TRANS-TEXAS WATER PROGRAM

SOUTHEAST AREA

Memorandum Report

Engineering Analysis of the Interbasin Transfer Strategy

April 1998

Sabine River Authority of Texas
Lower Neches Valley Authority
San Jacinto River Authority
City of Houston
Brazos River Authority
Texas Water Development Board

This document is a product of the Trans-Texas Water Program: Southeast Area. The program's mission is to propose the best economically and environmentally beneficial methods to meet water needs in Texas for the long term. The program's four planning areas are the Southeast Area, which includes the Houston-Galveston metropolitan area, the South-Central Area (including Corpus Christi), the North-Central Area (including Austin) and the West-Central Area (including San Antonio).

The Southeast Area of the Trans-Texas Water Program draws perspectives from many organizations and citizens. The Policy Management Committee and its Southeast Area subcommittee guide the program; the Southeast Area Technical Advisory Committee serves as program advisor. Local sponsors are the Sabine River Authority of Texas, the Lower Neches Valley Authority, the San Jacinto River Authority, the City of Houston and the Brazos River Authority.

The Texas Water Development Board is the lead Texas agency for the Trans-Texas Water Program. The Board, along with the Texas Natural Resource Conservation Commission, the Texas Parks & Wildlife Department and the Texas General Land Office, set goals and policies for the program pertaining to water resources management and are members of the Policy Management Committee.

Brown & Root and Freese & Nichols are consulting engineers for the Trans-Texas Water Program: Southeast Area. Blackburn & Carter and Ekistics provide technical support. This document was prepared under the supervision of:

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1.0 Introduction

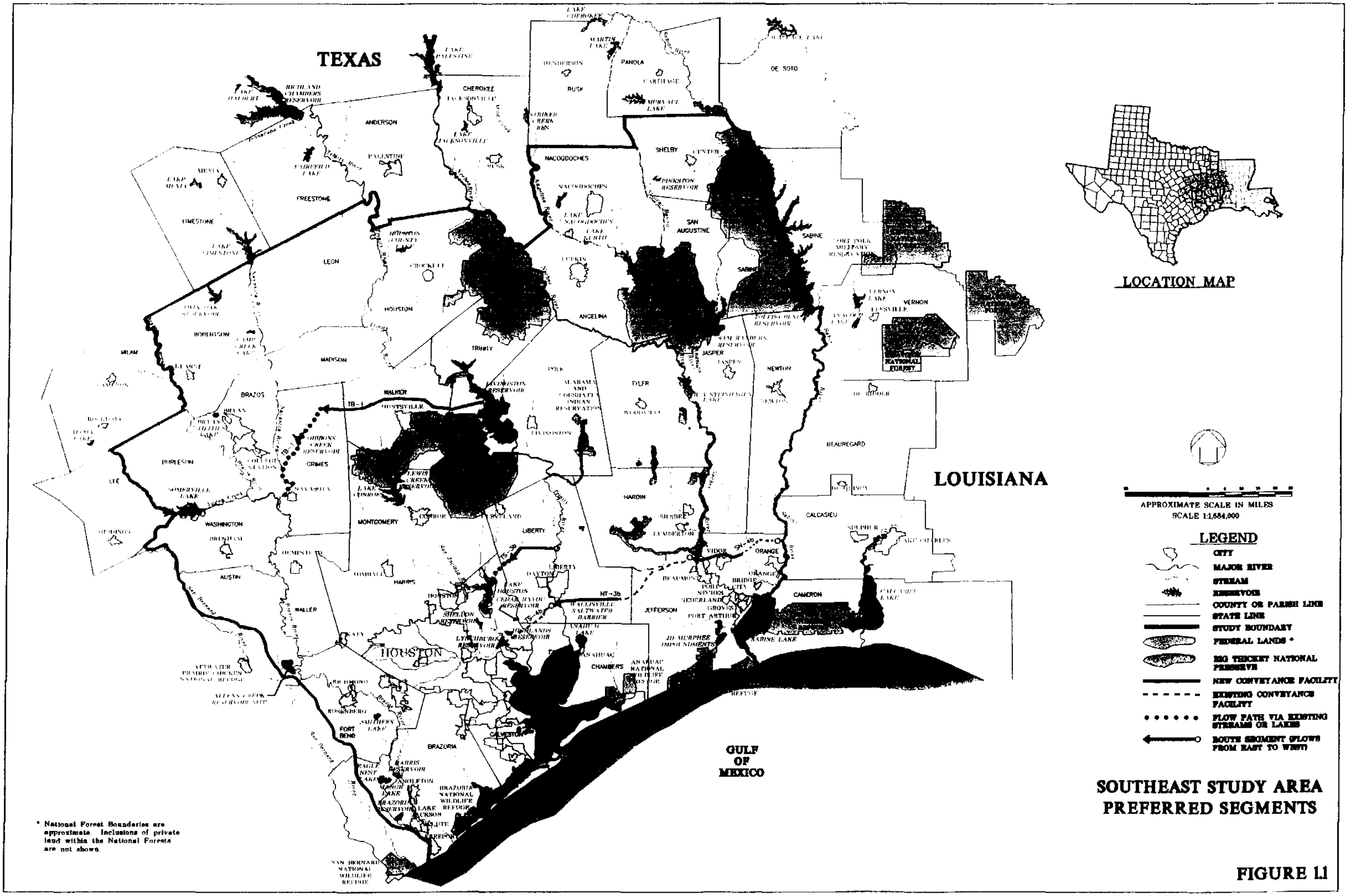
The Trans-Texas Water Program (TTWP) is a comprehensive water resources planning program created to evaluate a full range of water management strategies. The overall goal of the TTWP is to identify the most cost-effective and environmentally sensitive strategies for meeting the current and future water needs of some areas in Texas. The TTWP focuses on the Southeast, South-Central, North-Central, and West-Central Study Areas in Texas (Texas Water Development Board, 1995). This report focuses on the Southeast Study Area shown in Figure 1.1.

Phase I of the TTWP was intended as an initial screening of a broad range of water management strategies for each study area. Each alternative was evaluated in terms of technical feasibility, cost, legal and institutional issues, and other factors. Phase I produced a conceptual water management plan consisting of alternatives for further investigation in Phase II. The plan recommended that the following water management strategies be evaluated in Phase II:

- implementation of aggressive water conservation programs in the Houston metropolitan area;
- wastewater reclamation and reuse, particularly by industries in the Houston area;
- systems operation of existing surface-water reservoirs to increase their effective yield;
- contractual water transfers;
- new surface-water supply projects (i.e., a permanent saltwater barrier on the lower Neches River and the new Allens Creek Reservoir); and
- **transfer of water from the Sabine River Basin to the Houston area.**

This report deals with the transfer of water from the Sabine Basin to the Houston area and to the San Antonio area. As part of Phase II, all of the transfer segments that passed the Phase I screening were studied to determine which ones were the most environmentally favorable. The results of this environmental study were published in the February 1998 draft report *Environmental Analysis of Potential Transfer Routes*. The transfer segments that were recommended for the Trans-Texas Interbasin Transfer Strategy are shown in Figure 1.1.

This report describes the conceptual design of the interbasin transfer route. Costs contained in this report are reconnaissance level only, and more detailed design and costing of this strategy should be done prior to actual implementation of the project.



SOUTHEAST STUDY AREA
PREFERRED SEGMENTS

FIGURE 1.1

2.0 Projected Water Transfers

During the environmental analysis of potential interbasin transfer routes, each segment of the transfer was analyzed individually. A segment is defined as the path of transfer from one river basin to another. All of the potential transmission projects between each major river basin were compared and one was selected.

These transfer segments will be considered in the context of the three water demand scenarios described in the Phase I report. Scenario 1 represents a plan to transfer water from the Southeast Area to the San Antonio area. A transfer of water from the Southeast would be necessary beginning in 2010 and would increase to 600,000 acre-feet per year by 2050.

Scenario 2 includes additional local projects and wastewater reuse west of the Southeast Area, delaying the need for Southeast water transfers until the year 2020. This results in a need of 300,000 acre-feet per year west of the Brazos by 2050.

Scenario 3 assumes extensive development of local water resources west of the Brazos River basin and does not include any Southeast Area water supplying the San Antonio area. A summary of the transfer amounts through each segment is presented in Table 2-1.

Table 2-1
Projected 2050 Water Transfers Through Preferred Segments
(Amounts are Annual Need in Acre-Feet)

Segment	Scenario 1	Scenario 2	Scenario 3
Sabine to Neches (SN-4b)	791,000	659,100	359,100
Neches to Trinity (NT-3b)	935,200	659,100	359,100
Trinity to San Jacinto (TS-4b)	996,800	996,800	996,800
Trinity to San Jacinto (TS-3b)	496,700	496,700	496,700
Trinity to Brazos (TB-1)	600,000	300,000	0

All of these scenarios also include interbasin transfer of water within the Southeast Area to meet the area's own needs. Water from the Sabine, Neches and Trinity Basins will be transferred westward to the Houston area. By the year 2030, Houston will have a water deficit of 59,000 acre-feet per year. This need can be met by Trinity Basin transfers. By the year 2050, the deficit will grow to 418,100 acre-feet per year. This will require transfers from the Sabine Basin to make up the difference (359,100 acre-feet per year). This water is transferred from the Sabine Basin to the Trinity River. The water is then transferred along with Houston's currently permitted supplies from the Trinity (1,075,400 acre-feet per year) to the Houston area. This describes the projected transfer amounts listed in Table 2-1 for Scenario 3.

Scenario 2 includes the same transfers as Scenarios 3, but includes an additional 300,000 acre-feet per year from the Sabine which will be transferred to the Brazos. Scenario 1 is generally the same, except an additional 600,000 acre-feet per year will go to the Brazos River. All available excess supplies from the Sabine and Neches basin will be used to meet this need.

3.0 Environmentally Preferred Segments

3.1 Route to Houston Only

The following transfer segments are preferred for Scenario 3. This scenario transfers water within the Southeast Area to meet the future water needs of the Houston area only.

Sabine River to Neches River, Segment SN-4b: This segment begins at the Sabine River Authority's Pump Station and canal system. It uses the SRA canal for 14.2 miles. Then a new canal will be built continuing 14.8 miles westward, going under the Neches River, and terminating at the Lower Neches Valley Authority's First Lift Station.

Neches River to Trinity River, Segment NT-3b: This segment continues on where SN-4b terminates (LNVA First Lift Station). It uses the LNVA Main Canal for 23.3 miles. It then branches off the Main Canal into the Nolte Canal (an existing LNVA facility) for 3.4 miles. From that point, 20.8 miles of new canal will be constructed westward to a point on the Trinity River near the existing Trinity River Pump Station, which is owned and operated by the Coastal Water Authority (CWA).

Trinity River to San Jacinto River, Segment TS-4b: This segment uses the existing CWA canal for its entire length (22 miles) and terminates at the Lynchburg Reservoir.

Trinity River to San Jacinto River, Segment TS-3b: This segment follows the path of the proposed Luce Bayou Diversion Project. This project has been planned by the City of Houston as one of its ultimate facilities to bring water from the Trinity River Basin to the Houston area. Water is diverted from the Trinity River and transferred westward to Luce Bayou, a tributary of the San Jacinto River. This segment terminates in Lake Houston.

3.2 Route to Houston and the Brazos River

The following segment will be used in conjunction with all of the segments listed above to deliver water to the Houston area and to the Brazos River.

Trinity River to Brazos River, TB-1: This segment begins at Lake Livingston and travels westward 52 miles to the headwaters of Gibbons Creek, a tributary of the Brazos. The geography of this area is not suited for a canal, so this segment will consist of pipeline for its entire length to Gibbons Creek. The segment will then use existing stream channel to convey the water to the Brazos.

The water delivered to the Brazos will be available for further transfer into the San Antonio area, but it was beyond the scope of this study to analyze transfer westward from the Brazos.

4.0 Planning and Design Criteria

Existing facilities were used whenever possible. The existing Sabine River Authority (SRA) canal and pump station, Lower Neches Valley Authority (LNVA) Main Canal and pump stations, and the Coastal Water Authority (CWA) canal and pump station were all used in different segments of the proposed transfer route. Wherever these facilities did not have enough capacity for the projected future flow, they were assumed to be expanded.

Typical **canal dimensions** were assumed for various flow rates and varied with allowable gradients. The typical canal section is shown in Figure C-1 in Appendix C. A range of capacities and allowable gradients is listed on this figure along with the typical dimensions for those capacities and gradients. The actual canal dimensions assumed for each segment were based on the given flow through that segment for the specified scenario and the gradient that would best fit the topography. The **Right-of-Way Width** is also based on the dimensions shown in Figure C-1. **Velocity** in the canals was kept under 2.5 feet per second in all cases and was generally kept below 2 feet per second.

The flow capacity of each segment was based on the average annual volumes that must be delivered through that segment. (These flows are listed in Table 2-1.) Several other factors were added to these base flows. **Canal losses** were assumed to be three percent of the total flow per segment. Most losses are due to seepage which is directly related to head. (Only a very small portion of the loss is due to evaporation.) Current estimates of loss in existing canals at existing heads were correlated with proposed heads and flows to derive this three percent loss factor. For this study, we have assumed that there will be **terminal storage** at the end user location such that the segments do not need to carry the maximum day flow - only the average day flow. Additional capacity has been assumed in the canals to allow for peak pumping and pumping downtime. This **seasonal variation** is estimated at 20 percent of the average flow (with losses). In addition to base flows, losses and seasonal variation, the segments utilizing the SRA and LNVA canals must also have the capacity to carry the currently contracted water to SRA and LNVA existing customers. All existing flow through the CWA canal is interbasin transfer from the Trinity River to the San Jacinto River and is included in the base flow projections listed in Table 2-1.

The *Environmental Analysis of Potential Transfer Routes* identified how much wetland area (in acres) each segment would cross. These acreages were based on a 100 foot right-of-way for existing facilities and a 200 foot right-of-way for new facilities. For this project, right-of-way widths varied with the flows for each project. For each of the scenarios, specific acreages of imposed wetlands were calculated based on the ratio of actual right-of-way to the previously assumed right-of-way. **Wetlands mitigation** can vary greatly with individual situations. Mitigation land required can range from two to ten times the wetland areas affected. For this study, we have assumed a mitigation ratio of five to one.

The concept of **water wheeling** is assumed to be used in this project. Water wheeling is simply the contractual transfer or "trading" of water. Water wheeling is very useful in situations where two entities have similar water rights in locations such that each one's water source is located closer to the other entity's need.

In this study, the best opportunity to apply water wheeling occurs at the Trinity River through use of City of Houston water supplies. The proposed water wheeling concept is applied where existing City of Houston Lake Livingston water supplies are used to meet Central Texas Water demands. Water is then delivered from East Texas to the Trinity River at the Coastal Water Authority's existing pump station to meet the City of Houston water needs that would have been supplied from Lake Livingston.

Water is proposed for transfer further west from three separate locations on the Trinity River, two of which are north of CWA's pump station. A transfer is accomplished contractually. The City of Houston would trade some of its water supply in Lake Livingston to users west of the Brazos, to be delivered to the Brazos through segment TB-1. In exchange, the City of Houston would use water delivered to the CWA pump station (on the lower Trinity River) from the Sabine and Neches River Basins. This water is then delivered directly to the City of Houston through the CWA canal (Segment TS-4b).

The City of Houston currently has the right to divert and use 450,000 acre-feet per year from the Trinity River at the point where segment TS-3b (Luce Bayou Project) begins. This study plans for an annual amount of 496,700 acre-feet to be diverted from the Luce Bayou diversion point. The additional diversion needed here could also be met through contractual transfer. It is assumed that all users in the Trans-Texas program will agree and contract to trade water whenever necessary for this transfer to be accomplished.

5.0 Route to Houston Only

Scenario 3 of the Trans-Texas Water Program includes transfer of water within the Southeast Area to meet the future water needs of the area, particularly Houston's water needs. This scenario does not include any transfer west of the Southeast Area (west of the Brazos River). This section identifies the transfer facilities needed for Scenario 3. These facilities are projected to be needed by 2040.

5.1 Sabine River to Neches River (SN-4b)

This segment consists of 14.2 miles of the existing SRA canal and 14.8 miles of a new canal. As shown in Table 2-1, this segment must deliver 359,100 acre-feet annually from the Sabine River to the Neches River (at the LNVA Neches First Lift Station). Using this base flow and accounting for losses, seasonal variation, and existing SRA delivery requirements, the capacity of the canal must be 540 million gallons per day (mgd). This capacity must be maintained from the SRA pump station on the Sabine River to the canal crossing at Highway 62. Most of SRA's customers are located in this section. A relatively small flow requirement from SRA customers exists downstream of Highway 62. From Highway 62 to the beginning of the new canal, the capacity must be 494 mgd. The new canal section must carry only the Trans-Texas water transfer (and no SRA delivery to customers) which is 485 mgd.

The existing SRA canal has a capacity of 309 mgd. For this scenario, various improvements will have to be made to the pump station and to the 14.2 miles of the canal, including road crossings and other conflicts. In addition to upgrading the existing facilities, 14.8 miles of new canal must be added. The proper permitting and mitigation for wetlands will also be acquired for this segment. Table B-1 in Appendix B shows the preliminary opinion of probable costs for this segment and scenario. The total cost shown is $58,419,646.

5.2 Neches River to Trinity River (NT-3b)

This segment uses the existing LNVA Main and Nolte Canals for 26.7 miles and then travels through a new 21 mile canal. As listed in Table 2-1, this segment must also deliver 359,100 acre-feet annually from the Neches River (LNVA First Lift Station) to the Trinity River. As in the previous segment, this canal must have the capacity to carry the base flow plus additional flow accounting for losses, seasonal variation, and existing LNVA customers. This flow capacity amounts to 823 mgd. This capacity must be maintained through the existing Main Canal. In the Nolte Canal section, LNVA's customer requirements are less than in the Main Canal, so the total Trans-Texas transfer capacity needed is 518 mgd. The new canal section must have a capacity of 456 mgd which includes the base flow plus losses and seasonal variation flow. (There are no LNVA customers to serve in this section.)

The existing LNVA Main Canal varies in capacity through its reach. The Main Canal is interconnected with the Neches B1 Canal and the capacities of the canals are affected by backwater from that interconnection. The combined capacity of the Main and B1 canals upstream of the Main Canal Junction is 840 mgd. This capacity is to the top of the levee and includes no freeboard. Very minimal improvements to the levee will increase this capacity to 1,066 mgd. From the Main Canal Junction to the Nolte Canal, the capacity of the Main Canal is 750 mgd. The Nolte Canal has the capacity of about 86 mgd.

Improvements that will be required for this segment and this scenario include: raising existing canal levee, expanding existing pump stations, building a new canal, permitting and mitigation. Table B-2 shows the preliminary opinion of probable costs for segment NT-3b for Scenario 3 to be $65,176,678.

5.3 Trinity River to San Jacinto River

5.3.1 Segment TS-4b

This segment consists of the existing Coastal Water Authority's (CWA) Trinity River pump station and canal system. CWA has recently contracted with Brown and Root, Inc. to design an expansion to the Trinity River Pump Station to bring its pumping capacity up to the flow capacity of the canal which is 1,300 mgd. The canal has this capacity from the pump station to the Cedar Point Lateral Turnout. From that point to the terminus (Lynchburg Reservoir), the capacity is 1,100 mgd. In order to avoid making structural improvements to the CWA canal, the amount of Houston's water demand delivered through this segment is assumed to be equal to the capacity of the canal. The remainder of Houston's water needs from the Trinity River will be delivered through the Luce Bayou Diversion Project (Segment TS-3b).

The preliminary opinion of cost for the Trinity River Pump Station was provided by Brown and Root, Inc. One portion of the expansion, which includes a pump replacement and two additional pumps at the existing station, is estimated to cost $1.76 million. The rest of the expansion, which includes construction of an adjacent new pump station, is estimated to cost $36 million. These costs are presented in Table B-3.

5.3.2 Segment TS-3b

This segment follows the proposed Luce Bayou Diversion Project and terminates in Lake Houston. It consists of a pump station on the Trinity River, 3.5 miles of pipeline, 2.5 miles of canal, and 8.1 miles of stream channel rectification on Luce Bayou. None of the facilities for this segment currently exists.

All three scenarios of the Trans-Texas Water Program call for the same amount of water to be delivered annually through this route (496,700 acre-feet per year from Table 2-1). This amount represents the remaining portion of Houston's water needs that were not delivered through the CWA canal. Including losses and seasonal variation, this segment should be sized to carry a maximum flow of 550 mgd. The preliminary opinion of probable cost presented in Table B-4 gives a total capital cost of this project of $54,005,114.

APPENDIX B

6.0 Route to Houston and the Brazos River

Scenario 2 of the Trans-Texas Water Program includes transfer of water within the Southeast Area to meet the region's future water needs (particularly Houston's) and the transfer of an additional 300,000 acre-feet per year west of the Southeast Area to the Brazos River. Scenario 1 includes meeting Southeast Area needs plus transferring 600,000 acre-feet of water per year to the Brazos River. This section identifies the facilities (with costs) needed for both of these scenarios. For Scenario 2, the transfer segment from the Trinity to the Brazos River is projected to be needed by 2020. For Scenario 1 this segment will be needed by 2010. All other facilities will be needed by 2040.

6.1 Sabine River to Neches River (SN-4b)

This segment is described in the previous section. For Scenario 2, this segment must have a capacity of: 896 mgd from the pump station to Highway 62; 849 mgd from Highway 62 to the new canal; and 841 mgd from the new canal to the LNVA Neches First Lift Station. Improvements for this scenario are itemized and quantified in Table B-5. The total preliminary opinion of probable cost is $81,730,209.

For Scenario 1 this segment must have the following capacities: 1,063 mgd from the pump station to Highway 62; 1,017 mgd from Highway 62 to the new canal; and 1,009 mgd from the new canal to the LNVA Neches First Lift Station. The cost estimate for these improvements is in Table B-6. The segment improvements are estimated to cost $89,765,273.

6.2 Neches River to Trinity River (NT-3b)

This segment is also described in section 4 of this report. For Scenario 2, the LNVA Main Canal must have a capacity of 1,167 mgd, the Nolte Canal must have a capacity of 862 mgd and the new canal must have a capacity of 800 mgd. The improvements for this scenario are estimated to cost $87,824,547 as shown in Table B-7.

For Scenario 1, the LNVA Main Canal must have a capacity of 1,483 mgd, the Nolte Canal must have a capacity of 1,178 mgd, and the new canal must have a capacity of 1,115 mgd. The improvements for this scenario are estimated to cost $108,336,340 as shown in Table B-8.

6.3 Trinity River to Brazos River (TB-1)

As stated at the beginning of this section, Scenario 2 requires transferring 300,000 acre-feet to the Brazos River from the Southeast Area. All of this water will be directly transferred through a pipeline from Lake Livingston on the Trinity River to Gibbons Creek, a tributary of the Brazos River. When adding capacity for losses and pumping variation, the capacity of the pipeline must be 357 mgd. A new pump station will be built on Lake Livingston. Channel rectification may be needed on Gibbons Creek and the Navasota River downstream of its confluence with

Gibbons Creek. A cost estimate for this scenario is listed in Table B-9. The cost is estimated at $261,539,299.

Scenario 1 includes the same facilities as Scenario 2. For Scenario 2, these facilities must be sized to convey 714 mgd. This pipeline and pump station system will annually deliver the necessary 600,000 acre-feet of water to the Brazos River. The cost estimate for this scenario is $500,936,499, as shown in Table B-10.

7.0 Cost Estimates

Capital cost estimates were based on the following:

- previous work done by Freese and Nichols (updated by ENR construction cost indices)
- current unit costs of construction items
- previous cost estimates developed for the Luce Bayou Diversion Project (updated by ENR indices), and
- preliminary cost estimates for CWA's Trinity River Pump Station expansion which is under design at this time.

Operation and maintenance (O&M) cost estimates were based on standard pumping cost equations (at $0.06 per kilowatt hour) and estimated labor costs for operations, maintenance, and administration personnel. Fifteen percent of the total capital cost has been added to all cost estimates for Administration and Engineering (including construction representation). Twenty-five percent has been added for contingencies. It is likely that SRA, LNVA, and CWA will charge some type of administrative or usage fee for the use of their facilities in this strategy. This fee amount is not known and was therefore not included in these cost estimates.

The estimate capital costs and operation and maintenance (O&M) costs of the segments are summarized in Table 7-1. (The detailed capital cost estimates are in Appendix B). A life cycle analysis was performed for each of the three Trans-Texas scenarios to illustrate the present worth cost of each one. The life cycle cost analysis were performed using the following assumptions:

- Capital costs were assumed to be financed over 30 years at an interest rate of 8.5 percent per year.
- The discount rate was set at 4.5 percent
- The inflation rate was set at 4.5 percent
- The unit cost of electricity was assumed to be 6 cents per kilowatt-hour.

The present worth value of Scenario 1 as shown on Table 7.2 ranges from $0.36 per thousand gallons in the first year (2010) to $0.17 per thousand gallons in year 2069. Based on the unit costs shown in Table 7.2, the average annual per unit cost for Scenario 1 is $0.23 per thousand gallons.

The present worth value of Scenario 2 as shown on Table 7.3 ranges from $0.40 per thousand gallons in the first year (2020) to $0.20 per thousand gallons in year 2069. Based on the unit costs shown in Table 7.3, the average annual per unit cost for Scenario 2 is $0.27 per thousand gallons.

The present worth value of Scenario 3 as shown on Table 7.4 ranges from $0.30 per thousand gallons in the first year (2040) to $0.20 per thousand gallons in year 2069. Based on the unit costs shown in Table 7.4, the average annual per unit cost for Scenario 3 is $0.24 per thousand gallons.

These costs are based on full delivery of the 2050 water demand from the initiation of the project. In reality the use will gradually increase up to the full 2050 demand. During that interim time when only partial use of the facilities is made, the unit costs will be somewhat higher than the costs listed in this report.

It should be noted that these costs are for the delivery of *raw* water. The cost of treatment will be the responsiblity of the end user.

Table 7.1
Summary of Estimated Costs
(1998 Dollars)

Segment	Scenario 1 Capital Cost	Scenario 1 Annual O&M Cost	Scenario 2 Capital Cost	Scenario 2 Annual O&M Cost	Scenario 3 Capital Cost	Scenario 3 Annual O&M Cost
SN-4b	$89,765,273	$3,699,000	$81,730,209	$3,288,000	$58,419,646	$2,410,000
NT-3b	$108,336,340	$10,541,000	$87,824,547	$8,495,000	$65,176,678	$6,346,000
TS-4b	$37,760,000	$6,300,000	$37,760,000	$6,300,000	$37,760,000	$6,300,000
TS-3b	$54,005,114	$6,000,000	$54,005,114	$6,000,000	$54,005,114	$6,000,000
TB-1	$500,936,499	$23,758,000	$261,539,299	$14,876,000	$0	$0
TOTAL	$790,803,226	$50,298,000	$522,859,169	$38,959,000	$215,361,438	$21,056,000

Table 7.2: Scenario I - Life Cycle Cost Analysis

YEAR	DELIVERED AMOUNT (ac-ft/yr)	BOND PAYMENT ($1,000)	O&M COSTS ($1,000)	TOTAL COSTS ($1,000)	UNIT COSTS ($/1000 gal)	PRESENT VALUE (1998$) ($/1000 gal)
2010	600,000	$79,049	$40,291	$119,340	$0.61	$0.36
2011	600,000	$79,049	$42,104	$121,153	$0.62	$0.35
2012	600,000	$79,049	$43,999	$123,048	$0.63	$0.34
2013	600,000	$79,049	$45,978	$125,028	$0.64	$0.33
2014	600,000	$79,049	$48,047	$127,097	$0.65	$0.32
2015	600,000	$79,049	$50,210	$129,259	$0.66	$0.31
2016	600,000	$79,049	$52,469	$131,518	$0.67	$0.30
2017	600,000	$79,049	$54,830	$133,879	$0.68	$0.30
2018	600,000	$79,049	$57,298	$136,347	$0.70	$0.29
2019	600,000	$79,049	$59,876	$138,925	$0.71	$0.28
2020	600,000	$79,049	$62,570	$141,619	$0.72	$0.27
2021	600,000	$79,049	$65,386	$144,435	$0.74	$0.27
2022	600,000	$79,049	$68,328	$147,377	$0.75	$0.26
2023	600,000	$79,049	$71,403	$150,452	$0.77	$0.26
2024	600,000	$79,049	$74,616	$153,665	$0.79	$0.25
2025	600,000	$79,049	$77,974	$157,023	$0.80	$0.24
2026	600,000	$79,049	$81,483	$160,532	$0.82	$0.24
2027	600,000	$79,049	$85,150	$164,199	$0.84	$0.23
2028	600,000	$79,049	$88,981	$168,030	$0.86	$0.23
2029	600,000	$79,049	$92,985	$172,035	$0.88	$0.22
2030	600,000	$79,049	$97,170	$176,219	$0.90	$0.22
2031	600,000	$79,049	$101,542	$180,592	$0.92	$0.22
2032	600,000	$79,049	$106,112	$185,161	$0.95	$0.21
2033	600,000	$79,049	$110,887	$189,936	$0.97	$0.21
2034	600,000	$79,049	$115,877	$194,926	$1.00	$0.20
2035	600,000	$79,049	$121,091	$200,140	$1.02	$0.20
2036	600,000	$79,049	$126,540	$205,589	$1.05	$0.20
2037	600,000	$79,049	$132,235	$211,284	$1.08	$0.19
2038	600,000	$79,049	$138,185	$217,234	$1.11	$0.19
2039	600,000	$79,049	$144,404	$223,453	$1.14	$0.19
2040	1,018,000	$171,317	$319,474	$490,791	$1.48	$0.23
2041	1,018,000	$171,317	$333,850	$505,167	$1.52	$0.23
2042	1,018,000	$171,317	$348,873	$520,191	$1.57	$0.23
2043	1,018,000	$171,317	$364,572	$535,890	$1.61	$0.22
2044	1,018,000	$171,317	$380,978	$552,296	$1.66	$0.22
2045	1,018,000	$171,317	$398,122	$569,440	$1.72	$0.22
2046	1,018,000	$171,317	$416,038	$587,355	$1.77	$0.21
2047	1,018,000	$171,317	$434,759	$606,077	$1.83	$0.21
2048	1,018,000	$171,317	$454,324	$625,641	$1.89	$0.21
2049	1,018,000	$171,317	$474,768	$646,086	$1.95	$0.21
2050	1,018,000	$171,317	$496,133	$667,450	$2.01	$0.20
2051	1,018,000	$171,317	$518,459	$689,776	$2.08	$0.20
2052	1,018,000	$171,317	$541,789	$713,107	$2.15	$0.20
2053	1,018,000	$171,317	$566,170	$737,487	$2.22	$0.20
2054	1,018,000	$171,317	$591,647	$762,965	$2.30	$0.20
2055	1,018,000	$171,317	$618,272	$789,589	$2.38	$0.19
2056	1,018,000	$171,317	$646,094	$817,411	$2.46	$0.19
2057	1,018,000	$171,317	$675,168	$846,485	$2.55	$0.19
2058	1,018,000	$171,317	$705,551	$876,868	$2.64	$0.19
2059	1,018,000	$171,317	$737,300	$908,618	$2.74	$0.19
2060	1,018,000	$171,317	$770,479	$941,796	$2.84	$0.19
2061	1,018,000	$171,317	$805,150	$976,468	$2.94	$0.18
2062	1,018,000	$171,317	$841,382	$1,012,700	$3.05	$0.18
2063	1,018,000	$171,317	$879,244	$1,050,562	$3.17	$0.18
2064	1,018,000	$171,317	$918,810	$1,090,128	$3.28	$0.18
2065	1,018,000	$171,317	$960,157	$1,131,474	$3.41	$0.18
2066	1,018,000	$171,317	$1,003,364	$1,174,681	$3.54	$0.18
2067	1,018,000	$171,317	$1,048,515	$1,219,833	$3.68	$0.18
2068	1,018,000	$171,317	$1,095,698	$1,267,016	$3.82	$0.18
2069	1,018,000	$171,317	$1,145,005	$1,316,322	$3.97	$0.17
TOTAL	***48,540,000***	***$7,510,998***	***$21,948,166***	***$29,459,165***		

Table 7.3: Scenario 2 - Life Cycle Cost Analysis

YEAR	DELIVERED AMOUNT (ac-ft/yr)	BOND PAYMENT ($1,000)	O&M COSTS ($1,000)	TOTAL COSTS ($1,000)	UNIT COSTS ($/1000 gal)	PRESENT VALUE (1998$) ($/1000 gal)
2020	300,000	$64,094	$39,178	$103,272	$1.06	$0.40
2021	300,000	$64,094	$40,941	$105,035	$1.07	$0.39
2022	300,000	$64,094	$42,784	$106,877	$1.09	$0.38
2023	300,000	$64,094	$44,709	$108,802	$1.11	$0.37
2024	300,000	$64,094	$46,721	$110,814	$1.13	$0.36
2025	300,000	$64,094	$48,823	$112,917	$1.15	$0.35
2026	300,000	$64,094	$51,020	$115,114	$1.18	$0.34
2027	300,000	$64,094	$53,316	$117,410	$1.20	$0.33
2028	300,000	$64,094	$55,715	$119,809	$1.23	$0.33
2029	300,000	$64,094	$58,223	$122,316	$1.25	$0.32
2030	300,000	$64,094	$60,843	$124,936	$1.28	$0.31
2031	300,000	$64,094	$63,580	$127,674	$1.31	$0.31
2032	300,000	$64,094	$66,442	$130,535	$1.33	$0.30
2033	300,000	$64,094	$69,431	$133,525	$1.37	$0.29
2034	300,000	$64,094	$72,556	$136,649	$1.40	$0.29
2035	300,000	$64,094	$75,821	$139,914	$1.43	$0.28
2036	300,000	$64,094	$79,233	$143,326	$1.47	$0.28
2037	300,000	$64,094	$82,798	$146,892	$1.50	$0.27
2038	300,000	$64,094	$86,524	$150,618	$1.54	$0.26
2039	300,000	$64,094	$90,418	$154,511	$1.58	$0.26
2040	718,000	$218,539	$247,453	$465,992	$1.99	$0.31
2041	718,000	$218,539	$258,588	$477,127	$2.04	$0.31
2042	718,000	$218,539	$270,224	$488,764	$2.09	$0.30
2043	718,000	$218,539	$282,385	$500,924	$2.14	$0.30
2044	718,000	$218,539	$295,092	$513,631	$2.19	$0.29
2045	718,000	$218,539	$308,371	$526,910	$2.25	$0.28
2046	718,000	$218,539	$322,248	$540,787	$2.31	$0.28
2047	718,000	$218,539	$336,749	$555,288	$2.37	$0.27
2048	718,000	$218,539	$351,902	$570,442	$2.44	$0.27
2049	718,000	$218,539	$367,738	$586,277	$2.50	$0.27
2050	718,000	$154,446	$384,286	$538,732	$2.30	$0.23
2051	718,000	$154,446	$401,579	$556,025	$2.38	$0.23
2052	718,000	$154,446	$419,650	$574,096	$2.45	$0.23
2053	718,000	$154,446	$438,535	$592,980	$2.53	$0.23
2054	718,000	$154,446	$458,269	$612,714	$2.62	$0.22
2055	718,000	$154,446	$478,891	$633,336	$2.71	$0.22
2056	718,000	$154,446	$500,441	$654,886	$2.80	$0.22
2057	718,000	$154,446	$522,961	$677,406	$2.89	$0.22
2058	718,000	$154,446	$546,494	$700,939	$2.99	$0.21
2059	718,000	$154,446	$571,086	$725,532	$3.10	$0.21
2060	718,000	$154,446	$596,785	$751,231	$3.21	$0.21
2061	718,000	$154,446	$623,640	$778,086	$3.32	$0.21
2062	718,000	$154,446	$651,704	$806,150	$3.44	$0.21
2063	718,000	$154,446	$681,031	$835,476	$3.57	$0.20
2064	718,000	$154,446	$711,677	$866,123	$3.70	$0.20
2065	718,000	$154,446	$743,703	$898,148	$3.84	$0.20
2066	718,000	$154,446	$777,169	$931,615	$3.98	$0.20
2067	718,000	$154,446	$812,142	$966,587	$4.13	$0.20
2068	718,000	$154,446	$848,688	$1,003,134	$4.29	$0.20
2069	718,000	$154,446	$886,879	$1,041,325	$4.45	$0.20
TOTAL	**27,540,000**	**$6,556,177**	**$16,325,433**	**$22,881,610**		

Table 7.4: Scenario 3 - Life Cycle Cost Analysis

YEAR	DELIVERED AMOUNT (ac-ft/yr)	BOND PAYMENT ($1,000)	O&M COSTS ($1,000)	TOTAL COSTS ($1,000)	UNIT COSTS ($/1000 gal)	PRESENT VALUE (1998$) ($/1000 gal)
2040	418,100	$127,283	$133,740	$261,023	$1.92	$0.30
2041	418,100	$127,283	$139,758	$267,041	$1.96	$0.30
2042	418,100	$127,283	$146,047	$273,330	$2.01	$0.29
2043	418,100	$127,283	$152,619	$279,902	$2.05	$0.28
2044	418,100	$127,283	$159,487	$286,770	$2.10	$0.28
2045	418,100	$127,283	$166,664	$293,947	$2.16	$0.27
2046	418,100	$127,283	$174,164	$301,447	$2.21	$0.27
2047	418,100	$127,283	$182,001	$309,284	$2.27	$0.26
2048	418,100	$127,283	$190,191	$317,474	$2.33	$0.26
2049	418,100	$127,283	$198,750	$326,033	$2.39	$0.25
2050	418,100	$127,283	$207,694	$334,977	$2.46	$0.25
2051	418,100	$127,283	$217,040	$344,323	$2.53	$0.25
2052	418,100	$127,283	$226,807	$354,090	$2.60	$0.24
2053	418,100	$127,283	$237,013	$364,296	$2.67	$0.24
2054	418,100	$127,283	$247,678	$374,962	$2.75	$0.23
2055	418,100	$127,283	$258,824	$386,107	$2.83	$0.23
2056	418,100	$127,283	$270,471	$397,754	$2.92	$0.23
2057	418,100	$127,283	$282,642	$409,925	$3.01	$0.22
2058	418,100	$127,283	$295,361	$422,644	$3.10	$0.22
2059	418,100	$127,283	$308,652	$435,936	$3.20	$0.22
2060	418,100	$127,283	$322,542	$449,825	$3.30	$0.22
2061	418,100	$127,283	$337,056	$464,339	$3.41	$0.21
2062	418,100	$127,283	$352,224	$479,507	$3.52	$0.21
2063	418,100	$127,283	$368,074	$495,357	$3.63	$0.21
2064	418,100	$127,283	$384,637	$511,920	$3.76	$0.21
2065	418,100	$127,283	$401,946	$529,229	$3.88	$0.20
2066	418,100	$127,283	$420,033	$547,316	$4.02	$0.20
2067	418,100	$127,283	$438,935	$566,218	$4.15	$0.20
2068	418,100	$127,283	$458,687	$585,970	$4.30	$0.20
2069	418,100	$127,283	$479,328	$606,611	$4.45	$0.20
TOTAL	***12,543,000***	***$3,818,497***	***$8,159,062***	***$11,977,559***		

8.0 Summary and Conclusions

Interbasin transfer is one of several water supply strategies studied in the Trans-Texas Water Program. A preliminary environmental study was performed to determine the preferred routes for interbasin transfer. This report is the result of an engineering analysis of those routes. This report contains reconnaissance level construction cost estimates for the interbasin transfer routes.

The interbasin transfer Scenario 1, which meets the needs of the Southeast Area and also exports 600,000 acre-feet per year to the Brazos River, consists of the following segments: SN-4b, NT-3b, TS-3b, TS-4b, and TB-1. (See Figure 1.1 for a map of these segments.) The present worth value of this option is $0.36 per thousand gallons in the first year of operation (2010). By year 2069 when all of the debt service payments have been made, the present worth value is $0.17. The average present worth value is $0.23 per thousand gallons.

Scenario 2 meets the Southeast Area's needs as well as exports 300,000 acre-feet per year. It consists of the same segments as Scenario 1. The present worth value of this option ranges from $0.40 per thousand gallons in 2020 to $0.20 per thousand gallons in 2069. The average present worth value is $0.27 per thousand gallons.

Scenario 3 meets only the Southeast Area's needs with no exports. This route uses segments SN-4b, NT-3b, TS-3b and TS-4b, and would need to be in operation by the year 2040. The present worth value beginning in year 2040 is $0.30. It decreases to $0.20 by the year 2069, and it averages $0.24 per thousand gallons.

The interbasin transfer strategy requires large capital investments and extensive coordination between all parties involved. This strategy should be carefully weighed against the other Trans-Texas strategies to determine which strategies best meet the water needs of Texas.

APPENDIX A

Appendix A
References

Freese and Nichols, Inc.
Preliminary Feasibility Study, Interbasin Water Transfer from the Sabine River to the San Jacinto River Authority Service Area, prepared for the Sabine River Authority of Texas and the San Jacinto River Authority, November 1989.

Brown and Root, Inc.
Preliminary Engineering Report on Luce Bayou Diversion Project, prepared for the City of Houston, February 1973.

Brown and Root, Inc.
Environmental Report, the City of Houston's Luce Bayou Diversion Project, January 1979.

Freese and Nichols, Inc.
Environmental Analysis of Potential Transfer Routes (draft report), prepared for the Trans-Texas Water Program, February 1998.

Freese and Nichols, Inc.
Computer Model of Main Canal Hydraulics (draft report), prepared for the Lower Neches Valley Authority, May 1996.

Table B-1
Sabine River to Neches River, Segment SN-4b
Preliminary Opinion of Probable Cost
Scenario 3

Item	Units	Quantity	Unit Cost	Total Cost
Existing Canal Expansion				
Mobilization	5%	1	$805,218	$805,218
Excavation	CY	974,000	2.50	2,435,000
Compacted Fill	CY	2,142,000	1.50	3,213,000
Borrow Material	CY	1,314,000	3.00	3,942,000
Clearing	ACRE	135	4,265	574,854
Grubbing	ACRE	95	4,265	404,382
Grassing	ACRE	249	4,265	1,061,985
Pump Station Enlargement	LS	1	1,558,000	1,558,000
Check Structures	EA	3	215,000	645,000
Additional Right-of-Way	ACRE	135	4,000	539,136
Conflicts-Roads, RR, Creeks, Pipelines	EA	14	Varies	1,731,000
New Canal Construction				
Mobilization	5%	1	$1,017,559	1,017,559
Excavation	CY	988,000	2.50	2,470,000
Compacted Fill	CY	1,024,000	1.50	1,536,000
Borrow Material	CY	184,000	3.00	552,000
Clearing	ACRE	388	4,265	1,653,924
Grubbing	ACRE	324	4,265	1,382,133
Grassing	ACRE	251	4,265	1,071,368
New Pump Station	EA	1	935,000	935,000
Drop Structures	EA	1	100,000	100,000
Check Structures	EA	2	215,000	430,000
Right-of-Way	ACRE	388	4,000	1,551,160
Fencing	MI	14.9	124,000	1,847,600
Access Road	MI	14.9	60,000	894,000
Conflicts-Roads, RR, Creeks, Pipelines	EA	35	Varies	5,528,000
O&M Facilities	EA	1	400,000	400,000
Permitting & Environmental Studies				
404 Permit	LS	1	250,000	250,000
404 Environmental Assessment	LS	1	500,000	500,000
Wetlands Mitigation Land	AC	425	4,000	1,700,000
Water Right (including studies)	LS	1	1,000,000	1,000,000
Subtotal				$41,728,319
Administration & Engineering (15%)				6,259,248
Contingencies (25%)				10,432,080
Total				$58,419,646

Table B-2
Neches River to Trinity River, Segment NT-3b
Preliminary Opinion of Probable Cost
Scenario 3

Item	Units	Quantity	Unit Cost	Total Cost
Existing Canal Expansion				
Mobilization	5%	1	$648,901	$648,901
Compacted Fill	CY	1,239,000	1.50	1,858,500
Borrow Material	CY	1,239,000	3.00	3,717,000
Clearing	ACRE	56	4,265	238,840
Grubbing	ACRE	56	4,265	238,840
Grassing	ACRE	56	4,265	238,840
Pump Station Enlargement	LS	2	1,371,000	2,742,000
Check Structures	EA	5	250,000	1,250,000
Additional Right-of-Way	ACRE	56	4,000	224,000
Conflicts-Roads, RR, Creeks, Pipelines	EA	23	Varies	2,470,000
New Canal Construction				
Mobilization	5%	1	$1,430,374	1,430,374
Excavation	CY	1,890,000	2.50	4,725,000
Compacted Fill	CY	1,915,000	1.50	2,872,500
Borrow Material	CY	309,000	3.00	927,000
Clearing	ACRE	484	4,265	2,064,260
Grubbing	ACRE	207	4,265	882,855
Grassing	ACRE	324	4,265	1,381,860
New Pump Station	EA	1	2,648,000	2,648,000
Drop Structures	EA	1	148,000	148,000
Check Structures	EA	3	250,000	750,000
Discharge Structure	EA	1	400,000	400,000
Right-of-Way	ACRE	484	4,000	1,936,000
Fencing	MI	21.0	124,000	2,604,000
Access Road	MI	21.0	60,000	1,260,000
Conflicts-Roads, RR, Creeks, Pipelines	EA	54	Varies	5,608,000
O&M Facilities	EA	1	400,000	400,000
Permitting & Environmental Studies				
404 Permit	LS	1	250,000	250,000
404 Environmental Assessment	LS	1	500,000	500,000
Wetlands Mitigation Land	AC	285	4,000	1,140,000
Water Right (including studies)	LS	1	1,000,000	1,000,000
Subtotal				$46,554,770
Administration & Engineering (15%)				6,983,215
Contingencies (25%)				11,638,692
Total				$65,176,678

Table B-4
Trinity River to San Jacinto River through Luce Bayou, Segment TS-3b
Preliminary Opinion of Probable Cost
Scenarios 1, 2, & 3

Item	Units	Quantity	Unit Cost	Total Cost
Pipeline Construction				
Mobilization	5%	1	$1,287,800	$1,287,800
Pump Station	LS	1	7,100,000	7,100,000
132" Pipeline	LF	18,000	490	8,820,000
Parallel 132" Pipeline	LF	18,000	490	8,820,000
Discharge Structure	LS	1	600,000	600,000
Right-of-Way	ACRE	104	4,000	416,000
Access Road	MI	3.4	60,000	204,000
Fencing	MI	3.4	124,000	421,600
Clearing	ACRE	104	4,265	443,560
Grubbing	ACRE	94	4,265	400,910
Canal Construction				
Mobilization	5%	1	$185,582	185,582
Excavation	CY	148,000	2.50	370,000
Compacted Fill	CY	150,000	1.50	225,000
Borrow Material	CY	24,000	3.00	72,000
Clearing	ACRE	71	4,265	302,815
Grubbing	ACRE	66	4,265	281,490
Grassing	ACRE	45	4,265	191,925
Check Structure	EA	1	159,000	159,000
Discharge Structure	LS	1	600,000	600,000
Right-of-Way	ACRE	70	4,000	280,000
Fencing	MI	2.6	124,000	322,400
Access Road	MI	2.6	60,000	156,000
Conflicts - Light Duty Road	EA	2	175,500	351,000
O&M Facilities	EA	1	400,000	400,000
Channel Rectification	LS	1	2,110,000	2,110,000
Right-of-Way	ACRE	221	4,000	884,000
Permitting & Environmental Studies				
404 Permit	LS	1	250,000	250,000
404 Environmental Assessment	LS	1	500,000	500,000
Wetlands Mitigation Land	AC	355	4,000	1,420,000
Water Right (including studies)	LS	1	1,000,000	1,000,000
Subtotal				$38,575,082
Administration & Engineering (15%)				5,786,262
Contingencies (25%)				9,643,770
Total				$54,005,114

Table B-5
Sabine River to Neches River, Segment SN-4b
Preliminary Opinion of Probable Cost
Scenario 2

Item	Units	Quantity	Unit Cost	Total Cost
Existing Canal Expansion				
Mobilization	5%	1	$1,194,676	$1,194,676
Excavation	CY	1,256,000	2.50	3,140,000
Compacted Fill	CY	2,954,000	1.50	4,431,000
Borrow Material	CY	1,886,000	3.00	5,658,000
Clearing	ACRE	181	4,265	771,965
Grubbing	ACRE	126	4,265	537,390
Grassing	ACRE	261	4,265	1,113,165
Pump Station Enlargement	LS	1	3,614,000	3,614,000
Check Structures	EA	3	270,000	810,000
Additional Right-of-Way	ACRE	181	4,000	724,000
Conflicts-Roads, RR, Creeks, Pipelines	EA	14	Varies	3,094,000
New Canal Construction				
Mobilization	5%	1	$1,403,835	1,403,835
Excavation	CY	1,453,000	2.50	3,632,500
Compacted Fill	CY	1,583,000	1.50	2,374,500
Borrow Material	CY	348,000	3.00	1,044,000
Clearing	ACRE	469	4,265	2,000,285
Grubbing	ACRE	392	4,265	1,671,880
Grassing	ACRE	273	4,265	1,164,345
New Pump Station	EA	1	1,246,000	1,246,000
Drop Structures	EA	1	148,000	148,000
Check Structures	EA	2	270,000	540,000
Right-of-Way	ACRE	469	4,000	1,874,580
Fencing	MI	14.9	124,000	1,847,600
Access Road	MI	14.9	60,000	894,000
Conflicts-Roads, RR, Creeks, Pipelines	EA	35	Varies	9,239,000
O&M Facilities	EA	1	400,000	400,000
Permitting & Environmental Studies				
404 Permit	LS	1	250,000	250,000
404 Environmental Assessment	LS	1	500,000	500,000
Wetlands Mitigation Land	AC	515	4,000	2,060,000
Water Right (including studies)	LS	1	1,000,000	1,000,000
Subtotal				$58,378,721
Administration & Engineering (15%)				8,756,808
Contingencies (25%)				14,594,680
Total				$81,730,209

Table B-3
Trinity River to San Jacinto River through CWA Canal, Segment TS-4b
Preliminary Opinion of Probable Cost
Scenarios 1, 2, & 3

Item	Units	Quantity	Unit Cost	Total Cost
Existing Pump Station Expansion*	LS	1	$1,760,000	$1,760,000
New Pump Station*	LS	1	36,000,000	36,000,000
Total				$37,760,000

* Costs taken from Brown & Root's 1998 preliminary study for CWA and the City of Houston. Brown & Root has contracted with CWA to design these capital improvements based on these costs.

Table B-6
Sabine River to Neches River, Segment SN-4b
Preliminary Opinion of Probable Cost
Scenario 1

Item	Units	Quantity	Unit Cost	Total Cost
Existing Canal Expansion				
Mobilization	5%	1	$1,357,728	$1,357,728
Excavation	CY	1,311,000	2.50	3,277,500
Compacted Fill	CY	3,394,000	1.50	5,091,000
Borrow Material	CY	2,280,000	3.00	6,840,000
Clearing	ACRE	198	4,265	844,470
Grubbing	ACRE	138	4,265	588,570
Grassing	ACRE	268	4,265	1,143,020
Pump Station Enlargement	LS	1	4,237,000	4,237,000
Check Structures	EA	3	285,000	855,000
Additional Right-of-Way	ACRE	198	4,000	792,000
Conflicts-Roads, RR, Creeks, Pipelines	EA	14	Varies	3,486,000
New Canal Construction				
Mobilization	5%	1	1,512,179	1,512,179
Excavation	CY	1,492,000	2.50	3,730,000
Compacted Fill	CY	1,667,000	1.50	2,500,500
Borrow Material	CY	399,000	3.00	1,197,000
Clearing	ACRE	477	4,265	2,034,405
Grubbing	ACRE	399	4,265	1,701,735
Grassing	ACRE	273	4,265	1,164,345
New Pump Station	EA	1	1,682,000	1,682,000
Drop Structures	EA	1	158,000	158,000
Check Structures	EA	2	285,000	570,000
Right-of-Way	ACRE	477	4,000	1,908,000
Fencing	MI	14.9	124,000	1,847,600
Access Road	MI	14.9	60,000	894,000
Conflicts-Roads, RR, Creeks, Pipelines	EA	35	Varies	10,456,000
O&M Facilities	EA	1	400,000	400,000
Permitting & Environmental Studies				
404 Permit	LS	1	250,000	250,000
404 Environmental Assessment	LS	1	500,000	500,000
Wetlands Mitigation Land	AC	525	4,000	2,100,000
Water Right (including studies)	LS	1	1,000,000	1,000,000
Subtotal				$64,118,052
Administration & Engineering (15%)				9,617,708
Contingencies (25%)				16,029,513
Total				$89,765,273

Table B-7
Neches River to Trinity River, Segment NT-3b
Preliminary Opinion of Probable Cost
Scenario 2

Item	Units	Quantity	Unit Cost	Total Cost
Existing Canal Expansion				
Mobilization	5%	1	$1,126,576	$1,126,576
Compacted Fill	CY	2,240,000	1.50	3,360,000
Borrow Material	CY	2,240,000	3.00	6,720,000
Clearing	ACRE	56	4,265	238,840
Grubbing	ACRE	56	4,265	238,840
Grassing	ACRE	56	4,265	238,840
Pump Station Enlargement	LS	2	3,365,000	6,730,000
Check Structures	EA	5	295,000	1,475,000
Additional Right-of-Way	ACRE	56	4,000	224,000
Conflicts-Roads, RR, Creeks, Pipelines	EA	23	Varies	3,306,000
New Canal Construction				
Mobilization	5%	1	$1,712,558	1,712,558
Excavation	CY	2,450,000	2.50	6,125,000
Compacted Fill	CY	2,477,000	1.50	3,715,500
Borrow Material	CY	395,000	3.00	1,185,000
Clearing	ACRE	569	4,265	2,426,785
Grubbing	ACRE	246	4,265	1,049,190
Grassing	ACRE	346	4,265	1,475,690
New Pump Station	EA	1	4,050,000	4,050,000
Drop Structures	EA	1	207,000	207,000
Check Structures	EA	3	295,000	885,000
Right-of-Way	ACRE	569	4,000	2,276,000
Fencing	MI	21.0	124,000	2,604,000
Access Road	MI	21.0	60,000	1,260,000
Conflicts-Roads, RR, Creeks, Pipelines	EA	54	Varies	6,592,000
O&M Facilities	EA	1	400,000	400,000
Permitting & Environmental Studies				
404 Permit	LS	1	250,000	250,000
404 Environmental Assessment	LS	1	500,000	500,000
Wetlands Mitigation Land	AC	340	4,000	1,360,000
Water Right (including studies)	LS	1	1,000,000	1,000,000
Subtotal				$62,731,819
Administration & Engineering (15%)				9,409,773
Contingencies (25%)				15,682,955
Total				$87,824,547

Table B-8
Neches River to Trinity River, Segment NT-3b
Preliminary Opinion of Probable Cost
Scenario 1

Item	Units	Quantity	Unit Cost	Total Cost
Existing Canal Expansion				
Mobilization	5%	1	$1,649,230	$1,649,230
Compacted Fill	CY	3,629,000	1.50	5,443,500
Borrow Material	CY	3,629,000	3.00	10,887,000
Clearing	ACRE	141	4,265	601,365
Grubbing	ACRE	141	4,265	601,365
Grassing	ACRE	141	4,265	601,365
Pump Station Enlargement	LS	2	4,486,000	8,972,000
Check Structures	EA	5	330,000	1,650,000
Additional Right-of-Way	ACRE	141	4,000	564,000
Conflicts-Roads, RR, Creeks, Pipelines	EA	23	Varies	3,664,000
New Canal Construction				
Mobilization	5%	1	$1,883,775	1,883,775
Excavation	CY	2,811,000	2.50	7,027,500
Compacted Fill	CY	2,793,000	1.50	4,189,500
Borrow Material	CY	404,000	3.00	1,212,000
Clearing	ACRE	606	4,265	2,584,590
Grubbing	ACRE	262	4,265	1,117,430
Grassing	ACRE	352	4,265	1,501,280
New Pump Station	EA	1	4,860,000	4,860,000
Drop Structures	EA	1	230,000	230,000
Check Structures	EA	3	330,000	990,000
Right-of-Way	ACRE	612	4,000	2,448,000
Fencing	MI	20.8	124,000	2,579,200
Access Road	MI	20.8	60,000	1,248,000
Conflicts-Roads, RR, Creeks, Pipelines	EA	54	Varies	7,288,000
O&M Facilities	EA	1	400,000	400,000
Permitting & Environmental Studies				
404 Permit	LS	1	250,000	250,000
404 Environmental Assessment	LS	1	500,000	500,000
Wetlands Mitigation Land	AC	360	4,000	1,440,000
Water Right (including studies)	LS	1	1,000,000	1,000,000
Subtotal				$77,383,100
Administration & Engineering (15%)				11,607,465
Contingencies (25%)				19,345,775
Total				$108,336,340

Table B-9
Trinity River to Brazos River, Segment TB-1
Preliminary Opinion of Probable Cost
Scenario 2

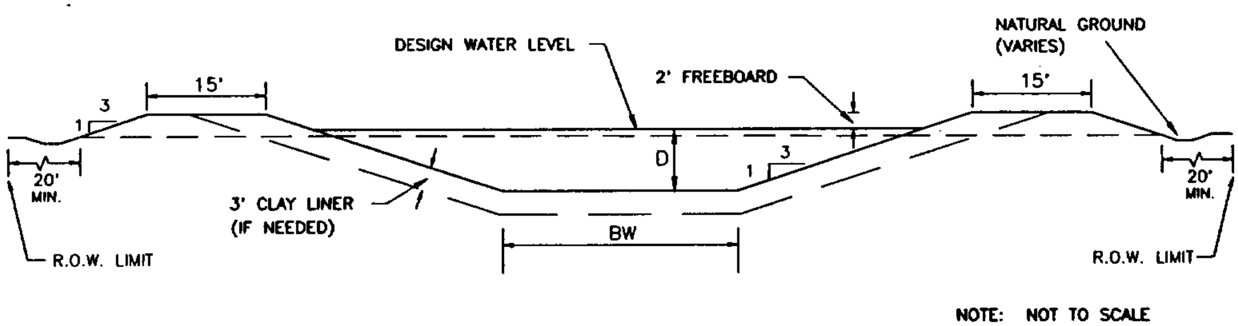
Item	Units	Quantity	Unit Cost	Total Cost
Pipeline Construction				
Mobilization	5%	1	$8,782,000	$8,782,000
Intake Pump Station	LS	1	7,710,000	7,710,000
96" Pipeline	LF	276,000	276	76,176,000
Parallel 96" Pipeline	LF	276,000	276	76,176,000
Booster Pump Station	LS	1	6,240,000	6,240,000
8 Million Gallon Storage Tank	EA	1	1,100,000	1,100,000
Discharge Structure	LS	1	400,000	400,000
Right-of-Way	ACRE	711	4,000	2,844,000
Clearing	ACRE	711	4,265	3,032,415
Grubbing	ACRE	458	4,265	1,953,370
Permitting & Environmental Studies				
404 Permit	LS	1	250,000	250,000
404 Environmental Assessment	LS	1	500,000	500,000
Wetlands Mitigation (w/ inhancement)	AC	65	10,000	650,000
Water Right (including studies)	LS	1	1,000,000	1,000,000
Subtotal				$186,813,785
Administration & Engineering (15%)				28,022,068
Contingencies (25%)				46,703,446
Total				$261,539,299

Table B-10
Trinity River to Brazos River, Segment TB-1
Preliminary Opinion of Probable Cost
Scenario 1

Item	Units	Quantity	Unit Cost	Total Cost
Pipeline Construction				
Mobilization	5%	1	$16,924,000	$16,924,000
Intake Pump Station	LS	1	9,000,000	9,000,000
144" Pipeline	LF	276,000	564	155,664,000
Parallel 144" Pipeline	LF	276,000	564	155,664,000
Booster Pump Station	LS	1	7,630,000	7,630,000
8 Million Gallon Storage Tank	EA	2	1,100,000	2,200,000
Discharge Structure	LS	1	500,000	500,000
Right-of-Way	ACRE	711	4,000	2,844,000
Clearing	ACRE	711	4,265	3,032,415
Grubbing	ACRE	458	4,265	1,953,370
Permitting & Environmental Studies				
404 Permit	LS	1	250,000	250,000
404 Environmental Assessment	LS	1	500,000	500,000
Wetlands Mitigation (w/ inhancement)	AC	65	10,000	650,000
Water Right (including studies)	LS	1	1,000,000	1,000,000
Subtotal				$357,811,785
Administration & Engineering (15%)				53,671,768
Contingencies (25%)				89,452,946
Total				$500,936,499

Figure C-1

TYPICAL CANAL SECTION



Design Capacity (MGD)	Gradient (ft/mile)	Standard Bottom Width (ft)	Standard Depth (ft)	Right of Way Width (ft)	Velocity (ft/sec)
450	0.17	30	10	220	1.16
	0.26	30	9	200	1.36
	0.41	30	8	195	1.61
	0.52	25	8	190	1.78
500	0.17	35	10	225	1.19
	0.26	35	9	215	1.39
	0.41	35	8	200	1.64
	0.51	30	8	195	1.79
550	0.17	40	10	230	1.22
	0.26	40	9	220	1.41
	0.41	40	8	205	1.67
	0.50	35	8	200	1.81
800	0.18	50	11	250	1.36
	0.26	50	10	240	1.55
	0.39	50	9	230	1.79
	0.46	45	9	225	1.91
850	0.21	50	11	250	1.44
	0.30	50	10	240	1.65
	0.44	50	9	230	1.90
	0.52	45	9	225	2.03
900	0.16	50	12	265	1.35
	0.23	50	11	250	1.53
	0.33	50	10	240	1.74
	0.50	50	9	230	2.01
	0.39	45	10	235	1.86
	0.58	45	9	225	2.15

Design Capacity (MGD)	Gradient (ft/mile)	Standard Bottom Width (ft)	Standard Depth (ft)	Right of Way Width (ft)	Velocity (ft/sec)
1000	0.18	55	12	270	1.42
	0.25	55	11	260	1.60
	0.36	55	10	245	1.82
	0.53	55	9	235	2.10
	0.41	50	10	240	1.94
	0.62	50	9	230	2.24
1100	0.21	55	12	270	1.56
	0.30	55	11	260	1.76
	0.43	55	10	245	2.01
	0.50	50	10	240	2.13
1150	0.17	55	13	280	1.46
	0.23	55	12	270	1.63
	0.33	55	11	260	1.84
	0.47	55	10	245	2.10
	0.38	50	11	260	1.95
	0.54	50	10	240	2.23
1500	0.19	60	14	300	1.63
	0.26	60	13	285	1.81
	0.35	60	12	275	2.02
	0.29	55	13	280	1.90
	0.40	55	12	270	2.13

APPENDIX C

APPENDIX D

COMMENTS

RESPONSE TO COMMENTS

No Comments Received