follows.

Capital Costs

Capital costs contain three distinct categories: Construction, Engineering, and Contingency. Construction represents the costs associated with the materials and labor to build the facilities. Engineering is costs associated with the design, bid, and oversight of the construction process. Contingency is a factor of safety of the unknown costs and is applied to both the construction and the engineering costs.

Construction

The capital costs include an estimate of the construction costs for a new water treatment plant and distribution system, including but not limited to equipment, land acquisition, site work, concrete, electrical, pipelines, booster stations, contractors overhead and profit, and easements. The costs were compiled from recent projects of similar size and scope. For the purposes of this study, capital costs are assumed to occur at the midpoint of construction.

Engineering

The cost for engineering and construction administration includes the fee for designing, bidding, and administering the construction contract from the conceptual stage to final acceptance of the work. The engineering costs for this project is estimated at fifteen percent of the construction cost and construction administration cost is assumed to be six percent of the construction costs. GCWA administration costs during this phase are estimated at three percent of construction cost.

Contingency

Any construction project can have certain unpredictable expenses, including both minor and major changes in preliminary and final design, estimating deviations, rapid price changes in equipment, labor shortages and strikes. To cover the costs of these unpredictable expenses, an allowance for various contingencies is included to reduce project risk. The contingency will vary according to the type of project, complexity of design, and geographical location. This allowance can be reduced as the design progresses from concept through final construction documents, but some contingency must remain throughout the life of the project as a reserve for events that experience shows will likely occur. Contingency is applied to total construction cost which includes the construction estimate with engineering and construction administration included.

Three types of contingency are included in this job: Engineering Estimating, Cost Estimating, and Construction Bidding and Change Order. The contingency for cost estimating covers the unknown project components and fluctuations in the equipment and labor rates and at this early stage is approximated at twenty percent of the construction cost. At this preliminary stage, it should be recognized that the engineering is not based on detailed information and some level of contingency is needed to cover additional costs as the design evolves in detail. For the purposes of this study, a ten percent engineering estimating contingency will be used. Both the engineering estimating and cost estimating contingency should be reduced as the design progresses from conceptual to final. The last contingency component represents change orders during construction and bidding. The contingency will remain with the project until final acceptance of work and is estimated at 5 percent of the construction cost.

Operating and Maintenance Costs

The operating and maintenance costs for the facility include the costs associated with producing and delivering the water demand to the Participating Utilities. Operation and maintenance costs include, but not limited to the following items:

- Electricity,
- Maintenance,
- Water treatment chemicals,
- Labor,
- Sludge disposal, and
- Administration

Water Treatment Plant Process Alternative Analysis

Since each treatment process is capable of meeting the established finished water quality and is adaptable to future changes in water quality regulations, economic costs will determine the recommended water treatment plant process.

The selection of the treatment plant process was based on the relative present worth investment required to construct and operate a regional water treatment plant with an ultimate capacity of 150 MGD. The cost assumes water production equal to capacity. Detailed breakdowns of the construction cost estimates for each of the conventional process, high-rate conventional process, and membrane can be found in **Section 4**.

A summary of the construction and O&M costs for a 2-phased 150 MGD water treatment plant for each treatment alternatives appears in **Figures 7-2 and Figure 7-3**.

FIGURE 7-2
PROBABLE CONSTRUCTION COSTS OF 2-PHASED
150 MGD WTP (YR 2000$)

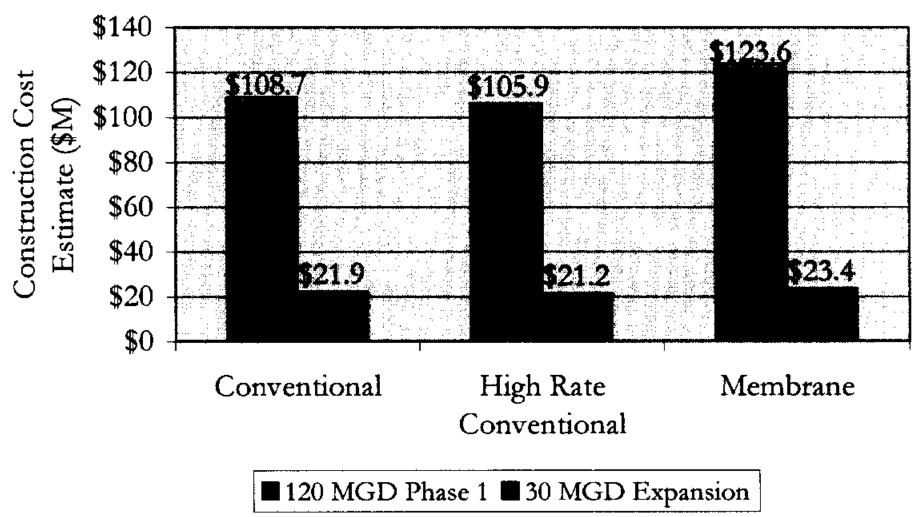
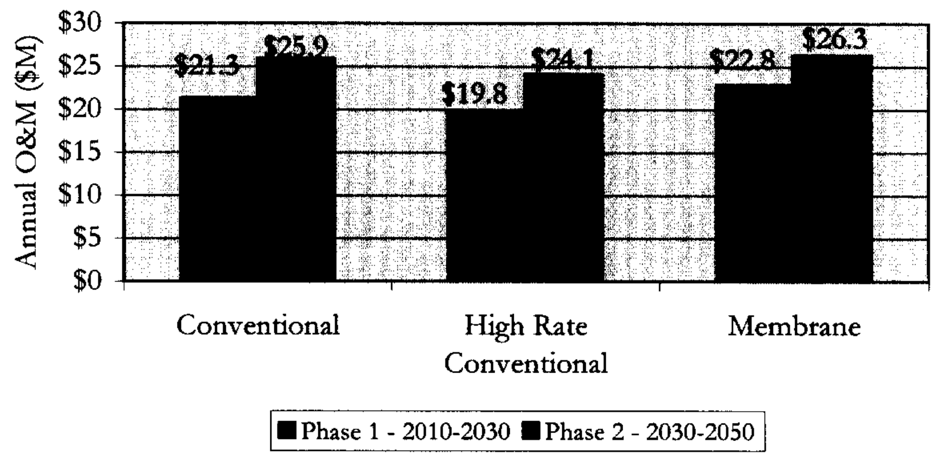


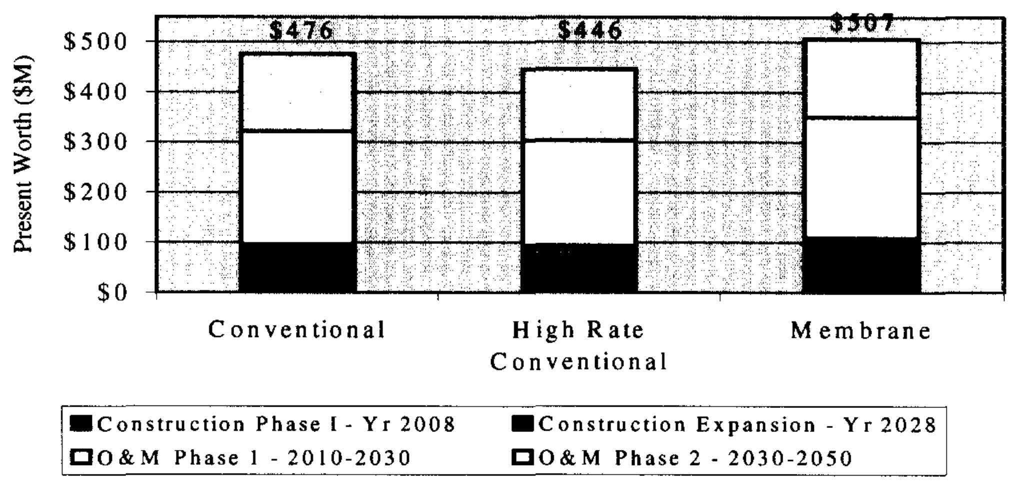
FIGURE 7-3
PROBABLE ANNUAL O&M COSTS (YR 2000$)



The high rate conventional plant has the lowest estimated construction cost of $127 M, which equates to $0.85 cents per gallon of capacity. The high-rate conventional O&M costs are also the least expensive at $19.8M per annum over the first twenty years of operation with an increase to $24.1M per annum for the last twenty years of operation. These O&M costs exclude high service pumping and raw water delivery costs which are a function of plant location and will be considered in the site location study. Construction contingency and engineering fees are not included in these calculations since they are percentages of construction and do not impact the process selection.

To find the overall project costs for each treatment alternative, a present worth analysis was conducted to find the required investment of Year 2000 dollars to fund the construction and operation of the plant from project startup through forty years of operation. The results of the present worth analysis are shown in **Figure 7-4**. The analysis indicates that the least expensive process alternative is the high-rate conventional treatment process.

FIGURE 7-4
TREATMENT PROCESS ALTERNATIVE PRESENT WORTH (YR 2000 $)



As the high-rate conventional process is the least expensive process alternative and is easily adaptable to changes in regulations, this process is recommended as the preferred regional water plant treatment process.

WATER TREATMENT PLANT SITE ALTERNATIVE ANALYSIS

In the previous chapters, alternatives for the water treatment process and treatment plant locations were developed. This alternative analysis will focus on the six plant site alternatives discussed in **Section 5**. A summary of these alternatives is:

- 150 MGD WTP at the Sugar Land Site
- 150 MGD WTP at the FBWCID No.2 Site
- 115 MGD WTP at the Sugar Land Site, 35 MGD WTP at Manvel Site
- 115 MGD WTP at the Sugar Land Site, 35 MGD WTP at Alvin Site
- 115 MGD WTP at FBWCID No.2 Site, 35 MGD WTP at Manvel Site
- 115 MGD WTP at FBWCID No.2 Site, 35 MGD WTP at Alvin Site

For each of these alternatives, the non-economic impacts for each plant site and the economic costs of the construction and operating of the water treatment plant facilities, finished water transmission, and raw water delivery system were developed. These factors were the reviewed and the low-cost alternative that maximizes flexibility in design and plant operations while minimizing impacts to the surrounding community was selected as the recommended facility plan.

Non-Economic Factors

The project impacts not included as costs are termed as non-economic factors. These impacts are often difficult to quantify in terms of dollars and lend themselves to a more subjective analysis. The methodology for the non-economic criteria evaluation for the redundant raw water alternatives and the water treatment process alternatives is general discussion of the pros and cons of each alternative.

The methodology for the non-economic factor evaluation for the plant site alternatives is a more complex matrix approach involving distinct criteria and a scoring system. The Participating Utility Team met on June 8, 2000 to discuss the non-economic factors involved in site selection and developed the following list of criteria. Each criterion appears with a general description of the items included in each category.

Public Acceptance:	Aesthetics of water plant Community position Loss of pastures and agricultural land Impact on adjacent land Future land use
Expandability:	Future capacity expansion past year 2050 Adaptability for future treatment requirements
Reliability:	On-site storage capacity Secondary raw water source
Environmental Impacts:	Noise Traffic Wetlands
Permitting:	Regulatory approval Relationship with current land owner

The methodology for evaluating these non-economic factors was first, to establish a relative weight of each of these criteria against one another and second, to score each potential plant site against the criteria. After this was complete, an aggregate score of the sum of the criterion weight times the plant site score was developed. In this manner, subjective factors could be graded and ranked for each alternative.

The Participating Utility Team decided to weight each of these five criteria based on the importance of the criteria to the project. The criteria with the highest grade was given a weight of five, the next highest a four, and so on until the lowest important criteria was assigned a weight of one.

The weights assigned by the Participating Utilities to each of the five criteria are shown in **Table 7-1**.

TABLE 7-1
NON-ECONOMIC CRITERIA WEIGHTS

Criteria	Rank
Public Acceptance	2
Expandability	3
Reliability / Raw Water	5
Environmental Impacts	1
Permitting	4

Once the weights were established, each alternative was compared against the criteria and given a favorable, neutral, or unfavorable ranking. A favorable ranking was given a score of 1, neutral a score of 0 and an unfavorable ranking was assigned a -1. A total score for each alternative was then obtained by multiplying the weight of the factor times the "ranking" for each alternative and summing the total for

Permitting

All sites will require similar permits and the Participating Utility Team felt that the required permits can be obtained at any site. One known permitting issue with the Sugar Land site is the potential role of the Federal Aviation Administration. The Sugar Land site lies within a five-mile radius of the Sugar Land Airport and may require a permit from the FAA for construction.

The State of Texas reviewed each of the potential water treatment sites and indicated that a detailed archaeological report will have to be submitted to the State. Due to these issues, all sites were graded as neutral.

Summary

Given these discussions, the rankings were entered into the site selection matrix and the total non-economic score for each site alternative was determined. Each alternative's criteria ranking, criteria weight, and overall score are shown in **Table 7-2**. The Sugar Land and FBWCID No. 2 sites tied with an aggregate score of 0.2. The Participating Utilities felt that there was no discernable difference between these sites and that siting the plant at the Sugar Land or FBWCID No.2 site would have the same impact on the community. The analysis indicated that the Manvel site outscored the Alvin site and was the preferred site for a small water treatment plant based on non-economic factors.

TABLE 7-2
NON-ECONOMIC SITE SELECTION MATRIX

			Demand Area A Plant Site		Demand Area B Plant Site	
Criteria	Rank	Weight	Sugar Land	FBWCID No. 2	Manvel	Alvin
Public Acceptance	2	13%	0	1	0	0
Expandability	3	20%	1	0	0	1
Reliability / Raw Water	5	33%	0	0	1	0
Environmental Impacts	1	7%	0	1	0	1
Permitting	4	27%	0	0	0	0
Total Score		100%	0.20	0.20	0.33	0.27

Alternative Water Plant Scenario Costs

To identify the economic cost of each water plant scenario, the construction, operation and maintenance costs of the raw water conveyance system improvements, water treatment facilities, and finished water transmission system for each alternative must be summarized. A present worth analysis was used to relate all of these costs to evaluate the comparative costs of these different alternative.

For the 150 MGD Plant alternative at either the Sugar Land or FBWCID No.2 site, the cost of the water plant will be based on an initial 120 MGD construction in the year 2010 and then a 30 MGD expansion in the year 2030. For the two plant alternatives, the cost of the water plants will be based on constructing two plants. The proposed capacity of the plant will be phased as follows. For the purposes of the cost estimate, capital costs will be assumed to be incurred at the midpoint of construction, which is approximately two years before the following dates:

Year 2010 - 95 MGD plant at the Sugar Land or FBWCID No. 2 site
- 24 MGD plant at the Manvel or Alvin Site

Year 2010 - 20 MGD expansion of the Sugar Land or FBWCID No. 2 plant
- 11 MGD expansion of the Manvel or Alvin plant

Raw Water Conveyance Improvements

In **Section 6** of this report, the raw water improvements for each plant site alternative were identified and the construction and annual operation and maintenance costs were estimated. The raw water improvements will be phased to match the capacity of the water plant and the construction and annual operating costs for a 2-phased construction program are shown in **Table 7-3**.

TABLE 7-3
RAW WATER IMPROVEMENT CONSTRUCTION AND O&M COSTS (YR 2000 $)

Construction Item	Plant Site Alternative					
	Sugar Land	FBWCID No.2	Sugar Land / Manvel	Sugar Land / Alvin	FBWCID No. 2 / Manvel	FBWCID No. 2 / Alvin
Phase 1 Raw Water Conveyance Improvements						
Raw Water Pump Stations	$1,470,000	$2,940,000	$1,760,000	$1,760,000	$2,940,000	$2,940,000
Canals	$430,000	$550,000	$490,000	$550,000	$490,000	$550,000
Total	$1,900,000	$3,490,000	$2,250,000	$2,310,000	$3,430,000	$3,490,000
Annual Operating Cost: Year 2010-2030	$300,000	$560,000	$360,000	$360,000	$560,000	$560,000
Phase 2 Raw Water Conveyance Improvements						
Raw Water Pump Stations	$370,000	$740,000	$500,000	$500,000	$740,000	$740,000
Annual Operating Cost: Year 2030-2050	$370,000	$690,000	$440,000	$440,000	$690,000	$690,000

Finished Water Transmission

In **Section 6** of this report, the finished water transmission system for each water plant alternative was developed. The costs for each component were identified and a summary of these costs is shown in **Table 7-4.** The finished water pipelines will be constructed entirely in Phase 1 to minimize the expense of the overall cost of the transmission program.

TABLE 7-4
FINISHED WATER CONSTRUCTION AND O&M COSTS (YR 2000 $)

Construction Item	Plant Site Alternative					
	Sugar Land	FBWCID No.2	Sugar Land / Manvel	Sugar Land / Alvin	FBWCID No. 2 / Manvel	FBWCID No. 2 / Alvin
Phase 1 Finished Water Transmission System						
High Service Pump Stations	$6,720,000	$6,720,000	$6,720,000	$6,720,000	$6,720,000	$6,720,000
Pipeline Network	$68,250,000	$61,050,000	$56,960,000	$44,240,000	$53,060,000	$40,340,000
Total	$74,970,000	$67,770,000	$63,680,000	$50,960,000	$59,780,000	$47,060,000
Annual Operating Cost: Year 2010-2030	$2,590,000	$2,370,000	$2,740,000	$2,710,000	$2,930,000	$2,900,000
Phase 2 Finished Water Transmission System						
High Service Pump Stations	$1,680,000	$1,680,000	$1,680,000	$1,680,000	$1,680,000	$1,680,000
Annual Operating Cost: Year 2030-2050	$3,300,000	$2,980,000	$2,840,000	$2,810,000	$2,930,000	$3,000,000

Water Treatment Plant Cost

The water treatment plant costs will be based on the capacity of the plant and will be based on a high-rate conventional process. The construction and O&M costs to construct and operate a high-rate conventional plants can be found in the **Appendix E** and are summarized in **Table 7-5**.

TABLE 7-5
WATER TREATMENT PLANT CONSTRUCTION AND O&M COSTS (YR 2000 $)

Ultimate Capacity	Capital		Annual O&M	
	Phase I Year 208	Phase II Year 2028	Phase I: 2010-2030	Phase II: 2030-2050
150 MGD	$105,920,000	$21,240,000	$19,800,000	$24,080,000
115 MGD	$88,810,000	$15,960,000	$15,870,000	$18,890,000
35 MGD	$34,470,000	$11,360,000	$5,160,000	$6,960,000

In addition to the cost of the water treatment plant cost, each alternative plant site has unique costs related to the land acquisition costs, and other facilities which must be improved to make the plant site suitable for a regional water plant.

Land

Each plant site has a cost to acquiring the required land for the water treatment plant site. The unit price of the land varies from site to site. Conversations were held with the landowners of each potential water treatment site to determine if the property could be subdivided or if the property was for sale. The unit price of the property and the minimum acreage that would have to be purchased are shown in **Table 7-6**.

TABLE 7-6
SITE ACQUISITION COSTS

Site	Acreage	Cost Per Acre	Land Cost
Sugar Land Site	225	$ 15,000	$3,400,000
FBWCID No. 2	79	$ 9,500	$ 750,000
Manvel	54	$ 13,000	$ 700,000
Alvin	60	$ 10,000	$ 600,000

Other Economic Consideration

Additional site work is anticipated at several of the sites to counteract unfavorable site conditions. These conditions include soil bearing strength, wetlands, and flooding. To prepare the site for a regional water plant, additional capital must be spent to construct facilities that mitigate the risk of flooding, relocate wetlands, or add structural support. A list of these additional costs are:

- Sugar Land Site – additional structural support due to loamy sandy soils. Probable Cost: five percent of construction.
- Manvel Site – Establishment of flood protection levee. Probable Construction Cost: $60,000.
- Alvin Site – Road Replacement from State Highway 35 to WTP to handle H-20 loads. Probable Construction Cost: $480,000.

Cost Summary

The capital and O&M costs for the raw water delivery, finished pipeline, and plant structure construction packages for each alternative, including contingency and engineering are summarized in the **Appendix F**. A summary of the capital and O&M costs for each alternative are shown in **Tables 7-7 and 7-8.**

TABLE 7-7
CAPITAL EXPENDITURE (YR 2000 $)

Alternative	Phase I Year 2008	Phase II Year 2028
Sugar Land	$ 317,290,000	$ 40,970,000
FBWCID No. 2	$ 294,660,000	$ 39,830,000
Sugar Land / Manvel	$ 331,250,000	$ 51,250,000
Sugar Land /Alvin	$ 310,750,000	$ 48,980,000
FBWCID No. 2 / Manvel	$ 312,190,000	$ 49,380,000
FBWCID No. 2 / Alvin	$ 291,730,000	$ 49,380,000

TABLE 7-8
ANNUAL O&M ($ PER YR, YR 2000 $)

Alternative	Phase 1 2010-2030		Phase II 2030-2050
Sugar Land	$	22,690,000	$ 27,750,000
FBWCID No. 2	$	22,730,000	$ 27,750,000
Sugar Land/Manvel	$	24,130,000	$ 29,130,000
Sugar Land/Alvin	$	24,100,000	$ 29,100,000
FBWCID No. 2/Manvel	$	24,520,000	$ 29,470,000
FBWCID No. 2/Alvin	$	24,490,000	$ 29,540,000

Present Worth

Given the economic assumptions and the construction and operating and maintenance costs provided above, each alternative was subject to a present worth analysis. The results of the present worth analysis are shown in the **Table 7-9**. The alternative with the lowest present worth cost is the 150 MGD plant at the FBWCID No. 2 site. This site benefits from lower pumping requirements and a smaller finished water pipeline system.

TABLE 7-9
PLANT SITE ALTERNATIVES PRESENT WORTH SUMMARY

Alternative	Present Worth Cost ($M)
150 MGD Plant at FBWCID No.2 Site	$658
150 MGD Plant at Sugar Land Site	$676
115 MGD Plant at FBWCID No. 2 Site and 35 MGD Plant at Alvin Site	$689
115 MGD Plant at Sugar Land Site and 35 MGD Plant at Alvin Site	$697
115 MGD Plant at FBWCID No. 2 Site and 35 MGD Plant at Manvel Site	$705
115 MGD Plant at Sugar Land Site and 35 MGD Plant at Manvel Site	$715

RECOMMENDATIONS OF WATER PLANT FACILITY LOCATION

The present worth cost of the alternatives including contingency and engineering ranged from the $658M to $715M. The present worth analysis indicates that a two plant scenario is not as cost effective as a one plant scenario and as such, it is recommended that the facility plan be developed around one 150 MGD plant serving the entire planning area.

For the one plant alternatives, the present worth analysis shows that the overall project costs do not vary significantly from one site to the other and the non-economic analysis indicated that there is no significant savings to placing the water plant at one location over the other. The difference in probable present worth cost between the FBWCID No.2 site and the Sugar Land site is within the contingency of the cost estimate. Based on the results of this study, the following recommendations are made:

- Construct a 150 MGD high-rate conventional process surface water treatment plant at the FBWCID No.2 site to serve the residents of Harris, Brazoria, and Fort Bend Counties with treated surface water. This alternative has the apparent low present worth cost and is has the fewest anticipated construction issues. This alternative also allows the project work to begin as the site is owned by FBWCID No.2 and has been designated as a future water treatment plant site. The facility plan for implementing the regional treatment plant is developed in **Section 8**.

- Begin easement acquisition, permitting, preliminary planning and engineering for water plant site, and transmission main alignments.
- Consider purchasing an option for Sugar Land so that the land remains available for a regional water treatment plant in case unforeseen constraints hamper development of the FBWCID No. 2 site.

A plan to construct, operate, and maintain the facilities to provide potable water for the nine Participating Utilities will be based on the recommendations from the alternative analysis. The recommendations were to construct a high rate conventional water treatment plant at the FBWCID No. 2 plant site with an initial capacity of 120 mgd and an ultimate capacity of 150 mgd. This plant and facilities would serve the growing water demands of the Participating Utilities through the year 2050, given the following regional operating strategy.

REGIONAL OPERATING STRATEGY

The demand projections are based on utilizing the surface water plant to provide an annual average of 80 percent of the regionally water demand with groundwater production providing 20 percent of the average demand. The water treatment plant capacity is sized to serve 80 percent of the Participating Utilities average annual demand. The Participating Utilities will provide the infrastructure to meet all demand beyond the 80 percent level, including all peak day and peak hour demands. These demands will be met through groundwater production and storage facilities. During low water demands, it is anticipated that water from the surface water plant will likely meet the regional water demands and groundwater wells may not be required during this time period. Over an entire year, the production at the plant would equate to 80 percent of the demand for the Participating Utilities.

Gulf Coast Water Authority (GCWA) will construct, operate, and maintain facilities necessary to provide a contracted amount of flow to the Participating Utilities defined take points. The GCWA will have ownership of all facilities on the upstream side of the take point including flow metering facilities. Payment for the treated water will be based on contracts between the Participating Utility and the GCWA and will likely have a fixed capital recovery portion and a variable portion based upon each utilities water usage.

CAPITAL IMPROVEMENT PROGRAM

The recommended capital improvement programs to design, construct, and operate a regional water treatment plant and associated transmission facilities will utilize phased construction to match expected surface water demand. As surface water demand is tied to the HGSCD and FBSD DRP, construction of the water plant and ancillary facilities should be timed to meet the requirements of these subsidence plans. As the FBSD promulgates rules, the timing of the need for the regional water plant should be reviewed and the construction timeline adjusted to mimic the subsidence regulations for the planning area. This plan assumes that the surface water conversion will be required for the planning area by the year 2010 and by the year 2030, the maximum groundwater withdrawal will be limited to 20 percent of overall water demand.

The first phase will involve engineering and construction for a 120 mgd high-rate conventional water plant and the associated water transmission network. This will meet the projected surface water demand through the year 2030. It is recommended that the entire finished water transmission network be constructed during this phase to minimize future expansion and cost. The design and construction for this phase will require approximately four to five years.

The second phase of the project would expand the treatment plant capacity from 120 mgd to 150 mgd. According to the Participating Utility water demand projections, expansion will be required by the year 2030 to meet expected water demand. The construction for the expansion will require to approximately two years.

MONTGOMERY WATSON

GCWA / TWBD FACILITY PLAN

150 MGD CONVENTIONAL WTP
LAYOUT AT FBWCID No. 2 SITE

FIGURE 8-1

FACILITIES DESCRIPTION

The facilities to be constructed fall in to three distinct construction packages: water treatment plant, raw water delivery system, and finished water transmission. Each package will be discussed in detail.

Water Treatment Plant

The water treatment plant will be located at the FBWCID No. 2 site and will encompass approximately 80 acres. **Figure 8-1** shows the plant site. It is expected that Lexington Road will be extended west of Murphy Road and this new road will be primary access to the site. The site will be fenced and access monitored through a front gate. The site will have a one-day storage reservoir, process equipment and administration and maintenance facilities. The process design will utilize a high-rate conventional process with pulsed upflow clarifiers and deep bed, dual media filters. The process flow diagram for the plant is shown on **Figure 8-2**.

Water will be drawn from the American Canal downstream of the 2nd Lift Station through a vertical turbine pump station and stored in a 15 foot deep forebay. Water will then be pumped out of the storage reservoir using vertical turbine pumps to the pulsed-upflow clarifiers after injection of coagulation chemicals. The clarifier effluent will flow through dual media filters containing granular activated carbon. Provisions are made in the site layout for the addition of a future disinfection contact chamber, as future regulations require stricter finished water quality. From the filters, chemicals will be added to control corrosion and provide residual disinfection in the transmission lines and the finished water will be stored in ground storage tanks. High service pumps will then distribute finished water to the take points through the potable water transmission pipelines. Seven high service pumps will be dedicated to provide 150 mgd to the Participating Utilities in Demand Area A and Demand Area B. The pumps at the water treatment plant will operate at approximately 74 psi.

Sludge will be treated by gravity thickeners and centrifuges to increase the solids content of the sludge. The sludge will then be transported off site for ultimate disposal. Design criteria and preliminary sizing of the major process equipment is shown in **Appendix G.** A proposed layout of the major process trains and ancillary facilities are shown on **Figure 8-3**. Facilities shown with dashed lines are future processes and will be built as part of the expansion in the year 2030 or as future regulations require. The layout was designed to maximize common wall construction and to allow for flexibility for additional processes to meet future changes in treatment regulations.

Raw Water Delivery System

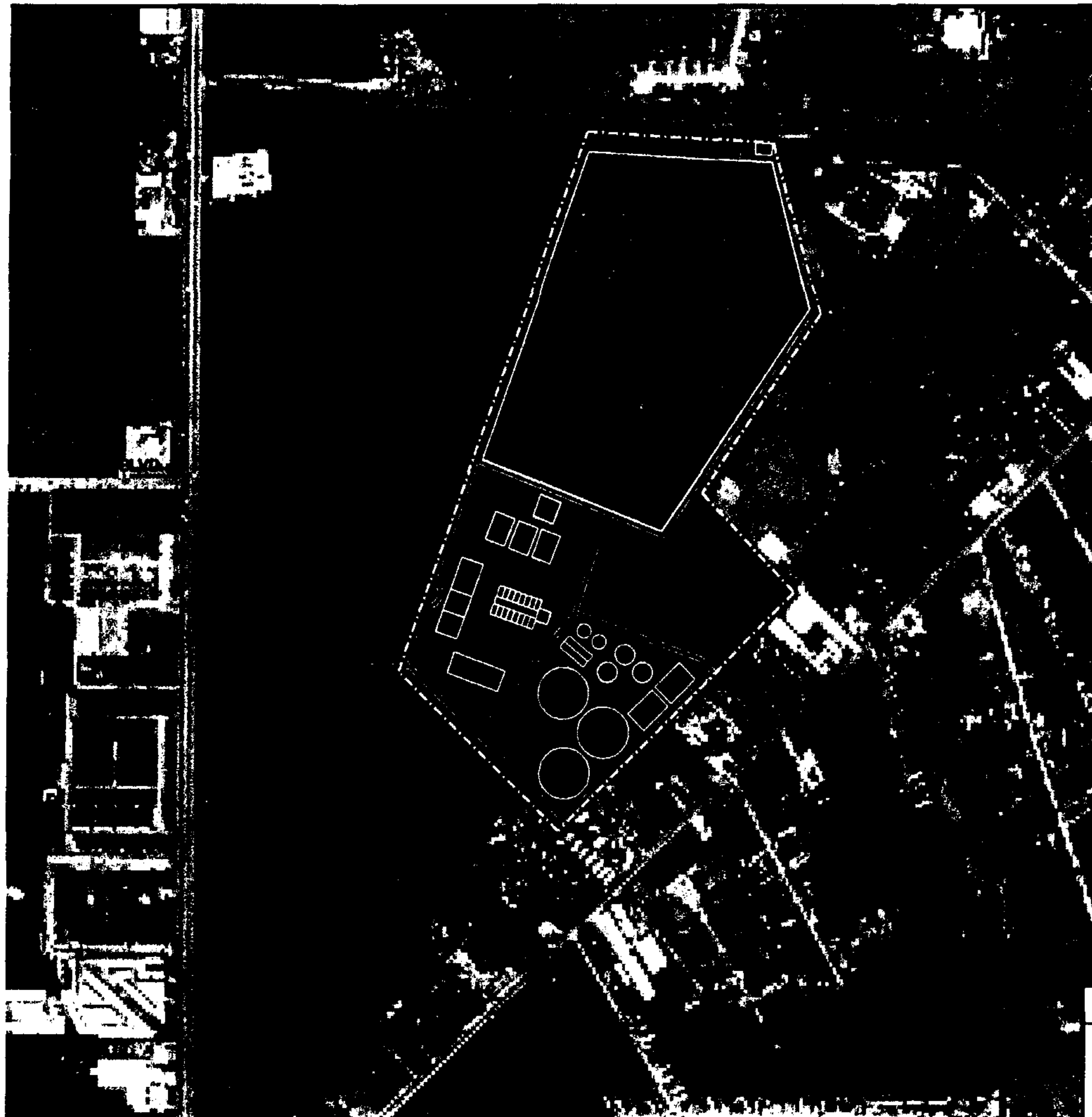
To transport 150 mgd from the Brazos River to the FBWCID No. 2 site, the following facilities will be required.

1) Five –38 mgd electrically powered vertical turbine pumps at the Shannon Lift Station and the 2nd Lift Station. These pumps will operate at 20 foot of head. One pump will serve as backup. Alternate power or fuel driven motors should be provided to ensure raw water delivery.

2) Assuming that the American Canal carries the flow associated with the new regional water plant and the existing GCWA industrial, municipal, and agricultural customers, the Jones / Oyster Creek section of the American Canal will need to be upgraded to a silted capacity of 368 mgd..

Finished Water Transmission System

From the 150 mgd water treatment plant at the FBWCID No. 2 site, the finished water will be delivered to the Participating Utility take points through the transmission network shown in **Figure 8-4**. The

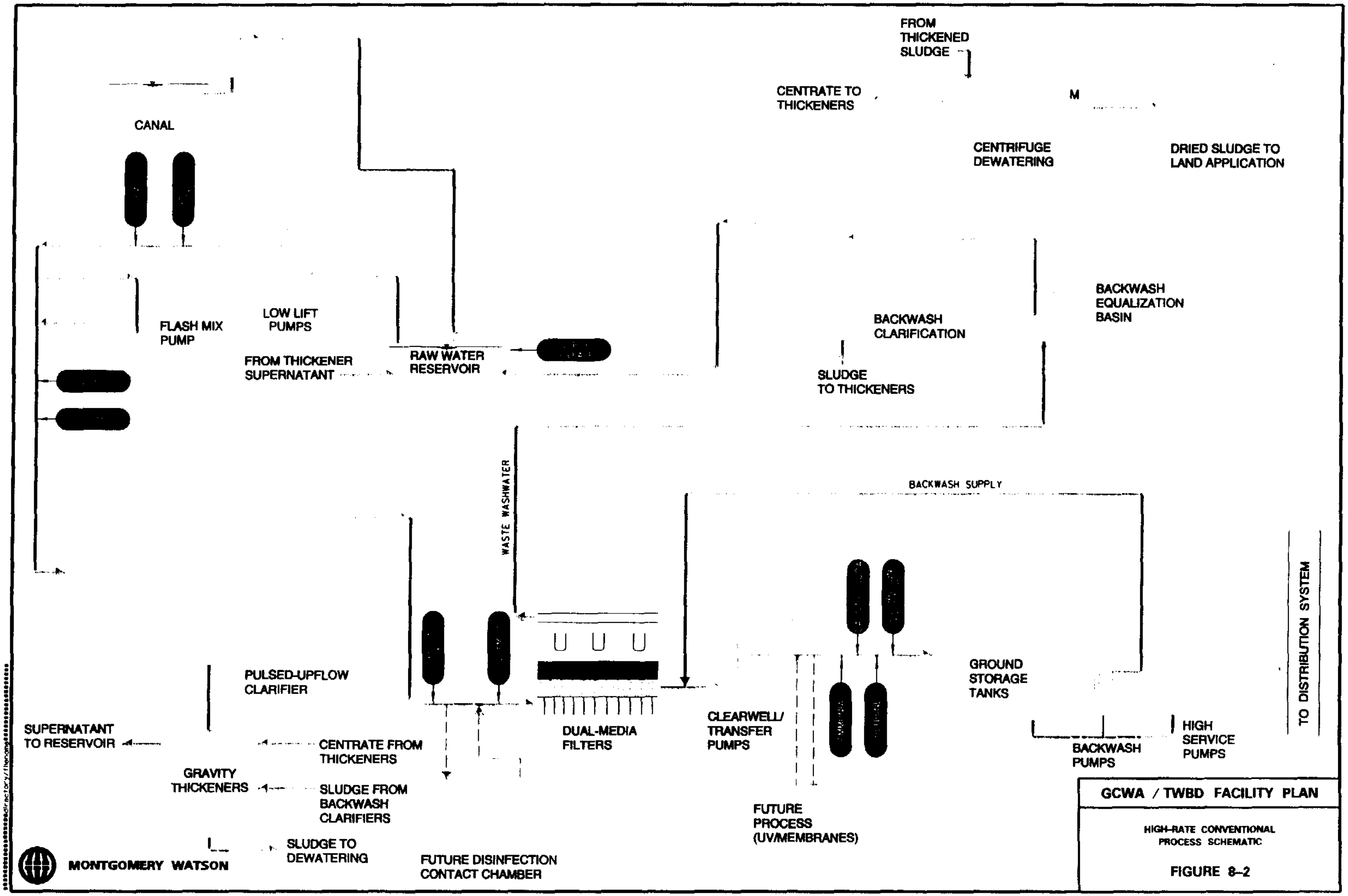


MONTGOMERY WATSON

GCWA / TWBD FACILITY PLAN

150 MGD CONVENTIONAL WTP
LAYOUT AT FBWCID No. 2 SITE

FIGURE 8-1

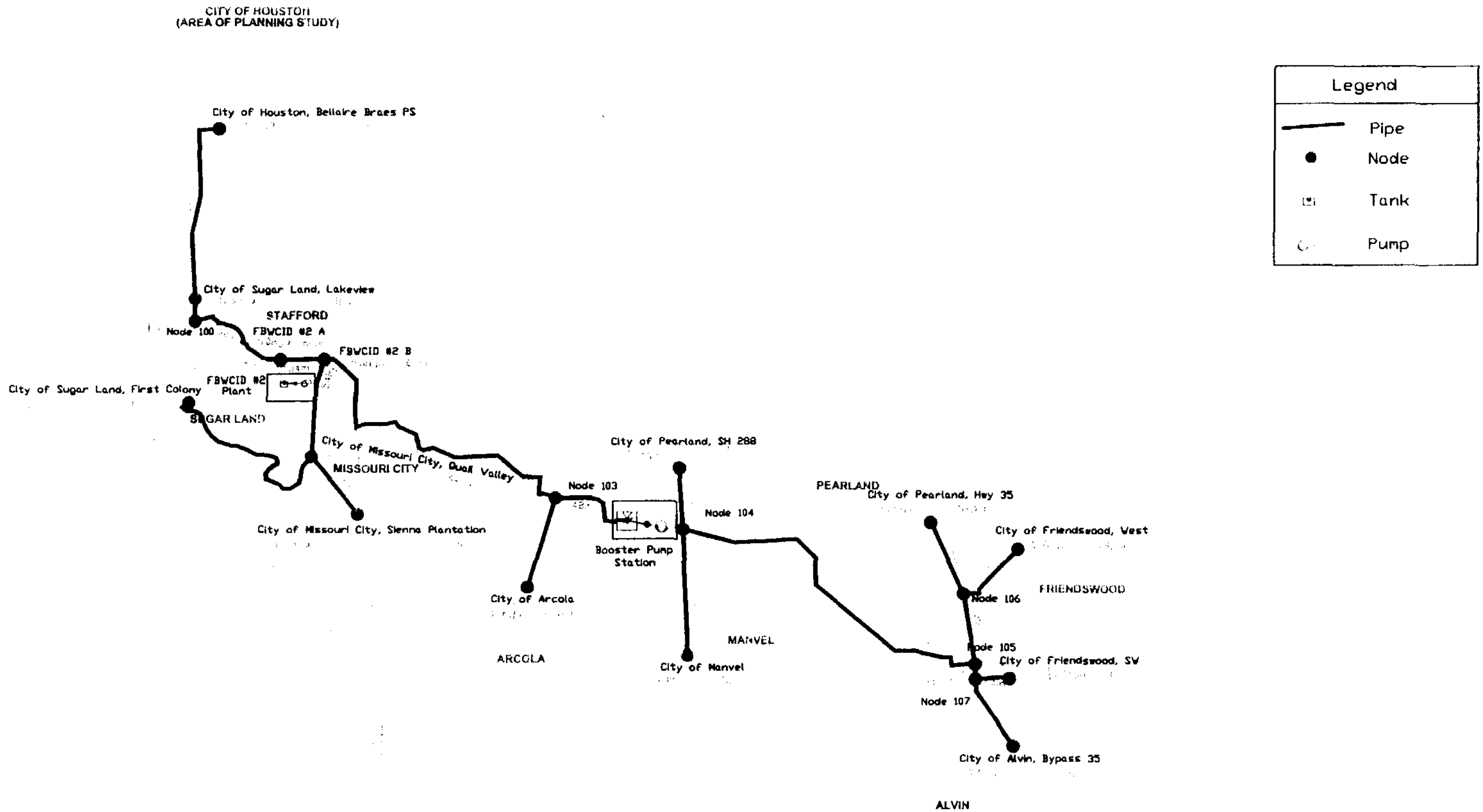


GCWA / TWBD FACILITY PLAN

HIGH-RATE CONVENTIONAL PROCESS SCHEMATIC

FIGURE 8-2


LEGEND
PHASE 1 CONSTRUCTION
FUTURE EXPANSION
GCWA / TWBD FACILITY PLAN
150 MGD HIGH-RATE CONVENTIONAL WTP
LAYOUT AT FBWCID No. 2 SITE
FIGURE 8-3



MONTGOMERY WATSON

GCWA / TWBD FACILITY PLAN

FINISHED WATER PIPELINE FROM FBWCID#2 PLANT SITE

FIGURE 8-4

network is designed to deliver 80 percent of the utilities average daily water demand to the utilities take points at the required pressures. Several utilities will take water at system pressure and will feed water directly into their distribution system. Other utilities will take water through a ground storage tank and provide distribution pressure to their customers. A summary of projected water demands and requested delivery pressure are shown in the following table.

TABLE 8-1
REQUESTED FLOW AND PRESSURE AT UTILITY TAKE POINTS

Utility	Take Point Name	Average Water Demand (mgd)	Delivery Pressure (psi)
City of Houston	Bellaire Braes PS	59.20	Fill Tank
City of Sugar Land	First Colony	17.47	Fill Tank
	Lakeview	11.65	Fill Tank
City of Missouri City	Quail Valley	8.46	Fill Tank
	Sienna Plantation	8.46	Fill Tank
FBWCID No. 2	Site B	5.00	60
	Avenue E	5.00	60
City of Pearland	SH 288	7.19	50
	SH 35	7.19	50
City of Manvel	Site E	3.52	50
City of Arcola	Town Center	0.13	Fill Tank
City of Alvin	Bypass 35	5.60	65
City of Friendswood	West Friendswood	5.71	65
	SW Friendswood	5.71	65

The transmission system includes an intermediate booster station located at the intersection of the American Canal and State Highway 288. The station will boost the water pressure for Demand Area B to 89 psi in order to maintain the customer requested pressures. A 2-mg pre-stressed concrete ground storage tank will be located at this station to mitigate surge pressures and to provide storage volume in the transmission system. A chlorine booster station will be also be added at this location to provide additional chlorine so as to maintain a chlorine residual throughout the transmission system for Demand Area B.

Water Treatment Plant Operations

The water treatment plant will be operated and maintained by the GCWA. GCWA will monitor the water quality, make treatment process adjustments, maintain distribution system pressure, and maintain the water treatment and transmission facilities.

Staffing Plan

The plant will be staffed 24 hours per day. The following staff will be required for operation and maintenance of the water plant and finished water transmission network.

- Process Operators– 9
- Electricians and Instrument Technicians – 4
- Maintenance – 5
- Administration – 2
- Plant Superintendent – 1

The plant operations will be divided into three shifts. Two operators will cover the day and swing shifts, with one operator on the night shift. Maintenance and electrical staff will serve as backup operators to handle vacations and sick days. The plant will be staffed with maintenance and electrical crews, who will work in tandem with the existing electrical and maintenance crews at the Dr. Thomas Mackey WTP to provide O&M services on the raw water delivery system, water treatment plant facilities, and finished water transmission system.

The operators will handle daily laboratory functions for process adjustments at the new plant, but detailed laboratory work for reporting and other functions will be handled through the lab staff at the Dr. Thomas Mackey WTP. Samples will be collected at the new plant and transported to the Dr. Thomas Mackey plant for evaluation.

The plant superintendent will plan and manage operations at the plant in conjunction with existing GCWA staff.

Operations Control

The regional water plant will be controlled through a Supervisory Control and Data Acquisition (SCADA) system. The SCADA system will provide a platform that will not only provide monitoring and control of the operation facilities, but also provide an interface to other applications including:

- Maintenance management system,
- Electronic operation and maintenance manuals,
- Laboratory information management system,
- Advanced operational strategies and planning through water system hydraulics and water quality models,
- Energy management system,
- Facilities security and protection through a Site Security and Video Surveillance System, and
- Management information system.

UTILITY SERVICE CONCEPTS

Electrical

The plant will require electrical service to power the water plant facilities, including low lift pumping, high service pumping, and plant process equipment. It is estimated that the daily electrical demand for a 150 mgd plant will be approximately 200 MW. We recommend that this demand be met through redundant substation feeds from a local electrical utility provider. Conversations with Reliant Energy indicate that power for the plant could be obtained from the Quail Valley and Dewalt substations.

Sanitary

We recommend that the water treatment plant wastewater be collected and transported to the FBWCID No.2 wastewater treatment plant. This plant is less than 1000 feet from the water treatment plant and has available capacity. Normal wastewater production at the plant will be less than 500 gallons per day with maximum daily production in the range of 2000 gpd.

Sludge Processing

Sludge processing at the plant will produce sludge with a solids content of approximately 30 percent. Disposal of this sludge is budgeted through a third party vendor who will collect, transport, and dispose of the sludge at local land farms. Conversations with various vendors indicate that the cost for hauling and disposing of the centrifuge sludge will be approximately $325 per truck load. As each truck can hold 22 cubic yards, approximately 8 truckloads of sludge will be produced each day. The vendors indicate that they will rotate empty trucks through the facility and maintain sludge disposal operations 24 hours a day, 7 days a week.

Another option for sludge disposal is to transport the wet sludge to the FBWCID No.2 wastewater treatment plant at a unit cost. FBWCID No.2 is currently in the process of reviewing this alternative to develop a unit fee for accepting and processing the water treatment plant sludge. The potential cost savings of this alternative are significant, as this option would eliminate the centrifuges and other sludge handling equipment. Sludge operations at the water plant would be consist of a sludge pump station to pump 2-4 percent solidsto the wastewater treatment plant.

Transportation

We anticipate that the surrounding transportation thoroughfares are sufficient to support chemical delivery trucks, sludge trucks, and general operations associated with the plant. A truck scale should be installed inside the water treatment plant site to gauge chemical deliveries and sludge disposal.

Storm Sewer Management

It is anticipated that storm water from the site will be collected and discharged into Stafford Run. Permits from the Fort Bend Drainage District and TNRCC will be required.

OPINION OF PROBABLE COSTS

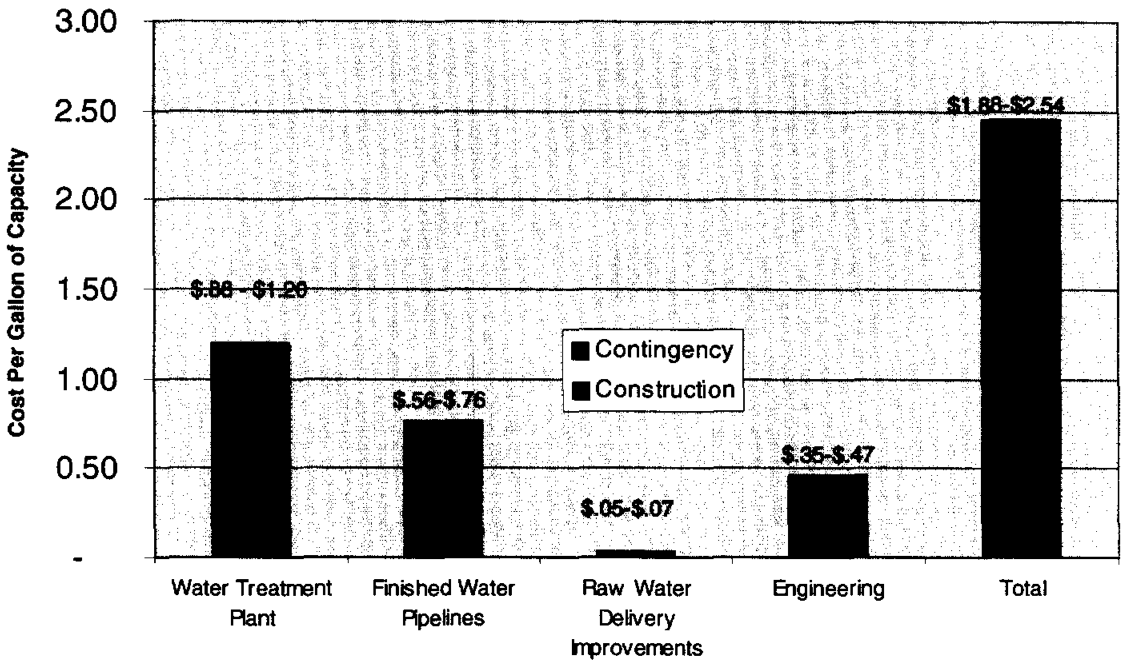
Construction

A summary of the preliminary opinion of probable construction costs for the recommended facility plan is shown in **Table 8-2**. The costs for the major process components, the raw water delivery system, and the finished water pipelines are provided. These costs are reported in year 2000 dollars and will have to be adjusted for the actual cost in the year of construction. As the design of the facility advances, the level of contingency may be reduced. Without contingency, the estimated capital cost for the first phase of the project, including raw water delivery improvements, water treatment plant, and finished water pipelines is $225 million, with an additional $25 million for the 30 MGD expansion by the year 2030. With a 35 percent contingency, the estimated capital costs are $304 million and $34 million, respectively for the first phase of construction and the year 2030 water treatment plant expansion. The overall project costs for this phase are estimated to be in the range between $225 and $304 million depending on the incurred contingencies. A breakdown of these unit costs by construction package, engineering, and contingency for the initial 120 MGD facility is shown in **Figure 8-5.**

TABLE 8-2
PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COSTS

ITEMS	COST ($, YR 2000)	
	120 MGD Initial Phase	30 MGD Expansion
Water Treatment Plant		
Property	$750,000	-
Sitework	$6,000,000	-
Yard Piping	$7,200,000	$1,800,000
Low Lift Pumping	$4,830,000	$360,000
Mixing/Flocculation/Sedimentaiton	$10,310,000	$2,580,000
Filters	$20,260,000	$5,060,000
Transfer Pumping	$4,200,000	$320,000
PAC System	$630,000	$130,000
Backwash Equalization Tank	$3,570,000	-
Backwash Clarification	$360,000	$120,000
Gravity thickeners/holding tanks	$1,980,000	$660,000
Chemical Systems, Building, Tanks	$4,950,000	$1,490,000
Centrifuges	$2,520,000	$840,000
Centrifuge Building	$3,230,000	-
Ground Storage Tanks	$10,500,000	$2,800,000
Electrical, Instrumentation, and Controls	$10,470,000	$2,100,000
Mobilization	$2,730,000	$550,000
Construction Mgmt, Insurance, Bonds, Profit	$12,180,000	$2,440,000
Sub Total	$106,670,000	$21,250,000
Finished Water Transmission		
High Service Pump Station	$6,720,000	$1,680,000
Booster Pump Station and Ground Storage	$2,440,000	$270,000
Chlorine Booster Station	$450,000	$50,000
Pipelines	$56,030,000	-
Easements	$1,770,000	-
Sub Total	$67,410,000	$2,000,000
Raw Water Improvements		
Canals	$430,000	-
Raw Water Pump Stations	$2,940,000	$740,000
Sub Total	$3,370,000	$740,000
Construction Total	$177,450,000	$23,990,000
Engineering	$26,620,000	$3,600,000
Construction Administration	$8,870,000	$1,200,000
GCWA Administration	$5,320,000	$720,000
Subtotal	$218,260,000	$29,510,000
Engineering Contingency (10%)	$21,830,000	$2,950,000
Construction Contingency (5%)	$10,910,000	$1,480,000
Cost Contingency (20%)	$43,650,000	$5,900,000
Total Capital	$294,650,000	$39,840,000

Figure 8-5
Unit Cost of Initial 120 MGD Surface Water Treatment Facility



Therefore we estimate that the unit cost of capital outlay for the first phase will run between $1.88 and $2.54 dollars per gallon, including water treatment plant, finished water pipelines, raw water delivery improvements, engineering, construction oversight and contingency. The overall project cost of the 30 MGD expansion will be between $1.64 and $2.00 dollars per gallon.

Operating and Maintenance

The estimated operating and maintenance costs for the water treatment plant, raw water delivery system, and finished water transmission are shown in **Table 8-3**. Annual operating costs over the first 20 years of operation will be $19.4 million, with annual O&M costs jumping to $23.6 million after the expansion in the year 2030. This cost represents a unit cost of $.44 per 1000 gallon produced during the first 20 years and a unit rate reduction to $.43 per 1000 gallon after the plant is expanded to its ultimate capacity of 150 MGD.

TABLE 8-3
PRELIMINARY OPINION OF ANNUAL O&M COSTS

Category	Annual O&M Costs (YR 2000 $) Year 2010-2030 Flow = 120 MGD	Year 2010-2030 Flow = 150 MGD
Electrical		
Raw Water	$ 480,000	$ 600,000
Plant Process	$ 1,670,000	$ 1,970,000
High Service Pumps	$ 2,200,000	$ 2,800,000
Sub Total	$ 4,350,000	$ 5,370,000
Chemical	$ 8,340,000	$ 10,430,000
Sludge Disposal	$ 950,000	$ 1,190,000
Maintenance		
Raw Water	$ 80,000	$ 90,000
Plant Process	$ 1,800,000	$ 2,160,000
Finished Water	$ 170,000	$ 180,000
Sub Total	$ 2,050,000	$ 2,430,000
GAC Replacement	$ 1,840,000	$ 2,300,000
Staff	$ 1,220,000	$ 1,220,000
Administration	$ 600,000	$ 600,000
Cost of Raw Water	$ 3,370,000	$ 4,220,000
Total Annual O&M	$ 22,720,000	$ 27,760,000

Funding Mechanism

Funding for the project will be based on revenue bonds and grants secured by GCWA. Participating Utilities will enter into a contract with the GCWA for a "reserve" capacity in the plant. The reserve capacity is defined as the portion of the water plant capacity that is reserved for that Participating Utility. This reserve capacity is what the Participating Utility is guaranteed to have available during the duration of the contract. The capital costs associated with constructing the water plant, raw water improvements, and finished water transmission network will be apportioned to each Participating Utility based on the percentage of the overall plant capacity that the utility has reserved and recovered in the fixed portion of each utility's bill.

O&M costs will be billed based on the Participating Utility's actual water demand measured at the take point flow meter. GCWA's annual O&M costs will be summarized and divided on a per gallon basis. Each utility's annual O&M costs will be calculated as the utility's actual water demand times the annual per gallon cost.

Section 9
Projected Wholesale Rates

The cost of the constructing, operating, and maintaining the regional surface water treatment and transmission program will be shared by the Participating Utilities. This section reviews the estimated capital and O&M costs, available funding mechanisms, and projected water demand to estimate a wholesale water rate for each Participating Utility. It should be noted that all economic rates presented in this section are for planning purposes only and do not represent final rates that Participating Utilities will pay for wholesale water.

FUNDING APPROACH

The Gulf Coast Water Authority (GCWA) will finance, construct, and operate the new regional water facilities. Construction costs for the water plant, transmission network, and canal raw water costs will be paid at rates to each of the Participating Utilities based on their contracted reserve capacity. O&M costs will be based on each Utility's actual water usage (take-or-pay). The following is synopsis of the general components of each Participating Utilities wholesale water bill.

Capital Debt Retirement

It is anticipated that the GCWA will secure grants and bonds in the amount necessary to finance the initial construction of the water treatment plant, transmission network, and raw water improvements. Thirty year financing will provide funding for debt and GCWA administration costs associated with the revenue bonds needed to construct the project. Participating Utilities' wholesale water rates will provide for repayment of the bonds. Prorated capital debt service for each Participating Utility will be fixed throughout the lifespan of the bond. Prorated rates will be based on the amount of contract water purchased and the extent of infrastructure constructed to transport finished water to the individual Participating Utilities.

Participating Utilities may share capital debt retirement costs in one of two plans. Transmission main costs may be shared equally among all participants, or may be prorated based on usage of the transmission mains. Both plans utilize the concept of "reserve" capacity, which is defined as the quantity of water each Participating Utility is guaranteed to have available throughout the duration of the contract. The sum of all Participating Utilities reserve water contracts equates to the design capacity of the regional water treatment plant. Associated raw water improvements and transmission network is also sized on this basis. A description of each plan follows:

Shared Transmission Plan

In this plan, the total capital debt retirement costs associated with design and construction of raw water improvements, water treatment plant, and transmission network, are uniformly distributed to each Participating Utility. Uniformly distributed costs are based on relative percentage of capacity that each Utility "reserves" in the regional water plant. Each Participating Utility pays the same debt service rate associated with constructing the water plant, raw water improvements, and transmission network. This cooperative type plan allows potential utilities in outlying areas to participate in the regional water supply facility at the same rate as the utilities located much closer to the facility. By adding more participating utilities, the design capacity of the regional water plant becomes larger and a unit capital and O&M cost savings can be realized because of the economy of scale. As shown later in this section, this plan will result in somewhat higher rates to Participating Utilities located near the regional facility in order to share the cost of transmission mains to outlying utilities.

Prorated Transmission Plan

Similar to the "Shared Transmission Approach", capital debt retirement costs associated with design and construction of raw water improvements and the regional water treatment plant are uniformly distributed to each Participating Utility. But this plan differs, in that the cost of the transmission network will be allocated to individual Participating Utilities based on the percentage of facilities necessary to deliver water to the established take points. Only those Participating Utilities utilizing specific pipelines, booster pumps, or storage tanks will have debt service rates accounting for those items. . Additionally, debt service costs for transmission facilities shared by more than one utility will be prorated based upon relative percentage of "reserve" contracted capacity. For example, the 18-inch pipeline between Missouri City's Quail Valley take point and Sienna Plantation take point delivers water only to the City of Missouri City. The entire cost of this pipeline would be totally allocated to Missouri City. In contrast, the 42-inch pipeline between State Highway 288 and State Highway 35 in Alvin is intended to deliver finished water to the City of Pearland, City of Alvin, and the City of Friendswood. These three Participating Utilities would share in the cost of this pipeline with prorated debt service rates. Prorated debt service rates would be based on the percentage of design flow (equal to each utility's "reserve" contract capacity) in that pipeline. This plan will result in somewhat higher rates to Participating Utilities not located near the regional facility.

Operation and Maintenance

Operation and maintenance costs have been estimated for raw water conveyance canals and reservoir, water treatment facility, high service pump station, and transmission mains. O&M costs associated with treatment and delivery of potable water to the Participating Utilities will vary with overall water demand (take-or-pay rates). All Participating Utilities will pay a common rate for O&M. The total cost to each Participating Utility will therefore be based on each Utility's actual usage. GCWA will provide an efficient operation resulting in the lowest water rates possible. Rates for O&M will be reviewed on a basis as identified in the water contracts with Participating Utilities. Obviously, the costs for O&M will increase over time as water demand and production increases, but the rate should significantly decrease due to the economy of scale.

WHOLESALE WATER RATES

Wholesale water rate analyses have been performed by First Southwest Co. to project the wholesale water rates under the alternative funding approaches. The following section highlights the findings of the rate analyses. The analyses are based upon the assumptions:

- The facility plan presented in Section 8 will serve the region through the year 2050.
- All numbers presented in the rates are in Year 2000 dollars.
- The financial debt service rates are calculated at an estimated interest rate of six percent and a debt service period of 30 years.
- Rates for debt service such as water plant and distribution network construction, as well as canal raw water costs will be based on Participating Utilities' contract reserve capacity (i.e. the debt service rate will be applied to each Utility's contracted reserve capacity).
- O&M rates will apply to actual water used (take-or-pay).
- Capital costs are as shown in **Table 9-1.**

TABLE 9-1
SUMMARY OF PROBABLE CONSTRUCTION COSTS

ITEMS	COST ($, YR 2000) 120 MGD Initial Phase	COST ($, YR 2000) 30 MGD Expansion
Water Treatment Plant	**$106,670,000**	**$21,250,000**
Finished Water Transmission	**$67,410,000**	**$2,000,000**
Raw Water Improvements	**$3,370,000**	**$740,000**
Construction Total	$177,450,000	$23,990,000
Engineering	$26,620,000	$3,600,000
Construction Administration	$8,870,000	$1,200,000
GCWA Administration	$5,320,000	$720,000
Subtotal	$218,260,000	$29,510,000
Engineering Contingency (10%)	$21,830,000	$2,950,000
Construction Contingency (5%)	$10,910,000	$1,480,000
Cost Contingency (20%)	$43,650,000	$5,900,000
Total Capital	$294,650,000	$39,840,000

- Annual O&M costs for the facilities are expected to be $22,720,000 from 2010-2030 and increase to $27,760,000 after the expansion in 2030.

Shared Transmission Plan

Under the shared transmission plan, GCWA will obtain grants (as available), loans, and sell bonds totaling $294,650,000 to construct a 120 MGD water treatment plant and transmission network to provide the nine Participating Utilities with treated surface water. All participating utilities would pay the same wholesale water rate regardless of their location or reserve contract amount. **Table 9-2** shows the estimated wholesale water rate that each utility would pay under this scenario. The debt service is divided into the portion dedicated to the water treatment plant and the distribution network so as to aid in comparison to the prorated transmission alternative. The O&M costs are divided into the cost of facilities operations and maintenance, and the cost of the raw water from the Brazos River.

TABLE 9-2
ESTIMATED WHOLESALE WATER RATE
($/1000 GALLONS)
INITIAL 120 MGD PHASE - YEAR 2010 UNDER
SHARED TRANSMISSION APPROACH

Customer	Reserve Capacity Rate				Take or Pay Rate	Estimated Total Rate
	Debt Service					
	Water Treatment Plant	Transmission	Canal Raw Water Cost	Subtotal Reserve Capacity Rate	O&M	
Alvin	$ 0.396	$ 0.206	$ 0.07	$ 0.672	$ 0.441	$ 1.113
Arcola	$ 0.396	$ 0.206	$ 0.07	$ 0.672	$ 0.441	$ 1.113
Manvel	$ 0.396	$ 0.206	$ 0.07	$ 0.672	$ 0.441	$ 1.113
Pearland	$ 0.396	$ 0.206	$ 0.07	$ 0.672	$ 0.441	$ 1.113
Missouri City	$ 0.396	$ 0.206	$ 0.07	$ 0.672	$ 0.441	$ 1.113
FBWCID No. 2	$ 0.396	$ 0.206	$ 0.07	$ 0.672	$ 0.441	$ 1.113
Sugar Land	$ 0.396	$ 0.206	$ 0.07	$ 0.672	$ 0.441	$ 1.113
Friendswood	$ 0.396	$ 0.206	$ 0.07	$ 0.672	$ 0.441	$ 1.113
Houston	$ 0.396	$ 0.206	$ 0.07	$ 0.672	$ 0.441	$ 1.113

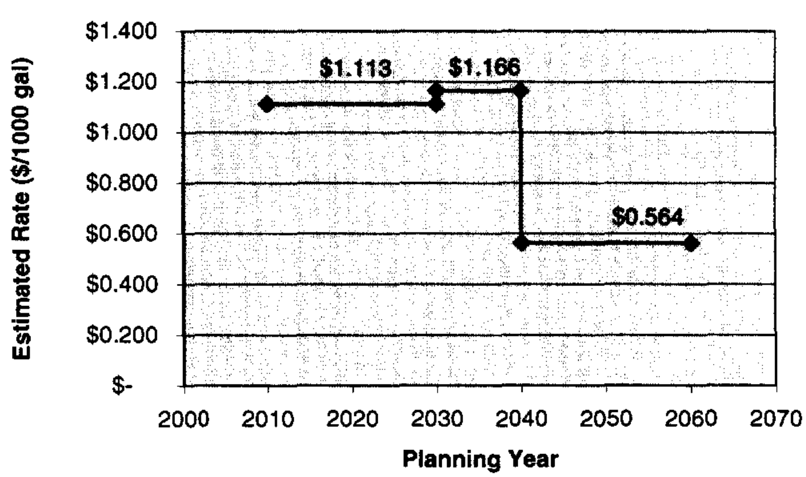
In this funding approach, each utility plays an estimated flat rate of $0.603 per 1000 gallons for debt service. The estimated rate for O&M costs would approach $0.511 per 1000 gallons at year 2029 when the plant production approaches design capacity. The O&M rate will vary depending on actual water production and the rate would be updated based on the terms of the agreement between GCWA and the Participating Utilities. The estimated total wholesale water rate under this plan would approach $1.114 per 1000 gallons. This estimated rate should be used as a comparitive rate for Participating Utilities' planning purposes until the year 2030. At year 2030, the plant would undergo an expansion to 150 MGD. GCW A will provide an estimated $39,480,000 in financing for design and construction of the expansion. **Table 9-3** shows the estimated impact to wholesale water rates under the expanded plant.

TABLE 9-3
ESTIMATED WHOLESALE WATER RATE
($/1000 GALLONS)
30 MGD PLANT EXPANSION - YEAR 2030 UNDER SHARED TRANSMISSION APPROACH

Customer	Reserve Capacity Rate				Take or Pay Rate	
	Debt Service					
	Water Treatment Plant	Transmission	Canal Raw Water Cost	Subtotal Reserve Capacity Rate	O&M	Estimated Total Rate
Alvin	$ 0.063	$ 0.001	$ 0.07	$ 0.134	$ 0.430	$ 0.564
Arcola	$ 0.063	$ 0.001	$ 0.07	$ 0.134	$ 0.430	$ 0.564
Manvel	$ 0.063	$ 0.001	$ 0.07	$ 0.134	$ 0.430	$ 0.564
Pearland	$ 0.063	$ 0.001	$ 0.07	$ 0.134	$ 0.430	$ 0.564
Missouri City	$ 0.063	$ 0.001	$ 0.07	$ 0.134	$ 0.430	$ 0.564
FBWCID No. 2	$ 0.063	$ 0.001	$ 0.07	$ 0.134	$ 0.430	$ 0.564
Sugar Land	$ 0.063	$ 0.001	$ 0.07	$ 0.134	$ 0.430	$ 0.564
Friendswood	$ 0.063	$ 0.001	$ 0.07	$ 0.134	$ 0.430	$ 0.564
Houston	$ 0.063	$ 0.001	$ 0.07	$ 0.134	$ 0.430	$ 0.564

As the rates are based on 30 year loans, during the period from 2030-2040 the Participating Utilities will be paying the debt service on both the initial 120 MGD phase (see Table 9-2) and the 30 MGD expansion (see Table 9-3). During this period, the estimated debt service rate will be $0.667, while the O&M rate is estimated to drop to $.0500 to reflect the greater economy of scale with the increased plant capacity. The sum wholesale water rate represents approximately a $0.05 increase over the rate for the first twenty years. **Figure 9-1** shows estimated wholesale water rates for planning purposes as a function of time.

FIGURE 9-1
ESTIMATED WHOLESALE RATE STRUCTURE - SHARED TRANSMISSION COSTS



Prorated Transmission Plan

Under the prorated transmission plan, GCWA would still obtain grants and loans as available, and sell bonds totaling $294,650,000 to construct a 120 MGD water treatment plant and transmission network. However, overall debt service rate would vary for each Participating Utility based on the cost of the transmission network required to reach the individual Participating Utilities take points. **Appendix I** shows the breakdown of transmission network costs for Participating Utilities.

Table 9-4 shows the estimated wholesale water rates that each utility would pay under this scenario. The estimated rate for water plant debt service and the O&M are common to all Participating Utilities and therefore the same as the shared transmission funding alternative previously discussed. The estimated rate for debt service on transmission facilities is based on the total cost of the facilities necessary to carry water from the plant to the individual Participating Utilities take points.

**TABLE 9-4
ESTIMATED WHOLSALE WATER RATE
($/1000 GALLONS)
INITIAL 120 MGD PHASE - YEAR 2010 UNDER
PRORATED TRANSMISSION APPROACH**

Customer	Reserve Capacity Rate				Take or Pay Rate	Estimated Total Rate
	Debt Service					
	Water Treatment Plant	Transmission	Canal Raw Water Cost	Subtotal Reserve Capacity Rate	O&M	
Alvin	$ 0.396	$ 0.617	$ 0.07	$ 1.083	$ 0.441	$ 1.525
Arcola	$ 0.396	$ 1.779	$ 0.07	$ 2.245	$ 0.441	$ 2.686
Manvel	$ 0.396	$ 0.318	$ 0.07	$ 0.784	$ 0.441	$ 1.225
Pearland	$ 0.396	$ 0.621	$ 0.07	$ 1.087	$ 0.441	$ 1.528
Missouri City	$ 0.396	$ 0.054	$ 0.07	$ 0.520	$ 0.441	$ 0.961
FBWCID No. 2	$ 0.396	$ 0.010	$ 0.07	$ 0.476	$ 0.441	$ 0.917
Sugar Land	$ 0.396	$ 0.114	$ 0.07	$ 0.580	$ 0.441	$ 1.021
Friendswood	$ 0.396	$ 0.762	$ 0.07	$ 1.228	$ 0.441	$ 1.669
Houston	$ 0.396	$ 0.119	$ 0.07	$ 0.585	$ 0.441	$ 1.026

The estimated rates vary from $0.917 for FBWCID No.2 to $2.686 for the City of Arcola. In this scenario, the wholesale water rates for the Cities of Alvin, Arcola, Manvel, Pearland, and Friendswood are larger than those utilities located closer to the regional water plant, because these cities require a larger portion of transmission network facilities to transport water from the plant across Brazoria county.

When the plant expansion occurs in the year 2030, the estimated rates for each utility will follow the rates under the Shared Transmission alternative as the transmission facilities are scheduled to be installed in the first phase and will not significantly impact the rates during the later half of the facility plan. Again, during the loan overall between the year 2030 and 2040, the Participating Utilities will pay a rate equivalent to the debt service in the first phase. **Table 9-5** shows the rates during this overlap period.

TABLE 9-5
ESTIMATED WHOLESALE WATER RATE
($/1000 GALLONS)
30 MGD PLANT EXPANSION - YEAR 2030 UNDER
PRORATED TRANSMISSION APPROACH

Customer	Reserve Capacity Rate				Take or Pay Rate	Estimated Total Rate
	Debt Service			Subtotal Reserve Capacity Rate	O&M	
	Water Treatment Plant	Transmission	Canal Raw Water Cost			
Alvin	$ 0.063	$ 0.001	$ 0.07	$ 0.134	$ 0.430	$ 0.564
Arcola	$ 0.063	$0.001	$ 0.07	$ 0.134	$ 0.430	$ 0.564
Manvel	$ 0.063	$0.001	$ 0.07	$ 0.134	$ 0.430	$ 0.564
Pearland	$ 0.063	$ 0.001	$ 0.07	$ 0.134	$ 0.430	$ 0.564
Missouri City	$ 0.063	$ 0.00	$ 0.07	$ 0.133	$ 0.430	$ 0.563
FBWCID No. 2	$ 0.063	$0.00	$ 0.07	$ 0.133	$ 0.430	$ 0.563
Sugar Land	$ 0.063	$0.00	$ 0.07	$ 0.133	$ 0.430	$ 0.563
Friendswood	$ 0.063	$0.001	$ 0.07	$0.134	$ 0.430	$ 0.564
Houston	$ 0.063	$0.00	$ 0.07	$ 0.133	$ 0.430	$ 0.563

Similar to the shared pipeline cost plan, the rates are based on 30 year loans. During the period from 2030-2040 the Participating Utilities will be paying the debt service on both the initial 120 MGD phase and the 30 MGD expansion. During this period, the estimated debt service rate will include each Participating Utility's initial phase rate (see **Table 9-4**) plus the expansion debt service estimated rate of $0.063 (see **Table 9-5**). The O&M rate is estimated to drop to $.0500 to reflect the greater economy of scale with the increased plant capacity. **Table 9-6** shows total estimated wholesale water rates over the planning period for each Participating Utility.

TABLE 9-6
ESTIMATED WHOLSALE WATER RATES
($/1000 GALLONS) IN PLANNING PERIOD
PRORATED TRANSMISSION MAIN APPROACH

Customer	Planning Period Year 2010 thru 2029	Year 2030 thru 2040	Year 2041 thru 2060
Alvin	$ 1.525	$ 1.578	$ 0.564
Arcola	$ 2.686	$ 2.739	$ 0.564
Manvel	$ 1.226	$ 1.278	$ 0.564
Pearland	$ 1.529	$ 1.582	$ 0.564
Missouri City	$ 0.962	$ 1.013	$ 0.563
FBWCID No. 2	$ 0.918	$ 0.970	$ 0.563
Sugar Land	$ 1.022	$ 1.073	$ 0.563
Friendswood	$ 1.669	$ 1.721	$ 0.563
Houston	$ 1.027	$ 1.079	$ 0.563

WHOLESALE WATER RATE IMPACTS

The estimated wholesale water rates presented in this section are a function of the facility plan presented in Section 8 of this report. The facility plan assumes one single regional water plant to serve the entire planning area, and that the listed nine Participating Utilities contract 80% of average annual demand from the single surface water plant. If the number of participants changes, or if participation level changes, the resulting wholesale water rate will vary accordingly. In addition, relocation of take points could impact rates, however it is not anticipated that the overall rate structure would be significantly impacted by these types of changes

- The single regional water facility described in Section 8 was selected because it was shown to be the most cost effective alternative on a present worth basis. The present worth analysis cannot take the resulting rates into consideration. In this section, it has been shown that the overall cost of the single regional water facility is impacted by the extensive transmission mains required to convey water to the Participating Utilities in Brazoria County and Friendswood. This cost impact can be shared equally among all participants or prorated to the participants that the transmission mains would serve as discussed above. In considering the resulting estimated water rates for the single regional facility, it becomes apparent that even though most of the rates are attractive and competitive, the Utilities in Brazoria County and Friendswood may be able to be served by a regional water facility located in Brazoria County. If the Utilities in Brazoria County were to not participate, the resulting rates for the rest of the Utilities would be impacted. In Section 7, the scenario of two regional water plants was evaluated. Using the costs developed for the two plants, resulting wholesale water rates can be estimated for all of the Participating Utilites. Table 9-7 shows estimated wholesale water rates if two regional surface water plants were constructed with associated raw water and finished water transmission networks. The estimated water rates are based upon the following assumptions: A 115 MGD surface water facility would be built at the FBWCID No. 2 site to serve the City of Houston, FBWCID No. 2, City of Missouri City, and the City of Sugar Land. Transmission pipeline costs are assumed to be shared equally among all Participating Utilities.

- A 35 MGD surface water facility would be built at the Alvin site to serve Arcola, Alvin, Friendswood, Pearland, and Manvel. Transmission pipeline costs are assumed to be shared equally among all Participating Utilities.
- Each regional system would have its own transmission network and wholesale water rates would be for each system would be independent of one another.
- Financing at 6 percent interest over 30 year term.

The corresponding wholesale water rates for the two plant option are shown in **Table 9-7**.

TABLE 9-7
ESTIMATED WHOLESALE WATER RATE
($/1000 GALLONS)
YEAR 2010-2039 UNDER
TWO PLANT ALTERNATIVE - SHARED TRANSMISSION APPROACH

Customer	Reserve Capacity Rate: Debt Service: Water Treatment Plant	Reserve Capacity Rate: Debt Service: Transmission	Reserve Capacity Rate: Canal Raw Water Cost	Reserve Capacity Rate: Subtotal Reserve Capacity Rate	Take or Pay Rate: O&M	Estimated Total Rate
35 MGD Plant at Alvin Site						
Alvin	$0.64	$0.30	$ 0.07	$ 1.01	$ 0.59	$1.60
Arcola	$0.64	$0.30	$ 0.07	$ 1.01	$ 0.59	$1.60
Manvel	$0.64	$0.30	$ 0.07	$ 1.01	$ 0.59	$1.60
Pearland	$0.64	$0.30	$ 0.07	$ 1.01	$ 0.59	$1.60
Friendswood	$0.64	$0.30	$ 0.07	$ 1.01	$ 0.59	$1.60
115 MGD Plant at FBWCID No. 2 Site						
Missouri City	$0.41	$0.10	$ 0.07	$ 0.580	$ 0.46	$1.04
FBWCID No. 2	$0.41	$0.10	$ 0.07	$ 0.580	$ 0.46	$1.04
Sugar Land	$0.41	$0.10	$ 0.07	$ 0.580	$ 0.46	$1.04
Houston	$0.41	$0.10	$ 0.07	$ 0.580	$ 0.46	$1.04

SUMMARY

The need to begin planning for regional surface water facilities for Fort Bend, Harris and Brazoria Counties has been shown in this report. Three different plans for developing wholesale water rates have been presented in this section. In each of the plans, attractive, competitive rates can be realized for the Participating Utilities. Each of the plans will solve the needs of all the Participating Utilities, however the rate pricing must be carefully considered by each Utiliy. This information can be used by each Participating Utility in planning their strategy for future water supplies. For ease of comparison, Table 9-8 indicates a comparison of the three different plans. The numbers for the two plant option assume ultimate buildout at the onset of the project and do not include plant expansions.

**TABLE 9-8
SUMMARY OF ESTIMATED WHOLESALE WATER RATES
($/1000 GALLONS)
BY RATE STRUCTURE PLAN**

Customer	One Regional Plant Shared Transmission Costs			One Regional Plant Prorated Transmission Costs			Two Regional Plants Shared Transmission Costs		
	2010 to 2029	2030 to 2040	2041 to 2060	2010 to 2029	2030 to 2040	2041 to 2060	2010 to 2029	2030 to 2040	2041 to 2060
Alvin	$1.11	$1.17	$0.56	$1.53	$1.58	$0.56	$1.60	$1.60	$0.66
Arcola	$1.11	$1.17	$0.56	$2.69	$2.74	$0.56	$1.60	$1.60	$0.66
Manvel	$1.11	$1.17	$0.56	$1.23	$1.28	$0.56	$1.60	$1.60	$0.66
Pearland	$1.11	$1.17	$0.56	$1.53	$1.58	$0.56	$1.60	$1.60	$0.66
Friendswood	$1.11	$1.17	$0.56	$1.67	$1.72	$0.56	$1.60	$1.60	$0.66
Missouri City	$1.11	$1.17	$0.56	$0.96	$1.01	$0.56	$1.04	$1.04	$0.53
FBWCID No. 2	$1.11	$1.17	$0.56	$0.92	$0.97	$0.56	$1.04	$1.04	$0.53
Sugar Land	$1.11	$1.17	$0.56	$1.02	$1.07	$0.56	$1.04	$1.04	$0.53
Houston	$1.11	$1.17	$0.56	$1.03	$1.08	$0.56	$1.04	$1.04	$0.53

Appendix A
Bibliography

Bibliography

1. Gulf Coast Water Authority Water Audit Summary, Freese and Nichols, 9/28/99
2. Dr. Thomas Mackey Water Treament Plant Expansion, Conceptual Design Report, October 1996
3. 1999 Harris Galveston County Subsidence District Regulatory Plan
4. Recommended Population and Water Use Projections for GCWA Customers, Freese and Nichols, December 1999
5. Texas Water Development Board: 2002 State Water Plan Regional Population Projections
6. USGS Water Quality Monitoring Network Data – Station 08114000 Brazos River at Richmond, TX
7. Option Agreement – Gulf Coast Water Authority – Fort Bend County WCID No. 2 – August 1994
8. Option Agreement – Gulf Coast Water Authority – City of Sugar Land – July 1997
9. Option Agreement – Gulf Coast Water Authority – City of Missouri City – July 1997
10. Option Agreement – Gulf Coast Water Authority – City of Pearland – April , 1998
11. Gulf Coast Water Authority, Water Conservation Plan and Drought Emergency Contingency Plan, August, 1999
12. TNRCC Reports of Surface Water Used for The Year Ending December, 31 1997
13. Gulf Coast Water Authority, Raw Water Facilities Audit, Vol. 1 and 2, latest edition, 1998
14. Kawamura, Susumu, *Intergating Design of Water Treatment Facilities*, John Wiley and Sons, 1991

Appendix B
GCWA Existing Customer Water Demand

Customer	County	Contract/ Option (MGD)	1997 Use in MGD	Projected Average Annual Use in MGD					
				2000	2010	2020	2030	2040	2050
Industrial/Irrigation Customers									
Solutia, Inc. (Monsanto)	Brazoria	10.000	4.188	8.500	10.000	10.000	10.000	10.000	10.000
OxyChem	Brazoria	7.866	4.976	5.500	7.866	7.866	7.866	7.866	7.866
Chocolate Bayou Water Company	Brazoria	12.999	12.973	12.999	12.999	12.999	12.999	12.999	12.999
American Golf	Fort Bend	0.296	0.167	0.296	0.296	2.960	0.296	0.296	0.296
Sugar Creek Country Club	Fort Bend	0.210	0.238	0.210	0.210	0.210	0.210	0.210	0.210
Fluor Daniel	Fort Bend	0.080	0.039	0.080	0.080	0.080	0.080	0.080	0.080
Texas Brine	Fort Bend	0.826	0.423	0.826	0.826	0.826	0.826	0.826	0.826
Golf Unlimited	Fort Bend	0.178	0.078	0.178	0.178	0.178	0.178	0.178	0.178
River Bend Country Club	Fort Bend	0.137	0.087	0.137	0.137	0.137	0.137	0.137	0.137
Texas Department of Corrections	Fort Bend	0.164	0.011	0.164	0.164	0.164	0.164	0.164	0.164
Amoco Oil	Galveston	28.600	26.017	28.600	33.000	36.000	37.000	38.000	39.000
Marathon Petroleum	Galveston	4.000	2.929	3.000	4.000	4.400	4.400	4.400	4.400
Sterling Chemicals	Galveston	8.542	8.058	9.630	13.000	13.000	13.000	13.000	13.000
Union Carbide	Galveston	20.391	10.625	12.000	12.000	14.100	16.200	18.300	20.391
Valero Energy	Galveston	8.910	3.711	4.410	8.910	8.910	8.910	8.910	8.910
ISP	Galveston	1.000	0.917	1.000	1.000	1.000	1.000	1.000	1.000
Eagle Concrete	Galveston	0.019	0.000	0.019	0.019	0.019	0.019	0.019	0.019
Subtotal (Industrial/Irrigation)		104.218	75.437	87.549	104.685	112.849	113.285	116.385	119.476
Texas City Water Plant Customers									
Texas City	Galveston	8.500	6.506	7.124	7.428	7.623	8.081	8.072	8.417
La Marque	Galveston	2.000	1.709	1.966	2.073	2.694	2.339	2.262	2.355
Galveston County WCID #1 (Dickinson)	Galveston	3.500	2.350	2.423	2.676	2.813	2.956	3.108	3.267
Bacliff MUD	Galveston	1.000	0.403	0.425	0.430	0.436	0.444	0.452	0.460
Bayview MUD	Galveston	0.125	0.113	0.411	0.445	0.479	0.502	0.525	0.548
San Leon MUD	Galveston	0.500	0.469	0.486	0.557	0.582	0.618	0.655	0.716
Galveston County WCID #12 (Kemah)	Galveston	0.750	0.427	0.594	0.713	0.784	0.862	0.948	1.043
Houston Lighting and Power	Galveston	1.625	0.830	1.200	1.625	1.625	1.625	1.625	1.625
Galveston	Galveston	16.000	15.404	18.960	21.030	24.090	27.700	31.310	34.920
Galveston County FWD #6 (Tiki Island)	Galveston	0.000	0.000	0.000	0.188	0.203	0.218	0.230	0.236
Hitchcock	Galveston	0.000	0.000	0.000	0.969	1.087	1.213	1.227	1.277
Galveston County WCID #8 (Santa Fe)	Galveston	0.000	0.000	0.000	0.671	0.944	1.038	1.142	1.256
Galveston County MUD #12 (Bayou Vista)	Galveston	0.000	0.000	0.000	0.363	0.363	0.363	0.363	0.363
Subtotal for Texas City Water Plant		34.000	28.211	33.589	39.168	43.723	47.959	51.919	56.483

Appendix C
TWDB Region H Population and Water Use Projections

BRAZORIA COUNTY
MOST LIKELY GROWTH SCENARIO

Forecast Item	1990	2000	2010	2020	2030	2040	2050
ALVIN							
Population	19,220	24,075	28,723	33,822	40,240	45,715	51,935
1990 Use	2,589						
Below Normal Rainfall							
* Expected Conservation		3,290	3,668	4,092	4,733	5,274	5,934
Advanced Conservation		3,182	3,443	3,826	4,462	5,018	5,643
Normal rainfall							
Expected Conservation		3,020	3,378	3,751	4,327	4,762	5,410
Advanced Conservation		2,912	3,185	3,523	4,102	4,609	5,178
MANVEL							
Population	3,733	5,152	6,084	7,080	8,352	9,412	10,606
1990 Use	519						
Below Normal Rainfall							
* Expected Conservation		710	784	856	983	1,075	1,212
Advanced Conservation		687	730	785	917	1,013	1,140
Normal rainfall							
Expected Conservation		624	681	746	852	928	1,033
Advanced Conservation		601	634	690	795	886	986
PEARLAND (P)							
Population	17,234	29,480	39,464	49,742	61,929	73,332	86,834
1990 Use	2,788						
Below Normal Rainfall							
* Expected Conservation		4,458	5,569	6,631	8,046	9,364	11,088
Advanced Conservation		4,293	5,217	6,129	7,562	8,871	10,408
Normal rainfall							
Expected Conservation		4,260	5,305	6,352	7,700	8,953	10,505
Advanced Conservation		4,128	4,995	5,850	7,215	8,461	9,921

FORT BEND COUNTY
MOST LIKELY GROWTH SCENARIO

Forecast Item	1990	2000	2010	2020	2030	2040	2050
HOUSTON (P)							
Population	27,027	51,378	71,751	97,235	127,570	161,304	203,958
1990 Use	4,749						
Below Normal Rainfall							
* Expected Conservation		10,360	13,824	17,972	23,150	28,729	36,097
Advanced Conservation		10,071	13,181	16,991	22,006	27,645	34,726
Normal rainfall							
Expected Conservation		8,748	11,654	15,139	19,434	24,031	30,157
Advanced Conservation		8,575	11,172	14,377	18,720	23,309	29,472
MISSOURI CITY (P)							
Population	32,219	56,517	72,282	92,580	117,269	145,778	181,218
1990 Use	6,005						
Below Normal Rainfall							
* Expected Conservation		10,636	12,873	15,659	19,441	23,840	29,637
Advanced Conservation		10,319	12,145	14,623	18,258	22,535	28,014
Normal rainfall							
Expected Conservation		9,624	11,578	14,104	17,471	21,391	26,389
Advanced Conservation		9,306	10,930	13,170	16,551	20,411	25,170
STAFFORD (P)							
Population	8,090	16,410	21,296	27,547	35,119	43,794	54,614
1990 Use	931						
Below Normal Rainfall							
* Expected Conservation		2,169	2,600	3,148	3,896	4,758	5,872
Advanced Conservation		2,077	2,409	2,869	3,580	4,414	5,505
Normal rainfall							
Expected Conservation		1,783	2,123	2,561	3,147	3,826	4,711
Advanced Conservation		1,709	1,979	2,346	2,911	3,581	4,466
SUGAR LAND							
Population	42,856	79,758	98,651	122,975	151,477	183,031	217,453
1990 Use	4,253						
Below Normal Rainfall							
* Expected Conservation		13,936	16,134	19,147	23,246	27,677	32,883
Advanced Conservation		13,401	15,249	17,770	21,548	25,832	30,691
Normal rainfall							
Expected Conservation		11,883	13,813	16,253	19,682	23,373	27,769
Advanced Conservation		11,435	13,040	15,152	18,495	22,142	26,063

GALVESTON COUNTY
MOST LIKELY GROWTH SCENARIO

Forecast Item	1990	2000	2010	2020	2030	2040	2050
FRIENDSWOOD (P)							
Population	14,979	21,079	27,673	35,063	42,936	48,310	54,357
1990 Use	1,873						
Below Normal Rainfall							
* Expected Conservation		3,070	3,720	4,438	5,290	5,845	6,576
Advanced Conservation		2,952	3,471	4,045	4,858	5,412	6,089
Normal rainfall							
Expected Conservation		2,668	3,193	3,771	4,521	4,978	5,601
Advanced Conservation		2,550	2,976	3,457	4,184	4,654	5,237

HARRIS COUNTY
MOST LIKELY GROWTH SCENARIO

Forecast Item	1990	2000	2010	2020	2030	2040	2050
FRIENDSWOOD (P)							
Population	7,835	11,337	17,089	26,504	38,491	57,649	77,708
1990 Use	980						
Below Normal Rainfall							
* Expected Conservation		1,651	2,297	3,355	4,743	6,974	9,401
Advanced Conservation		1,587	2,144	3,058	4,355	6,458	8,704
Normal rainfall							
Expected Conservation		1,435	1,972	2,850	4,053	5,941	8,008
Advanced Conservation		1,371	1,838	2,613	3,751	5,553	7,486
HOUSTON (P)							
Population	1,603,524	1,811,146	2,046,871	2,361,424	2,548,364	2,783,683	3,040,732
1990 Use	281,801						
Below Normal Rainfall							
* Expected Conservation		365,174	394,360	436,447	462,434	495,782	538,157
Advanced Conservation		355,030	376,018	412,641	439,598	477,073	517,721
Normal rainfall							
Expected Conservation		308,368	332,454	367,674	388,217	414,711	449,600
Advanced Conservation		302,282	318,698	349,158	373,943	402,238	439,381
MISSOURI CITY (P)							
Population	3,957	6,941	8,040	9,442	10,334	11,591	13,003
1990 Use	737						
Below Normal Rainfall							
* Expected Conservation		1,306	1,432	1,597	1,714	1,896	2,126
Advanced Conservation		1,268	1,351	1,492	1,610	1,792	2,010
Normal rainfall							
Expected Conservation		1,182	1,287	1,439	1,539	1,701	1,893
Advanced Conservation		1,142	1,215	1,343	1,458	1,623	1,807
PEARLAND (P)							
Population	1,463	2,503	2,883	3,363	3,640	4,006	4,409
1990 Use	237						
Below Normal Rainfall							
* Expected Conservation		379	408	448	474	511	563
Advanced Conservation		364	381	414	445	484	529
Normal rainfall							
Expected Conservation		361	388	430	453	489	534
Advanced Conservation		351	366	396	424	462	504
STAFFORD (P)							
Population	307	623	751	904	1,005	1,123	1,254
1990 Use	35						
Below Normal Rainfall							
* Expected Conservation		82	92	104	111	122	134
Advanced Conservation		79	84	95	102	114	127
Normal rainfall							
Expected Conservation		68	75	84	90	98	109
Advanced Conservation		65	70	77	83	92	102

Appendix D
Treatment Process Capital and O&M Costs

Conventional Treatment System

CAPITAL COSTS FOR 120 MGD INITIAL PHASE - CONVENTIONAL SYSTEM

Unit	Cost Estimate	Notes	Unit Cost	Units	Quantity
Sitework	$6,000,000		$120,000	per acre	50
Yard Piping	$7,200,000		$60,000	per mgd	120
Low Lift Pumping	$4,830,000	Includes VFDs	$35,000	per mgd	138
Mixing/Flocculation/Sedimentaiton	$12,420,000		$90,000	per mgd	138
Filters	$20,257,600	Deep bed, GAC/sand, air scour	$1,100	per sf	18,416
Transfer Pumping	$4,200,000	Includes VFDs	$35,000	per mgd	120
PAC System	$625,000	Silo storage	$125,000	per sys	5
Backwash Equalization Tank	$3,570,000	Tank and recycle pumps	$0.70	per gal	5,100,000
Backwash Clarification	$360,000	Lamella settlers	$120,000	per mgd	3.0
Gravity thickeners/holding tanks	$1,980,000		$600,000	per mgd	3.3
Chemical Systems,Building, Tanks	$4,950,000	Chlorine, caustic soda, ammonia, ferric,PEC,PEA, chlorine dioxide, flouride,orthophosphate,spare	$450,000	each	11
Centrifuges	$2,520,000		$840,000	each	3.0
Centirfuge Building	$3,230,000	Incl. conveyors, polymer,garage	$85	per sf	38,000
Ground Storage Tanks	$10,500,000		$0.35	per gal	30,000,000
Subtotal	**$82,642,600**				
Electrical, Instrumentation, and Controls	$10,743,538	Allowance	13%		
Subtotal	**$93,386,138**				
Mobilization	$2,801,584	Allowance	3%		
Subtotal	**$96,187,722**				
Construction Management, Insurance, Bonds,Profit	$12,504,404	Allowance	13%		
Construction Cost Subtotal	$108,692,126				
Total Capital Cost	$108,700,000	Rounded			
	$0.91	Per Gallon of Capacity			

Notes:

1. 150 MGD Finished Water Capacity
2. 120 MGD First Phase

CAPITAL COSTS FOR 30 MGD EXPANSION - CONVENTIONAL SYSTEM

Unit	Cost Estimate	Notes	Unit Cost	Units	Quantity
Sitework	$0		$120,000	per acre	0
Yard Piping	$1,800,000		$60,000	per mgd	30
Low Lift Pumping	$362,250	Includes VFDs	$10,500	per mgd	35
Mixing/Flocculation/Sedimentaiton	$3,105,000		$90,000	per mgd	35
Filters	$5,064,400	Deep bed, GAC/sand, air scour	$1,100	per sf	4,604
Transfer Pumping	$315,000	Includes VFDs	$10,500	per mgd	30
PAC System	$125,000	Silo storage	$125,000	per sys	1
Backwash Equalization Tank	$0	Tank and recycle pumps	$0.70	per gal	0
Backwash Clarification	$120,000	Lamella settlers	$120,000	per mgd	1.0
Gravity thickeners/holding tanks	$660,000		$600,000	per mgd	1.1
Chemical Systems,Building, Tanks	$1,485,000	Chlorine, caustic soda, ammonia, ferric,PEC,PEA, chlorine dioxide, flouride,orthophosphate,spare	$135,000	each	11
Centrifuges	$840,000		$840,000	each	1.0
Centirfuge Building	$0	Incl. conveyors, polymer,garage	$85	per sf	0
Ground Storage Tanks	$2,800,000		$0.35	per gal	8,000,000
Subtotal	**$16,676,650**				
Electrical, Instrumentation, and Controls	$2,167,965	Allowance	13%		
Subtotal	**$18,844,615**				
Mobilization	$565,338	Allowance	3%		
Subtotal	**$19,409,953**				
Construction Management, Insurance, Bonds,Profit	$2,523,294	Allowance	13%		
Construction Cost Subtotal	$21,933,247				
Total Capital Cost	$21,940,000	Rounded			
	$0.73	Per Gallon of Capacity			

Notes:

1. 150 MGD Finished Water Capacity
2. 30 MGD Expansion

High Rate Conventional Treatment System

CAPITAL COSTS FOR 120 MGD INITIAL PHASE - HIGH RATE CONVENTIONAL SYSTEM

Unit	Cost Estimate	Notes	Unit Cost	Units	Quantity
Sitework	$6,000,000		$120,000	per acre	50
Yard Piping	$7,200,000		$60,000	per mgd	120
Low Lift Pumping	$4,830,000	Includes VFDs	$35,000	per mgd	138
Mixing/Flocculation/Sedimentaiton	$10,306,400	Superpulsators			
Filters	$20,257,600	Deep bed, GAC/sand, air scour	$1,100	per sf	18,416
Transfer Pumping	$4,200,000	Includes VFDs	$35,000	per mgd	120
PAC System	$625,000	Silo storage	$125,000	per sys	5
Backwash Equalization Tank	$3,570,000	Tank and recycle pumps	$0.70	per gal	5,100,000
Backwash Clarification	$360,000	Lamella settlers	$120,000	per mgd	3.0
Gravity thickeners/holding tanks	$1,980,000		$600,000	per mgd	3.3
Chemical Systems,Building, Tanks	$4,950,000	Chlorine, caustic soda, ammonia, ferric,PEC,PEA, chlorine dioxide, flouride,orthophosphate,spare	$450,000	each	11
Centrifuges	$2,520,000		$840,000	each	3.0
Centirfuge Building	$3,230,000	Incl. conveyors, polymer,garage	$85	per sf	38,000
Ground Storage Tanks	$10,500,000		$0.35	per gal	30,000,000
Subtotal	**$80,529,000**				
Electrical, Instrumentation, and Controls	$10,468,770	Allowance	13%		
Subtotal	**$90,997,770**				
Mobilization	$2,729,933	Allowance	3%		
Subtotal	**$93,727,703**				
Construction Management, Insurance, Bonds,Profit	$12,184,601	Allowance	13%		
Construction Cost Subtotal	$105,912,305				
Total Capital Cost	$105,920,000	Rounded			
	$0.88	Per Gallon of Capacity			

Notes:

1. 150 MGD Finished Water Capacity
2. 120 MGD First Phase

CAPITAL COSTS FOR 30 MGD EXPANSION - HIGH RATE CONVENTIONAL SYSTEM

Unit	Cost Estimate	Notes	Unit Cost	Units	Quantity
Sitework	$0		$120,000	per acre	0
Yard Piping	$1,800,000		$60,000	per mgd	30
Low Lift Pumping	$362,250	Includes VFDs	$10,500	per mgd	35
Mixing/Flocculation/Sedimentaiton	$2,576,600	Superpulsators			
Filters	$5,064,400	Deep bed, GAC/sand, air scour	$1,100	per sf	4,604
Transfer Pumping	$315,000	Includes VFDs	$10,500	per mgd	30
PAC System	$125,000	Silo storage	$125,000	per sys	1
Backwash Equalization Tank	$0	Tank and recycle pumps	$0.70	per gal	0
Backwash Clarification	$120,000	Lamella settlers	$120,000	per mgd	1.0
Gravity thickeners/holding tanks	$660,000		$600,000	per mgd	1.1
Chemical Systems,Building, Tanks	$1,485,000	Chlorine, caustic soda, ammonia, ferric,PEC,PEA, chlorine dioxide, flouride,orthophosphate,spare	$135,000	each	11
Centrifuges	$840,000		$840,000	each	1.0
Centirfuge Building	$0	Incl. conveyors, polymer,garage	$85	per sf	0
Ground Storage Tanks	$2,800,000		$0.35	per gal	8,000,000
Subtotal	**$16,148,250**				
Electrical, Instrumentation, and Controls	$2,099,273	Allowance	13%		
Subtotal	**$18,247,523**				
Mobilization	$547,426	Allowance	3%		
Subtotal	**$18,794,948**				
Construction Management, Insurance, Bonds,Profit	$2,443,343	Allowance	13%		
Construction Cost Subtotal	$21,238,291				
Total Capital Cost	$21,240,000	Rounded			
	$0.71	Per Gallon of Capacity			

Notes:

1. 150 MGD Finished Water Capacity
2. 30 MGD First Phase

OPERATING AND MAINTENACE COSTS FOR HIGH RATE CONVENTIONAL SYSTEM

150.0 MGD Finished Water Capacity

VARIABLE COSTS

Electrical Costs — Cost per kW-hr = **$0.06**

	No. of Units	Horsepower	% Utilization	Power Consumption, kW-	Cost per kgal produced
Low Lift Pumps	4	473	100%	33,850	$0.0135
Clarifier System	4	25	100%	1,790	$0.0007
Backwash pumps and blowers	1	500	5%	448	$0.0002
Transfer Pumps	4	473	100%	33,850	$0.0135
WW EQ Recycle Pum[	4	50	75%	2,686	$0.0011
Sludge pumping and ı	6	75	75%	6,043	$0.0024
Centrifuge	3	300	47%	7,573	$0.0030
Miscellanous	1	200	100%	3,581	$0.0014
				Electrical Costs Subtotal	**$0.036**

Chemical Costs

		Cost ($/Ton-Dry Equivalent)	Dose (mg/l of dry equivalent)	Flow (mgd)	Cost per kgal produced
Ferric		$450	30	165.0	$0.062
Cationic Polymer		$1,000	5	165.0	$0.023
Anionic Polymer		$1,500	1	165.0	$0.003
Sodium Chlorite	(1.5 mg/l Chlorine dioxide dose)	$1,000	0.8	165.0	$0.004
Chlorine - ClO2	(1.5 mg/l Chlorine dioxide dose)	$400	0.8	165.0	$0.002
Chlorine - BW		$400	5	7.5	$0.000
Chlorine - Residual Disinfectant		$400	3	150.0	$0.005
Ammonia		$350	1.0	150.0	$0.001
PAC		$1,100	10.0	165.0	$0.050
Caustic Soda		$600	10.0	150.0	$0.025
Flouride		$1,500	0.6	150.0	$0.004
Corrosion Inhibitor, mg/L		$5,200	0.5	150.0	$0.011
				Chemical Costs Subtotal	**$0.190**

Sludge Disposal Costs

Sludge Produced, cy wet sludge/YR	Dried Percent Solids	Handling/Disposal, $/cy	Cost per kgal produced
79,000	**30%**	**$15.0**	**$0.022**

Raw Water Costs

Flow (MGD)	Cost ($ per 1000 gal)	Cost per kgal produced
165.0	**$0.07**	**$0.077**

Variable Operating Costs, cost per kgal treated **$0.325**

FIXED COSTS

Maintenance — % of CC's **1.7%**; Capital Costs $127,160,000; **$2,161,720**

GAC Replacement — 23,000 cu ft/yr; $ 100.00 per cu ft; **$2,300,000**

Labor

	No. of Equivalent Full-Time	Avg. $/Hr	Avg. Burdened Salary $/Hr	
Total	21	$18.67	$28.00	**$1,223,040**
Process Operators	9	$17.00	$25.50	$477,360
Electrician, Instrument Tech	4	$22.50	$33.75	$280,800
Maintenance	5	$18.00	$27.00	$280,800
Administration	2	$13.00	$19.50	$81,120
Superintendent	1	$33.00	$49.50	$102,960

Burden Multiplier 1.5

Admin **$600,000**

Fixed Operating Costs, cost per year **$6,284,760**

Membrane
Treatment System

CAPITAL COSTS FOR 120 MGD INTIAL PHASE - MEMBRANE SYSTEM

Unit	Cost Estimate	Notes	Unit Cost	Units	Quantity
Sitework	$7,500,000		$150,000	per acre	50
Yard Piping	$7,200,000		$60,000	per mgd	120
Low Lift Pumping	$4,830,000	Includes VFDs	$35,000	per mgd	138
Pretreatment Clarifiers	$8,479,728	Superpulsators			
Membrane Building	$9,244,800		$60	per sf	154,080
Membrane Equipment	$26,450,000	Membranes, feed pumps,BW pumps,CIP sys., control sys.			
PAC System	$625,000	Slurry tanks	$125,000	per sys	5
Backwash Equalization Tank	$3,060,000	Tank and recycle pumps	$0.60	per gal	5,100,000
Backwash Clarification	$3,900,000	Lamella settlers	$130,000	per mgd	30.0
Chemical Systems,Building, Tanks	$2,700,000	Chlorine, caustic soda, ammonia,ferric,chlorine dioxide	$450,000	ls per sys.	6
Gravity thickeners and holding tanks	$2,115,000		$600,000	per mgd	3.5
Centrifuges	$2,520,000		$840,000	per unit	3.0
Centirifuge Building	$3,230,000		$85	per sf	38,000
Ground Storage Tanks	$10,500,000		$0.35	per gal	30,000,000
Subtotal	**$92,354,528**				
Electrical, Instrumentation, and Controls	$13,853,179	Allowance	15%		
Subtotal	**$106,207,707**				
Mobilization	$3,186,231	Allowance	3%		
Subtotal	**$109,393,938**				
Construction Management, Insurance, Bonds,Profit	$14,221,212	Allowance	13%		
Construction Cost Subtotal	$123,615,150				
Total Capital Cost	$123,620,000	Rounded			
	$1.03	Per Gallon of Capacity			

Notes:

1. 150 MGD Ultimate Water Capacity
2. 120 MGD First Phase Construction

CAPITAL COSTS FOR 30 MGD EXPANSION - MEMBRANE SYSTEM

Unit	Cost Estimate	Notes	Unit Cost	Units	Quantity
Sitework	$0		$150,000	per acre	0
Yard Piping	$1,800,000		$60,000	per mgd	30
Low Lift Pumping	$362,250	Includes VFDs	$10,500	per mgd	35
Pretreatment Clarifiers	$2,119,932	Superpulsators			
Membrane Building	$0		$60	per sf	0
Membrane Equipment	$6,612,500	Membranes, feed pumps,BW pumps,CIP sys., control sys.			
PAC System	$125,000	Slurry tanks	$125,000	per sys	1
Backwash Equalization Tank	$0	Tank and recycle pumps	$0.60	per gal	0
Backwash Clarification	$1,300,000	Lamella settlers	$130,000	per mgd	10.0
Chemical Systems,Building, Tanks	$810,000	Chlorine, caustic soda, ammonia,ferric,chlorine dioxide	$135,000	ls per sys.	6
Gravity thickeners and holding tanks	$705,000		$600,000	per mgd	1.2
Centrifuges	$840,000		$840,000	per unit	1.0
Centirifuge Building	$0		$85	per sf	0
Ground Storage Tanks	$2,800,000		$0.35	per gal	8,000,000
Subtotal	**$17,474,682**				
Electrical, Instrumentation, and Controls	$2,621,202	Allowance	15%		
Subtotal	**$20,095,884**				
Mobilization	$602,877	Allowance	3%		
Subtotal	**$20,698,761**				
Construction Management, Insurance, Bonds,Profit	$2,690,839	Allowance	13%		
Construction Cost Subtotal	$23,389,600				
Total Capital Cost	$23,390,000	Rounded			
	$0.78	Per Gallon of Capacity			

Notes:

1. 150 MGD Finished Water Capacity
2. 30 MGD Expansion

OPERATING AND MAINTENACE COSTS FOR MEMBRANE SYSTEM

150.0 MGD Finished Water Capacity

VARIABLE COSTS

Electrical Costs — Cost per kW-hr = **$0.06**

	No. of Units	Horsepower	% Utilization	Power Consumption, kW-	Cost per kgal produced
Membrane FeedPump	20	200	100%	71,616	$0.0286
Recirculation Pumps	92	50	50%	41,179	$0.0165
Backwash pumps	10	40	100%	7,162	$0.0029
Low Lift Pumps	4	500	100%	35,808	$0.0143
Clarifier System	7	15	100%	1,880	$0.0008
WW EQ Recycle Pum	6	120	75%	9,668	$0.0039
Centrifuge	3	300	70%	11,280	$0.0045
Miscellanous	1	400	100%	7,162	$0.0029
				Electrical Costs Subtotal	**$0.074**

Chemical Costs

		Cost ($/Ton-Dry Equivalent)	Dose (mg/l of dry equivalent)	Flow (mgd)	Cost per kgal produced
Ferric		$450	15	172.5	$0.032
Sodium Chlorite	(1.5 mg/l Chlorine dioxide dose)	$1,000	0.8	172.5	$0.004
Chlorine - ClO2	(1.5 mg/l Chlorine dioxide dose)	$400	0.8	172.5	$0.002
Chlorine - BW		$400	5	14.9	$0.001
Chlorine - Residual Disinfectant		$400	3	150.0	$0.005
Ammonia		$350	1.0	150.0	$0.001
PAC		$1,100	10.0	172.5	$0.053
Caustic Soda		$600	10.0	150.0	$0.025
Flouride		$1,500	0.6	150.0	$0.004
Corrosion Inhibitor, mg/L		$5,200	0.5	150.0	$0.011
				Chemical Costs Subtotal	**$0.137**

Membrane Cleaning

No. per Year	\vg Chemical Cost	Cost per kgal produced
4	$ 249,250	**$ 0.018**

Sludge Disposal Costs

Sludge Produced, cy wet sludge/YR	Dried Percent Solids	Handling/Disposal, $/cy	Cost per kgal produced
110,000	**30%**	**$15.0**	**$0.030**

Raw Water Costs

Flow (MGD)	Cost ($ per 1000 gal)	Cost per kgal produced
172.5	**$0.07**	**$0.081**

Variable Operating Costs, cost per kgal treated **$0.341**

FIXED COSTS

Maintenance

% of CC's	Capital Costs	
2.5%	$147,010,000	**$3,675,000**

Membrane Replacement **$2,008,800**

Labor	No. of Equivalent Full-Time	Avg. $/Hr	Avg. Burdened Salary $/Hr	
Total	23	$28.21	$42.31	**$1,349,400**
Process Operators	9	$17.00	$25.50	$477,360
Electrician, Instrument Tech	5	$22.50	$33.75	$351,000
Maintenance	6	$18.00	$27.00	$336,960
Administration	2	$13.00	$19.50	$81,120
Superintendent	1	$33.00	$49.50	$102,960

Burden Multiplier 1.5

Admin **$600,000**

Fixed Operating Costs, cost per year **$7,633,200**

Appendix E
Construction and O&M Costs for High Rate Conventional Plant

35 MGD Plant

CAPITAL COSTS FOR 24 MGD INTIAL PHASE - HIGH RATE CONVENTIONAL SYSTEM

Unit	Cost Estimate	Notes	Unit Cost	Units	Quantity
Sitework	$3,500,000		$175,000	per acre	20
Yard Piping	$2,040,000		$85,000	per mgd	24
Low Lift Pumping	$1,104,000	Includes VFDs	$40,000	per mgd	28
Mixing/Flocculation/Sedimentaiton	$2,150,400	Superpulsators			
Filters	$6,006,857	Deep bed, GAC/sand, air scour	$1,500	per sf	4,005
Transfer Pumping	$1,104,000	Includes VFDs	$40,000	per mgd	28
PAC System	$250,000	Silo storage	$125,000	per sys	2
Backwash Equalization Tank	$540,000	Tank and recycle pumps	$0.90	per gal	600,000
Backwash Clarification	$78,750	Lamella settlers	$175,000	per mgd	0.5
Gravity thickeners/holding tanks	$450,000		$1,200,000	per mgd	0.4
Chemical Systems,Building, Tanks	$4,950,000	Chlorine, caustic soda, ammonia, ferric,PEC,PEA, chlorine dioxide, flouride,orthophosphate,spare	$450,000	ls per sys.	11
Sludge Lagoons	$1,633,333		$175,000	per acre	9.3
Ground Storage Tanks	$2,400,000		$0.40	per gal	6,000,000
Subtotal	**$26,207,340**				
Electrical, Instrumentation, and Controls	$3,406,954	Allowance	13%		
Subtotal	**$29,614,295**				
Mobilization	$888,429	Allowance	3%		
Subtotal	**$30,502,724**				
Construction Management, Insurance, Bonds,Profit	$3,965,354	Allowance	13%		
Construction Cost Subtotal	$34,468,078				
Total Capital Cost	$34,470,000	Rounded			
	$1.44	Per Gallon of Capacity			

Notes:

1. 35 MGD Finished Water Capacity
2. 24 MGD First Phase

OPERATING AND MAINTENACE COSTS FOR HIGH RATE CONVENTIONAL SYSTEM

24.0 MGD Finished Water Capacity

VARIABLE COSTS

Electrical Costs Cost per kW-hr = **$0.06**

	No. of Units	Horsepower	% Utilization	Power Consumption, kW-hr	Cost per kgal produced
Low Lift Pumps	4	100	100%	7,162	$0.0179
Clarifier System	2	15	100%	537	$0.0013
Backwash pumps and blowers	1	400	5%	358	$0.0009
Transfer Pumps	4	100	100%	7,162	$0.0179
WW EQ Recycle Pum	2	30	75%	806	$0.0020
Sludge pumping and	4	30	75%	1,611	$0.0040
Centrifuge	0	300	70%	0	$0.0000
Miscellanous	1	100	100%	1,790	$0.0045
				Electrical Costs Subtotal	**$0.049**

Chemical Costs

		Cost ($/Ton-Dry Equivalent)	Dose (mg/l of dry equivalent)	Flow (mgd)	Cost per kgal produced
Ferric		$450	30	26.4	$0.062
Cationic Polymer		$1,000	5	26.4	$0.023
Anionic Polymer		$1,500	1	26.4	$0.003
Sodium Chlorite	(1.5 mg/l Chlorine dioxide dose)	$1,000	0.8	26.4	$0.004
Chlorine - ClO2	(1.5 mg/l Chlorine dioxide dose)	$400	0.8	26.4	$0.002
Chlorine - BW		$400	5	1.2	$0.000
Chlorine - Residual Disinfectant		$400	3	24.0	$0.005
Ammonia		$350	1.0	24.0	$0.001
PAC		$1,100	10.0	26.4	$0.050
Caustic Soda		$600	10.0	24.0	$0.025
Flouride		$1,500	0.6	24.0	$0.004
Corrosion Inhibitor, mg/L		$5,200	0.5	24.0	$0.011
				Chemical Costs Subtotal	**$0.190**

Sludge Disposal Costs

Sludge Produced, cy wet sludge/YR	Dried Percent Solids	Handling/Disposal, $/cy	Cost per kgal produced
5,623	**45%**	**$15.0**	**$0.010**

Raw Water Costs

Flow (MGD)	Cost ($ per 1000 gal)	Cost per kgal produced
26.4	**$0.07**	**$0.077**

Variable Operating Costs, cost per kgal treated **$0.326**

FIXED COSTS

Maintenance

% of CC's	Capital Costs	Annual Cost
1.7%	$34,470,000	**$585,990**

GAC Replacement **3999 cu ft/yr** $ 100.00 per cu ft **$399,909**

Labor		No. of Equivalent Full-Time	Avg. Salary $/Hr	Avg. Burdened Salary $/Hr	
	Total	12.5	$18.44	$27.66	**$719,160**
	Process Operators	6	$17.00	$25.50	$318,240
	Electrician, Instrument Tech	2	$22.50	$33.75	$140,400
	Maintenance	3	$18.00	$27.00	$168,480
	Administration	1	$13.00	$19.50	$40,560
	Superintendent	0.5	$33.00	$49.50	$51,480
	Burden Multiplier	1.5			

Admin **$600,000**

Fixed Operating Costs, cost per year **$2,305,059**

CAPITAL COSTS FOR 11 MGD EXPANSION - HIGH RATE CONVENTIONAL SYSTEM

Unit	Cost Estimate	Notes	Unit Cost	Units	Quantity
Sitework	$0		$175,000	per acre	0
Yard Piping	$935,000		$85,000	per mgd	11
Low Lift Pumping	$151,800	Includes VFDs	$12,000	per mgd	13
Mixing/Flocculation/Sedimentaiton	$985,600	Superpulsators			
Filters	$2,753,143	Deep bed, GAC/sand, air scour	$1,500	per sf	1,835
Transfer Pumping	$132,000	Includes VFDs	$12,000	per mgd	11
PAC System	$0	Silo storage	$125,000	per sys	0
Backwash Equalization Tank	$0	Tank and recycle pumps	$0.90	per gal	0
Backwash Clarification	$26,250	Lamella settlers	$175,000	per mgd	0.2
Gravity thickeners/holding tanks	$150,000		$1,200,000	per mgd	0.1
Chemical Systems,Building, Tanks	$1,485,000	Chlorine, caustic soda, ammonia, ferric,PEC,PEA, chlorine dioxide, flouride,orthophosphate,spare	$135,000	ls per sys.	11
Sludge Lagoons	$816,667		$175,000	per acre	4.7
Ground Storage Tanks	$1,200,000		$0.40	per gal	3,000,000
Subtotal	**$8,635,460**				
Electrical, Instrumentation, and Controls	$1,122,610	Allowance	13%		
Subtotal	**$9,758,069**				
Mobilization	$292,742	Allowance	3%		
Subtotal	**$10,050,811**				
Construction Management, Insurance, Bonds,Profit	$1,306,605	Allowance	13%		
Construction Cost Subtotal	$11,357,417				
Total Capital Cost	$11,360,000	Rounded			
	$0.32	Per Gallon of Capacity			

Notes:

1. 35 MGD Finished Water Capacity
2. 11 MGD Expansion

OPERATING AND MAINTENACE COSTS FOR HIGH RATE CONVENTIONAL SYSTEM

35.0 MGD Finished Water Capacity

VARIABLE COSTS

Electrical Costs — Cost per kW-hr = **$0.06**

	No. of Units	Horsepower	% Utilization	Power Consumption, kW-	Cost per kgal produced
Low Lift Pumps	4	200	100%	14,323	$0.0246
Clarifier System	2	15	100%	537	$0.0009
Backwash pumps and blowers	1	400	5%	358	$0.0006
Transfer Pumps	4	200	100%	14,323	$0.0246
WW EQ Recycle Pum	2	30	75%	806	$0.0014
Sludge pumping and	4	30	75%	1,611	$0.0028
Centrifuge	0	300	70%	0	$0.0000
Miscellanous	1	100	100%	1,790	$0.0031
				Electrical Costs Subtotal	**$0.058**

Chemical Costs

		Cost ($/Ton-Dry Equivalent)	Dose (mg/l of dry equivalent)	Flow (mgd)	Cost per kgal produced
Ferric		$450	30	38.5	$0.062
Cationic Polymer		$1,000	5	38.5	$0.023
Anionic Polymer		$1,500	1	38.5	$0.003
Sodium Chlorite	(1.5 mg/l Chlorine dioxide dose)	$1,000	0.8	38.5	$0.004
Chlorine - ClO2	(1.5 mg/l Chlorine dioxide dose)	$400	0.8	38.5	$0.002
Chlorine - BW		$400	5	1.8	$0.000
Chlorine - Residual Disinfectant		$400	3	35.0	$0.005
Ammonia		$350	1.0	35.0	$0.001
PAC		$1,100	10.0	38.5	$0.050
Caustic Soda		$600	10.0	35.0	$0.025
Flouride		$1,500	0.6	35.0	$0.004
Corrosion Inhibitor, mg/L		$5,200	0.5	35.0	$0.011
				Chemical Costs Subtotal	**$0.190**

Sludge Disposal Costs

Sludge Produced, cy wet sludge/YR	Dried Percent Solids	Handling/Disposal, $/cy	Cost per kgal produced
8,200	**45%**	**$15.0**	**$0.010**

Raw Water Costs

Flow (MGD)	Cost ($ per 1000 gal)	Cost per kgal produced
38.5	**$0.07**	**$0.077**

Variable Operating Costs, cost per kgal treated **$0.335**

FIXED COSTS

Maintenance

% of CC's	Capital Costs	
1.7%	$45,830,000	**$779,110**

GAC Replacement 5832 **cu ft/yr** $ 100.00 per cu ft **$583,200**

Labor

	No. of Equivalent Full-Time	Avg. Salary $/Hr	Avg. Burdened Salary $/Hr	
Total	12.5	$18.44	$27.66	**$719,160**
Process Operators	6	$17.00	$25.50	$318,240
Electrician, Instrument Tech	2	$22.50	$33.75	$140,400
Maintenance	3	$18.00	$27.00	$168,480
Administration	1	$13.00	$19.50	$40,560
Superintendent	0.5	$33.00	$49.50	$51,480

Burden Multiplier 1.5

Admin **$600,000**

Fixed Operating Costs, cost per year **$2,681,470**

115 MGD Plant

CAPITAL COSTS FOR 95 MGD INITIAL PHASE - HIGH RATE CONVENTIONAL SYSTEM

Unit	Cost Estimate	Notes	Unit Cost	Units	Quantity
Sitework	$5,250,000		$150,000	per acre	35
Yard Piping	$5,700,000		$60,000	per mgd	95
Low Lift Pumping	$3,823,750	Includes VFDs	$35,000	per mgd	109
Mixing/Flocculation/Sedimentaiton	$7,666,583	Superpulsators			
Filters	$17,744,348	Deep bed, GAC/sand, air scour	$1,200	per sf	14,787
Transfer Pumping	$3,823,750	Includes VFDs	$35,000	per mgd	109
PAC System	$375,000	Silo storage	$125,000	per sys	3
Backwash Equalization Tank	$800,000	Tank and recycle pumps	$0.80	per gal	1,000,000
Backwash Clarification	$511,875	Lamella settlers	$175,000	per mgd	2.9
Gravity thickeners/holding tanks	$1,530,000		$600,000	per mgd	2.6
Chemical Systems,Building, Tanks	$4,950,000	Chlorine, caustic soda, ammonia, ferric,PEC,PEA, chlorine dioxide, flouride,orthophosphate,spare	$450,000	each	11
Centrifuges	$2,520,000		$840,000	each	3.0
Centirfuge Building	$3,230,000	Incl. conveyors, polymer,garage	$85	per sf	38,000
Ground Storage Tanks	$9,600,000		$0.40	per gal	24,000,000
Subtotal	**$67,525,305**				
Electrical, Instrumentation, and Controls	$8,778,290	Allowance	13%		
Subtotal	**$76,303,595**				
Mobilization	$2,289,108	Allowance	3%		
Subtotal	**$78,592,703**				
Construction Management, Insurance, Bonds,Profit	$10,217,051	Allowance	13%		
Construction Cost Subtotal	$88,809,754				
Total Capital Cost	$88,810,000	Rounded			
	$0.93	Per Gallon of Capacity			

Notes:

1. 115 MGD Finished Water Capacity
2. 95 MGD First Phase

OPERATING AND MAINTENACE COSTS FOR HIGH RATE CONVENTIONAL SYSTEM

95.0 MGD Finished Water Capacity

VARIABLE COSTS

Electrical Costs

Cost per kW-hr = **$0.06**

	No. of Units	Horsepower	% Utilization	Power Consumption, kW-	Cost per kgal produced
Low Lift Pumps	4	300	100%	21,485	$0.0136
Clarifier System	4	20	100%	1,432	$0.0009
Backwash pumps and blowers	1	500	5%	448	$0.0003
Transfer Pumps	4	300	100%	21,485	$0.0136
WW EQ Recycle Pum	3	20	75%	806	$0.0005
Sludge pumping and	4	50	75%	2,686	$0.0017
Centrifuge	4	300	35%	7,520	$0.0047
Miscellanous	1	200	100%	3,581	$0.0023
				Electrical Costs Subtotal	**$0.038**

Chemical Costs

		Cost ($/Ton-Dry Equivalent)	Dose (mg/l of dry equivalent)	Flow (mgd)	Cost per kgal produced
Ferric		$450	30	104.5	$0.062
Cationic Polymer		$1,000	5	104.5	$0.023
Anionic Polymer		$1,500	1	104.5	$0.003
Sodium Chlorite	(1.5 mg/l Chlorine dioxide dose)	$1,000	0.8	104.5	$0.004
Chlorine - ClO2	(1.5 mg/l Chlorine dioxide dose)	$400	0.8	104.5	$0.002
Chlorine - BW		$400	5	4.8	$0.000
Chlorine - Residual Disinfectant		$400	3	95.0	$0.005
Ammonia		$350	1.0	95.0	$0.001
PAC		$1,100	10.0	104.5	$0.050
Caustic Soda		$600	10.0	95.0	$0.025
Flouride		$1,500	0.6	95.0	$0.004
Corrosion Inhibitor, mg/L		$5,200	0.5	95.0	$0.011
				Chemical Costs Subtotal	**$0.190**

Sludge Disposal Costs

Sludge Produced, cy wet sludge/YR	Dried Percent Solids	Handling/Disposal, $/cy	Cost per kgal produced
53,696	**30%**	**$15.0**	**$0.023**

Raw Water Costs

Flow (MGD)	Cost ($ per 1000 gal)	Cost per kgal produced
104.5	**$0.07**	**$0.077**

Variable Operating Costs, cost per kgal treated **$0.328**

FIXED COSTS

Maintenance

% of CC's	Capital Costs	
1.7%	$88,810,000	**$1,509,770**

GAC Replacement 14,803 **cu ft/yr** $ 100.00 per cu ft **$1,480,348**

Labor

	No. of Equivalent	Avg. $/Hr	Avg. Burdened Salary $/Hr	
Total	15.5	$18.58	$27.87	**$898,560**
Process Operators	7	$17.00	$25.50	$371,280
Electrician, Instrument Tech	3	$22.50	$33.75	$210,600
Maintenance	4	$18.00	$27.00	$224,640
Administration	1	$13.00	$19.50	$40,560
Superintendent	0.5	$33.00	$49.50	$51,480

Burden Multiplier 1.5

Admin **$600,000**

Fixed Operating Costs, cost per year **$4,488,678**

CAPITAL COSTS FOR 20 MGD EXPANSION - HIGH RATE CONVENTIONAL SYSTEM

Unit	Cost Estimate	Notes	Unit Cost	Units	Quantity
Sitework	$0		$150,000	per acre	0
Yard Piping	$1,200,000		$60,000	per mgd	20
Low Lift Pumping	$241,500	Includes VFDs	$10,500	per mgd	23
Mixing/Flocculation/Sedimentaiton	$1,614,017	Superpulsators			
Filters	$3,735,652	Deep bed, GAC/sand, air scour	$1,200	per sf	3,113
Transfer Pumping	$210,000	Includes VFDs	$10,500	per mgd	20
PAC System	$125,000	Silo storage	$125,000	per sys	1
Backwash Equalization Tank	$0	Tank and recycle pumps	$0.80	per gal	0
Backwash Clarification	$170,625	Lamella settlers	$175,000	per mgd	1.0
Gravity thickeners/holding tanks	$510,000		$600,000	per mgd	0.9
Chemical Systems,Building, Tanks	$1,485,000	Chlorine, caustic soda, ammonia, ferric,PEC,PEA, chlorine dioxide, flouride,orthophosphate,spare	$135,000	each	11
Centrifuges	$840,000		$840,000	each	1.0
Centirfuge Building	$0	Incl. conveyors, polymer,garage	$85	per sf	0
Ground Storage Tanks	$2,000,000		$0.40	per gal	5,000,000
Subtotal	**$12,131,795**				
Electrical, Instrumentation, and Controls	$1,577,133	Allowance	13%		
Subtotal	**$13,708,928**				
Mobilization	$411,268	Allowance	3%		
Subtotal	**$14,120,196**				
Construction Management, Insurance, Bonds,Profit	$1,835,625	Allowance	13%		
Construction Cost Subtotal	$15,955,821				
Total Capital Cost	$15,960,000	Rounded			
	$0.80	Per Gallon of Capacity			

Notes:

1. 115 MGD Finished Water Capacity
2. 20 MGD Expansion

OPERATING AND MAINTENACE COSTS FOR HIGH RATE CONVENTIONAL SYSTEM

115.0 MGD Finished Water Capacity

VARIABLE COSTS

Electrical Costs Cost per kW-hr = **$0.06**

	No. of Units	Horsepower	% Utilization	Power Consumption, kW-	Cost per kgal produced
Low Lift Pumps	4	400	100%	28,646	$0.0149
Clarifier System	4	20	100%	1,432	$0.0007
Backwash pumps and blowers	1	500	5%	448	$0.0002
Transfer Pumps	4	400	100%	28,646	$0.0149
WW EQ Recycle Pum	3	20	75%	806	$0.0004
Sludge pumping and	4	50	75%	2,686	$0.0014
Centrifuge	4	300	35%	7,520	$0.0039
Miscellanous	1	200	100%	3,581	$0.0019
				Electrical Costs Subtotal	**$0.038**

Chemical Costs

		Cost ($/Ton-Dry Equivalent)	Dose (mg/l of dry equivalent)	Flow (mgd)	Cost per kgal produced
Ferric		$450	30	126.5	$0.062
Cationic Polymer		$1,000	5	126.5	$0.023
Anionic Polymer		$1,500	1	126.5	$0.003
Sodium Chlorite	(1.5 mg/l Chlorine dioxide dose)	$1,000	0.8	126.5	$0.004
Chlorine - ClO2	(1.5 mg/l Chlorine dioxide dose)	$400	0.8	126.5	$0.002
Chlorine - BW		$400	5	5.8	$0.000
Chlorine - Residual Disinfectant		$400	3	115.0	$0.005
Ammonia		$350	1.0	115.0	$0.001
PAC		$1,100	10.0	126.5	$0.050
Caustic Soda		$600	10.0	115.0	$0.025
Flouride		$1,500	0.6	115.0	$0.004
Corrosion Inhibitor, mg/L		$5,200	0.5	115.0	$0.011
				Chemical Costs Subtotal	**$0.190**

Sludge Disposal Costs

Sludge Produced, cy wet sludge/YR	Dried Percent Solids	Handling/Disposal, $/cy	Cost per kgal produced
65,000	**30%**	**$15.0**	**$0.023**

Raw Water Costs

Flow (MGD)	Cost ($ per 1000 gal)	Cost per kgal produced
126.5	**$0.07**	**$0.077**

Variable Operating Costs, cost per kgal treated **$0.329**

FIXED COSTS

	% of CC's	Capital Costs	
Maintenance	**1.7%**	$104,770,000	**$1,781,090**

GAC Replacement 17,920 **cu ft/yr** $ 100.00 per cu ft **$1,792,000**

Labor	No. of Equivalent Full-Time	Avg. $/Hr	Avg. Burdened Salary $/Hr	
Total	15.5	$18.58	$27.87	**$898,560**
Process Operators	7	$17.00	$25.50	$371,280
Electrician, Instrument Tech	3	$22.50	$33.75	$210,600
Maintenance	4	$18.00	$27.00	$224,640
Administration	1	$13.00	$19.50	$40,560
Superintendent	0.5	$33.00	$49.50	$51,480

Burden Multiplier 1.5

Admin **$600,000**

Fixed Operating Costs, cost per year **$5,071,650**

150 MGD Plant

CAPITAL COSTS FOR 120 MGD INITIAL PHASE - HIGH RATE CONVENTIONAL SYSTEM

Unit	Cost Estimate	Notes	Unit Cost	Units	Quantity
Sitework	$6,000,000		$120,000	per acre	50
Yard Piping	$7,200,000		$60,000	per mgd	120
Low Lift Pumping	$4,830,000	Includes VFDs	$35,000	per mgd	138
Mixing/Flocculation/Sedimentaiton	$10,306,400	Superpulsators			
Filters	$20,257,600	Deep bed, GAC/sand, air scour	$1,100	per sf	18,416
Transfer Pumping	$4,200,000	Includes VFDs	$35,000	per mgd	120
PAC System	$625,000	Silo storage	$125,000	per sys	5
Backwash Equalization Tank	$3,570,000	Tank and recycle pumps	$0.70	per gal	5,100,000
Backwash Clarification	$360,000	Lamella settlers	$120,000	per mgd	3.0
Gravity thickeners/holding tanks	$1,980,000		$600,000	per mgd	3.3
Chemical Systems,Building, Tanks	$4,950,000	Chlorine, caustic soda, ammonia, ferric,PEC,PEA, chlorine dioxide, flouride,orthophosphate,spare	$450,000	each	11
Centrifuges	$2,520,000		$840,000	each	3.0
Centirfuge Building	$3,230,000	Incl. conveyors, polymer,garage	$85	per sf	38,000
Ground Storage Tanks	$10,500,000		$0.35	per gal	30,000,000
Subtotal	**$80,529,000**				
Electrical, Instrumentation, and Controls	$10,468,770	Allowance	13%		
Subtotal	**$90,997,770**				
Mobilization	$2,729,933	Allowance	3%		
Subtotal	**$93,727,703**				
Construction Management, Insurance, Bonds,Profit	$12,184,601	Allowance	13%		
Construction Cost Subtotal	$105,912,305				
Total Capital Cost	$105,920,000	Rounded			
	$0.88	Per Gallon of Capacity			

Notes:

1. 150 MGD Finished Water Capacity
2. 120 MGD First Phase

OPERATING AND MAINTENACE COSTS FOR HIGH RATE CONVENTIONAL SYSTEM

120.0 MGD Finished Water Capacity

VARIABLE COSTS

Electrical Costs — Cost per kW-hr = **$0.06**

	No. of Units	Horsepower	% Utilization	Power Consumption, kW-	Cost per kgal produced
Low Lift Pumps	4	378	100%	27,080	$0.0135
Clarifier System	4	25	100%	1,790	$0.0009
Backwash pumps and	1	500	5%	448	$0.0002
Transfer Pumps	4	378	100%	27,080	$0.0135
WW EQ Recycle Pumps	4	50	75%	2,686	$0.0013
Sludge pumping and mixing	6	75	75%	6,043	$0.0030
Centrifuge	3	300	47%	7,573	$0.0038
Miscellanous	1	200	100%	3,581	$0.0018
				Electrical Costs Subtotal	**$0.038**

Chemical Costs

		Cost ($/Ton-Dry Equivalent)	Dose (mg/l of dry equivalent)	Flow (mgd)	Cost per kgal produced
Ferric		$450	30	132.0	$0.062
Cationic Polymer		$1,000	5	132.0	$0.023
Anionic Polymer		$1,500	1	132.0	$0.003
Sodium Chlorite	(1.5 mg/l Chlorine dioxide dose)	$1,000	0.8	132.0	$0.004
Chlorine - ClO2	(1.5 mg/l Chlorine dioxide dose)	$400	0.8	132.0	$0.002
Chlorine - BW		$400	5	6.0	$0.000
Chlorine - Residual Disinfectant		$400	3	120.0	$0.005
Ammonia		$350	1.0	120.0	$0.001
PAC		$1,100	10.0	132.0	$0.050
Caustic Soda		$600	10.0	120.0	$0.025
Flouride		$1,500	0.6	120.0	$0.004
Corrosion Inhibitor, mg/L		$5,200	0.5	120.0	$0.011
				Chemical Costs Subtotal	**$0.190**

Sludge Disposal Costs

	Sludge Produced, cy wet sludge/YR	Dried Percent Solids	Handling/Disposal, $/cy	Cost per kgal produced
	63,200	**30%**	**$15.0**	**$0.022**

Raw Water Costs

	Flow (MGD)	Cost ($ per 1000 gal)	Cost per kgal produced
	132.0	**$0.07**	**$0.077**

Variable Operating Costs, cost per kgal treated **$0.327**

FIXED COSTS

Maintenance			% of CC's **1.7%**	Capital Costs $105,920,000	**$1,800,640**
GAC Replacement		18,400 cu ft/yr	$ 100.00	per cu ft	**$1,840,000**

Labor		No. of Equivalent Full-Time	Avg. $/Hr	Avg. Burdened Salary $/Hr	
	Total	21	$18.67	$28.00	**$1,223,040**
	Process Operators	9	$17.00	$25.50	$477,360
	Electrician, Instrument Tech	4	$22.50	$33.75	$280,800
	Maintenance	5	$18.00	$27.00	$280,800
	Administration	2	$13.00	$19.50	$81,120
	Superintendent	1	$33.00	$49.50	$102,960
	Burden Multiplier	1.5			

Admin **$600,000**

Fixed Operating Costs, cost per year **$5,463,680**

CAPITAL COSTS FOR 30 MGD EXPANSION - HIGH RATE CONVENTIONAL SYSTEM

Unit	Cost Estimate	Notes	Unit Cost	Units	Quantity
Sitework	$0		$120,000	per acre	0
Yard Piping	$1,800,000		$60,000	per mgd	30
Low Lift Pumping	$362,250	Includes VFDs	$10,500	per mgd	35
Mixing/Flocculation/Sedimentaiton	$2,576,600	Superpulsators			
Filters	$5,064,400	Deep bed, GAC/sand, air scour	$1,100	per sf	4,604
Transfer Pumping	$315,000	Includes VFDs	$10,500	per mgd	30
PAC System	$125,000	Silo storage	$125,000	per sys	1
Backwash Equalization Tank	$0	Tank and recycle pumps	$0.70	per gal	0
Backwash Clarification	$120,000	Lamella settlers	$120,000	per mgd	1.0
Gravity thickeners/holding tanks	$660,000		$600,000	per mgd	1.1
Chemical Systems,Building, Tanks	$1,485,000	Chlorine, caustic soda, ammonia, ferric,PEC,PEA, chlorine dioxide, flouride,orthophosphate,spare	$135,000	each	11
Centrifuges	$840,000		$840,000	each	1.0
Centirfuge Building	$0	Incl. conveyors, polymer,garage	$85	per sf	0
Ground Storage Tanks	$2,800,000		$0.35	per gal	8,000,000
Subtotal	**$16,148,250**				
Electrical, Instrumentation, and Controls	$2,099,273	Allowance	13%		
Subtotal	**$18,247,523**				
Mobilization	$547,426	Allowance	3%		
Subtotal	**$18,794,948**				
Construction Management, Insurance, Bonds,Profit	$2,443,343	Allowance	13%		
Construction Cost Subtotal	$21,238,291				
Total Capital Cost	$21,240,000	Rounded			
	$0.71	Per Gallon of Capacity			

Notes:

1. 150 MGD Finished Water Capacity
2. 30 MGD First Phase

OPERATING AND MAINTENACE COSTS FOR HIGH RATE CONVENTIONAL SYSTEM

150.0 MGD Finished Water Capacity

VARIABLE COSTS

Electrical Costs — Cost per kW-hr = **$0.06**

	No. of Units	Horsepower	% Utilization	Power Consumption, kW-	Cost per kgal produced
Low Lift Pumps	4	473	100%	33,850	$0.0135
Clarifier System	4	25	100%	1,790	$0.0007
Backwash pumps and blowers	1	500	5%	448	$0.0002
Transfer Pumps	4	473	100%	33,850	$0.0135
WW EQ Recycle Pum]	4	50	75%	2,686	$0.0011
Sludge pumping and ı	6	75	75%	6,043	$0.0024
Centrifuge	3	300	47%	7,573	$0.0030
Miscellanous	1	200	100%	3,581	$0.0014
				Electrical Costs Subtotal	**$0.036**

Chemical Costs

		Cost ($/Ton-Dry Equivalent)	Dose (mg/l of dry equivalent)	Flow (mgd)	Cost per kgal produced
Ferric		$450	30	165.0	$0.062
Cationic Polymer		$1,000	5	165.0	$0.023
Anionic Polymer		$1,500	1	165.0	$0.003
Sodium Chlorite	(1.5 mg/l Chlorine dioxide dose)	$1,000	0.8	165.0	$0.004
Chlorine - ClO2	(1.5 mg/l Chlorine dioxide dose)	$400	0.8	165.0	$0.002
Chlorine - BW		$400	5	7.5	$0.000
Chlorine - Residual Disinfectant		$400	3	150.0	$0.005
Ammonia		$350	1.0	150.0	$0.001
PAC		$1,100	10.0	165.0	$0.050
Caustic Soda		$600	10.0	150.0	$0.025
Flouride		$1,500	0.6	150.0	$0.004
Corrosion Inhibitor, mg/L		$5,200	0.5	150.0	$0.011
				Chemical Costs Subtotal	**$0.190**

Sludge Disposal Costs

Sludge Produced, cy wet sludge/YR	Dried Percent Solids	Handling/Disposal, $/cy	Cost per kgal produced
79,000	**30%**	**$15.0**	**$0.022**

Raw Water Costs

Flow (MGD)	Cost ($ per 1000 gal)	Cost per kgal produced
165.0	**$0.07**	**$0.077**

Variable Operating Costs, cost per kgal treated **$0.325**

FIXED COSTS

			% of CC's	Capital Costs	
Maintenance			**1.7%**	$127,160,000	**$2,161,720**
GAC Replacement	23,000 **cu ft/yr**	**$**	100.00	per cu ft	**$2,300,000**

Labor		No. of Equivalent Full-Time	Avg. $/Hr	Avg. Burdened Salary $/Hr	
	Total	21	$18.67	$28.00	**$1,223,040**
	Process Operators	9	$17.00	$25.50	$477,360
	Electrician, Instrument Tech	4	$22.50	$33.75	$280,800
	Maintenance	5	$18.00	$27.00	$280,800
	Administration	2	$13.00	$19.50	$81,120
	Superintendent	1	$33.00	$49.50	$102,960
	Burden Multiplier	1.5			

Admin **$600,000**

Fixed Operating Costs, cost per year **$6,284,760**

Appendix F
Alternative Plant Site Costs

Capital and O&M Costs		
Alternative 1B: 150 MGD Plant at Sugar Land Site With Intermediate Booster Pump Station		
ITEMS	COST (M$, YR 2000)	
	120 MGD Initial Phase	30 MGD Expansion
Water Treatment Plant		
Property	$ 3,400,000	$ -
Plant	$ 105,920,000	$ 21,240,000
Additional Structural	$ 5,300,000	$ 1,060,000
Finished Water Transmission		
High Service Pump Station	$ 6,720,000	$ 1,680,000
Booster Pump Station and Ground Storage	$ 2,440,000	$ 270,000
Chlorine Booster Station	$ 450,000	$ 50,000
Pipelines	$ 63,180,000	$ -
Easements	$ 1,770,000	$ -
Raw Water Improvements		
Canals	$ 430,000	$ -
Raw Water Pump Station	$ 1,470,000	$ 370,000
Subtotal	**$ 191,080,000**	**$ 24,670,000**
Engineering Contingency (10%)	$ 19,110,000	$ 2,470,000
Construction Contingency (5%)	$ 9,550,000	$ 1,230,000
Cost Contingency (20%)	$ 38,220,000	$ 4,930,000
Total Construction	**$ 257,960,000**	**$ 33,300,000**
Engineering (15%)	$ 38,690,000	$ 5,000,000
Construction Administration (5%)	$ 12,900,000	$ 1,670,000
GCWA Administration (3%)	$ 7,740,000	$ 1,000,000
Total Capital Cost	**$ 317,290,000**	**$ 40,970,000**

Annual O&M Costs		
ITEMS	COST (M$, YR 2000)	
	2010-2030 (120 MGD)	2030-2050 (150 MGD)
Plant	$ 19,800,000	$ 24,080,000
Finished Water Pumping and Pipelines	$ 2,590,000	$ 3,300,000
Raw Water	$ 300,000	$ 370,000
Total Annual O&M Cost	**$ 22,690,000**	**$ 27,750,000**

Capital and O&M Costs

Alternative 2B: 150 MGD Plant at FBWCID No.2 Site With Intermediate Booster Pump Station

ITEMS	COST (M$, YR 2000)	
	120 MGD Initial Phase	30 MGD Expansion
Water Treatment Plant		
Property	$ 750,000	$ -
Plant	$ 105,920,000	$ 21,240,000
Finished Water Transmission		
High Service Pump Station	$ 6,720,000	$ 1,680,000
Booster Pump Station and Ground Storage	$ 2,440,000	$ 270,000
Chlorine Booster Station	$ 450,000	$ 50,000
Pipelines	$ 56,030,000	$ -
Easements	$ 1,770,000	$ -
Raw Water Improvements		
Canals	$ 430,000	$ -
Raw Water Pump Stations	$ 2,940,000	$ 740,000
Subtotal	**$ 177,450,000**	**$ 23,980,000**
Engineering Contingency (10%)	$ 17,750,000	$ 2,400,000
Construction Contingency (5%)	$ 8,870,000	$ 1,200,000
Cost Contingency (20%)	$ 35,490,000	$ 4,800,000
Total Construction	**$ 239,560,000**	**$ 32,380,000**
Engineering (15%)	$ 35,930,000	$ 4,860,000
Construction Administration (5%)	$ 11,980,000	$ 1,620,000
GCWA Administration (3%)	$ 7,190,000	$ 970,000
Total Capital Cost	**$ 294,660,000**	**$ 39,830,000**

Annual O&M Costs

ITEMS	COST (M$, YR 2000)	
	2010-2030 (120 MGD)	2030-2050 (150 MGD)
Plant	$ 19,800,000	$ 24,080,000
Finished Water Pumping and Pipelines	$ 2,370,000	$ 2,980,000
Raw Water	$ 560,000	$ 690,000
Total Annual O&M Cost	**$ 22,730,000**	**$ 27,750,000**

Capital and O&M Costs		
Alternative 3: 115 MGD Plant at Sugar Land Site and 35 MGD Plant at Manvel Site		
ITEMS	COST (M$, YR 2000)	
	120 MGD Initial Phase	30 MGD Expansion
Water Treatment Plants		
Property	$ 4,100,000	$ -
Plant	$ 123,280,000	$ 27,320,000
Additional Structural at Sugar Land Site	$ 6,160,000	$ 1,370,000
Manvel Site Flood Plain	$ 60,000	$ -
Finished Water Transmission		
High Service Pump Station	$ 6,720,000	$ 1,680,000
Booster Pump Station and Ground Storage	$ -	$ -
Chlorine Booster Station	$ -	$ -
Pipelines	$ 56,150,000	$ -
Easements	$ 760,000	$ -
Raw Water Improvements		
Canals	$ 490,000	$ -
Raw Water Pump Stations	$ 1,760,000	$ 500,000
Subtotal	**$ 199,480,000**	**$ 30,870,000**
Engineering Contingency (10%)	$ 19,950,000	$ 3,090,000
Construction Contingency (5%)	$ 9,970,000	$ 1,540,000
Cost Contingency (20%)	$ 39,900,000	$ 6,170,000
Total Construction	**$ 269,300,000**	**$ 41,670,000**
Engineering (15%)	$ 40,400,000	$ 6,250,000
Construction Administration (5%)	$ 13,470,000	$ 2,080,000
GCWA Administration (3%)	$ 8,080,000	$ 1,250,000
Total Capital Cost	**$ 331,250,000**	**$ 51,250,000**

Annual O&M Costs

ITEMS	COST (M$, YR 2000)	
	2010-2030 (120 MGD)	2030-2050 (150 MGD)
Plant	$ 21,030,000	$ 25,850,000
Finished Water Pumping and Pipelines	$ 2,740,000	$ 2,840,000
Raw Water	$ 360,000	$ 440,000
Total Annual O&M Cost	**$ 24,130,000**	**$ 29,130,000**

Capital and O&M Costs

Alternative 4: 115 MGD Plant at Sugar Land Site and 35 MGD Plant at Alvin Site

ITEMS	COST (M$, YR 2000)	
	120 MGD Initial Phase	30 MGD Expansion
Water Treatment Plants		
Property	$ 4,000,000	$ -
Plant	$ 123,280,000	$ 27,320,000
Additional Structural at Sugar Land Site	$ 6,160,000	$ -
Alvin Site Improvements - Transportation	$ 480,000	$ -
Finished Water Transmission		
High Service Pump Station	$ 6,720,000	$ 1,680,000
Booster Pump Station and Ground Storage	$ -	$ -
Chlorine Booster Station	$ -	$ -
Pipelines	$ 43,550,000	$ -
Easements	$ 640,000	$ -
Raw Water Improvements		
Canals	$ 550,000	$ -
Raw Water Pump Stations	$ 1,760,000	$ 500,000
Subtotal	**$ 187,140,000**	**$ 29,500,000**
Engineering Contingency (10%)	$ 18,710,000	$ 2,950,000
Construction Contingency (5%)	$ 9,360,000	$ 1,480,000
Cost Contingency (20%)	$ 37,430,000	$ 5,900,000
Total Construction	**$ 252,640,000**	**$ 39,830,000**
Engineering (15%)	$ 37,900,000	$ 5,970,000
Construction Administration (5%)	$ 12,630,000	$ 1,990,000
GCWA Administration (3%)	$ 7,580,000	$ 1,190,000
Total Capital Cost	**$ 310,750,000**	**$ 48,980,000**

Annual O&M Costs

ITEMS	COST (M$, YR 2000)	
	2010-2030 (120 MGD)	2030-2050 (150 MGD)
Plant	$ 21,030,000	$ 25,850,000
Finished Water Pumping and Pipelines	$ 2,710,000	$ 2,810,000
Raw Water	$ 360,000	$ 440,000
Total Annual O&M Cost	**$ 24,100,000**	**$ 29,100,000**

Capital and O&M Costs

Alternative 5: 115 MGD Plant at FBWCID No. 2 Site and 35 MGD Plant at Manvel Site

ITEMS	COST (M$, YR 2000)	
	120 MGD Initial Phase	30 MGD Expansion
Water Treatment Plants		
Property	$ 1,450,000	$ -
Plant	$ 123,280,000	$ 27,320,000
Manvel Site Flood Plain	$ 60,000	$ -
Finished Water Transmission		
High Service Pump Station	$ 6,720,000	$ 1,680,000
Booster Pump Station and Ground Storage	$ -	$ -
Chlorine Booster Station	$ -	$ -
Pipelines	$ 52,320,000	$ -
Easements	$ 760,000	$ -
Raw Water Improvements		
Canals	$ 490,000	$ -
Raw Water Pump Stations	$ 2,940,000	$ 740,000
Subtotal	**$ 188,020,000**	**$ 29,740,000**
Engineering Contingency (10%)	$ 18,800,000	$ 2,970,000
Construction Contingency (5%)	$ 9,400,000	$ 1,490,000
Cost Contingency (20%)	$ 37,600,000	$ 5,950,000
Total Construction	**$ 253,820,000**	**$ 40,150,000**
Engineering (15%)	$ 38,070,000	$ 6,020,000
Construction Administration (5%)	$ 12,690,000	$ 2,010,000
GCWA Administration (3%)	$ 7,610,000	$ 1,200,000
Total Capital Cost	**$ 312,190,000**	**$ 49,380,000**

Annual O&M Costs

ITEMS	COST (M$, YR 2000)	
	2010-2030 (120 MGD)	2030-2050 (150 MGD)
Plant	$ 21,030,000	$ 25,850,000
Finished Water Pumping and Pipelines	$ 2,930,000	$ 2,930,000
Raw Water	$ 560,000	$ 690,000
Total Annual O&M Cost	**$ 24,520,000**	**$ 29,470,000**

Capital and O&M Costs

Alternative 6: 115 MGD Plant at FBWCID No. 2 Site and 35 MGD Plant at Alvin Site

ITEMS	COST (M$, YR 2000)	
	120 MGD Initial Phase	30 MGD Expansion
Water Treatment Plants		
Property	$ 1,350,000	$ -
Plant	$ 123,280,000	$ 27,320,000
Alvin Site Improvements - Transportation	$ 480,000	$ -
Finished Water Transmission		
High Service Pump Station	$ 6,720,000	$ 1,680,000
Booster Pump Station and Ground Storage	$ -	$ -
Chlorine Booster Station	$ -	$ -
Pipelines	$ 39,720,000	$ -
Easements	$ 640,000	$ -
Raw Water Improvements		
Canals	$ 550,000	$ -
Raw Water Pump Stations	$ 2,940,000	$ 740,000
Subtotal	**$ 175,680,000**	**$ 29,740,000**
Engineering Contingency (10%)	$ 17,570,000	$ 2,970,000
Construction Contingency (5%)	$ 8,780,000	$ 1,490,000
Cost Contingency (20%)	$ 35,140,000	$ 5,950,000
Total Construction	**$ 237,170,000**	**$ 40,150,000**
Engineering (15%)	$ 35,580,000	$ 6,020,000
Construction Administration (5%)	$ 11,860,000	$ 2,010,000
GCWA Administration (3%)	$ 7,120,000	$ 1,200,000
Total Capital Cost	**$ 291,730,000**	**$ 49,380,000**

Annual O&M Costs

ITEMS	COST (M$, YR 2000)	
	2010-2030 (120 MGD)	2030-2050 (150 MGD)
Plant	$ 21,030,000	$ 25,850,000
Finished Water Pumping and Pipelines	$ 2,900,000	$ 3,000,000
Raw Water	$ 560,000	$ 690,000
Total Annual O&M Cost	**$ 24,490,000**	**$ 29,540,000**

Appendix G
Water Treatment Plant Design Criteria and Preliminary Sizing

Appendix G
Water Treatment Plant Design Criteria and Preliminary Sizing

DESIGN CRITERIA FOR 150 MGD HIGH-RATE CONVENTIONAL TREATMENT PLANT

Criteria	Unit	Value
Plant Capacity		
Finished Water Flow	MGD	150
Raw Water Flow	MGD	161
Raw Water Reservoir		
Capacity	MGD	150
Area	acres	30.6
Depth	ft	15
Storage Volume	day	1
Low Lift Pumping		
Number of Units	each	4
Type	Vertical Turbine	
Pump Capacity	MGD	40.5
Pump Head	ft	50
Total Installed Motor Capacity	HP	1900
Mixing		
No. of Pumps	each	3
Type of Pump	Vertical Centrifugal	
Capacity	MGD	7.5
Clarifier		
Clarifier Type	Pulsed-Upflow	
Unit Capacity	MGD	25
Number of Units	each	7
Length	ft	130
Width	ft	90
Water Level	ft	15.75
Average Daily Sludge Flow	gpd	4,400,000
Media Filters		
Type	Deep Bed, Dual Media (GAC/Sand)	
No.	each	20
Surface Area Per Filter	ft^2	1151
Transfer Pumping		
Number of Units	each	4
Type	Vertical Turbine	
Pump Capacity	MGD	40.5
Pump Head	ft	50
Total Installed Motor Capacity	HP	2000
High Service Pumping		
Number of Units	each	7
Type	Vertical Turbine	
Pump Capacity	MGD	150
Pump Head	Ft	170
Total Installed Motor Capacity	HP	5590

Appendix G
Water Treatment Plant Design Criteria and Preliminary Sizing

DESIGN CRITERIA FOR 150 MGD HIGH-RATE CONVENTIONAL TREATMENT PLANT SOLIDS PROCESSING

Criteria	Unit	Value
Gravity Thickener		
Type	Circular, Center Rake	
Solids Capacity	Ft^2	5210
Hydraulic Capacity	Ft^2	6420
No of Units	Each	4
SWD	Ft	14
Diameter	Ft	90
Percent Solids	%	4
Waste Washwater Equalization		
Type	Rectangular, Sloped Bottom	
Number of Units	Each	2
Length	Ft	134
Width	Ft	33.45
SWD	Ft	16
Storage Volume	Gal	1,071,000
Average Daily Backwash Flow	Gpd	2,380,000
Waste Washwater Clarification		
Clarifier Type	Lamella	
Diameter	Ft	63
Effective Area	Ft^2	2480
Total Settling Area	Ft^2	3100
Number of Units	Each	2
Recycle Pumps		
Number of Units	Each	4
Type	Vertical Turbine	
Capacity	Gpm	990
Motor Size	Hp	30
Dewatering		
Holding Tank Capacity	Days	4
Holding Tank Length	Ft	46
Holding Tank Width	Ft	46
Holding Tank Depth	Ft	30
Centrifuge Type	Vertical Turbine	
Centrifuge Total Power	Hp	300
Capacity	gpm/unit	200
Number of Units	Each	4
Operation	hr/day	16
Operation	days/week	5
Percent Solids	%	35
Average Annual Quantity Disposed	Cy	68,440

Appendix G
Water Treatment Plant Design Criteria and Preliminary Sizing

DESIGN CRITERIA FOR 150 MGD HIGH-RATE CONVENTIONAL TREATMENT PLANT BUILDINGS

Criteria	Unit	Value
Administration	Ft^2	
Laboratory	Ft^2	1,500
Offices / Reception	Ft^2	3,000
Conference	Ft^2	1,000
Restrooms / Lockers / Kitchen	Ft^2	1,000
Control Room	Ft^2	1,000
File Storage	Ft^2	1,000
General Storage	Ft^2	1,500
Total	Ft^2	10,000
Maintenance Building		
Garage	Ft^2	3,000
Instrument / Mechanics Shop	Ft^2	4,000
Offices / Restroom	Ft^2	1,000
Storage	Ft^2	5,000
Total	Ft^2	13,000
Chemical Building	Ft^2	10,000
Outside Chemical Storage	Ft^2	15,000
Ground Storage		
Number of Units	Each	4
Diameter	Ft	131
Height	Ft	30
Centrifuge Building	Ft^2	38,000
Disinfection Basin		
Number of Basins	Each	4
Volume	Ft^3	73,000
Depth	Ft	25
Area	Ft^2	2920

Appendix H
Draft Report Comments and Response

GULF COAST WATER AUTHORITY
REGIONAL WATER SUPPLY FACILITY GRANT
CONTRACT #2000-483-329

Comments on Draft Report Issued July 31, 2000

Comments 1-50 are from the Texas Water Development Board

1. Table of Contents - The following titles of tables and figures in the table of contents do not match the captions of the tables and figures appearing in the text: Tables 3-7, 4-6, 4-7, 4-8, 4-9, 6-11, 6-12, 7-3, 7-4, 7-5, 7-7, and 7-8 and Figures ES-1, ES-3, 3-4, 3-5, 4-1, 4-2, 4-3, 5-3, 5-4, 5-5, 5-6, 6-2, 6-3, 6-5, 6-6. 6-7, 6-8, 6-9, 6-10, 6-11, 6-12, 6-13, 7-2, 7-3, 7-4, 8-1, 8-2, 8-3, and 8-4.

Response: Tables and Figure titles have been updated.

2. Table of Contents - The (behind or on) page numbers for the following figures are incorrect: ES-2, 2-4, 4-2, 4-3, 5-2, 5-3, 5-4, 5-5, 5-6, 6-2, 6-3, 6-4, 6-13, and 7-1.

Response: Figure page numbers have been updated

3. Lowering of Piezometric Heads - The second paragraph of the Executive Summary on pg. ES-1 and the first paragraph of Section 1 on pg. 1-1 refer to well owners seeking alternative sources of water due to the lowering of piezometric heads. Another concern that might be included is the increase in TDS that often accompanies the lowering of piezometric heads.

Response: Comment Incorporated into Final Report

4. Harris-Galveston Coastal Subsidence District Regulatory Plan - The third paragraph of the Executive Summary on pg. ES-1 and the second paragraph of Section 1 on pg. 1-1 state that in April 1999 the Harris-Galveston Coastal Subsidence District (HGCSD) issued a District Regulatory Plan (DRP). It would be more accurate to refer to the April 1999 DRP, as a revised DRP, since it was a revision of the 1992 DRP.

Response: Comment Incorporated into Final Report

5. Editorial - The report would benefit from an editorial review to correct inconsistencies and errors of word choice, missing words, verb tense, and punctuation. The following are selected examples, which appear in the executive summary: First sentence in the third paragraph of pg. ES-1, states, "groundwater water will be required". The second sentence under SURFACE WATER CONVERSION on pg. ES-2 states, "availability groundwater will become limited". The second sentence in the last paragraph on pg. ES-3 states, "Interstate 59 in Sugar Land Texas". The fourth sentence in the first paragraph on pg. ES-5 states, "approach

consisted on three distinct steps". Bullet two under Alternative Raw Water Supply on pg. ES-7 states, "This option would minimizes risk ....from the Brazos the regional water authority".

Response: Comment Incorporated into Final Report

6. Figure ES-1 - The last sentence in the first paragraph on pg. ES-2 refers to Lateral 10. Lateral 10 is not labeled in Figure ES-1.

Response: Figure ES-1 has been updated to identify Lateral 10

7. Population Estimates in Executive Summary - The first sentence under Water Demand on pg. ES-3 refers to the TWDB estimates of current population and water demand. The population and water demand estimates in question were developed and proposed by the Region H water planning group and approved by the TWDB.

Response: Reference to TWDB has been updated to Region H Water Planning Group

8. Regional Plan in Executive Summary - The third sentence under FACILITY DEMAND on pg. ES-3 refers to the overall regional plan for HGCSD. The reference should be to the HGCSD's regulatory plan or possibly groundwater management plan to avoid possible confusion with the regional water plan being completed by the Region H water planning group.

Response: Comment Incorporated into Final Report

9. Table ES-1 - On pg. ES-3 the words area and surface in the title for Table ES-1 should be separated.

Response: Comment Incorporated into Final Report

10. Higher O & M Costs for Conventional and Membrane Processes - The second to last sentence on pg. ES-5 and other portions of the report state in effect that conventional and membrane processes have greater O & M costs than a high rate conventional process. The report should provide documentation through references or otherwise of the relative O & M costs of these processes.

Response: O&M Costs have been clarified as part of the response to Comment Number 40

11. Appendix A - The report does not cite or refer to Appendix A.

Response: Reference to Appendix A added in Section 1

12. TWDB Population and Water Demands - The second paragraph under PLANNING AREA on pg. 1-2 refers to TWDB estimates of the population and water demand for the planning area. The report should explain how these estimates were developed from the Region H approved population and water demands, as Region H provided population and water demands for certain municipalities and the county other portions of Brazoria and Fort Bend Counties, but not the planning area per se.

Response: Reference to TWDB has been updated to Region H Water Planning Group. Text added to indicated Utility estimates were used where Region H Water Planning Group population numbers were not available.

13. Water Allocation - The second paragraph under AVAILABLE SURFACE WATER on pg. 1-2 states, "The State of Texas, through the Brazos River Authority (BRA), currently allocates water from the Brazos River". The BRA does not have regulatory authority for water permits. The Texas Natural Resource Conservation Commission exclusively allocates the surface waters of the State of Texas through water permits.

Response: Text updated to reference the TNRCC

14. Run of River Rights - The first sentence on pg. 2-2 states, "run of the Brazos river water". In matters of water allocation the term, run of river rights, generally is used.

Response: Comment Incorporated into Final Report

15. Stored BRA water - The discussion in the first and second paragraphs on pg. 2-2 on stored BRA water is confusing. It states that the Gulf Coast Water Authority (GCWA) has contracts with the BRA for stored water, the text thereafter should refer to contracted water rather than stored water. Also the nature of the contract between the GCWA and the BRA is unclear. It is an option contract or a water contract?

Response: BRA water is a water contract. The text in the final report has been clarified.

16. GCWA Water Audit and Water Use Projections Report - The first sentence under Canal Capacity on pg. 2-4 refers to a GCWA Water Audit and Water Use Projections Report. This report should be included by the same name in Appendix A.

Response: Comment Incorporated into Final Report

17. GCWA Canal Capacities - The second sentence in the paragraph under Table 2-2 on pg. 2-5 states that the capacity of the Jones and Oyster Creek section could be upgraded to approximately 1,200 mgd, raising the limiting capacity of the American Canal System above Lateral 10 to 197 mgd. These values do not correspond to the capacities of 175 mgd and 220 mgd in Table 2-2 for clean capacities of these respective canal segments.

Response: Text has been inserted to clarify the limiting capacity of the canal.

18. Sugar Land - The second sentence in the first paragraph under City of Sugar Land on pg. 2-6 gives the estimated population for Sugar Land. Reference should be made to Appendix C for that population estimate.

Response: Comment Incorporated into Final Report. Reference is made on Page 2-6

19. Missouri City - The second sentence in the first paragraph under City of Missouri City on pg. 2-7 gives the estimated population for Missouri City. Reference should be made to Appendix C for that population estimate. Also Missouri City is served by 16 municipal utility districts, whereas only two take points are listed in Table 6-1 on pg. 6-2. The report might address the role of Missouri City as a possible wholesaler to the various municipal utility districts.

Response: Comment Incorporated into Final Report.

20. Friendswood - The second sentence in the first paragraph under City of Friendswood on pg. 2-7 gives the estimated population for Friendswood. Reference should be made to Appendix C for that population estimate. The third sentence in the first paragraph under City of Friendswood refers to the City of Houston Southeast Water Purification Plant. This infers that the City of Houston owns the Southeast Water Purification Plant, when in fact there are multiple owners.

Response: Comment Incorporated into Final Report.

21. Ft. Bend WCID No. 2 - The third sentence under Ft. Bend WCID No. 2 on pg. 2-7 provides an estimate of the current population served. A reference should be provided for that population estimate.

Response: Comment Incorporated into Final Report.

22. City of Arcola - The first sentence under City of Arcola on pg. 2-7 provides an estimate of the current population served and states that Arcola is served through a small groundwater plant. A reference should be provided for that population estimate. TWDB records show that the residents of Arcola are served by private wells and not a central system. **NOTE:** The City of Arcola is in court receivership with respect to its central sewerage system. The development of central water supply financially tied to the sewerage system, through this project or otherwise, could be beneficial to this community.

Response: Comment Incorporated into Final Report.

23. City of Manvel - The third sentence under City of Manvel on pg. 2-7 provides an estimate of the current population served. Reference should be made to Appendix C for that population estimate.

Response: Comment Incorporated into Final Report.

24. City of Alvin - The first sentence under City of Alvin on pg. 2-8 provides an estimate of the current population served. Reference should be made to Appendix C for that population estimate.

Response: Comment Incorporated into Final Report.

25. City of Pearland - The third sentence under City of Pearland on pg. 2-8 provides an estimate of the current population served. Reference should be made to Appendix C for that population estimate.

Response: Comment Incorporated into Final Report.

26. Current Population and Water Usage - The first sentence under Current Population and Water Usage on pg. 3-1 refers to the "Texas Water Development Board Population & Water Demand Projections: Board Approved Regional Projections to be Used in the 2002 State Water Plan". While the information is accurate, there is no report by that title, and thus the quotes should be omitted.

Response: Comment Incorporated into Final Report.

27. Table 3-1 - The caption for Table 3-1 on pg. 3-1 credits the TWDB for the population and water demand estimates, whereas as pointed out in Comment 7 above, the population and water demands were developed by the Region H water planning group. Also Table 3-1 includes estimates for Arcola, FBWCID No. 2 and Houston. The Region H water planning group did not prepare separate estimates for Arcola, FBWCID No. 2. or, as pointed out on pg. 3-2 of the report, the portion of Houston within the planning area.

Response: Comment Incorporated into Final Report.

28. Modified Population and Water Use Projections - The third paragraph under Projected Population and Water Usage on pg. 3-1 states that the Participating Utilities felt that the population and water use projections for GCWA customers prepared by Freese and Nichols reflected more realistic projections than those prepared by the Region H water planning group. Furthermore the same paragraph states that these projections were then modified with data obtained from recent questionnaires. Section 2 of Article II of the contract between the GCWA and the TWDB states "The CONTRACTOR(S) will consider BOARD population and water use projections, and if not used in the REGIONAL FACILITY PLAN, provide an explanation of why not used." Justification for selecting the projections prepared by Freese and Nichols and modifying with data from questionnaires needs to be added to the report. **NOTE:** Data on the numbers of recent water connections and recent approvals of subdivision plats and/or building permits, such as may be provided on questionnaires, are helpful

for short-term planning on the order of ten years, but are not a good basis for long-term planning on the order of fifty years.

Response: In the February and March progress meetings, data was presented to the Participating Utilities, including the TWDB on the difference between the TWDB and "Modified" GCWA numbers prepared by Freese and Nichols. At this meeting, the Participating Utilities approved the use of the Modified numbers as they felt that the Region H numbers underestimated growth in their communities. Several utilities reported that the actual 2000 population and water use projection greatly exceed the population and water use projections listed in the Region H report. As such, the Participating Utilities decided to use the Modified population and water use numbers in planning the capacity of the Regional Facility. Furthermore, the GCWA added that the Freese and Nichols survey and water use projections were based on Region H numbers.

29. <u>TWDB Projections</u> - The first paragraph under Participating Utility Projected Population and the two paragraphs under Population Projection Comparison on pg. 3-2 refer to TWDB Region H population projections, TWDB numbers, TWDB projections, presented by TWDB, TWDB board projections and TWDB population estimates. In each case the reference should be to the Region H water planning group.

Response: Reference to TWDB has been updated to Region H Water Planning Group. Text added to indicated Utility estimates were used where Region H Water Planning Group population numbers were not available.

30. <u>Figure 3-3</u> - The per capita water demands presented in Figure 3-3 on pg. 3-4 show increases over time for several Participating Utilities. With very few exceptions, the water demand estimates prepared by the sixteen regional water planning groups and approved by the TWDB show a decline in per capital water demand for all municipal users by decade. The declining per capita water demands were based on the plumbing code and the effectiveness of educational efforts, and are consistent with trends observed for municipalities throughout Texas and other states. The report should show the same per capital water demands as adopted by the Region H water planning group or provide documentation as to why the per capita demands for the Participating Utilities are anticipated to increase or stay constant. **NOTE:** The concern is of methodology and adherence to accepted planning principles. The TWDB does not object to the GCWA developing water supply capability beyond the comparable amount projected by the Region H water planning group. The additional surface water supply will be needed by and could be sold to water districts and municipal water utility districts that are in the planning area but for various reasons have not participated in this study.

Response: Figure 3-3 shows four utilities with increasing per capita water usage over time. As agreed to by the Participating Utilities and TWDB in the March, 2000 Progress meeting, the feasibility report would be based on the "TWDB modified" population and water use numbers. The per capita demands represented in this table for these utilities *are based on the Recommended Population and Water Use Projections for GCWA Customers Report prepared by Freese and Nichols and reflect these utilities best estimates of population growth and projected water growth. This report was based on Region H numbers.*

31. Subsidence District - The first two paragraphs under Water Plant Capacity on pg. 3-5 and second paragraph on pg. 3-6 refer to the Subsidence District, meaning the HGCSD, when the reference should include the FBSD. The section should be revised to be consistent with the information provided on pg. 1-1 and the first paragraph under CAPITAL IMPROVEMENT PROGRAM on pg. 8-1, including a statement that the 20 percent limit for groundwater is an assumed condition using the current HGCSD rules as a guide.

Response: Comment Incorporated into Final Report.

32. Peak Hour Demands - The fourth bullet in the second paragraph on pg. 3-6 states in effect that groundwater infrastructure will be used to met peak hour demands. This creates confusion with the statement in the second sentence of the first paragraph on pg. 3-6, that elevated and ground storage tanks would be used to meet peak hour demands.

Response: Comment Incorporated into Final Report.

33. Section Designations - The third sentence in the first paragraph on pg. 3-10 refers to Chapter 2. For consistency, it should be Section 2.

Response: Comment Incorporated into Final Report.

34. Table 3-7 - The column "Existing Customer Water Demand (mgd)" in Table 3-7 on pg. 3-10, should show a range from the year 2000 demand (approximately 114 mgd) to the projected year 2050 demand of 174 mgd. The column presently lists 174 mgd in each row.

Response: The report shows the existing Customer Contract Water. The table has been renamed..

35. WAM Model - The last paragraph on pg. 3-11 refers to the water commitment analysis of the Brazos River by the State of Texas. Assuming this is the intent, the paragraph should refer specifically to the Water Availability Modeling (WAM) being conducted by the Texas Natural Resource Conservation Commission. The WAM results will help clarify water rights and will be utilized in regional water planning.

Response: Comment Incorporated into Final Report.

36. Raw Water Quality - The third paragraph under Historical Raw Water Quality on pg. 4-1 states that the Brazos River contained elevated levels of several constituents

including bromide and total organic carbon. It would be helpful if the federal or State standards for bromide and total organic carbon were added to the report.

Response: Bromide and total organic carbon are water quality parameters that are important when considering process alternatives, but they are not regulated contaminents. Bromide is important because it is a precursor to bromate, which has an MCL of 0.010 mg/l. Total organic carbon is important because when exposed to chlorine-based compounds, halogentated by-products such as trihalomethanes or haloacetic acids are formed. THMs and HAAs are regulated. TOC does not have an MCL, although plant must now remove minimum percentages of the TOC from raw water. This minimum requirement is dependent on the raw water TOC and alkalinty. This treatment technique is listed in Table 4-2 under the subsection on disinfectants as "enhanced coagulation".

37. The second sentence in the second paragraph under FEDERAL AND STATE STANDARDS on pg. 4-1 incorrectly refers to the limits for total trihalomethanes and total haloacetic acids in the (EPA) Stage 2 Disinfectants/Disinfection By-Products Rule. The sentence should be revised to state that the Rule as enacted lowers the maximum contaminant levels for total trihalomethanes from the current 80 to 60 μg/l and for total haloacetic acids from the current 40 to 30 μg/l. This requirement will be effective in January 2002.

Response: Comment will be incorporated. It should be noted that the current position of the Federal Advisory Committee is that the MCLs for TTHMs and THAAs will remain at 80 and 60 ug/l, respectively, and will not be lowered. Instead, more stringent distribution system monitoring will be imposed.

38. Table 4-2 - The title of Table 4-2 on pg. 4-3 and 4-4 is SUMMARY OF FEDERAL AND STATE STANDARDS. The entries in the table that are solely State maximum contaminant levels should be so designated, as the present format doesn't separate between State and federal standards.

Response: Comment will be incorporated. The table name will be changed to "Summary of Federal Standards". Specific differences between federal and state standards are noted in the text.

39. TNRCC Standards - The second sentence in the first paragraph under FINISHED WATER QUALITY GOALS on pg. 4-5 refers to TNRCC standards from its draft proposal for Chapter 290, Subchapter D, Rules and Regulations for Public Water Systems. The sentence should clarify which amendment of Subchapter D of Chapter 290.

Response: Comment Incorporated into Final Report.

40. Level of Maintenance - The first complete paragraph on pg. 4-11 contains the sentence, "The level of maintenance for Alternative 2 is lower that (than) the

conventional alternative because there is less equipment." Table 4-8 on pg. 4-14 contains an annual maintenance cost for the high rate conventional process that is 15 percent lower than the annual maintenance cost for conventional. Table 4-9 on pg. 4-15 contains an annual maintenance cost for a membrane process that is 25 percent. higher than that for conventional. As noted in Comment 10 above, additional documentation should be provided for these estimates.

Response: The annual maintenance costs for the alternatives were estimated using a percentage of the original capital cost of the equipment. For the conventional process alternative, 2.0% of capital costs were assumed as annual fixed maintenance costs. The conventional alternative is based on four stages of flocculation followed by rectangular plug-flow sedimentation basins. The 2.0% value is required because of the maintenance required to maintain the large number of flocculators with variable frequency drives, and the multiple sludge collector drives. A percentage value of 1.7% of capital costs was used for the high-rate conventional process alternative. This process assumed SUPERPULSATOR technology to replace the flocculation/sedimentation basins in the conventional alternative. SUPERPULSATORs have no moving parts within the basin. The 1.7% value gives credit to the fewer number of pieces of rotating equipment that must be maintained as compared to the conventional process. Maintenance costs for periodic replacement of GAC filter media was included for both the conventional and high-rate alternatives. The estimate for the membrane system is based on 2.5% of capital costs. This higher value is due to the maintenance required for the automated membrane skids (actuated valves, variable frequency drives on feed pumps, flow and pressure controllers). A separate maintenance costs was included: replacement of membrane modules. For this cost, estimates were obtained from the membrane manufacturers of the life expectancy and replacement costs of the membrane modules.

41. Treatability Testing - The second complete paragraph on pg. 4-11 states in effect that the TNRCC requires several months of treatability testing to gain regulatory approval for a membrane process. Although the statement is accurate, this paragraph might point out that it generally is advisable to run a pilot plant in advance of constructing a major water treatment plant. This would be consistent with the last sentence on pg. 4-9 which recommends that a pilot plant be established for all alternatives to test and optimize chemical doses.

Response: Comment Incorporated into Final Report.

42. Size of Membrane Facility - The second complete paragraph on pg. 4-11 states that there is no membrane facility in the United States of the size being proposed for this facility. This statement may not be pertinent, as the capacity of a membrane facility is linearly related to the number of membranes. There is no inherent reason that a large facility would perform any differently than a small or medium membrane facility.

Response: It is true that that capacity of a membrane facility is linearly related to the number of membranes, and that there should be no difference in performance. It is for *this reason that economics has limited the size of membrane facilities. Large capacity conventional plants offer significant savings as compared to membrane systems because of the economy of scale that is realized when constructing large concrete sedimentation basins and filters. This economy does not yet exist with membranes because this linear capacity relationship requires that additional units are needed as the capacity of the plant becomes larger. The lack of large scale membrane facilities is due to simple economics, not because of limiting process performance.*

43. Flooding Concerns - The paragraph under Evaluation of Site Surface Features on pg. 5-7 states that the Sugar Land, Pearland ETJ, Manvel and Alvin sites will be impacted by the flood plain. However the paragraph under Other Economic Consideration on pg. 7-11 addresses flooding at only the Manvel site.

Response: It is anticipated that only the Manvel site will require improvements which will impact project costs as the flood plain impacts on this site are extensive, while proper site layout on the other sites will mitigated the potential impact of flooding.

44. Table 6-12 - The words ANNUAL and O&M should be separated in the title of Table 6-12 on pg. 6-16.

Response: Comment Incorporated into Final Report.

45. Dr. Thomas Mackey Plant - The first sentence on pg. 7-5 states, "As the high-rate conventional process is proven to adequately treat Brazos River water at the Dr. Thomas Mackey Plant, ..." This statement appears in conflict with the second paragraph under Dr. Thomas Mackey Water Treatment Plant on pg. 2-5 which describes the Dr. Thomas Mackey Water Treatment Plant as a conventional filtration plant.

Response: As defined in Section 4, the words high rate have been removed from the description of the Dr. Thomas Mackey WTP.

46. Archeological Report - The first complete paragraph on pg. 7-8 states that the State of Texas reviewed each of the potential water treatment sites and indicated that a detailed archeological report will have to be submitted to the State. In accordance with Item L in the Scope of Services both alternative water plant sites and pipeline route alternatives are to be submitted to the Texas Historical Commission. The report needs to document that this was done for the pipeline route alternatives. The third sentence in the first paragraph on pg. 6-3 notes that construction costs increase if the pipeline passes through an environmental sensitive area; however it isn't clear where those possible costs are budgeted. In addition the report should include cultural resource surveys as a capital cost.

Response: A letter dated October 16, 2000 has been submitted to the Texas Historical Commission regarding a cultural resources assessment along the proposed pipeline *corridors. A copy of the letter is attached. The majority of the pipelines are within existing TXDOT right of ways and GCWA easements and as these are previously disturbed areas, it is not expected to impact the project. If required, the cost of the cultural resources survey will be included in the estimate of the design engineering.*

47. Reliant Energy Inc. - The paragraph under Electrical on pg. 8-4 refers to Houston Lighting and Power. The current name of Houston Lighting and Power is Reliant Energy Inc.

Response: Comment Incorporated into Final Report.

48. Bibliography - The Bibliography in Appendix A lists Texas Water Development Board: 2002 State Water Plan Regional Population Projections as Item 5. As pointed out in Comment 26, there is no publication by that title. Also dates are missing for Items 13 and 14.

Response: Comment Incorporated into Final Report.

49. Appendix C - Appendix C is titled TWDB Population and Water Use Projections. As pointed out in Comment 7, the title should reflect that the population and water use estimates were developed by the Region H water planning group.

Response: Comment Incorporated into Final Report.

50. Positives - The report was well organized, and generally the graphics are excellent. Most of the engineering estimates, with some possible exceptions noted herein, are reasonable. The contractor is to be complimented for its public participation efforts with the participating utilities.

Participating Utilities Comments on the
GCWA Regional Water Plant Feasibility Study Draft Report Comments

1. City of Alvin: I think the overall report was very well prepared and has valuable data. I am concerned about the rate data that was presented at the last meeting. Per our conversation, the rates were based on the plant capacity. We collect revenues based on average daily flows which will initially be significantly less than the plant capacity. How will this affect our initial costs?

Response: The contracted plant capacity buy-in (contract reserve) will be larger than the initial average daily flow (contract take-or pay). Contract "reserve" is the participant's system buy in capacity and is defined as the peak water demand (thousand gallons per minute). Contract "take or pay" is defined as the average daily water take calculated over 120-day period. The contract reserve quantity determines debt service and canal system raw water costs. The actual take or pay quantity purchased determines operations costs.
Example: Assume the scenario adopted is that presented in Table 9-2 where one initial 120 MGD plant is constructed and the transmission line cost is shared. Also assume that the participant contract reserve is 3,000 thousand gallon per day with an initial take or pay of 1,000 thousand gallon per day, and then later the take or pay increased to 2,500 thousand gallon per day. Under these conditions the initial rate for water would be $2.46 per thousand gallons. The rate would decrease to $1.228 per thousand gallons the closer the take or pay is to the contract reserve capacity.

Debt Costs = $0.603 / 1,000 gal
Canal System Raw Water Costs = $0.07 / 1,000 gal
O&M Costs = $0.441 / 1,000 gal, assume the rate decreases as plant produces more gallons per day to $0.42 / 1,000 gal.

Initial costs at a take or pay of 1,000 thousand gallons per day:
3,000 KGD ($0.603/KGD + $0.07/KGD) + 1,000 KGD ($0.441/KGD) = $ 2,460/D
$2460/D / 1,000 KGD = ***$2.46/KG***

Future costs at a higher take or pay of 2,500 thousand gallons per day:
3,000 KGD ($0.603/KGD + $0.07/KGD) + 2,500 KGD ($0.42/KGD) = $ 3,069/D
$3,069/D / 2,500 KGD = ***$1.228/KG***

2. City of Sugar Land:
   Page ES-8: Change tow to two
   Page 2-6: Change citiy's to city's
   Page 2-6: Arcola in Fort Bend County has individual wells, no distribution system
   Page 2-7: Ft. Bend WCID No. 2 does not serve Sugar Land
   Page 2-7: Change 60 square acres to 60 square miles

Response: Comment Incorporated into Final Report

3. City of Manvel: You still show only 1 Takeup Point for Manvel...we should have 2....one at Iowa Lane and Hwy 6 and one at the NW corner of 288 and Hwy 6....other than that, great job. Thanks!

Response: As these take points are within one mile of another, the second take point is best served with a distribution main, not a transmission form GCWA.

4. City of Pearland: Page ES-3: We do not believe we can achieve the 20% groundwater usage by 2010 without the surface water already being available.

Response: Implementation of First Phase of Surface Water Plant can be accelerated to meet Participating Utilities needs, but the feasibility study and projected costs are based on the conservative assumption that the plant is on-line by the year 2010.

5. City of Pearland: Page ES-3: Who gets what, when, during drought conditions and when the Brazos is low?

Response: When the Brazos River is low the following responses will be made: First, GCWA will discontinue water supply to customers with non-firm "Spot Water" and "When Available" water contracts (i.e. golf courses, ranches, etc.). Second, GCWA will notify the Brazos River Authority to release stored reservoir water to meet GCWA firm water contract needs not met by run of river permits as a result of drought. GCWA pays the Brazos River Authority each year for stored water contracts currently totalling 32,668 acre-feet per year (10,650,000,000 gallons). The purchased stored water is in addition to permitted water. It provides insurance and backup when permitted water is insufficient. The Authority will seek to increase the amount of stored water purchased when the regional water facility is commissioned. And third, GCWA will prorate the available water based on reserve capacity contracts to all firm capacity customers. GCWA customers will then use a combination of conservation measures and wells to make up their deficit.

6. City of Pearland: Page ES-3: Will Pearland need additional pump stations?.

Response: This study did not address the specific needs of the distribution system of the City of Pearland. The City should conduct a water master plan to determine if and where booster pump station would be required to maintain system pressure through the City of Pearland.

7. City of Pearland: Page ES-4: Where did 7.19 X 2 MGD come from? Is there adequate supply for us to take this much?

Response: The water demands for each city were calculated based on 80% of the projected year 2050 average annual water demand. The City of Pearland's demand was equally split between 2 take points, one on the western edge of the City and one on the *eastern portion of the City. Raw water supply issues were discussed in Section 3 of the report and are summarized below.*

"Although the current GCWA water rights fall short of the amount needed for the region through the year 2050, GCWA is actively pursuing additional water rights and it is the expectation of GCWA to secure reliable raw water yield within the next few years. Additionally, the Texas Natural Resource Conservation Commission is currently completing a water availibility modeling (WAM) effort to help clarify water rights. The results from this study will show the impacts of current withdrawal during drought conditions and will be used to craft the next version of the State Water. "

8. City of Pearland: Page ES-8: Typo...First word of second sentence (Tow) under Heading Economic Evaluation.?
Page 2-8: City of Pearland's current population is approximately 45,000 (not 31,893). Total planning area, including ETJ is approximately 75 square miles (not 58.4).
Page 3-1: Population is approximately 45,000.

Response: Comment Incorporated into Final Report

9. City of Pearland: Page 3-4: Why does our per-capita figure drop after 2000?

Response: We have reported water demand and population as reported by the Region H Board. The per-capita figure is a calculation from these Board approved numbers. It is our understanding that the Board considered improvements in plumbing code and the effectiveness of education efforts in developing water demand projections.

10. City of Pearland: Page 3-5: Our peaking factor seems low in light of recent consumption. 2.0 would be better?

Response: Comment Incorporated into Final Report

11. City of Pearland: Page 3-9: "Fill Tank" contradicts previous text. Pearland will take at "system pressure".

Response: Comment Incorporated into Final Report

12. City of Pearland: Appendix C: Pearland population is inconsistent with our estimates. 2050 is estimated at 212,000 for entire 75 square mile planning area.

Response: Appendix C contains Board Approved Region C population and water use projections and can not be modified in this report. However, in Section 3 of the report, the Participating Utilities decided to utilize "modified" population and water use projections that were more representative of recent growth. The City of Pearlands revised populations are included in this calculation.

13. City of Pearland: General: How will the Cities initial costs associated with plant capacity verses actual daily flows be handled?

Response: See Section 9 for detailed financial breakdown

14. City of Friendswood: Page 2-7: Replace Brazoria with Harris in the first sentence under the City of Friendswood subtitle.
Page 2-7: Delete the second sentence in the second paragraph, The city's existing.....
Page 3-2: Estimated Friendswood population at build out is 57,400 that may occur sometimes between 2015-2020.

Response: Comment Incorporated into Final Report.

15. City of Friendswood: Page 3-2: Estimated Friendswood population at build out is 57,400 that may occur sometimes between 2015-2020

Response: The Region H population projections for Friendswood are considerably higher. The higher numbers will be used in calculation of projections water demand and facility sizing.

MONTGOMERY WATSON

TEN YEARS IN HOUSTON

October 16, 2000

Department of Antiquities Protection
Texas Historical Commission
P.O. Box 12276
Austin, Texas 78711

Subject: Gulf Coast Water Authority / Texas Water Development Board Regional Surface Water Plant

Dear Sir or Madam:

The Gulf Coast Water Authority (GCWA) requests a cultural resources assessment of the proposed transmission pipelines from the GCWA Regional Water Plant to be located in Stafford, Texas. This cultural assessment is requested as part of a study to determine the feasibility of locating a new regional water plant in the northern Brazoria / Fort Bend County area. The results from this cultural resources assessment will be used in design to minimize impact on the cultural resources of Texas.

The attached figure shows the proposed alternate pipelines routes. Figure 8-4 shows the overall recommended plan and details of each pipeline routing can be found on Figures 6-4 through 6-6. Construction of each pipeline will require a strip of land approximately 20 feet in width along the entire length of the proposed pipelines. The majority of the proposed pipelines are aligned within existing TXDOT and GCWA easements and construction of these pipelines will occur in areas that have been previously disturbed.

Please let me know if any further information is necessary. If you have any questions or need additional information, please feel free to call me. If the results of the cultural resources assessment shows any areas where construction is not feasible, please let me know as soon as possible as the final feasibility study will be issued in early November.

Sincerely,

Chris Canonico
Project Engineer

5100 Westheimer, Suite 580
Houston, Texas
77056-5507

Tel: 713 403 1600
Fax: 713 850 7901

Serving the World's Environmental Needs

Appendix I
Prorated Transmission Cost Breakdown

Prorated Transmission Breakdown for FBWCID No.2 Plant Option

Pipeline	Plant B w/ booster Pipeline Length (ft)	Pipeline Diameter (in)	Total Cost	Alvin	Arcola	Manvel	Pearland	Missouri City	FBWCID 2	Sugar Land	Friendswood	Houston	Notes
Lakeview to Bellaire Braes PS	31,900	48	$ 7,656,000									$ 7,656,000	
Site A out of WTP	-	-											
Site A split to Lakeview	-	-											
Lakeview to Site A	-	-											
Site A to First Colony	-	-											
From 30" to First Colony	-	-											
First Colony to Missouri City TP	35,580	30	$ 5,337,000							$ 5,337,000			
Quail Valley to Sienna Plantation	11,300	16	$ 904,000					$ 904,000					
Lakeview to FBWCID A	18,105	54	$ 4,888,350							803,710.79		4,084,639.21	City of Houston -59.2 MGD, City of Sugar Land - 11.6 MGD
FBWCID A to FBWCID B	6,700	54	$ 1,809,000						119,255.18	277,816.88		1,411,927.94	City of Houston -59.2 MGD, City of Sugar Land - 11.6 MGD, FBWCID No.2 - 5 MGD
FBWCID B to Arcola Split [(1)]	50,800	48	$ 9,753,600	$ 1,558,684.55	$ 35,627.08	$ 979,744.57	$ 4,003,555.48				$ 3,175,988.32		Arcola - .13 MGD, Alvin - 5.6 MGD, Manvel, 3.52 MGD, Pearland, 14.38 MGD, Friendswood, 11.41 MGD
Arcola Line	14,100	8	$ 451,200		$ 451,200								
Arcola Split to PS [(1)]	22,366	48	$ 4,294,272	$ 688,766.63		$ 432,939.02	$ 1,769,129.87				$ 1,403,436.48		Alvin - 5.6 MGD, Manvel, 3.52 MGD, Pearland, 14.38 MGD, Friendswood, 11.41 MGD
Arcola Split to Pearland Split [(1)]	-	-											
Pearland Split to Pearland 288	9,350	24	$ 897,600				$ 897,600						
Pearland Split to Manvel	19,200	16	$ 1,228,800				$ 1,228,800						
Pearland Split to Friendswood/Alvin Split [(1)]	55,400	42	$ 9,307,200	$ 2,153,506.30			$ 2,765,691.73				$ 4,388,001.97		Alvin - 5.6 MGD, Pearland, 7.19 MGD, Friendswood, 11.41 MGD
Friendswood/Alvin Split to Friendswood W Split	10,000	36	$ 1,800,000				$ 1,003,740.64				$ 796,259.36		Pearland, 7.19 MGD, Friendswood, 5.7 MGD
Friendswood/Alvin Split to Friendswood SW	2,300	24	$ 276,000	$ 136,714.60							$ 139,285.40		Alvin - 5.6 MGD, Pearland, 7.19 MGD, Friendswood, 11.41 MGD
Line to Friendswood SW	5,300	24	$ 636,000								$ 636,000		
Friendswood/Alvin Split to Alvin Bypass 35	10,100	20	$ 1,010,000	$ 1,010,000									
Friendswood Split to Pearland 35	11,700	24	$ 1,404,000				$ 1,404,000						
Friendswood Split to Friendswood West	11,200	24	$ 1,344,000								$ 1,344,000		
Site B to FBWCID B	3,830	54	$ 1,034,100	$ 49,970.22	$ 1,142.18	$ 31,409.85	$ 128,350.88		$ 89,232.53	$ 103,938.05	$ 101,819.72	$ 528,236.58	Arcola - .13 MGD, Alvin - 5.6 MGD, Manvel 3.52 MGD, Pearland 14.38 MGD, Friendswood 11.41 MGD, Houston 59.2 MGD, Sugar Land 11.6 MGD, FBWCID No. 2, 10 MGD
Site B to Quail Valley	11,100	36	$ 1,998,000					$ 982,964.90		$ 1,015,035.10			
Site E to Arcola	-	-											
Site E to Pearland Split	-	-											
Site G to Pearland Split	-	-											
Site G to Arcola	-	-											
Site G to Friendswood/Alvin Spli	-	-											
Total Pipeline			$ 56,029,122	$ 5,597,642	$ 487,969	$ 1,444,093	$ 13,200,869	$ 1,886,965	$ 208,488	$ 7,537,501	$ 11,984,791	$ 13,680,804	
35 MGD Booster Station			$ 1,764,000	$ 282,931.39		$ 177,842.59	$ 726,722.73				$ 576,503.29		90% of construction cost - 1st phase Alvin - 5.6 MGD, Manvel, 3.52 MGD, Pearland, 14.38 MGD, Friendswood, 11.41 MGD
2 MGD GST			$ 675,000	$ 108,264.56		$ 68,052.01	$ 278,082.68				$ 220,600.75		
Chlorine Booster			$ 450,000	$ 72,176.37		$ 45,368.01	$ 185,388.45				$ 147,067.17		
Easements Length	Length	Cost ($/acre)											
FBWCID B to Arcola Split [(1)]	50,800	20,000.00	$ 700,000	$ 111,864.25	$ 2,556.90	$ 70,314.67	$ 287,328.66				$ 227,935.51		Arcola - .13 MGD, Alvin - 5.6 MGD, Manvel, 3.52 MGD, Pearland, 14.38 MGD, Friendswood, 11.41 MGD
Arcola Split to PS [(1)]	22,366	20,000.00	$ 310,000	$ 49,721.50		$ 31,253.52	$ 127,712.05				$ 101,312.94		Alvin - 5.6 MGD, Manvel, 3.52 MGD, Pearland, 14.38 MGD, Friendswood, 11.41 MGD
Pearland Split to Friendswood/Alvin Split [(1)]	55,400	20,000.00	$ 760,000	$ 175,849.32			$ 225,838.68				$ 358,312.01		Alvin - 5.6 MGD, Pearland, 7.19 MGD, Friendswood, 11.41 MGD
Total Easements				$ 337,435.08	$ 2,556.90	$ 101,568.19	$ 640,879.38				$ 687,560.46		
Total Pipeline Costs			$ 60,688,122	$ 6,398,450	$ 490,526	$ 1,836,924	$ 15,031,942	$ 1,886,965	$ 208,488	$ 7,537,501	$ 13,616,523	$ 13,680,804	