WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION

IMPLEMENTATION PLAN

APPENDIX IV

DEFINITION AND EVALUATION OF ALTERNATIVE SYSTEMS

MARCH 1988

DEC

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WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION
IMPLEMENTATION PLAN

APPENDIX IV

DEFINITION AND EVALUATION OF ALTERNATIVE SYSTEMS

Prepared by:
DANNENBAUM ENGINEERING CORPORATION
Houston, Texas

The purpose of this study, undertaken by the West Harris County Surface Water Supply Corporation (WHCSWSC), is to produce an implementation program that will provide a reliable, long-term surface water supply to West Harris County.

This appendix is prepared as part of the overall implementation program and deals with the Definition and Evaluation of Alternative Systems for the WHCSWSC study area.

Further information on the content of this document or the overall implementation plan may be obtained from:

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We request comments on this draft by April 4, 1988.

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ISSUED TO: Mr. John Miloy - Texas Water Development Board

WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION

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EXECUTIVE SUMMARY

Purpose and Scope

The West Harris County Surface Water Supply Corporation (WHCSWSC) study is targeted at producing an implementation program that will provide a reliable long-term surface water supply to West Harris County.

The project scope of work for this phase of the implementation program deals with the definition and evaluation of alternative conveyance and transmission systems to service the projected water demands of the WHCSWSC study area.

Three alternate Northeast Conveyance Systems and six Alternate Southwest Conveyance Systems have been defined and evaluated in this Appendix.

The transmission system required to deliver surface water within the WHCSWSC study area will also be evaluated for the alternate service areas previously defined in Appendix II - "Water Demand and Supply - Revision One". The surface water supply source for the Northeast System will be Lake Houston. The surface water supply source for the Southwest System will be the Brazos River, the Brazos River Canal System, and/or the proposed Allen's Creek Reservoir.

Alternate conveyance and transmission systems will be ranked against each other with the highest rated systems to be detailed further in Phase V - "Detailed Evaluation of Selected Alternatives".

Projected Water Demands

The water demands used in this Appendix are based on the revised water demands previously presented in Appendix II, "Water Supply and Demand - Revision One".

Maximum day demands were used to size treatment plants, conveyance systems and transmission systems. HGCSD surface water requirements were calculated by using 80% of the total maximum daily demand within each of the HGCSD regulatory areas. For the purpose of this study, HGCSD regulatory area eight was assumed to have an 80% surface water conversion requirement in 2030.

Table 1 outlines the projected water demands by alternate service areas to meet the HGCSD surface water conversion requirements. Maximum daily demands for the entire WHCSWSC service area are as follows:

Year	Demand
1995	65.27
2000	105.97
2005	115.62
2010	170.77
2030	231.26

Surface Water Sources

Northeast Supply System

The assumed surface water source for the Northeast System is Lake Houston which is comprised of existing raw water from the San Jacinto and Trinity River System and future developed raw water from the Sabine River System. For the purposes of this study, it is assumed that the HWMP Alternate 4 will be developed.

Southwest Supply System

The assumed surface water source for the Southwest System is the Brazos River, the proposed Allen's Creek Reservoir and/or the Brazos River Canal System. The WHCSWSC will be required to obtain permission to transfer Brazos River Basin water to the San Jacinto River Basin which presently encompasses the entire WHCSWSC service area. Both the Brazos River and San Jacinto River Authorities have agreed in principal to the mentioned transfer, therefore, this requirement is not perceived to affect the viability of this implementation plan.

Correspondence received from the Brazos River Authority (BRA) outlines a proposal for an incrementally developed raw water source of up to 134 MGD (average daily supply) with the ability to meet the WHCSWSC maximum daily demands through operations of the entire Brazos River Basin. The initial increment of supply available immediately from existing sources is 67.0 MGD. The second increment of supply will come from the proposed Allen's Creek reservoir to be developed by the BRA. This second increment will increase the available supply of raw water to 107.2 MGD by the year 2000. The third increment is planned to be supplied by the proposed South Bend Reservoir Project. This supply will increase the available raw water supply to 134.0 MGD in 2030. However, the available raw water to WHCSWSC will only be a portion of the total available water which has been defined as current use water in the BRA. The portion available to WHCSWSC will be as follows:

Year	Cumulative Water Available (MGD)
1995	40
2000	67
2005	72
2010	107
2015	116
2020	116
2025	116
2030	134

Table 2 presents a summary of supply source allocations for the WHCSWSC Southwest System. Exhibit 3 shows a graphical representation of the BRA proposal. Raw water sources were sized to handle the average daily demands of the alternate service areas with the ability to meet maximum daily demands as required. If the Southwest Conveyance System Alternate Site 4B or 5 are chosen the WHCSWSC would need to request the BRA to construct Allens Creek Reservoir by the year 1995.

Raw Water Characteristics

The raw water from the Brazos River System which would be used to supply the WHCSWSC service area compares favorably with other regional water sources such as Lake Conroe or the Trinity River. The following table gives a summary comparison of Brazos River System water to these other supplies.

COMPARISON OF REGIONAL SURFACE WATER QUALITY[1/]

Parameter (Units)	Lake Conroe[2/] Brazos River	Benbrook Lake[2/] (San Jacinto River)	(Trinity River)
Turbidity (ntu)	16 - 111	N.A.[3/]	N.A.[3/]
Alkalinity (mg/l ◘ $CaCO_3$)	78 - 250	39 - 140	110-160
pH (units)	7.9 - 8.9	6.4 - 8.4	6.9 - 8.6
Fluoride (mg/l)	0.28 - 0.34	0.1 - 0.2	0.2 - 0.4
Calcium Hardness (mg/l ◘ $CaCO_3$)	128 - 140	37 - 85	97-155
Hardness (mg/l ◘ $CaCO_3$)	148 - 180	46 - 100	130-180
Zinc (mg/l)	N.A.[3/]	0.01 - 0.03	N.A.[3/]
Iron (mg/l)	2.7 - 3.8	0.01 - 8.3	0.01 - 0.79

Raw water quality conditions of the Brazos River itself have been monitored over the past 20 years by the USGS at its gauging station near Richmond, Texas. Of importance with respect to raw water supply and treatment are the amount of dissolved solids, chlorides and sulfates monitored in the raw water. In 95% of the samples taken the total dissolved

solids were less than or equal to 730.0 milligrams per liter (mg/l), chlorides were equal to or less than 240.0 mg/l and sulfates were equal to or less than 130.5 mg/l. Other criteria related to water quality of the Brazos River can also be seen on Table 4.

Treatment Processes

Northeast System

According to the City of Houston's Water Quality Section, the treatment process needed for the Northeast Plant will be very similar to the process presently used by the City in the East and Southeast Treatment Plants. As a result, operations cost for the proposed Northeast Plant should approximate the operations cost at the City's existing treatment plants.

Southwest System

Raw water from the Brazos River System has been successfully treated in the past by industry and municipalities. The Galveston County Water Authority (GCWA) began treatment of Brazos River water in 1983 and is currently producing approximately 12 MGD of finished water. According to operation reports from GCWA, the costs of operation and treatment is expected to approximate the operation and treatment costs at the City's existing treatment plants.

Conveyance Systems

- **Raw Water Conveyance**

  Raw water conveyance lines are those facilities required to pump and transfer raw water from the source to the treatment plant site.

- **Termination Storage/Pumping**

  The termination storage required at each of the alternate Southwest Treatment Plant general locations was based on a desired water quality which would limit chloride concentrations in the raw water to less than 240 mg/l. Historic water quality data obtained from the BRA shows that this is possible 95% of the time. Under this assumption raw water would need to be pumped from a termination storage facility rather than directly from the Brazos River System 5% of the time during the year. Termination storage facilities were sized for each alternate service area by using the maximum daily demand multiplied by the number of days required to satisfy the 5% limit. Assuming a usable depth of 16.0 feet, the volume of termination storage varied from 658 acres to 424 acres for Alternate Service Areas No. 1 to No. 4, respectively and was sized at 808 acres for Alternate Service Area No. 7.

- **Treatment Facilities**

  Northeast System

  This study utilized the City of Houston proposed Northeast Treatment Plant. The WHCSWSC will present its surface water demand to the City of Houston which, if practical, will size the Northeast Treatment Plant to accommodate this requirement.

  Southwest System

  The Southwest Treatment Plant will be located within one of five general locations presented later in this report. The raw water supply for this plant would be from the Brazos River Basin as mentioned previously. The estimated ultimate capacity of the Southwest Treatment Plant will be from 150 MGD to 250 MGD (maximum daily capacity); however, if the Fort Bend County area agrees to participate the ultimate capacity could increase to 300 MGD.

- **Treated Water Storage/Pumping**

  Treated water storage and pumping facilities are those facilities located at the treatment plant used to store the treated water and distribute it into the conveyance system.

- **Treated Water Conveyance**

  Treated water conveyance lines are those facilities required to transport water from the treatment plant to the boundary of the WHCSWSC study area. All treated water conveyance lines were sized to handle the maximum daily demands of their respective service areas.

Transmission Systems

The Transmission System for the WHCSWSC study area will be a delivery system which will supply wholesale treated surface water in the vicinity of groups of political subdivisions within the study area. The individual political subdivisions will be responsible for organizing and constructing the facilities needed to transport treated surface water from WHCSWSC transmission system to each individual political subdivision existing ground storage facility resulting in little or no disruptions during implementation.

Computer Model

The hydraulic network analysis for the various conveyance and transmission systems was accomplished through the use of computer modeling using a program called KYPIPE "Steady State Pipe Network Analysis" by the University of Kentucky. The program is based on the Hazen-Williams formula and provides pressure information, hydraulic grade line, head losses, pump heads, flow rates, velocities and system inflow and demand summaries for a variety of system configurations and components.

Network design criteria used in the various system models were as follows:

a. Design flow is maximum daily demand.
b. System pressures will not drop below 45 psi.
c. Velocities will not exceed 7 fps under maximum daily flow.
d. "C" Values when new will be 110 for line sizes up to 30" and 120 for line sizes 30" and larger.

Northeast Conveyance Systems

The Northeast Conveyance System, as referred to in this implementation plan, is comprised of the following components: a shared portion of the proposed City of Houston Northeast Treatment Plant, a shared portion of distribution pumping capacity capable of delivering treated water into a proposed WHCSWSC ground storage facility and pump station, and the WHCSWSC shared portion of the treated water conveyance line from the treatment plant to the ground storage facilities located at the WHCSWSC boundary line.

This study evaluated the following Northeast Conveyance Systems:

- Beltway 8 Route
- NHCWSC Route
- F.M. 1960 Route

Southwest Conveyance Systems

The components of the Southwest Conveyance System consist of a raw water pump station drawing from the Brazos River System, a raw water conveyance line from the source to the plant site, termination storage facilities for the raw water, a proposed Southwest Treatment Plant, ground storage and distribution pumping capabilities, and a treated water conveyance line to transport treated water from the plant site to the WHCSWSC boundary. A specific site for a proposed Southwest Treatment Plant will be recommended and further detailed in Phase V. However, this Appendix does evaluate and recommend a siting area for the Plant. In this Appendix, the following five different locations resulting in six different alternatives have been identified and evaluated.

Site 1. Oyster Creek/Dairy Ashford Conveyance System
Site 2. Brazos River/Highway 6 Conveyance System
Site 3. Oyster Creek/Highway 6 Conveyance System
Site 4A. Jones Creek/Grand Parkway Conveyance System
Site 4B. Allens Creek/Grand Parkway Conveyance System
Site 5. Allens Creek/F.M. 1093 Conveyance System

The above Sites 1, 2, 3 and 4A require termination storage facilities. Sites 4B and 5 do not require termination storage and utilize the proposed Allens Creek Reservoir.

Transmission Systems

The transmission system for the WHCSWSC study area was analysed using the following alternate service areas defined previously in Appendix II, "Water Demand and Supply":

- Alternate No. 1 - Boundary at Highway 290
- Alternate No. 2 - Boundary at F.M. 529
- Alternate No. 3 - Boundary at Clay Road
- Alternate No. 4 - Boundary at I.H. 10
- Alternate No. 7 - Entire Service Area Served by Southwest Supply System

Phasing of these Alternate Service Area Transmission Systems was accomplished in accordance with the time frame and regulatory areas as outlined by the HGCSD surface water conversion plan.

Figures 3 through 6A show the specific details of the Alternate Service Area Transmission Systems.

Cost Analysis

Considerations and Assumptions

- Northeast raw water supply costs are based on the following:

Year	Raw Water Cost
1990-2009	$0.25/1000 Gallons
2010-2029	$0.38/1000 Gallons
2030-After	$0.32/1000 Gallons

- Southwest raw water supply costs are based on the BRA offer consisting of $0.37/1000 gallons with additional capital costs resulting in an additional $0.09/1000 gallons.

- Raw water pumping/conveyance costs are based on $0.05/kilowatt-hour using an 85% efficiency factor.

- Termination storage costs for each site was based on water quality criteria aimed at limiting chlorides to 240 mg/l. This resulted in the following requirements for Southwest Conveyance System alternate Sites 1, 2, 3 and 4A:

Service Area	Ultimate Southwest Maximum Daily Demand (MGD)	Required Storage (Acres)
Alternate 1	187	658
Alternate 2	177	623
Alternate 3	140	525
Alternate 4	121	424
Alternate 7	231	808

Capital costs associated with termination storage include the construction cost to build such a facility plus the cost of the land required.

- All treatment plant capital cost estimates were based on current construction costs for similar facilities in the Houston area and include land costs, engineering and contingencies.

- The Northeast Treatment Plant capital cost used in this study was approximately $0.80 per gallon which increased to $1.08/gallon when adding land cost and site development cost. The Southwest Treatment Plant capital cost was based on $0.80 per gallon for actual treatment facilities. This figure was increased depending on the plant site alternate to include land cost and site development.

- The costs of operations and treatment at the proposed Northeast Treatment Plant are estimated to be in the range of $0.40 to $0.50 per 1000 gallons. A figure of $0.40 per 1000 gallons was used for this study.

- Operations and treatment costs at the proposed Southwest Treatment Plant are estimated to be $0.42 per 1000 gallons based on data received from the GCWA.

- Treated water pumping/conveyance and transmission capital costs were based on current construction costs for similar facilities constructed in the Houston area and the associated operating costs were based on $0.05/kilowatt-hour with maintenance costs estimated at $0.04/1000 gallons.

Capital Cost Estimates

Northeast Conveyance System

The Northeast Conveyance System capital costs varied from $96,578,000 to $232,048,000 depending on the route and service area alternate investigated. For further details concerning these costs see Table 6 on Page 91.

Southwest Conveyance System

Capital costs for the Southwest Conveyance System varied from $285,408,000 to $355,253,000 depending on the route and service area investigated. For further details concerning these costs see Table 7 on Page 92.

Service Area Alternate Transmission System

The total capital costs associated with the Service Area Alternate Transmission Systems varied from $353,684,000 to $380,662,000 depending on the service area alternates investigated. For further details concerning these costs see Table 8 on Page 94.

Annualized Cost Analysis

The annualized cost for each alternate was determined by adding capital cost amortized at 8% over 30 years with the associated annual operation and maintenance cost. The annual cost was further refined into annual cost per thousand gallons of water delivered by dividing the annual cost by the maximum daily water delivered for each phase of conversion. This final refinement will place the alternates on a comparable basis independent of the amount of water delivered by the phased developments.

Annualized costs for the Northeast Conveyance System ranged from $1.31/1000 gallons to $6.21/1000 gallons. For further details see Table 9 on Page 98.

Annualized costs for the Southwest Conveyance System ranged from $1.24/1000 gallons to $1.58/1000 gallons. For further details see Table 10 on Page 99.

Annualized costs for the Service Area Alternates including Conveyance and Transmission Systems varied from $1.54/1000 gallons to $1.77/1000 gallons at the end of the study (Year 2030). For further details see Table 11 on Page 101.

Present Worth Analysis

The present worth analysis presented in this study was calculated assuming the following assumptions:

- o Project capital cost have a 30 year life and are amortized at 8%.
- o Time period beginning 1988 and ending in 2030 (Study Period).
- o All present worth cost in 1988 dollars.
- o Operation and maintenance cost (O & M) are considered annually throughout study period.
- o O & M Costs are inflated at 10% per year.
- o The normalized present worth analysis was used for the Conveyance System Alternates by dividing the present worth by the million gallons per day (MGD) of maximum daily water delivered.
- o The actual present worth amounts were used when comparing Service Area Alternates (Through Year 2030) because the ultimate water delivered (231 MGD) was consistent for all Service Area Alternates.
- o Capital cost for each component was calculated as previously mentioned.

Normalized present worth for the Northeast Conveyance System ranged from $7.53/MGD to $8.99/MGD. For further details see Table 12 on Page 103.

Normalized present worth for the Southwest Conveyance System ranged from $10.46/MGD to $15.51/MGD. For further details see Table 13 on Page 104.

The normalized present worth for each Northeast or Southwest Conveyance System must be compared only within each Service Area Alternate. Comparing conveyance routes between Service Area Alternates or between the Northeast and the Southwest would not be valid due to the fact that all three components - Northeast Conveyance, Southwest Conveyance and Transmission System are needed in combination to serve the WHCSWSC demands.

The present worth in total dollars for the Service Area Alternates is shown below. The present worth analysis of the Service Area Alternates did not need normalizing since all of the alternates would ultimately deliver the same amount of treated water (231 MGD).

PRESENT WORTH
SERVICE AREA ALTERNATES
(Total Dollars)

SERVICE AREA ALTERNATES	SITE 4B	SITE 5
SERVICE AREA ALTERNATE 1	$2,980,823,000	$2,869,244,000
SERVICE AREA ALTERNATE 2	2,984,829,000	2,875,663,000
SERVICE AREA ALTERNATE 3	2,962,650,000	2,888,405,000
SERVICE AREA ALTERNATE 4	2,965,835,000	2,898,512,000
SERVICE AREA ALTERNATE 7	2,952,546,000	2,818,814,000

If the present worth costs were normalized using 231 MGD, then costs would range between $12.20/MGD in Service Area Alternate 7 to $12.90 in Service Area Alternate 4.

Ranking of Alternates

Methodology

Previous Appendices along with the previous sections of this Appendix have identified three Northeast Conveyance System Alternates, six Southwest Conveyance System Alternates and seven Service Area Alternates. At the request of the WHCSWSC Board, Service Area Alternates No. 5 and No. 6 were deleted from further consideration before beginning Appendix IV. Alternates 5 and 6 were deleted because of the lack of interest on the part of the city of Houston in developing the HWMP's "Western Alternative" which includes the WHCSWSC's North Supply System.

Since the majority of alternatives have both advantages and disadvantages when compared to one another, a systematic method of identifying the most feasible alternate must be developed. The method chosen to rank alternates in this Appendix will address the following general categories:

- Technical
- Environmental
- Community/Social
- Phasing
- Financial

Each set of Alternate Systems was evaluated and ranked in varying levels of detail within each of the general categories mentioned above.

Northeast Conveyance System Alternates

After detailed evaluation within the five general categories, it has been determined that the Beltway 8 Route is superior in all categories for the following reasons:

Technical

- Superior hydraulic characteristics producing a maximum of 16 psi more residual pressure at the WHCSWSC boundary than the other two routes.
- Reduced line lengths; 9 miles and 4 miles shorter than the F.M. 1960 and NHCWSC routes, respectively.
- Reduced possibility of needed land acquisitions outside existing street rights-of-way.
- Reduced possibility of problems during construction due to large rights-of-way, decreasing the construction time.

Environmental and Community/Social

- Routed through less existing and possible future residential developments than the NHCWSC and F.M. 1960 routes.
- Minimizes disruptions to traffic flow and utility relocations.
- Preferred route by the City of Houston.

Phasing and Financial

- Beltway 8 Route results in a shorter route and smaller cost to convey treated water to the WHCSWSC service area within the first conversion date of 2005 as determined by the HGCSD.
- Utilizes a portion of the NHCWSC proposed routing scheme producing a reduction in cost due to pro rata share with NHCWSC.
- Reduction in present worth cost of approximately $6,000,000.
- Reduction in operating cost.

As a result of the advantages previously listed, a numerical ranking was not performed when evaluating the Northeast Conveyance System Alternates. This appendix concludes that the Beltway 8 route is the preferred route over the two routes previously discussed. The Beltway 8 route will be used as the recommended Northeast Conveyance System Alternate when evaluating and ranking the Service Area Alternates later in this section.

Southwest Conveyance System Alternate

After initial review, the six alternate Southwest Conveyance Systems considered for study are as listed below:

Site 1: Oyster Creek/Dairy Ashford
Site 2: Brazos River/Highway 6
Site 3: Oyster Creek/Highway 6
Site 4A: Jones Creek/Grand Parkway
Site 4B: Allens Creek/Grand Parkway
Site 5: Allens Creek/F.M. 1093

After initial review and because of the importance attached to the selection of a Southwest Conveyance System, a very detailed ranking criteria and methodology has been developed within the confines of the previously mentioned five general ranking categories. Each of the general ranking categories were evaluated based on the sub-categories outlined in the Individual Ranking Form located in Attachment 1 of Appendix IV.

The final conveyance system rankings for individual raters; the final average ranking between raters and the final overall ranking of each system can be viewed in the chart below:

FINAL RANKING OF ALTERNATES
SOUTHWEST CONVEYANCE SYSTEM

RANKING COMMITTEE MEMBER	SOUTHWEST CONVEYANCE ALTERNATES SITE 1	SITE 2	SITE 3	SITE 4A	SITE 4B	SITE 5
RATER NO. 1	6	4	5	3	1	2
RATER NO. 2	6	4	5	2	1	3
RATER NO. 3	6	5	4	3	1	2
RATER NO. 4	6	4	5	2	1	3
RATER NO. 5	6	4	5	2	2	1
RATER NO. 6	6	4	5	3	2	1
RATER NO. 7	6	5	4	3	2	1
FINAL AVERAGE RATING	6	4.3	4.7	2.6	1.4	1.9
FINAL RANKING	(6)	(4)	(5)	(3)	(1)	(2)

From the final ranking chart it can be concluded that Site 4B, the Allens Creek/Grand Parkway Alternate is the ranking committee's preferred Southwest Conveyance System alternate. Site 5, the Allens Creek/F.M. 1093 system was very close with Site 4A, the Jones Creek/Grand Parkway, a distant third. It can be concluded that Site 1 (Oyster Creek/Dairy Ashford); Site 2 (Brazos River/Highway 6); and Site 3 (Oyster Creek/Highway 6) are the least preferred.

It was concluded after reviewing the sensitivity of each of the five general ranking categories that the elimination of any one category would not affect the conclusion recommending Site 4B as the preferred Southwest Conveyance alternate.

Service Area Alternates

The Service Area Alternates considered for evaluation and ranking are described as follows:

- Alternate No. 1 - Boundary at Highway 290
- Alternate No. 2 - Boundary at F.M. 529
- Alternate No. 3 - Boundary at Clay Road
- Alternate No. 4 - Boundary at I.H.10
- Alternate No. 7 - Entire Service Area Served by Southwest Supply System

It is apparent that the Service Area Alternate that follows the HGCSD Conversion Plan would be preferable. The HGCSD's earliest conversion dates of 1995 and 2000 are located in the southwest and the remaining conversion dates of 2005, 2010 and the assumed 2030 are located in the north and far northwest of the WHCSWSC study area. As a result, the Service Area Alternate that has its first phases in the southwest will be less expensive from a phasing standpoint. Service Area Alternate 7 which proposes to serve the study area from south to north produces the least cost from both an annualized and present worth analysis.

As a result of the above analogy, we recommend Alternate No. 7 as the preferred Service Area Alternate. However, this recommendation could be changed in future updates to this study without appreciable affecting the final ultimate cost of the entire transmission system.

Conclusions and Recommendations

Appendix IV concludes with the following recommendations:

- **The Northeast Conveyance System should follow the Beltway 8 Route eliminating the NHCWSC and F.M. 1960 Routes from further study.**

- **Eliminate the Southwest Conveyance System Alternates 1, 2, 3 and 4A from further study.**

- The Southwest Conveyance System Alternates No. 4B (Allens Creek/Grand Parkway) and No. 5 (Allens Creek/F.M. 1093) should be considered for further study.

- Phase V should study in detail the possibility of locating a plant along F.M. 1093, in the area of the Grand Parkway/F.M. 1093 intersection, west to the proposed Allens Creek Reservoir site.

- The Southwest Conveyance System plant site should be located to allow future development of an alternate and/or additional raw water source utilizing the available water rights in the BRA Canal System. This would enhance the possibility of surface water regionalization with entities in Fort Bend County.

- The Southwest Conveyance System should obtain its raw water supply directly from Allens Creek Reservoir which will result in a higher quality water supply.

- Phase V should further study the Allens Creek Reservoir operational procedures required to limit chloride concentrations to 100 mg/l.

- The Southwest Conveyance System plant site should contain sufficient acreage to develop an ultimate plant capacity of approximately 300 MGD allowing the flexibility to meet demands due to possible Service Area modifications. This capacity is based on Service Area Alternate No. 7's ultimate capacity of 231 MGD, maximizing the water supply offer by the BRA, and the possibility of treating the available water rights of approximately 60 MGD from the BRA Canal System for possible wholesale to entities in Fort Bend County.

- Phase V should further study the ultimate transmission system utilizing the demands developed from either Service Area Alternate No. 7 or No. 4. This would maintain the flexibility required to meet future Service Area modifications at a increased cost of less than 5 percent of the total ultimate transmission system cost.

- WHCSWSC should request the BRA to upgrade its recent proposal based on the conclusions and recommendations outlined in this Appendix. The BRA proposal should include the construction of Allens Creek Reservoir by 1995.

- WHCSWSC should authorize the Engineer to begin Phase V - The Detail Evaluation of Selected Alternatives, as soon as possible.

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1.0 INTRODUCTION

1.0 INTRODUCTION

Purpose and Scope

The purpose of this study undertaken by the West Harris County Surface Water Supply Corporation (WHCSWSC), is to produce an implementation program that will provide a reliable long-term surface water supply to West Harris County. This proposed implementation program is an extension of the Houston Water Master Plan (HWMP) and will refine the HWMP, providing details necessary for implementation within the WHCSWSC study area.

The project scope of work for this phase of the implementation program deals with the definition and evaluation of alternative conveyance and transmission systems to serve the projected water demands of the WHCSWSC study area. The Northeast Conveyance System, as referred to in this implementation plan, is comprised of the following components: a shared portion of the proposed City of Houston Northeast Treatment Plant, a shared portion of distribution pumping capacity capable of delivering treated water into a proposed WHCSWSC ground storage facility and pump station, and the WHCSWSC shared portion of the treated water conveyance line from the treatment plant to the ground storage facilities located at the WHCSWSC boundary line. The Southwest Conveyance System is comprised of raw water pumping and conveyance facilities, termination storage facilities for the raw water, a proposed Southwest Treatment Plant,

treated water ground storage and pumping facilities and treated water conveyance pipeline from the treatment plant to the WHCSWSC boundary line. The Transmission System is defined as the pipeline, ground storage facilities and booster pump stations required to deliver treated water from the conveyance systems to locations throughout the WHCSWSC service area. The demands used in this Appendix are the revised surface water requirements as previously defined in Appendix II, "Water Demand and Supply - Revision One". To satisfy these requirements with regard to the long-term conversion plan as outlined by the Harris-Galveston Coastal Subsidence District (HGCSD), a method of conveying surface water from sources located northeast and southwest of the WHCSWSC study area must be determined.

The northeast raw water supply source will be taken from Lake Houston. Three alternate Northeast Conveyance Systems will be defined and evaluated based on Technical, Environmental, Community/Social, Phasing and Financial criteria.

The southwest raw water supply source will be the Brazos River, the proposed Allen's Creek Reservoir and/or the Brazos River Canal System. Six alternate Southwest Conveyance Systems along with five general geographical areas have been identified and will be evaluated based on the previously mentioned criteria. Included in the evaluation of alternate Southwest Conveyance Systems will be the evaluation of a location for a proposed Southwest Water Treatment Plant.

The Transmission System required to deliver wholesale treated surface water from the previously defined conveyance systems to specific customers within the WHCSWSC study area will also be defined. Alternate Service Areas No. 1 through 4, as previously defined in Appendix II, and No. 7 will be evaluated based on capital and operational costs, and the phased construction of each alternate transmission system to satisfy HGCSD surface water conversion target dates. Alternative conveyance and transmission systems will be compared and rated with respect to each other. The highest rated systems will be further refined in Phase V, "Detailed Evaluation of Selected Alternatives".

2.0 DESIGN CONSIDERATIONS AND ASSUMPTIONS

2.0 DESIGN CONSIDERATIONS AND ASSUMPTIONS

Projected Water Demands

Table 1 presents a summary of alternate service area water requirements which are based on the revised projected water demands previously defined in Appendix II, "Water Supply and Demand - Revision One". The projected water demands were updated to be consistent with the recent revision to the water demands in the City of Houston Water Master Plan (HWMP). These revisions resulted in pushing back the projected water demands by five years after 1990. Also, included in the table is the projected water demands for an alternate that considers serving all of the WHCSWSC service area from the Southwest Supply, hereafter referred to as Alternate No. 7.

Projected water demands were determined by assigning demand criteria to population and employment projections developed by Rice Center for each census tract and Municipal Demand Area within the service area. The surface water supply requirements were based on using average daily water demands. To be consistent with the sizing criteria presented in the HWMP, the WHCSWSC study uses maximum day demands to size treatment plants, conveyance systems and transmission systems. Maximum daily demands were computed by multiplying average daily demands by a peak factor which

ranged from 1.6 to 2.0. Refer to Exhibit 1 for a graphical representation of the WHCSWSC projected average daily demands and Exhibit 2 for the corresponding maximum daily demands.

The surface water required by the HGCSD conversion plan was calculated by using 80% of the total maximum daily demand within each of the HGCSD regulatory areas. The regulatory areas will not be required to increase surface water usage until another conversion date is reached and as a result the surface water requirements increase in a stair step fashion. The HGCSD plan ends in 2020, however, for purposes of computing surface water requirements for this study, it was assumed that HGCSD regulatory area eight will require 80% conversion to surface water in 2030. The HGCSD plan permits increases in groundwater withdrawal so long as surface water use is not decreased. Therefore, in this study it was assumed that the amount of surface water required at each regulatory area conversion date remained constant throughout the duration of the study. Increases in demand due to growth along with peak demands would be satisfied with available groundwater supplies.

The surface water requirements projected in this study have not been reduced to account for the enactment of a future water conservation plan. Any reduction experienced due to water conservation measures will only serve to postpone future phases. As a result for planning purposes the water conservation measures have been neglected to produce a worst case scenario. The water conservation measures will be reviewed when updating this plan for future expansions.

TABLE 1

SUMMARY OF SURFACE WATER DEMANDS BY ALTERNATE
TO MEET HGCSD CONVERSION REQUIREMENTS
(MAXIMUM DAILY DEMANDS)

YEAR	CITY OF HOUSTON SOUTHWEST (MGD)	WHCSWSC SOUTHWEST (MGD)	TOTAL SOUTHWEST (MGD)	TOTAL NORTHEAST (MGD)	TOTAL ALL AREAS (MGD)
ALTERNATE 1 - BOUNDARY AT U.S. 290					
1985	0.00	0.00	0.00	0.00	0.00
1995	65.27	0.00	65.27	0.00	65.27
2000	89.82	16.14	105.96	0.00	105.96
2005	89.82	16.14	105.96	9.66	115.62
2010	89.82	44.76	134.58	36.18	170.76
2012	101.17	44.76	145.93	36.18	182.11
2020	101.17	44.76	145.93	36.18	182.11
2030**	101.17	86.25	187.42	43.85	231.27
ALTERNATE 2 - BOUNDARY AT F.M. 529					
1985	0.00	0.00	0.00	0.00	0.00
1995	65.27	0.00	65.27	0.00	65.27
2000	89.82	16.14	105.96	0.00	105.96
2005	89.82	16.14	105.96	9.66	115.62
2010	89.82	39.25	129.07	41.69	170.76
2012	101.17	39.25	140.42	41.69	182.11
2020	101.17	39.25	140.42	41.69	182.11
2030**	101.17	76.29	177.46	53.80	231.26
ALTERNATE 3 - BOUNDARY AT CLAY ROAD					
1985	0.00	0.00	0.00	0.00	0.00
1995	65.27	0.00	65.27	0.00	65.27
2000	89.82	15.74	105.56	0.41	105.97
2005	89.82	15.74	105.56	10.06	115.62
2010	89.82	15.74	105.56	65.21	170.77
2012	101.17	15.74	116.91	65.21	182.12
2020	101.17	15.74	116.91	65.21	182.12
2030**	101.17	38.79	139.96	91.30	231.26

**Harris-Galveston Coastal Subsidence District Plan for surface water use ends at 2020. Required surface water for 2030 was estimated assuming that Area 8 will be required to convert to 80% surface water in that year.

TABLE 1 (CONT'D)

SUMMARY OF SURFACE WATER DEMANDS BY ALTERNATE
TO MEET HGCSD CONVERSION REQUIREMENTS
(MAXIMUM DAILY DEMANDS)

YEAR	CITY OF HOUSTON SOUTHWEST (MGD)	WHCSWSC SOUTHWEST (MGD)	TOTAL SOUTHWEST (MGD)	TOTAL NORTHEAST (MGD)	TOTAL ALL AREAS (MGD)
ALTERNATE 4 - BOUNDARY AT I.H. 10					
1985	0.00	0.00	0.00	0.00	0.00
1995	65.27	0.00	65.27	0.00	65.27
2000	89.82	12.49	102.31	3.66	105.97
2005	89.82	12.49	102.31	13.31	115.62
2010	89.82	12.49	102.31	68.46	170.77
2012	101.17	12.49	113.66	68.46	182.12
2020	101.17	12.49	113.66	68.46	182.12
2030**	101.17	19.79	120.96	110.30	231.26
ALTERNATE 7 - ENTIRE WHCSWSC AREA SERVED BY SOUTHWEST SYSTEM					
1985	0.00	0.00	0.00	0.00	0.00
1995	65.27	0.00	65.27	0.00	65.27
2000	89.82	16.14	105.97	0.00	105.97
2005	89.82	25.80	115.62	0.00	115.62
2010	89.82	80.95	170.77	0.00	170.77
2012	101.17	80.95	182.12	0.00	182.12
2020	101.17	80.95	182.12	0.00	182.12
2030**	101.17	130.09	231.26	0.00	231.26

**Harris-Galveston Coastal Subsidence District Plan for surface water use ends at 2020. Required surface water for 2030 was estimated assuming that Area 8 will be required to convert to 80% surface water in that year.

EXHIBIT NO. 1

SURFACE WATER REQUIREMENT
(AVERAGE DAILY DEMAND)

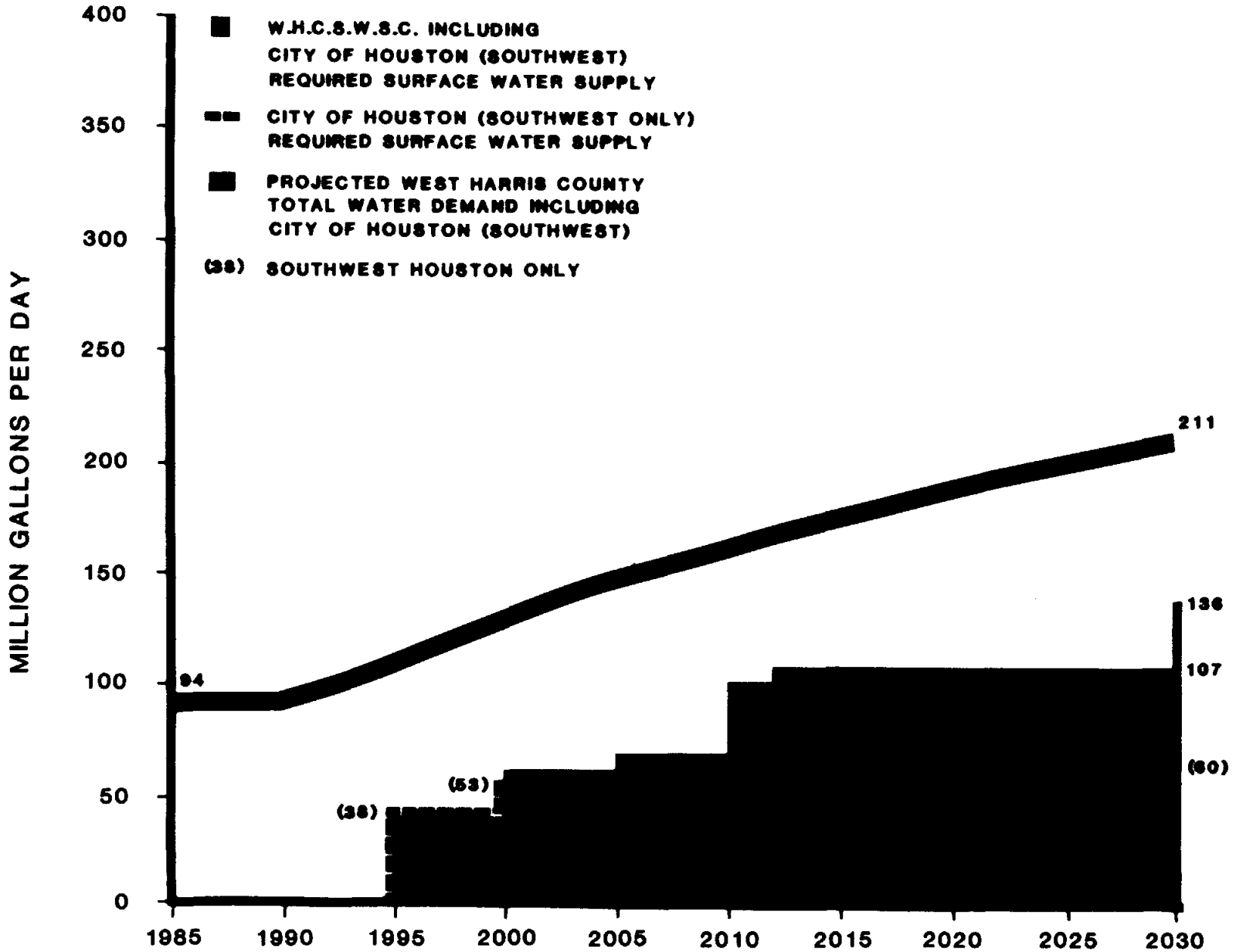
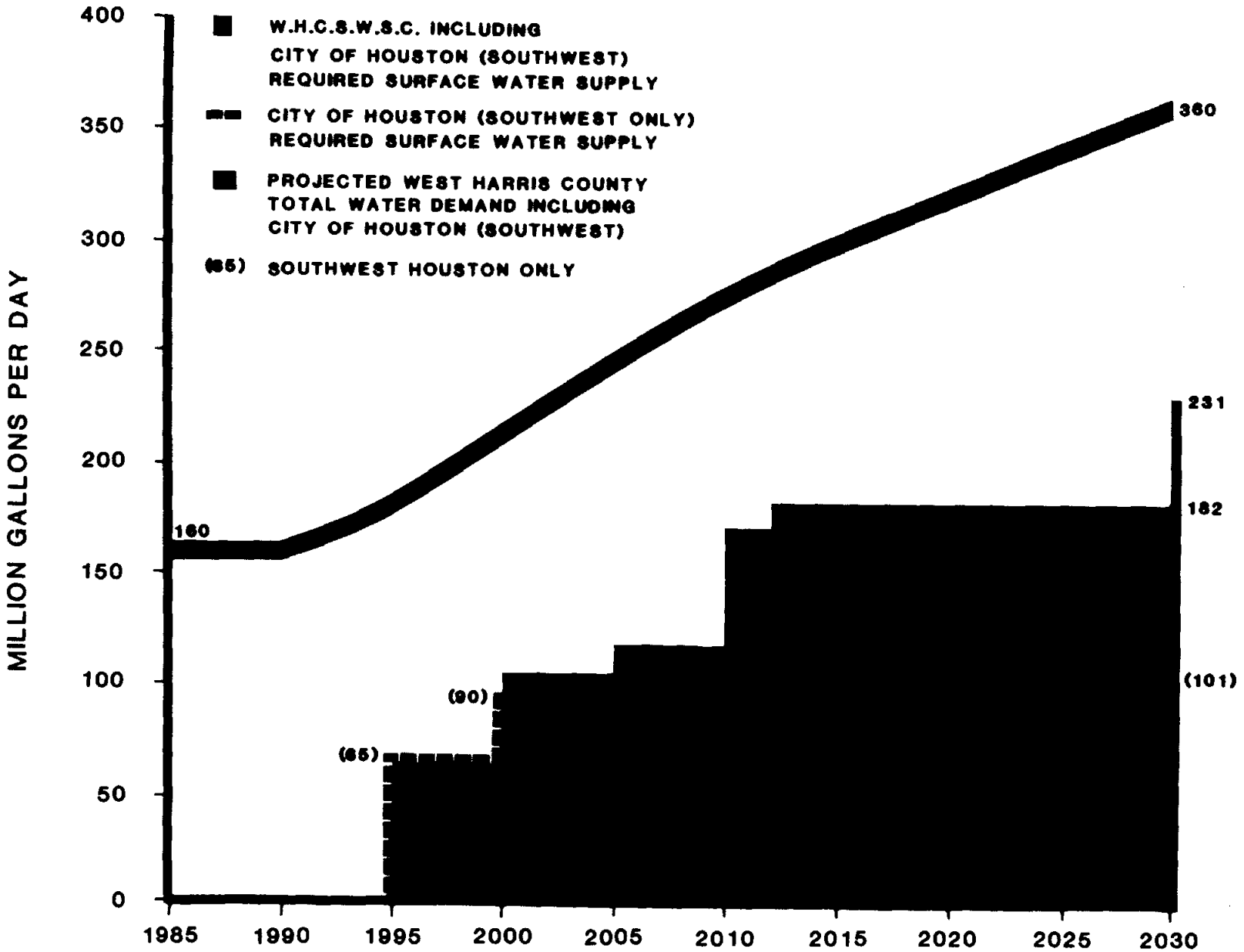


EXHIBIT NO. 2

SURFACE WATER REQUIREMENT
(MAXIMUM DAILY DEMAND)



Surface Water Sources

The assumed surface water source for the Northeast System is Lake Houston. Lake Houston is located approximately 20 miles east of the eastern boundary of the WHCSWSC study area and impounds San Jacinto River water. Lake Houston is owned and operated by the City of Houston and currently serves as a raw water source for the City. Various projects are underway or currently being investigated to bring additional water to Lake Houston from adjacent river basin systems which will assure a sufficient quantity of water available in Lake Houston to meet future demands.

The assumed surface water source for the Southwest System is the Brazos River, the proposed Allen's Creek Reservoir and/or the Brazos River Canal System which flows in a southeast direction approximately 4 miles southwest of the WHCSWSC study area boundary. The WHCSWSC will be required to obtain permission to transfer Brazos River Basin water to the San Jacinto River Basin which presently encompasses the entire WHCSWSC service area. Both the Brazos River and San Jacinto River Authorities have agreed in principal to the mentioned transfer, therefore, this requirement is not perceived to affect the viability of this implementation plan.

Correspondence received from the Brazos River Authority (BRA) outlines a proposal for an incrementally developed raw water source of up to 134 MGD (average daily supply) with the ability to meet the WHCSWSC maximum

daily demands through operations of the entire Brazos River Basin. The initial increment of supply available immediately from existing sources is 67.0 MGD. The second increment of supply will come from the proposed Allen's Creek reservoir to be developed by the B.R.A. This second increment will increase the available supply of raw water to 107.2 MGD by the year 2000. The third increment is planned to be supplied by the proposed South Bend Reservoir Project. This supply will increase the available raw water supply to 134.0 MGD in 2030. However, the available raw water to WHCSWSC will only be a portion of the total available water which has been defined as current use water in the BRA proposal. The portion offered to WHCSWSC will be as follows:

Year	Cumulative Water Offered (MGD)
1995	40
2000	67
2005	72
2010	107
2015	116
2020	116
2025	116
2030	134

Table 2 presents a summary of supply source allocations for the WHCSWSC Southwest System. Exhibit 3 shows a graphical representation of the BRA proposal. Raw water sources were sized to handle the average daily demands of the alternate service areas with the ability to meet maximum daily demands as required. If the Southwest Conveyance System Alternate Site 4B or 5 is chosen, the WHCSWSC would need to request the BRA to construct Allens Creek Reservoir by the year 1995.

EXHIBIT NO. 3

SURFACE WATER SUPPLY
BRAZOS RIVER AUTHORITY
(AVERAGE DAILY DEMAND)

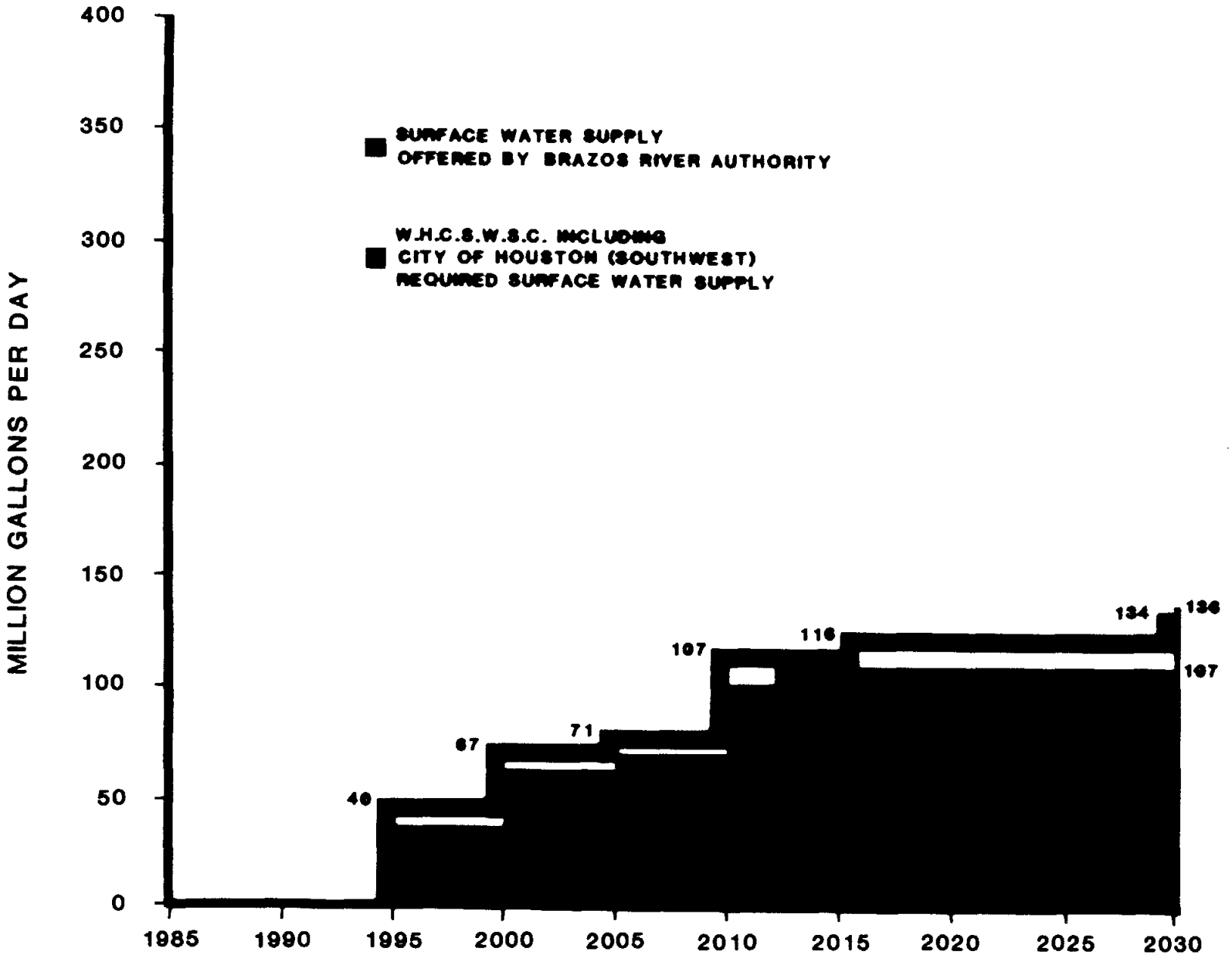


TABLE 2

WHCSWSC SOUTHWEST SYSTEM ALLOCATIONS FROM
SOUTHWEST SUPPLY SOURCE
(BRAZOS RIVER BASIN)

Supply Source	Supply Year Needed	Supply Source Amount (AF/YR)	Allocations* from Supply Source WHCSWSC (AF/YR)	Allocations* from Supply Source Option Grp (AF/YR)	Cumulative Total Allocated Supplies WHCSWSC (AF/YR)	Cumulative Total Allocated Supplies Option Grp (AF/YR)
Existing BRA Reservoir System	1988	90,000 (80.4) (mgd)	75,000 (67.0) (mgd)	15,000 (13.4) (mgd)	75,000 (67.0) (mgd)	15,000 (13.4) (mgd)
Allen's Creek	2000	70,000 (62.5) (mgd)	45,000 (40.2) (mgd)	25,000 (22.3) (mgd)	120,000 (107.2) (mgd)	40,000 (35.7) (mgd)
South Bend	2010	110,000 (98.2) (mgd)	30,000 (26.8) (mgd)	80,000 (71.5) (mgd)	150,000 (134.0) (mgd)	120,000 (107.2) (mgd)

*Each group would be allocated a total supply up to this amount. Water not designated Current Use Water for immediate use would be designated Future Use Water.

Raw Water Characteristics

The raw water from the Brazos River System which would be used to supply the WHCSWSC service area compares favorably with other regional water sources such as Lake Conroe or the Trinity River. Table 3 gives a summary comparison of Brazos River System water to these other supplies.

The Brazos River System contains the Brazos River and its reservoirs as well as the canal system which is comprised of portions of Jones Creek, Oyster Creek, and the manmade canal south of Missouri City which transfers raw water as far as the Texas City area. The head water flow of Oyster Creek originates as pumpage from the Brazos River at a pump station operated by the Brazos River Authority. From this pump station water flows into Jones Creek, which has been modified to flow into Oyster Creek. A second pump station delivers water out of Oyster Creek into Canal System A which serves Brazoria and Galveston Counties with irrigation and municipal water supply. Overflow of Dam No. 3 downstream of this second pumping station provides the only upstream flow to the lower part of Oyster Creek. The desired water uses for Oyster Creek as determined by the Texas Water Commission are contact recreation, high quality aquatic habitat, and domestic water supply.

TABLE 3

COMPARISON OF REGIONAL SURFACE WATER QUALITY[1/]

Parameter (Units)	Brazos River	Lake Conroe[2/] (San Jacinto River)	Benbrook Lake[2/] (Trinity River)
Turbidity (ntu)	16 - 111	N.A.[3/]	N.A.[3/]
Alkalinity (mg/l @ $CaCO_3$)	78 - 250	39 - 140	110-160
pH (units)	7.9 - 8.9	6.4 - 8.4	6.9 - 8.6
Fluoride (mg/l)	0.28 - 0.34	0.1 - 0.2	0.2 - 0.4
Calcium Hardness (mg/l @ $CaCO_3$)	128 - 140	37 - 85	97-155
Hardness (mg/l @ $CaCO_3$)	148 - 180	46 - 100	130-180
Zinc (mg/l)	N.A.[3/]	0.01 - 0.03	N.A.[3/]
Iron (mg/l)	2.7 - 3.8	0.01 - 8.3	0.01 - 0.79

1/ Source of Data: GCWA Monthly Reports, 1983 - 1985.
2/ Source of Data: U.S.G.S. Water Resources Data 1982.
3/ NA: Not Analyzed.

**Reproduced from G.C.W.A. Investigation of Potable Water Complaints in Dickinson, Texas by Malcolm Pirnie, May 1986.

The following numerical criteria have been established for the upper Oyster Creek segment to insure that the water quality will be maintained for the desired uses.

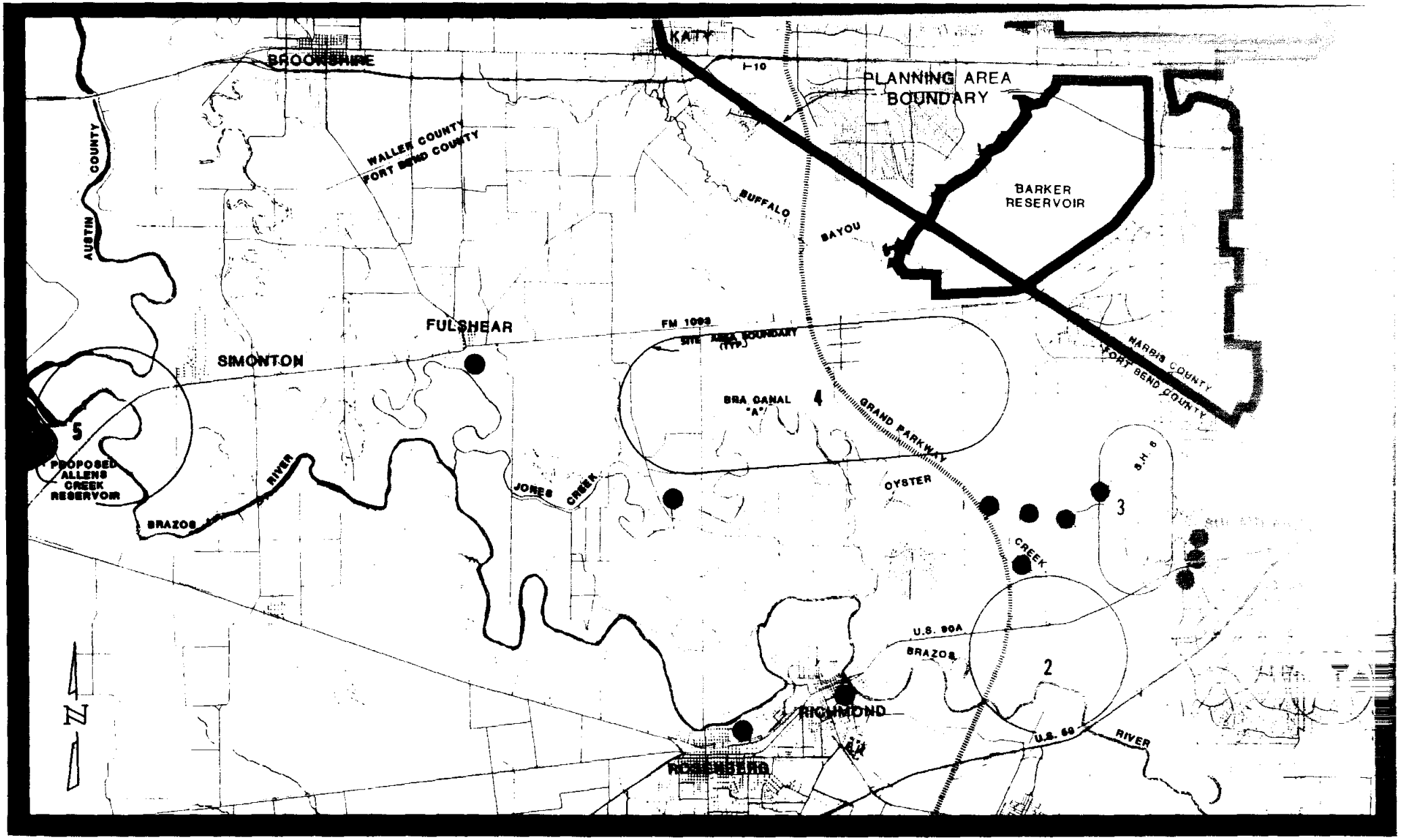
Parameter	Criteria
Dissolved Oxygen	Not less than 5.0 mg/l
pH	Not less than 6.5 nor more than 9.0
Temperature	Not to exceed 95^{o} F.
Chloride	Annual average not to exceed 140 mg/l
Sulfate	Annual average not to exceed 75 mg/l
Total Dissolved Solids	Annual average not to exceed 1070 mg/l
Fecal Coliform	30-Day geometric mean not to exceed 200 per 100 ml.

The Texas Water Commission maintains an active monitoring station of Oyster Creek at U.S. Highway 90A in Sugar Land. A draft report dealing with the wasteload evaluation for Upper Oyster Creek was published June 20, 1985. This document reports that data gathered over 4 years from the period of January 1, 1981 through December 31, 1984 indicate that water quality at this location is not meeting the state criteria for the following parameters: dissolved oxygen, temperature and pH. The average dissolved oxygen concentration for the period is 4.4 mg/l which is below the minimum allowable concentration of 5.0 mg/l. Maximum temperatures have been recorded up to 99^{o}F. which exceed the maximum allowable of

95°F. The minimum pH observed was 6.1 which is less than the minimum criteria of 6.5. Recorded values for chlorides, sulfates, total dissolved solids and fecal coliform bacteria have been within the allowable criteria. Exhibit 4 shows the approximate locations of effluent discharge points into the Canal A system including Jones and Oyster Creeks.

Raw water quality conditions of the Brazos River itself have been monitored over the past 20 years by the USGS at its gauging station near Richmond, Texas. Table 4, taken from data prepared by the USGS, gives a description of water quality conditions in the Brazos River along with statistical and recurrence intervals for each criteria. Of importance with respect to raw water supply and treatment are the amount of dissolved solids, chlorides and sulfates monitored in the raw water. In 95% of the samples taken the total dissolved solids were less than or equal to 730.0 milligrams per liter (mg/l), chlorides were equal to or less than 240.0 mg/l and sulfates were equal to or less than 130.5 mg/l. Other criteria related to water quality of the Brazos River can also be seen in this table.

Raw water taken from the Brazos River System is characteristically high in color, with variable turbidity, high organic content, high iron and seasonally high algae content. The high algae and organic content of the raw water results in the potential for taste and odor problems to develop during treatment and distribution.



4 TREATMENT PLANT AREA

● WASTE DISCHARGE LOCATION

SOUTHWEST CONVEYANCE SYSTEM STUDY AREA

(WASTE DISCHARGE SURVEY)

EXHIBIT NO. 4

TABLE 4

STATISTICAL SUMMARY OF SELECTED WATER-QUALITY DATA

STATION NUMBER: 08114000 STATION NAME: BRAZOS RIVER AT RICHMOND, TEX.

LATITUDE: 293456 LONGITUDE: 0954527 COUNTY: FORT BEND DRAINAGE AREA: 45307.00 SQUARE MILES

SUMMARY OF SELECTED WATER QUALITY DATA COLLECTED AT PERIODIC INTERVALS FROM OCT 1967 TO AUG 1986

WATER-QUALITY CONSTITUENT	DESCRIPTIVE STATISTICS				PERCENT OF SAMPLES IN WHICH VALUES WERE LESS THAN OR EQUAL TO THOSE SHOWN				
	SAMPLE SIZE	MAXIMUM	MINIMUM	MEAN	95	75	MEDIAN 50	25	5
TEMPERATURE (DEG C)	330	35.50	3.50	20.35	30.50	26.00	20.00	15.00	8.00
STREAMFLOW, INSTANTANEOUS (CFS)	244	98100.00	120.00	10510.12	44979.96	12250.00	4969.00	1777.50	742.00
TURBIDITY (FTU)	55	890.00	0.40	140.97	556.00	200.00	74.00	20.00	2.54
COLOR (PLATINUMCOBALT UNITS)	61	180.00	5.00	45.70	158.00	50.00	25.00	10.00	5.00
SPECIFIC CONDUCTANCE (UMHOS)	315	1900.00	220.00	753.58	1298.00	936.00	725.00	519.00	304.40
OXYGEN, DISSOLVED (MG/L)	120	14.30	5.40	8.77	11.40	9.80	8.60	7.60	6.70
OXYGEN, DISSOLVED (PERCENT SATURATION)	119	160.00	66.00	93.17	119.00	104.00	97.00	91.00	76.00
OXYGEN DEMAND, BIOCHEMICAL, 5 DAY (MG/L)	119	8.10	0.10	2.33	4.60	2.80	2.10	1.40	0.60
OXYGEN DEMAND, CHEMICAL (LOW LEVEL) (MG/	12	43.00	7.00	17.67	43.00	18.75	16.50	11.25	7.00
PH (UNITS)	302	8.60	6.20	7.75	8.30	8.00	7.80	7.50	7.10
ALKALINITY FIELD (MG/L AS CACO3)	293	248.00	76.00	136.29	190.00	158.50	136.00	116.00	89.00
CARBONATE FET-FLD (MG/L AS CO3)	251	9.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00
SOLIDS, RESIDUE AT 105 DEG. C, SUSPENDED	62	2260.00	15.00	384.74	1036.50	539.50	136.50	41.25	20.15
SOLIDS, VOLATILE, SUSPENDED (MG/L)	57	2220.00	0.00	108.09	332.40	103.50	50.00	16.50	0.00
NITROGEN, ORGANIC TOTAL (MG/L AS N)	94	7.20	-0.03	0.85	1.75	1.10	0.75	0.45	0.13
NITROGEN, ORGANIC DISSOLVED (MG/L AS N)	12	1.20	0.37	0.70	1.20	0.97	0.65	0.52	0.37
NITROGEN, AMMONIA DISSOLVED (MG/L AS N)	42	0.18	0.00	0.06	0.14	0.08	0.05	0.03	0.00
NITROGEN, AMMONIA TOTAL (MG/L AS N)	103	1.10	0.00	0.08	0.22	0.08	0.05	0.02	0.00
NITROGEN, NITRITE DISSOLVED (MG/L AS N)	6	0.05	0.00	0.01	0.03	0.01	0.00	0.00	0.00
NITROGEN, NITRITE TOTAL (MG/L AS N)	88	0.25	0.00	0.02	0.13	0.02	0.01	0.00	0.00
NITROGEN, NITRATE DISSOLVED (MG/L AS N)	2	0.94	0.64						
NITROGEN, NITRATE TOTAL (MG/L AS N)	172	2.20	0.00	0.52	1.34	0.80	0.50	0.20	0.00
NITROGEN,AMMONIA + ORGANIC DIS. (MG/L AS	12	1.30	0.46	0.77	1.30	0.95	0.73	0.63	0.46
NITROGEN,AMMONIA + ORGANIC TOTAL (MG/L A	76	7.30	0.01	1.09	1.95	1.20	0.93	0.72	0.46
NITROGEN, NO2+NO3 TOTAL (MG/L AS N)	76	1.50	0.00	0.40	1.10	0.62	0.41	0.02	0.00
NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	42	1.30	0.00	0.48	1.18	0.72	0.48	0.00	0.00
PHOSPHORUS, TOTAL (MG/L AS P)	111	0.95	0.03	0.24	0.66	0.31	0.19	0.11	0.07
PHOSPHORUS, DISSOLVED (MG/L AS P)	42	0.26	0.00	0.10	0.18	0.13	0.09	0.07	0.05
CARBON, ORGANIC TOTAL (MG/L AS C)	54	44.00	2.70	9.94	13.50	12.00	9.25	5.38	3.10
CARBON, ORGANIC DISSOLVED (MG/L AS C)	4	25.00	4.20						
CARBON, ORGANIC SUSPENDED TOTAL (MG/L AS	4	1.30	0.40						
HARDNESS (MG/L AS CACO3)	293	470.00	88.00	203.01	293.00	240.00	200.00	160.00	110.00
HARDNESS, NONCARBONATE (MG/L CACO3)	293	300.00	0.00	67.23	140.00	91.00	59.00	33.50	16.70
CALCIUM DISSOLVED (MG/L AS CA)	290	110.00	28.00	51.73	86.00	72.00	62.00	50.00	36.00
MAGNESIUM, DISSOLVED (MG/L AS MG)	290	71.00	3.20	11.67	20.00	15.25	12.00	7.77	4.45
SODIUM, DISSOLVED (MG/L AS NA)	180	240.00	9.50	77.54	169.00	110.00	69.50	40.00	16.05
SODIUM ADSORPTION RATIO	289	23.00	0.50	2.31	4.00	3.00	2.00	1.25	0.70
POTASSIUM, DISSOLVED (MG/L AS K)	142	7.50	1.30	4.59	5.89	5.10	4.50	4.10	3.40
CHLORIDE, DISSOLVED (MG/L AS CL)	295	370.00	11.00	111.01	240.00	150.00	98.00	53.00	22.00
SULFATE DISSOLVED (MG/L AS SO4)	294	220.00	13.00	71.40	130.50	92.00	67.00	46.00	21.50
FLUORIDE, DISSOLVED (MG/L AS F)	230	0.60	0.00	0.26	0.50	0.30	0.30	0.20	0.15
SILICA, DISSOLVED (MG/L AS SIO2)	294	40.00	0.30	8.19	11.00	9.50	8.40	6.97	3.68
COLIFORM, FECAL, 0.7 UM-MF (COLS./100 ML	42	7300.00	20.00	1107.00	5714.90	1175.00	535.00	137.50	42.50

TABLE 4 (CONT'D)

STATISTICAL SUMMARY OF SELECTED WATER-QUALITY DATA IN THE UPPER TRINITY RIVER BASIN, TEXAS

STATION NUMBER: 08114000 STATION NAME: BRAZOS RIVER AT RICHMOND, TEX.

LATITUDE: 293456 LONGITUDE: 0954527 COUNTY: FORT BEND DRAINAGE AREA: 45007.00 SQUARE MILES

SUMMARY OF SELECTED WATER QUALITY DATA COLLECTED AT PERIODIC INTERVALS FROM OCT 1967 TO AUG 1986

WATER-QUALITY CONSTITUENT	DESCRIPTIVE STATISTICS				PERCENT OF SAMPLES IN WHICH VALUES WERE LESS THAN OR EQUAL TO THOSE SHOWN				
	SAMPLE SIZE	MAXIMUM	MINIMUM	MEAN	95	75	MEDIAN 50	25	5
STREPTOCOCCI FECAL, KF AGAR (COLS. PER 1	42	9100.00	20.00	1374.33	8149.97	1100.00	240.00	130.00	32.60
PHENOLS (UG/L)	12	21.00	0.00	2.92	21.00	2.75	0.00	0.00	0.00
METHYLENE BLUE ACTIVE SUBSTANCE (MG/L)	16	0.05	0.00	0.01	0.05	0.01	0.00	0.00	0.00
SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED	42	915.00	136.00	495.50	906.95	674.25	486.00	314.75	159.75
SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (	290	1100.00	128.00	424.98	760.00	550.00	408.50	289.75	170.00
SED. SUSP. SIEVE DIAM. % FINER THAN .062	155	100.00	10.00	68.71	99.00	97.00	91.00	84.00	69.60
SEDIMENT, SUSPENDED (MG/L)	159	7360.00	12.00	1333.20	4820.00	1680.00	350.00	173.00	20.00
SEDIMENT, DISCHARGE, SUSPENDED (T/DAY)	159	500000.00	23.00	90910.31	496999.91	63400.00	12500.00	2010.00	56.00

Treatment Processes

Northeast Supply (San Jacinto/Trinity/Sabine River Water)

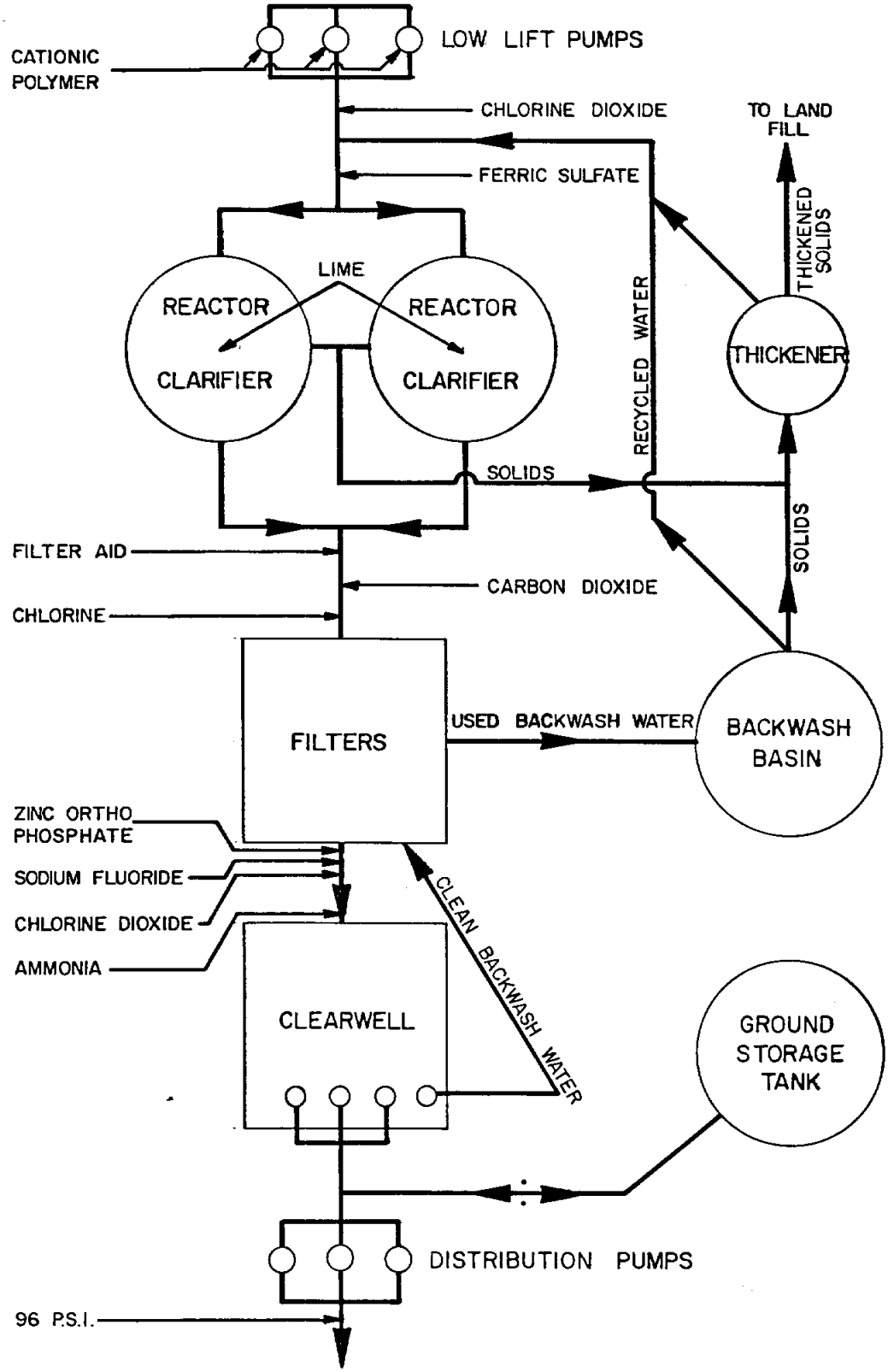
The northeast raw water supply will originate from Lake Houston and will eventually be a mixture of San Jacinto, Trinity and Sabine River water. According to the City of Houston's Water Quality Section, the treatment process needed for the Northeast Plant will be very similar to the process presently used by the City in the East and Southeast Treatment Plants. As a result, operations cost for the proposed Northeast Plant should approximate the operations cost at the City's existing treatment plants.

Southwest Supply (Brazos River Water)

Raw water from the Brazos River System has been successfully treated in the past by industry and municipalities. The Galveston County Water Authority (GCWA) began treatment of Brazos River water in 1983 and is currently producing approximately 12 MGD of finished water. At the GCWA plant, low lift pumps raise the water from the inlet channel to a pair of reactor clarifiers. Cationic polymer is added as a coagulant which causes the particles suspended in the water to clump together and settle out, clearing the water. Chlorine dioxide is added to destroy algae, taste and odor. Lime is added for pH adjustment and water softening. Reactor clarifiers are used to clarify the raw water with flocculation, clarification and softening taking place in the same unit. Filter aid, chlorine and carbon

dioxide are added prior to filtration. The filters consist of two feet of crushed anthracite coal, nine inches of sand and one foot of gravel. A clearwell holds the filtered water where post disinfection with chlorine dioxide takes place. Water from the clearwell also serves as backwash water for the filters. Transfer pumps, supply treated water to the ground storage facilities. Exhibit 5 shows a typical flow diagram for this treatment process using reactor clarifiers similar to the GCWA plant.

EXHIBIT NO. 5



WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION

WATER TREATMENT PLANT FLOW DIAGRAM

Conveyance Systems

Raw Water Conveyance

Raw water conveyance lines are those facilities required to pump and transfer raw water from the source to the treatment plant site. At sites requiring termination storage, raw water conveyance lines will pump and transfer water from the source into a termination storage facility and then into the treatment facility. Raw water conveyance lines were sized to handle the maximum daily demands of the alternate service areas. Maximum design velocities in the raw water conveyance systems were held to less than 7 feet per second (fps).

Termination Storage/Pumping

The termination storage required at each of the alternate Southwest Treatment Plant general locations was based on a desired water quality which would limit chloride concentrations in the raw water to less than 240 mg/l which is below the EPA recommended level of 250 mg/l. Historic water quality data previously presented in Table 4 shows that this is possible 95% of the time. Under this assumption raw water would need to be pumped from a termination storage facility rather than directly from the Brazos River System 5% of the time during the year. Termination storage facilities were sized for each alternate service area by using the maximum daily demand multiplied by the number of days required to satisfy the 5% limit. Assuming a usable depth of 16.0 feet, the volume of termination storage varied from 658 acres to 424 acres for Alternate

Service Areas No. 1 to No. 4, respectively and was sized at 808 acres for Alternate Service Area No. 7.

Treatment Facilities

The City of Houston is currently proceeding with design and has purchased the site for a proposed Northeast Treatment Plant. The proposed plant would be located adjacent to Lake Houston near Beltway 8. The raw water supply for this plant would be Lake Houston. Correspondence recently received from the City of Houston indicates that initially the proposed Northeast Treatment Plant will have a nominal peak production capacity of 35 to 50 MGD and could be in operation as early as 1991. No firm schedule for future plant expansions currently exists, however, planning projections call for the ultimate capacity of the Northeast Treatment Plant to be up to 600 MGD.

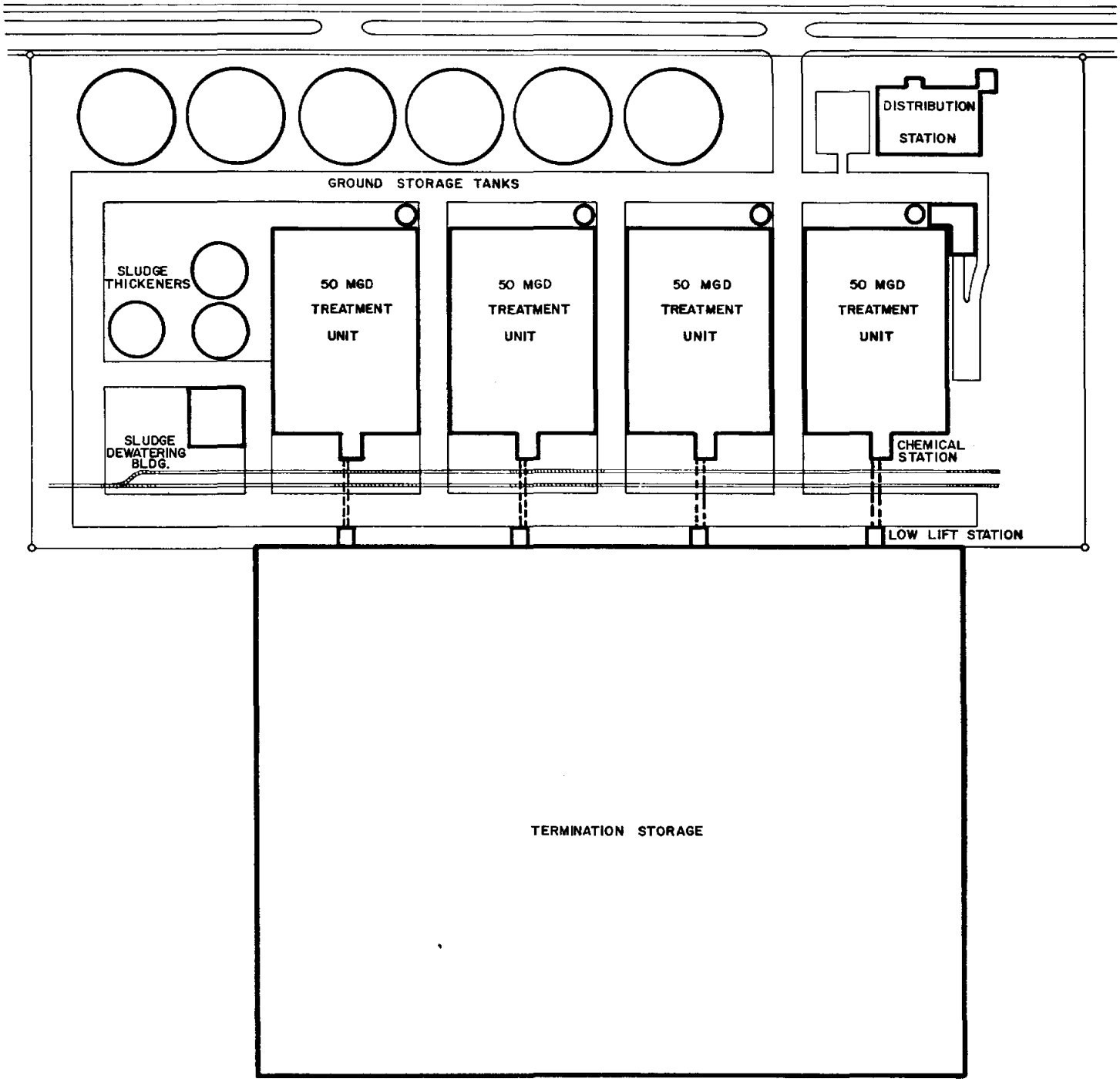
Although, the final design of the Northeast Treatment Plant must be completed to establish the exact discharge pressures and pump operations, it is anticipated that the design will be similar to the existing Southeast Treatment Plant. The WHCSWSC will present its surface water demand to the City of Houston which, if practical, will size the Northeast Treatment Plant to accommodate this requirement.

The Southwest Treatment Plant will be located within one of five general locations presented later in this report. The raw water supply for this plant would be from the Brazos River Basin as mentioned

previously. The estimated ultimate capacity of the Southwest Treatment Plant will be from 150 MGD to 250 MGD (maximum daily capacity); however, if the Fort Bend County area agrees to participate the ultimate capacity could increase to 300 MGD. Exhibits 6, 7 and 8 show three different water treatment plant site layouts which may occur depending on whether raw water is taken from a termination storage facility, directly out of the Allen's Creek Reservoir or from a raw water conveyance line. These exhibits are laid out using the City of Houston's present requirement of treatment trains instead of individual reactor clarifiers as previously presented. This configuration is usually more economical in larger plants because of the reduction in land needed for the plant site.

Treatment plants were sized to accommodate the maximum daily demands of their respective service areas. A discharge pressure of approximately 95 PSI was assumed for the alternatives examined, which is consistent with present discharge pressures for existing City of Houston treatment plants.

EXHIBIT NO. 6

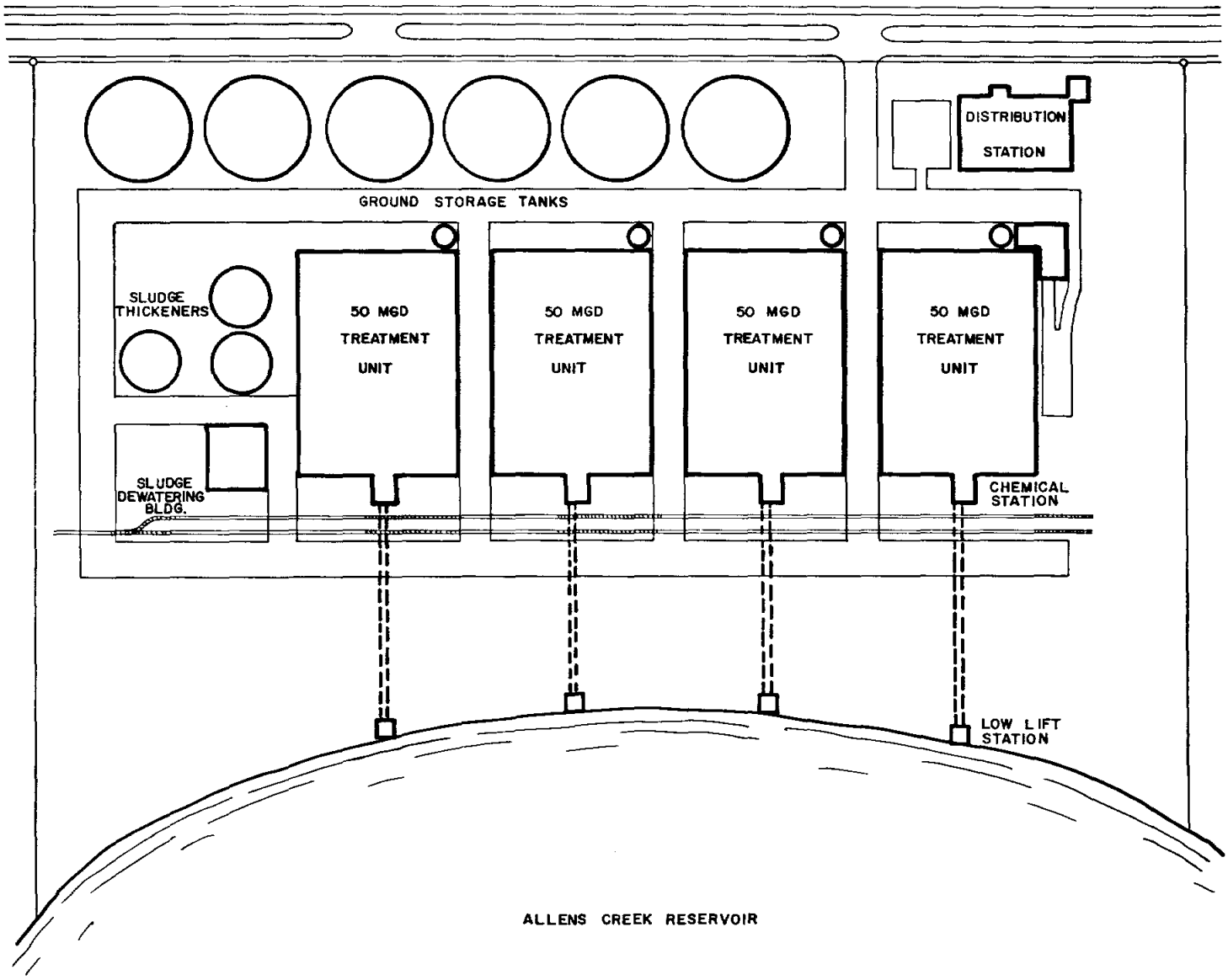


WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION

TYPICAL WATER TREATMENT PLANT SITE LAYOUT

NO SCALE

EXHIBIT NO. 7

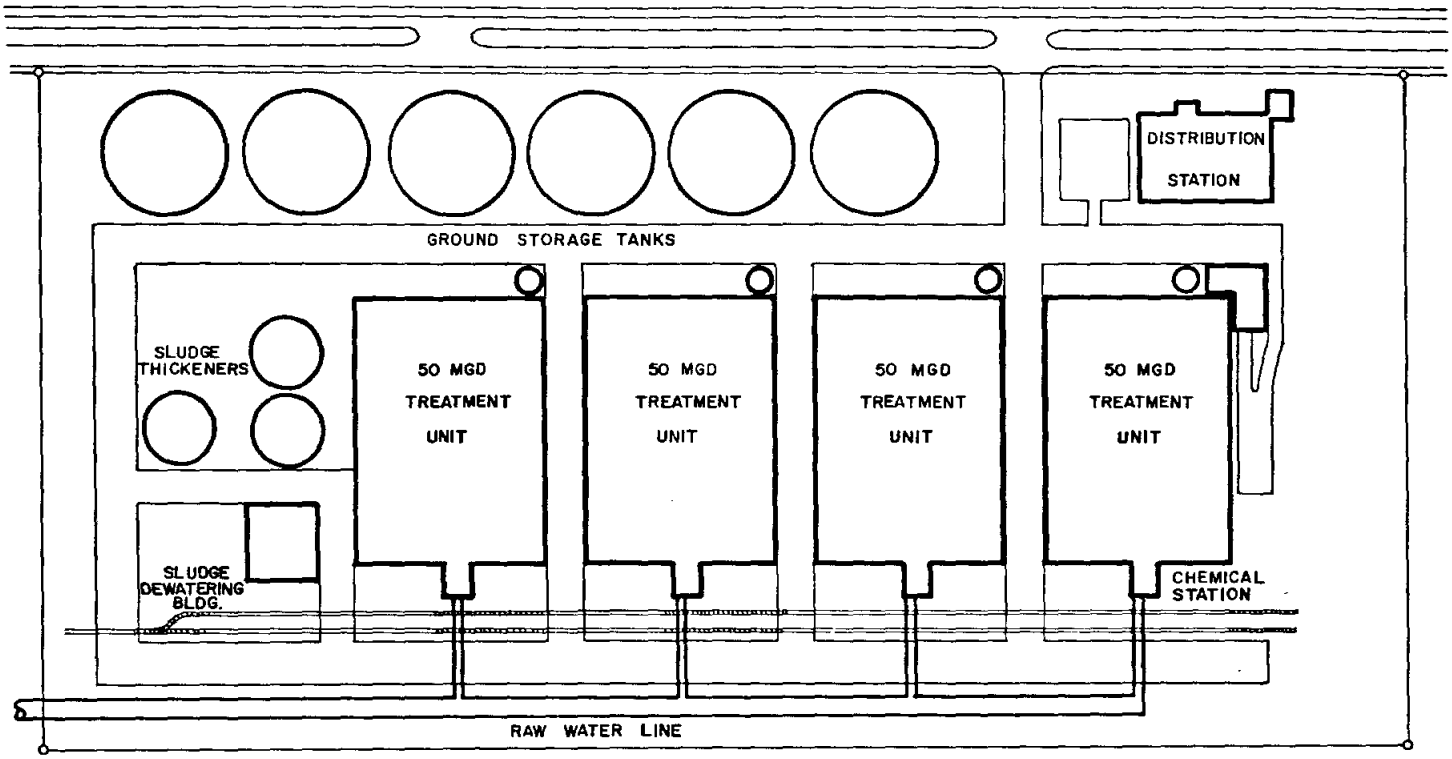


WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION

TYPICAL WATER TREATMENT PLANT SITE LAYOUT

NO SCALE

EXHIBIT NO. 8



WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION

TYPICAL WATER TREATMENT PLANT SITE LAYOUT

NO SCALE

Treated Water Storage/Pumping

Treated water storage and pumping facilities are those facilities located at the treatment plant used to store the treated water and distribute it into the conveyance system. Ground storage tanks were sized to provide 6 hour maximum daily demands for the alternate service areas. Distribution pumping capacity was also sized to handle the maximum daily demands of the alternate service areas.

Treated Water Conveyance

Treated water conveyance lines are those facilities required to transport water from the treatment plant to the boundary of the WHCSWSC study area. All treated water conveyance lines were sized to handle the maximum daily demands of their respective service areas. A minimum delivery pressure of 20 PSI was assumed for the Northeast Conveyance System which would be adequate to fill a ground storage tank at a booster pump station located at the WHCSWSC study area boundary. This requirement was set for estimating the WHCSWSC pro rata cost of the Northeast Conveyance System. It is understood that this conveyance system would be ultimately sized by the City of Houston and operate similar to the transmission systems to be discussed later.

The treated water conveyance lines in the Southwest Conveyance System will be designed based on the same criteria as outlined in the transmission systems discussed later in this appendix. The lines will be designed for maximum daily demands at a maximum velocity of 7 feet per second (fps).

Transmission System

Transmission Pipeline

The Transmission System for the WHCSWSC study area will be a delivery system which will supply wholesale treated surface water in the vicinity of groups of political subdivisions within the study area. The individual political subdivisions will be responsible for organizing and constructing the facilities needed to transport treated surface water from WHCSWSC transmission system to each individual political subdivisions existing ground storage facility. Each subdivision will then utilize its existing water distribution system for distributing the treated water to retail customers. Under this assumption each political subdivision will be able to use its existing groundwater wells to supplement the surface water supply during peak hour periods or as an emergency supply back-up. As a result it is expected that little or no disruption in service will occur upon implementation of this plan.

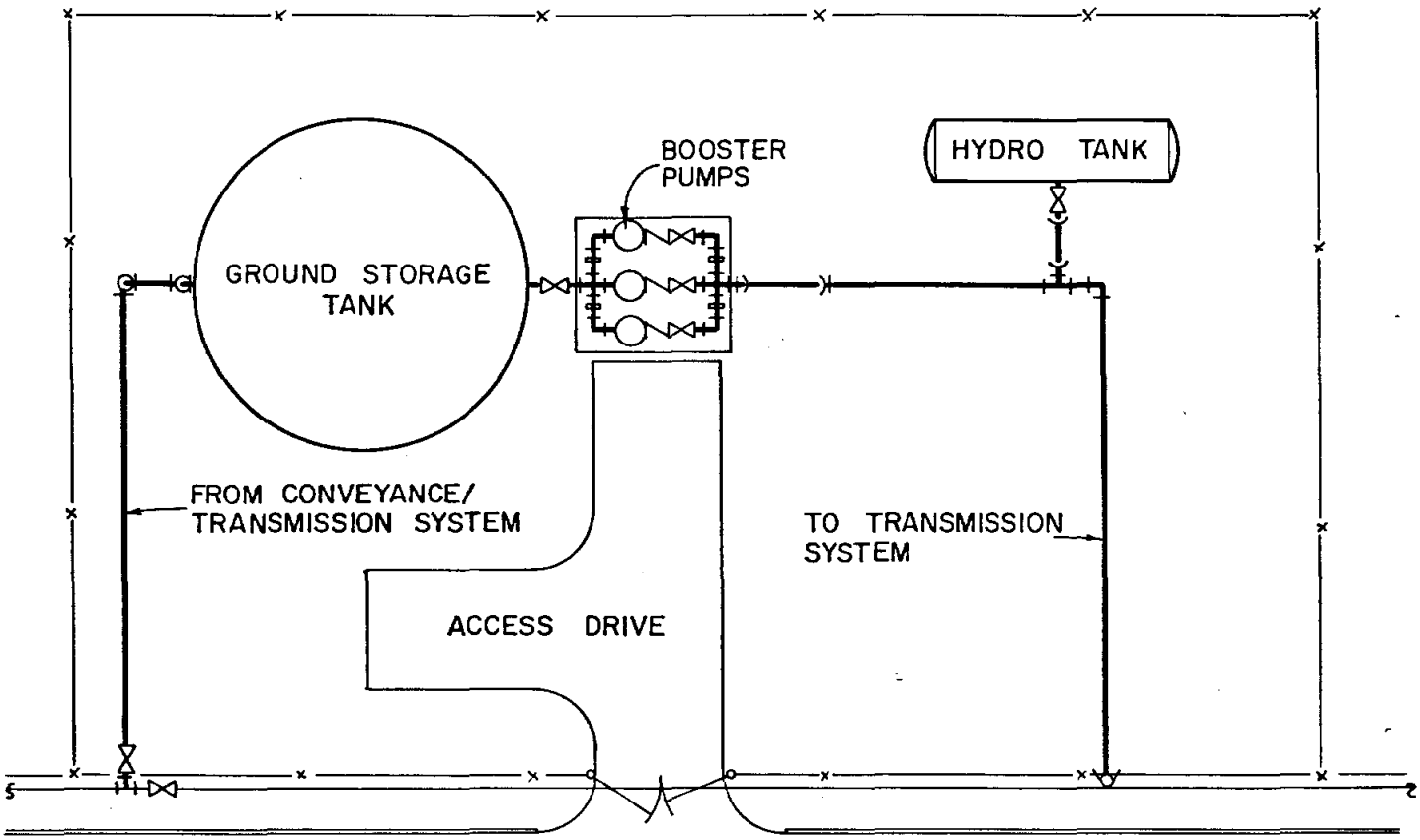
The WHCSWSC Transmission System was sized to handle maximum daily demands with additional peak hour or fire flow demands being met by groundwater and/or stored water from each individual political subdivisions water system. A minimum pressure of 45 PSI was maintained throughout the system which will be adequate to deliver surface water to the various district ground storage tanks located within the study area. Maximum design velocities in the transmission system were held to less than 7 fps. The transmission system lines have been sized to allow

comparisons of the alternatives and should not be construed as final. The recommended transmission system will be further evaluated in Phase V at which time a detailed plan will be recommended.

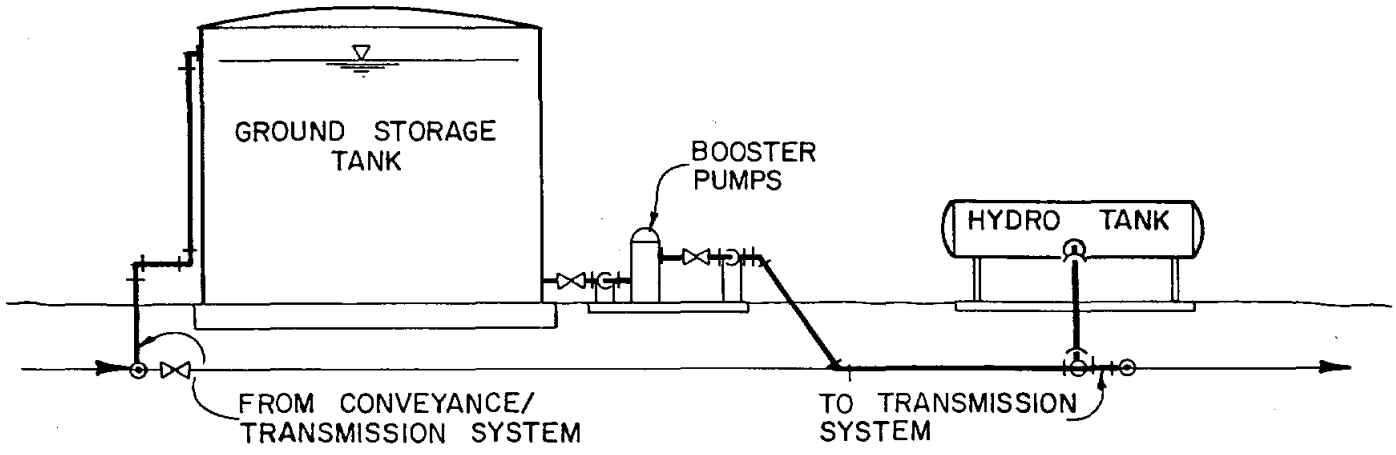
Ground Storage and Booster Pump Stations

Booster pump stations were located strategically within the WHCSWSC transmission system to supply the flow and boost pressures the required amount to serve the alternate service area demands. A typical booster pump station site layout is presented on Exhibit 9. Ground storage at each site will supplement each political subdivisions ground storage facilities and serve as a back-up supply source in the event of a temporary disruption in the surface water supply from the treatment facility.

EXHIBIT NO. 9



PLAN



ELEVATION

WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION

TYPICAL BOOSTER PUMP STATION SITE LAYOUT

Computer Model

The hydraulic network analysis for the various conveyance and transmission systems was accomplished through the use of computer modeling using a program called KYPIPE "Steady State Pipe Network Analysis" by the University of Kentucky. The program is based on the Hazen-Williams formula and provides pressure information, hydraulic grade line, head losses, pump heads, flow rates, velocities and system inflow and demand summaries for a variety of system configurations and components.

The various treated water conveyance and transmission systems were modeled as a series of junction nodes and pipe elements. User demands were taken out of the system at appropriate node locations. The system was supplied at a fixed grade node with a pump described by the useful horsepower needed to supply the demands of the system. A typical system contained approximately 100 pipes, 75 junction nodes and 2 fixed grade nodes. Treated water conveyance and transmission lines were located on base maps and were routed within existing street right-of-ways. Elevations of junction and fixed grade nodes were taken from USGS topographic quad maps, adjusted for depth of bury of lines, and input into the computer model. Demands were divided among junction nodes within each demand area to approximate service area water usage.

Network design criteria used in the various system models were as follows:

a. Design flow is maximum daily demand.

b. System pressures will not drop below 45 psi.

c. Velocities will not exceed 7 fps under maximum daily flow.

d. "C" Values when new will be 110 for line sizes up to 30" and 120 for line sizes 30" and larger.

Treated water conveyance and transmission systems were analyzed for various flow rate and pressure conditions which represent the water demands for a particular alternate or system routing. Output data was analyzed and compared to the established system operating criteria, improvements were made to the model as needed and the model was rerun. This procedure was repeated until all components of the system conformed to the established criteria.

In addition to the hydraulic analysis performed the computer model simulation allowed for checking of each system for disconnected lines, redundant lines, agreement of supply versus demand, and general physical layout. Line lengths and sizes determined using the computer model were taken directly from the output for use in preparing construction cost estimates.

3.0 CONVEYANCE SYSTEMS

3.0 CONVEYANCE SYSTEMS

Northeast Conveyance System

General

The Northeast Conveyance System is defined as the WHCSWSC shared portion of the proposed Northeast Treatment Plant with pumping capacity and conveyance lines sized to deliver treated water at minimum pressure to a ground storage and booster pump station located at the WHCSWSC boundary line. Figure 1 presents the alternative routes investigated for the Northeast Conveyance System.

Beltway 8 Route

The Beltway 8 Route for the Northeast Conveyance System begins at the proposed Northeast Treatment Plant Site adjacent to Lake Houston and Beltway 8. From that point the proposed conveyance line runs westward along the alignment of the Beltway approximately 19 miles to the northeast boundary of the WHCSWSC study area. The elevation at Lake Houston is approximately 50.0 feet MSL while the northeastern boundary of the study area is around 113.0 feet MSL. Because of the considerable difference in elevation and length of this conveyance line, it is assumed that a pump station will be located at the WHCSWSC study area northeast boundary to repressurize and distribute the water within the WHCSWSC service area. This allows the Northeast Conveyance line and Northeast Treatment Plant pumps to be sized to supply only

the required amounts of treated water at a minimum pressure of around 20 psi. This will save WHCSWSC considerable money in both pipeline and pumping costs from the proposed Northeast Water Treatment Plant. However, as previously mentioned, it is understood that the City of Houston will probably operate this line similar to the City's transmission system.

NHCWSC Route

WHCSWSC's alternate route referred to as the NHCWSC Route for the Northeast Conveyance System would also begin at the proposed Northeast Treatment Plant site. This routing runs westward along Beltway 8 to Vickery Drive where it turns north to Greens Road. The route then proceeds west again along Greens Road to Aline Westfield Road where it again turns north until it intersects Rankin Road. The line continues west along Rankin and Spears Road until it intersects Richey Road where it turns southwest to intersect the WHCSWSC study area boundary. The total length of conveyance line for this routing is approximately 23 miles. Elevations at the beginning and end of this route are similar to those of the Beltway 8 route, with an approximately 63.0 feet of difference in elevation from Lake Houston to the WHCSWSC boundary line. As previously mentioned a pump station and ground storage facility are proposed at the northeast boundary of the WHCSWSC study area to repressurize and distribute water from the conveyance line. Routing for this alternate is consistent with the route proposed by the North Harris County Water Supply Corporation (NHCWSC) for a conveyance line to serve the NHCWSC service area.

FM 1960 Route

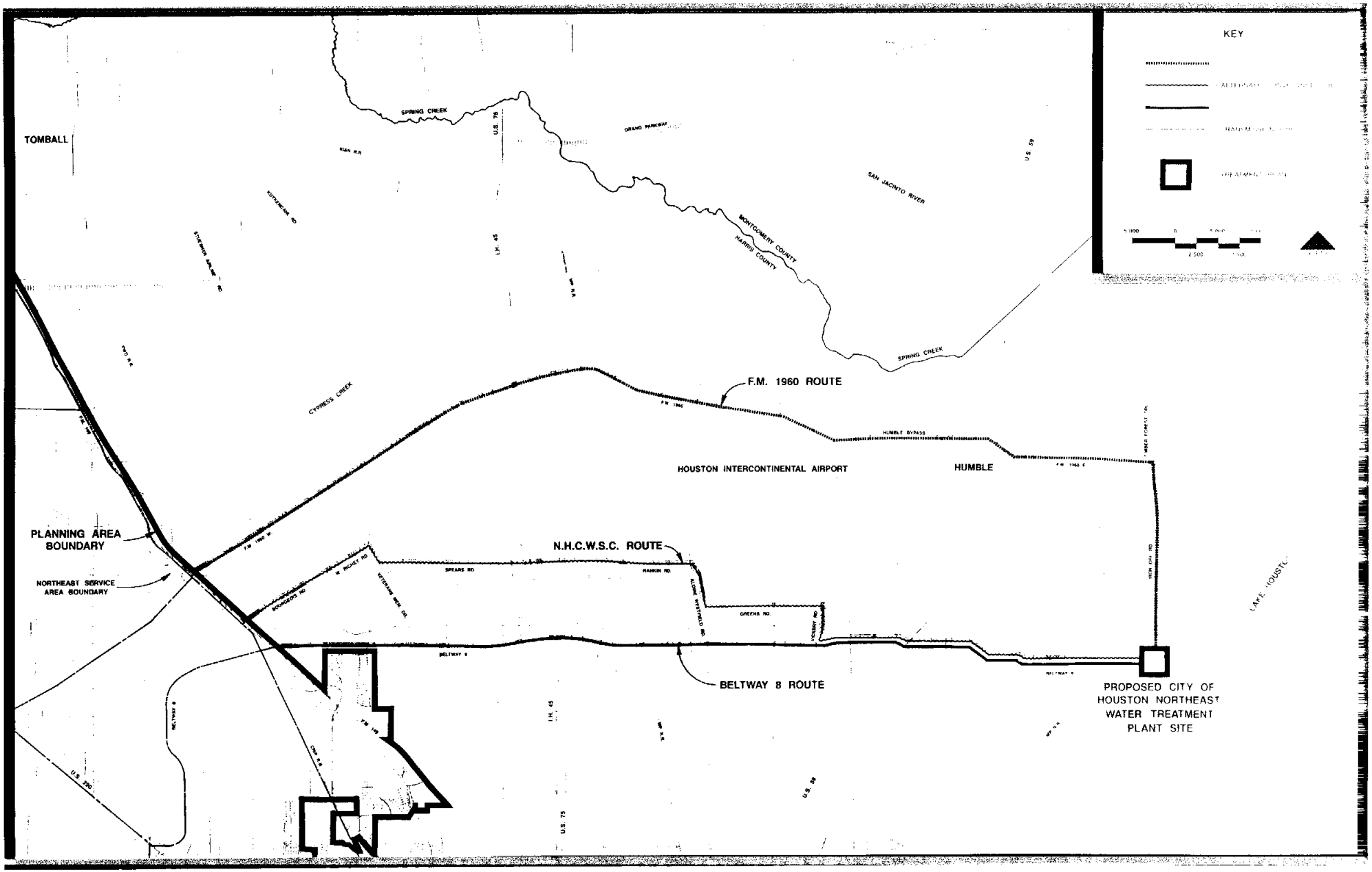
The FM 1960 Route for the Northeast Conveyance System also originates at the proposed Northeast Treatment Plant near Lake Houston. From that point it runs north along Iron Ore Road and Timber Forest Trail until it intersects FM 1960, where it turns west to follow the alignment of FM 1960 until it reaches the northeast boundary of the WHCSWSC study area. The approximate length of this route is 28 miles. A 68.0 feet elevation difference exists with Lake Houston elevation at approximately 50.0 feet MSL and the WHCSWSC boundary elevation being 118.0 feet MSL. Again, as previously assumed, a pump station will be located at the WHCSWSC study area boundary to repressurize the water prior to entering the WHCSWSC study area.

Comparison of Alternate Conveyance Systems

The alternate routings for the Northeast Conveyance System were evaluated on the basis of Technical, Environmental, Community/Social, Phasing and Financial criteria. Treated water conveyance line sizes varied from 66" to 90" to convey the required amounts of treated water which varied from 43.85 MGD to 110.30 MGD maximum daily demand (Year 2030), depending on the alternate service area investigated. For Alternate Service Area 7, the Northeast Supply was not used.

As part of the Northeast Conveyance System technical evaluation, the hydraulics of each system were investigated. To compare the three alternate treated water conveyance routes from a hydraulic standpoint, identical horsepowers were used to pump water from the proposed Northeast Treatment Plant site to the WHCSWSC northeast boundary through conveyance lines sized according to the previously presented system design criteria. Four different amounts of water were pumped through the treated water conveyance system relating to alternate service area 1 through 4 demands. Output from the computer model consistently showed that the Beltway 8 Route was hydraulically superior over the NHCWSC Route. The FM 1960 Route was consistently the worst route from a hydraulic standpoint. Delivery pressures at the WHCSWSC boundary for the Beltway 8 Route were approximately 6 psi higher than the NHCWSC Route and approximately 16 psi higher than the FM 1960 Route for the four alternate service area demands investigated. Both hydrostatic and frictional head losses increase as line lengths, elevation differences, and number of bends in the line increase. Although the sizes of the treated water conveyance lines were similar between the three alternate routes, the lengths of the routes differed somewhat. The Beltway 8 Route is the shortest route, approximately 4 miles shorter than the NHCWSC Route and 9 miles shorter than the FM 1960 Route. The Beltway 8 Route will provide substantial savings in materials compared to the other routes. Ease of construction, interferences with existing utilities and structures, and community disruption was also considered as part of the Environmental and

Community/Social evaluation. Congested areas with limited right-of-way and high numbers of existing utilities will cause difficulties in constructing the conveyance system.



NORTHEAST CONVEYANCE SYSTEM ALTERNATE ROUTES

W.H.C.S.W.S.C.
FIGURE NO. 1

Southwest Conveyance System

The Southwest Conveyance System consists of raw water pumping and conveyance facilities needed to deliver raw water from the supply source to either the treatment plant facilities in Alternate Nos. 4B and 5 or to a termination storage facility in Alternate Nos. 1, 2, 3 and 4A. The system also consist of termination storage facilities as required, treatment plant facilities, treated water storage and pumping facilities and treated water conveyance lines to transport the treated water to the WHCSWSC service area.

Numerous geographical areas exist south and southwest of the WHCSWSC study area which could serve as possible locations for a proposed Southwest Treatment Plant. After a preliminary evaluation, it was determined that this entire area could be narrowed down to five general areas. The five general areas considered for further study are the Oyster Creek/Dairy Ashford Area, Brazos River/Highway 6 Area, Oyster Creek/Highway 6 Area, F.M. 1093/Grand Parkway/Jones Creek Area and the Allens Creek/F.M. 1093 Area. After further evaluation of the five general areas, it was determined that six alternate conveyance systems should be considered which are listed below:

Site 1. Oyster Creek/Dairy Ashford Conveyance System

Site 2. Brazos River/Highway 6 Conveyance System

Site 3. Oyster Creek/Highway 6 Conveyance System

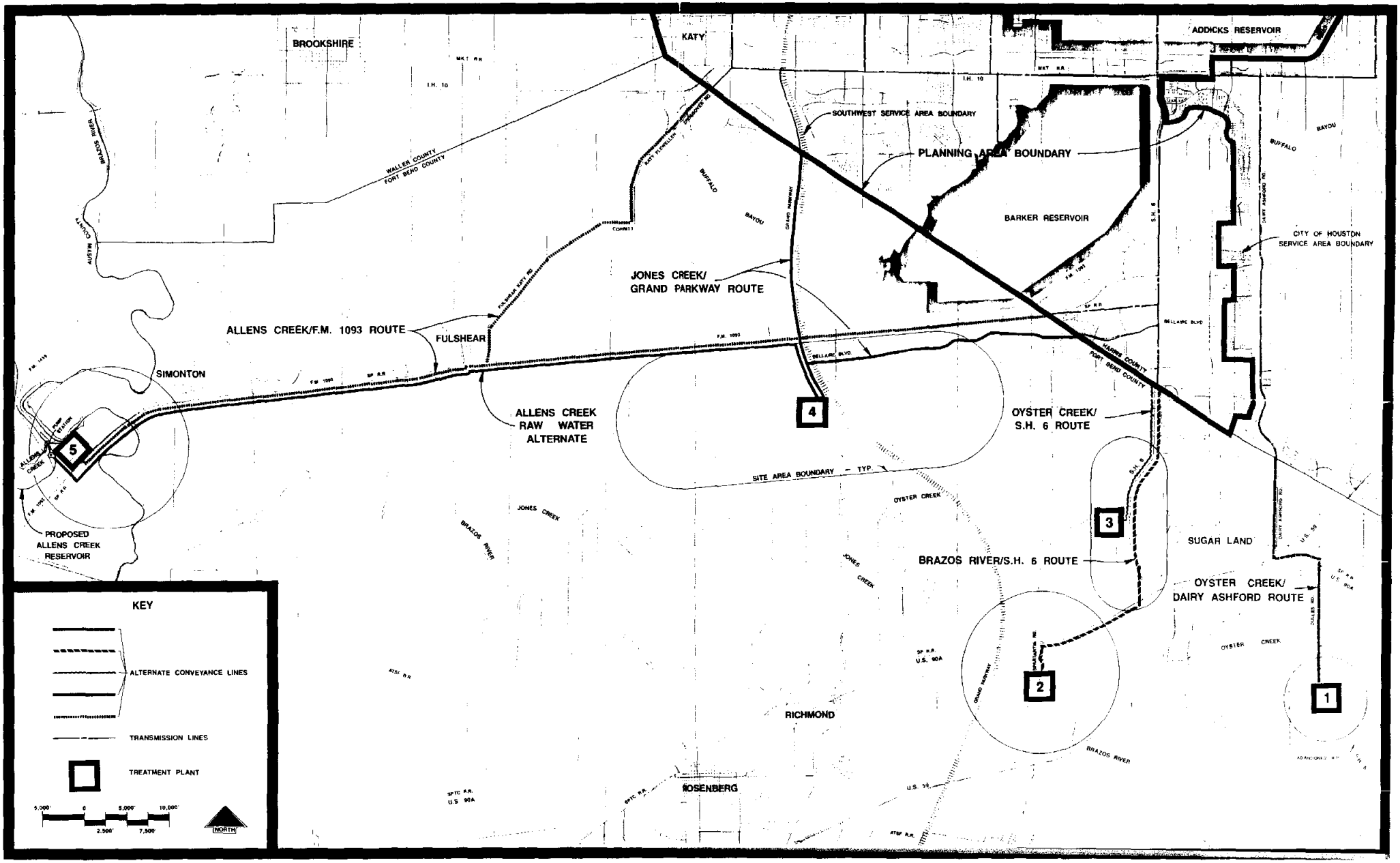
Site 4A. Jones Creek/Grand Parkway Conveyance System

Site 4B. Allens Creek/Grand Parkway Conveyance System

Site 5. Allens Creek/F.M. 1093 Conveyance System

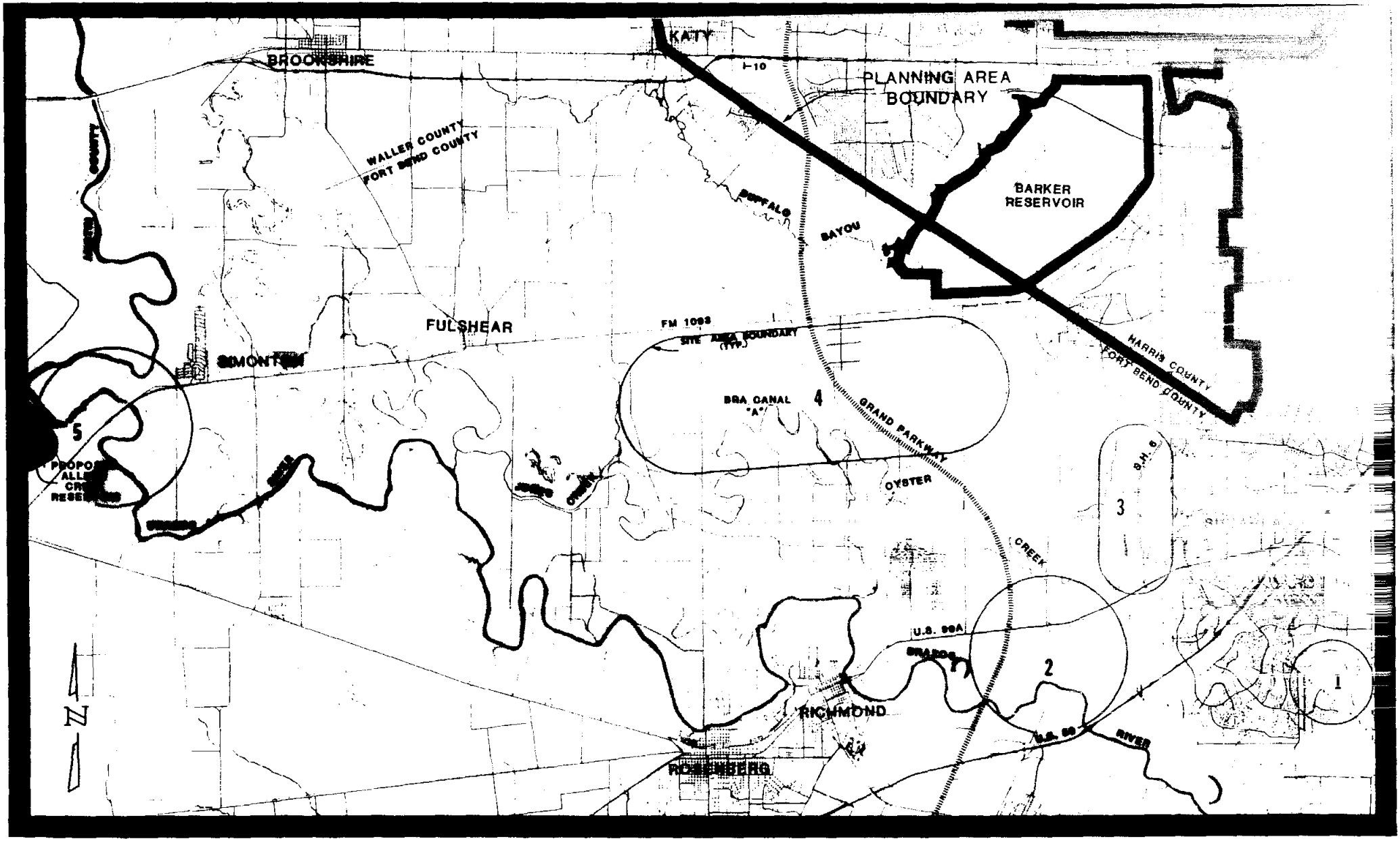
Alternate Sites 4A and 4B have similar treatment plant site locations as well as similar treated water conveyance systems. However, they differ in that 4A contains a termination storage facility and obtains raw water from the BRA Canal System while 4B has no termination storage, but does contain a raw water conveyance line from Allens Creek Reservoir.

Figure 2 shows the alternate sites and conveyance line routings investigated for the alternate Southwest Conveyance Systems. Also, refer to Exhibit 10 for 100-year flood plain locations and Exhibit 11 for general surface fault patterns as well as salt dome locations presently existing throughout the Southwest Conveyance System study area.



SOUTHWEST CONVEYANCE SYSTEM ALTERNATE ROUTES

W.H.C.S.W.S.C.
FIGURE NO. 2



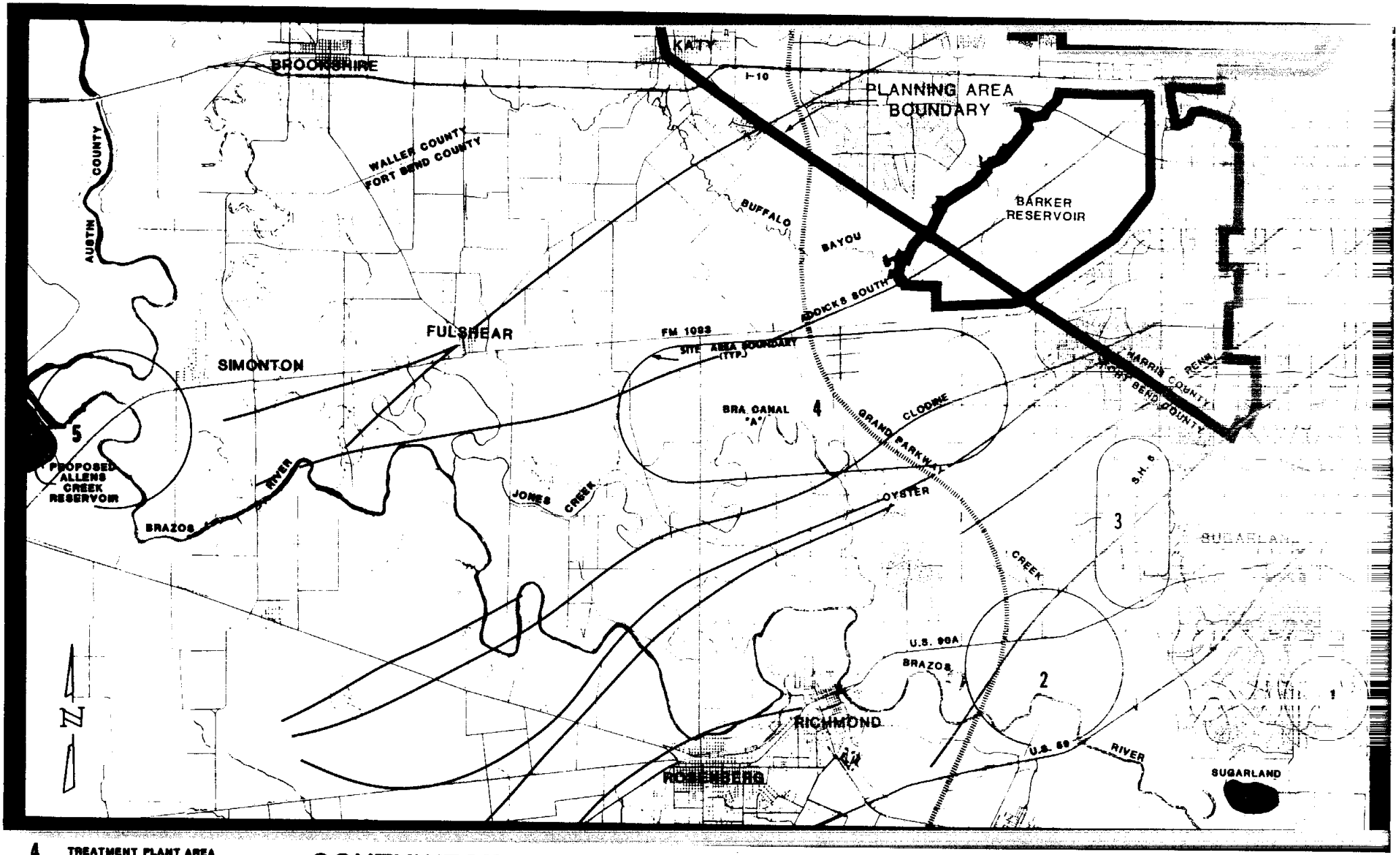
4 TREATMENT PLANT AREA

100 YEAR FLOOD PLAIN

SOUTHWEST CONVEYANCE SYSTEM STUDY AREA

(100 YEAR FLOOD PLAINS)

EXHIBIT NO. 10



4 TREATMENT PLANT AREA

FAULT LINE

SALT DOME

SOUTHWEST CONVEYANCE SYSTEM STUDY AREA

(GENERAL SURFACE FAULT PATTERN)

EXHIBIT NO. 11

SITE 1: Oyster Creek/Dairy Ashford

The first area investigated as a possible site for a proposed Southwest Treatment Plant is in the vicinity of Dulles Road and State Highway 6, south of Stafford. A plant at this location would treat raw water taken from Oyster Creek, which is part of the BRA canal system.

Site 1 has a sole source of raw water which is Brazos River water pumped and transferred through Oyster Creek within the BRA Canal System. The feasibility and reliability of using raw water from Oyster Creek at this site depends on several factors. Site 1 is located downstream of a number of industries and municipalities who presently dump effluent into Oyster Creek. The quantity and quality of this effluent will directly impact raw water taken from Oyster Creek at any downstream location. Site 1 is also downstream from the American Water Canal Diversion (a manmade canal) from which Galveston and Brazoria Counties receive their raw water supply. The portion of Oyster Creek downstream of this diversion only receives water which overflows BRA Dam No. 3. Modifications to the present operation of the BRA Canal System would be required to allow water to flow into this lower portion of Oyster Creek. The reliability of the canal system is linked to the reliability of the Brazos River pump station which delivers water from the Brazos River into the canal system. Site 1 is, however, downstream of several retention structures which the BRA maintains for water storage in the event of pump station failure.

Site 1 has approximately 10 percent of its land area within the 100-year flood plain of Oyster Creek as determined from Federal Emergency Management Agency (FEMA) maps for the area. Mitigation of the site to eliminate the hazard of flooding is unlikely. On site drainage of the site would be collected by an internal storm sewer system with an outfall located offsite.

The general terrain for Site 1 is fairly level prairie land with elevations ranging from 65.0 MSL to 70.0 MSL. Two small, shallow lakes are located in the eastern part of the site and several lower, marshy areas exist adjacent to these lakes. Soils in the area of Site 1 are generally clayey and loamy with slow permeability and somewhat poorly drained. A general overview of faulting in the area indicates a large salt dome located directly southwest of Site 1. Numerous ground faults are normally associated with these salt domes which could reduce the amount of land suitable for major treatment plant facilities.

General access to the proposed Southwest Treatment Plant site by automobile, truck and rail is important. Both personnel and material suppliers must have adequate means of reaching the plant site. In general all of the alternate sites have fairly good access from at least one major highway. Site 1 has one major highway, State Highway 6, which runs through it and several arterial roads such as Cartwright and Dulles which connect to major highways.

The Missouri Pacific Railroad Company (MPRR) had a track running parallel to State Highway 6, however, this track has been abandoned. Therefore, direct rail access to Site 1 does not presently exist.

Quadrangle maps published by the U.S. Geological Survey were used as an aid to preliminarily spot existing pipelines and overhead transmission lines running through each of the alternate sites. Site 1 is crossed on the west by overhead H.L. & P transmission lines which run north-south parallel to Oil Field Road. The southeast part of Site 1 is crossed by one pipeline running in a northeast direction.

Preliminary information supplied by H.L. & P. shows both 345 kv and 138 kv transmission lines in the vicinity of Site 1, which could possibly supply the proposed treatment plant.

Raw water taken from Oyster Creek would need to be stored in a termination storage facility. The termination storage facility would supply a proposed Southwest Treatment Plant located nearby. The available land for a large termination storage facility at Site 1 is limited.

The Oyster Creek/Dairy Ashford Route for the treated water conveyance line begins at the proposed Southwest Treatment Plant Site 1. From that location the proposed conveyance line runs north along Dulles Road to U.S. Highway 90A, where it turns west passing under U.S. Highway 59 to Dairy Ashford. The line then runs north along Dairy Ashford until it intersects

the WHCSWSC study area southwestern boundary. The total length of the conveyance system for this route is approximately 6.5 miles. The elevation at the proposed Southwest Treatment Plant site is approximately 67.0 feet MSL, while the elevation at the point of tie-in to the transmission system is approximately 78.0 feet MSL, around 11.0 feet higher. There are no booster pump stations proposed along this route of the Southwest Conveyance System.

SITE: 2: **Brazos River/Highway 6**

The second possible site for a proposed Southwest Treatment Plant is approximately 3 miles west of First Colony between U.S. Highway 59 and U.S. Highway 90A. A plant located here would treat raw water taken directly from the Brazos River and/or the Brazos River Canal System.

Possibilities exist for Site 2 to have a dual source of raw water with the primary source being the Brazos River and the secondary source being Brazos River water transferred through Oyster Creek. Site 2 is located on Oyster Creek upstream from the majority of the industries and municipalities effluent discharge points which should increase the water quality over Site 1. Site 2 is also located upstream of the American Water Canal Diversion of Oyster Creek. Site 2 is located on the Brazos River downstream of the cities of Richmond and Rosenberg. Quantity and quality of effluent dumped into the Brazos River from these cities may affect the raw water downstream at Site 2. Reliability of raw water taken directly from the Brazos River is not dependent on transfer pumping as is raw water taken from Oyster Creek.

Approximately three fourths of the land area of Site 2 is located within the 100-year flood plain of the Brazos River. Mitigation of the site to avoid flooding would most likely be required which would in turn affect the economics of this site.

Site 2 has similar terrain to Site 1 being generally level prairie land with elevations ranging from 75.0 MSL to 80.0 MSL. Soil characteristics are also similar to Site 1. Known faulting in the area of Site 2 is restricted to one fault line passing through the northeast portion of the area.

Site 2 contains two major highways, U.S. Highway 90A as well as U.S. Highway 59 which runs adjacent to the site on the southeast. Smaller roadways such as Sartartia Road and Pecan Road run within the site but most likely would need to be improved somewhat to assure better access.

The Southern Pacific Railroad Company (SPRR) has a track which runs east-west along Highway 90A. This track runs through the north half of Site 2 and could provide rail service to a plant located in the area with some modifications. The track presently exists on the north side of Highway 90A. If a treatment plant site were located south of the highway, it would be necessary to cross Highway 90A with the railroad extension.

Site 2 does not appear to have major pipelines running through the area, however, several overhead power lines do cross to the west and south.

Preliminary information provided by H.L.&P. shows 138 kv transmission lines in the vicinity of Site 2 which could possibly supply a proposed Southwest Treatment Plant.

Raw water would be pumped from the Brazos River into a termination storage facility located adjacent to the river at Site 2. A proposed Southwest Treatment Plant would be supplied from this termination storage.

The Brazos River/Highway 6 Route for the treated water conveyance line begins at the proposed Southwest Treatment Plant Site 2. From that location the proposed conveyance line runs east to Flannigan Road before heading north on Flannigan Road to State Highway 6. The proposed conveyance line continues north on State Highway 6 until it intersects the WHCSWSC study area boundary. The total length of conveyance system for this route is approximately 8.0 miles. The elevation at the proposed Southwest Treatment Plant site is 75.0 feet MSL while the elevation at the point of connection to the transmission system is approximately 18.0 feet higher at 93.0 feet MSL. There are no proposed booster pump stations proposed along this route of the Southwest Conveyance System.

SITE 3: **Oyster Creek/Highway 6**

The third possible location for a proposed Southwest Treatment Plant is near the intersection of State Highway 6 and Oyster Creek in the vicinity of Hull Airport. A plant located at this site would treat raw water taken from Oyster Creek, which is part of the Brazos River Canal System.

The sole source of raw water for Site 3 is Brazos River water pumped into and transferred through Oyster Creek within the BRA Canal System. Site 3 is located upstream from the majority of industrial and municipal effluent discharge points and upstream from the American Water Canal Diversion. The reliability of Oyster Creek as a raw water source is dependent on the Brazos River pump station. Site 3 is upstream of the BRA retention facilities which store water for use in event of pump failure.

Site 3 has less than 10 percent of its land area within the 100-year flood plain making the need for extensive site mitigation unlikely. Site drainage would be accomplished by an internal storm sewer system with an outfall located offsite.

Site 3 is fairly flat prairie land with the southeast at elevation 75.0 MSL and the northwest at elevation 90.0 MSL. Several small lakes exist in the middle and southern parts of the area. Soil characteristics of Site 3 are similar to the previously mentioned sites. Known faulting

in the area is limited to one fault line which passes directly through the middle of the area.

Site 3 has two major highways, U.S. Highway 90A and State Highway 6 which run through it. Arterial roadways such as Voss Road, West Airport Blvd. and Old Richmond Road also cross the site. The location of Hull Airport may block access from Highway 6 if a plant is located behind the airport but otherwise the site is accessible.

The same SPRR track that could serve Site 2 also runs along the southern border of Site 3 along Highway 90A. Rail service to Site 3 could be accomplished by extending a track north through the area from this existing SPRR track.

Site 3 contains two pipelines and several power lines which cross in a northwest direction north of Oyster Creek.

Preliminary information from H.L.&P. shows 138 kv transmission lines in the vicinity of Site 3 which could possibly provide electrical service to a proposed treatment plant located in the area.

Raw water would be taken from Oyster Creek and stored in a termination storage facility at Site 3. This termination storage would supply a proposed Southwest Treatment Plant located in the vicinity.

The Oyster Creek/Highway 6 Route for the treated water conveyance line begins at the proposed Southwest Treatment Plant Site 3. From that location the proposed conveyance line runs north on State Highway 6 until it reaches the WHCSWSC study area southwestern boundary. The total length of conveyance system for this routing is approximately 3.0 miles. The elevation at the proposed Southwest Treatment Plant site is approximately 80.0 feet MSL. At the point of connection to the transmission system the elevation is approximately 13.0 feet higher at 93.0 feet MSL. No booster pump stations are proposed along this route of the Southwest Conveyance System.

SITE 4A: Jones Creek/Grand Parkway

The fourth possible site for a proposed Southwest Treatment Plant is approximately 2 miles southeast of Gaston near the intersection of Peek Road and the proposed Grand Parkway. A plant located here would treat Brazos River water taken from Jones Creek, which is part of the Brazos River Canal System.

Site 4 has one source of raw water which is Brazos River water obtained from Jones Creek. Jones Creek forms the upper part of the Brazos canal system and has been modified to flow into Oyster Creek. Few municipal and industrial effluent discharges exist upstream of this portion of the canal system from which Site 4 would be supplied. The reliability of this source is dependent, however, on the reliability of the Brazos River pump station which delivers water from the Brazos River into the canal system.

Site 4 has less than 20 percent of its land area within the 100-year flood plain making the need for extensive site mitigation unlikely. Drainage of the site would be through an internal storm sewer system with an outfall at offsite.

In general Site 4 is also fairly flat prairie land with the eastern portions at elevation 95.0 MSL and the western portions at 115.0 MSL. The central part of the area adjacent to Jones Creek contains several small

shallow lakes. Similar soils characteristics exist at Site 4 with soil being generally clayey and loamy with slow permeability. An overview of faulting within the area shows the Addicks South fault line passing through the northwest edge of the area and the Clodine fault line passing through the southwest portion of the area.

Site 4 is accessible from the North by F.M. 1093 which runs parallel to the northern boundary of the site. F.M. 723, F.M. 359, and the proposed Grand Parkway also run through the site. Extensions of Bellaire Blvd., Beechnut and Bissonet are also proposed within the area. Other roadways are Peek Road, Harlem Road, Canal Road and Precint Line Road.

The Southern Pacific Railroad Company (SPRR) has a track running east-west along F.M. 1093. Site 4 could easily be served from this track since it is located on the south side of F.M. 1093.

Preliminary information from H.L.&P. shows both 345 kv and 138 kv transmission lines in the vicinity of Site 4 which could possibly serve a proposed Southwest Treatment Plant located in the area.

Raw water taken from Jones Creek would be stored in a termination storage facility at Site 4. This termination storage would supply a proposed Southwest Treatment Plant located in the vicinity.

The Jones Creek/Grand Parkway Route for the treated water conveyance line begins at the proposed Southwest Treatment Plant Site 4. The conveyance system branches from that point with one line running east along Bellaire Blvd. to connect to the transmission line running along Dairy Ashford. The other branch of the conveyance system runs north from the plant site along the proposed Grand Parkway to intersect the WHCSWSC study area southwestern boundary. The total length of conveyance system for this routing is approximately 12.0 miles. The elevation of the proposed southwest Treatment Plant site is approximately 105.0 feet MSL. At the point of connection to the transmission system at Dairy Ashford the elevation is approximately 74.0 feet MSL, while at the point of connection to the transmission system at Interstate 10, the elevation is approximately 130.0 feet MSL. No booster pump stations are proposed along either of the two branches of this Southwest Conveyance System route.

SITE 4B: **Allens Creek/Grand Parkway**

Site 4B has the same geographical boundaries as Site 4A. The difference between the two sites is the raw water supply source. The raw water supply source for Site 4B would be obtained from the proposed Allen's Creek Reservoir instead of Jones Creek as mentioned in Site 4A. Raw water conveyance lines would be constructed from Allen's Creek Reservoir to Site 4 along F.M. 1093. Allen's Creek would serve as the termination storage facility for the proposed Southwest Treatment Plant located at Site 4. By using Allen's Creek Reservoir as the termination storage facility, the water quality can be increased without additional capital cost. The construction of Allens Creek Reservoir as proposed by the BRA offer would have to be changed from the year 2000 to the year 1995 to be compatible with the development of a Phase I Southwest System.

The termination storage facilities proposed in Sites 1, 2, 3 and 4B were sized assuming a maximum chloride concentration of 240 mg/l, however, by restricting the operations of Allen's Creek Reservoir the maximum chloride concentration could be reduced to around 100 mg/l and the total dissolved solids to 440 mg/l without reducing the reservoirs yield or increasing the capital cost. By reducing the chloride to 100 mg/l the possibility of producing treated water that exceeds the maximum allowable chloride concentration is minimized. This site also offers the flexibility of using two raw water sources, Allens Creek Reservoir and the BRA Canal System. Site 4B also offers the greatest flexibility of plant

expansion to allow treatment of raw water outside of the raw water offered in the BRA proposal. This site would increase the possibility of regionalizing treatment facilities capable of serving WHCSWSC's service area as well as portions of Fort Bend County without sacrificing water quality. The Treatment plant site criteria and Grand Parkway Route for the treated water conveyance line would be the same as previously outlined for Site 4A.

SITE 5: **Allens Creek/F.M. 1093**

The final site investigated as a possible location for a proposed Southwest Treatment Plant is approximately 3 miles west of Simonton near the intersection of the Brazos River and Allens Creek. A plant located at this site would treat raw water taken from a proposed reservoir on Allens Creek. The construction time frame of the Allens Creek Reservoir as proposed by the BRA offer would have to be changed as previously mentioned in Site 4B.

Site 5 has two sources of raw water. The primary source would be the proposed Allen's Creek reservoir. In case of the contamination of Allen's Creek Reservoir, the nearby Brazos River could be used as an alternate source of raw water. This differs from the advantages offered in Site 4B in that the second source, the Brazos River, would not provide additional water rights from the BRA Canal System which is considered instrumental in the participation of certain Fort Bend County areas in regional water treatment.

Site 5 has approximately 60 percent of its land area within the 100-year flood plain. Site mitigation may be likely along with the need for a Corp of Engineers permit. On site drainage would be by an internal storm sewer system with an outfall located offsite.

Site 5 has the most drastic variation in topography of any of the previously mentioned sites. The areas adjacent to the Brazos River and to the southwest are at approximately 135.0 MSL. Across the Brazos River to the north and east the elevations are somewhat lower at approximately 105.0 MSL. General soils characteristics at Site 5 are similar to the previously mentioned sites. Faulting within the area is not documented.

Site 5 is accessible from F.M 1093 which runs through the site. F.M. 1458 and Melmar Road also provide access to the site. The Brazos River, which winds its way through the site limits access somewhat to the southwestern portions of the area.

Site 5 could be served from the same SPRR track which runs along F.M. 1093 north of Site 4. At this location the tracks exist on the north side of F.M. 1093 and could be extended to a plant site located in the northern half of the area without crossing over F.M. 1093.

Site 5 has two pipelines which cross over the Brazos River on the southeast side of the area. Preliminary investigations do not indicate any major concentrations of existing utilities.

Preliminary information from H.L.&P. shows 138 kv transmission lines located to the south of Site 5 near Wallis which could possibly serve a plant located in the area.

The proposed reservoir would serve as termination storage and raw water supply for a proposed Southwest Treatment Plant located adjacent to the reservoir. The increase in water quality for this alternate is similar to Site 4B.

The Allens Creek/FM 1093 Route for the treated water conveyance line begins at the proposed Southwest Treatment Plant Site 5. From that location the proposed conveyance line runs east along FM 1093 to just east of Fulshear where it splits into two branches. One branch continues eastward along FM 1093 and Alief-Clodine Road until it reaches the WHCSWSC transmission line which runs along Dairy Ashford. The other branch heads northeast from FM 1093 east of Fulshear along Fulshear-Katy Road and Katy-Flewellen Road to intersect the WHCSWSC study area southwestern boundary. The total length of conveyance system for this route is approximately 31.5 miles. The elevation at the proposed Southwest Treatment Plant site is approximately 135.0 feet MSL. At the point of connection to the transmission system at Dairy Ashford the approximate elevation is 74.0 feet MSL while at the point of connection to the transmission system at Interstate 10 the elevation is approximately 130.0 feet MSL. As with the other alternate routes, there are no proposed booster pumps along this routing of the Southwest Conveyance System.

Comparison of Alternate Conveyance Systems

All six of the alternate Southwest Conveyance Systems are feasible, however, each conveyance system has advantages as well as disadvantages that need to be compared before recommending an alternate. As will be explained later in the ranking section of this Appendix, the majority of the advantages and disadvantages can be grouped under five general categories: technical, environmental, community/social, phasing and financial. This section will describe the comparisons between the first four categories listed above. The fifth category, financial, will be discussed in the cost analysis section of this Appendix.

The alternate Southwest Conveyance Systems, as in the Northeast, are dependent upon which WHCSWSC service area alternate is chosen. The Southwest Conveyance System could have an ultimate capacity that ranges from 121 MGD to 231 MGD maximum daily demand (Year 2030), depending on the alternate service area chosen. This ultimate capacity could increase to approximately 300 MGD, if entities in Fort Bend County opted to participate. However, this Appendix does not address demands in Fort Bend County. The amount of land needed for treatment plant facilities, termination storage facilities and sludge disposal facilities is dependent on the plant's ultimate capacity which in turn is dependent on the service area alternate. The amount of land assumed for the mentioned facilities for each alternate is listed below.

ALTERNATE SERVICE AREA	ULTIMATE S.W.PLANT CAPACITY (MGD) (2030)	ULTIMATE LAND REQUIREMENTS (ACRES) PLANT	SLUDGE	STORAGE
NO. 1	187	100	80	658
NO. 2	177	100	80	623
NO. 3	140	80	60	525
NO. 4	121	70	60	424
NO. 7	231	120	100	808

The decision of choosing an alternate service area as well as alternate conveyance systems including plant sites should be flexible and able to satisfy the changing requirements that may occur 10-15 years after this study has been completed. With this thought in mind, we recommend that the land requirements for the Southwest Conveyance System treatment plant, sludge disposal and termination storage facilities be evaluated using the ultimate capacity that results from the largest alternate service area, Service Area Alternate No. 7. This would give the Southwest Conveyance System the ability to expand without being land locked.

Considering this assumption, the ultimate capacity for the proposed Southwest Treatment Plant is assumed to be 231 MGD excluding Fort Bend County's participation. This ultimate capacity translates into a land requirement of approximately 1028 acres for treatment plant, sludge disposal and termination storage facilities for Site 1, 2, 3 and 4A. For Site 4B and 5, the land requirement is 220 acres which results in the elimination of termination storage. All of the general areas evaluated

have the required available land except Area No. 1. The purchase price of land varies with the land located further west of the WHCSWSC study area being more economical than the property in the vicinity of Highway 59 and Highway 6.

Line sizes for the alternate routings of the Southwest Conveyance System varied from 72" to 120" to convey from 120.96 MGD to 231.27 MGD maximum daily demands (Year 2030) depending on the service area supplied.

Similar amounts of treated water were pumped through each of the alternate treated water conveyance systems. Review of the computer output data revealed that the Allens Creek/FM 1093 Route required the least pump horsepower to pump the required amount of water at the desired pressures while the Oyster Creek/Dairy Ashford Route required the greatest pump horsepower. The main reason for this is that the plant site at Allens Creek is at a higher elevation than the plant site at Oyster Creek/Dairy Ashford. Ground elevations increase from the southeast to the northwest through the WHCSWSC study area. This allows the treated water conveyance lines routed further northwest to have better hydraulic characteristics than those further southeast. The length of line and the number of bends in its route, also contributed somewhat in that shorter straight runs of line produce less head losses and require less pumping horsepower.

The sizes of treated water conveyance lines used for the alternate routings were fairly consistent, however, the lengths of the different routes varied substantially. The Oyster Creek/Highway 6 Route is the

shortest route, approximately 3.5 miles shorter than the Oyster Creek/Dairy Ashford Route. The longest route by far is the Allens Creek/FM 1093 Route, approximately 28.5 miles longer than the Oyster Creek/Highway 6 Route. A factor that increased the lengths of those routes farthest west was the need to run separate branches eastward to convey water to the southeast portion of the WHCSWSC study area and the City of Houston quadrant which have the earliest HGCSD conversion requirements. The Oyster Creek/Highway 6 Route, being the shortest route, will provide the most savings in materials to construct. Another consideration in evaluating the different routes is the ease of construction. Congested areas with many interferences with existing utilities and structures will make construction of the conveyance line difficult and costly.

The water quality of the raw water supply is a very important factor to consider in selecting a treatment plant site. As mentioned early, Sites 4B and 5 treat raw water obtained directly from the proposed Allen's Creek Reservoir. This allows Sites 4B and 5 to assure a better quality of raw water supply than the other sites evaluated. This should translate into possible lower treatment costs, improved treated water quality and a reduction in the possibility of major future expenditures in plant upgrading due to the changing EPA water quality requirements that are in existence or will be in existence in the future.

4.0 TRANSMISSION SYSTEMS

4.0 TRANSMISSION SYSTEMS

Alternate 1 Service Area Transmission System

Figure 3 presents the Alternate 1 Service Area Transmission System. The boundary line for the Alternate 1 service area is U.S. 290. Although ultimately, the transmission system for the entire WHCSWSC study area would be tied together, under this Alternate the portion of the study area south of U.S. 290 would be served from the Southwest Supply System while the area north of U.S. 290 would be served from the Northeast Supply System. The City of Houston quadrant would be served from the Southwest Supply System.

Phasing of this Alternate would begin in 1995 with the construction of Southwest System conveyance and transmission lines to serve the City of Houston quadrant located within HGCSD Regulatory Area 3. In 2000, the Southwest transmission system would be extended west of Addicks Reservoir to serve those areas located in HGCSD Regulatory Area 4. In 2005, the first phase of the Northeast System would be constructed to serve the demands located within HGCSD Regulatory Area 6. At this time, the Northeast System and Southwest System would be tied together. In 2010, the transmission lines within HGCSD Regulatory Area 7 would be constructed with approximately half of the added lines being in the Northeast System and half being in the Southwest. The final additions to the Transmission System would occur in 2030 when the remaining lines in HGCSD regulatory area 8 would be constructed.

Alternate 2 Service Area Transmission System

Figure 4 shows the Alternate 2 Service Area Transmission System. The boundary line for the Alternate 2 service area is F.M. 529 from the western edge of Harris County to Highway 6, then northeast along Highway 6 to U.S. 290. Under this Alternate the portion of the WHCSWSC study area south of this boundary would be served from the Southwest Supply System while the remainder of the area would be served from the Northeast Supply System. These two systems would ultimately be tied together to form the transmission system for the entire WHCSWSC study area. The City of Houston quadrant would be served from the Southwest Supply System.

Phasing of this Alternate would begin in the Southwest System in 1995. At that time the City of Houston quadrant located within HGCSD regulatory area 3 would need to be served. In 2000, the Southwest System would be extended to serve the areas located in HGCSD regulatory area 4. The Northeast System would be constructed in 2005 to service those areas within HGCSD regulatory area 6, and at that time would be connected to the Southwest System. In 2010, both the Northeast and Southwest Transmission Systems would be expanded to serve areas within HGCSD regulatory area 7. Finally in 2030, the remaining transmission lines needed to serve the WHCSWSC service area would be constructed completing the WHCSWSC service area transmission system.

Alternate 3 Service Area Transmission System

Figure 5 shows the Alternate 3 Service Area Transmission System. The boundary line for the Alternate 3 service area is Clay Road. Under this Alternate the portion of the WHCSWSC study area south of Clay Road would be served by the Southwest Supply System while the area north of Clay Road would be served by the Northeast Supply System. The Southwest Supply System would serve the City of Houston quadrant.

Phasing of this Alternate would begin in 1995 in the Southwest. The first phase of construction would be completed to serve the portion of the City of Houston located within HGCSD regulatory area 3. In 2000, the Southwest System would be extended to serve areas located within HGCSD regulatory area 4. The first phase of the Northeast System would begin in 2005 with lines being constructed to serve the areas located within HGCSD regulatory area 6. As in previous alternates the Northeast and Southwest Systems would be tied together in 2005. In 2010, no construction would occur in the Southwest while the Northeast System would be expanded to serve areas located within HGCSD regulatory area 7. In 2030, the remaining lines of the WHCSWSC transmission system would be constructed with the majority of the additions being in the Northeast.

Alternate 4 Service Area Transmission System

Figure 6 shows the Alternate 4 Service Area Transmission System. The boundary line for the Alternate 4 service area is Interstate 10. Under this Alternate the portion of the WHCSWSC study area south of Interstate 10 would be served by the Southwest Supply System. The area north of Interstate 10 would be served by the Northeast System. The Southwest Supply System would serve the City of Houston quadrant with both systems ultimately being tied together to form a single transmission system.

Phasing of this Alternate would begin in 1995 in the Southwest to serve of the City of Houston quadrant located within HGCSD regulatory area 3. Unlike the previous alternates, Phase I of the Northeast System would have to be constructed in 2000 to serve those areas located within HGCSD regulatory area 4. For this alternate, the Northeast and Southwest Systems would be tied together in 2000. The Northeast System would be expanded in 2005 to serve areas located within HGCSD regulatory area 6. In 2010, the Northeast System would again be expanded to serve the demands located within HGCSD regulatory area 7. In 2030, the transmission system would be completed with the majority of the lines added being in the Northeast System.

Alternate 7 Service Area Transmission System

Figure 6A shows the Alternate 7 Service Area Transmission System. Under this alternate the entire WHCSWSC service area would be served by the Southwest Supply System.

Phasing of this alternate would begin in 1995 with the construction of Southwest System conveyance and transmission lines to serve the City of Houston quadrant located within HGCSD regulatory area 3. In 2000, the Southwest Transmission System would be extended to serve those areas located within HGCSD regulatory area 4. In 2005, the Southwest Transmission System would again be extended to serve the demands in HGCSD regulatory area 6. In 2010, additional transmission lines would be constructed to serve those areas within HGCSD regulatory area 7. The final additions to the transmission system would be constructed in 2030 to serve the demands within HGCSD regulatory area 8.

Comparison of Transmission System Alternates

Figure 7 shows the schematic model used to analyze the Alternate Service Area Transmission Systems. In alternates 1 through 4, flows were varied through the conveyance lines from the proposed Northeast and Southwest Treatment Plants to correspond to the alternate service areas being investigated. For Alternate 7 the entire WHCSWSC service area was supplied from the Southwest System. Each alternate service area model was supplied from the five different Southwest Plant site locations. Lines were sized according to the criteria mentioned previously in Section 2 - "Design Considerations and Assumptions" with velocities not exceeding 7.0 fps and pressures throughout the system kept above 45 psi through the use of strategically located booster pump stations. The service area generally slopes in a northwest to southeast direction with those areas in the extreme northwest being approximately 180 feet higher than areas in the extreme southeast. Because of this elevation difference, areas of lowest pressure (approximately 45 psi) occurred in the northwest around Waller for all of the alternatives investigated. The areas of highest pressure were located in the south and southeast near the proposed locations for the Southwest Treatment Plant. Pressures in the range of 90-95 psi occurred in the conveyance line portions of the system and dropped to the 75 psi to 85 psi range upon entering the transmission system pipe network. Pressures required from the Northeast System ranged from 70-75 psi to deliver the required flows for each service area alternate. The five Alternate Service Area Transmission Systems vary only

slightly when compared in their ultimate state when both the Northeast and Southwest Systems are tied together. The varying amounts of treated water supplied from the conveyance systems for the alternate service areas affects line sizes of only those lines of the transmission system closest to the entry point of the conveyance system into the transmission system.

When investigating the Alternate Service Area Transmission System in regard to phasing, however, several observations can be made. The dates investigated for transmission system phasing are 1995, 2000, 2005, 2010 and 2030.

The earliest conversion dates set forth by the HGCSD are located in the southwest. This area can be easily served by the Southwest System as shown in Alternates 1, 2, 3 and 7. In Alternate 4, however, a substantial amount of line would have to be constructed in year 2000 to serve the areas located in HGCSD regulatory area 4 from a Northeast System. This makes Alternative 4 less attractive because of the substantial initial costs involved to serve such a small demand.

5.0 COST ANALYSIS

5.0 COST ANALYSIS

CONSIDERATIONS AND ASSUMPTIONS

Raw Water Costs

The raw water supply source for the Northeast System will be taken from Lake Houston. Previous reports and studies indicate an estimated raw water cost from Lake Houston to be presently in the range of $0.22 to $0.25 per thousand gallons. Correspondence recently received from the City of Houston states that for preliminary cost analysis a figure of $0.25 per thousand gallons ($0.25/1000 gal.) would be an appropriate raw water cost from Lake Houston. This cost of $0.25/1000 gallons is based on the City's cost of developing the raw water sources that presently supply the Lake Houston System. However, the City projects that this cost will increase when additional sources are developed. The HWMP considers the Lake Houston System as part of the City's "Eastern Water Alternatives". These alternatives are referred to in the HWMP as the Toledo Bend Alternative (Alternative No. 4) and the Toledo Bend plus Wallisville Alternative (Alternative No. 9). For this study the HWMP's Toledo Bend Alternative will be used for projecting future raw water costs in the Lake Houston System. After reviewing the HWMP, it was determined that the Toledo Bend Conveyance System is projected to be on line by 2010. According to the HWMP this project will increase the raw water cost in the Lake Houston System to $0.38/1000 gallons in 2010, and raw water cost will remain at this figure until 2029. In 2030 the cost of raw water will

decrease to $0.32/1000 gallons. This decrease in cost is due to an increase in demand allowing the City to amortize the cost of the Toledo Bend Water over a larger customer base. For cost purposes this study will use the following raw water cost for the Northeast System:

Year	Raw Water Cost
1990-2009	$0.25/1000 Gallons
2010-2029	$0.38/1000 Gallons
2030-After	$0.32/1000 Gallons

The raw water supply source for the Southwest System will be taken from the Brazos River and/or one of its canals. Correspondence received from the Brazos River Authority (BRA) outlines an incremental schedule of water supply developments tailored to meet the demands of the WHCSWSC service area. Table 5 presents the supply designation schedule for the Southwest System. The price quoted by the BRA for future use water is $40.00 per acre-foot ($0.12 per thousand gallons) and the price for current use water is $120.00 per acre-foot ($0.37 per thousand gallons). All of the cost tables presented in this study considered the cost for future use water as a capital cost for raw water.

TABLE 5

SUPPLY DESIGNATION SCHEDULE
WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION
(Based on Average Daily Supply)

Projection Year	Supply Increments	Future Use Water AF/YR (MGD)		Minimum Current Use Water AF/YR (MGD)	
1988	First Increment (1)	75,000	(67.0 MGD)	0	0
1995	First Increment (1)	30,000	(26.8 MGD)	45,000	(40.2 MGD)
2000	Second Increment (2)	40,000	(35.7 MGD)	80,000	(71.5 MGD)
2010	Third Increment (3)	30,000	(26.8 MGD)	120,000	(107.2 MGD)
2015	Third Increment (3)	20,000	(17.9 MGD)	130,000	(116.1 MGD)
2020	Third Increment (3)	20,000	(17.9 MGD)	130,000	(116.1 MGD)
2025	Third Increment (3)	20,000	(17.9 MGD)	130,000	(116.1 MGD)
2030	Third Increment (3)	0	0	150,000	(134.0 MGD)

(1) To be furnished from existing sources.

(2) Now expected to be furnished from the Allen's Creek Project.

(3) Now expected to be furnished from the South Bend Project.

Raw Water Pumping/Conveyance Costs

Cost estimates were prepared to determine the capital and operational costs associated with the transfer of raw water from each alternate raw water supply source to the alternate treatment plant sites.

Capital cost estimates include the construction costs for raw water pump stations at each source plus the construction costs for the necessary raw water conveyance pipelines and appurtenances. All capital cost estimates were based on current construction costs for similar facilities constructed in the Houston area.

Operation costs for raw water conveyance were based on using an estimated power cost of $0.05/kilowatt-hour and an efficiency factor of 85 percent. Maintenance costs were estimated based on historical data.

Delivery costs associated with raw water taken from the Brazos Canal System were provided to the WHCSWSC from the BRA. This cost was based on utilizing the existing BRA pumps at the Brazos River and minimum improvements to the Canal System. The projected delivery cost provided by the BRA was $0.06/1000 gallons.

Termination Storage Costs

Termination storage requirements for each site were based on a water quality criteria aimed at limiting chlorides to 240 mg/l. From

previously presented historic water quality data for the Brazos River (Station No. 08114000), it can be seen that chlorides are below this level approximately 95% of the time. This would mean that 5% of the time raw water would need to be pumped from storage rather than directly from the Brazos River. Termination storage facilities were sized based on this assumption of pumping maximum daily demands from storage for 5% of the year. The volume of termination storage required is as follows, assuming a usable depth of 16 feet:

Service Area	Ultimate Southwest Maximum Daily Demand (MGD)	Required Storage (Acres)
Alternate 1	187	658
Alternate 2	177	623
Alternate 3	140	525
Alternate 4	121	424
Alternate 7	231	808

Capital costs associated with termination storage include the construction cost to build such a facility plus the cost of the land required. Construction costs were based on similar construction in the Houston area and land costs were obtained from County Tax Records as well as the present cost of major tracts in the vicinity of the general areas evaluated for a proposed Southwest Plant site.

Treatment Costs

All treatment plant capital cost estimates were based on current construction costs for similar facilities in the Houston area and include land costs, engineering and contingencies.

Facilities related to the Northeast System are the WHCSWSC share of the Northeast Treatment Plant and the large booster pump station connected to the Northeast Conveyance line at the WHCSWSC boundary. Costs for the WHCSWSC share of the Northeast Treatment Plant are based on recent bids for the City of Houston Southeast and East Water Purification Plants. In allocating costs, differentiation must be made between the cost of treatment capacity and the cost of treated water pumping capacity. The transmission of treated water within the WHCSWSC service area will be accomplished from separate pump stations and local pumping facilities as opposed to facilities at the treatment plants.

The Northeast Treatment Plant capital cost used in this study was approximately $0.80 per gallon which increased to $1.08/gallon when adding land cost and site development cost. The Southwest Treatment Plant capital cost was based on $0.80 per gallon for actual treatment facilities. This figure was increased depending on the plant site alternate to include land cost and site development.

Operating and treatment costs associated with the Northeast and Southwest Treatment Plants include costs for power to run the equipment, treatment chemicals, maintenance costs and supplies.

The costs of operations and treatment at the proposed Northeast Treatment Plant are estimated to be in the range of $0.40 to $0.50 per thousand gallons based on information provided by the City of Houston. For planning purposes for the WHCSWSC study, a figure of $0.40 per thousand gallons will be used for operations and treatment costs at the proposed Northeast Treatment Plant.

Operations and treatment costs at the proposed Southwest Treatment Plant are estimated to be $0.42 per thousand gallons. This figure is based on detailed cost data compiled over the past year by the Galveston County Water Authority (GCWA) who presently treats raw water taken from the Brazos River System using the BRA Canal System for conveyance purposes.

Treated Water Pumping/Conveyance Costs

Conveyance System cost estimates were prepared for each of the three Northeast Conveyance System alternate routes and each of the five Southwest Conveyance System alternate routes. Estimates were based on current construction costs for similar facilities constructed in the

Houston area. The majority of the conveyance lines were routed within existing street right-of-ways. Where this was not possible, allowances were included for right-of-way acquisitions. Included in the estimates were costs for crossing waterways and major thoroughfares, valves and appurtenances, corrosion protection, engineering and contingencies.

Operating costs associated with the conveyance systems includes energy costs to run the pumps required to maintain flow and system pressures and the associated maintenance of these facilities. Exact costs for the maintenance of such facilities is not readily available, however, costs for repairs to pumps, line leaks, valve failures and similar repairs were accounted for by using an estimated $0.04 per thousand gallon cost. A figure of $0.05 per kilowatt-hour was used to estimate annual pumping costs assuming an 85 percent efficiency factor.

The above costs do not include administrative costs such as record keeping, reporting, billing and system administration.

Transmission System Costs

Transmission System cost estimates were prepared for each of the alternate service areas investigated. Costs were determined for the ultimate (Year 2030) transmission system, as well as phases of construction corresponding to years 1995, 2000, 2005, 2010 and 2030. All

estimates were based on current construction costs for similar facilities constructed in the Houston area and include costs for crossing major thoroughfares and waterways, valves and appurtenances, corrosion protection, engineering and contingencies. An effort was made to route the transmission lines within existing street right-of-ways. Where it was not possible, allowances were included for right-of-way acquisition.

Facilities common to both the Northeast and Southwest Transmission Systems are the three ground storage and booster pump stations required within the transmission system to maintain flow and pressure. Capital costs for these facilities were based on current construction costs for similar facilities constructed in the Houston area. Operation costs for the pumps were based on $0.05 per kilowatt-hour using an 85% efficiency factor.

CAPITAL COST ESTIMATES

General

The capital cost estimates shown in this section are for comparison purposes only. The capital cost used in this study include 10 percent construction cost increase for engineering as well as a 10 percent increase for contingencies. The capital cost shown here are for ultimate conditions from the year 1995 (Phase I) through 2030 (Phase V).

Northeast Conveyance System Alternates

The ultimate capital cost estimates for each of the three alternate Northeast Conveyance Systems are presented on Table 6 shown below. All costs are in 1988 dollars and include engineering and contingency.

TABLE 6

NORTHEAST CONVEYANCE SYSTEM CAPITAL COST
(ULTIMATE SYSTEM - YEAR 2030)
(In Thousands)

NORTHEAST CONVEYANCE ALTERNATE	SERVICE AREA ALTERNATE NO. 1	NO. 2	NO.3	NO. 4	NO. 7
Beltway 8 Route	$96,578	$114,775	$173,533	$205,787	0
NHCWSC Route	102,382	122,293	185,066	219,107	0
F.M. 1960 Route	106,957	128,539	195,701	232,048	0

Southwest Conveyance System Alternates

The ultimate capital cost estimates for each of the six alternate Southwest Conveyance Systems are presented on Table 7 shown below. All costs are in 1988 dollars and include engineering and contingency. The cost shown below are ultimate costs and are not normalized to account for the varying amounts of treated water produced in each Service Area Alternate.

TABLE 7

SOUTHWEST CONVEYANCE SYSTEM CAPITAL COST
(ULTIMATE SYSTEM - YEAR 2030)
(In Thousands)

SOUTHWEST CONVEYANCE ALTERNATE	SERVICE AREA ALTERNATE NO. 1	NO. 2	NO. 3	NO. 4	NO. 7
SITE 1 Oyster Creek/ Dairy Ashford	$285,408	$271,044	$224,893	$195,746	$344,109
SITE 2 Brazos River/ Highway 6	282,111	266,734	222,974	195,626	333,221
SITE 3 Oyster Creek/ Highway 6	266,023	252,003	208,091	181,742	320,022
SITE 4A Jones Creek/ Grand Parkway	281,883	266,167	221,287	189,808	331,727
SITE 4B Allens Creek/ Grand Parkway	304,076	289,554	248,497	220,566	346,247
SITE 5 Allens Creek/ F.M. 1960	313,082	296,029	248,913	220,153	355,253

Transmission System Service Area Alternates

The ultimate transmission system capital cost estimates for the years 1995 through 2030 are shown on Table 8. All costs are in 1988 dollars and include engineering and contingencies costs. As shown in the following table, the transmission system costs for each Service Area Alternate is higher when using the Southwest Conveyance System alternates Site 2 and 3. However, the cost differential is offset by the smaller Southwest Conveyance System capital cost of Site 2 and 3. Refer to Table 7 for details on these Southwest Conveyance System costs.

TABLE 8

TRANSMISSION SYSTEM CAPITAL COST
(ULTIMATE SYSTEM - YEAR 2030)
(In Thousands)

SERVICE AREA ALTERNATE	SOUTHWEST CONVEYANCE SYSTEM ALTERNATE SITE 1	SITE 2	SITE 3	SITE 4A	SITE 4B	SITE 5
ALTERNATE 1						
SERVICE AREA						
Northeast	$151,865	$151,865	$151,865	$151,865	$151,865	$151,865
Southwest	$215,312	$228,797	$215,287	$215,287	$215,287	$215,698
TOTAL	**$367,177**	**$380,622**	**$380,662**	**$367,152**	**$367,152**	**$367,563**
ALTERNATE 2						
SERVICE AREA						
Northeast	$183,437	$183,437	$183,437	$183,437	$183,437	$183,437
Southwest	$170,247	$194,126	$194,126	$182,112	$182,112	$183,786
TOTAL	**$353,684**	**$377,563**	**$377,563**	**$365,549**	**$365,549**	**$367,223**
ALTERNATE 3						
SERVICE AREA						
Northeast	$246,498	$246,498	$246,498	$242,504	$242,504	$242,504
Southwest	$116,357	$131,026	$131,026	$121,425	$121,425	$116,386
TOTAL	**$362,855**	**$377,524**	**$377,524**	**$363,929**	**$363,929**	**$358,890**
ALTERNATE 4						
SERVICE AREA						
Northeast	$288,262	$288,262	$288,262	$284,267	$284,267	$284,267
Southwest	$ 69,509	$ 85,583	$ 85,583	$ 76,539	$ 76,539	$ 72,248
TOTAL	**$357,771**	**$373,845**	**$373,845**	**$360,806**	**$360,806**	**$356,515**
ALTERNATE 7						
SERVICE AREA						
Northeast	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Southwest	$360,164	$373,649	$373,649	$360,139	$360,139	$360,551
TOTAL	**$360,164**	**$373,649**	**$373,649**	**$360,139**	**$360,139**	**$360,551**

COST COMPARISONS

General

The evaluation of cost between numerous combinations of alternatives is a complicated issue. The information previously presented identifies five service area alternatives, six southwest conveyance system alternatives and three northeast conveyance system alternatives which produces approximately 100 different combinations. This section of the report will only compare in detail five service area alternates in combination with the recommended Northeast Conveyance System Alternate (Beltway 8 Route) and the top two ranked Southwest Conveyance System Alternates as identified and recommended in the following sections of this appendix. The top two ranked Southwest Conveyance System Alternates are Alternate No. 4B (Allens Creek/Grand Parkway) and Alternate No. 5 (Allens Creek/F.M. 1093).

This study has utilized two cost methods when comparing cost between alternatives, total annualized cost analysis and present worth analysis.

Annualized Cost Analysis

The annualized cost for each alternate was determined by adding capital cost amortized at 8% over 30 years with the associated annual operation and maintenance cost. The annual cost was further refined into annual cost per thousand gallons of water delivered by dividing the

annual cost by the maximum daily water delivered for each phase of conversion. This final refinement will place the alternates on a comparable basis independent of the amount of water delivered by the phased developments. Tables 9, 10 and 11 present the cumulative annualized cost of each phase for the Southwest Conveyance System Alternates, the Northeast Conveyance System Alternates and the Service Area Alternates. The annualized cost table for the Service Area Alternates includes the recommended alternatives for the Northeast and Southwest Conveyance Systems as previously mentioned.

Table 9 shows that the Beltway 8 Route is the least expensive Northeast Conveyance System route with regards to annualized cost in all alternatives and all phases. Table 10 shows that the Southwest Conveyance System Alternate Site 5 produces a significantly lower annualized cost in the year 2030 than the remaining alternate sites studied. As can be seen in Table 11, Service Area Alternate 7 produces the lowest overall annualized cost in the year 2030 with the remaining Service Area Alternates producing an annualized cost within 5 percent of Service Area Alternate 7. The Service Area Alternate annualized costs for Phases III, IV and V as shown on Table 11 do not reflect the real cost differences between serving an area with Southwest versus Northeast water. When combining the annualized Southwest Conveyance, Northeast Conveyance and Transmission System costs for various Service Area Alternates, the cost differences appear quite small. This cost difference reduction is due to the large difference in annualized cost between serving an area from the

Southwest versus the Northeast. An example of the subsidizing affect by the Southwest System can be explained by evaluating the Southwest System separately from the Northeast System in each phase within each Service Area Alternate. When evaluating annualized cost in Phase III (Year 2005) it was determined that the area under mandate to convert in Phase III would cost approximately $1.62/1000 gallons if served from the Southwest and approximately $5.10/1000 gallons when served from the Northeast. Further justification of the advantages in the early phases of using southwest water over northeast water can be found when evaluating Phase II (Year 2000). It was determined that the area between I-10 and Clay Road could be served from the Southwest at a cost of $1.59/1000 gallons, however, to serve this area from the Northeast it would cost approximately $7.14/1000 gallons. As a result of the above comparisons, it can be concluded that it is significantly cheaper to serve the areas mandated in the years 1995, 2000 and 2005 from the Southwest System rather than the Northeast System.

TABLE 9

ANNUALIZED COST PER 1,000 GALLONS
(CUMULATIVE)
NORTHEAST CONVEYANCE SYSTEM

NORTHEAST CONVEYANCE ALTERNATE	*NORTHEAST CONVEYANCE SYSTEM ($/1000 GALLONS) PHASE I	PHASE II	PHASE III	PHASE IV	PHASE V
BELTWAY 8 ROUTE					
Service Area Alt. 1	0	0	2.06	1.43	1.37
Service Area Alt. 2	0	0	2.20	1.44	1.35
Service Area Alt. 3	0	0	2.63	1.40	1.32
Service Area Alt. 4	0	4.81	2.30	1.42	1.31
Service Area Alt. 7	0	0	0	0	0
NHCWSC ROUTE					
Service Area Alt. 1	0	0	2.19	1.47	1.39
Service Area Alt. 2	0	0	2.37	1.48	1.38
Service Area Alt. 3	0	0	2.89	1.44	1.35
Service Area Alt. 4	0	5.52	2.54	1.47	1.34
Service Area Alt. 7	0	0	0	0	0
F.M. 1960 ROUTE					
Service Area Alt. 1	0	0	2.29	1.50	1.42
Service Area Alt. 2	0	0	2.52	1.51	1.41
Service Area Alt. 3	0	0	3.13	1.48	1.38
Service Area Alt. 4	0	6.21	2.77	1.52	1.37
Service Area Alt. 7	0	0	0	0	0

*All costs are compounded from previous phases and annualized at 8% for 30 years.

All costs above are for the Northeast Conveyance System only.

TABLE 10

ANNUALIZED COST PER 1,000 GALLONS
(CUMULATIVE)
SOUTHWEST CONVEYANCE SYSTEM

SOUTHWEST CONVEYANCE ALTERNATE	*SOUTHWEST CONVEYANCE SYSTEM ($/1000 Gallon) PHASE I	PHASE II	PHASE III	PHASE IV	PHASE V
SITE 1					
Service Area Alt.1	1.58	1.46	1.48	1.44	1.41
Service Area Alt.2	1.56	1.46	1.47	1.44	1.42
Service Area Alt.3	1.53	1.44	1.45	1.47	1.45
Service Area Alt.4	1.50	1.42	1.44	1.46	1.46
Service Area Alt.7	1.58	1.46	1.46	1.40	1.38
SITE 2					
Service Area Alt.1	1.49	1.38	1.40	1.36	1.33
Service Area Alt.2	1.47	1.37	1.39	1.36	1.33
Service Area Alt.3	1.53	1.41	1.42	1.44	1.41
Service Area Alt.4	1.42	1.35	1.37	1.39	1.39
Service Area Alt.7	1.49	1.38	1.38	1.32	1.30
SITE 3					
Service Area Alt.1	1.48	1.40	1.42	1.39	1.37
Service Area Alt.2	1.47	1.39	1.41	1.39	1.37
Service Area Alt.3	1.45	1.38	1.40	1.42	1.40
Service Area Alt.4	1.43	1.37	1.39	1.41	1.41
Service Area Alt.7	1.48	1.40	1.40	1.36	1.34
SITE 4A					
Service Area Alt.1	1.46	1.38	1.40	1.38	1.39
Service Area Alt.2	1.44	1.38	1.39	1.38	1.40
Service Area Alt.3	1.43	1.37	1.38	1.40	1.44
Service Area Alt.4	1.40	1.35	1.37	1.39	1.45
Service Area Alt.7	1.46	1.38	1.39	1.35	1.36
SITE 4B					
Service Area Alt.1	1.46	1.35	1.37	1.38	1.37
Service Area Alt.2	1.45	1.34	1.36	1.39	1.38
Service Area Alt.3	1.42	1.33	1.35	1.37	1.39
Service Area Alt.4	1.40	1.33	1.34	1.36	1.41
Service Area Alt.7	1.46	1.35	1.35	1.33	1.33

*All costs are compounded from previous phases and annualized at 8% for 30 years.

All costs above are for the Southwest Conveyance System only.

TABLE 10 (CONT'D)

ANNUALIZED COST PER 1,000 GALLONS
(CUMULATIVE)
SOUTHWEST CONVEYANCE SYSTEM

SOUTHWEST CONVEYANCE ALTERNATE	*SOUTHWEST CONVEYANCE SYSTEM ($/1000 Gallon) PHASE I	PHASE II	PHASE III	PHASE IV	PHASE V
SITE 5					
Service Area Alt.1	1.43	1.31	1.33	1.28	1.32
Service Area Alt.2	1.41	1.30	1.32	1.29	1.33
Service Area Alt.3	1.38	1.28	1.30	1.32	1.38
Service Area Alt.4	1.37	1.28	1.30	1.32	1.41
Service Area Alt.7	1.43	1.31	1.30	1.24	1.27

*All costs are compounded from previous phases and annualized at 8% for 30 years.

All costs above are for the Southwest Conveyance System only.

TABLE 11

ANNUALIZED COST PER 1,000 GALLONS
(CUMULATIVE)
SERVICE AREA ALTERNATIVES

SERVICE AREA ALTERNATE	SERVICE AREA ALTERNATE ($/1000 GALLONS) PHASE I	PHASE II	PHASE III	PHASE IV	PHASE V
SERVICE AREA ALT. 1					
S.W. Conveyance Site 4B	1.69	1.59	1.71	1.76	1.77
S.W. Conveyance Site 5	1.64	1.54	1.66	1.67	1.73
SERVICE AREA ALT. 2					
S.W. Conveyance Site 4B	1.69	1.59	1.71	1.76	1.77
S.W. Conveyance Site 5	1.64	1.54	1.66	1.68	1.73
SERVICE AREA ALT. 3					
S.W. Conveyance Site 4B	1.69	1.59	1.74	1.74	1.76
S.W. Conveyance Site 5	1.64	1.54	1.69	1.71	1.75
SERVICE AREA ALT. 4					
S.W. Conveyance Site 4B	1.69	1.75	1.75	1.75	1.76
S.W. Conveyance Site 5	1.64	1.71	1.71	1.72	1.75
SERVICE AREA ALT. 7					
S.W. Conveyance Site 4B	1.69	1.59	1.63	1.70	1.73
S.W. Conveyance Site 5	1.64	1.54	1.58	1.60	1.68

ASSUMPTIONS:

(1) All costs assume Northeast Conveyance - Beltway 8 Route.
(2) $/1000 Gallons above include cost of conveyance and transmission systems per Service Area Alternate.
(3) All costs are compounded from previous phases and annualized at 8% for 30 years.
(4) Phase I costs for all service area alternates include Southwest System only based on 65 MGD maximum daily capacity.

Present Worth Analysis

The annualized cost analysis presented previously is important in analyzing the cost per unit of water delivered for each phase of a particular alternate. However, this annualized analysis does not consider the timing or (phasing) of projects within a particular alternate. The present worth analysis can be defined as the amount of money required to put in the bank at the beginning of a study period that will meet all capital and operational costs throughout the study period. For example two alternates with similar total cost might have projects that come on line at different times. The alternate with a large project required early would be less preferable than the alternate whose first major project is not required for several years. Furthermore, the present worth analysis must be normalized to compare alternates that produce varying amounts of water.

The present worth analysis presented in this section was calculated assuming the following assumptions:

- Project capital cost have a 30 year life and are amortized at 8%.
- Time period beginning 1988 and ending in 2030 (Study Period).
- All present worth cost in 1988 dollars.
- Operation and maintenance cost (O & M) are considered annually throughout study period.

- o O & M Costs are inflated at 10% per year.
- o The normalized present worth analysis was used for the Conveyance System Alternates by dividing the present worth by the million gallons per day (MGD) of maximum daily water delivered.
- o The actual present worth amounts were used when comparing Service Area Alternates (Through Year 2030) because the ultimate water delivered (231 MGD) was consistent for all Service Area Alternates.
- o Capital cost for each component was calculated as previously mentioned.

Table 12 presents the normalized present worth of the Northeast Conveyance System Alternates within each Service Area Alternate.

TABLE 12

NORMALIZED PRESENT WORTH PER MGD
NORTHEAST CONVEYANCE SYSTEM
($/MGD)

NORTHEAST CONVEYANCE ALTERNATE	ALT. 1	ALT. 2	ALT. 3	ALT. 4	ALT. 7
BELTWAY 8 ROUTE	8.73	8.22	7.77	7.53	0
NHCWSC ROUTE	8.87	8.37	7.91	7.70	0
F.M. 1960 ROUTE	8.99	8.50	8.04	7.86	0

(The above normalized present worth costs include only the Northeast Conveyance System.)

Within each Service Area Alternate the Beltway 8 Route always produces the least Northeast Conveyance System cost with regard to normalized present worth. The normalized present worth for each Northeast Conveyance System must be compared within each Service Area Alternate. Comparison of conveyance routes between Service Area Alternatives would not be a valid comparison due to the Northeast Conveyance System being only one component out of the total cost to serve the WHCSWSC demands.

Table 13 presents the normalized present worth of the Southwest Conveyance System Alternates for each Service Area Alternate.

TABLE 13

NORMALIZED PRESENT WORTH PER MGD
SOUTHWEST CONVEYANCE SYSTEM
($/MGD)

SOUTHWEST CONVEYANCE ALTERNATE	ALT. 1	ALT. 2	ALT. 3	ALT. 4	ALT. 7
SITE 1	12.42	12.78	14.18	15.51	11.72
SITE 2	11.59	11.91	13.22	14.46	10.93
SITE 3	12.11	12.46	13.83	15.14	11.45
SITE 4A	12.22	12.58	13.98	15.30	11.54
SITE 4B	11.73	12.08	13.26	14.55	11.04
SITE 5	11.14	11.47	12.77	14.03	10.46

(The above normalized present worth costs include only the Southwest Conveyance System.)

Within each Service Area Alternate the Southwest Conveyance Site 5 always produces the least Southwest Conveyance System cost with regard to normalized present worth. The normalized present worth for each Southwest Conveyance System must be compared within each Service Area Alternate. Comparing conveyance routes between Service Area Alternates would not be a valid comparison due to the Southwest Conveyance System being only one component out of the total cost to serve the WHCSWSC demands.

Table 14 presents the present worth of the Service Area Alternates including the recommended Northeast Conveyance System Alternate (Beltway 8 Route) and the top two recommended Southwest Conveyance System Alternates (4B and 5) as previously described. The present worth analysis of the Service Area Alternates did not need normalizing since all of the Alternates would ultimately deliver the same amount of treated water (231 MGD). If the present worth costs were normalized using 231 MGD, then the normalized present worth would range between $12.20/MGD in Service Area Alternate No. 7 to $12.90/MGD in Service Area Alternate 4.

TABLE 14

PRESENT WORTH
SERVICE AREA ALTERNATES
(Total Dollars)

SERVICE AREA ALTERNATES	SITE 4B	SITE 5
SERVICE AREA ALTERNATE 1	$2,980,823,000	$2,869,244,000
SERVICE AREA ALTERNATE 2	2,984,829,000	2,875,663,000
SERVICE AREA ALTERNATE 3	2,962,650,000	2,888,405,000
SERVICE AREA ALTERNATE 4	2,965,835,000	2,898,512,000
SERVICE AREA ALTERNATE 7	2,952,546,000	2,818,814,000

(The above total present worth costs include the Northeast Conveyance System, Southwest Conveyance System and Transmission System.)

When investigating Table 14, it is apparent that when combining the cost of all three components (the Northeast Conveyance System, the Southwest Conveyance System and the associated Transmission System) that Service Area Alternate No. 7 produces the least total present worth cost from either Southwest Conveyance Site 4B or Site 5.

6.0 RANKING OF ALTERNATES

6.0 RANKING OF ALTERNATES

Methodology

Previous Appendices along with the previous sections of this Appendix have identified three Northeast Conveyance System Alternates, six Southwest Conveyance System Alternates and seven Service Area Alternates. At the request of the WHCSWSC Board, Service Area Alternates No. 5 and No. 6 were deleted from further consideration before beginning Appendix IV. Alternates 5 and 6 were deleted because of the lack of interest on the part of the city of Houston in developing the HWMP's "Western Alternative" which includes the WHCSWSC's North Supply System.

Since the majority of alternatives have both advantages and disadvantages when compared to one another, a systematic method of identifying the most feasible alternate must be developed. The method chosen to rank alternates in this Appendix will address the following general categories:

- Technical
- Environmental
- Community/Social
- Phasing
- Financial

Each set of Alternate Systems were evaluated and ranked in varying levels of detail within each of the general categories mentioned above.

Northeast Conveyance System Alternates

After initial comparisons it was found that the Northeast Conveyance System Alternates could be evaluated and ranked independent of the Southwest Conveyance System Alternates. The sizing of facilities within the Northeast Conveyance System Alternates is dependent upon the amount ofwater demand produced in each Service Area Alternate. As a result, the selection of a Service Area Alternate could affect the ranking of the Northeast Conveyance Systems.

After initial review, the Northeast Conveyance System alternates which are the Beltway 8 route; the NHCWSC route; and the F.M. 1960 route, were all determined feasible and consistent with the HWMP. However, after detailed evaluation within the five general categories it has been determined that the Beltway 8 route is superior in all categories for the following reasons:

Technical

- Superior hydraulic characteristics producing a maximum of 16 psi more residual pressure at the WHCSWSC boundary than the other two routes.

- Reduced line lengths; 9 miles and 4 miles shorter than the F.M. 1960 and NHCWSC routes, respectively.

- Reduced possibility of needed land acquisitions outside existing street rights-of-way.

- Reduced possibility of problems during construction due to large rights-of-way, decreasing the construction time.

Environmental and Community/Social

- Routed through less existing and possible future residential developments than the NHCWSC and F.M. 1960 routes.

- Minimizes disruptions to traffic flow and utility relocations.

- Preferred route by the City of Houston.

Phasing and Financial

- Beltway 8 Route results in a shorter route and smaller cost to convey treated water to the WHCSWSC service area within the first conversion date of 2005 as determined by the HGCSD.

- Utilizes a portion of the NHCWSC proposed routing scheme producing a reduction in cost due to pro rata share with NHCWSC.

- o Reduction in present worth cost of approximately $6,000,000.

- o Reduction in operating cost.

As a result of the advantages previously listed, a numerical ranking was not performed when evaluating the Northeast Conveyance System Alternates. This appendix concludes that the Beltway 8 route is the preferred route over the two routes previously discussed. The Beltway 8 route will be used as the recommended Northeast Conveyance System Alternate when evaluating and ranking the Service Area Alternates later in this section.

Southwest Conveyance System Alternates

The Southwest Conveyance System is defined as the facilities required to pump, convey and store raw water from the supply source to the treatment plant. Also, included is treatment facilities and treated water storage and conveyance facilities needed to deliver treated water to the WHCSWSC Service Area. After initial review, the six alternate Southwest Conveyance Systems considered for study are as listed below:

Site 1: Oyster Creek/Dairy Ashford

Site 2: Brazos River/Highway 6

Site 3: Oyster Creek/Highway 6

Site 4A: Jones Creek/Grand Parkway

Site 4B: Allens Creek/Grand Parkway

Site 5: Allens Creek/F.M. 1093

(Refer to Figure 2 Southwest Conveyance System Alternates for a graphical representation of these systems.)

As mentioned previously, the Southwest Conveyance System evaluation and ranking is independent of the Northeast Conveyance System selection, but could be affected by the Service Area Alternate selection. However, it was determined that the Southwest Conveyance System should be evaluated and selected before a detailed evaluation is made of the individual Service Area Alternates. The reasoning behind this decision is that the recommended Service Area Alternates may be altered before future phases are completed; however, after the Southwest Conveyance System treatment plant site is constructed, it is fixed throughout the life of the project. As a result the selection of a treatment plant site within the Southwest Conveyance System is more important than the selection of a final Service Area Alternate. To effectively evaluate treatment plant alternates, the entire conveyance system associated with the treatment plant alternate, must also be evaluated.

After initial review and because of the importance attached to the selection of a Southwest Conveyance System, a very detailed ranking criteria and methodology has been developed within the confines of the previously mentioned five general ranking categories. Each of the general ranking categories were evaluated based on the sub-categories outlined in the Individual Ranking Form located in Attachment 1 of this Appendix.

A ranking committee was established that included experts in the field of water resource development including a member of the City of Houston's Public Works Department assigned by the Director of Public Works. All of the committee members attended a briefing on the facts and findings with regards to the varying Southwest Conveyance System Alternates. Each committee member assigned a weighted percentage to each of the five general ranking categories, as well as, each sub-category. The weighted percentages were averaged among the committee members and then applied to the individual numerical ratings given to each category. This resulted in a final individual ranking schedule that contained final numerical point totals for each Southwest Conveyance System, as well as, ranking orders for each conveyance system that ranged from one to six with one being the most preferred site. The final conveyance system rankings for individual raters; the final average ranking between raters and the final overall ranking of each system can be viewed in the chart below:

FINAL RANKING OF ALTERNATES
SOUTHWEST CONVEYANCE SYSTEM

RANKING COMMITTEE MEMBER	SOUTHWEST CONVEYANCE ALTERNATES SITE 1	SITE 2	SITE 3	SITE 4A	SITE 4B	SITE 5
RATER NO. 1	6	4	5	3	1	2
RATER NO. 2	6	4	5	2	1	3
RATER NO. 3	6	5	4	3	1	2
RATER NO. 4	6	4	5	2	1	3
RATER NO. 5	6	4	5	2	2	1
RATER NO. 6	6	4	5	3	2	1
RATER NO. 7	6	5	4	3	2	1
FINAL AVERAGE RATING	6	4.3	4.7	2.6	1.4	1.9
FINAL RANKING	(6)	(4)	(5)	(3)	(1)	(2)

From the final ranking chart it can be concluded that Site 4B, the Allens Creek/Grand Parkway Alternate is the ranking committee's preferred Southwest Conveyance System alternate. Site 5, the Allens Creek/F.M. 1093 system was very close with Site 4A, the Jones Creek/Grand Parkway, a distant third. It can be concluded that Site 1 (Oyster Creek/Dairy Ashford); Site 2 (Brazos River/Highway 6); and Site 3 (Oyster Creek/Highway 6) are the least preferred. However, before final conclusions can be drawn, the ranking system should be evaluated for the sensitivity of individual major categories. Due to the subjectivity of this ranking methodology, the final ranking chart was re-evaluated five different times deleting one of the general categories in each re-evaluation. As can be seen in the final sensitivity chart below, Site

4B remains the preferred alternate throughout all five evaluations. Site 5 remains second and Site 4A third with Site 1, 2 and 3 varying between third and sixth.

SENSITIVITY CHART - FINAL RANKING
SOUTHWEST CONVEYANCE SYSTEM

ELIMINATED RANKING CATEGORY		SUMMARY - AVERAGE RANKING					
		SITE 1	SITE 2	SITE 3	SITE 4A	SITE 4B	SITE 5
1.0	TECHNICAL	(6)	(5)	(4)	(3)	(1)	(2)
2.0	ENVIRONMENTAL	(6)	(5)	(4)	(3)	(1)	(2)
3.0	COMMUNITY/ SOCIAL	(6)	(4)	(5)	(3)	(1)	(2)
4.0	PHASING	(6)	(4)	(5)	(3)	(1)	(2)
5.0	FINANCIAL	(6)	(4)	(5)	(3)	(1)	(2)

It can be concluded from the above chart that the sensitivity of each of the five general ranking categories has no effect on the conclusion recommending Site 4B as the preferred Southwest Conveyance alternate. However, due to the relative close ranking (it could be concluded that an exact plant site located along F.M. 1093 within Areas 4 and 5 between the proposed Grand Parkway and the proposed Allens Creek Reservoir would be accepted as a preferred site. Another conclusion that can be obtained from this ranking exercise is that it is more preferable to select a conveyance system site that utilizes raw water directly from Allens Creek

Reservoir as proposed in Alternates 4B and 5. Therefore, only Southwest Conveyance System Alternates 4B and 5 will be included in the following evaluation of the Service Area Alternates.

Service Area Alternates

The Service Area Alternates considered for evaluation and ranking are described as follows:

- o Alternate No. 1 - Boundary at Highway 290
- o Alternate No. 2 - Boundary at F.M. 529
- o Alternate No. 3 - Boundary at Clay Road
- o Alternate No. 4 - Boundary at I.H.10
- o Alternate No. 7 - Entire Service Area Served by Southwest Supply System

The boundaries mentioned in the descriptions refer to the service area boundary between the Northeast and Southwest Supply Systems.

The following Service Area Alternatives will be ranked and evaluated considering the Beltway 8 Route as the preferred Northeast Conveyance System Alternate. Both the Allens Creek/Grand Parkway Route (Site 4B) as well as the Allens Creek/F.M. 1093 Route (Site 5) will be considered as

the preferred Southwest Conveyance System Alternates. The ranking evaluation for the Service Area Alternates will be based on the five general categories mentioned in the previous ranking evaluations.

The evaluation, ranking and eventual selection of a particular Service Area Alternate is somewhat different than the Conveyance System Rankings. The proposed facilities within each Service Area Alternate are sized for ultimate conditions (Year 2030). The selection of a Service Area Alternate has little affect on the ultimate transmission line sizes. This study is based on the initial assumption that all transmission lines constructed will be designed for ultimate conditions regardless of the phasing. The advantages and disadvantages corresponding to two of the general ranking categories, Environmental and Community/Social are similar for all Service Area Alternates. The Technical category has two major issues that may differ between Service Area Alternates:

- o Availability of an ample raw water source to supply each alternate;
- o Possibility of maximizing the use of existing water supply facilities.

The only general categories to be evaluated involve phasing and financial. The phasing issue becomes a function of when and how much transmission system is built. The financial issue becomes a function of the cost associated with each phase and how that phased cost affects the

cost per unit of water delivered. Also, associated with the financial issue is the present worth value of the ultimate conveyance and transmission systems based on the timing of the phases as dictated by the Service Area Alternates.

After careful evaluation, it can be concluded that the Service Area Alternates that initially maximize the Southwest Supply System would produce a more economical transmission system during the early phases of transmission system development. This is due to the fact that the earliest HGCSD Conversion Dates within WHCSWSC's boundaries are located in the southwest area which is geographically closer to the Southwest Supply System, therefore, reducing the amount and cost of the transmission system.

When evaluating each Service Area Alternate in detail, it is apparent that Service Area Alternate No. 7 which maximizes the use of southwest water is less costly from both an annualized cost per unit of water delivered and ultimate present worth. The cumulative annualized cost per thousand gallons in the year 2030 for Alternate No. 7 is $1.68/1000 gallons which is approximately $0.07/1000 gallons less expensive than the nearest Service Area Alternate. However, the large differences in annualized costs are produced when analyzing the Northeast System against the Southwest System in Phases I through III within each Service Area Alternate. As mentioned previously the cost to serve the area between I-10 and Clay Road in Phase II from the southwest is $1.59/1000 gallons while the cost would increase to $7.19/1000 gallons if serving the same

area from the northeast. In Phase III the cost would be $5.10/1000 gallons when serving from the northeast and $1.62/1000 gallons when serving from the southwest. As a result, it is more economical on an annual basis to serve areas from the Southwest Supply.

The ultimate present worth for Service Area Alternate 7 is $2,952,546,000 when assuming Southwest Conveyance Site 4B and $2,818,814,000 when considering Site 5. Service Area Alternate 7 would require $13,000,000 less in 1988 dollars than Service Area Alternate 4 to serve the WHCSWSC service area when assuming Site 4B and $80,000,000 less when assuming Site 5. However, it should be pointed out that the ultimate present worth and compounded annualized cost for all of the assumed Service Area Alternates are very close. As a result, the financial differences in Service Area Alternates when considering the final study year (2030) is not as important as the phasing issue. However, when evaluating the normalized present worth per unit of water delivered for each component in each service area alternate, it can be readily shown that Service Area Alternate 7 utilizing the Southwest Conveyance Alternate Site 5 produces a significant reduction in the normalized present worth for the conveyance system components. The normalized present worth for the transmission systems in each Service Area Alternate are approximately equal at around $2.50/MGD of water delivered. To prove this point, the normalized present worth for each component within the two extreme service area alternates is shown below.

Service Area Alternate	NORMALIZED PRESENT WORTH/MGD Southwest Conveyance (Site 5)	Northeast Conveyance (Beltway 8)	Total Transmission
Alternate 7 (Maximizing Southwest Water)	10.46	0	2.50
Alternate 4 (Maximizing Northeast Water)	14.03	7.53	2.50

It is apparent that the Service Area Alternate that follows the HGCSD Conversion Plan would be preferable. The HGCSD's earliest conversion dates of 1995 and 2000 are located in the southwest and the remaining conversion dates of 2005, 2010 and the assumed 2030 are located in the north and far northwest of the WHCSWSC study area. As a result, the Service Area Alternate that has its first phases in the southwest will be less expensive from a phasing standpoint. Service Area Alternate 7 which proposes to serve the study area from south to north produces the least cost from both an annualized and present worth analysis.

As a result of the above analogy, we recommend Alternate No. 7 as the preferred Service Area Alternate. However, this recommendation could be changed in future updates to this study without appreciable affecting the final ultimate cost of the entire transmission system.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.0 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

General

Several conclusions can be reached after reviewing this Appendix. The most important conclusion is that the entire WHCSWSC Service Area, including the City of Houston Southwest, as previously defined, can be served by a Southwest Supply System (Brazos River Basin) at a cost equal to or less than the cost that would be experienced if using a Northeast Supply System (treated water from City of Houston Northeast Treatment Plant). Also, obtained from this Appendix are the following general conclusions:

- The Brazos River Authority has the available water from the Brazos River Basin (Southwest Supply) without utilizing water rights from the BRA Canal System to supply the entire WHCSWSC service area including City of Houston Southwest.

- The City of Houston can make enough water available to serve the entire WHCSWSC service area if the "Eastern Alternative" of HWMP is developed.

- It is not economical to serve the entire WHCSWSC service area with the Northeast Supply due to the earliest conversion mandate being located in the Southwest as set by HGCSD Plan.

- Treatment of Brazos River water is viable with the operations and treatment cost being within 10 percent of the cost presently experienced by the City when treating Lake Houston water.

- The entire project cost differential is more sensitive to the phasing cost than the ultimate cost.

Northeast Conveyance System Alternate

The major conclusion reached when evaluating the Northeast Conveyance System Alternate is that the Beltway 8 Route is superior over the NHCWSC and F.M. 1960 Routes for the following reasons:

- Superior hydraulic characteristics producing a maximum of 16 psi more residual pressure at the WHCWSC boundary than the other two routes.

- Reduced line lengths; 9 miles and 4 miles shorter than the F.M. 1960 and NHCSWSC routes, respectively.

- Reduced possibility of needed land acquisitions outside existing street rights-of-way.

- Reduced possibility of problems during construction due to large rights-of-way, decreasing the construction time required.

- o Routed through fewer residential developments than the NHCWSC and F.M. 1960 routes.

- o Minimizes disruptions to traffic flow and utility relocations.

- o Preferred route by the City of Houston.

- o Beltway 8 Route results in a shorter route and less cost to convey treated surface water to the area within the first conversion date of 2005 as determined by the HGCSD.

Southwest Conveyance System Alternates

Several conclusions can be reached after evaluating the information presented in this Appendix with regards to the Southwest Conveyance System Alternates. The most noticeable conclusion is that the financial comparisons of the Southwest Conveyance System Alternates are not as significant as the decisions regarding water quality and existing land usages. All of the alternate Southwest Conveyance System costs are within 10% of each other and as a result of this the decision becomes technical and not financial.

After evaluating the various site alternatives and performing a detailed ranking analysis it became readily apparent that the Allens Creek/Grand Parkway (Site 4B) and the Allens Creek/F.M. 1093 (Site 5) were

the most preferred routes by the Ranking Committee. The remaining sites ranked considerably lower and as a result, Sites 1, 2, 3 and 4A are the least preferred. Also, concluded from this Appendix is the following:

- Water quality is substantially higher in Alternate Site 4B and 5 due to the direct use of Allen's Creek Reservoir.

- Water quality for Sites 1, 2, 3 and 4A are marginal when utilizing the termination storage design assumption limiting chlorides to a minimum of 240 mg/l.

- Sites 4B and 5 could lower chloride contamination to 100 mg/l without added cost while at the other alternate sites the termination storage cost would more than double to achieve these results.

- The Southwest Conveyance System should be based on the maximum daily demand experienced in Service Area Alternate No. 7 (231 MGD), maximizing the southwest water supply while maintaining the flexibility needed to accommodate service area changes.

- Site 4B has the potential of providing a more versatile water supply than Site 5 due to the possibility of utilizing the BRA Canal System as an alternate source. Along with this versatility brings the possibility of additional water rights from the BRA enhancing the possibility of regionalization with Fort Bend County.

- Sites 1 and 3 are least preferred because of the lack of undeveloped land, increased land cost, increased chances of reduction in water quality and close proximity to residential developments.

- Site 2 is not preferred because of reduction in water quality and flood plain restrictions.

- Site 4B and 5 better fits City of Houston's goal of maximizing water quality while minimizing costs.

- Site 5 produces the least annual cost in the year 2030.

- Site 5 produces the smallest normalized present worth cost when utilizing either of the Service Area Alternates.

Service Area Alternates

The conclusions reached regarding Service Area Alternates are not as concrete as the conclusions reached when evaluating the Conveyance System Alternates. Flexibility is the most important item to be considered when formulating conclusions with regards to the Service Area Alternates. The final decision and recommendations today may change in the future due to unforeseen circumstances. This Appendix has considered flexibility in Service Area boundaries as the prime issue when making the following conclusions:

- The ultimate transmission system will basically be identical for all Service Area Alternates.

- The ultimate transmission line size will be constructed regardless of phasing, however, phasing will determine when and how much line is to be built.

- Service Area Alternates that produce Phase I (1995) and Phase II (2000) treatment facilities and raw water supplies geographically closer to the Southwest area are more economical with respect to the phasing cost.

- The recommended Service Area Alternate will include the Beltway 8 Route for its Northeast Conveyance System and either Allens Creek/Grand Parkway (Site 4B) or the Allens Creek/F.M. 1093 (Site 5) as the preferred Southwest Conveyance System.

- Service Area Alternate No. 7 is more economical throughout the study period based on an annualized and present worth analysis.

- A Service Area Alternate that utilizes all northeast water was not considered because of obvious major economic disadvantages in Phase I and Phase II which would produce the most expensive present worth cost. As a result, it was eliminated from consideration in this Appendix.

- Service Area Alternate No. 7 produces relative constant annual cost throughout life of the study which is directly due to Alternate No. 7's phasing compatibility with the HGCSD plan.

- Service Area Alternate No. 4 will produce the least desirable annual cost curve throughout the study period. The cost of conversion in Phases I, II, and III are significantly higher when using Service Area Alternate No. 4 which could result in the need for volatile water rates when amortizing the increased up front cost of development.

RECOMMENDATIONS

Appendix IV concludes with the following recommendations:

- The Northeast Conveyance System should follow the Beltway 8 Route eliminating the NHCWSC and F.M. 1960 Routes from further study.

- Eliminate the Southwest Conveyance System Alternates 1, 2, 3 and 4A from further study.

- The Southwest Conveyance System Alternates No. 4B (Allens Creek/Grand Parkway) and No. 5 (Allens Creek/F.M. 1093) should be considered for further study.

- Phase V should study in detail the possibility of locating a plant along F.M. 1093, in the area of the Grand Parkway/F.M. 1093 intersection, west to the proposed Allens Creek Reservoir site.

- The Southwest Conveyance System plant site should be located to allow future development of an alternate and/or additional raw water source utilizing the available water rights in the BRA Canal System. This would enhance the possibility of surface water regionalization with entities in Fort Bend County.

- The Southwest Conveyance System should obtain its raw water supply directly from Allens Creek Reservoir which will result in a higher quality water supply.

- Phase V should further study the Allens Creek Reservoir operational procedures required to limit chloride concentrations to 150 mg/l and total dissolved solids to 500 mg/l.

- The Southwest Conveyance System plant site should contain sufficient acreage to develop an ultimate plant capacity of approximately 300 MGD allowing the flexibility to meet demands due to possible Service Area modifications. This capacity is based on Service Area Alternate No. 7's ultimate capacity of 231 MGD, maximizing the water supply offer by the BRA, and the possibility of treating the available water rights of approximately 60 MGD from the BRA Canal System for possible wholesale to entities in Fort Bend County.

- Phase V should further study the ultimate transmission system utilizing the demands developed from either Service Area Alternate No. 7 or No. 4. This would maintain the flexibility required to meet future Service Area modifications at a increased cost of less than 5 percent of the total ultimate transmission system cost.

- **WHCSWSC should request the BRA to upgrade its recent proposal based on the conclusions and recommendations outlined in this Appendix. The BRA proposal should include the construction of Allens Creek Reservoir by 1995.**

- **WHCSWSC should authorize the Engineer to begin Phase V - The Detail Evaluation of Selected Alternatives, as soon as possible.**

ATTACHMENTS

ATTACHMENT 1

INDIVIDUAL RANKING FORM

WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION
SOUTHWEST CONVEYANCE SYSTEM
INDIVIDUAL RANKING FORM

I. INDIVIDUAL RANKING BY COMMITTEE MEMBER

A. WEIGHTING FACTOR EVALUATION

0.0 GENERAL

	WEIGHTING PERCENTAGE							AVERAGE
CRITERIA DESCRIPTION (GENERAL)	RATER NO. 1	RATER NO. 2	RATER NO. 3	RATER NO. 4	RATER NO. 5	RATER NO. 6	RATER NO. 7	WEIGHTING FACTOR
1.0 TECHNICAL								
2.0 ENVIRONMENTAL								
3.0 COMMUNITY/SOCIAL								
4.0 PHASING								
5.0 FINANCIAL								
TOTAL: (%)	100	100	100	100	100	100	100	100

I. INDIVIDUAL RANKING BY COMMITTEE MEMBER

A. WEIGHTING FACTOR EVALUATION

1.0 TECHNICAL

	WEIGHTING PERCENTAGE							AVERAGE WEIGHTING FACTOR
CRITERIA DESCRIPTION (TECHNICAL)	RATER NO. 1	RATER NO. 2	RATER NO. 3	RATER NO. 4	RATER NO. 5	RATER NO. 6	RATER NO. 7	
A. AVAILABLE LAND								
B. AVAILABLE/QUALITY RAW WATER								
C. TREATMENT PLANT ACCESS								
D. UTILITY ACCESS								
E. DRAINAGE								
F. GEOTECHNICAL								
G. TERMINATION STORAGE								
H. SLUDGE DISPOSAL								
I. OPERATIONS/ MAINTENANCE								
TOTAL: (%)	100	100	100	100	100	100	100	100

I. INDIVIDUAL RANKING BY COMMITTEE MEMBER

A. WEIGHTING FACTOR EVALUATION

2.0 ENVIRONMENTAL

	WEIGHTING PERCENTAGE							AVERAGE
CRITERIA DESCRIPTION (ENVIRONMENTAL)	RATER NO. 1	RATER NO. 2	RATER NO. 3	RATER NO. 4	RATER NO. 5	RATER NO. 6	RATER NO. 7	WEIGHTING FACTOR
A. FLOOD PLAIN								
B. WETLANDS								
C. AIR QUALITY								
D. PLANT WASTE BY-PRODUCT DISPOSAL								
E. NOISE								
F. OPERATIONAL PROCEDURES (PLANT)								
TOTAL (%)	100	100	100	100	100	100	100	100

I. INDIVIDUAL RANKING BY COMMITTEE MEMBER

A. WEIGHTING FACTOR EVALUATION

3.0 COMMUNITY/SOCIAL

CRITERIA DESCRIPTION (COMMUNITY/SOCIAL)	WEIGHTING PERCENTAGE							AVERAGE WEIGHTING FACTOR
	RATER NO. 1	RATER NO. 2	RATER NO. 3	RATER NO. 4	RATER NO. 5	RATER NO. 6	RATER NO. 7	
A. POLITICAL SUBDIVISION JURISDICTION								
B. COUNTY CONTROL								
C. FLOOD CONTROL/ DRAINAGE DISTRICT								
D. CORP OF ENGINEERS CONTROL								
E. TEXAS WATER COMMISSION REQM'TS								
F. BRAZOS RIVER AUTH.								
G. GALVESTON COUNTY WATER AUTHORITY								
TOTAL (%)	100	100	100	100	100	100	100	100

I. INDIVIDUAL RANKING BY COMMITTEE MEMBER

A. WEIGHTING FACTOR EVALUATION

4.0 PHASING

CRITERIA DESCRIPTION (PHASING)	WEIGHTING PERCENTAGE							AVERAGE WEIGHTING FACTOR
	RATER NO. 1	RATER NO. 2	RATER NO. 3	RATER NO. 4	RATER NO. 5	RATER NO. 6	RATER NO. 7	
A. AVAILABILITY TO MEET DEMANDS								
B. EXPANSION CAPABILITIES								
C. AVAILABILITY TO MEET HGCSD PLAN								
D. COMPATABILITY WITH RAW WATER AVAILABILITY								
E. FLEXIBILITY TO MEET FUTURE DEMANDS OUTSIDE SERVICE AREA								
TOTAL (%)	100	100	100	100	100	100	100	100

I. INDIVIDUAL RANKING BY COMMITTEE MEMBER

A. WEIGHTING FACTOR EVALUATION

5.0 FINANCIAL

CRITERIA DESCRIPTION (FINANCIAL)	WEIGHTING PERCENTAGE							AVERAGE WEIGHTING FACTOR
	RATER NO. 1	RATER NO. 2	RATER NO. 3	RATER NO. 4	RATER NO. 5	RATER NO. 6	RATER NO. 7	
A. PHASE I - PRESENT WORTH (1988)$								
B. PHASE I - ANNUAL COST								
C. PHASE II - PRESENT WORTH (1988)$								
D. PHASE II ANNUAL COST								
E. PHASE III - PRESENT WORTH (1988)$								
F. PHASE III - ANNUAL COST								
G. PHASE IV - PRESENT WORTH (1988)$								
H. PHASE IV - ANNUAL COST								
TOTAL: (%)	100	100	100	100	100	100	100	100

I. INDIVIDUAL RANKING BY COMMITTEE MEMBER

B. INDIVIDUAL RANKING OF SOUTHWEST CONVEYANCE SYSTEM

1.0 TECHNICAL

COMMITTEE MEMBER: RATER NO. 1							
CRITERIA DESCRIPTION (TECHNICAL)	INDIVIDUAL SITE RATING: S.W. CONVEYANCE SYSTEM						
	1	2	3	4A	4B	5	
A. AVAILABLE LAND							
B. AVAILABLE/QUALITY RAW WATER							
C. TREATMENT PLANT ACCESS							
D. UTILITY ACCESS							
E. DRAINAGE							
F. GEOTECHNICAL							
G. TERMINATION STORAGE							
H. SLUDGE DISPOSAL							
I. OPERATIONS/ MAINTENANCE							

*MAXIMUM 100 POINTS WITH 100 POINTS BEING MOST FAVORABLE.

I. INDIVIDUAL RANKING BY COMMITTEE MEMBER

B. INDIVIDUAL RANKING OF SOUTHWEST CONVEYANCE SYSTEM

2.0 ENVIRONMENTAL

COMMITTEE MEMBER: RATER NO. 1							
CRITERIA DESCRIPTION (ENVIRONMENTAL)	INDIVIDUAL SITE RATING: S.W. CONVEYANCE SYSTEM						
	1	2	3	4A	4B	5	
A. FLOOD PLAIN							
B. WETLANDS							
C. AIR QUALITY							
D. PLANT WASTE BY-PRODUCT DISPOSAL							
E. NOISE							
F. OPERATIONAL PROCEDURES (PLANT)							

*MAXIMUM 100 POINTS WITH 100 POINTS BEING MOST FAVORABLE.

I. INDIVIDUAL RANKING BY COMMITTEE MEMBER

B. INDIVIDUAL RANKING OF SOUTHWEST CONVEYANCE SYSTEM

3.0 COMMUNITY/SOCIAL

COMMITTEE MEMBER: RATER NO. 1							
CRITERIA DESCRIPTION (COMMUNITY/SOCIAL)	INDIVIDUAL SITE RATING: S.W. CONVEYANCE SYSTEM						
	1	2	3	4A	4B	5	
A. POLITICAL SUBDIVISION JURISDICTION							
B. COUNTY CONTROL							
C. FLOOD CONTROL/ DRAINAGE DISTRICT							
D. CORP OF ENGINEERS CONTROL							
E. TEXAS WATER COMMISSION REQM'TS							
F. BRAZOS RIVER AUTH.							
G. GALVESTON COUNTY WATER AUTHORITY							

*MAXIMUM 100 POINTS WITH 100 POINTS BEING MOST FAVORABLE.

I. INDIVIDUAL RANKING BY COMMITTEE MEMBER

B. INDIVIDUAL RANKING OF SOUTHWEST CONVEYANCE SYSTEM

4.0 PHASING

COMMITTEE MEMBER: RATER NO. 1							
CRITERIA DESCRIPTION (PHASING)	INDIVIDUAL SITE RATING: S.W. CONVEYANCE SYSTEM						
	1	2	3	4A	4B	5	
A. AVAILABILITY TO MEET DEMANDS							
B. EXPANSION CAPABILITIES							
C. AVAILABILITY TO MEET HGCSD PLAN							
D. COMPATABILITY WITH RAW WATER AVAILABILITY							
E. FLEXIBILITY TO MEET FUTURE DEMANDS OUTSIDE SERVICE AREA							

*MAXIMUM 100 POINTS WITH 100 POINTS BEING MOST FAVORABLE.

I. INDIVIDUAL RANKING BY COMMITTEE MEMBER

B. INDIVIDUAL RANKING OF SOUTHWEST CONVEYANCE SYSTEM

5.0 FINANCIAL

COMMITTEE MEMBER: RATER NO. 1							
CRITERIA DESCRIPTION (FINANCIAL)	INDIVIDUAL SITE RATING: S.W. CONVEYANCE SYSTEM						
	1	2	3	4A	4B	5	
A. PHASE I - PRESENT WORTH (1988)$							
B. PHASE I - ANNUAL COST							
C. PHASE II - PRESENT WORTH (1988)$							
D. PHASE II ANNUAL COST							
E. PHASE III - PRESENT WORTH (1988)$							
F. PHASE III - ANNUAL COST							
G. PHASE IV - PRESENT WORTH (1988)$							
H. PHASE IV - ANNUAL COST							

*MAXIMUM 100 POINTS WITH 100 POINTS BEING MOST FAVORABLE.

ATTACHMENT 2

DETAILED CAPITAL COST TABLES

TABLE A-1

NORTHEAST CONVEYANCE SYSTEM CAPITAL COST
BELTWAY 8 ROUTE

	ITEM	ALTERNATE 1	ALTERNATE 2	ALTERNATE 3	ALTERNATE 4	ALTERNATE 7
1.	Raw Water Conveyance	4,800,000	5,300,000	5,800,000	6,300,000	0
2.	Treatment Plant (WHCSWSC Portion)	39,070,000	47,090,000	78,240,000	94,440,000	0
3.	Treated Water Conveyance Lines, Incl.Crossings, Cathodic Protection, Valves and Appurtenances	31,371,433	36,875,583	52,450,993	60,958,863	0
4.	Booster Pump Station/ Ground Storage	5,240,000	6,380,000	8,120,000	9,790,000	0
	SUB-TOTAL	80,481,433	95,645,583	144,610,993	171,488,863	0
5.	Contingency (10%)	8,048,143	9,564,558	14,461,099	17,148,886	0
6.	Engineering (10%)	8,048,143	9,564,558	14,461,099	17,148,886	0
	TOTAL CAPITAL COSTS	96,577,720	114,774,700	173,533,192	205,786,635	0

TABLE A-2

NORTHEAST CONVEYANCE SYSTEM CAPITAL COST
NHCWSC ROUTE

	ITEM	ALTERNATE 1	ALTERNATE 2	ALTERNATE 3	ALTERNATE 4	ALTERNATE 7
1.	Raw Water Conveyance	4,800,000	5,300,000	5,800,000	6,300,000	0
2.	Treatment Plant (WHCSWSC Portion)	39,070,000	47,090,000	78,240,000	94,440,000	0
3.	Treated Water Conveyance Lines, Incl.Crossings, Cathodic Protection, Valves and Appurtenances	36,208,014	43,140,632	62,062,013	72,059,554	0
4.	Booster Pump Station/ Ground Storage	5,240,000	6,380,000	8,120,000	9,790,000	0
	SUB-TOTAL	85,318,014	101,910,632	154,222,013	182,589,554	0
5.	Contingency (10%)	8,531,801	10,191,063	15,422,201	18,258,955	0
6.	Engineering (10%)	8,531,801	10,191,063	15,422,201	18,258,955	0
	TOTAL CAPITAL COSTS	102,381,617	122,292,758	185,066,416	219,107,465	0

…HEAST CONVEYANCE SYSTEM CAPITAL COST
F.M. 1960 ROUTE

ITEM	ALTERNATE 1	ALTERNATE 2	ALTERNATE 3	ALTERNATE 4	ALTERNATE 7
1. Raw Water Conveyance	4,800,000	5,300,000	5,800,000	6,300,000	0
2. Treatment Plant (WHCSWSC Portion)	39,070,000	47,090,000	78,240,000	94,440,000	0
3. Treated Water Conveyance Lines, Incl.Crossings, Cathodic Protection, Valves and Appurtenances	40,020,431	48,345,769	70,924,519	82,843,257	0
4. Booster Pump Station/ Ground Storage	5,240,000	6,380,000	8,120,000	9,790,000	0
SUB-TOTAL	89,130,431	107,115,769	163,084,519	193,373,257	0
5. Contingency (10%)	8,913,043	10,711,577	16,308,452	19,337,326	0
6. Engineering (10%)	8,913,043	10,711,577	16,308,452	19,337,326	0
TOTAL CAPITAL COSTS	106,956,517	128,538,923	195,701,423	232,047,908	0

TABLE A-4

SOUTHWEST CONVEYANCE SYSTEM CAPITAL COST
SITE 1 - OYSTER CREEK/DAIRY ASHFORD ROUTE

ITEM	ALTERNATE 1	ALTERNATE 2	ALTERNATE 3	ALTERNATE 4	ALTERNATE 7
1. Raw Water Conveyance	3,370,000	3,191,400	2,511,600	2,173,000	4,140,800
2. Termination Storage/ Pump Station	37,290,000	35,490,000	30,050,000	24,770,000	48,675,000
3. Treatment Plant	160,622,000	152,400,600	121,830,400	106,419,000	196,488,700
4. Treated Water Pump/ Storage/Conveyance Lines Incl. Crossings Cathodic Protection, Valves & Appurtenances	36,557,880	34,788,240	33,018,600	29,759,260	37,452,630
SUB-TOTAL	237,839,880	225,870,240	187,410,600	163,121,260	286,757,130
5. Contingency (10%)	23,783,988	22,587,024	18,741,060	16,312,126	28,675,713
6. Engineering (10%)	23,783,988	22,587,024	18,741,060	16,312,126	28,675,713
TOTAL CAPITAL COSTS	285,407,856	271,044,288	224,892,720	195,745,512	344,108,556

TABLE A-5

SOUTHWEST CONVEYANCE SYSTEM CAPITAL COST
SITE 2 - BRAZOS RIVER/HIGHWAY 6 ROUTE

ITEM	ALTERNATE 1	ALTERNATE 2	ALTERNATE 3	ALTERNATE 4	ALTERNATE 7
1. Raw Water Conveyance	4,112,000	3,894,000	3,065,000	2,651,000	5,052,500
2. Termination Storage/ Pump Station	23,472,000	22,407,000	19,025,000	15,866,000	30,300,000
3. Treatment Plant	161,414,000	152,342,000	122,546,000	107,525,000	194,746,000
4. Treated Water Pump/ Storage/Conveyance Lines Incl. Crossings, Cathodic Protection, Valves & Appurtenances	46,094,800	43,635,400	41,176,000	36,979,730	47,586,050
SUB-TOTAL	235,092,800	222,278,400	185,812,000	163,021,730	277,684,550
5. Contingency (10%)	23,509,280	22,227,840	18,581,200	16,302,173	27,768,455
6. Engineering (10%)	23,509,280	22,227,840	18,581,200	16,302,173	27,768,455
TOTAL CAPITAL COSTS	282,111,360	266,734,080	222,974,400	195,626,076	333,221,460

TABLE A-6

SOUTHWEST CONVEYANCE SYSTEM CAPITAL COST
SITE 3 - OYSTER CREEK/HIGHWAY 6 ROUTE

ITEM	ALTERNATE 1	ALTERNATE 2	ALTERNATE 3	ALTERNATE 4	ALTERNATE 7
1. Raw Water Conveyance	3,120,000	2,955,000	2,325,000	2,011,000	3,833,600
2. Termination Storage/ Pump Station	30,710,000	29,260,000	24,800,000	20,530,000	39,925,000
3. Treatment Plant	159,807,000	150,872,000	120,502,000	105,216,000	194,280,900
4. Treated Water Pump/ Storage/Conveyance Lines Incl. Crossings, Cathodic Protection, Valves & Appurtenances	28,048,760	26,915,480	25,782,200	23,694,520	28,645,260
SUB-TOTAL	221,685,760	210,002,480	173,409,200	151,451,520	266,684,760
5. Contingency (10%)	22,168,576	21,000,248	17,340,920	15,145,152	26,668,476
6. Engineering (10%)	22,168,576	21,000,248	17,340,920	15,145,152	26,668,476
TOTAL CAPITAL COSTS	266,022,912	252,002,976	208,091,040	181,741,824	320,021,712

TABLE A-7

SOUTHWEST CONVEYANCE SYSTEM CAPITAL COST
SITE 4A - JONES CREEK/GRAND PARKWAY ROUTE

ITEM	ALTERNATE 1	ALTERNATE 2	ALTERNATE 3	ALTERNATE 4	ALTERNATE 7
1. Raw Water Conveyance	3,120,000	2,955,000	2,325,000	2,011,000	3,833,600
2. Termination Storage/ Pump Station	22,156,000	21,161,000	17,975,000	15,018,000	28,550,000
3. Treatment Plant	156,065,000	148,060,000	118,015,000	102,924,000	185,369,000
4. Treated Water Pump/ Storage/Conveyance Lines Incl. Crossings, Cathodic Protection, Valves & Appurtenances	53,561,400	49,629,600	46,090,500	38,220,400	58,686,300
SUB-TOTAL	234,902,400	221,805,600	184,405,500	158,173,400	276,438,900
5. Contingency (10%)	23,490,240	22,180,560	18,440,550	15,817,340	27,643,890
6. Engineering (10%)	23,490,240	22,180,560	18,440,550	15,817,340	27,643,890
TOTAL CAPITAL COSTS	281,882,880	266,166,720	221,286,600	189,808,080	331,726,680

TABLE A-8

SOUTHWEST CONVEYANCE SYSTEM CAPITAL COST
SITE 4B - ALLENS CREEK/GRAND PARKWAY ROUTE

ITEM	ALTERNATE 1	ALTERNATE 2	ALTERNATE 3	ALTERNATE 4	ALTERNATE 7
1. Raw Water Conveyance	43,770,000	43,605,000	42,975,000	42,661,000	44,483,600
2. Termination Storage/ Pump Station	0	0	0	0	0
3. Treatment Plant	156,065,000	148,060,000	118,015,000	102,924,000	185,369,000
4. Treated Water Pump/ Storage/Conveyance Lines Incl. Crossings, Cathodic Protection, Valves & Appurtenances	53,561,400	49,629,600	46,090,500	38,220,400	58,686,300
SUB-TOTAL	253,396,400	241,294,600	207,080,500	183,805,400	288,538,900
5. Contingency (10%)	25,339,640	24,129,460	20,708,050	18,380,540	28,853,890
6. Engineering (10%)	25,339,640	24,129,460	20,708,050	18,380,540	28,853,890
TOTAL CAPITAL COSTS	304,075,680	289,553,520	248,496,600	220,566,480	346,246,680

TABLE A-9

SOUTHWEST CONVEYANCE SYSTEM CAPITAL COST
SITE 5 - ALLENS CREEK/F.M. 1093 ROUTE

ITEM	ALTERNATE 1	ALTERNATE 2	ALTERNATE 3	ALTERNATE 4	ALTERNATE 7
1. Raw Water Conveyance	3,784,000	3,583,000	2,820,000	2,440,000	4,640,000
2. Termination Storage/ Pump Station	0	0	0	0	0
3. Treatment Plant	155,412,000	147,443,000	117,531,000	102,506,000	181,528,060
4. Treated Water Pump/ Storage/Conveyance Lines Incl. Crossings, Cathodic Protection, Valves & Appurtenances	101,705,560	95,664,880	87,076,900	78,514,620	109,876,000
SUB-TOTAL	260,901,560	246,690,880	207,427,900	183,460,620	296,044,060
5. Contingency (10%)	26,090,156	24,669,088	20,742,790	18,346,062	29,604,406
6. Engineering (10%)	26,090,156	24,669,088	20,742,790	18,346,062	29,604,406
TOTAL CAPITAL COSTS	313,081,872	296,029,056	248,913,480	220,152,744	355,252,872

TABLE A-10

TRANSMISSION SYSTEM CAPITAL COST
ALTERNATE 1 SERVICE AREA

NORTHEAST SYSTEM	SITE 1	SITE 2	SITE 3	SITE 4A	SITE 4B	SITE 5
1. Treated Water Transmission Lines Incl. Crossings, Cathodic Protection, Valves, and Appurtenances	123,204,568	123,204,568	123,204,568	123,204,568	123,204,568	123,204,568
2. Booster Pump Station/Ground Storage	3,350,000	3,350,000	3,350,000	3,350,000	3,350,000	3,350,000
3. Contingency (10%)	12,655,457	12,655,457	12,655,457	12,655,457	12,655,457	12,655,457
4. Engineering (10%)	12,655,457	12,655,457	12,655,457	12,655,457	12,655,457	12,655,457
NORTHEAST TOTAL	151,865,482	151,865,482	151,865,482	151,865,482	151,865,482	151,865,482
SOUTHWEST SYSTEM						
1. Treated Water Transmission Lines Incl. Crossings, Cathodic Protection, Valves, and Appurtenances	177,766,647	189,003,818	189,003,818	177,745,595	177,745,595	178,088,636
2. Booster Pump Station/Ground Storage	1,660,000	1,660,000	1,660,000	1,660,000	1,660,000	1,660,000
3. Contingency (10%)	17,942,665	19,066,382	19,066,382	17,940,560	17,940,560	17,974,864
4. Engineering (10%)	17,942,665	19,066,382	19,066,382	17,940,560	17,940,560	17,974,864
SOUTHWEST TOTAL	215,311,976	228,796,582	228,796,582	215,286,714	215,286,714	215,698,363
GRAND TOTAL	367,177,458	380,622,064	380,662,064	367,152,196	367,152,196	367,563,845

TABLE A-11

TRANSMISSION SYSTEM CAPITAL COST
ALTERNATE 2 SERVICE AREA

NORTHEAST SYSTEM	SITE 1	SITE 2	SITE 3	SITE 4A	SITE 4B	SITE 5
1. Treated Water Transmission Lines Incl. Crossings, Cathodic Protection, Valves, and Appurtenances	147,854,575	147,854,575	147,854,575	147,854,575	147,854,575	147,854,575
2. Booster Pump Station/Ground Storage	5,010,000	5,010,000	5,010,000	5,010,000	5,010,000	5,010,000
3. Contingency (10%)	15,286,458	15,286,458	15,286,458	15,286,458	15,286,458	15,286,458
4. Engineering (10%)	15,286,458	15,286,458	15,286,458	15,286,458	15,286,458	15,286,458
NORTHEAST TOTAL	183,437,490	183,437,490	183,437,490	183,437,490	183,437,490	183,437,490
SOUTHWEST SYSTEM						
1. Treated Water Transmission Lines Incl. Crossings, Cathodic Protection, Valves, and Appurtenances	141,872,244	161,771,894	161,771,894	151,759,952	151,759,952	153,155,129
2. Booster Pump Station/Ground Storage	0	0	0	0	0	0
3. Contingency (10%)	14,187,224	16,177,189	16,177,189	15,175,995	15,175,995	15,315,513
4. Engineering (10%)	14,187,224	16,177,189	16,177,189	15,175,995	15,175,995	15,315,513
SOUTHWEST TOTAL	170,246,693	194,126,273	194,126,273	182,111,942	182,111,942	183,786,155
GRAND TOTAL	353,684,183	377,563,763	377,563,763	365,549,432	365,549,432	367,223,645

TABLE A-12

TRANSMISSION SYSTEM CAPITAL COST
ALTERNATE 3 SERVICE AREA

NORTHEAST SYSTEM	SITE 1	SITE 2	SITE 3	SITE 4A	SITE 4B	SITE 5
1. Treated Water Transmission Lines Incl. Crossings, Cathodic Protection, Valves, and Appurtenances	200,405,284	200,405,284	200,405,284	197,076,429	197,076,429	197,076,429
2. Booster Pump Station/Ground Storage	5,010,000	5,010,000	5,010,000	5,010,000	5,010,000	5,010,000
3. Contingency (10%)	20,541,528	20,541,528	20,541,528	20,208,643	20,208,643	20,208,643
4. Engineering (10%)	20,541,528	20,541,528	20,541,528	20,208,643	20,208,643	20,208,643
NORTHEAST TOTAL	246,498,341	246,498,341	246,498,341	242,503,715	242,503,715	242,503,715
SOUTHWEST SYSTEM						
1. Treated Water Transmission Lines Incl. Crossings, Cathodic Protection, Valves, and Appurtenances	96,964,391	109,188,248	109,188,248	101,187,298	101,187,298	96,988,119
2. Booster Pump Station/Ground Storage	0	0	0	0	0	0
3. Contingency (10%)	9,696,439	10,918,825	10,918,825	10,118,730	10,118,730	9,698,812
4. Engineering (10%)	9,696,439	10,918,825	10,918,825	10,118,730	10,118,730	9,698,812
SOUTHWEST TOTAL	116,357,269	131,025,898	131,025,898	121,424,758	121,424,758	116,385,743
GRAND TOTAL	362,855,610	377,524,239	377,524,239	363,928,473	363,928,473	358,889,458

TABLE A-13

TRANSMISSION SYSTEM CAPITAL COST
ALTERNATE 4 SERVICE AREA

NORTHEAST SYSTEM	SITE 1	SITE 2	SITE 3	SITE 4A	SITE 4B	SITE 5
1. Treated Water Transmission Lines Incl. Crossings, Cathodic Protection, Valves, and Appurtenances	235,208,403	235,208,403	235,208,403	231,879,548	231,879,548	231,879,548
2. Booster Pump Station/Ground Storage	5,010,000	5,010,000	5,018 000	5,010,000	5,010,000	5,010,000
3. Contingency (10%)	24,021,840	24,021,840	24,021,840	23,688,955	23,688,955	23,688,955
4. Engineering (10%)	24,021,840	24,021,840	24,021,840	23,688,955	23,688,955	23,688,955
NORTHEAST TOTAL	288,262,084	288,262,084	288,262,084	284,267,458	284,267,458	284,267,458
SOUTHWEST SYSTEM						
1. Treated Water Transmission Lines Incl. Crossings, Cathodic Protection, Valves, and Appurtenances	57,924,183	71,319,191	71,319,191	63,782,594	63,782,594	60,206,900
2. Booster Pump Station/Ground Storage	0	0	0	0	0	0
3. Contingency (10%)	5,792,418	7,131,919	7,131,919	6,378,259	6,378,259	6,020,690
4. Engineering (10%)	5,792,418	7,131,919	7,131,919	6,378,259	6,378,259	6,020,690
SOUTHWEST TOTAL	69,509,020	85,583,029	85,583,029	76,539,113	76,539,113	72,248,280
GRAND TOTAL	357,771,104	373,845,113	373,845,113	360,806,571	360,806,571	356,515,738

TABLE A-14

TRANSMISSION SYSTEM CAPITAL COST
ALTERNATE 7 SERVICE AREA

NORTHEAST SYSTEM	SITE 1	SITE 2	SITE 3	SITE 4A	SITE 4B	SITE 5
1. Treated Water Transmission Lines Incl. Crossings, Cathodic Protection, Valves, and Appurtenances	0	0	0	0	0	0
2. Booster Pump Station/Ground Storage	0	0	0	0	0	0
3. Contingency (10%)	0	0	0	0	0	0
4. Engineering (10%)	0	0	0	0	0	0
NORTHEAST TOTAL	0	0	0	0	0	0
SOUTHWEST SYSTEM						
1. Treated Water Transmission Lines Incl. Crossings, Cathodic Protection, Valves, and Appurtenances	295,126,915	306,364,086	306,364,086	295,105,863	295,105,863	295,448,904
2. Booster Pump Station/Ground Storage	5,010,000	5,010,000	5,010,000	5,010,000	5,010,000	5,010,000
3. Contingency (10%)	30,013,692	31,137,409	31,137,409	30,011,586	30,011,586	30,045,890
4. Engineering (10%)	30,013,692	31,137,409	31,137,409	30,011,586	30,011,586	30,045,890
SOUTHWEST TOTAL	360,164,298	373,648,903	373,648,903	360,139,036	360,139,036	360,550,685
GRAND TOTAL	360,164,298	373,648,903	373,648,903	360,139,036	360,139,036	360,550,685

ATTACHMENT 3

BRAZOS RIVER AUTHORITY PROPOSAL

BRAZOS RIVER AUTHORITY

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WACO, TEXAS 76714-7555

January 11, 1988

Mr. Louis H. Jones, Jr., P.E.
Dannenbaum Engineering Corporation
P. O. Box 22292
Houston, Texas 77027

Re: West Harris County Surface Water Supply Corporation (WHCSWSC)

Dear Mr. Jones:

This letter and its attachments are submitted in response to your letter dated November 6, 1987.

The Brazos River Authority operates a basin-wide water supply system consisting of 11 major reservoirs, from which water is committed to supply needs both in the immediate vicinities of the individual reservoirs and in areas downstream all the way to the Gulf of Mexico. Essentially all of the long-term dependable yield of this basin-wide system has for years been contractually committed. On the basis of option contracts with water users ("the Option Group") in a number of growing regions in the mid Brazos Basin, the Authority is currently engaged in preconstruction planning of a major new water supply reservoir in the upper basin.

Within the past year, an opportunity to recapture substantial amounts of presently committed water supplies and to acquire the Allen's Creek Reservoir site for future development has raised the possibility of more economically meeting the future water supply needs of the Option Group if we can find another sizeable customer to share the costs and customer benefits with them. Accordingly, in June 1987, we offered the City of Houston an opportunity to contract for a substantial amount of currently available water and an option for a substantial additional amount to come from, and be contingent upon, the development of a reservoir at the Allen's Creek site. Our offer to Houston was firm until December 31, 1987. Since we have had no reply of any kind in response to this offer, we now consider ourselves free to offer to others the water supplies and options included in the offer to Houston.

The offer to WHCSWSC contained herein contemplates use of the water previously offered to Houston and has been developed in coordination with an offer that is being made concurrently to the Option

Group, based upon joint use by WHCSWSC and the Option Group of water from existing and proposed future sources of supply. Both offers are tailored to the schedule of development that will most economically meet the combination of the needs of WHCSWSC corresponding to Alternative No. 3 in your November 6, 1987 letter and the projected needs of the Option Group. On the basis of this approach, the offer to WHCSWSC is for an incrementally developed water supply of 150,000 acre-feet per year on the following terms:

1. The initial increment of supply will consist of 75,000 acre-feet of water per year from existing sources, which can be made available for immediate diversion by WHCSWSC from the Brazos River, subject only to obtaining a State permit for inter-basin diversion of the water and the necessary State and Federal permits for the actual diversion facilities.

   a. In accordance with the attached "Supply Designation Schedule", which was developed based on the projections you provided for Alternative No. 3, this entire 75,000 acre-feet per year can initially be committed as "Future Use Water". WHCSWSC may at any time designate any amount up to the entire 75,000 acre-feet per year it wishes to have made available for diversion and use. The amount so designated shall be considered "Current Use Water". Beginning with the years shown in the Supply Designation Schedule and thereafter, the amounts designated as Current Use Water may be more but may not be less than the corresponding amounts shown as "Minimum Current Use Water" in the Schedule. The entire 75,000 acre-feet per year of the initial increment of supply shall be designated as Current Use Water beginning January 1, 2000, if not so designated prior to that date.

   b. Water not designated as Current Use Water shall continue to be considered Future Use Water. The amount of water that has been designated as Current Use Water cannot be reduced.

   c. The price for Future Use Water shall be $40.00 per acre-foot (in 1988 dollars) and the price for Current Use Water shall be $120.00 per acre-foot (in 1988 dollars). Both prices shall be subject to escalation in accordance with the Consumer Price Index (CPI).

2. The second increment of supply will come from a source yet to be developed. The schedule for the planning, design, and construction of this new source, now proposed to be a new reservoir developed by BRA at the Allen's Creek site, will correspond to the combined demands of both the WHCSWSC and the Option Group. Using the projected demands for Alternative No. 3 in the Dannenbaum letter dated November 6, 1987, and the projected demands for the Option Group as prepared by the Authority staff, water from the second increment supply source will be needed in the year 2000.

   a. Projections of water needs will be updated annually, and BRA will be obligated to schedule and use its best efforts to complete the second increment supply source by the time the water from it is needed, contingent upon being able to obtain permits and provide for financing and construction.

   b. WHCSWSC will be allocated an additional water supply of 45,000 acre-feet per year to be available upon completion of the second increment supply source. The amount can be less if WHCSWSC so desires and others can be found to contract for the balance, or more if additional supplies become available as a result of the desire of others to release all or a part of their allocation, or as a result of additional development.

   c. The 45,000 acre-feet per year committed to WHCSWSC from the second increment supply source will be designated as Current Use Water and Future Use Water in accordance with the attached Supply Designation Schedule. As discussed in Item 1.a., the WHCSWSC may designate any additional amounts of its Future Use Water as Current Use Water, but the minimum amounts of Current Use Water will be designated according to the attached Schedule. The entire 45,000 acre-feet per year shall be designated Current Use Water beginning January 1, 2010, if not so designated prior to that date.

   d. The amount of water that has been designated as Current Use Water cannot be reduced. Water not designated as Current Use Water shall continue to be considered Future Use Water.

   e. The price for all Current Use Water and Future Use Water shall, after completion of the second incre-

ment of supply, be determined based on the cost of developing the source for the second increment of supply. Based on the best estimates and projections of demands now available, the prices for Current Use Water and Future Use Water in 1988 dollars would continue to be the prices quoted in Item 1.c., above.

f. Upon execution of a contract based upon this offer, the Authority proposes to acquire an option to purchase the Allen's Creek site in order to have the site available for development to meet the requirements as set forth in the attached Schedule for the second increment of supply.

3. The third increment of supply is presently planned to come from the proposed South Bend Reservoir Project. According to the current WHCSWSC Alternative No. 3 projections and the Authority's projections for the Option Group, the third increment of water supply will be needed by the year 2010.

   a. Projections of water needs will continue to be updated annually, and BRA will be obligated to schedule and use its best efforts to complete the third increment supply source by the time water from it is needed, contingent upon being able to obtain permits and provide for financing and construction.

   b. Upon completion of the supply source for the third increment of water supply, the WHCSWSC would have an additional allocation of 30,000 acre-feet per year of water supply to be available upon completion of the third increment supply source. The amount can be less if WHCSWSC so desires and others can be found to contract for the balance, or more if additional supplies become available as a result of the desire of others to release all or a part of their allocation, or as a result of additional development.

   c. The 30,000 acre-feet per year allocated to WHCSWSC from the third increment supply source will be designated as Current Use Water and Future Use Water in accordance with the attached Supply Designation Schedule. As discussed in Item 1.a., the WHCSWSC may designate any additional amounts of its Future Use Water as Current Use Water, but the minimum

amounts of Current Use Water will be designated according to the attached Schedule. The entire 30,000 acre-feet per year shall be designated Current Use Water beginning January 1, 2030, if not so designated prior to that date.

d. The amount of water that has been designated as Current Use Water cannot be reduced. Water not designated as Current Use Water shall continue to be considered Future Use Water.

e. The price for all Current Use Water and Future Use Water shall, after completion of the third increment of supply, be determined based on the cost of developing the source for the third increment of supply. Based on the best estimates and projections of demands now available, the prices for Current Use Water and Future Use Water in 1988 dollars would continue to be the prices quoted in Item 1.c., above.

The relationship of this offer to the activities we have in progress to meet the needs of the Option Group and the fact that our offer to Houston is still open, though no longer exclusive, makes it urgent that we have your response as soon as possible.

A number of attachments have been included to respond to most of your list of information requests. Under Attachment No. 1, we have summarized and provided tables and graphs to show the incremental water supply development for meeting the WHCSWSC and Option Group demands through the year 2030. Estimates on the cost of delivery are provided under Attachment No. 2. A discussion of the termination storage impoundments that might be needed is provided under Attachment No. 3. Under Attachment No. 4, the water quality for both the Lower Brazos River and the Allen's Creek Project are discussed. Attachment No. 5 includes information and a report on the treatability of Brazos River water. We would also encourage you to discuss the matter of treatability with Mr. Joe Willhelm of the Galveston County Water Authority. Finally, some additional information on the Canal System A, its pumping station, and the Oyster Creek - Jones Creek conveyance, is provided under Attachment No. 6.

The cost information that we have provided is limited to information that we have directly available. We have provided some general guidelines on impoundment sizes and the cost of similar type projects, but we have not provided the cost estimates or any detail on the types of projects that would be specifically needed by the WHCSWSC. We hope the information that is provided will help you to make these decisions and to determine appropriate cost.

Please review the offer outlined and the information in the attachments. If you have any questions about this information, please contact Mr. Tom Ray on the water supply schedule and the engineering information, Mr. Gary Neighbors on the price for water supply, or me.

Very truly yours,

CARSON H. HOGE, P.E.
General Manager

CHH:cg
Attachments

BRAZOS RIVER AUTHORITY

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WACO, TEXAS 76714-7555

October 29, 1987

Mr. Louis H. Jones, Jr., P.E.
Dannenbaum Engineering Corporation
3100 West Alabama
Houston, Texas 77098

Dear Louis:

The following is furnished in response to your request for our basis for estimating the cost of Allen's Creek Reservoir in the water supply package we have offered the City of Houston.

The original project known as the Allen's Creek Reservoir was designed by EBASCO Services Incorporated for Houston Lighting & Power Company (HL&P), the owner of the project site, to serve as a cooling pond for a planned thermonuclear generating plant. On the basis of a reevaluation of power needs in its service area, HL&P has now offered to sell the Allen's Creek Reservoir site to the Brazos River Authority as part of a package deal involving also the return of 87,400 acre-feet of water per year which Brazos River Authority is currently contracted to supply to HL&P from existing reservoir storage.

Data and information on the Allen's Creek Project, as originally planned by EBASCO for HL&P, is summarized on Attachment 1. EBASCO has performed a very preliminary re-analysis of the project modified for use as municipal water supply and updated the estimated project cost to 1986 dollars. Brazos River Authority has further updated the estimated project cost to 1987 dollars for a project with a yield of 75,000 acre-feet of water per year.

The analysis is for a reservoir having an 8,000-acre surface area at a maximum normal operating level of 118 feet above m.s.l., a total storage volume of 120,000 acre-feet and a useable storage volume between elevations 105 and 118 feet above m.s.l. of 95,000 acre-feet. The effects of honoring downstream water rights and of evaporation, which ranges at the site from an average of 0.1 foot per month in December to 0.5 foot per month in July, were taken into account. The analysis was run for the 1940-1984 period of record for the Brazos River Richmond Gauge of the USGS. The EBASCO cost estimates are summarized as follows:

Construction Costs

The original alignment of Allen's Creek dam for the 8,000 acres cooling pond was utilized. The dam, reservoir, spillway and

drainage canal were kept unchanged. The southern access road as well as the dam access road were also included in the cost estimate.

The Brazos River pumping station will house twelve 37,000 gpm, 1,250 HP pumping units and will be located in the same section of Brazos River as planned in the original nuclear project.

Allen's Creek pumping station (Allen's Creek Reservoir to the treatment plant) will have the same type of units as those selected for the Brazos River pumping station. Two units will be required to pump 150 cfs to the treatment plant located within an assumed radius of ten miles from the reservoir.

A ten-mile pipeline linking the pumping station to the treatment plant was included in the cost estimate.

The total capital cost was estimated to be 69,920,000 1981 dollars. Another 10,333,000 dollars was estimated for escalating prices to 1986. Adding interest during construction at 10 percent interest rate brings the total estimated cost to $97.4 million with the following major cost components:

- dam	14 million
- spillway	12 million
- water conveyance from Brazos River	14 million
- water conveyance to the treatment plant	20 million

Annual Costs

Fixed charges on capital investment, other fixed charges and O&M were estimated to be 15.6 percent of the total investment. The annual pumping energy costs estimated to be $1,085,600 were calculated based upon the on-peak and off-peak tariffs of Houston Lighting & Power Company. With the above assumptions the raw water cost amounts to 46 cents/1000 gal.

The update of the EBASCO cost estimates to 1987 dollars performed by BRA is summarized on Attachment 2. Estimated O&M costs, other than power costs, have been modified to accord with BRA costs for operation of similar existing projects. Land costs for the Allen's Creek Project have not been included in the cost estimate because BRA proposes to require the site with revenues from the sale of the water supplies from existing storage proposed to be recaptured from HL&P as part of the package deal.

The cost estimates shown on Attachment 2 were used by BRA in formulating the offer made to the City of Houston. You will note that, even without inclusion of land costs, the estimated

unit cost of water from Allen's Creek is greater than the anticipated price for water after development of Allen's Creek set out in our offer to the City of Houston. The reason for this is that the BRA offer to Houston contemplates averaging the costs of water from existing sources with the cost of water from the more expensive Allen's Creek to bring the overall cost to less than the cost of water from Allen's Creek alone. If Allen's Creek can be developed and operated within the estimated costs (in 1987 dollars) shown on Attachment 2, the price for water anticipated in the BRA offer to Houston will not be exceeded.

Please let me know if you have questions concerning the information herein furnished.

Very truly yours,

CARSON H. HOGE, P.E.
General Manager

CHH:gls
Encl.

ATTACHMENT 4

CORRESPONDENCE

CITY OF HOUSTON

Post Office Box 1562 • Houston, Texas 77251-1562

Kathryn J. Whitmire, Mayor

CITY COUNCIL MEMBERS: Larry McKaskle • Ernest McGowen, Sr. • George Greanias • Rodney Ellis • Frank O. Mancuso • John G. Goodner • Christin Hartung
Dale M. Gorczynski • Ben T. Reyes • Jim Westmoreland • Eleanor Tinsley • Jim Greenwood • Anthony W. Hall, Jr. • Judson Robinson, Jr. • CITY CONTROLLER: Lance Lalor

December 21, 1987

Mr. Louis H. Jones, P.E.
Project Manager
Dannenbaum Engineering Corporation
3100 West Alabama
P.O. Box 22292
Houston, Texas 77027

Subject: Projected Treated Surface Water Costs
Northeast Water Purification Plant

Dear Mr. Jones:

In response to your December 2, 1987 letter concerning the City's plans with regard to the Northeast Water Purification Plant, the following information is provided:

1. Redesign of the first increment of the Northeast Plant was recently authorized by the Houston City Council. This plant, which will have a nominal peak production capacity in the range of 35 to 50 mgd, could be completed and in operation by early 1991 if binding commitments are received from capital cost participants. To date, no such commitments have been provided. This initial plant construction project is to be designed to be consistent with an overall site development plan for providing peak daily production in the range of 600 mgd. No firm schedule for future plant expansions currently exists -- the construction of new facilities will undoubtedly "track" demand patterns in the area. You might be interested to know that the City's current master planning projections envision the capacity of the Northeast Plant to be 400 to 500 mgd by the year 2030.

2. Final design of the Northeast Plant facilities will establish exact discharge pressures and pump operating characteristics. It is anticipated that design concepts for this plant will closely mirror those used in the Southeast Plant, resulting in nominal discharge pressures in the range of 90 psi at the plant discharge header.

3. Our preliminary estimate of plant construction costs is $65

million. Of this cost, approximately $9.1 million is directly attributable to pumping and storage facilities, and another $18.3 million is assigned to general site improvements. On this basis, it is expected that approximately 20 percent of the total plant cost will be assigned to production/storage, with the remainder allocated to production/raw water supply.

4. Actual costs of treatment at the new plant are difficult to project at this time, given the uncertainty about initial dates of operation of the plant. It appears that a "current dollar" estimate of operating costs in the range of $0.40 to $0.50 per thousand gallons is appropriate for planning purposes.

5. Likewise, raw water costs may be impacted in the long term by major capital projects and changes in levels of demand, but it appears appropriate to use a current nominal raw water of approximately $0.25 per thousand gallons in preliminary cost analysis.

It should be clearly understood that the foregoing information is provided for your use in formulating and screening alternatives, and does not constitute a "commitment" by the City to construct any improvements according to a defined time schedule or at such times as required by your demand. Such a commitment would be best addressed through execution of a binding contract for surface water supply or capital cost participation.

Please feel free to contact me if you require further information.

Truly yours,

12.21.87

Michael S. Marcotte, P.E.
Assistant to the Director
Department of Pulic Works

MSM:pr
cc: Danny Davis

ATTACHMENT 5

GALVESTON COUNTY WATER AUTHORITY
OPERATING REPORTS

GALVESTON COUNTY WATER AUTHORITY SURFACE WATER TREATMENT PLANT
MONTHLY OPERATIONAL COST REPORT -- JANUARY 1987

Contract Water	$ 19,553.61		Operating Supplies	$	95.19
Salaries	44,969.78		Contract Service		2,595.00
Power	21,749.60		Lab Supplies		1,218.18
Admin. Central	31,217.35		Misc. Purchases		168.04
Chemicals:			Tools		0.00
Lime		$ 3,626.73	Mgmt. Expense		0.00
Phosphate		6,986.54	Office Supplies		61.29
Chlorine		2,142.83	Janitorial		754.71
Cat. Polymer		4,955.39	Uniforms		514.17
Carbon Dioxide		1,336.72	Safety Equipment		136.75
Fluoride		1,902.73	Training		51.94
Ferric Sulfate		454.67	Transportation		269.61
Sodium Chlorite		4,201.51	Cont. Svc.-Optg.		595.00
Ammonia		717.88	Sludge Disposal		4,858.50
Misc. Chemicals		66.00	Maintenance & Equip.		23,624.39
Sub-Total Chemicals		$26,391.00			

30 days	$212,304.90	TOTAL AMOUNT SPENT	$178,825.11
31 days	$219,381.73	TOTAL AMOUNT OF WATER TREATED	319,546 KGAL
		AVERAGE COST PER THOUSAND GALLONS	$ 0.5596
Available	$ 40,556.62	AVG. CHEMICAL COST PER THOUSAND	$ 0.0826

GALVESTON COUNTY WATER AUTHORITY SURFACE WATER TREATMENT PLANT
MONTHLY OPERATIONAL COST REPORT - FEBRUARY 1987

Contract Water	$19,553.61		Operating Supplies	$	0.00
Salaries	44,800.84		Contract Service		2,595.00
Power	16,204.38		Lab Supplies		326.11
Admin. Central	25,617.62		Misc. Purchases		129.19
Chemicals:			Tools		0.00
Lime		$ 3,797.66	Mgmt. Expense		0.00
Phosphate		4,562.58	Office Supplies		61.16
Chlorine		1,839.99	Janitorial Supplies		494.68
Cat. Polymer		4,085.18	Uniforms		504.20
Carbon Dioxide		1,160.80	Safety Supplies		56.00
Fluoride		1,645.46	Training		101.00
Ferric		743.66	Transportation		678.60
Sodium Chlorite		3,462.31	Cont. Svc. Optg.		0.00
Ammonia		601.29	Sludge Disposal		0.00
Misc. Chemicals		0.00	Maintenance & Equip.		36,223.01
Sub-Total Chemicals		$21,898.93			

30 days	$212,304.90	TOTAL AMOUNT SPENT	$169,244.33
31 days	$219,381.73	TOTAL AMOUNT OF WATER TREATED	273,431 KGAL
		AVERAGE COST PER THOUSAND GALLONS	$ 0.6190
Available	$ 43,060.57	AVG. CHEMICAL COST PER THOUSAND	$ 0.0800

GALVESTON COUNTY WATER AUTHORITY SURFACE WATER TREATMENT PLANT
MONTHLY OPERATIONAL COST REPORT - MARCH 1987

Contract Water	$ 19,553.61			Operating Supplies	$ 24.01
Salaries	44,411.16			Contract Service	2,595.00
Power	21,039.99			Lab Supplies	2,325.14
Administration Central	46,958.71			Misc. Purchases	94.12
Chemicals:				Tools	0.00
Lime		$ 4,280.30		Mgmt. Expense	213.00
Phosphate		6,849.70		Office Supplies	223.04
Chlorine		2,328.25		Janitorial Supplies	299.84
Cat. Polymer		5,700.00		Uniforms	507.40
Carbon Dioxide		1,113.96		Safety Equipment	56.00
Fluoride		1,868.76		Training	851.21
Ferric Sulfate		333.45		Transportation	336.65
Sodium Chlorite		4,385.92		Contract Svc.-Optg.	0.00
Ammonia		684.83		Sludge Disposal	0.00
Misc. Chemicals		0.00		Maintenance & Equip.	39,089.09
Sub-Total Chemicals		$ 27,545.17			

30 Days	$212,304.90	TOTAL AMOUNT SPENT	$206,123.14
31 Days	$219,381.73	TOTAL AMOUNT OF WATER TREATED	318,710 KGAL
		AVERAGE COST PER THOUSAND GALLONS	$ .6467
Available	$ 13,258.59	AVERAGE CHEMICAL COST PER THOUSAND	$ .0864

GALVESTON COUNTY WATER AUTHORITY SURFACE WATER TREATMENT PLANT
MONTHLY OPERATIONAL COST REPORT - APRIL 1987

Contract Water	$19,553.61		Operating Supplies	$	0.00
Salaries	46,939.01		Contract Service		2,595.00
Power	25,035.24		Lab Supplies		4,341.56
Admin. Central	29,307.09		Misc. Purchases		844.88
Chemicals:			Tools		0.00
Lime		$ 6,016.47	Mgmt. Expense		0.00
Phosphate		6,928.02	Office Supplies		334.13
Chlorine		2,384.03	Janitorial		415.45
Cat. Polymer		3,829.68	Uniforms		723.25
Carbon Dioxide		576.20	Safety Equipment		409.66
Fluoride		1,871.90	Training		344.47
Ferric		497.42	Transportation		425.85
Sodium Chlorite		5,511.28	Cont. Svc. Optg.		4,568.06
Ammonia		743.58	Sludge Disposal		0.00
Misc. Chemicals		0.00	Maint. & Equip.		42,090.41
Sub-Total Chemicals		$28,358.58			

30 days	$212,304.90	TOTAL AMOUNT SPENT	$206,286.25
31 days	$219,381.73	TOTAL AMOUNT OF WATER TREATED	348,602 KGAL
		AVERAGE COST PER THOUSAND GALLONS	$ .5918
Available	$ 6,018.65	AVG. CHEMICAL COST PER THOUSAND GALLONS	$ .0814

GALVESTON COUNTY WATER AUTHORITY SURFACE WATER TREATMENT PLANT
MONTHLY OPERATIONAL COST REPORT - MAY 1987

CONTRACT WATER	$ 19,553.61			OPERATING SUPPLIES	$ 0.00
SALARIES	44,817.21			CONTRACT SERVICE	2,595.00
POWER	21,699.39			LAB SUPPLIES	1,436.06
ADMIN. CENTRAL	28,006.87			MISC. PURCHASES	215.33
CHEMICALS:				TOOLS	0.00
LIME		$ 5,184.23		MGMT. EXPENSE	0.00
PHOSPHATE		7,098.08		OFFICE SUPPLIES	225.95
CHLORINE		2,578.16		JANITORIAL	433.40
CAT. POLYMER		3,512.84		UNIFORMS	616.00
CARBON DIOXIDE		139.64		SAFETY	114.85
FLUORIDE		1,912.79		TRAINING	124.17
FERRIC DULFATE		330.98		CONTRACT SER.-OPTG.	1,850.23
SODIUM CHLORITE		12,457.45		SLUDGE DISPOSAL	0.00
AMMONIA		697.37		MAINTENANCE & EQUIP.	24,776.37
MISC. CHEMICALS		3,013.24		TRANSPORTATION	533.35
SUB-TOTAL CHEMICALS		$ 36,924.78			

30 Days	$212,304.90	TOTAL AMOUNT SPENT	$183,922.57
31 Days	$219,381.73	TOTAL AMOUNT OF WATER TREATED	342,409 KGAL
		AVERAGE COST PER THOUSAND GALLONS	$ .5371
Available	$ 35,459.16	AVG. CHEMICAL COST PER THOUSAND	$ .1078

GALVESTON COUNTY WATER AUTHORITY SURFACE WATER TREATMENT PLANT
MONTHLY OPERATIONAL COST REPORT - JUNE 1987

Contract Water	$ 20,291.20		Operating Supplies	$	0.00
Salaries	49,501.74		Contract Service		2,595.00
Power	22,369.99		Lab Supplies		932.24
Admin. Central	29,378.10		Misc. Purchases		853.01
Chemicals:			Tools		0.00
Lime		$ 4,128.67	Mgmt. Expense		0.00
Phosphate		7,190.48	Office Supplies		209/78
Chlorine		4,775.59	Janitorial		599.10
Cat.Polymer		4,406.36	Uniforms		470.40
Carbon Dioxide		190.72	Safety Supplies		89.24
Fluoride		1,831.02	Training		44.93
Ferric Sulfate		389.88	Transportation		160.07
Sodium Chlorite		14,039.03	Contract Svc. Optg.		364.00
Ammonia		667.39	Sludge Disposal		0.00
Misc. Chemicals		0.00	Maintenance & Equip.		36,921.87
Sub-Total Chemicals		$37,618.14			

30 Days	$212,304.90	TOTAL AMOUNT SPENT	$202,399.91
31 Days	$219,381.73	TOTAL AMOUNT OF WATER TREATED	326,939 KGAL
		AVERAGE COST PER THOUSAND GALLONS	$ .6191
Available	$ 9,904.99	AVERAGE CHEMICAL COST PER THOUSAND	$ .1151

GALVESTON COUNTY WATER AUTHORITY SURFACE WATER TREATMENT PLANT
MONTHLY OPERATION COST REPORT - JULY 1987

Contract Water	$ 22,617.03		Operating Supplies	$	0.00
Salaries	69,940.28		Contract Service		2,595.00
Power	23,180.10		Lab Supplies		1,450.92
Admin. Central	33,812.41		Misc. Purchases		357.46
Chemicals:			Tools		0.00
Lime		$ 5,189.68	Mgmt. Expense		0.00
Phosphate		7,533.46	Office Supplies		161.52
Chlorine		2,962.41	Janitorial Supplies		1,084.09
Cat. Polymer		6,074.00	Uniforms		637.79
Carbon Dioxide		293.56	Safety Supplies		323.63
Fluoride		1,943.61	Training		53.00
Ferric		209.29	Transportation		1,085.11
Sodium Chlorite		15,131.27	Cont. Svc. Optg.		1,822.00
Ammonia		748.17	Sludge Disposal		1,134/00
Misc. Chemicals		573.50	Maintenance & Equip.		21,164.48
Sub-Total Chemicals		$40,658.95			

30 days	$212,304.90	TOTAL AMOUNT SPENT	$ 222,078.11
31 days	$219,381.73	TOTAL AMOUNT OF WATER TREATED	362,088 GKAL
		AVERAGE COST PER THOUSAND GALLONS	.6133
Available	$ -2,696.38	AVG. CHEMICAL COST PER THOUSAND GALLONS	.1123

Note: Three payroll periods during the month of July

GALVESTON COUNTY WATER AUTHORITY SURFACE WATER TREATMENT PLANT
MONTHLY OPERATIONAL COST REPORT - AUGUST 1987

Contract Water	$ 22,617.03			Operating Supplies	$ 0.00
Salaries	44,958.43			Contract Service	2,076.00
Power	25,357.08			Lab Supplies	1,990.65
Admin. Central	32,405.76			Misc. Purchases	138.30
Chemicals:				Tools	0.00
Lime		$ 6,185.17		Mgmt. Expense	0.00
Phosphate		7,926.38		Office Supplies	133.00
Chlorine		3,000.43		Janitorial Supplies	360.55
Cat. Polymer		6,266.21		Uniforms	499.55
Carbon Dioxide		550.36		Safety Supplies	71.00
Fluoride		1,657.42		Training	738.00
Ferric		223.92		Transportation	187.59
Sodium Chlorite		15,886.64		Cont. Svc. Optg.	436.00
Ammonia		766.22		Sludge Disposal	0.00
Misc. Chemicals		0.00		Maintenance & Equip.	20,824.73
Sub-Total Chemicals		$ 42,462.75			

30 Days	$212,304.90	TOTAL AMOUNT SPENT	$ 195,256.42
31 Days	$219,381.73	TOTAL AMOUNT OF WATER TREATED	381,320 KGAL
		AVERAGE COST PER THOUSAND GALLONS	$ .5121
Available	$ 24,125.31	AVG. CHEMICAL COST PER THOUSAND GALLONS	$ .1114

GALVESTON COUNTY WATER AUTHORITY
SURFACE WATER TREATMENT PLANT-
MONTHLY OPERATIONAL COST REPORT
SEPTEMBER 1987

CONTRACT WATER	$ 26,628.84		
SALARIES	47,977.30		
POWER	21,727.14		
ADMIN. CENTRAL	29,770.31		
CHEMICALS:			
SODIUM CHLORITE		$ 15,626.32	
ZINC PHOSPHATE		7,731.46	
CATIONIC POLYMER		5,518.39	
LIME		5,768.23	
FERRIC SULFATE		222.10	
FLUORIDE		1,703.14	
CARBON DIOXIDE		637.40	
CHLORINE		3,328.04	
AMMONIA		757.96	
MISC. CHEMICALS		0.00	
SUB-TOTAL CHEMICALS		$ 41,293.04	
OPERATING SUPPLIES	0.00		
CONTRACT SERVICE	2,076.00		
LAB SUPPLIES	2,720.26		
MISC. PURCHASES	322.76		
TOOLS	0.00		
MGMT. EXPENSE	0.00		
OFFICE SUPPLIES	912.16		
JANITORIAL	534.58		
UNIFORMS	500.40		
SAFETY SUPPLIES	1,368.50		
TRAINING	736.29		
TRANSPORTATION	835.69		
CONTRACT SVC. OPTG.	61.15		
SLUDGE DISPOSAL	250.00		
MAINT. & EQUIPMENT	30,008.19		
TOTAL AMOUNT SPENT		$ 207,662.61	
TOTAL AMOUNT OF WATER TREATED		371,940 KGAL	
AVERAGE COST PER THOUSAND GALLONS		$ .5582	
AVERAGE CHEMICAL COST PER THOUSAND GALLONS		$ .1110	

30 DAYS $ 206,337.00
31 DAYS $ 213,556.00 AVAILABLE $ -1,325.61

GALVESTON COUNTY WATER AUTHORITY
SURFACE WATER TREATMENT PLANT
MONTHLY OPERATIONAL COST REPORT
OCTOBER 1987

CONTRACT WATER	$	26,628.84
SALARIES		45,201.91
POWER		22,118.37
ADMIN. CENTRAL		30,417.46
SUB-TOTAL	$	124,267.58
CHEMICALS:		
SODIUM CHLORITE	$	6,616.11
ZINC PHOSPHATE		5,874.44
CATIONIC POLYMER		2,463.64
LIME		5,522.01
FERRIC SULFATE		196.12
FLUORIDE		1,910.22
CARBON DIOXIDE		982.88
CHLORINE		3,378.20
AMMONIA		684.22
MISC. CHEMICALS		0.00
SUB-TOTAL CHEMICALS	$	27,627.84
OPERATING SUPPLIES	$	0.00
CONTRACT SERVICE		2,234.78
LAB SUPPLIES		1,684.03
MISC. PURCHASES		144.47
TOOLS		0.00
MGMT. EXPENSE		446.00
OFFICE SUPPLIES		323.39
JANITORIAL		752.00
UNIFORMS		625.50
SAFETY SUPPLIES		264.95
TRAINING		145.00
TRANSPORTATION		221.75
CONTRACT SVC. OPTG.		398.00
SLUDGE DISPOSAL		236.44
MAINT. & EQUIPMENT		29,144.73
SUB-TOTAL	$	36,621.04
TOTAL AMOUNT SPENT	$	188,516.46
TOTAL AMOUNT OF WATER TREATED		330,841 KGAL
AVERAGE COST PER THOUSAND GALLONS	$	.5698
AVG.CHEMICAL COST PER THOUSAND GALLONS	$	.0835
31 DAYS $ 213,556.00 AVAILABLE	$	25,039.54

GALVESTON COUNTY WATER AUTHORITY
SURFACE WATER TREATMENT PLANT
MONTHLY OPERATIONAL COST REPORT
NOVEMBER 1987

CONTRACT WATER	$	26,628.84
SALARIES		44,119.71
POWER		20,871.52
ADMIN. CENTRAL		25,755.63
SUB-TOTAL	$	117,375.70
CHEMICALS:		
SODIUM CHLORITE	$	7,276.12
ZINC PHOSPHATE		5,271.86
CATIONIC POLYMER		1,964.47
LIME		6,562.72
FERRIC SULFATE		196.12
FLUORIDE		1,910.22
CARBON DIOXIDE		1,369.36
CHLORINE		2,567.66
AMMONIA		684.22
MISC. CHEMICALS		496.25
SUB-TOTAL CHEMICALS	$	28,399.00
OPERATING SUPPLIES	$	0.00
CONTRACT SERVICE		2,076.00
LAB SUPPLIES		1,284.35
MISC. PURCHASES		304.82
TOOLS		0.00
MGMT. EXPENSE		1,033.15
OFFICE SUPPLIES		182.50
JANITORIAL		270.62
UNIFORMS		600.60
SAFETY SUPPLIES		0.00
TRAINING		0.00
TRANSPORTATION		649.70
CONTRACT SVC. OPTG.		0.00
SLUDGE DISPOSAL		0.00
MAINT. & EQUIPMENT		6,958.37
SUB-TOTAL	$	13,260.11
TOTAL AMOUNT SPENT	$	158,934.81
TOTAL AMOUNT OF WATER TREATED		317,123 KGAL
AVERAGE COST PER THOUSAND GALLONS	$	.5012
AVG.CHEMICAL COST PER THOUSAND GALLONS	$	.0892
31 DAYS $ 206,337.00 AVAILABLE	$	47,402.19

ATTACHMENT 6

ACKNOWLEDGEMENTS

ACKNOWLEDGMENTS:

Prior reports and studies dealing with water demands and supplies in the City of Houston and surrounding areas were utilized as needed in preparing this study. Materials reviewed during the course of this project are as follows:

1. Houston Water Master Plan, Appendices A through M, August 1985 to March 1987 and latest revisions, by Metcalf and Eddy, Inc.

2. District Plan, Adopted November 1985, by Harris-Galveston Coastal Subsidence District.

3. Subsidence '87, February 1987 by Harris-Galveston Coastal Subsidence District.

4. Proposal to City of Houston on sale of Brazos River water, January 1988, by the Brazos River Authority.

5. Utility District Listing, Creation and Bond Issue Reports, Texas Water Commission Records, January 1987.

6. Yearly Groundwater Pumpage Records, Harris-Galveston Coastal Subsidence District.

7. Planning Report/Draft Environmental Statement, San Jacinto Project, Texas, September 1987, by United States Department of the Interior Bureau of Reclamation.

8. Surface Water Conversion Plan, North Harris County Water Supply Corporation, June 1987, by Pate Engineers/Jones & Carter.

9. West Harris County Surface Water Supply Corporation Implementation Plan, Appendix II (Including Revision One) - Water Demand and Supply, October 1987, by Dannenbaum Engineering Corporation.

10. Southeast Water Distribution Improvements, Preliminary Engineering Report, Volumes 1 through 4, July 1986, by Bovay Engineers, Inc.

11. Waste Load Evaluation for Upper Oyster Creek in the Brazos River Basin, Segment 1245, June 1985 by Texas Department of Water Resources.

12. Intensive Survey of Oyster Creek, Segment 1110, March 1984 by Texas Department of Water Resources.

13. Intensive Surface Water Monitoring Survey for Segment 1110, Oyster Creek - Above Tidal, September 1977 by Texas Department of Water Resources.

West Harris Surface Water Supply Corporation Implementation Plan
Appendix 4
Contract No.8-483-510

The following maps are not attached to this report. They are located in the official file and may be copied upon request.

Map No.1-Alternate 1 Service Area Transmission System
Map No.2-Alternate 2 Service Area
Map No.3-Alternate 3 Service Area
Map No.4-Alternate 4 Service Area
Map No.7-Alternate 7 Service Area
Map No.8 Transmission System Node Map

Please contact Research and Planning Fund Grants Management Division at (512) 463-7926 for copies.