TRANS–TEXAS WATER PROGRAM

SOUTHEAST AREA

Final Report

Phase II Report

April 22, 1998

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

Preface

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 three planning areas are the Southeast Area, which includes the Houston-Galveston metropolitan area, the South-Central Area (including Corpus Christi), 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.

This is the final version of this document.

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Executive Summary

The Trans-Texas Water Program (TTWP) began with the idea that long-range water supply planning could be more efficient and effective if approached from a regional, multi-basin perspective. Water requirements and water supply sources do not recognize political boundaries and, to meet the challenge of providing adequate fresh water for tomorrow's communities, local resource planners need new strategies. The State of Texas is charged with providing a state water plan updated each two years. The Texas Water Development Board, charged with preparing this plan, saw the merit in the regional approach and, in 1993, sponsored the TTWP. TTWP is a coordinated study of the fifty – year water requirements and supply alternatives for approximately one-third of the state's current population. This document reports on the TTWP efforts undertaken by the Southeast Area, one of four study areas participating in TTWP.

Over the course of the program the Southeast Area determined its long range water requirements, the long-range water availability for the area and the issues affecting decision-making in the region. It also investigated 13 different water management strategies for their potential contribution to satisfying the future water requirements of the Southeast Area. The program concluded:

- There is adequate surface and groundwater within the Southeast Area to meet all TTWP demands, both Southeast Area and those of Central Texas.
- There is a geographic disparity between water resource supply centers and demand centers.
- Water supply shortages are predicted for different geographic areas of the TTWP area at different times over the program horizon. Areas of greatest population growth, specifically the Houston Metro area, are predicted to experience shortages by 2030 if no new water sources are developed.
- Water conservation, wastewater reclamation and systems operations techniques can extend the period of adequate supply and delay the need for new resources development in the Houston Metro area for 15 – 20 years.
- Other strategies, such as the Neches Salt Water Barrier, create additional supplies from existing resources.
- The development of Allens Creek Reservoir can provide a new supply source for the western side of the Southeast Area.
- Contractual Transfers of some existing supplies can be arranged which will result in additional reduced water availability and reduced conveyance requirements for certain regions. A projection of reduced irrigation demand throughout the Southeast study area offers an opportunity for contractual transfer of significant dependable surface water supplies to municipal and manufacturing areas.
- Interbasin transfer is currently used to meet Southeast Area water demands and will continue to be needed to meet the

future water requirements of both the Southeast and Central Texas areas. Several of the alternative strategies investigated require the use of interbasin transfers.

- Desalination, a viable alternative under some conditions, is not an economic or environmentally appropriate strategy for use in the Southeast Area.

There were many issues addressed in TTWP Southeast Area activities with regard to meeting the long-range water needs of the Southeast Area. These include:

- Public access to the decision-making processes.
- Methods of projecting population and water demands.
- Environmental criteria to be used when evaluating impacts to streams, bays and estuaries, and wetlands.
- Economic impacts associated with water supply decisions.
- Equity arrangements between exporting and importing basins and the representation of "third party interests" in these arrangements.
- Mechanisms for establishing regional goals and regional decision-making processes and undertaking regional programs.

The Omnibus Water Bill, Senate Bill 1 enacted in 1997 Texas State Legislature, has made regional water management planning the law. The TTWP experience in regional planning has placed the Southeast Area on track in moving toward SB 1 planning requirements. The TTWP Southeast Area sponsors begin the process with:

- Detailed planning data including population and water demand projections and water resource data evaluated by basin, county and water use type.
- Technical studies on local supply - and demand – side water management strategies and the impacts associated with their use.
- A broad understanding of local water related issues including those of environmental, social and economic interests.
- New methods of involving the public in decision-making processes and an awareness of third-party interests in the Southeast Area.
- Needed environmental research on the Sabine Lake and Galveston Bay systems and a better understanding of the potential impacts of various water use regimens.
- Partnerships with various water management stake-holders in Texas and Louisiana.

Much work remains to be done, but the TTWP Southeast Area project should provide a solid foundation for future water supply planning throughout the region.

1. Introduction

The 1990 Texas Water Plan determined that while there are adequate water supplies to meet the projected fifty-year demand for the State of Texas, a geographic disparity exists between areas with available water supply and projected demand. The eastern part of the state has an abundance of water, far in excess of projected local demands. Some western and coastal regions of the state are projected to experience shortfalls in water supply before the year 2020. The need to correct this imbalance and provide for the water needs of all Texas communities in a cost-effective and environmentally sensitive way provided the impetus for the Trans-Texas Water Program (TTWP).

The TTWP recognizes the regional nature of water supply/demand issues and was created to develop sound regional water management strategies for areas of Southeast, South-Central and West-Central Texas through 2050. Rapid growth in these regions' core urban cities of Houston, San Antonio, Austin and Corpus Christi has increased the need to investigate short and long-term water supply strategies. Historically, whenever an area had difficulty meeting increased demands from existing supply, it would unilaterally develop new supply sources, typically either ground water well fields or surface water reservoirs. Today, water planners face a very different situation. Environmental issues and cost considerations demand a new approach.

The 1997 Texas Legislature adopted Senate Bill 1 (SB1) which mandates additional regional water planning for the entire state. The Year 2000 State Water Plan will incorporate the water management plans developed by each of 16 regions of the state. Under the legislation a public body representing local government, water providers, industry, community and environmental interests will guide each regional master planning effort. Each region will develop a plan for meeting its projected fifty-year water demand while recognizing unique regional, environmental and equity issues. SB1 reflects an understanding of the current standard of water resource planning and is a logical progression from the efforts begun in the TTWP.

The TTWP, and now SB1, acknowledge the wide range of water needs; human and environmental; urban, rural, and agricultural; industrial and commercial; residential and recreational. This increased awareness causes pressure on existing water supplies. The City of Houston uses groundwater to meet a large portion of its local demand. Land subsidence, resulting from the removal of groundwater, requires the city to develop alternate water supplies for current and projected water demands. San Antonio has also depended upon groundwater from the Edwards Aquifer to meet local needs. Federal court rulings in 1993 require that pumping from the Edwards be sharply reduced to protect endangered species. San Antonio must also find alternative water supplies to meet future demands. For differing reasons, similar situations exist in Austin, Corpus Christi and other major cities in the state.

These Texas cities must concentrate on making effective use of existing supply through better water conservation practices, expanded reclamation and reuse, and more efficient operation of multiple-source sys-

tems. They must also look to new strategies and approaches to matching existing supplies with current and projected demands.

These Texas cities must concentrate on making effective use of existing supply through better water conservation practices, expanded reclamation and reuse and more efficient operation of multiple-source systems. They must also look to new strategies and approaches to matching existing supplies with current and projected demands.

The TTWP began this process under the leadership of the mayors of Houston, San Antonio and Corpus Christi in 1992. They initiated a coordinated planning process to identify projected water needs and available water supplies and to attempt to balance supply and demand in a cost-effective and environmental responsible manner. The Texas Water Development Board (TWDB) recognized the value of this concept and agreed to sponsor further investigations through what became the TTWP. The mission and approach of the state-wide TTWP is shown in Figure 1.1.

It should be noted that in the TTWP the responsibility still rested with local communities to plan and implement water supply and management programs as necessary to meet their individual local needs. The TTWP represents a regional framework within which the local management programs could be formulated and coordinated; regional planning guiding local action. Initially three study areas were created: the Southeast, including the Houston metropolitan area as the primary demand center; the South-Central, with Corpus Christi as primary demand center; and the West-Central, with San Antonio as primary demand center. A North-Central study area, with Austin as the primary demand center, was identified later and added to the program. This report summarizes the technical study and planning efforts undertaken by the Southeast Study Area.

1.1 TTWP Goals and Objectives

Figure 1.2 illustrates both the statewide program goals and the Southeast Area's program objectives. Phase I objectives assumed the necessity of large-scale water transfers in the near or mid term to meet Southeast Area supply shortfalls. Revised planning data indicate that transfers will not be required to meet Southeast Area demand before the end of the planning period, approximately 2045. There will still be a need to develop additional local supplies and to provide additional supply for other TTWP areas within the 2000 - 2050 time frame.

Mission Statement:	To determine the best method of providing for the short and long term (50-year) supplies of water to meet Texas' needs in a cost-effective and environmentally sensitive manner.
Approach:	A cooperative effort of local, regional, and State of Texas water resources agencies and suppliers to manage the state's water resources to meet projected needs in the southeast, south-central and west-central areas.

Figure 1.1: Trans-Texas Water Program Mission and Approach

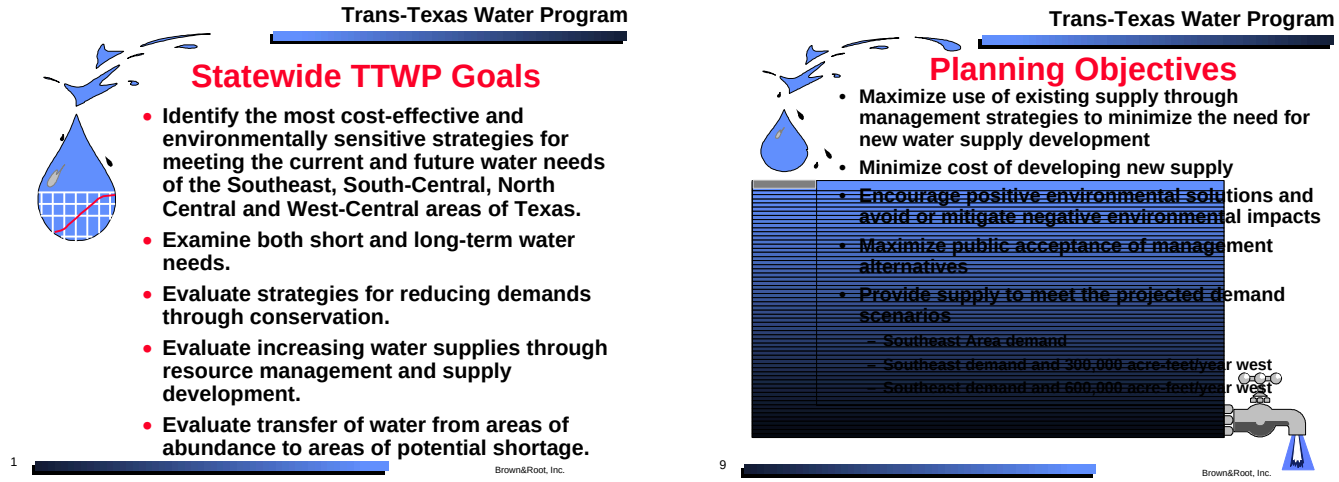

Figure 1.2: Trans-Texas Water Program Goals and Objectives

1.2 *Phase II Report* Purpose and Organization

This *Phase II Report* completes the Southeast Study Area's Trans-Texas Water

Program. It summarizes all planning and technical memoranda prepared within the TTWP Southeast Study Area program. It documents the results of all TTWP studies and their importance to the regional water management planning mandated through SB1.

Phase II efforts were directed by the initial Phase I recommendations and modified by the changing needs of water management planning in the state. Planning and technical analysis memoranda document the methodology of each study, present the study findings and analyze the impact of each on water management for the Southeast Study Area.

The planning memoranda define the parameters of water supply and demand for the region as well as investigate other issues or conditions that may affect water management in the region. Members of advisory committees received a copy of each memorandum. These memoranda include:

- Enhanced Public Participation (August, 1995)
- Planning Information Update (September, 1996)
- Phase II Program Update (September, 1996)
- The Sabine Lake Conference (September, 1996)
- Projected Water Needs and Supply of the Upper Neches and Sabine River Basins (September, 1997)
- Equity Issues Related to Water Transfers (January, 1998)
- Galveston Bay Freshwater Inflow Study (March, 1998)
- Impact of Potential Toledo Bend Operational Changes (January, 1998)
- Sabine Lake Salinity Analysis (April, 1998)

Technical Memoranda report on the investigations of recommended water management

strategies identified in the *Phase I Report*. These include:

- Allens Creek Reservoir Studies: Status of Environmental Issues; Operations Studies and Opinions of Cost, Vol. I and II (April, 1997)
- Water Conservation (January, 1998)
- System Operation of Surface Water Supply Sources in the Houston Area (January, 1998)
- Wastewater Reclamation and Reuse (March, 1998)
- Environmental Analysis for the Neches Salt Water Barrier (February, 1998)
- Desalination (February, 1998)
- Environmental Analysis of Potential Transfer Routes, Screening Report (February, 1998)
- Engineering Analysis of Potential Transfer Routes, Screening Report (March, 1998)
- Contractual Transfers Analysis (March, 1998).

Finally, the *Phase II Report* compiles information from each of the water management alternatives for their potential contribution to the Southeast Area's future water supply. The products of the TTWP Phase II efforts provide valuable information and insight to the Senate Bill 1 planning bodies as they begin the work of regional water management planning. This report identifies issues of regional importance and topics that require additional research under SB1 regional planning.

1.3 TTWP Background

The TTWP is divided into four study areas: the Southeast, South-Central, North-Central and West-Central. The TTWP is the foundation of an integrated regional water resource system and an important element in the 1996 Texas Water Plan. Technical evaluations completed in the TTWP provide valuable base data for the new SB1 regional planning efforts. The TTWP Southeast Area is located in the southeastern corner of the state, and comprises an area from the Sabine River on the Louisiana border west to the Brazos River basin. It includes 32 counties, all or part of eight river and coastal basins, and the Houston/Galveston and Golden Triangle metropolitan and industrial areas. The region encompasses about one-fourth of the state's population and one fifth of the state's total water demands. Figure 1.3 is a map of the 32-county region defined as the Southeast Area of the TTWP.

1.4 Program Organization

The Policy Management Committee (PMC) which establishes planning parameters and guidelines for all studies and provides coordination between the four study areas determines TTWP policy. The PMC also reviews all program deliverables and serves as a decision-making body regarding program recommendations. As shown in Figure 1.4, the PMC consists of the primary water resource planning and regulatory agencies for the State of Texas and major surface water supply entities.

Technical Advisory Committees (TACs) were established for each study area. These groups provide a forum for involvement and input by parties interested in or potentially affected by the TTWP. Appendix B includes a list of Southeast Study Area TAC members representing over 75 civic, environmental, industrial and recreational interests.

Figure 1.3: Trans-Texas Water Program Southeast Area

1.5 Public Involvement in TTWP

Public access was built into every level of the TTWP. Program sponsors organized the TTWP to encourage widespread dissemination of the program's progress. In the Southeast Study Area both the PMC and TAC serve as vehicles for public and agency involvement. During Phase I of the program there were three statewide PMC meetings, two Southeast PMC meetings and one Southeast TAC meeting.

Public involvement increased greatly during Phase II. The Southeast PMC, recognizing the importance of public involvement to the success of the TTWP, began Phase II with an investigation of ways to increase local involvement. The *Enhanced Public Participation Memorandum* (August, 1995) identified local issues and recommended methods to improve public involvement in the TTWP. The TAC was expanded from 50 to over 75 agencies, organizations and individuals. Topic specific focus groups (Planning Information, Water Resource Management and Environmental), were created to discuss issues of interest to specific subsets of the TAC. Notice of all PMC and TAC meetings expanded and meeting times and locations varied to permit greater participation.

Public meetings held during Phase II included:

- 8 statewide PMC,
- 11 Southeast PMC,
- 5 Southeast TAC. and
- 12 focus group or other public meetings.

A major symposium on the Sabine Lake was also sponsored by the TTWP. Preceding each meeting, notices and reports or support materials were sent to each committee member. In addition, the Southeast Study Area mailing list was added to the TWDB distribution of its quarterly TTWP newsletter. A list of each Phase II meeting held in the Southeast Study Area is included in Appendix C.

1.6 TTWP Southeast Area: Phase I

Phase I of the Southeast Area program, Project Initiation and Conceptual Planning, undertook preliminary analysis of projected water demand and estimated water supply for a fifty year planning period from 2000 through 2050. It concluded with the outline of a conceptual water management plan for the Southeast Area. This initial work indicated the potential for significant water shortages in some areas of the region, principally in areas served by the City of Houston, as early as year 2020. Phase I proposed an integrated water management program for the region that included a range of water management techniques designed to provide short and long term water supply for the entire Southeast Area and possibly for the demands of other Trans–Texas Water Program areas.

- The results of this initial analysis are presented in the *Trans–Texas Water Program, Southeast Area, Phase I Report* completed in March 1994. This document identifies existing Southeast Area water supplies, water demand projections, water ownership, and potential future water management options and opportunities. Based on this information, the *Phase I Report* lists five principal conclusions:
- "Sufficient water supplies currently exist within the Southeast Area to meet the projected demands within that area through approximately the year 2050 if

ground water development occurs as predicted by the Texas Water Development Board (TWDB).

- "Much of the available water supply is not located in the areas of demand and will require major water transfers to achieve the needed balance.
- "Sufficient supplies do not currently exist within the Southeast Area to enable the Trans–Texas Water Program as a whole to meet all of the potential transfer requirements of the three study areas through 2050.
- "Feasible water management methods are available to hold the Southeast Area demands within reasonable levels, extend the use of water sources that already exist, and create new supply.
- "Effective application of the full scope of such methods in the Southeast Area should allow the Trans–Texas Water Program to satisfy the projected demands and interbasin transfer requirements of the entire region through 2050."[1]

The *Phase I Southeast Area Report* observes that within the Southeast Area's eight watershed basins, three basins (Sabine, Neches, Trinity) have supply surpluses in year 2050 while the other five basins show supply deficits. The total Southeast Area had a supply deficit of approximately 90,000 acre-feet per year in year 2050. All four TTWP program areas collectively are shown to need over 900,000 acre-feet of water per year by year 2050.

Potentially viable water management methods addressing these problems are identified and included in the Phase I conceptual water management plan. These management techniques include:

- Water conservation;
- Wastewater reclamation;
- Existing reservoir surplus supply use;
- Coordinated reservoir system operation;
- Interbasin transfers;
- Contractual transfers.

The initial water management analyses conclude that, while the application of many resource management techniques could satisfy this level of shortfall, no single management method could address these demands alone. Further, some of the management techniques must be used in combination. For example, several of these techniques rely on interbasin conveyance to function.

The *Southeast Area Phase I Report* concludes that an imbalance of supply and demand exists within the Southeast study area and that a suite of water resource management techniques should be employed to address projected water supply shortfalls. It also identifies interbasin transfer as key to addressing this imbalance because interbasin transfer can convey existing supply surpluses to areas of demand without the environmental and economic costs associated with the construction of new reservoirs and other additional supply sources. The *Phase I Report* also concludes that Sabine and Neches river waters are needed to meet the demand shortfall because these basins contain the largest sources of uncommitted surplus supply.

1.7 TTWP Southeast Area Phase II

- The initial Phase II goal was the development an implementable water management plan for the Southeast Area.

Figure 1.4: TTWP Organizational Chart

This changed with the adoption of SB1. The new Phase II goal is providing SB1 planners with solid technical evaluation of the water management alternatives identified as potential strategies for the Southeast Area.

The following sections of this report summarize the finding of each study undertaken in Phase II. These reports satisfy this goal by providing data and technical guidance on water management issues for the Southeast Area.

2. Planning Memoranda

There are a total of six planning reports prepared during Phase II of the TTWP Southeast Area. Each of these reports investigates either demand or supply parameters associated with water resource management for the study area. Defining the size of demand in various water demand centers and for specific water uses across the planning horizon (1990 through 2050), determines the amount, type and location of water supply necessary to meet community needs.

The following sections will summarize the findings of each report and then evaluate these findings for their importance to short and long range water supply planning for the study area.

2.1 Planning Information Update Report

Decisions regarding future water management strategies, and ultimately system facilities, are based on projected future population and water demand. Phase II utilized the 1994 Consensus Water Planning projections for population and water demand through the year 2050. These data replaced previous projections developed by the TWDB in 1992 for the Texas Water Plan. The TWDB, TNRCC and TPWD developed the Consensus Water Planning projections in a cooperative process involving broad public review. The projections reflect significant procedural and technical modifications in methodology from previous data sets prepared by the state for planning purposes. In addition to the innovation of the consensus approach and increased interagency and public review, the methodology recognized the effects of generally lower population growth rates throughout the state in the early 1990s and the impact of increased conservation required under the 1991 State of Texas Plumbing Fixtures regulations on water demand.

The *Planning Information Update*[2] incorporates the revised data and updates the previous Phase I planning projections to reflect the projected population and water demand currently accepted by all state agencies. These data are included in *Water for Texas – Today and Tomorrow: A 1996 Consensus—Based Update to the Texas Water Plan. The* Southeast PMC adopted these data for all Phase II planning efforts. The primary conclusion of this memorandum follows.

*2.1.1 **Population***

Projected populations for the Southeast Area were slightly increased, about 2 percent, for most of the study time periods. Populations in the San Jacinto, San Jacinto-Brazos, and Brazos basins, the high growth Houston Metro Region, are projected to grow at higher rates that previously expected. The Phase II 2050 population for the Houston Metro area increases by over three percent. Lower rates of growth are expected in the Sabine, Neches, Neches-Trinity and Trinity basins. Figure 2.1 illustrates the difference between Phase I and II population projections for the Southeast Area.

2.1.2 Water Requirements

While the Phase II populations are slightly increased over previous data sets, projected.

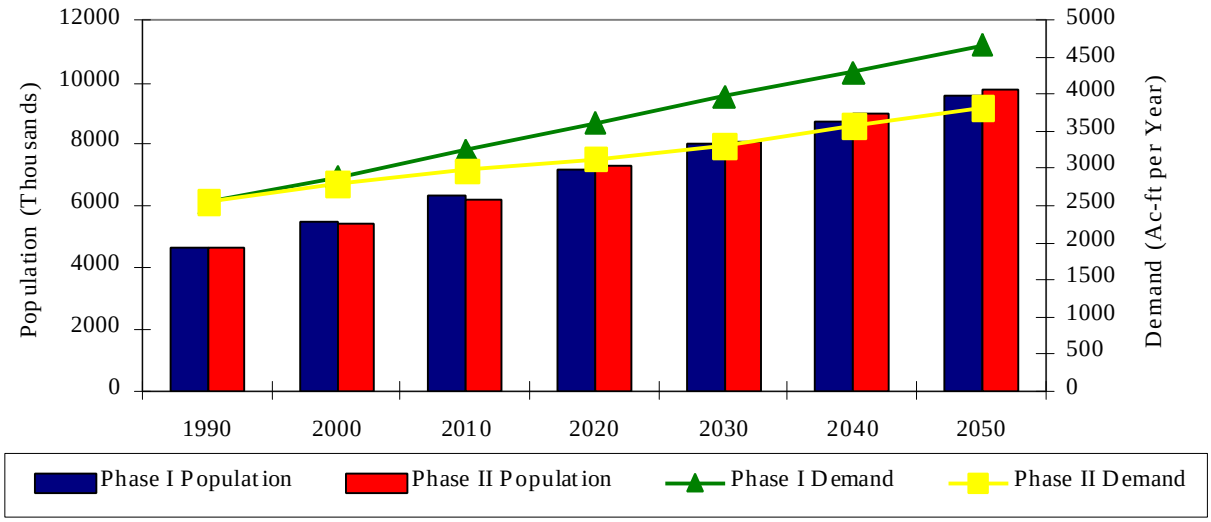

Figure 2.1: Population Projections and Water Demand for the Southeast Area

water requirements are reduced by 18 percent through the year 2050. The primary reason for the reduced projected demands is the application of different assumptions for municipal per capita water use and regional industrial growth. Additional reductions in demand result from water conservation savings and lower irrigation demands for the area in the future. See Figure 2.1.

2.1.3 Water Supply

Estimates of existing ground water and surface water in the Southeast Area are decreased by 82,100 acre-feet per year. This decrease is the result of revised 2050 groundwater estimates for Harris and Galveston counties indicating a decrease of 150,100 acre-feet per year. Projected surface water supply in 2050 is estimated to increase by 68,000 acre-feet per year, primarily as a result of larger available surface water supplies in the San Jacinto-Brazos the net decrease estimated for the area.

2.1.4 Impacts of Revised Data

These revised data indicate a different picture of the long-term water availability for the Southeast area.

- Revised water demands for the area indicate that current water supplies will be adequate to meet the regions needs for a longer period of time than previously expected.
- The eight-county Houston Metro Region, while requiring significantly less water than previously predicted, is the major demand center for the Southeast Area. The Metro Region will experience supply shortages by approximately 2030, twenty-five years later than Phase I projected. In spite of a regional surplus of water, localized shortages are expected to occur within the fifty-year planning period.
- There are substantial surplus surface water supplies throughout the 50-year planning period in the eastern basins, the Sabine, Neches, and Trinity River Basins. The Sabine Basin has surplus

supplies eight times larger than projected 2050 in-basin demand.

- After meeting all in-basin demands there remain adequate surplus water supplies in the southeast Area to meet all projected TTWP demand requirements. See Table 2.1, Southeast Area Water Supply Availability: 2000 – 2050 for detailed summary of both projected supply and demand by decade for each basin in the study area.
- As indicated in Table 2.2, even after meeting the highest export demand required for other TTWP areas, the Southeast Area continues to have an available supply surplus of 70,400 acre-feet per year.
- All conclusions regarding surplus supply in the Southeast Area precede a determination of the environmental need for water. The amount of water required for freshwater inflows to bays and to support riverine and wetlands environments has not yet been quantified. Any supply identified for the environment reduces the supply available for other uses in the study area.

2.2 Phase II Program Update

The *Phase II Program Update*[3] is a companion to the *Planning Information Update*. This report evaluates the impacts of the revised planning data upon the program objectives and the conclusions set forth in the original S*outheast Area Phase I Report*.

2.2.1 Reevaluation of Phase I Program Objectives

Phase I program objectives require reevaluation in the light of new planning data. A reduction of projected water demand and changes in estimated water supply shifted the timing for needed new supply and altered program objectives. The impacts of the revised planning data on Phase I program objectives are:

- The first TTWP objective, formulation of a water resource management plan to meet the entire TTWP region's short and long-term needs, remains a valid program effort. The second Phase I objective, use of interbasin transfer from Sabine and Neches River basins as the foundation of the TTWP to meet Southeast 2.2 Area water demands, is not currently valid. Interbasin transfers will continue to be needed both in the Southeast Area and elsewhere in the state but the large-scale transfer of Sabine and Neches River water may be unnecessary in the Southeast Area until the end of the planning period.
- While the Southeast Area has adequate supplies, the Houston Metro region will require a reallocation of existing water supplies to meet future demand. Current excess supplies exist within the Trinity River basin. These supplies must be conveyed into the northern San Jacinto and San Jacinto - Brazos River basins to meet future projected demands.
- Sufficient surplus supplies exist within the Sabine and Neches basins to meet projected in-basin water demands past year 2050 and also serve all of the West-Central supply shortfalls. As in the Southeast Area, revised demand projections for the West-Central area may further reduce those shortfalls.
- The transfer of Sabine and Neches surplus waters is no longer viewed as appropriate for the near term program. The importance of interbasin transfer of

Table 2-1: Southeast Area Water Supply Availability: 2000—2050

	Amount (Thousands of Acre-Feet/Year)								
Category	***Sabine***	***Neches***	***Neches-Trinity***	***Trinity***	***Trinity-San Jacinto***	***San Jacinto***	***San Jacinto -Brazos***	***Brazos***	***Total Southeast***
2000									
In-Basin Demands	86.0	261.4	329.9	138.5	143.2	949.7	464.2	427.3	2800.2
In-Basin Supplies									
Groundwater	23.3	110.5	7.5	34.3	26.6	451.7	74.9	130.5	859.3
Surface Water	1190.4	846.9	0.0	1356.4	0.0	257.7	57.8	488.2	4197.6
TOTAL	1213.7	957.4	7.5	1390.7	26.6	709.4	132.7	618.7	5056.7
Surface Water Transfers									
Imported Supplies	0.9	1.4	322.4	0.0	116.6	300.3	331.5	0.0	1073.1
Export Demands	1.4	280.5	0.0	582.5	0.0	60.0	0.0	142.9	1073.1
In-Basin Reserves	282.9	209.1	0.0	0.0	0.0	0.0	0.0	0.0	492.0
Net Surface Water Availability	**844.3**	**207.8**	**0.0**	**669.7**	**0.0**	**0.0**	**0.0**	**42.7**	**1764.5**
2010									
In-Basin Demands	93.9	275.4	316.6	141.0	147.9	1,030.9	497.8	463.4	2966.9
In-Basin Supplies									
Groundwater	23.3	111.6	7.9	36.6	25.7	292.3	80.9	141.9	720.2
Surface Water	1190.4	846.9	0.0	1356.4	0.0	257.7	57.8	487.6	4196.8
TOTAL	1213.7	958.5	7.9	1393.0	25.7	550.0	138.7	629.5	4917.0
Surface Water Transfers									
Imported Supplies	1.0	2.0	308.7	0.0	122.2	540.9	359.1	0.0	1333.9
Export Demands	2.0	279.5	0.0	839.2	0.0	60.0	0.0	153.2	1333.9
In-Basin Reserves	282.9	209.1	0.0	0.0	0.0	0.0	0.0	0.0	492.0
Net Surface Water Availability	**835.8**	**196.5**	**0.0**	**412.8**	**0.0**	**0.0**	**0.0**	**12.9**	**1458.1**
2020									
In-Basin Demands	102.4	287.3	304.4	144.0	152.6	1,128.7	529.7	492.7	3141.9
In-Basin Supplies									
Groundwater	23.3	112.8	8.3	38.7	31.1	251.1	87.1	156.1	708.5
Surface Water	1190.4	846.9	0.0	1356.4	0.0	257.7	57.8	487.1	4196.3
TOTAL	1213.7	959.7	8.3	1395.1	31.1	508.8	144.9	643.2	4904.8
Surface Water Transfers									
Imported Supplies	1.0	2.6	296.1	0.0	121.5	679.9	384.8	0.0	1485.9
Export Demands	2.6	266.9	0.0	993.4	0.0	60.0	0.0	163.0	1485.9
In-Basin Reserves	282.9	209.1	0.0	0.0	0.0	0.0	0.0	0.0	492.0
Net Surface Water Availability	**826.7**	**199.0**	**0.0**	**257.7**	**0.0**	**0.0**	**0.0**	**-12.5**	**1271.0**

Table 2-1: Southeast Area Water Supply Availability: 2000 - 2050, Continued.

Amount (Thousands of Acre-Feet/Year)

Category	*Sabine*	*Neches*	*Neches -Trinity*	*Trinity*	*Trinity-San Jacinto*	*San Jacinto*	*San Jacinto -Brazos*	*Brazos*	*Total Southeast*
2030									
In-Basin Demands	111.0	299.4	303.1	148.1	156.9	1,201.4	567.7	529.1	3316.7
In-Basin Supplies									
Groundwater	23.4	114.6	8.7	41.2	27.9	266.3	87.8	169.4	739.3
Surface Water	1190.4	846.9	0.0	1356.4	0.0	257.7	57.8	486.6	4195.8
TOTAL	1213.8	961.5	8.7	1397.6	27.9	524.0	145.6	656.0	4935.1
Surface Water Transfers									
Imported Supplies	1.0	4.1	294.4	0.0	129.0	726.2	422.1	0.0	1576.8
Export Demands	4.1	265.3	0.0	1072.6	0.0	60.0	0.0	174.7	1576.7
In-Basin Reserves	282.9	209.1	0.0	0.0	0.0	0.0	0.0	0.0	492.0
Net Surface Water Availability	**816.8**	**191.8**	**0.0**	**176.9**	**0.0**	**-11.2**	**0.0**	**-47.8**	**1126.5**
2040									
In-Basin Demands	123.1	321.7	306.7	159.3	167.0	1,298.3	617.9	583.2	3577.2
In-Basin Supplies									
Groundwater	23.5	116.3	8.8	43.8	29.6	280.5	88.8	181.1	772.4
Surface Water	1190.4	846.9	0.0	1356.4	0.0	257.7	57.8	486.0	4195.2
TOTAL	1213.9	963.2	8.8	1400.2	29.6	538.2	146.6	667.1	4967.6
Surface Water Transfers									
Imported Supplies	1.0	4.6	297.7	0.0	123.5	710.9	460.8	0.0	1598.7
Export Demands	4.6	268.7	0.0	1075.3	0.0	60.0	0.0	190.1	1598.7
In-Basin Reserves	282.9	209.1	0.0	0.0	0.0	0.0	0.0	0.0	492.0
Net Surface Water Availability	**804.3**	**168.3**	**0.0**	**165.6**	**-13.9**	**-109.2**	**-10.5**	**-106.2**	**898.4**
2050									
In-Basin Demands	135.8	344.8	310.6	174.5	179.9	1,386.4	668.4	639.2	3839.6
In-Basin Supplies									
Groundwater	23.6	118.3	9.0	46.7	31.0	291.8	89.7	197.3	807.4
Surface Water	1190.4	846.9	0.0	1356.4	0.0	257.7	57.8	485.4	4194.6
TOTAL	1214.0	965.2	9.0	1403.1	31.0	549.5	147.5	682.7	5002.0
Transfers									
Imported Supplies	1.1	5.1	301.6	0.0	123.5	710.9	476.3	0.0	1618.5
Export Demands	5.3	272.2	0.0	1075.4	0.0	60.0	0.0	205.6	1618.5
In-Basin Reserves	282.9	209.1	0.0	0.0	0.0	0.0	0.0	0.0	492.0
Net Surface Water Availability	**791.0**	**144.2**	**0.0**	**153.2**	**-25.4**	**-186.0**	**-44.6**	**-162.1**	**670.4**

Table 2-2: Trans-Texas Water Program Supply Availability: 2000-2050

Category	Amount (Thousands of Acre-Feet/Year) 2000	2010	2020	2030	2040	2050
Scenario 1						
Available Southeast Supply	1764.5	1458.1	1271	1126.5	898.4	670.4
West-Central Demand	-	-	150	300	450	600
Net Surface Water Availability	**1764.5**	**1458.1**	**1121**	**826.5**	**448.4**	**70.4**
Scenario 2						
Available Southeast Supply	1764.5	1458.1	1271	1126.5	898.4	670.4
West-Central Demand	-	-	-	100	200	300
Net Surface Water Availability	**1764.5**	**1458.1**	**1271**	**1026.5**	**698.4**	**370.4**
Scenario 3						
Available Southeast Supply	1764.5	1458.1	1271	1126.5	898.4	670.4
West-Central Demand	0	0	0	0	0	0
Net Surface Water Availability	**1764.5**	**1458.1**	**1271**	**1126.5**	**898.4**	**670.4**

existing supplies has diminished in terms of priority.

2.2.2 Phase II Program Modifications

The Phase II program was modified as a result of this evaluation. These modifications are:

- Reduced effort associated with the definition of conceptual interbasin transfer routes from Sabine and Neches River basins.
- Increased effort in defining water quality issues associated with Sabine Lake.
- Increased analysis of the socio-economic impacts of interbasin transfer on exporting and importing basins.

2.3 Public Issues Memoranda

Two memoranda report on investigations of public involvement issues; *Enhanced Public Participation*[4] and *Equity Issues Related to Water Transfers*[5]. Each of these describes the TTWP Southeast Area research into the program's public access and its responsiveness to public concerns. Very early in the TTWP process the Southeast Area sponsors recognized that directly involving members

of the public in the water planning process was necessary for program success. Early and meaningful citizen involvement may resolve major disputes and avoid future litigation. Phase II work began with an investigation of ways to broaden the initial public participation efforts on two fronts: by identifying individuals and groups who may not have been included in the TAC process, and by conducting one-on-one interviews with TAC members and others to ensure that issues were identified in time to be addressed within the TTWP study and planning process.

Enhanced Public Participation documents the conclusions drawn from over 70 personal interviews of project sponsors and representatives from local, state and federal government agencies, river authorities, environmental, recreation, civic and industry groups. The interviews sought information about perceptions, understanding and attitudes of the TTWP in general and the Southeast Area study specifically. A copy of the interview protocol and list of entities included in the interview process are included in Appendix D. The primary conclusions drawn from these interviews are as follows.

- Develop and disseminate public information about the TTWP and about the broad range of management alternative being considered.
- Provide better information regarding the population and water demand projections used in TTWP.
- Provide more information about the importance and impact of water conservation on water demand, specifically in the Houston Metro region.
- Investigate the complete range of impacts associated with interbasin transfers from the Sabine River basin including environmental, social and economic impacts and third party equity issues.
- Evaluate the impacts to the Sabine Lake and area wetlands from large-scale water transfers out of the basin.

TTWP addressed these issues in several ways.

- TAC membership was expanded with directed out-reach activities to interest groups that were not represented or under-represented. Representatives from Louisiana were invited to join the TAC.
- Convened the Sabine Lake Conference providing a forum for sharing of available scientific and other information among the academic community, technical staff of agencies and consultants, policy makers and the interested pubic.
- Focus groups and task forces met to provide substantive information and input to several areas of study including environmental impacts, equity issues and planning projections.
- Made additional TTWP presentations to interested groups and organizations.
- Expanded the distribution of planning and technical memoranda.
- Included in Phase II an examination of the equity issues associated with interbasin transfer.

The *Equity Issues Related to Water Transfers; Southeast Area* memorandum reports on this effort. The report examines equity issues related to a major transfer of water from the Sabine Basin. Two major types of issues were identified: environmental im-

pacts and "our water" basin of origin concerns. The basic approach recommended for accomplishing water transfers in the Southeast Area is informed negotiation with compensation and mitigation for impacts. The study recommendations are:

- The State of Texas take the lead in identifying and supporting a planning entity to undertake information gathering needed for decision-making in the Southeast Area.
- Following data collection, involved parties enter into negotiation seeking a solution that will recognize the full cost of a water transfer.

2.4 Projected Water Needs and Supply of the Upper Neches and Sabine River Basins

The TTWP Southeast Area includes only part of the Sabine and Neches River basins. Part or all of 21 counties are included in the upstream reaches of these two basins that lie outside of the program study area. Figure 2.2 illustrates the location of these counties relative to the TTWP Southeast Area. The populations of these counties rely upon the same river systems to meet water demands. These demands must be considered when determining the total demand for water within these basins and provided for when determining available supply in these basins.

Therefore, a detailed analysis of this issue was prepared and presented in *Projected Water Needs and Supply of the Upper Neches and Sabine River Basins*[6] in Phase II. The TWDB Consensus population and water requirement projections were used in this study. The report concluded that:

- All projected 2050 requirements in the Upper Neches Basin can be met with either existing sources or from the proposed Eastex project. There is no present indication that the future needs of the upper Neches area through the year 2050 will require water from the TTWP Southeast Area.
- The situation in the upper Sabine River Basin is more complex. Essentially all of the firm yields of the existing surface water reservoirs in the upper Sabine are already committed. A comparison of water requirements and available supply in the upper Sabine Basin in 2050 indicates a supply shortfall of at least 103,061 acre-feet per year. The shortages may be larger depending upon the location of demand and supply source within the basin.
- There are no new reservoir projects under development in the upper Sabine Basin and no water right has been granted for a major new reservoir in the area. Based on the consensus projections it is likely that the upper Sabine Basin could need to draw water from the Southeast Area over the study time horizon. The upper Sabine Basin total demand could be in the range of 100,000 to 200,000 acre-feet per year.

The report also notes:

- Projections of future population growth and water use area always uncertain. Any major development in the area could significantly alter population and water demand projections for the upper basin counties.
- There remains uncertainty in the amount of groundwater that can be developed in the upper basins. The report assumed that 1990 pumpage was a reasonable

Figure 2.2: Upper Neches and Sabine River Basins

predictor of long-term dependable groundwater use.

2.5 Sabine Lake Characterization

Initial investigation of environmental impacts of water transfers from the Sabine River Basin on the Sabine Lake system indicate a lack of base-line information on the environmental conditions of Sabine Lake and adjacent uplands and wetlands. TTWP undertook two activities to expand the knowledge about the lake and the potential impacts of large-scale transfer on the area's environment.

The Sabine Lake Conference: Where Texas and Louisiana Come Together[7] (September, 1996) assembled experts on the lake and surrounding uplands and wetlands from both Texas and Louisiana to share and document existing information. Presentations during the two-day conference provided an overview of the climatologic, geologic, hydrologic, ecologic and economic conditions associated with the lake as well as stewardship issues in both states.

The *Sabine Lake Salinity Analysis* looked at hydrodynamic and meteologic data collected from five water monitoring stations over a twelve-month period. The data were analyzed for flow and salinity patterns within Sabine Lake resulting from a reduction of freshwater inflows, using a two-dimensional hydrodynamic simulation model. This effort is continuing and final results will be available later in the year.

2.6 Galveston Bay Freshwater Inflows Assessment

The Galveston Bay Freshwater Inflows Group (GBFIG) began as a TTWP focus group of individuals concerned with maintaining the health and productivity of Galveston Bay. The 33,000 square mile Galveston Bay watershed consists of the Trinity and San Jacinto River Basins and the Neches-Trinity, Trinity-San Jacinto, and San Jacinto-Brazos Coastal basins. The bay consists of four separate embayments; Galveston, Trinity, East and West Bays. The TWDB has studied the health and productivity of Galveston Bay over the past several years in the Galveston Bay and Estuary program (B&E Program), specifically with regard to the freshwater inflows into the bay to optimize annual fisheries harvests. The B&E Program analysis determined that 5,220,000 af/y were required to produce the optimum fishery harvest in the bay.

The Board presented its findings on recommended inflows to the bay in 1997 but the GBFIG determined that a number of additional water availability hydrologic investigations were necessary to analyze current and future projected inflows into the bay. The *Galveston Bay Freshwater Inflows Assessment*[8] technical memorandum documents the first of these studies, an investigation of freshwater inflows estimating inflows under naturalized, intermediate and full development inflow conditions. The study analyzes the statistical frequency of obtaining certain hydrologic flow conditions within the Galveston Bay watershed based on water rights diversions upstream of the bay.

A complex multi-river basin simulation model determined projected freshwater inflows. The naturalized flow scenario assumed no water rights diversions. The intermediate and full development condition scenarios assumed water usage diversions for intermediate use and maximum use of current permitted diversions respectively. Comparing the results of this modeling with the TWDB B&E Program modeling indicate the following.

- Increases in water rights diversions will continue to decrease the availability of freshwater inflows that enter Galveston Bay. Future projected diversions could decrease inflows by as much as 30 percent from historical naturalized flow conditions.
- The bay and estuary maximun harvest monthly inflow targets can be achieved in eight months of the year (January, February, April, July, August, September, October, and November) upon maximum use of existing water rights permits. Projected water rights diversions will not negatively impact the bay in these months.
- Maximum use of existing water rights permits are projected to reduce monthly inflow into the bay below the bay and estuary maximun harvest targets by approximately 12 percent in the months of March, May, June, and December. Additional hydrologic analysis should occur to determine the impact of these inflow reductions.
- The geographic distribution of inflows is projected to shift. In upper Trinity Bay flows will decrease. In Upper Galveston, East and West Bays flows will increase as compared to historical events.

- The studies indicate that total inflows quantity, monthly distribution, and geographic distribution will change. It was not analyzed which of these parameters may have the greatest impact on fisheries productivity.
- Projected worst-case inflow conditions should significantly improve suggesting that future drought condition inflows may not be as low as has historically occurred due to increased return flows into the bay.

The GBFIG plans to continue to meet independent of TTWP to study other issues of concern with regard to the impacts of water resource development on Galveston Bay.

2.7 Impact of Potential Toledo Bend Operational Changes

TTWP investigated the potential impacts of changes in the operation of Toledo Bend Reservoir under various hydrologic conditions. Toledo Bend Reservoir was built to provide water supply for municipal, industrial and irrigation use and for generation of hydroelectric power. The total firm yield of the reservoir is estimated at 2,086,600 af/y. Under terms of an interstate agreement, the Toledo Bend Compact, Louisiana and Texas each own half of this supply (1,043,300 af/y each). The existing water rights of the Sabine River Authority of Texas provide for diversion and use of 750,000 af/y from Toledo Bend Reservoir. The present water rights in Texas leave some 293,300 af/y of the Texas firm yield unallocated.

This memorandum documents the investigation of the potential environmental significance of:

- increasing the permitted diversions for use in Texas from 750,000 to Texas' total firm yield share of 1,043,300 af/y;
- obtaining an interbasin transfer amendment and transferring 672,000 af/y (600 MGD) to areas west of the Sabine and Neches River Basins with no return flows to Sabine Lake.

Reservoir operation studies were made for two different fifty-year scenarios (1940 – 1989) at Toledo Bend. The first scenario examines impacts of full use of permitted supply. The second scenario examines a modified operating condition where the Texas use is increased to full use of its share of the firm yield (1,043,300 af/y) and an interbasin transfer of 672,000 af/y is transferred to areas from which there would be no return flows to the basin. Both scenarios assume greater use from Toledo Bend Reservoir than is now occurring. The analysis evaluates changes in the monthly lake levels, spills, inflows to Sabine Lake, Sabine River flows and recreation.

The study concludes that:

- Increased uses associated with full use of existing rights and export would lower Toledo Bend Reservoir levels an average of 0.9 foot and up to a maximum of 3.3 feet. There would be no noticeable decrease in lake levels one third of the time.
- 70 percent of the time there would be no change in spills. The other 30 percent of the time Toledo Bend Dam spills decrease, especially in February through May.
- Decreased flows to Sabine Lake range from 12.2 percent under the existing condition scenario to 20.7 percent under the modified condition scenario.
- Toledo Bend Reservoir tends to increase flows into Sabine Lake in summer months over natural flows.

- Toledo Bend Reservoir increases the shortages in the environmental flows specified in the TTWP environmental criteri, especially January through May, under all scenarios.
- Impacts on the Toledo Bend Reservoir or the lower Sabine River recreational activities of fishing and boating are not significant.
- The modified scenario heavily influences the estimated losses of freshwater inflow to Sabine Lake.

Please refer to the memorandum *Impact of Potential Toledo Bend Operational Changes*[9], January 1998 for complete information.

3. Technical Memoranda

Ten technical memoranda report on the investigation of water management alternatives considered within the Phase II TTWP Southeast Area study. Each of these reports documents the analysis of one water management strategy recommended for further study in the *Phase I Report*. Each memoranda includes a discussion of the strategy involved, a discussion of its relative importance to the TTWP, a projected amount of supply produced or saved by this strategy, its costs, and impacts associated with the strategy's use. The following sections briefly summarize each memoranda and list the primary factors and conclusions reported. Copies of the full technical reports are available from project sponsors and are recommended for a more complete understanding of each alternative.

A comparison of each alternative and its relative contribution to the TTWP Southeast Area long-range water management planning is included in the next section of this report.

3.1 Water Conservation

Water conservation is a demand management strategy designed to manipulate water usage characteristics and facilitate more efficient use of existing water supplies. It does not create new supply but allows existing supply sources to serve demand for a longer period of time and delays the need to develop new supply options. The demand reduction associated with implementation of conservation practices is calculated as the volume of conservation "savings". These savings are then evaluated against the originally projected water demand defined for the area.

The TTWP Southeast Area water conservation effort, as reported in *Water Conservation*,[10] provides a means to communicate the City of Houston's *Water Conservation and Reservoir Systems Operation Plan*[11] effort throughout the Southeast Area. To that end the TTWP used the City plan as baseline data for this evaluation.

The study assesses the viability of an "advanced" degree of water conservation defined as the implementation of conservation measures sooner and in addition to the "expected" conservation already incorporated into TWDB demand projections. The assessment concludes:

- The total quantity of conservation savings directly attributable to the advanced conservation measures examined in the study varies from 23,880 af/y to a maximum level of 64,773 af/y. This represents savings of approximately 2.9 to 6.3 percent of the total projected Houston Metro water demand. See Figure 3.1 for a comparison of water demand under expected and advanced conservation scenarios.
- The impact of these conservation savings on total Southeast Area water availability is to allow existing area supplies to meet projected demands for an additional 10 years in the San Jacinto, Trinity-San Jacinto, and San Jacinto-Brazos Basins. Appendix E, Southeast Area Water Availability with Advanced Conservation Strategy 2000 –

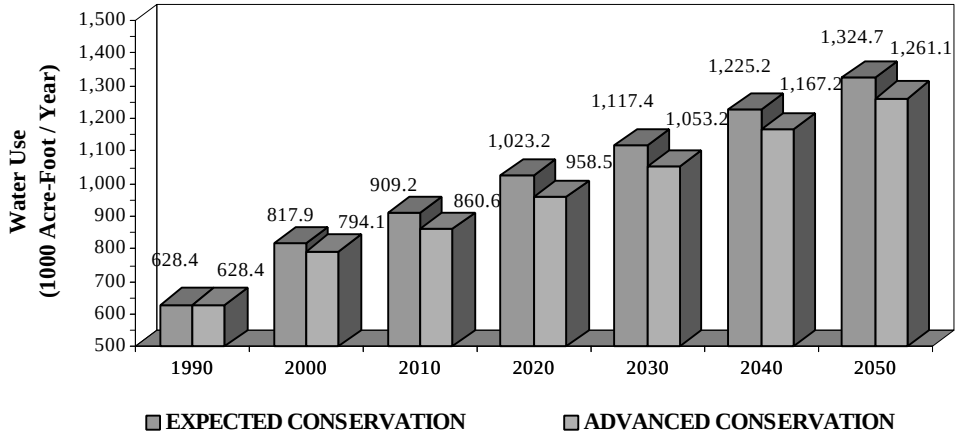

Figure 3.1: Comparison of Projected Municipal Water Demand with Conservation

2050, details these savings across the study time horizon and basins.

Minimal environmental impacts are expected from the City of Houston's conservation activities. Construction-related impacts are limited to building interiors and existing urban streetscapes. Minor reductions in water quantity within the basin due to reduced return flows may occur. Consumers may experience short-term price increases to compensate the

- utility for loss of revenue from water sales. This minor impact (1.2 percent) is due to the positive impact of deferred capital cost expenditures needed for construction of additional water and wastewater treatment facilities. The cost of "saved" water is approximately $120 per acre-foot.

3.3 Desalination

The TTWP evaluated the potential desalination of brackish groundwater to provide additional supply in the high demand Harris, Fort Bend, Brazoria county area. Preliminary investigations, published in *Desalination,*[12] indicated that, for cost-effectiveness, the desalination strategy would be configured to address mid- to long-term demand shortfalls in the Trinity-San Jacinto, San Jacinto, San Jacinto-Brazos and Brazos basins. The analysis investigated developing a desalination facility that could contribute to the water supply in this area. The source supply for the facility would be a groundwater well field in Harris County withdrawing brackish water from the lower Evangeline and upper Jasper aquifers. A desalination plant utilizing a reverse osmosis (RO) process would extract dissolved solids from the groundwater to provide 44,600 af/y to southeastern Harris and northern Galveston counties. Brine concentrate effluent would be discharged directly into the Houston Ship Channel. See Figure 3.2.

Key findings of the analysis are:

- The desalination strategy can meet projected San Jacinto-Brazos basin demands through the year 2050 however, even when coupled with existing regional water supplies, projected water deficits will exist within the Houston region by 2020.
- Environmental impacts associated with a desalination strategy appear to be potentially significant. The additional salt

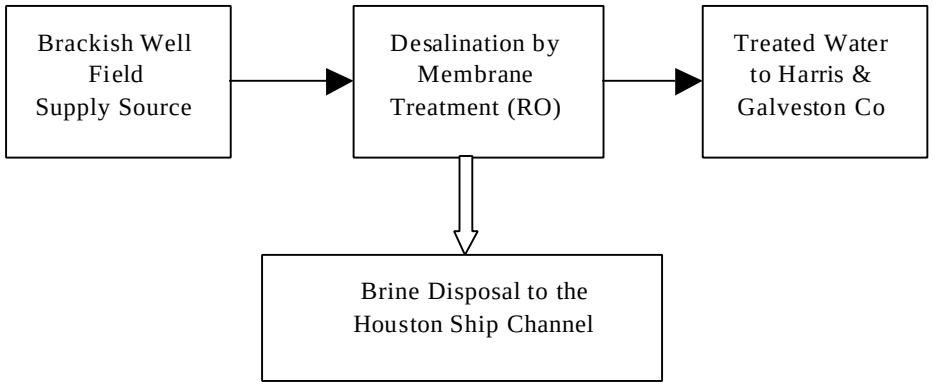

Figure 3.2*: *Desalination Process Diagram

concentrate disposal into the Houston Ship Channel may cause localized aquatic environmental impacts. Potential land subsidence impacts could also eliminate this alternative from consideration.

Total capital costs of implementing the proposed desalination strategy are approximately $151 million. This is approximately $1,270 per acre-foot of supply.

3.4 Wastewater Reclamation

An investigation of Wastewater Reclamation as a strategy for Southeast Area TTWP examines the potential of meeting some of the Houston Metro region shortages through the use of reclaimed wastewater from the City of Houston's 69th Street, Sims Bayou North, and Sims Bayou South Waste Water Treatment Plants (WWTPs). A technical memorandum, *Wastewater Reclamation*,[13] documents the results of this study. The strategy consists of diverting effluent from these three city WWTPs, treating the wastewater to a quality acceptable to industrial customers for process and cooling water uses, and transmitting the treated wastewater to customers through the Coastal Water Authority's (CWA) industrial raw water distribution system.

The system proposed would be designed to meet the water demand of 9 industrial customers located along the existing CWA B1 line. The design criteria are configured to supply 100 percent of the demand 100 percent of the time. The proposed system transmits 95 million gallons per day (MGD) of wastewater from the three City of Houston WWTPs to a Wastewater Reclamation Plant (WRP). The WRP will employ a membrane (reverse osmosis) treatment process to remove all identified pollutants before flowing to the finished water pump station for distribution to industrial users through the CWA B-1 line. Brine concentrate, the process effluent, would be discharged into the Houston Ship Channel. See Figure 3.3.

The key findings of the analysis are:

- An 81-MGD capacity reclamation facility would provide approximately 90,700 af/y of water to meet future demands of approximately 9 industries along the

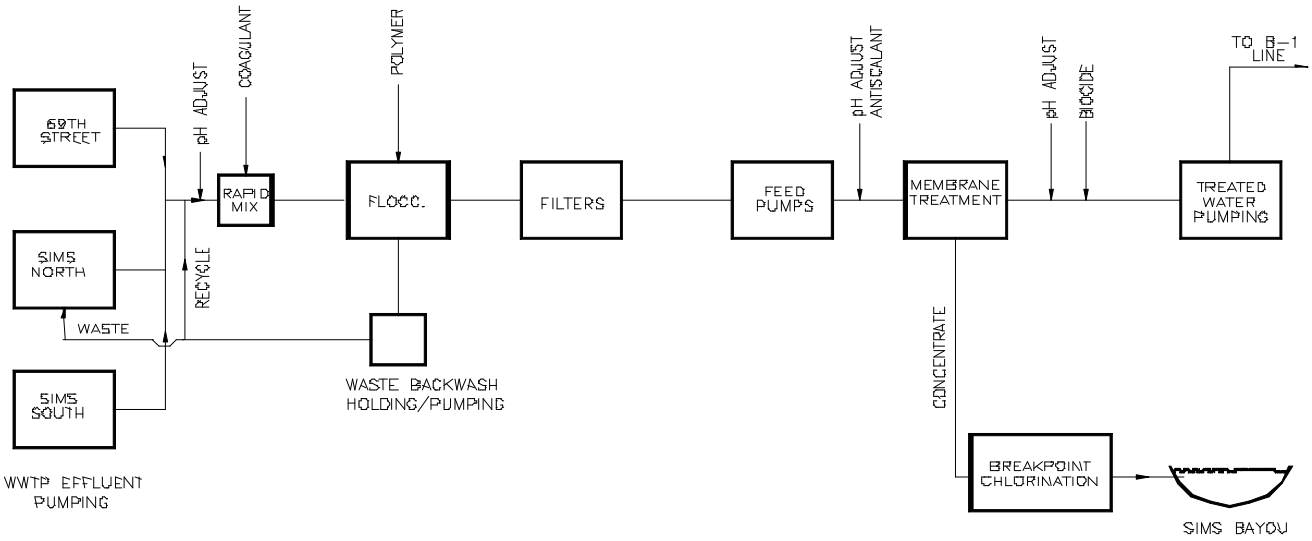

Figure 3.3: Wastewater Reclamation Plant Schematic

CWA B-1 line in the Houston Metro area.

- The environmental impacts associated with this strategy do not appear to be significant. The additional WRP salt concentrate disposal into the Houston Ship Channel is similar to existing water quality. Localized environmental impacts from the discharge of nitrate-nitrogen may be mitigated through the removal of ammonia-nitrogen by use of breakpoint chlorination treatment facilities.
- This strategy would have a total capital cost of $103.4 million for an average per unit cost of approximately $825 per acre-foot.

3.5 Systems Operation of Surface Water Supply Sources in the Houston Area

Where a surface water system has more than one source of supply, it is often possible to coordinate operation of the overall system in a way that will produce more yield than could be obtained if the various sources were each operated independently. This study examined the potential gain from coordinated system operation of Lake Houston, Lake Conroe, Lake Livingston and the Wallisville salt-water barrier. Lake Houston and Lake Conroe have been functioning to some degree as a system for over 20 years. It is also generally understood that Lake Livingston and the Wallisville barrier will also function as a system when construction of the barrier is complete. This study reviews the applicable system operation methods, and explains how much additional yield can potentially be gained through these methods.

A technical memorandum, *Systems Operation of Surface Water Supply Sources in the Houston Area*[14] cites the following key items.

- The total current firm yields of the three existing major reservoirs is 1,169,583 af/y based upon the complete

use of each reservoir's conservation storage during the critical drought and excluding return flows of treated wastewater.

- The Wallisville salt-water barrier, when complete and in operation, will have no conservation storage and thus no firm yield. Its benefit is preventing salt water from moving upstream during low flow periods. This "frees" fresh water supplies used to keep salt-water away from diversion intakes on the lower river.
- A gain in firm yield of 101,517 af/y could result from the coordinated operation of Lakes Houston and Conroe due to increased efficiency of operation and minimizing spills at Lake Houston. Operation to maximize system yield would result in severe drawdown of Lake Houston.
- If releases from Lake Livingston are coordinated closely with the natural runoff in the Trinity River downstream from Livingston Dam, the available supply would be increased by 72,147 ac/y.
- The combined additional supply resulting from the coordinated system operation concepts is 173,664 af/y.
- Modeling that assumed less severe drawdown conditions on Lake Houston (leaving moderate volumes in storage) indicates a gain of 135,060 af/y from system operations of Lakes Conroe, Houston and Livingston.
- Modification of existing water rights would be necessary to effectively use these gains.
- The system operation of Lakes Conroe and Houston should have minimal environmental impact on Lake Conroe. Any impacts associated with the altered operation should be positive. The increased instream flows in the San Jacinto River between the lakes should have a positive impact on most aquatic species. A detailed analysis is needed to determine these impacts before plan implementation.
- The reduction in the freshwater flows to the Trinity-San Jacinto estuary resulting from decreased Lake Houston releases should have minimal impacts since it accounts for one percent, or less, of total monthly inflows.
- Impacts to Lake Houston associated with the strategy would be significant under either proposed scenarios, particularly for fisheries and recreational opportunities. A comprehensive analysis of impacts to Lake Houston should be conducted after an operations plan is developed.
- An examination of the siltation and yield loss outlooks for Lakes Houston and Livingston indicate that between years 2000 and 2030 firm yield losses in the two lakes are predicted to be 6,213 af/y and 22,723 af/y respectively. Dredging costs (1997 dollars) to restore these losses would be approximately $3.2 million per year for Lake Houston. Lake Livingston dredging costs would be $23 million per year.

3.6 Allens Creek Reservoir

The Allens Creek reservoir site, located on the west bank of the Brazos River near Wallis in Austin County, was originally planned as a cooling water source for a proposed nuclear power plant. The plant was never developed and the site has been rec-

ognized as a potentially valuable strategy for a regional surface water reservoir.

The TTWP investigations include hydrologic studies, costs estimates and environmental impacts of the proposed project. The proposed reservoir would have a conservation capacity of 142,892 acre-feet. It would have a small drainage area on Allens Creek and would receive supplemental inflows from a Brazos River pump station. Based upon computer simulation the project would have a use rate of 70,000 af/y and a pumping capacity of 1,600 cfs at the Brazos River. The memoranda *Operation Studies and Opinions of Cost for Allen's Creek Reservoir; Volumes I and II* and *Status of Environmental Issues for Allens Creek Reservoir*[15] document the following key findings.

- The median chloride and total dissolved solid concentrations in the reservoir would be approximately 94 milligrams per liter (mgl) and 425 mgl respectively, in accordance with the environmental criteria adopted for studies of the TTWP.
- The impact of the Allens Creek project on instream flows and water quality in the Brazos River would not be significant.
- Environmental impacts of the Allens Creek project include the loss of about 700 acres of wetlands and bottomland hardwoods in the area known as Alligator Hole. Realignment of the northern end of the embankment would exclude Alligator Hole from the reservoir and would be both feasible and desirable.
- Mitigation would be required for the inundation of wetlands and riparian zones. Including Alligator Hole, wetlands total 1,628 acres, and there are 480 acres of bottomland hardwoods. Acreage of required mitigation wetlands might vary from 3,256 to 8,140 acres.
- Several significant archeological sites will be adversely impacted by the proposed project. These impacts may be mitigated by prior recovery efforts at the site.
- Several endangered and threatened species may be impacted by the proposed reservoir. Surveys for some of these species may be required and impacts, if any, addressed at that time.
- The proposed project will require a Texas Natural Resource Conservation Commission water rights permit, a U.S. Army Corps of Engineers permit issued under Section 404 of the Clean Water Act and other permits. It will also require review by the Federal Emergency Management Agency (FEMA) and the local floodplain administrator for compliance with FEMA regulations. Local governmental review may also be required.
- The project is estimated to generate $24 million to $67 million annually through enhanced recreational use.
- The project would have a capital cost of $169 million for a unit cost of $351 per acre-foot with an average present worth unit cost of $0.28 per thousand gallons.

3.7 Neches Salt Water Barrier

The Neches River saltwater barrier project at Beaumont has been proposed as a means of protecting the fresh water supplies of the Lower Neches Valley Authority (LNVA) and the City of Beaumont. Both LNVA and Beaumont have water supply intakes located below sea level and these are threatened

with saltwater flows during times of low flow in the river. Releases of fresh water from the B. A. Steinhagen/Lake Sam Rayburn system supplement natural inflows below the lakes to prevent salt water from reaching these intakes. Releases from the system represent a significant loss of usable freshwater yield from the lake system.

The construction of temporary salt water barrier structures provide some protection from the salt water intrusions but, due to the temporary condition of the barrier, fresh water supplies from the Steinhagen/Rayburn system must be reserved to provide the flows necessary to prevent salt water intrusion if needed. The construction of a permanent salt-water barrier would provide a permanent solution to the problem and free up fresh water yield for municipal, industrial or other use. The *Environmental Analysis for the Neches Salt Water Barrier; Beaumont, Texas*[16] evaluates the existing environmental conditions and potential impact of construction, operation and maintenance associated with the structure.

The proposed plan (Site #6), located at river mile 29.7, protects both LNVA and the primary City of Beaumont intake structures from salt water intrusion. It eliminates several problems associated with the temporary barriers and promotes benefits to the natural and human environment. The study concludes that the permanent barrier would accomplish the following.

- Restore year round fresh water to the Neches River and Pine Island Bayou.
- Improve upstream water quality and thereby enhance the overall aquatic habitat and recreation value of the river.
- Free up usable yield in the Steinhagen/Rayburn system.
- Support the natural conditions of and provide unrestricted boat access to the Big Thicket National Preserve (BTNP).
- Allow private and commercial navigation of the river.

There are however potentially significant environmental impacts associated with the construction and operation of the permanent barrier. These include the loss of 60 acres of high quality cypress-tupelo swamp and bottomland hardwood as well as wetlands, emergent aquatic vegetation and scrub shrubs and potential impacts to several threatened or endangered species or their habitats. The report notes several issues that must be addressed before a complete picture of the full impacts can be established including: an in-depth Habitat Evaluation Procedure; cultural resource survey; and permitting and regulatory issues regarding compliance with Federal Emergency Management Agency floodplain regulations and the Texas Coastal Coordination Council's Texas Coastal Management Plan.

Construction of the permanent saltwater barrier at the proposed location would "save" 156,800 af/y of firm yield from the Rayburn/Steinhagen system that could be allocated to municipal, industrial or other use. The analysis indicates that this strategy would have a capital cost of $60.4 million equaling a unit cost of approximately $35 per acre-foot.

3.8 Contractual Transfers

A contractual water transfer is the temporary or permanent transfer of water supplies from one party to another that may or may not involve an exchange of water rights. The primary advantage of contractual transfers is the opportunity to reduce or defer the construction of major new water convey-

ance facilities. Contractual transfers range from the simple execution of agreements between two parties for the re-allocation of existing supplies to more complex transfers including construction of physical facilities that allow replacement of supplies. Contractual transfers make the most efficient use of existing water supplies by allocating available supplies to entities needing the water.

Four specific contractual transfer alternatives were recommended for further study in Phase II of the TTWP Southeast Area. These four alternatives include:

- Replacing Brazos River water owned by the Gulf Coast Water Authority with other available supplies.
- Replacing Lake Conroe water owned by City of Houston with other available supplies.
- Replacing City of Houston and Trinity River Authority water with other available supplies in order to meet West-Central study area needs.
- Transferring irrigation water supplies to municipal or industrial purposes.

The results of these investigations are reported in the technical memorandum *Contractual Transfers.*[17]

3.8.1 *GCWA/Brazos*

- The GCWA/Brazos contractual transfer could potentially replace approximately 122 mgd (136,600 af/y) of Brazos River water at the Texas City Reservoir with Trinity River water supplies, making available that same quantity of new supply into the Brazos basin.
- The GCWA/Brazos transfer requires construction of water system improvements with a construction cost of approximately $100 million. The cost of developing this project is approximately $455 per acre-foot.

3.8.2 *City of Houston/San Jacinto*

- The City of Houston/San Jacinto contractual transfer provides for the re-allocation of existing water supplies between the City of Houston and the SJRA. The purpose of this transfer is to satisfy the long-term water needs of Montgomery County through year 2050 by allocating all of the City's Lake Conroe water supplies (66,667 af/y) to the SJRA. In exchange, the SJRA would contract an appropriate quantity of their current supplies within the lower San Jacinto River basin to the City of Houston.
- There are no physical facilities needed to accomplish the City of Houston/San Jacinto basin transfer; therefore no capital cost is required. Likewise, no environmental impacts are associated with this strategy because all of the existing water supplies, water facilities, and permits are in place to accomplish the necessary contractual transfers. However, there are a number of institutional issues associated with valuation of water supplies and future use of water system facilities that would have to be determined by each of the contracting parties.

3.8.3 *City of Houston/Trinity*

- The City of Houston and Trinity River Authority/Trinity basin contractual transfer could provide the mechanism to facilitate conveyance of large quantities of water supply from the TTWP Southeast Area to the West-Central Area.

This transfer utilizes the strategic location and capacity of Lake Livingston to provide for the transfer of 300,000 or 600,000 acre-feet/year from the Trinity basin to the Brazos basin. This contractual transfer consists of conveying east Texas water supplies via interbasin transfer into the lower Trinity River basin for use by the City of Houston and the Trinity River Authority. These supplies would supplant existing City of Houston and TRA water supplies in Lake Livingston and therefore allow conveyance of similar quantities of supply to the Brazos basin for use by TTWP West-Central water supply entities.

- The incremental capital cost of supplying 300,000 and 600,000 af/y to the West-Central Area is approximately $307.5 million and $575.4 million, resulting in a water cost of approximately $1025 and $960 per acre-foot, respectively.

3.8.4 *Irrigation*

- Irrigation contractual transfers are possible due to the expectation that a significant decrease in water demand will occur for irrigation interests with senior water rights from the Sabine, Neches, Trinity, and Brazos Rivers. Potentially available irrigation water supplies are projected to increase from approximately 475,000 af/y in year 1990 to over 641,000 af/y in year 2050. These available supplies are established within existing water rights permits and are reliable senior rights that could be used for municipal and industrial water use purposes.
- Based on the location of these irrigation supplies, it is expected that the Brazos basin supplies (44,400 af/y) will remain in that basin and be re-permitted for municipal and industrial uses. No new water system improvements would be necessary to make these supplies available to the region.
- A total of approximately 178,000 af/y of irrigation supplies are projected to become available within the lower Trinity basin. These supplies would have to be transferred to municipal and industrial water suppliers, but no significant new water system improvements would be necessary to make use of these supplies.
- Approximately 418,300 af/y of irrigation supplies are projected to be available within the lower Neches and Sabine River basins. These supplies represent over 50% of the total available irrigation supplies within the entire TTWP Southeast Area. Use of these supplies would require construction of an interbasin conveyance system with a capital cost of approximately $215.4 million and a water cost of approximately of $955 per acre-foot. Significant institutional and equity issues would also require resolution in order to implement this contractual transfer opportunity.

3.9 Interbasin Transfers

Transfer of surplus water supply from the Sabine and Neches River basins to the Houston Metro area or areas west of the Southeast Study Area was one of the initial program goals. The Phase I Report identified specific transfer routes for further study to determine which ones were most environmentally favorable. The *Environmental Analysis of Potential Transfer*

Routes[18] documents the results of this study. The conceptual design and cost estimates for the transfer route segments that were recommended for the Trans-Texas Interbasin Transfer Strategy are described in *Engineering Analysis of the Interbasin Transfer Strategy.*[19] Together these reports define the TTWP interbasin transfer strategy.

Three transfer scenarios are evaluated:

Scenario 1: Out-of-region transfers needed up to 600,000 af/y to the San Antonio area beginning in year 2020;

Scenario 2: Additional supply availability west of the Southeast Area delaying transfers until year 2030 and reducing the needed volume of out-of-region transfers to 300,000 af/y;

Scenario 3: Extensive development of local supplies west of the Southeast Area with no out-of-region transfers required.

All of these scenarios assume interbasin transfer of water within the Southeast Area to meet the area's needs. Water from the Trinity Basin is transferred westward to the Houston area to meet local shortfalls by year 2030. By 2050, shortfalls are expected to exceed the supply available from other sources within the Southeast Area and transfers from the Sabine and Neches Basins will be required to meet in-region demands.

The existing environment along each of 16 transfer segments is described in terms of:

- length,
- compatible land use,
- threatened and endangered species,
- river and stream crossings,
- wetlands,
- water quality,
- prime farmland soils,
- geology,
- public lands, and
- traffic.

Sensitive natural communities, vegetation areas, fisheries, and cultural resources are discussed for the general vicinity surrounding the segments. Static lift, or the total increase in elevation from the beginning to the end of a segment, is also included in the general description of each segment. Based on these criteria and the level of potential environmental impacts predicted three preferred segments were recommended for further consideration:

- Sabine River to Neches River, Segment SN-4b;
- Neches River to Trinity River, Segment NT-3b; and
- Trinity River to Brazos River, Segment TB-1.
- Additional segments evaluated to provide for transport to the Houston Metro area including Trinity River to San Jacinto River, Segments TS-3b and for San Jacinto river to Brazos River, Segment SB-1b.

For further information on the environmental evaluation please refer to the report. A map of alternative route segments is included as Figure 3.4.

The conceptual planning assumed that existing facilities would be used whenever possible including the Sabine River Authority canal and pump station, Lower Neches Valley Authority Main Canal and pump stations, and the Coastal Water Authority canal and pump station. Consideration for canal losses, terminal storage,

seasonal variation and wetlands mitigation requirements were included in the analysis. Water wheeling, the contractual transfer or "trading" of water, discussed later in this report, is also assumed for this project.

The engineering analysis concludes that, for the routes recommended based on the environmental screening, the following costs can be predicted.

Scenario 1 meets the needs of the Southeast Area and also exports 600,000 af/y to the Brazos River for a maximum export of 1,018,000 acre-feet per year by year The route segments used are SN-4b, NT-3b, TS-3b, TS-4b, and TB-1. This scenario will have a total capital cost of $791 million, an average cost of $607 per acre-foot or a present worth average cost of $0.23 per 1,000 gallons.

Scenario 2 meets the Southeast Area's needs as well as export 300,000 af/y for a total maximum export of 718,000 af/y by year 2040. This scenario uses the same transfer route as Scenario 1 and has a capital cost of $523 million, an average acre-foot cost of $830 or a present worth average cost of $0.27 per 1,000 gallon.

Scenario 3 meets only the Southeast Area's needs with no out-of–region exports. It uses route segments SN-4b, NT-3b, TS-3b, TS-4b to transfer 418,000 af/y from year 2040. The capital cost is $215 million, average costs for this supply will be $955 per acre-foot or a present worth average cost of $0.24 per 1,000 gallon.

Figure 3.4: Southeast Study Area Alternative Route Segments

4. Summary of Results

The purpose of the TTWP was to evaluate a full range of water management strategies identifying the most cost-effective and environmentally sensitive strategies for meeting current and future water needs for one-third of the state's citizens. The Southeast Area, with some of the fastest growing communities in the nation, focused its efforts on

a. defining the projected water needs for each county and use type,

b. determining the level of existing water supply available by location and permitted use, and

c. examining specific water management strategies which can provide additional water supply to meet the region's future needs and the future needs of areas outside the Southeast Area.

The previous sections of this report have summarized each of these activities.

It is useful to review the results of each technical study in light of the demands identified for the Southeast Area and in the South -, West -, and North - Central portions of the state.

4.1. Southeast Area Population Projections

The population projections for the Southeast Area indicate that by 2050 there will be a total of 9.8 million people in the region. The Sabine River Basin will have the smallest population and the San Jacinto River Basin will have the greatest. Projections indicate a 165 percent increase in population over the 50 years for the San Jacinto - Brazos Coastal Basin but increases of 28 percent over the same time frame for the Trinity-Neches Coastal Basin. Table 4.1 details the population projections for the region.

4.2. Southeast Area Projected Water Demand

The *Planning Information Update* indicates that water demand within the Southeast Area will grow to almost 4 million acre-feet per year by 2050, an increase of 146 percent from the 1990 demand esti-

Table 4.1: Population Projections for the Southeast Study Area, 1990 - 2050

	Population (Thousands)						
River Basin	***1990***	***2000***	***2010***	***2020***	***2030***	***2040***	***2050***
Sabine	107	116	124	130	137	142	148
Neches	315	354	384	414	447	478	509
Neches-Trinity	194	210	220	231	238	244	249
Trinity	153	180	201	225	250	270	289
Trinity-San Jacinto	96	118	136	159	173	191	206
San Jacinto	2,771	3,208	3,737	4,389	4,839	5,365	5,783
San Jacinto-Brazos	705	857	1,034	1,247	1,459	1,675	1,874
Brazos	304	347	408	473	544	617	697
Total, Southeast Area	4,646	5,390	6,244	7,267	8,086	8,983	9,755

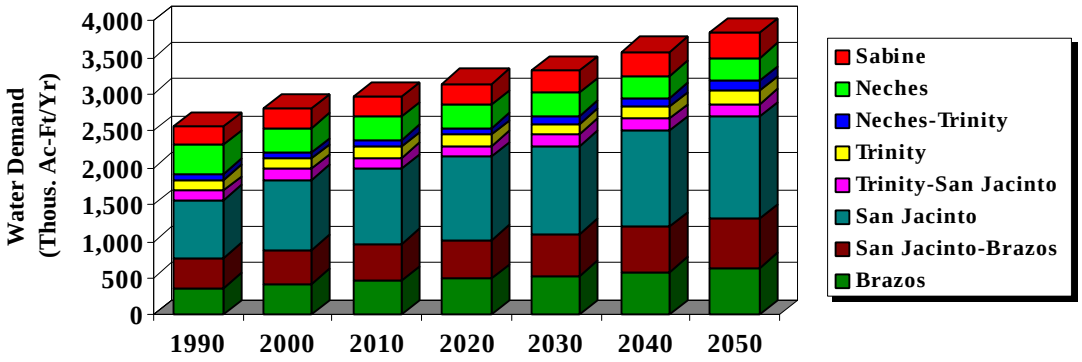

Figure 4.1: Cumulative Water Requirements for the Southeast Area

mates. The San Jacinto, Brazos and Sabine River basins, service areas for the Houston Metro area, account for the largest predicted increases. The basins on the eastern side of the region experience the lowest demand increases. Figure 4.1 illustrates the demand projections for each basin in the Southeast Area over the 50-year program.

4.3. Central Texas Water Demands

In addition to water demands within the Southeast Study area, the TTWP examines the potential for meeting Southeast Area demands and, in addition, transferring "surplus" supply to other TTWP study areas in central Texas. Three scenarios are investigated; transfers of 600,000 af/y, transfers of 300,000 af/y, and no transfers of Southeast Area supply west of the Brazos River basin.

Groundwater, surface water captured in reservoirs, and run-of-river sources comprise the available water supply within a river basin. Section 3.0 of the *Phase I Report* defines, in detail, the sources and amounts of groundwater and surface water supplies in the Southeast Area. In summary, estimates of groundwater pumpage in the region range over time from a low of 0.7 million af/y to a maximum of 0.9 million af/y. Total existing surface water available in the region amounts to 4.2 million af/y, which includes 495,800 af/y of run-of-river yield.

These supplies are not distributed evenly over the Southeast Area but are heavily concentrated in the eastern part of the Southeast Area, specifically in the Sabine, Neches and Trinity River Basins. Figure 4.2 illustrates this and its impact on long-term supply availability in the Southeast Area. Over time, supply shortages appear in the basins on the west side of the Southeast Area while significant supplies remain in the eastern basins. Interbasin transfers currently move water from water rich basins to the high demand areas in the San Jacinto River and coastal basins or shortages would already be occurring in the region. These transfers are permitted under existing water rights and will continue in the future. Further transfers will be needed to meet future demands both in the Southeast Area and in the rest of the state.

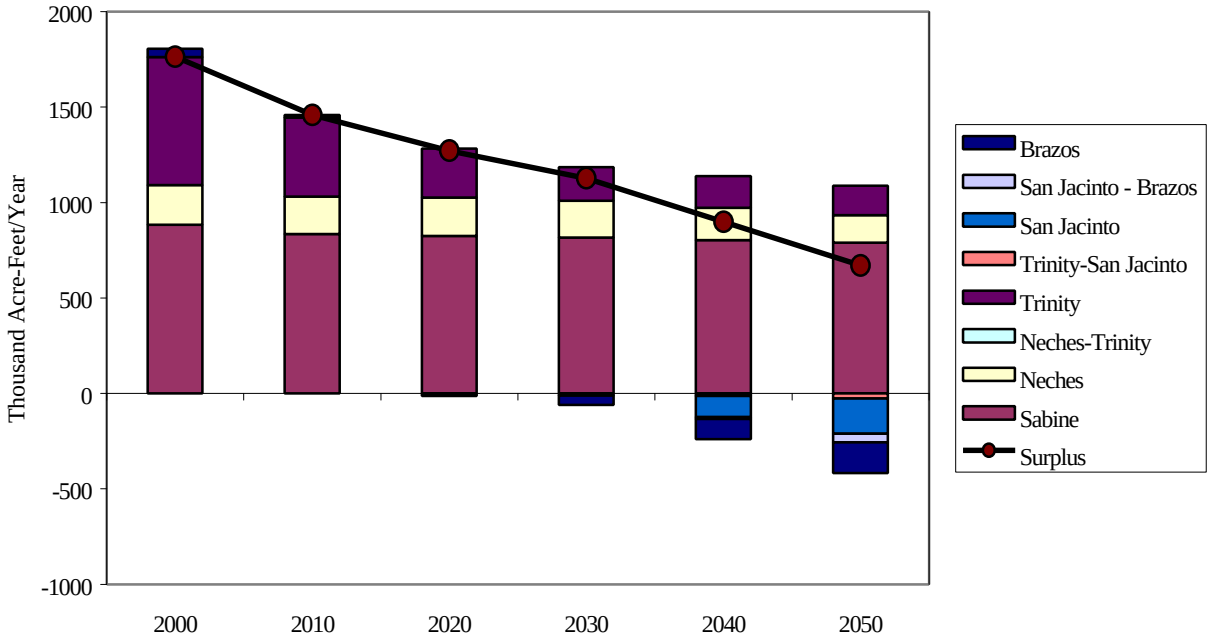

Figure 4.2: Southeast Area Water Supply Availability by Basin

4.4. Water Management Alternatives

The TTWP investigated 8 basic water management strategies; each reviewed in previous sections of this report. The purpose of these investigations was to explore new methods of meeting future demand requirements within the Southeast Area and in central Texas. Table 4.2 compares each of the technical strategies for additional supply generated (or saved), the cost to construct, cost per acre-foot of supply and the potential impacts on environmental, social and economic systems. The table also notes the proposed destination and the time frame for new supply resources.

4.5 Conclusions

There are several conclusions to be drawn from all of the assembled planning and technical data.

- The Southeast Area has a surplus of available supply. The supply is adequate to meet all regional needs through and beyond 2050, the planning horizon of the TTWP. Available water resources are adequate to meet all TTWP demands, both the Southeast Area needs and those of Central Texas.
- There is a disparity between resource centers (basins with "surplus" supply) and demand centers (basins with supply shortages). See Figure 4.2.
- Due to the need for additional supplies at differing times over the

TTWP horizon, it is unlikely that any single water management strategy could efficiently satisfy all TTWP supply requirements but implementation of a range of strategies is more likely to meet the TTWP goals.

- Implementation of water management strategies can extend the period of adequate supply and delay the need for developing new resources in areas of shortage. These strategies include water conservation in the Houston Metro area, contractual transfers between basins, and systems operations of Lakes Houston and Livingston. Combined, these strategies could delay the need for major new resource development by 15 to 20 years.
- Other strategies can increase the water supply from existing facilities such as the Neches Salt Water Barrier project. This strategy creates "new supply" from existing supplies not currently available for use.
- The development of Allens Creek Reservoir can, at a reasonable cost, provide a new supply source for the western side of the Southeast Area or act as a transfer-regulating storage reservoir for supplies being shipped from the Southeast Area to Central Texas.
- Many of the alternative strategies require interbasin transfers to connect supply and demand centers or to "wheel" water resources.
- Large-scale interbasin transfer of Sabine River supply is the only strategy that could solely meet the long-range Southeast Area demands and the demands of central Texas.
- Desalination, while a viable alternative, can not compete economically in the Southeast Area with other strategies at this time. In addition to its economic cost, desalination may have significant environmental impacts that will require further study before this alternative could be recommended.

It is also clear from these studies that providing for the long-range water needs of any single community will be increasingly difficult. Long-range planning requires a broader perspective than that of one community's need or source of supply. The issues facing tomorrow's facility planners extend beyond the corporate limits of cities or county boundaries. Issues such as public access to and consent on decisions regarding major construction projects, environmental and economic issues, questions of equity between exporting and importing basins will all require decision makers to take a broader view and to involve the public in the planning process. The TTWP provided valuable experience in learning how to identify interested parties, engage them in a discussion of these issues and involve them in the decision-making process.

Table 4.2: Southeast Area Wataer Supply Availability by Basin

5. The TTWP Legacy: Senate Bill 1 Regional Water Planning

In 1997 the Texas State Legislature passed the Omnibus Water Bill designated as Senate Bill 1. This bill directs sweeping changes in the way water resource planning will be conducted in this state. Among other things, it requires water master planning at the regional level for the entire state. From the year 2000 the State Water Plan will be a composite of the plans from some 16 regions. These plans must determine regional needs and available supplies evaluate alternative methods of meeting their water needs, involve a broadly defined public in the decision-making process, and acknowledge competing needs and equity issues in its plan. The TTWP was the forerunner of this bill.

The Trans-Texas Water Program grew out of a Southeast Area initiative to look at long-range water supply planning from a regional, multi - basin approach. In 1992, Mayor Bob Lanier convened a meeting of leaders from major demand centers in the state, Houston, San Antonio, Corpus Christi and Austin, and the primary water providers, the local river authorities, to discuss how rational, cost-efficient and environmentally sound solutions to long-range water supply could be accomplished. The State found merit in this regional approach and supported the effort creating the TTWP. Local sponsors of the Southeast Study Area have benefited from the program is several ways:

- Technical studies associated with the TTWP put the local sponsors far ahead in the newly mandated regional planning processes.
- Planning data have been assembled for each county and use type. Detailed information of water resources have been collected and evaluated.
- Specific management strategies have been investigated as to their engineering, economic and environmental appropriateness for local use.
- TTWP developed new methods of involving the public in making decisions and choosing among alternative solutions.
- Local interests and issues were identified and discussions on key issues of concern are on-going as with the Galveston Bay Freshwater Inflows Group.
- Needed environmental research has been conducted under TTWP including the Sabine Lake Conference and the Sabine Lake Salinity Study. This research will be crucial to decisions regarding water exports from the basin and protecting the river, adjacent wetlands, and lakes from environmental damage.
- Important issues of equity for “third party” interests in the Sabine and Neches Basins were identified and mechanisms for representing these interests explored. These issues and the need to accommodate them are recognized in SB1.
- Valuable partnerships have been forged both among different interests in the state and with Louisiana, which shares the Sabine River, Toledo Bend

Reservoir and the Sabine Lake system with Texas.

The road ahead for water resource planning is changed because of the TTWP. Decision-makers will look for regional solutions and opportunities. They will engage local citizens and interest groups in decision making. They will consider a wide range of alternative strategies when seeking solutions and they will evaluate these strategies over a wider range of criteria including engineering and economic criteria but also environmental and social ones. They will coordinate their planning efforts with others within their region and those of neighboring regions. They will be partners with the state planning authorities in shaping the elements of the State Water Plan for the next century.

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