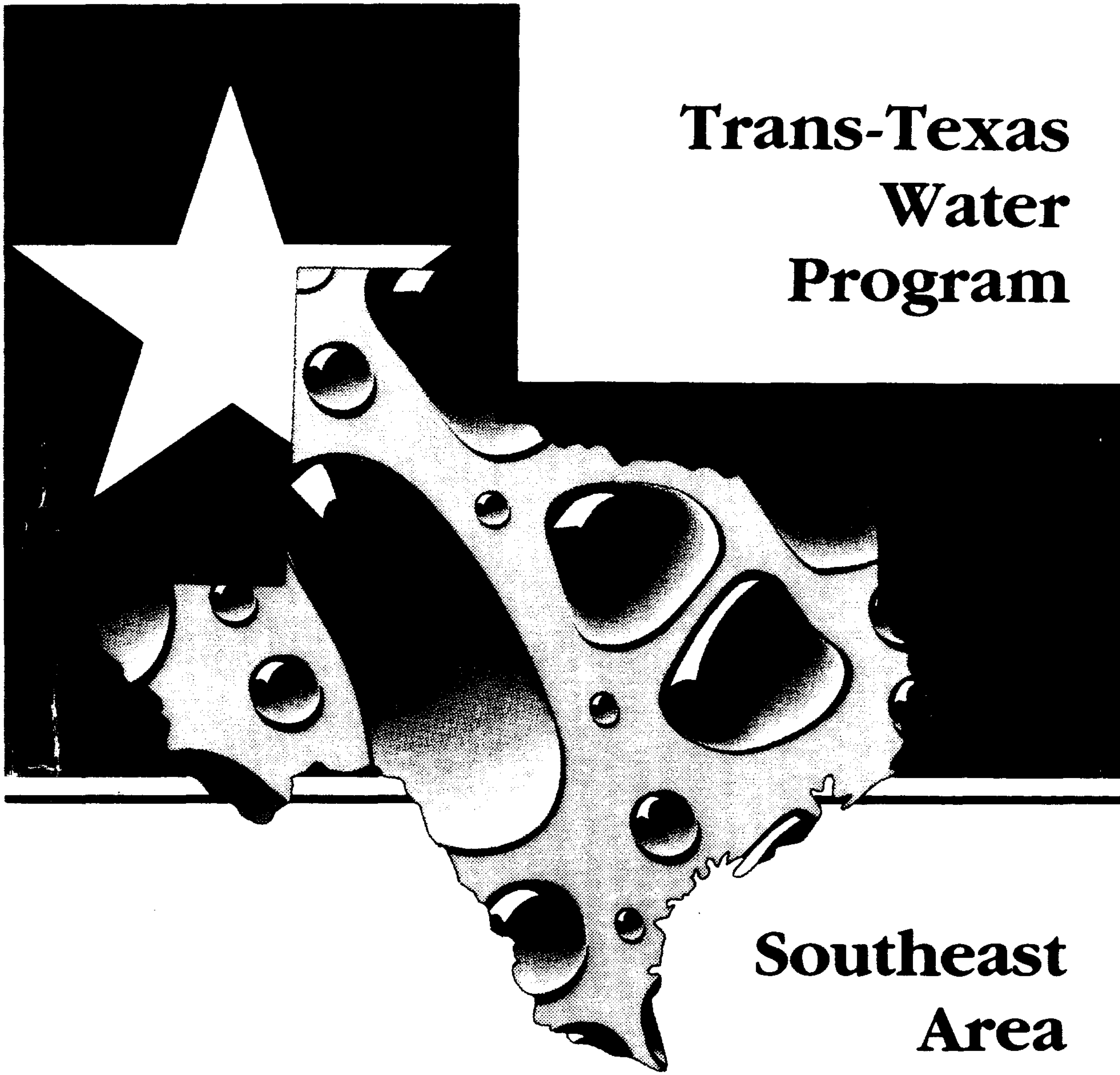

# Trans-Texas Water Program

## Southeast Area

# Phase I Report

**March 1994**

G6177.001

# Trans-Texas Water Program

***Local/Regional Participants***

*Austin*
*Bexar Metropolitan Water District*
*Brazos River Authority*
*Corpus Christi*
*Edwards Underground Water District*
*Guadalupe-Blanco River Authority*
*Houston*
*Lavaca-Navidad River Authority*
*Lower Colorado River Authority*
*Nueces River Authority*
*Sabine River Authority*
*San Antonio River Authority*
*San Antonio Water System*
*San Jacinto River Authority*

***State Agencies***

*Texas Water Development Board*
*Texas Natural Resource Conservation Commission*
*Texas Parks and Wildlife Department*
*Coastal Coordination Council*

**DATE:** March 18, 1994

**TO:** Trans Texas Water Program - Southeast Area
Technical Advisory Committee Members

**FROM:** Mr. Albert Gray
Sabine River Authority

**SUBJECT:** Phase I Report, Draft

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Please find enclosed the draft Phase I Report for the Trans Texas Water Program Southeast Area. This report reflects the investigation and compilation of planning information, water resource data, and assessment methodology for Phase I of this program. A conceptual plan has been developed and is proposed for further study in Phase II. An executive summary has also been included.

Your review and written questions and comments are encouraged. Please submit these to **Mr. Albert Gray, Sabine River Authority, P.O. Box 579, Orange, Texas,.77630**

You will be receiving a separate package regarding the next TAC meeting. A presentation of the draft report will be provided by the study consultants at that meeting and this will be an opportunity to discuss your comments and concerns regarding the enclosed material.

Thank you for your interest and participation in the Trans Texas Water Program.

AG/prb
Enclosure

c: Policy Management Committee - Southeast Area

*Printed on Recycled Paper*

# ACKNOWLEDGEMENTS

Many different organizations provided guidance, assistance, and information used in the preparation of this document.

**Local Sponsors** - City of Houston, the Brazos River Authority, Sabine River Authority, and the San Jacinto River Authority provided policy management decisions and program direction.

**State of Texas Agencies** - Texas Water Development Board, Texas Natural Resource Conservation Commission, the Texas Parks and Wildlife Department, and the Texas General Land Office provided key data and jointly established policy guidance on water resource and environmental issues.

**Southeast Technical Advisory Committee** - Over 50 regulatory and public interest groups provided information, input, and comments on issues encompassing water resources management, environmental impacts, financial considerations, and regulatory concerns. A partial list of these organizations and groups is included in Appendix D.

Others who have contributed to the preparation of this document are also referenced in the report as sources when appropriate .

Funding for this project was provided by the Texas Water Development Board, Sabine River Authority, San Jacinto River Authority, City of Houston and Brazos River Authority.

# TRANS-TEXAS WATER PROGRAM

## SOUTHEAST AREA

## CONCEPTUAL PROGRAM REPORT

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# EXECUTIVE SUMMARY

## Introduction

The Trans-Texas Water Program (TTWP) is a comprehensive water resources planning program created to evaluate a full range of water management strategies for an area of Texas encompassing about one-third of the state's current population. The overall goal of the TTWP is to identify the most cost-effective and environmentally sensitive strategies for meeting the current and future water needs of the Southeast, South-Central, and West-Central Areas of Texas. This report covers the Southeast Area and presents the results of a twelve-month study to examine both short- and long-term water needs and evaluate strategies for reducing demands through conservation, increasing water supplies through resource management and supply development, and transferring water from areas of abundance to areas of potential shortage. The study evaluates the alternatives in terms of technical feasibility, cost, and environmental acceptability.

Under the leadership of the Texas Water Development Board, the TTWP is a cooperative effort of local, regional, state and federal water resource agencies. The planning process developed for the TTWP encourages public involvement in the creation of an integrated program to satisfy the future needs of the study area. Similar to development of the Texas Water Plan, creation of the TTWP must consider associated water policy, environmental, legislative, and institutional issues. This document discusses these various issues to inform the reader and to solicit comment on the assumptions and direction of the program.

Due to the long-term impact which could result from implementation of the TTWP, state agencies with an interest in water planning have entered into a cooperative relationship. In July 1993, the Texas Water Development Board (TWDB), the Texas Natural Resource Conservation Commission (TNRCC), and the Texas Parks and Wildlife Department (TPWD) entered into an interagency Operating Agreement regarding "consensus water planning". The following mission statement is contained in the MOU:

> *To promote coordinated policy, planning, regulation, management, and wise use of the State's water resources and to minimize or avoid any needless and unproductive conflict in the management of such resources, the state water agencies shall develop and implement an on-going consensus planning and policy process to provide for the preservation, conservation, management, and development of the State's water resources. These recommended policies and management processes should avoid fragmentary, uncoordinated water resources management by applicable federal, state, regional, and local agencies in order to provide timely and responsible solutions to water resources problems. They should also provide for full and meaningful participation by affected groups and entities in the development of State water resources planning which avoid inequities and disproportionate effects on ethnic and low-income communities.*

A key objective of the TTWP is to maximize the efficient use of existing and future regional water supplies. The TTWP is expected to form the foundation of an integrated regional water resources system involving many local, regional, and state water agencies. However, the TTWP is not intended to address all of the local water issues of the study area. Responsibility still exists for local communities to plan and implement water supply and/or management programs as necessary to meet individual local needs. The TTWP would represent a regional framework within which the local management programs could be formulated.

**Water Demand**

The Southeast Area of the TTWP includes 32 counties and extends along the Texas coastal plain from the Sabine River to the Brazos River (Figure 1.1). Projected population growth and water demands were established for this area through year 2050. Potential water transfer requirements for the West-Central Area (San Antonio region) were also established through the year 2050. Water demands for the Southeast Area are expected to increase from approximately 2.5 million acre-feet per year in 1990 to approximately 4.7 million acre-feet per year in 2050. In the year 2050, it is estimated that approximately 70% of the

Southeast Area's total demand will be within the Houston area.

The municipal, irrigation, and manufacturing water use categories comprise over 91% of the total future water demand. Projected municipal water demand increases from approximately 0.7 million to 1.6 million acre-feet per year from 1990 through 2050. Municipal demand represents 35% of the total year 2050 water demand. Projected manufacturing water demand increases 238% over the planning period and, at 2.1 million acre-feet per year in 2050, represents 45% of the total demand. Unlike the manufacturing and municipal use categories, projected irrigation water demands significantly decrease from 0.7 to 0.4 million acre-feet per year from 1990 through 2050.

Projected requirements for transfers from the Southeast Area to the South-Central and West-Central Areas are being developed in separate studies and are not yet available. For purposes of the Southeast Area Phase I study, consideration was given to three different scenarios, in which the westward transfers might total (a) 600,000 acre-feet per year, (b) 300,000 acre-feet per year or (c) none.

**Water Supply**

A objective of the TTWP is to satisfy future water needs where feasible by using existing resources before developing new sources of supply. There are numerous existing surface water and groundwater supplies which are available to meet the future needs of the study area, and each such source of supply was considered in Phase I.

Toledo Bend Reservoir, the Sam Rayburn/B.A. Steinhagen reservoir system and the Lake Livingston/Wallisville Salt Water Barrier system are the only major surface water supplies within the Southeast Area that have yields in excess of their projected year 2050 in-basin water needs. All of the existing Sam Rayburn/B.A. Steinhagen system's available supply is committed to meet local area water demands and environmental requirements within the Neches and Neches-Trinity basins. Most of the Livingston/Wallisville system water is committed to serve future near-term (20-year) needs within the eight-county Houston metropolitan area. Toledo Bend Reservoir, with projected available excess supply of 672,000 acre-feet per year in 2050, is the only existing uncommitted surface water supply of any significant size available for potential use within the study area.

Existing excess groundwater supplies are also available for future use to meet projected demands. Groundwater use has been projected to increase from 814,000 acre-feet per year in 1990 to 958,000 acre-feet per year in year 2050. While even further quantities of groundwater remain available in year 2050, none of this excess exists within the coastal basins or the Houston area, which are the principal water demand areas.

Based on the analysis performed for this study, it was concluded that existing groundwater and surface water supplies are not sufficient to meet the maximum potential 2050 water demand projections for all of the Southeast, South-Central and West-Central areas. A shortfall of as much as 630,000 acre-feet per year is projected to exist in the year 2050. The TTWP must therefore utilize other water management methods to avoid the projected shortfall.

**Water Management Alternatives**

Proven water management methods can be used to extend the efficient use of existing water supplies within the Southeast Area. Regional implementation of permanent water management methods may potentially serve to significantly reduce projected water demands and/or prolong use of existing water supplies. Adoption of these methods is justified by the large volumes of available supply, large future projected water demands, and relatively concentrated geographic location of need.

The Phase I study covered ten water resource management alternatives, which can be classified in four general categories as follows.

- To make more complete or more effective use of supplies that already exist:
    - Conservation
    - Reclamation and reuse
    - Existing surface reservoirs
- To get more yield from existing sources of supply:
    - Coordinated system operation
    - Aquifer storage and recovery
- To develop new sources not previously utilized:
    - Demineralization
    - New groundwater supply
    - New surface water reservoirs
- To minimize the economic and environmental costs of supply based on one or more of the above alternatives:
    - Interbasin transfers
    - Contractual transfers

It was concluded that eight of the ten alternatives could be expected to contribute in some significant way to the long-range Trans-Texas Water Program. Two alternatives - demineralization and aquifer storage and recovery - were judged unlikely to play a significant part in the balance of supply and demand for the Southeast Area. Each of the remaining choices was found to have potential as a component of the overall plan.

It was noted that new groundwater and surface water supplies probably would be limited in their contributions. Groundwater use in the Southeast Area is forecast to increase by some 144,000 acre-feet per year by 2050; however, the increase is strictly due to greater demand in areas where dependable groundwater supplies remain available. Beyond that amount, there is no apparent prospect for further groundwater contributions prior to 2050. Major new surface water reservoirs are not a desirable alternative for environmental reasons in most instances, and other alternatives generally should be considered first. Two specific exceptions are the Neches salt water barrier and the Allens Creek project. Both projects are included in the Texas Water Plan and have the potential to supply significant dependable yield to the area. In addition, a permanent salt water barrier may well be the most feasible solution to significant environmental and hydrologic difficulties in the lower Neches River Basin, while Allens Creek Reservoir may prove to be the best point of transfer if Southeast Area water is to be moved to the South-Central and West-Central Areas.

Interbasin transfers and contractual transfers can help to lower the monetary and environmental costs of water supply but do not in themselves provide any new supply that would not exist without them. They must be utilized in combination with one or more of the other alternatives that do contribute additional yield.

**Conclusions and Recommendations**

The following major conclusions resulted from the Phase I investigations:

- Sufficient water supplies currently exist within the Southeast Area to meet the projected demands within that area through approximately the year 2050 if groundwater development occurs as predicted by the 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.

During the next fifty-year period, nontraditional methods of meeting the sustained long-term water demands will be necessary. Increasingly over time, pressures will develop to enact those water management alternatives which balance the impacts to all affected parties. Recognizing these needs, a conceptual plan for the Southeast Area is recommended for further evaluation in Phase II which includes a wide range of water management methods.

- Water Conservation - Adoption of specific water conservation management methods designed to improve water use efficiency and minimize waste.
- Wastewater Reclamation - Use of City of Houston treated wastewater for industrial and other non-potable purposes.
- Existing Reservoirs - Use of projected surplus from Texas' share of Toledo Bend Reservoir and uncommitted water from the Sam Rayburn/Steinhagen and Livingston/Wallisville projects.
- Coordinated System Operation - Operation of the existing San Jacinto and Trinity surface water reservoirs on a systems basis to achieve a greater dependable yield.
- New Surface Water Projects - Future construction of the Neches saltwater barrier and the Allens Creek Reservoir projects.
- Interbasin Transfers - Physical conveyance of available surface water to supply the needs of the projected water-short areas of Houston and/or regions to the west.
- Contractual Transfers - Reallocation of existing supplies through contractual or physical supply "trading" between entities to reduce future conveyance costs and/or re-apportion those supplies.

Some or all of the above elements are to be combined into an integrated program to create a proposed "regional water management plan" for the Southeast Area. Further definition of the elements will occur during Phase II of this study so that costs and associated impacts can be assessed. The recommended program will define the required actions for the various agencies, identify implementation schedules, and establish the major issues which require resolution in order for the plan to be effective.

# 1.0 INTRODUCTION

According to the 1990 Texas Water Plan (1), Texas as a whole has adequate water resources to meet its basic needs through the next fifty years and beyond. However, there is a geographic imbalance of available water supplies and projected demands. While the eastern part of the state has an abundance of water, some western and coastal regions lack adequate water resources to take them through the next twenty years. There is an increasing need to correct the imbalance through development of comprehensive water management strategies.

Historically, whenever an area began to have difficulty meeting increasing demands with their existing water supplies, the response has been to develop new sources of supply. Today, there is a growing recognition of the need to consider a much wider range of water management methods and to concentrate on making effective use of the sources already in operation. New supplies are still valid options in many cases, but other techniques such as better water conservation practices, expanded reclamation and reuse, more efficient operation of multiple-source systems, and increased interbasin transfers must also be considered.

The Trans-Texas Water Program (TTWP) was created to achieve cost-effective and environmentally sensitive responses to the future water needs of Southeast, South-central and West-central Texas. Development of sound regional water management strategies for those areas has become particularly urgent because of impending needs in the Houston, San Antonio and Corpus Christi metropolitan areas. In recent decades, Houston has experienced very rapid growth. Land subsidence due to the removal of groundwater is a major problem for much of the Houston area. Increasing water demand and decreasing groundwater availability due to subsidence have forced

(1) Numbers in parentheses match references listed in Appendix A

the City of Houston to explore new water resource opportunities throughout the region. The available surface water resources in the local river basins have been largely developed, and the permitting and construction of major new reservoirs in the area is considered difficult at best. The San Antonio region has historically used groundwater from the Edwards Aquifer and is now the largest city in the country that depends entirely on groundwater. In 1993, a federal court ruled that the pumpage rate from the Edwards must be sharply reduced in order to protect endangered species, and it is critical that San Antonio develop a feasible alternative water source (or sources) to supplement the limited Edwards Aquifer supply. Other cities in the region face similar difficulties in meeting their future water needs. The economic well-being of these urban areas is important to the entire state. It is very much in the interest of all Texans to find suitable solutions for these problems.

## 1.1 Project Conception

Under the leadership of the mayors of Houston, San Antonio and Corpus Christi, a water resources planning summit was held in Houston on May 7, 1992. That meeting resulted in a consensus among participating local and state officials to initiate 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 environmentally responsible manner. The Texas Water Development Board recognized the value of this concept and agreed to help sponsor further investigations through what has come to be called the Trans-Texas Water Program.

The mission statement and concept of the initial phase of the TTWP are as follows:

*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 study areas.*

Phase One is a preliminary study phase designed to define the requirements and potential problems and benefits of the TTWP as it relates to the needs of these major cities in Texas.

## 1.2 Coordination with Other Planning

Sections 16.051 and 16.055 of the Texas Water Code direct the Executive Administrator of the Texas Water Development Board (the Board) to prepare and maintain a comprehensive State Water Plan as a flexible guide for the orderly development and management of the state's water resources so sufficient water will be available at a reasonable cost to further the economic development of the entire state. In addition, the Board is directed to amend and modify the plan in response to experience and changed conditions. The results of the TTWP are anticipated to become an important element in the State Water Plan.

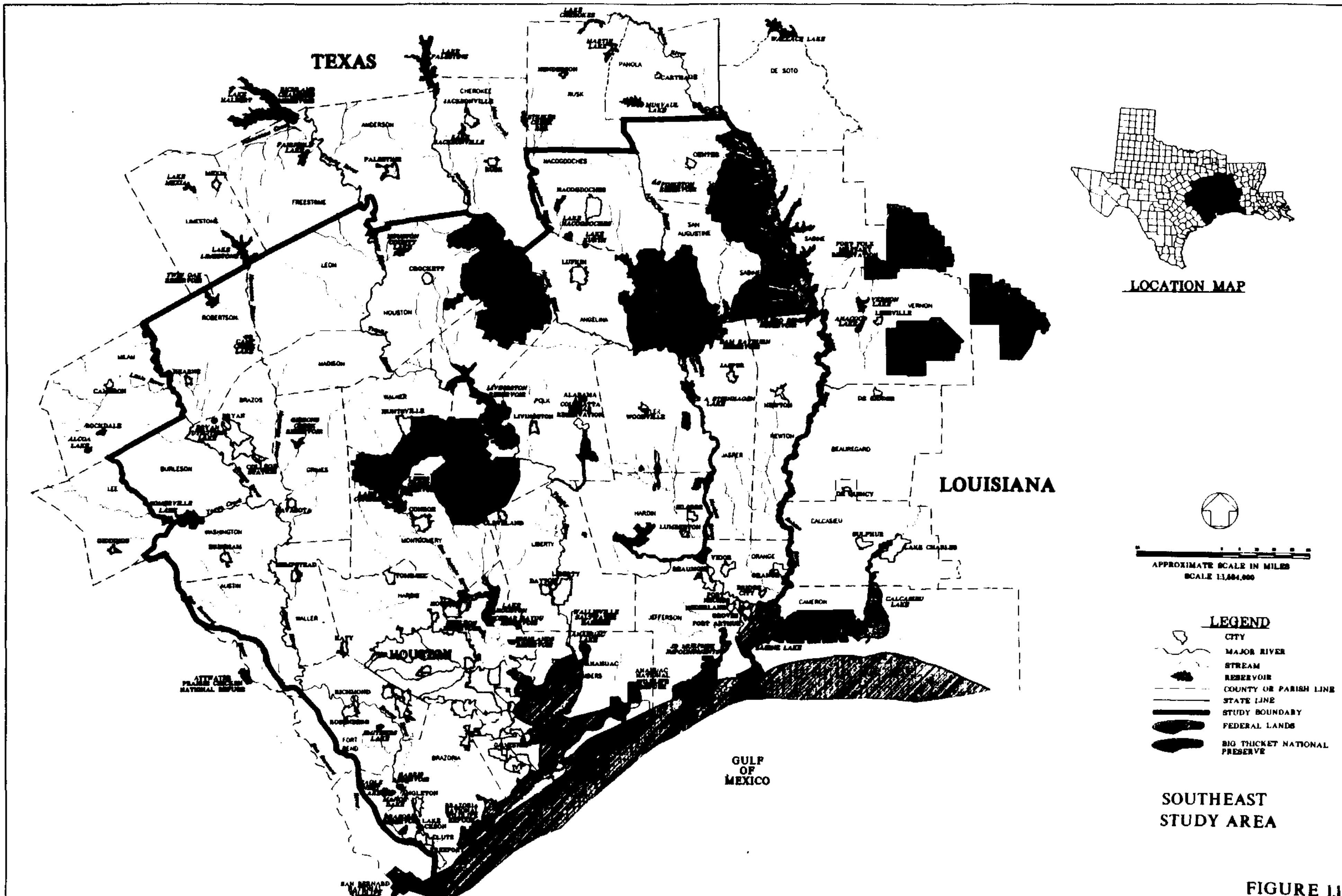
Upon its completion, the TTWP will create a detailed implementation document which specifies water resources management activities capable of supporting future growth and economic development requirements in the southeast region of the State. Future water resource planning will focus on the water management relationships between the four primary water-using interest groups: urban, manufacturing, agriculture, and the environment. Development of the TTWP will consider the current and future water use characteristics of each of these groups and provide a plan to best meet the projected needs of all. The TTWP is expected to form the foundation of an integrated regional water resources system involving many local, regional, and state water agencies. However, the TTWP is not intended to address all of the local water issues of the study area. Responsibility still exists for local communities to plan and implement water supply and/or management programs as necessary to meet individual local needs. The TTWP would represent a regional framework within which the local management programs could be formulated.

## 1.3 Study Area

Figure 1.1 is a map of the 32-county region defined as the Southeast Area of the TTWP. The study area extends along the Texas Gulf Coast from the Sabine River to the Brazos River and includes metropolitan Houston. Similar study areas were defined for the region from the Brazos River to the Nueces River, including the San Antonio, Austin, and Corpus Christi metropolitan areas. For planning purposes, the western study area has been divided into two sub-areas: a southern portion including Corpus Christi, called the South-Central Area, and a northern portion including San Antonio and Austin, called the West-Central Area. The Houston metropolitan area is the major water demand center for the Southeast Area. The Houston Standard Metropolitan Statistical Area (SMSA) includes eight counties (Harris, Chambers, Liberty, Montgomery, Waller, Fort Bend, Brazoria, and Galveston) and is shown in Figure 1.2.

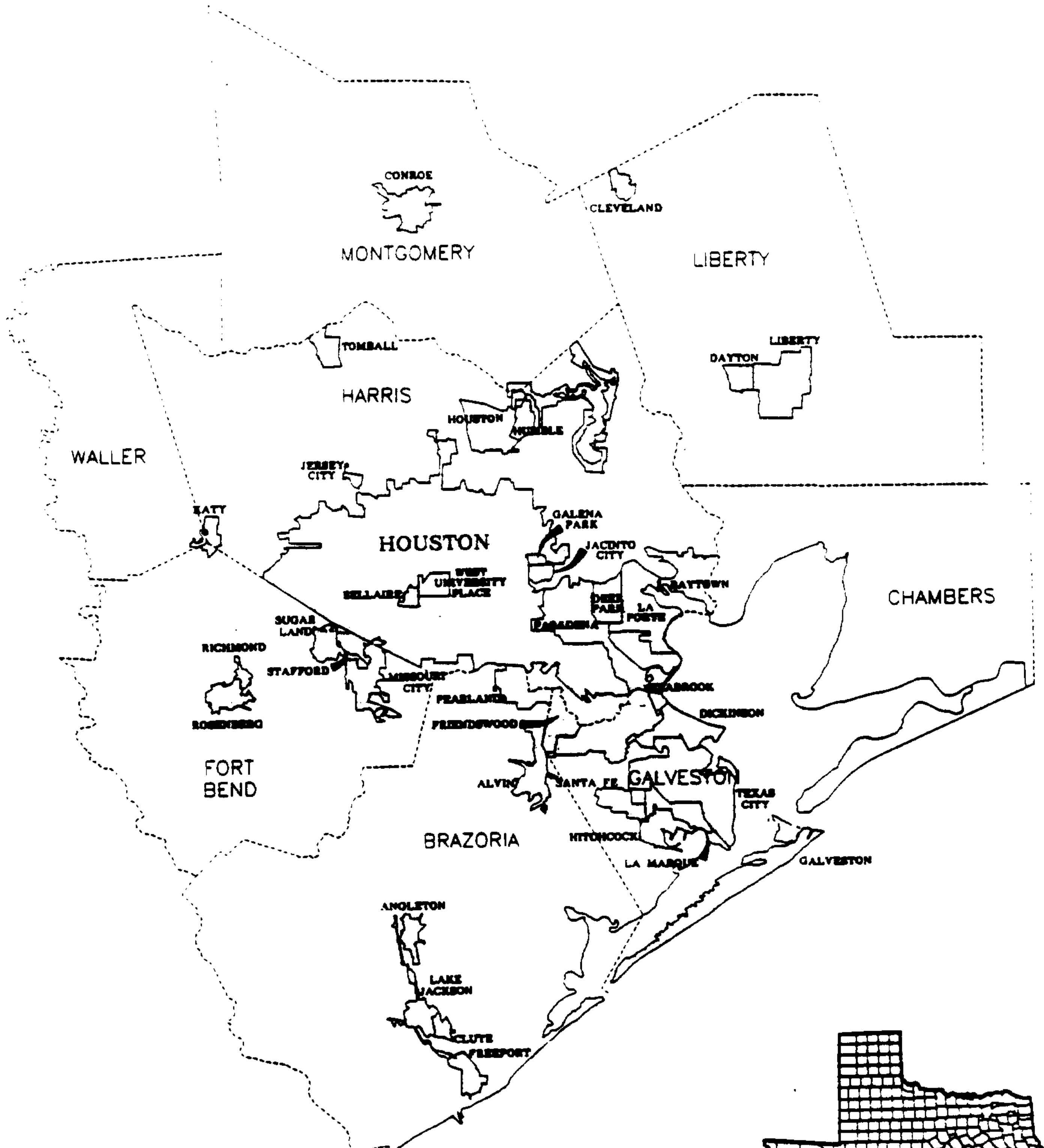
## 1.4 Authorization and Scope

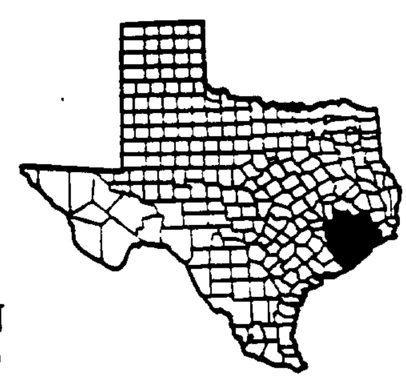
Consulting services for the Southeast Area are being provided by Brown & Root, Inc., and Freese and Nichols, Inc., under terms of a contract with the Sabine River Authority of Texas. Similar efforts for the South-Central and West-Central areas of the state are being sponsored by the Lavaca-Navidad River Authority and the San Antonio River Authority, respectively.




SOUTHEAST
STUDY AREA

FIGURE 1.1



HOUSTON 8-COUNTY
STANDARD METROPOLITAN
STATISTICAL AREA (SMSA)

Figure 1-2

The overall scope of work for the Southeast Area has been divided into five phases as described below.

**Phase I - Project Initiation/Conceptual Planning**

- Agency/Public Coordination - Assist in the establishment of both the regional Policy Management Committee (PMC) and the Technical Advisory Committee (TAC) and conduct meetings with each committee.

- Program Formulation - Set program goals; collect information from existing studies and reports regarding issues of concern for water resources development in southeastern Texas; formulate "issue papers" which investigate and compile potential questions, data needs, resource needs and assessment methods.

- Conceptual Planning - Collect information regarding population, water demand and water supplies of the study area; collect pertinent information on water supply facilities and the status of the environment; create conceptual water supply plans; prepare a Phase I report.

- Contract Administration - Prepare monthly progress reports and billings which summarize the work completed during the work period; prepare and update schedules, budgets and the work plan to illustrate the project status.

A more detailed explanation of the major elements of Phase I can be found in Appendix C.

**Phase II - Feasibility and Environmental Studies**

The second phase involves in-depth feasibility analysis of the alternatives that survive the initial screening process in Phase I. Analysis will focus on better definition of the benefits of each alternative, costs, environmental impacts, financing and pricing alternatives, and legal and institutional arrangements associated with the implementation of recommended alternatives. Particular emphasis will also be placed on the completion of environmental assessments to provide background information required for permitting activities anticipated in Phase III.

**Phase III - Preliminary System Design/State and Federal Permitting**

During this phase, a preferred water management plan will be further developed and information will be compiled for required state and federal permits. Also, institutional relationships and a detailed schedule for program implementation will be finalized.

**Phase IV - Property Acquisition/Final Design**

This phase will focus on property acquisition and final design of any recommended physical facilities, and implementation of recommended water management activities. Property acquisition will include surveys and property descriptions and assistance with negotiations. Final design of necessary facilities will include route surveys, geotechnical services, final engineering design, preparation of detailed plans and specifications, and preparation of contract documents for construction.

**Phase V - Construction, Start-up, and Operation**

The final phase includes construction of and physical facilities for the TTWP, followed by start-up, operation and administration of actual water deliveries.

## 1.5 Phase I Report

This report documents the findings of Phase I of the TTWP for the Southeast Area. Specifically, the report contains the following information:

- Analyses of the additional water needed within the study area through the year 2050.
- Tabulation of the water supplies, both ground and surface, available in the study area.
- Consideration of potential water supply development and water management

alternatives which can be used to meet identified water shortages.

- Preliminary screening and identification of the most feasible alternatives which deserve further study.

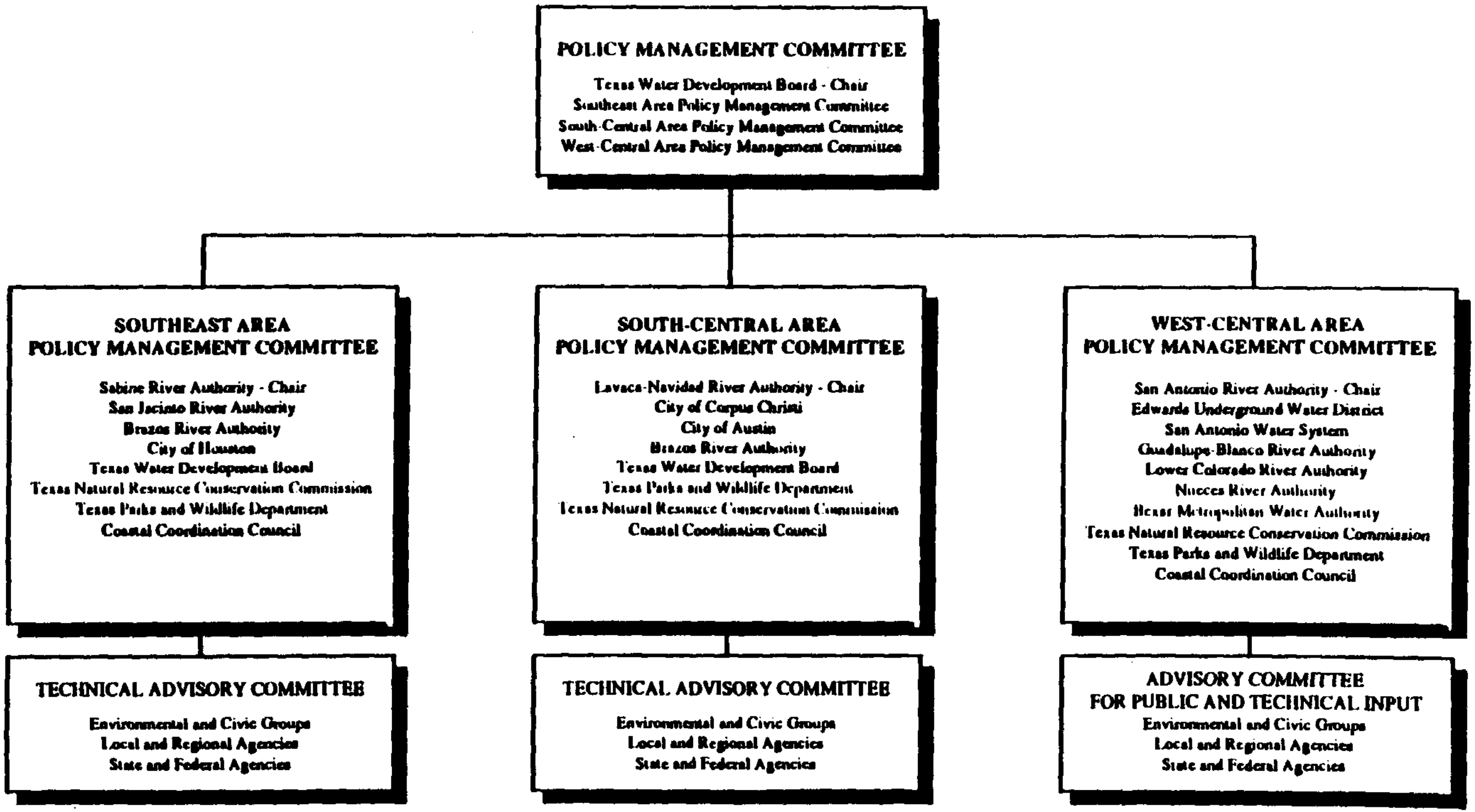
- An outline of the study elements planned for Phase II.

### 1.6 Program Organization

Figure 1.3 shows the agency and public participation committee structure implemented for the TTWP. At a policy level, guidance and coordination is provided by a Policy Management Committee (PMC). The role of the PMC is to establish planning parameters and guidelines that will be applied in all studies and to provide coordination between the study areas. The PMC also has the responsibility to review program deliverables and serve as a decision-making body with regard to program recommendations. In addition to the overall PMC, regional policy management committees have been formed to guide program activities within each study area. As shown in Figure 1.3, the PMC consists of the primary water resource planning and regulatory agencies for the State of Texas and major surface water supply entities. The PMC includes representatives from the Texas Water Development Board, the Texas Natural Resource Conservation Commission, the Texas Parks and Wildlife Department, and sponsors from the various entities involved in the program throughout the state.

Technical Advisory Committees (TAC's) have also been established for each study area. The purpose of these groups is to provide a forum for involvement and input by parties interested in or potentially affected by the TTWP. Appendix D includes a list of the more than 50 organizations which comprise the Southeast Area TAC.

# Figure 1.3
## Committee Structure



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## 1.7 Public and Agency Involvement in Phase I

Project sponsors organized the TTWP in a way that would encourage widespread dissemination of the program's progress. Both the PMC and the TAC serve as vehicles for public and agency involvement in the Southeast Area. The general PMC held three meetings and the Southeast Area PMC held two meetings during Phase I of the program. A summary of these meetings is included in Appendix E.

The TAC for the Southeast Area, at its April 13, 1993 meeting, reviewed the overall TTWP description and the Southeast Area "Program Issues" document. Program issues were identified for the areas of engineering, environmental, financial, legal and institutional concerns. This meeting was attended by representatives of five river authorities, five federal agencies, four state agencies, six environmental groups, three development-oriented organizations, three regional agencies, two cities, three counties, and six private companies. A summary of the meeting and comments and questions from TAC members is included in Appendix E.

## 1.8 Issue Papers

One of the PMC goals for Phase I was to initiate a dialogue concerning water resources issues. To begin the communication process, discussion papers on known or potentially unresolved issues related to the TTWP were developed to focus the attention of the participants on specific matters and to promote input from interested parties (5). These papers outline key questions which could potentially require resolution during the project. They are not detailed analyses of these matters, nor do they necessarily offer solutions to the problems. Their main purpose is to identify issues so they may be discussed and dealt with in an orderly and effective manner.

The following major subject areas are discussed in the issue papers:

Engineering

- Projected water requirements and supply
- Required basic system capabilities
- Route alternatives for conveyance facilities
- Engineering characteristics of the conveyance facilities, pump stations and other structures
- Relationships of engineering and environmental factors

Environmental

- Need for the project
- Terrestrial habitat
- Aquatic habitat
- Bays and estuaries
- Other environmental concerns
- Environmental permit requirements

Financial

- Capital costs and total annual costs
- Financing method
- User's cost and possible state subsidy
- Current use versus future capacity cost
- Initial state financial participation
- Potential public financial partnerships

Legal

- Water availability
- Water rights and permits
- Construction permits and authorizations
- Program operation and administration
- Temporary excess supplies

Institutional

- Organizational framework
- Large-scale interbasin transfers and protection of basins of origin
- Water allocation
- Water banking, contractual water transfers and water marketing

# 2.0 PLANNING INFORMATION

This section of the report compiles various data used in development of Phase I of the Trans-Texas Water Program. The regional scope of the TTWP requires the development of a broad information base comprised of detailed studies on population, water availability and water requirements for a large geographic area over an extended time horizon. In the past several years, numerous studies were undertaken to develop these data for specific or local project purposes. These individual efforts were reviewed for their applicability in the TTWP planning process and new data were compiled where appropriate to meet the objectives of this regional planning effort. Planning information presented in this section includes:

- A review of previous planning studies impacting the region.
- Population and resulting water demand projections for the Southeast Area.
- Interbasin transfer assumptions for the West-Central Area.
- A review of the status of existing water management programs in the Southeast Area.
- Water requirements for environmental protection.

## 2.1 Study Period

The study period for the TTWP was defined by the project participants as extending through the year 2050. This planning period was established in response to several considerations.

- Historically, the State of Texas has evaluated the merits of interbasin transfer requests based on protection of the future 50-year basin-of-origin water requirements.

- The planning horizon for major water resource supply projects (reservoirs, canals, etc.) is often as long as 20 years or more, due to the long development process (planning, permitting, design, construction) associated with these types of projects.
- Major water supply facilities are generally constructed for a design life in excess of 50 years.
- Financing for major water supply projects is normally based on a bond life of 30 to 35 years.

As a result of the complexity and size of the potential facilities being considered in the TTWP, the study and permitting process may require two to five years minimum time to complete; therefore, the 50-year planning horizon begins in the year 2000 and extends to 2050.

Studies have been performed in the past concerning water transfer and conveyance into the Houston metropolitan region. None of these studies used a 50-year study period for investigation of the population, water demand, water supply or facility needs of the area. Therefore, the current Phase I analysis includes a review and update of key information and conclusions from the previous planning efforts in light of the year 2050 planning horizon.

## 2.2 Previous Studies

In the late 1980's, a number of significant engineering studies were completed dealing with water supply and interbasin transfers within the study area. A review of these studies, along with a map showing the proposed routes for interbasin conveyance, is provided in Appendix B. These previous studies include:

- *Houston Water Master Plan*, Appendices A through M, City of Houston, published 1985 through 1990, (6).
- *Water Resources Development Plan*, San Jacinto River Authority, published 1988 (7).

- *Preliminary Feasibility Study - Interbasin Water Transfer from the Sabine River to the San Jacinto River Authority Service Area,* Sabine River Authority and San Jacinto River Authority, published 1989 (8).
- *Feasibility Study, Interbasin Transfer, Sabine to San Jacinto,* Sabine River Authority and San Jacinto River Authority, published 1987 (9).
- *Bon Weir Project, Texas Basins Project,* Bureau of Reclamation, published 1985 (10).
- *Texas Water Plan, Water for Texas, Today and Tomorrow,* Texas Water Development Board, published 1990 (1).

Each of these studies investigated the need and feasibility of importing surface water into the Houston SMSA. Phase I of the TTWP for the Southeast Area compares and contrasts present conditions, assumptions, and conclusions to these previous study efforts.

## 2.3 Population Projections

TTWP participants have agreed to use TWDB projections of population and water use during Phase I. The use of common data throughout the state offers a number of advantages, including uniformity of methodology between the various study areas and consistency with the State Water Plan as developed by the TWDB. The projections, as derived from the TWDB data for the study area, are presented here and the general methodology is explained in some detail. In addition, other local projections of population developed in recent years are compared with the adopted TWDB data.

### Methodology

The TWDB uses two population projection scenarios - a "high series" and a "low series". County population projections are calculated by means of a cohort-survival approach, in which the future numbers for various components of the population are projected and then combined to obtain county totals. For the TWDB's purposes, 64 cohorts (or groups) are projected and then combined for each projection period. Each cohort has a different combination of characteristics of age, sex and race. For example, one cohort may be black females, ages 21-25. Another cohort may be Hispanic males, ages 26-30. Birth, death, and migration characteristics of each cohort are used in forecasting future populations. These characteristics are obtained by adjusting the parameters established in national projections. For example, state-specific death rates for each cohort are developed for future time periods by adjusting projected national death rates for the same cohort, with allowance for observed differences between the state and the nation. Some characteristic rates are specific according to county and are adjusted from the state rates, much as the state rates are adjusted from the national rates. The projected population for each cohort is calculated by the following equation:

$$\text{Future population} = \text{Current population} + \text{Births} - \text{Deaths} + \text{Migration}$$

Preliminary results of the TWDB's high series and low series estimates of future population were forwarded to the 24 councils of government in Texas, which in turn distributed them to local governmental entities for review and comment. Where warranted, adjustments were made to the TWDB's population forecasts based on the public review.

**Results**

TWDB high series population projections for the entire study area are included in Appendix F and summarized in Table 2.1. The TWDB high-case scenario estimated the 1990 population for the state as a whole to be 17.562 million residents (1). The published U.S. Census count (11) estimated the 1990 Texas population to be 16.986 million, or approximately 3 percent less than the TWDB figure. A follow-up study by the Census Bureau to evaluate the accuracy of the 1990 enumeration concluded that

**Table 2.1**

**TWDB High Series Population Projections: Southeast Area**

| | Year | | | | | | |
|---|---|---|---|---|---|---|---|
| BASIN | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| Brazos | 304,473 | 373,033 | 450,969 | 532,739 | 613,542 | 670,301 | 732,618 |
| Neches | 314,775 | 352,645 | 390,228 | 426,123 | 467,802 | 508,058 | 552,724 |
| Neches-Trinity | 194,452 | 202,290 | 219,156 | 230,118 | 240,470 | 248,864 | 257,808 |
| Sabine | 106,860 | 115,369 | 124,712 | 132,753 | 142,211 | 151,563 | 161,801 |
| San Jacinto | 2,771,048 | 3,272,389 | 3,768,295 | 4,254,042 | 4,760,115 | 5,177,451 | 5,634,450 |
| San Jacinto-Brazos | 705,379 | 866,609 | 1,042,137 | 1,214,734 | 1,385,667 | 1,528,905 | 1,687,171 |
| Trinity | 152,985 | 183,468 | 212,700 | 242,282 | 275,514 | 302,425 | 332,451 |
| Trinity-San Jacinto | 95,809 | 119,847 | 136,525 | 152,884 | 169,300 | 186,050 | 204,474 |
| TOTAL | 4,645,781 | 5,485,650 | 6,344,722 | 7,185,675 | 8,054,621 | 8,773,617 | 9,563,497 |

the population of Texas may have been under-counted by 564.5 thousand residents. Adjustments to remove the under-count would bring the estimated census population to 17.551 million. This figure is almost identical to the TWDB's estimate made in 1990, and the TWDB has concluded that the 1990 Water Plan population forecasts are suitable for planning purposes for the present (12).

The Houston-Galveston Area Council serves the eight-county region around the City of Houston and provides population projections for this region (13). These projections, which have been made through the year 2010, are listed in Appendix G. The population estimates for 1990 were taken from preliminary census reports. The year 1996 and 2010 projections were produced with the assistance of the Inter-Agency Data Base Task Force and were based upon the results of earlier Rice Center econometric models for the Houston SMSA. Earlier projections were modified to reflect the area-wide recession of the mid and late 1980s. The HGAC projections can be compared with the TWDB at only two data points, the years 1990 and 2010. HGAC estimates a 1990 population 1.4 percent above, and a 2010 projection 0.9 percent above, that of the TWDB.

Population projections for the eight-county Houston SMSA developed by Rice Center for the Houston Water Master Plan (6) are also included in Appendix G. The Rice Center projections were produced using an econometric modeling technique and in 1986 were accepted as appropriate for planning long range water demands for the City of Houston. The master planning process continued through 1989, when population data were again reviewed. Growth had not occurred as rapidly as the 1986 projections had predicted, due to the delay in economic recovery for the Houston area. The City of Houston determined that growth had been delayed by approximately five years and decided to adjust the 1986 projections to reflect that five-year delay for planning future water demands in the area.

Table 2.2 and Figure 2.1 are comparisons of the Houston SMSA population projections for the TWDB high series, the HGAC projections, the Houston Water

## Table 2.2

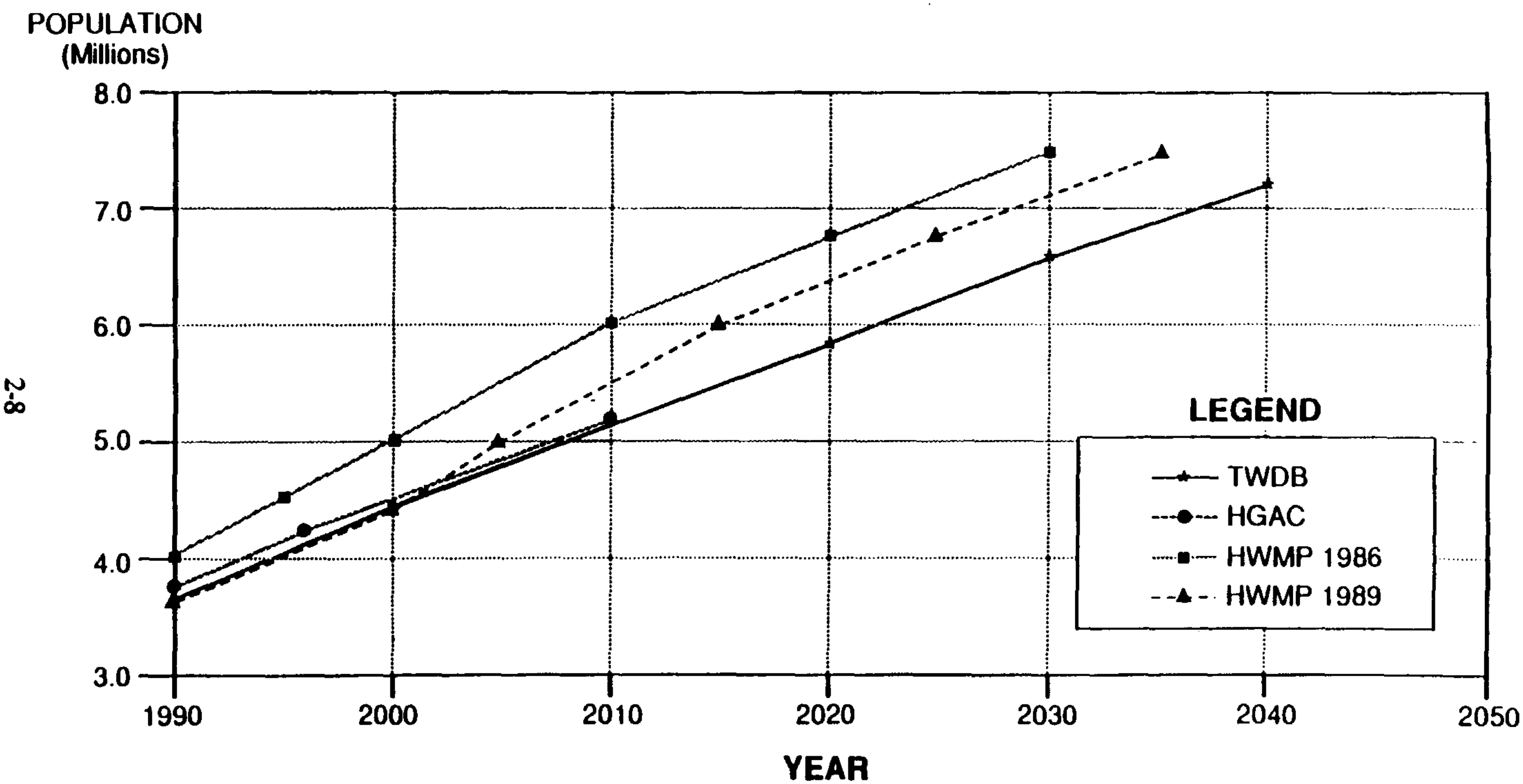
## Population Projections

## Houston SMSA

| | 1990 | 1995 | 1996 | 2000 | 2005 | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Texas Water Development Board | 3,680,941 | - | - | 4,400,186 | - | 5,122,660 | - | 5,833,698 | - | 6,561,703 | - |
| Houston Galveston Area Council | 3,731,132 | - | 4,165,619 | - | - | 5,168,000 | - | - | - | - | - |
| Houston Water Master Plan (1986) | 4,024,468 | 4,508,994 | - | 4,994,281 | - | 5,999,686 | - | 6,745,999 | - | 7,489,115 | - |
| Houston Water Master Plan (1989) | 4,024,468 | - | - | 4,508,994 | 4,994,281 | - | 5,999,686 | - | 6,745,999 | - | 7,489,115 |

Figure 2.1

## COMPARISON OF POPULATION PROJECTIONS
## for the Houston Metropolitan Area



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Master Plan 1 (1986) draft projections, and the Houston Water Master Plan 2 (1989) final draft projections. For the year 2030 (the last date covered in the original Houston Water Master Plan), the TWDB projection is some 12 percent below the 1986 Houston Water Master Plan number. A comparison of the TWDB projections and the U.S. Census projections for the population of the entire state is shown below. Here, the TWDB numbers are approximately 5 percent higher than the Census numbers. These two tables show that the TWDB projections fall within the range defined by the other projections, being slightly below those of the HGAC and the Houston Water Master Plan but higher than those of the Census Bureau. Based on this review of the various data and methods, the TWDB high series population projections appear to be a reasonable data set.

Population Projections: Texas

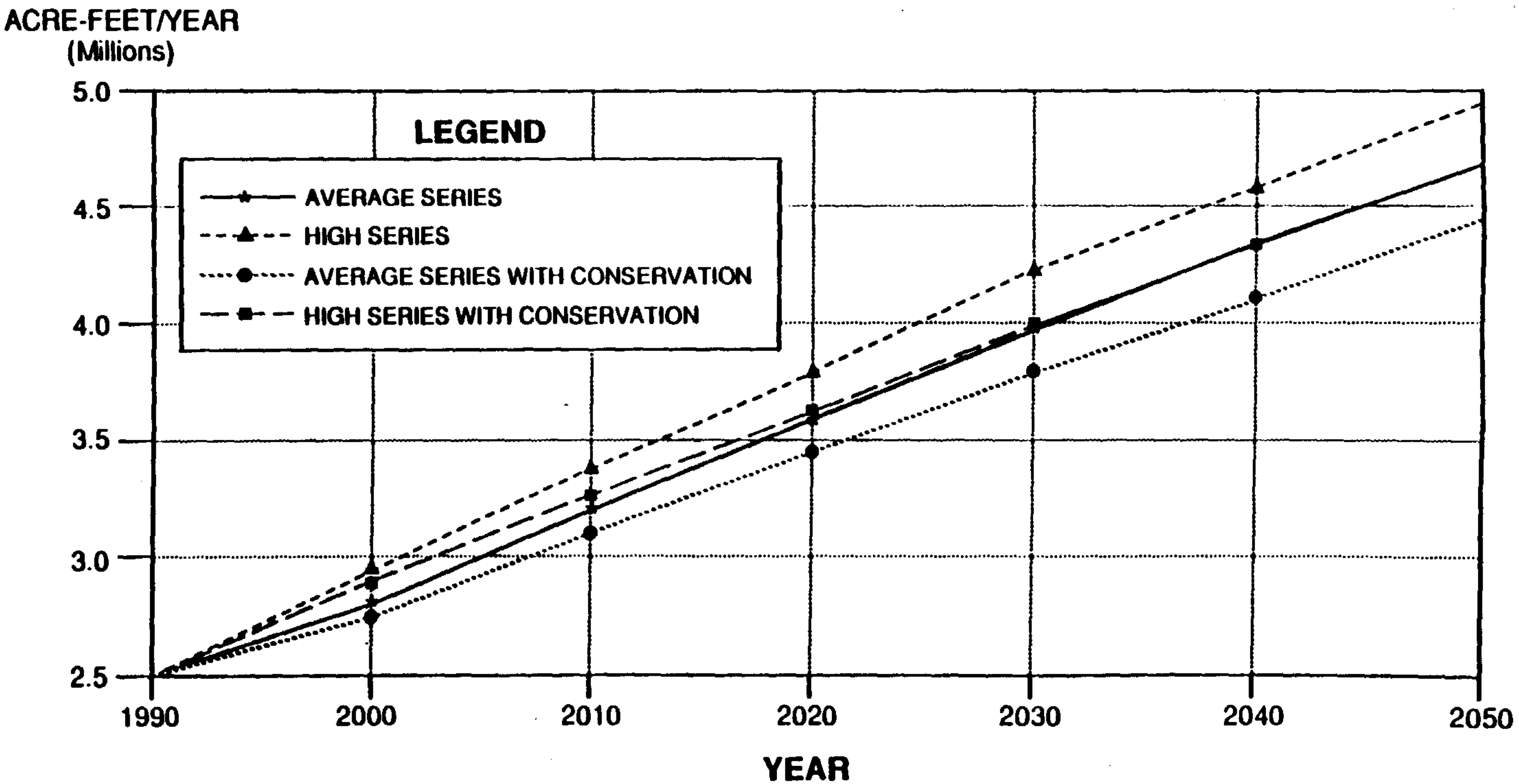
| | 2000 | 2020 |
|---|---|---|
| Texas Water Development Board | 21,016,408 | 28,425,539 |
| U.S. Census Bureau | 20,230,204 | 27,011,723 |

## 2.4 Southeast Area Water Requirements

Projections of water requirements for the Southeast Area have been adopted for this phase of TTWP from the Texas Water Development Board's 1990 Texas Water Plan update (1). The TWDB made several sets of projections for the 1990 Water Plan, some of which are shown in Figure 2.2 for the study area. The projections used for this study were based on (a) the high series population projections, (b) high per capita use (corresponding to low rainfall and runoff conditions), and (c) assumed continued implementation of water conservation measures statewide. This set of data

# Figure 2.2

## TWDB WATER DEMAND PROJECTIONS for Southeast Area

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is labeled "high series with conservation" in Figure 2.2. The methodology used in developing the TWDB projections is explained below for each category of water use and the resulting data are compared to previous studies done for this area.

**Methodology**

The TWDB water demand projections are generated for each city and county within the State of Texas. Water demands are created for six primary categories; municipal, manufacturing, steam electric power, mining, irrigated agriculture, and livestock watering. Municipal uses include both domestic and non-domestic consumers with water consumption based on typical per capita use in the study area. While conservation measures are proposed for all user groups, the impact of the expected water conservation efforts was reflected primarily in the municipal water use category. The average per capita consumption was predicted to decrease by 2.5 percent in 1990, 7.5 percent by year 2000, 12.5 percent by year 2010 and 15 percent for the years 2020 through 2040, the time horizon of the projections.

Manufacturing water use was estimated using national and statewide growth outlooks for each industrial category, historical water use, known facility expansions or construction, the industrial base of each county, and potential savings through recirculation and improved water use technology.

Steam-electric power generation cooling water needs were based on forecasts of power demands, fuel sources used for generation, cooling technology, and plans for expanding power generating capacity identified by the industry.
Mining water requirements were based on water use coefficients representative of each type of mining operation, historical national and state trends in mineral production, and expected trends in the use of fuels for energy production.

Water requirements for irrigated agriculture will depend on the acreage in production, the rate of water use per acre, water costs, and the availability of water supplies. Projections of irrigation water needs reflect quantities of water associated with typical Texas irrigated farming operation, including regional water supplies and cropping patterns.

Livestock water use rates were developed using livestock census information and animal nutrition data to determine daily water requirements.

As with the population projections, the TWDB water demand projections were also sent in 1990 to the 24 regional councils of government. This provided substantial opportunity for municipalities, utilities, and citizens to comment on the forecasts. Local comments were reviewed, and the projections were modified where appropriate.

**Results**

The TWDB's projected water demands for the Southeast Study Area, grouped according to river basins, are covered in Appendix H. Table 2.3 is a summary of those projections for the Southeast Area, using high series demands with conservation. Figure 2.3 reflects a comparison of the eight-county Houston SMSA water demand under various population and per capita assumptions. The TWDB projections were developed through the year 2040. Water demand projections for 2050 were extrapolated uniformly based on the same water use characteristics defined for TWDB years 2030 through 2040. The projected water demands summarized in Table 2.3 and Figure 2.3 are demands for fresh water and do not include demands supplied by diversions of brackish water or salt water (principally industrial and irrigation demands along the coastal areas). Therefore, the TWDB projections represent only those water use needs which must be satisfied through inland surface water or groundwater.

The Houston Water Master Plan (HWMP) also developed future water demand projections for Harris County, the Houston ETJ, and the eight-county SMSA.

## Table 2.3

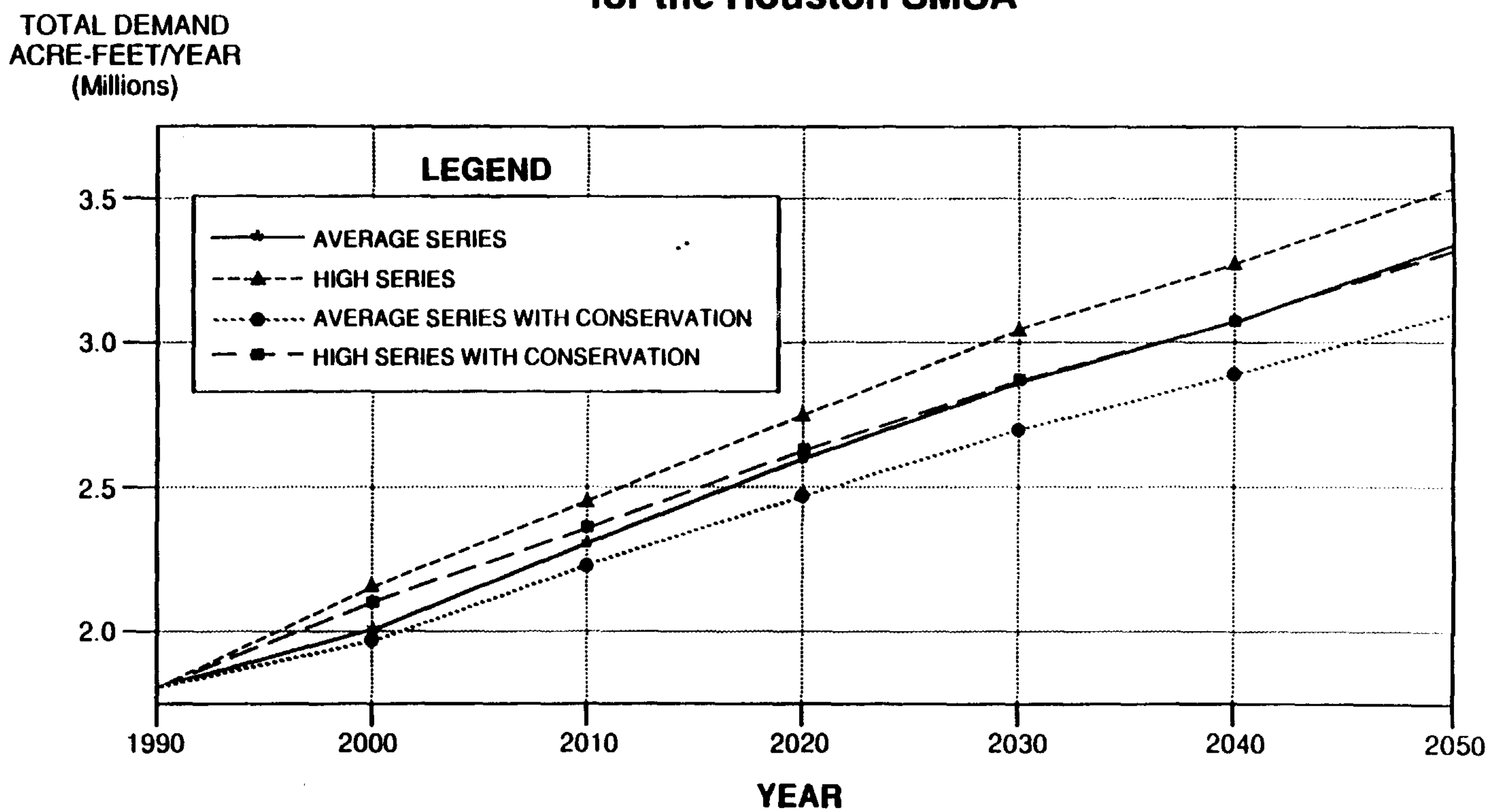
## Projected Water Requirements in the Southeast Area: 2000-2050

**- Thousands of Acre-Feet per Year -**

| | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|
| Sabine River Basin | 104.1 | 135.3 | 162.7 | 192.1 | 223.5 | 258.4 |
| Neches River Basin | 292.4 | 329.9 | 368.7 | 419.7 | 470.3 | 527.1 |
| Neches-Trinity Coastal Basin | 280.6 | 282.6 | 285.2 | 289.8 | 293.9 | 298.1 |
| Trinity River Basin | 98.4 | 114.0 | 137.0 | 161.0 | 174.1 | 189.4 |
| Trinity-San Jacinto Coastal Basin | 137.6 | 143.5 | 152.3 | 161.9 | 170.7 | 180.3 |
| San Jacinto River Basin | 1,051.5 | 1,166.3 | 1,287.3 | 1,425.7 | 1,551.0 | 1,689.7 |
| San Jacinto-Brazos Coastal Basin | 493.8 | 554.3 | 625.1 | 696.7 | 763.9 | 841.0 |
| Brazos River Basin | 441.9 | 519.7 | 606.6 | 641.8 | 666.3 | 698.3 |
| Total | 2,900.3 | 3,245.6 | 3,624.9 | 3,988.7 | 4,313.7 | 4,682.3 |

Figure 2.3

**WATER DEMAND PROJECTIONS**
**for the Houston SMSA**



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Average day demands were determined for each of 65 "municipal demand areas" used within that plan based on water billing records and were used to project future water demands. The demand for the eight-county SMSA for the year 2030 was projected to be 1.63 million acre-feet per year as compared to 2.80 million acre-feet per year for the TWDB high series with conservation. While the geographic areas are comparable, the differences in the methods used to calculate the water demand make a direct comparison between the HWMP figure and the 2030 TWDB projections impossible. First, the projections were calculated using differing water use components. The HWMP did not include all of the same demand categories as the TWDB projections, specifically excluding irrigation, livestock, power and mining. Secondly, the manufacturing use demands are defined differently for each study. Further, the TWDB and HWMP based their supply needs on slightly different service areas. The HWMP plan focused on portions of the city and surrounding counties to which the City of Houston would supply water services and did not include the entire eight-county SMSA, but only a unique service area within that SMSA.

For these reasons, the Trans-Texas Water Program has adopted the Texas Water Development Board demand projections. These projections are consistent with the Texas Water Plan and have taken into account the state's commitment to an aggressive water conservation program. While it is valid to consider "worst case" scenarios for long range planning purposes, it is also appropriate to moderate those projections to reflect current activities which will impact the long term demand for water in the region. The TWDB high series with conservation represents a credible and reasonable dataset for purposes of this study.

## 2.5 West-Central Area Water Requirements

In addition to water demands within the study area, one of the objectives of the TTWP is to evaluate the potential for "surplus" supplies in the Southeast Area to be used to serve the other study areas. The boundary between the Southeast Area and the South-Central and West-Central Areas is basically along the Brazos River. One of the objectives of the TTWP is to evaluate the feasibility of supplying water needs that occur west of the Brazos using water from east of the Brazos. Ongoing studies by the San Antonio River Authority in the West-Central Area will eventually develop definitive estimates of the projected water demands which might be met by southeastern supplies delivered through the TTWP. Unfortunately, those studies will not be completed until later in 1994. Therefore, the PMC has adopted preliminary estimates of the water demands west of the Brazos River based on the "management plan" developed by the TWDB for the Southern Edwards aquifer region in response to the federal lawsuit over the aquifer. Specifically, three scenarios were developed for consideration:

<u>Scenario 1:</u> This scenario represents the TWDB's proposed plan for new supply development in the San Antonio area. Under this plan, transfer of additional water from the southeast would need to begin by 2010 and would increase to 600,000 acre-feet per year by 2050.

<u>Scenario 2:</u> This plan includes the TWDB's proposed plan, but also adds additional local projects and wastewater reuse to the proposed supply, resulting in a delay of the need for southeast water transfers until the year 2020. This plan also results in a reduction of the amount needed west of the Brazos in 2050 to 300,000 acre-feet per year.

<u>Scenario 3:</u> This scenario assumes extensive development of local water resources and does not include any Southeast area water supplying the San Antonio area.

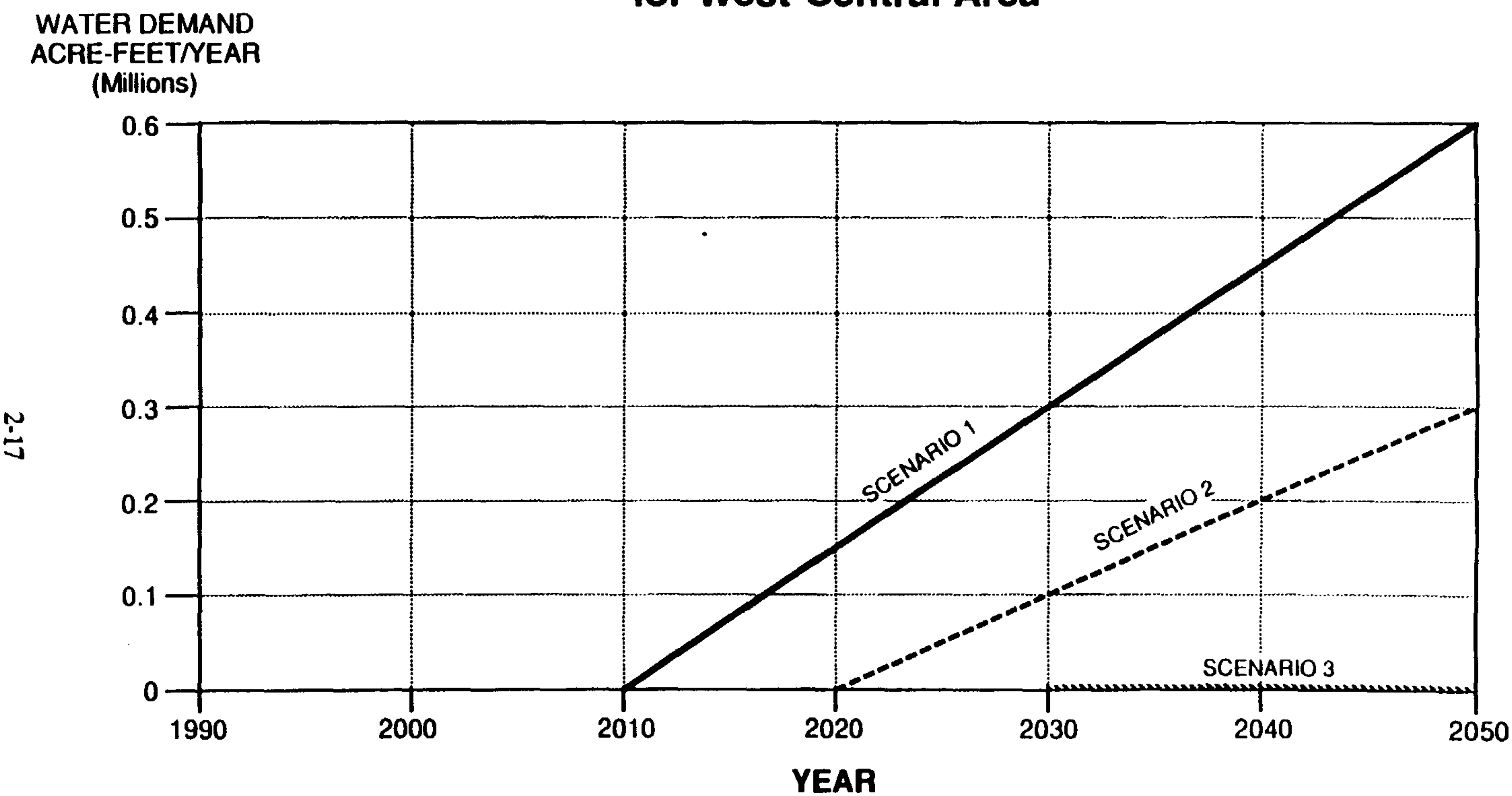
Each of these scenarios is shown graphically in Figure 2.4.

## 2.6 Existing Water Resource Management and Regulation

Existing water resource management in the Southeast Area is extensive. As a result of the large supplies of dependable surface water from rivers in this region and major underground aquifers, both surface water and groundwater sources have been developed for municipal, agricultural, manufacturing and the power industry needs.

Figure 2.4

## INTERBASIN TRANSFER WATER REQUIREMENTS
## for West-Central Area

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The current status of development of the supply sources is outlined in detail within Section 3.0 of this report. This section outlines the regulatory status of water resource management in the study area, including: water rights permits and contracts, interbasin transfers, groundwater management plans, wastewater reuse and reclamation, and water conservation.

**Water Rights and Contracts**

Information on water rights permits and water use contracts was obtained from the Texas Natural Resource Conservation Commission (TNRCC) and various regional and local water supply agencies. Existing water rights include those associated with major reservoirs, run-of-river diversions of fresh water, and diversions of brackish and salt water near the coast. Appendix I includes a list of water rights in the Southeast Area. It should be noted that the existing rights do not represent reliable water supplies in all cases. Also, the water rights shown in Appendix I include non-consumptive diversions for cooling and diversions of brackish water. As a result, the total water rights are not consistent with demand and supply figures given elsewhere in the report.

For most of the study area, securing additional water rights for reliable sources of surface water would require either the development of new water supply projects or a re-evaluation of the reservoir yield conditions resulting from system operation procedures. Additional water supplies to serve areas of local need may be provided by contracting with existing water permit holders to obtain quantities of "uncommitted" available surface water. It is a common practice for water supply entities (cities, river authorities, etc.) to obtain water rights permits from the TNRCC and to contract to supply a number of individual users within a given service area. A detailed list of current water contracts is included in Appendix I.

A review of the existing water rights and contracts indicates that all available water supplies are currently committed by the San Jacinto River Authority to long-term contracts within the San Jacinto River Basin. Water can be contractually purchased from the river authorities within all of the other study area river basins.

**Interbasin Transfers**

Interbasin transfer of surface waters is a common practice in the Southeast Area. Notable existing interbasin transfers include (a) the City of Houston's use of Trinity River water within the San Jacinto River Basin, and (b) the use of Trinity River water by the City of Galveston within the San Jacinto-Brazos coastal basin, (c) the Gulf Coast Water Authority's use of Brazos River Basin water to supply industrial and commercial users in the San Jacinto-Brazos coastal basin, (d) the use of Sabine River water in the Neches basin, and (e) the use of Neches water within the Neches-Trinity coastal basin.

The Southeast Area includes eight river basins, of which three are considered coastal basins. Water users in these areas (the Neches-Trinity, Trinity-San Jacinto, and San Jacinto-Brazos) commonly use surface waters from outside of their defined boundaries, since there are no reliable sources of surface water within their boundaries. Interbasin transfer is relatively economical in the coastal areas due to the flat terrain and consequent effectiveness of open canals for conveyance of raw water. As a consequence, about one third of the total surface water interbasin transfers within the State of Texas occurs in the Southeast Area.

A listing of the specific existing interbasin transfer permits within the Southeast Area is provided in Appendix J. Projections of future interbasin surface water supply imports and exports have also been developed by the TWDB. Table 2-4 provides a summary of these projections by river basin with the Southeast Area. In general, projected interbasin transfers are based on the existing water rights permits and contracts shown in Appendix I. The following observations can be made through

# Table 2.4

## Interbasin Transfer: Imports and Exports
**– Amounts in Acre–Feet/Year –**

### IMPORTS

| Basin | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|---|
| Sabine | 2,601 | 2,935 | 3,174 | 3,440 | 3,762 | 3,800 | 3,838 |
| Neches | 994 | 1,411 | 1,969 | 2,620 | 4,111 | 4,658 | 5,303 |
| Neches-Trinity | 321,088 | 270,499 | 277,143 | 284,889 | 294,806 | 303,787 | 313,347 |
| Trinity | 0 | 0 | 0 | 0 | 0 | 238 | 238 |
| Trinity-San Jacinto | 114,683 | 112,360 | 117,815 | 125,504 | 134,048 | 142,551 | 152,760 |
| San Jacinto | 400,948 | 495,003 | 596,119 | 731,960 | 853,749 | 913,254 | 975,147 |
| San Jacinto-Brazos | 206,439 | 238,835 | 258,466 | 303,666 | 140,039 | 123,446 | 125,905 |
| Brazos | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 1,046,753 | 1,121,043 | 1,254,686 | 1,452,079 | 1,430,515 | 1,491,734 | 1,576,538 |

### EXPORTS

| Basin | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|---|
| Sabine | 787 | 1,186 | 1,669 | 2,308 | 3,785 | 4,314 | 4,940 |
| Neches | 230,677 | 201,629 | 205,287 | 212,964 | 222,774 | 231,669 | 241,248 |
| Neches-Trinity | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Trinity | 672,565 | 770,413 | 892,132 | 1,074,474 | 1,022,615 | 1,072,067 | 1,144,207 |
| Trinity-San Jacinto | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| San Jacinto | 54,150 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 |
| San Jacinto-Brazos | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Brazos | 88,574 | 87,815 | 95,598 | 102,333 | 121,341 | 123,684 | 126,143 |
| TOTAL | 1,046,753 | 1,121,043 | 1,254,686 | 1,452,079 | 1,430,515 | 1,491,734 | 1,576,538 |

analysis of Table 2-4.

- Total Southeast Area interbasin transfers increase from approximately 1,047,000 acre-feet per year in 1990 to 1,576,500 acre-feet per year in 2050.

- The San Jacinto River Basin requires the largest quantity of imported water of all other basins within the study area. In year 2050, water imports into the San Jacinto Basin represent over 60 percent of all Southeast Area projected water imports.

- In year 2050, approximately 60 percent of the San Jacinto basin water demands are projected to be met from imported supplies.

- Approximately 1.1 million acre-feet per year of Trinity Basin water supply is projected to be exported in year 2050, virtually all into the San Jacinto Basin.

- Approximately 99 percent of the Brazos Basin export of water supplies in the Southeast Area is to the San Jacinto-Brazos Coastal Basin.

- Approximately 77 percent of the Neches Basin export of water supplies is to the Neches-Trinity Coastal Basin.

**Groundwater Management**

There are two existing groundwater management programs within the Southeast Area, both created to address the problem of land subsidence and saltwater intrusion created by over-use of groundwater. One program was initiated in 1989 and is located in Fort Bend County. The Fort Bend County Subsidence District is currently performing studies to assess the magnitude of existing and projected subsidence in that county. Following completion of these studies, a plan may be developed to limit use of groundwater in the area if the identified problems warrant such action. The other program is managed by the Harris Galveston Coastal Subsidence District (HGCSD). This program was begun in 1975 and has been very successful in reducing or eliminating serious subsidence previously occurring in those two counties.

The HGCSD created a groundwater withdrawal management plan which established goals for future levels of land subsidence throughout Harris and Galveston counties based on mathematical simulation of the groundwater withdrawal and subsidence phenomena. Seven subsidence "zones" were created under the current plan. Each zone is scheduled to convert to a pattern of 80 percent surface water use and 20 percent groundwater use by defined target dates. Figure 2.5 and Table 2.5 show the subsidence zones and the required target dates by which the ground water to surface water conversion should be accomplished. In addition, Table 2.5 details for each of the seven zones the estimated ground water and additional surface water needed to meet projected demand through 2030. Currently, the water suppliers in Harris and Galveston counties have successfully met the HGCSD plan requirements. It is anticipated that future surface water conversion requirements will continue to be met through appropriate governmental actions.

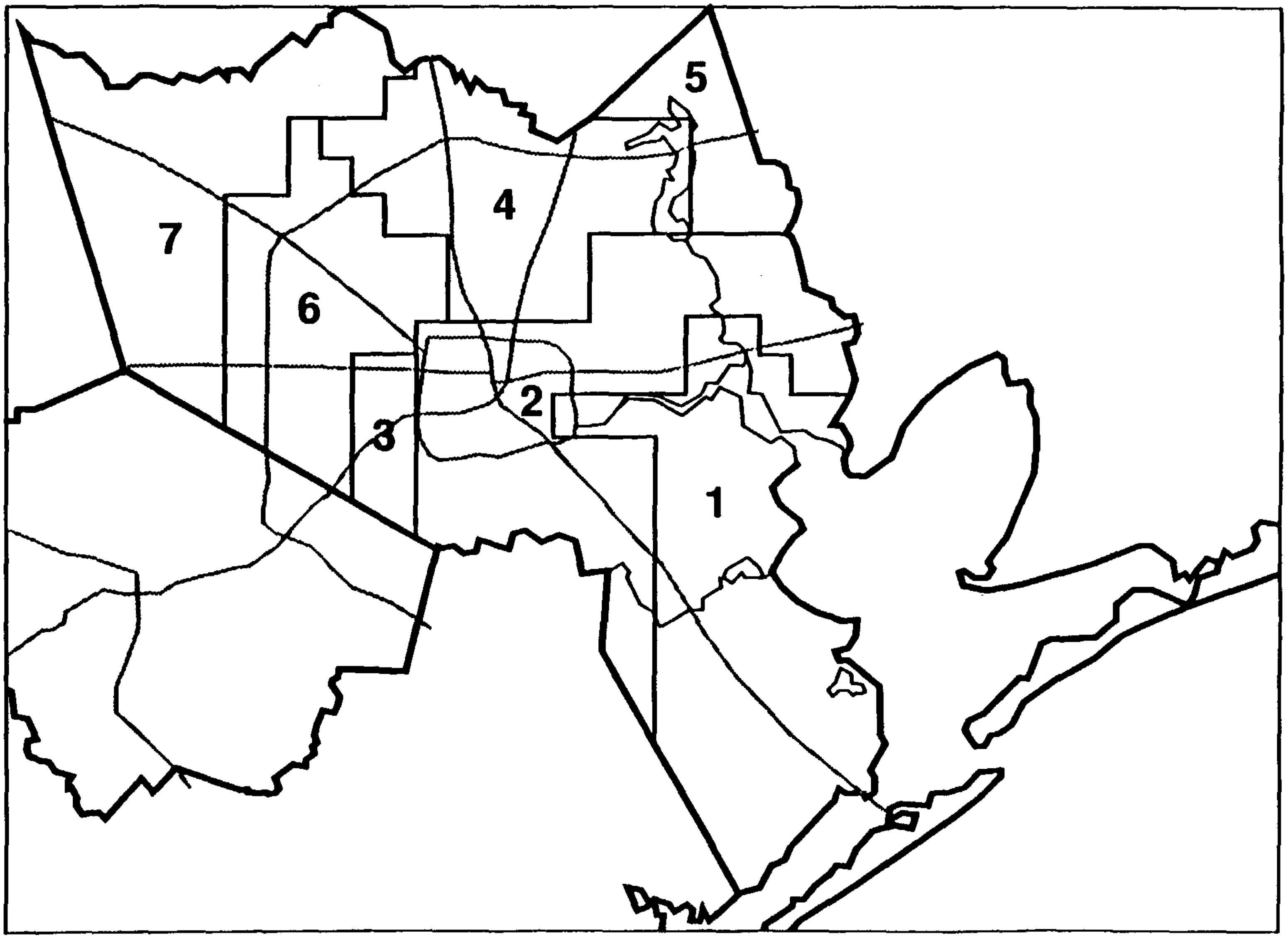
**Recycling/Reclamation and Reuse**

Recycling is the repeated use of water prior to its discharge. Reclamation and reuse involve treating wastewater effluent and reusing it before discharge to a receiving stream. While recycling is very common within the Southeast Area, no known existing instances of reclamation and reuse have been documented. Water recycling occurs particularly for industrial water users which use process waters or water used for cooling purposes repeatedly for various purposes within the same industrial facility.

Industries in the Southeast Area have increased the cycles of concentration (number of times water is recycled) in response to increased water costs and to environmental regulations regarding waste minimization. "Once-through" water use by heavy industry is now the exception rather than normal practice in this area. The quantity of recycled water has not been specifically documented for this study, but this general trend is reflected in the industrial water use projections developed by the TWDB. More detailed ongoing studies on this subject are currently underway at the TWDB and may be used in later phases of this study to update the projections as appropriate.

Figure 2.5

**HARRIS GALVESTON COASTAL SUBSIDENCE DISTRICT
REGULATORY AREAS**



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## Table 2.5

## Ground Water Conversion Plan: Harris Galveston Coastal Subsidence District

| AREA | YEAR | % GROUND WATER |
|---|---|---|
| 1 | 1990 | 10% |
| 2 | 2010 | 20% |
| | 2020 | 20% |
| 3 | 1995 | 20% |
| | 2020 | 20% |
| 4 | 2002 | 20% |
| | 2020 | 20% |
| 5 | 2005 | 20% |
| | 2020 | 20% |
| 6 | 2010 | 20% |
| | 2020 | 20% |
| 7 | 2020 | 20% |

### Cumulative Estimated Ground Water Requirements
### -Millions of Gallons per Day-

| AREA | 1995 | 2000 | 2005 | 2010 | 2020 | 2030 |
|---|---|---|---|---|---|---|
| 1 | 20 | 25 | 29 | 34 | 45 | 56 |
| 2 | 80 | 93 | 107 | 82 | 88 | 115 |
| 3 | 11 | 12 | 13 | 14 | 12 | 12 |
| 4 | 81 | 95 | 31 | 44 | 29 | 43 |
| 5 | 12 | 14 | 4 | 6 | 6 | 12 |
| 6 | 137 | 152 | 167 | 37 | 39 | 48 |
| 7 | 52 | 63 | 74 | 86 | 37 | 61 |
| TOTAL | 393 | 454 | 425 | 303 | 256 | 347 |

### Cumulative Estimated Surface Water Requirements
### -Millions of Gallons per Day-

| AREA | 1995 | 2000 | 2005 | 2010 | 2020 | 2030 |
|---|---|---|---|---|---|---|
| Existing Demand | 514 | 514 | 514 | 514 | 514 | 514 |
| 1 | 32 | 72 | 112 | 154 | 254 | 344 |
| 2 | 0 | 0 | 0 | 39 | 63 | 63 |
| 3 | 44 | 44 | 44 | 44 | 47 | 47 |
| 4 | 0 | 0 | 78 | 78 | 109 | 109 |
| 5 | 0 | 0 | 13 | 13 | 20 | 20 |
| 6 | 0 | 0 | 0 | 143 | 151 | 151 |
| 7 | 0 | 0 | 0 | 0 | 75 | 75 |
| TOTAL | 590 | 630 | 761 | 985 | 1,233 | 1,323 |

It is anticipated that water recycling will continue to increase throughout the study area.

**Water Conservation**

Water conservation, or the efficient use of water, has become one of the more common water resource management techniques in use today. Conservation is viewed as a water demand management method which reduces or manages water use as opposed to a method for developing additional supplies. Both federal legislation and State of Texas regulations now exist which mandate the use of water conservation for both the end user and water supply agencies.

The Federal Energy Policy Act of 1992 (PL 102-486) establishes water efficiency standards and mandates use of low flow plumbing fixtures (toilets, showerheads, etc.) manufactured after January, 1994. The State of Texas, in 1991, adopted Senate Bill 587, which established minimum plumbing fixture standards within Texas and now requires the manufacture and installation of low-flow plumbing fixtures by the plumbing industry throughout the state. Plumbing suppliers must comply with a fixture certification process prior to the sale of the equipment within Texas. In 1992, the Texas Water Commission enacted Title 31, Chapter 288, which requires the development of detailed water conservation plans to accompany all water rights applications requests. Conservation plans, per these regulations, must contain a detailed analysis of water user characteristics and identification and adoption of conservation best management practices to achieve efficient beneficial use of existing water supplies.

Each of the above regulations is expected to create future reductions in per capita use of water within Texas. Water demand management has proven beneficial and achievable in other regions of the country. The TWDB water projections presented previously for this area contain a residential per capita reduction for future use in comparison to year 1990 actual use. The TWDB projections also contain non-residential per unit water demand reductions. The TTWP water demand needs are developed in accordance with the reductions in water use factors used by the TWDB.

## 2.7 Water Requirements for Environmental Protection

Based upon the desire to incorporate potential environmental requirements for fresh water into the planning process at the earliest possible time, specific environmental guidelines were established and officially adopted for the TTWP at the initiation of the program. These guidelines are given in Appendix C. They cover water quality, instream flow requirements to protect fish and wildlife habitats, freshwater inflow requirements for bays and estuaries, and pass-through requirements for new reservoirs.

### Water Quality

Environmental guidelines pertaining to water quality impacts are defined within four broad analysis categories:

- Water Quality Standards Attainment
- Chemical and Biological Compatibility of Waters
- Salt Water Intrusion
- Nutrients

These guidelines establish baseline water quality requirements. In general, the Trans-Texas Water Program should be developed so as not to degrade water quality below existing conditions in any waterbody.

Each of these water quality parameters is a function of flow dependent analysis. Detailed analysis of the water quality impacts associated with the Trans-Texas Water

Program are currently planned to occur within Phase II of the project. Exact definition of flow quantities discharged into or removed from a specific waterbody will depend on the water supply components recommended for inclusion within the TTWP. Determination of specific conveyance routes and the use of water resource techniques including conservation, etc., will define hydrologic conditions which must be analyzed.

**Instream Flows**

The referenced guidelines define as an initial assumption a basis for estimating the minimum streamflows to be protected in order to maintain suitable fish and wildlife habitats in the streams affected by the TTWP. These minimum amounts are 60 percent of the median flows for each month from March through September and 40 percent of the median flows for each month from October through February. Any flow exceeding this amount is assumed to be potentially available for other beneficial uses and interbasin transfer. Water stored in existing reservoirs is not considered subject to this allocation for instream uses and is not subject to being released to enhance the instream flows.

Flow data used in calculating the median flows were obtained from the published gaging station records of the U.S. Geological Survey. The resulting instream flow requirements for the TTWP are shown in Table 2.6.

**Bays and Estuaries**

Freshwater inflow requirements of bays and estuaries are also addressed in the TTWP environmental guidelines. As an initial assumption, minimum inflows were set as the mean flows for each month for May and June and September and October, and the median flows for each month in the remaining months of the year. As with the instream flow requirements, water stored in existing reservoirs is not considered to be

# TABLE 2.6
## Instream Flow Values at Selected USGS Gaging Stations
## (Flows in Cubic Feet per Second)

| RIVER | | 40% OF MONTHLY MEDIAN | | | | | 60% OF MONTHLY MEDIAN | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GAGE | Per. of Record | October | November | December | January | February | March | April | May | June | July | August | September |
| **SABINE** | | | | | | | | | | | | | |
| Burkeville | 1956-1990 | 203 | 269 | 716 | 1,432 | 2,648 | 3,834 | 2,424 | 2,820 | 1,800 | 1,398 | 948 | 582 |
| Bon Weir | 1924-1990 | 313 | 480 | 1,240 | 3,144 | 3,820 | 5,934 | 4,434 | 4,140 | 2,190 | 1,206 | 732 | 612 |
| Ruliff | 1925-1991 | 480 | 656 | 1,628 | 4,160 | 4,960 | 7,260 | 5,874 | 5,220 | 2,976 | 1,812 | 1,224 | 924 |
| **NECHES** | | | | | | | | | | | | | |
| Rockland | 1904-1990 | 54 | 136 | 380 | 848 | 1,072 | 1,680 | 1,476 | 1,584 | 648 | 212 | 98 | 84 |
| Townbluff | 1952-1990 | 616 | 656 | 792 | 1,200 | 1,988 | 3,036 | 2,928 | 3,204 | 1,968 | 1,464 | 1,176 | 954 |
| Evadale | 1922-1991 | 308 | 568 | 1,000 | 2,344 | 3,232 | 4,980 | 4,332 | 3,978 | 2,322 | 1,326 | 762 | 579 |
| **TRINITY** | | | | | | | | | | | | | |
| Goodrich | 1967-1990 | 334 | 684 | 1,376 | 1,232 | 1,984 | 3,690 | 3,156 | 4,258 | 3,504 | 1,284 | 810 | 630 |
| Roymayor | 1925-1991 | 374 | 620 | 1,080 | 1,640 | 2,128 | 3,378 | 3,066 | 5,208 | 3,102 | 1,212 | 684 | 606 |
| **SAN JACINTO** | | | | | | | | | | | | | |
| W. Fork, Conroe | 1948-1990 | 14 | 26 | 56 | 72 | 97 | 91 | 65 | 72 | 39 | 20 | 15 | 19 |
| Porter | 1985-1990 | 25 | 88 | 104 | 89 | 150 | 119 | 63 | 61 | 67 | 32 | 24 | 44 |
| **BRAZOS** | | | | | | | | | | | | | |
| Bryan | 1919-1990 | 468 | 452 | 520 | 700 | 760 | 1,272 | 1,548 | 3,120 | 2,700 | 1,080 | 684 | 648 |
| Hempstead | 1939-1990 | 540 | 616 | 904 | 1,024 | 1,372 | 1,734 | 2,040 | 4,410 | 3,300 | 1,356 | 852 | 816 |
| Richmond | 1923-1991 | 664 | 760 | 1,020 | 1,360 | 1,708 | 2,472 | 2,454 | 4,614 | 3,576 | 1,380 | 846 | 930 |
| Rosharon | 1968-1980 & 1984-1990 | 600 | 1,136 | 1,468 | 1,932 | 2,320 | 3,084 | 3,252 | 5,436 | 4,134 | 1,260 | 888 | 1,068 |

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subject to allocation for bay and estuary uses. USGS flow data from the most downstream gages were used to determine minimum inflow requirements. Bay and estuary inflow requirements are summarized in Table 2.7.

**New Reservoirs**

Provisions were made in the basic environmental guidelines to address pass-through requirements for any new reservoir being considered. In the preliminary planning, it is assumed that new reservoirs would release inflows up to the mean flows for each month for April through June, and August through October, and up to the median flows for each month in the remaining months. If a reservoir drops below 60 percent of capacity, a drought contingency plan would be put into effect, and the reservoir would be assumed to pass inflows up to the median daily flows observed during the drought of record.

**Table 2.7**

**Bay and Estuary Inflow Guidelines**

**- Cubic Feet per Second -**

| River | Gage | Median Flow | | | | Mean Flow | | Median Flow | | Mean Flow | | Median Flow | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
| Sabine | Ruliff | 12,036 | 13,401 | 13,406 | 9,614 | 12,698 | 8,955 | 3,772 | 2,713 | 2,644 | 2,135 | 1,920 | 4,301 |
| Neches | Evadale | 6,621 | 8,907 | 8,810 | 7,706 | 10,488 | 7,175 | 2,650 | 1,449 | 1,700 | 1,717 | 1,506 | 2,666 |
| Trinity | Romayor | 5,747 | 7,230 | 7,744 | 7,214 | 15,649 | 11,591 | 2,566 | 1,291 | 2,103 | 3,084 | 2,124 | 5,222 |
| San Jacinto | Porter | 531 | 1,014 | 674 | 382 | 683 | 814 | 70 | 72 | 93 | 229 | 384 | 900 |
| Brazos | Rosharon | 7,531 | 9,273 | 7,620 | 7,467 | 13,892 | 13,876 | 2,272 | 1,422 | 3,253 | 3,982 | 2,681 | 3,731 |

# 3.0 WATER SUPPLY

This section of the report presents an inventory of existing available supplies of groundwater and surface water within the study area and establishes the future (through year 2050) water supply requirements based on the projected demands presented in Section 2.0 of the report. Subsequent report sections identify water supply alternatives available to meet these projected requirements and select the most promising alternatives for incorporation into the conceptual plan to be analyzed in Phase II of the program.

## 3.1 Groundwater

The aquifer that furnishes by far the most groundwater within the Southeast Area is the Gulf Coast aquifer, which extends from near the shoreline to approximately 100 to 120 miles inland. The other major aquifer in the study area is the Carrizo-Wilcox, which begins 115 to 125 miles inland and extends beyond the northern boundary of the study area. In addition, there are three minor aquifers in this part of the state. The Sparta and Queen City aquifers lie above the Carrizo-Wilcox along a relatively narrow strip at the northern edge of the region. The Brazos River alluvium occurs along the main stem of the Brazos as it passes through the area, except in Brazoria County.

**Existing Use**

Table 3.1 is a summary of groundwater pumpage in the study area during 1990, as compiled by the Texas Water Development Board. In 1990, some 814,000 acre-feet of groundwater were used from wells within the study area. Roughly 80 percent of this total was used in the Houston-Galveston area, and most of the remainder was in Jasper and Angelina Counties in the Neches basin.

## Table 3.1

## Summary of 1990 Groundwater Pumpage in the Aquifers of the Southeast Area

- Acre-Feet per Year-

| Acquifer | Sabine Basin | Neches Basin | Neches-Trinity | Trinity Basin | Trinity-San Jacinto | San Jacinto Basin | San Jacinto-Basin | Brazos Basin | Total |
|---|---|---|---|---|---|---|---|---|---|
| Gulf Coast | 20,338 | 71,637 | 2,843 | 16,124 | 17,237 | 469,686 | 68,555 | 43,766 | 710,196 |
| Carrizo-Wilcox | 2,261 | 23,261 | -- | -- | -- | -- | -- | 32,464 | 57,986 |
| Sparta | 38 | 318 | -- | -- | -- | -- | -- | 1,475 | 1,831 |
| Queen City | -- | 178 | -- | -- | -- | -- | -- | 706 | 884 |
| Brazos-Alluvium | -- | -- | -- | -- | -- | -- | 378 | 33,274 | 33,652 |
| Sub-Total | 22,637 | 95,394 | 2,843 | 16,124 | 17,247 | 469,686 | 68,933 | 111,685 | 804,549 |
| Undifferentiated | 44 | 6,185 | -- | 625 | -- | 513 | -- | 1,958 | 9,325 |
| Total | 22,681 | 101,579 | 2,843 | 16,749 | 17,247 | 470,199 | 68,933 | 113,643 | 813,874 |

The Gulf Coast aquifer accounted for approximately 88 percent of the pumpage for which a formation was identified in that year. The Carrizo-Wilcox aquifer provided another 7 percent, the Brazos River alluvium furnished approximately 4 percent, (almost entirely for irrigation purposes), and the Sparta and Queen City formations yielded only minor amounts of supply. (Together they produced a fraction of 1 percent of the identified pumpage.)

**Projected Use**

Table 3.2 shows the projected groundwater use within the study area by decades from 2000 through 2050, based on a basin-by-basin analysis of estimated future supply and demand. The amounts of sustainable groundwater pumpage were taken from the Texas Water Development Board's detailed evaluations that were used in preparation of the Texas Water Plan. The TWDB assumes that (a) groundwater will be used to satisfy future water demands from an aquifer as long as there is sufficient groundwater available, and (b) groundwater will also be used to supply increases in demands now being met from surface sources whenever the surface supplies reach their limits of dependable yield as long as there is still enough unused groundwater in the county to cover the increase. In cases where there is a predicted decrease in a demand now being met by groundwater, it was assumed that the result would be a corresponding decrease of groundwater use. Based on this methodology, the use of groundwater in the study area is predicted to grow from 881,000 acre-feet per year in 2000 to 958,000 acre-feet per year in 2050. These estimates and the methodology for allocations between ground and surface water are presented in greater detail in Appendices K and L.

**Further Development**

Various constraints restrict the ability to use groundwater to supply more of the project demand than currently anticipated. These constraints include water

**Table 3.2**

**Estimated Future Groundwater Pumpage in the Southeast Area: 2000-2050**

**- Amounts in Thousands of Acre-Feet per Year -**

| | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|
| Sabine River Basin | 23.3 | 23.3 | 23.3 | 23.4 | 23.5 | 23.6 |
| Neches River Basin | 110.5 | 111.6 | 112.8 | 114.6 | 116.3 | 118.3 |
| Neches - Trinity Coastal Basin | 7.8 | 8.1 | 8.5 | 8.8 | 9.1 | 9.4 |
| Trinity River Basin | 34.3 | 36.6 | 38.7 | 41.2 | 43.8 | 46.7 |
| Trinity - San Jacinto Coastal Basin | 27.5 | 31.5 | 37.5 | 43.5 | 49.6 | 56.0 |
| San Jacinto River Basin | 466.4 | 350.0 | 291.9 | 389.0 | 385.6 | 415.7 |
| San Jacinto - Brazos Coastal Basin | 80.7 | 85.7 | 91.0 | 90.8 | 90.6 | 90.4 |
| Brazos River Basin | 130.5 | 141.9 | 156.1 | 169.4 | 181.1 | 197.3 |
| Total | 881.0 | 788.7 | 759.8 | 880.7 | 899.6 | 957.5 |

Note: These amounts represent pumpage in the study area portions of the basins only, which in several cases do not include the entire basin.

quality, subsidence, and the location of the supply aquifers with respect to the demand areas. Increased use of groundwater beyond that level currently projected is possible, but would require development of additional facilities for extensive treatment, conveyance over long distances, or other special purposes not currently provided in the existing groundwater supply systems; therefore, further consideration of increased usage beyond the projection in Table 3.2 is considered as a future supply option similar to other alternatives evaluated in Section 4.0 of the report. Specifically, limitations to use of additional groundwater supply in various regions of the study area are further outlined in Section 4.7.

## 3.2 Surface Water Reservoirs

Table 3.3 is a list of the estimated year 2050 dependable yields available from existing and under-construction reservoirs in the various basins of the study area. The identified yields are predominantly for major reservoirs that provide water to the entire study area but also include other smaller projects that provide minor amounts of supply for local communities or industries located in the study area. The estimated yields shown in the table were obtained from the Texas Natural Resource Conservation Commission or from studies provided by individual river authorities for that basin. A brief description of the current conditions in each basin is provided below.

### Sabine

There is only one major surface water reservoir located in the Sabine Basin within the study area - Toledo Bend Reservoir, owned by the Sabine River Authorities of Texas and Louisiana. This reservoir is one of the largest in the southeastern U.S., and

## Table 3.3

## Summary of Projected Year 2050 Surface Reservoir Yields Available in the Southeast Area

**- Acre-Feet per Year -**

| | |
|---|---|
| Sabine River Basin | |
| Toledo Bend Reservoir[1] | 1,043,300 |
| | |
| Neches River Basin | |
| Rayburn/Steinhagen Reservoir System[2] | 664,300 |
| Other Reservoirs[3] | 44,900 |
| | |
| Trinity River Basin | |
| Lake Livingston[4] | 997,700 |
| Wallisville Salt Water Barrier (under construction)[4] | 157,000 |
| Other Reservoirs[5] | 11,200 |
| | |
| San Jacinto River Basin | |
| Lake Houston | 151,400 |
| Lake Conroe | 99,950 |
| Other Reservoirs[6] | 6,300 |
| | |
| Brazos River Basin | |
| Brazos River Authority System[7] | 188,100 |
| Lake Limestone | 63,400 |
| Other Reservoirs[8] | 22,900 |
| | |
| Total Existing Surface Reservoir Yield Available in the Study Area | 3,450,450 |

*Notes:

1. The yield of Toledo Bend Reservoir is Texas' share only.
2. As discussed in the text, the yield of the Rayburn/Steinhagen system assumes that the Lower Neches Valley Authority is able to build temporary salt water barriers when needed.
3. Lake Kurth, Lake Nacogdoches, and Pinkston Reservoir combined.
4. Lake Livingston and Wallisville salt water barrier function as a system. The yield of Lake Livingston assumes Wallisville salt water barrier is in operation.
5. Houston County Lake
6. Lake Lewis Reservoir
7. System uses reservoirs in the Brazos Basin including Possum Kingdom, Granbury, Belton, Stillhouse Hollow, Somerville, and Whitney. Only Somerville is physically located in study area, but all reservoirs can supply demands in the study area.
8. Twin Oak Reservoir and Gibbons Creek Reservoir.

currently has very little of its water supply committed to contract uses. The Sabine River Authority of Texas (SRA) was formed by the State of Texas in 1949 and the Sabine River Authority of Louisiana (SRA-LA) was formed by the State of Louisiana in 1950. These two authorities joined together to construct Toledo Bend Reservoir as a jointly owned and operated project. Funding of the project was accomplished by the sale of bonds by both states, a loan from the TWDB to the Sabine River Authority and a cash contribution from the State of Louisiana. An agreement between the two states provides for an equitable division of the available water of the Sabine River and establishes a Joint Operation to maintain and operate the reservoir. The Toledo Bend Reservoir was constructed by the two authorities during the early 1960's, and impoundment began on October 3, 1966. The Joint Operation of the two authorities has operated the reservoir since that time.

The yield of 1,043,300 acre-feet per year shown in Table 3.3 for Toledo Bend Reservoir is the Texas share (one-half) of the estimated total firm yield of the project (2,086,600 acre-feet). The State of Louisiana, through the SRA-LA, owns the other half of the total yield. The Texas share of the yield is more than the allowable annual diversion of 750,000 acre-feet per year currently permitted by TNRCC in the existing water rights of the SRA. For purposes of the TTWP, it is assumed that the SRA could obtain a permit amendment increasing its diversion rights to the full Texas share of the yield.

Several factors limit the availability of Toledo Bend Reservoir water considered for interbasin transfer. First, the Louisiana share of Toledo Bend is limited in its attractiveness as a source due to the economic and institutional issues involved in interstate water sales. Contracts for the sale of Louisiana's share of Toledo Bend would be through the SRA-LA and would likely involve review and approval of various Louisiana state agencies. This process may become involved in political concerns involving Louisiana's sovereignty over its waters. Also, water sales contracts generally require some form of immediate and continuing payment to reserve water for future use. Economic advantages associated with the supply source diminish in relationship with the time period that a water supply is reserved. Until an immediate need for the Louisiana water is identified, this reserve cost could become a substantial economic disincentive. These considerations suggest that it may be more prudent to utilize all available Texas in-state water supplies prior to considering alternatives associated with out-of-state supplies. For the purposes of the TTWP, none of the Louisiana share of Toledo Bend Reservoir is considered for use.

The Texas share of Toledo Bend is also limited in its availability for interbasin transfer in the TTWP. Future in-basin demands in the study area will be met from Toledo Bend Reservoir. In addition, the upper portion of the Sabine Basin (upstream from the study area) is projected to experience a deficit in available surface supplies. Plans for future reservoir construction in that area to meet that demand have been delayed, and their ultimate success is currently in doubt. Therefore, the SRA has identified a need to set aside a "reserve" of 283,000 acre-feet per year for potential future use throughout the basin.

The considerations associated with the availability of water outlined above result in the use of 672,000 acre-feet per year from Texas' share of the yield of Toledo Bend Reservoir for the Trans-Texas Water Program.

**Neches**

The major reservoir system of the Neches Basin is made up of Sam Rayburn Reservoir and the smaller B.A. Steinhagen Reservoir located just downstream from Rayburn. Both reservoirs are owned and operated by the U.S. Army Corps of Engineers. Steinhagen was completed in 1951, and Rayburn in 1965.

The water rights in the system are held by the Lower Neches Valley Authority and are for 820,000 acre-feet per year, which represents the maximum firm yield of the system.

At present, the combined usable yield of the reservoirs is 664,300 acre-feet per year as shown in Table 3.3, based on the assumption that diversion facilities in the lower basin are protected by temporary salt water barriers in times of critical drought. This assumption for estimated yield makes allowance for occasional water losses when the barriers must be repaired after brief rises of the river. Depending on actual operating procedures and on the federal policy regarding permits to build the temporary barriers, the yield available for beneficial use could be even less than indicated in Table 3.3, as further explained below.

The customary procedure used by the LNVA to protect its basic supply against salt water intrusion is to build temporary barriers of steel sheet-piling on the Neches and on Pine Island Bayou when there is not enough river flow to keep salt water below the confluence of those two streams. The LNVA and its predecessors have been using such structures for more than 50 years, and the barriers have provided an economical and dependable way to cope with the salt water problem. From time to time, there has been consideration of installing a permanent barrier structure, but the cost would be so much more than the expense of building the temporary barriers that the LNVA has so far not found a permanent facility to be economically viable.

In past years, the LNVA held a continuing permit, issued by the U.S. Army Corps of Engineers, which authorized the construction of temporary barriers whenever they were needed. Recently, however, the Corps has withdrawn that permit and required that a new permit must be sought before any further barriers can be installed. In 1992, the LNVA filed an application for a new permit, and the matter has now been under consideration by the Corps for more than a year. During the review process, there has been some indication that the Corps might conclude that there is no serious need for building the barriers until the lake level at Sam Rayburn drops to Zone 3 of the current operating rule curve.

The barriers serve a dual purpose. Their obvious use is to keep salt water away from the intakes. In doing that, however, they also help to conserve the yield of the basic supply sources, Sam Rayburn and B.A. Steinhagen Reservoirs. If the barriers are not in place during drought times, large releases must be made from Lake Steinhagen to hold the salt water downstream from the intakes. Those releases tend to deplete the reservoir storage at an unnecessarily high rate and reduce the dependable yield of both reservoirs. Once a drought has started, the longer the LNVA must operate without the barriers, the less firm yield there will be.

As a result of the current uncertainty associated with the continued use of temporary salt water barriers, the actual usable yield of the Rayburn/Steinhagen system is in doubt. The 664,300 acre-feet per year which has historically been available may not be the true firm yield. Consequently, the opportunity to use "surplus" yields from the Neches Basin for interbasin transfer is limited at this time. The LNVA presently maintains an extensive canal system which serves both the Neches River Basin and the Neches-Trinity Coastal Basin with supplies from the Rayburn/Steinhagen system. This service is expected to continue and grow as necessary to meet projected increases in demand within this service area; however, no additional basin transfers are considered possible at this time.

**Trinity**

The Trinity River basin has two major water supply reservoirs located in the study area - Lake Livingston and the Wallisville salt water barrier. Lake Livingston was sponsored jointly by the City of Houston and the Trinity River Authority (TRA), completed in 1968, and is now operated by the TRA to serve demands of the City of Houston and other local users in the Trinity Basin and the Neches-Trinity Coastal Basin. The City of Houston and the TRA are also local sponsors for the Wallisville Saltwater Barrier, which is currently under construction by the U.S. Army Corps of Engineers--Galveston District. This project has a long history of environmental litigation and has been modified extensively to reduce its environmental impacts.

Further federal appropriations to complete this project are now pending administrative and congressional action.

Lake Livingston and Wallisville salt water barrier are designed to operate as a system, Livingston primarily to store water, and Wallisville to protect water released from Livingston for downstream pump stations from contamination by salt water from Trinity Bay. Therefore, the sum of the permitted 997,700 and 157,000 acre-feet per year yields shown in Table 3.3 for Livingston and Wallisville, respectively, is the combined yield of the system (1,154,700 acre-feet per year). This yield makes allowance for significant upstream development that is given priority under the Livingston and Wallisville water rights permits but has not yet all taken place. Without the completion of the Wallisville salt water barrier, the firm yield of Lake Livingston would decrease by approximately 290,000 acre-feet per year to 865,000 acre-feet per year. This value was determined by the Corps of Engineers and represents Lake Livingston reservoir releases necessary to control salt water intrusion.

Currently, thirty percent of Livingston/Wallisville water rights are held by the TRA specifically to serve the lower Trinity Basin and areas to the east. The other seventy percent of rights are held by the City of Houston. The City of Houston, in light of its large forecast water demands and existing water supply conveyance system, has expressed interest in acquiring any unneeded portions of the TRA yield from this system. The TRA has indicated a willingness to consider such transfers as long as adequate supplies are retained and provided for residents of the basin service area both now and in the future.

**San Jacinto**

The San Jacinto River Basin has two major water supply reservoirs - Lake Houston and Lake Conroe. The entire water supply yield of Lake Houston is owned by and committed to the City of Houston. The San Jacinto River Authority diverts "run-of-river" water from Lake Houston (based on a prior water right of 55,000 acre-feet per year) which is the primary source of water for the Authority's Highlands Canal System. Lake Conroe was completed in 1973 and is owned by the San Jacinto River Authority, the City of Houston, and the Texas Water Development Board. The total permitted water rights in Lake Conroe amount to 100,000 acre-feet per year, of which the Authority owns one-third (33,333 acre-feet per year), and the City of Houston owns two-thirds (66,667 acre-feet per year). A portion of the Authority's one-third share is contingent on loan repayments to the Texas Water Development Board. The estimated 1990 yield of Lake Houston is 151,400 acre-feet per year. Lake Conroe has an estimated firm yield in 1990 of 99,950 acre-feet per year.

All of the existing water rights in these two reservoirs are committed to serve existing and contracted users. A question exists concerning the potential loss of yield from the two reservoirs in the future as a result of sedimentation. According to TWDB estimates, the yield of Lake Houston is projected to decrease to 127,500 acre-feet per year, and the yield of Lake Conroe to 88,920 acre-feet per year; a potential total loss of over 33,000 acre-feet per year supply from these reservoirs. The City of Houston currently has studies underway which may address this problem for Lake Houston and could serve to provide guidance for Lake Conroe, as well. Should continued sedimentation and resulting loss of storage capacity prove to be a significant issue, a potential loss of existing yield could result.

**Brazos**

As identified in Table 3.3, the situation regarding existing surface water reservoirs in the Brazos River Basin is somewhat different from the other basins. The Brazos River Authority (BRA) operates six major reservoirs within the basin on a "system-use" concept. Even though only one of the reservoirs (Somerville) is actually located within the study area, all reservoirs can provide surface water for use in the area as a result of this system-use approach. Under this concept, commitments can be made to downstream demands from any upstream reservoir storage available in the system, and the Authority can manage the system of reservoirs to supply those commitments in the most advantageous and optimal method possible. The total system yield estimated to be available from these reservoirs in 2020 is over 500,000 acre-feet per year; however, over 450,000 acre-feet per year of that yield is already committed under long-term and short-term contracts to various entities, both within and outside of the basin. Therefore, the system yield of 188,100 acre-feet per year shown in Table 3.3 represents only that portion of the yield currently available for continued or future commitment in the Southeast Study area of the Brazos River Basin or for additional interbasin transfer. Of that amount, 128,000 acre-feet per year are already committed to long-term contract in the Southeast Area. Therefore, the amount of uncommitted supply currently available to meet the future needs of the study area is 60,000 acre-feet per year. The actual amount of supply available for interbasin transfer could potentially be less than that amount due to in-basin demands which are currently not committed under existing long-term contracts. However, the 188,100 acre-feet per year amount is <u>currently</u> available for both in-basin demands within the study area, and theoretically, for additional interbasin transfers.

Lake Limestone, although not considered a system-use lake by the BRA, is situated in the upstream portion of the study area and could also be considered a system-use reservoir for TTWP. The 2020 estimated yield of over 65,000 acre-feet per year is projected to decrease to the 63,400 acre-feet per year value used in Table 3.3 by the year 2050. Over 70% of this future yield is already committed on a long-term basis to local uses.

## 3.3 Run-of-the-River Supply

In most of the river basins within the study area, there is an appreciable amount of uncontrolled drainage area between the downstream-most impoundment and the available diversion points near the mouth of the river. Consequently, there are in some cases significant run-of-the-river yields available for use in addition to the firm yields of the reservoirs. This is particularly true where the same entity holds the water rights covering diversions from the reservoirs and from the uncontrolled segment of the river. These entities are able to coordinate the operation of both water supply sources for optimum development of their combined potential.

In general, the run-of-river yields are estimates based upon the best available data in each basin as established by previous analyses associated with water rights adjudication in the basin. In the San Jacinto Basin, the location of Lake Houston precludes any significant run-of-river yields; therefore, any small amount of such yield is assumed to be included in the water rights established for Lake Houston. Likewise, due to size and configuration, there is no significant run-of-river yield assumed for any of the coastal basins in the study area. A summary of the approximate run-of-the-river yields available in coordination with the upstream reservoir yields is discussed below for each basin.

Run-of-the-River Yields
- Amounts in Acre-Feet per Year

| | |
|---|---|
| Sabine River | 147,100 |
| Neches River | 137,700 |
| Trinity River | 180,300 |
| Brazos River | 211,000 |
| Total Run-of-the-River Yield | 676,100 |

**Sabine Basin**

The Sabine River Authority has run-of-the-river water rights for 147,100 acre-feet per year (100,400 acre-feet per year municipal and industrial, 46,700 acre-feet per year irrigation.) Those rights are based on the 7-day low flows of the Sabine River with

Toledo Bend Reservoir in place. The municipal and industrial right is reliable, while the irrigation right is based on the 7-day 4-year low flow. (That is to say, every 4 years there is a week when the flow needed to make the diversions for irrigation would not be available). The only other major run-of-the-river right in the study area, held by DuPont, is on Adams Bayou. The diversion uses brackish water and there is little consumptive use. (The water is used for flow-through cooling.) Therefore, the total run-of-the-river supply available for the study area in the Sabine Basin is 147,100 acre-feet per year.

**Neches Basin**

Major run-of-the river rights in the lower Neches Basin are held by the City of Beaumont, the Lower Neches Valley Authority (LNVA), and a large number of industrial users. The major industrial run-of-the river rights are all downstream from the mouth of Pine Island Bayou. As such, they are supplied by brackish or saline water all or much of the time. The major rights supplied with fresh water, held by Beaumont and the LNVA, total 438,343 acre-feet per year. The LNVA and Beaumont rely on the Sam Rayburn - B.A. Steinhagen system to provide a dependable water supply, but they can get run-of-the-river yields beyond the system supply under their current rights. Analysis of historical flow records and the operation of the temporary saltwater barriers shows that up to 442,693 acre-feet of run-of-the-river flows originating downstream from B.A. Steinhagen would have been available for diversion over the 44-month critical period - an average of 120,700 acre-feet per year. In addition, the computed yield of the Sam Rayburn - B.A. Steinhagen system included the release of inflows averaging 17,000 acre-feet per year during the critical period. Thus the total run-of-river diversions available, beyond the Sam Rayburn - B.A. Steinhagen yield, are 137,700 acre-feet per year. The above analyses are all based on the assumed ability of the LNVA to continue installation of temporary salt water barriers when appropriate conditions exist. Any change in that ability could alter the available run-of-river yields from the Neches River Basin.

**Trinity Basin**

The major run-of-the river water rights on the main stem of the Trinity River are held by the Chambers-Liberty Counties Navigation District, Dayton Canal Company, and Trinity Water Reserve Inc. (formerly known as Devers or Boyt Realty). These water rights holders entered into agreements called Fixed Rights Agreements with the sponsors of the Livingston-Wallisville system. According to the Trinity River Authority, these agreements are accounted for in the yield of the Livingston-Wallisville system and indicate that the run-of-the-river rights supplied beyond the Livingston-Wallisville yield are as follows:

| | |
|---|---|
| Chambers-Liberty Counties Navigation District | 88,820 ac-ft/yr |
| Trinity Water Reserve, Inc. Canal System | 58,500 ac-ft/yr |
| Dayton Canal System | 33,000 ac-ft/yr |
| Total | 180,320 ac-ft/yr |

This number represents the total amount of reliable run-of-the-river supply for the Trinity Basin. The Trinity Water Reserve, Inc. (TWRI) Canal System also has an agreement with the Trinity River Authority for an additional 27,500 acre feet/year from the Livingston-Wallisville system. The Chambers-Liberty Counties Navigation District and the Dayton Canal System both have additional water rights which are not guaranteed by the Fixed Rights Agreements. Neither these additional water rights nor the smaller rights held by others are expected to provide a reliable supply.

**Brazos Basin**

The run-of-river yield of 211,000 acre-feet per year in the Brazos Basin is based on a TWDB estimate. This estimate is reported to be based on the historical 24-hour low-flow recorded at the most downstream U.S.G.S. river gage. Typically, this flow record would not reflect upstream diversion, status of return flows, or optimization of yield through storage options. However, no detailed studies have been conducted in the Brazos River Basin to establish a run-of-river yield estimate to a higher degree of reliability; therefore, the TWDB estimate has been adopted for purposes of this analysis.

A preliminary and cursory analysis of conditions in the Brazos Basin indicates that significantly higher run-of-river yields may theoretically be possible. The results of this analysis are further outlined and explained below.

Dow Chemical Company. Dow has the right to divert and use up to 280,000 acre-feet per year for industrial purposes under permits 1145, 1345, and 1964. Dow also has the rights to use Harris and Brazoria Reservoirs in their water supply operation. In 1960, Dow submitted a report on "Unappropriated Flow at Juliff Gage in Brazos River Available for Application No. 2158: 1940-1959" which estimated reliable yields of 219,000 acre-feet per year based on these permits. Significant changes in the basin have occurred since that study which would require re-evaluation of these estimates.

Gulf Coast Water Authority. The Gulf Coast Water Authority (GCWA - formerly Galveston County Water Authority) has the right to divert 99,932 acre-feet per year from the Brazos River under permit 1040 and the right to divert 125,000 acre-feet per year under permit 1299. The GCWA also has the right to use Galveston County Reservoir in its operation. TNRCC records provide estimates of the reliable yield from these two permits of 96,742 and 66,118 acre-feet per year, respectively.

Chocolate Bayou Water Company. Chocolate Bayou Water Company has the right to divert 80,000 acre-feet per year under permit 1145. (Chocolate Bayou also has the right to develop an additional 75,000 acre-feet per year of diversion with a priority date of July 25, 1983 under permit 1145.) Based on actual use records, the TNRCC estimates 40,000 acre-feet of dependable yield from permit

1145, but this amount could theoretically be increased by as much as 15,000 acre-feet per year.

Richmond Irrigation Company and Houston Lighting and Power. These entities have the right to divert 40,000 acre-feet per year from the Brazos for power plant cooling and irrigation under permit 1041. Houston Lighting and Power also has the right to maintain Smithers Lake on Dry Creek and to divert water from its watershed under permit 1812. The yield from permit 1041 is estimated by TNRCC to be 17,784 acre-feet per year.

Based on this report and on records of water use, the reliable run-of-the river supply from the senior water rights listed above could be as much as shown below:

| | |
|---|---|
| Dow Chemical Company | 219,000 acre-feet |
| Galveston County Water Authority | |
| - Permit 1040 | 96,742 acre-feet |
| - Permit 1299 | 66,118 acre-feet |
| Chocolate Bayou Water Company | |
| - Actual use (on first 40,000 ac-ft/yr) | 40,000 acre-feet |
| - Use on additional 40,000 (computed) | 15,000 acre-feet |
| Richmond Irrigation & Houston Lighting & Power | 17,784 acre-feet |
| Total | 454,644 acre-feet |

This represents a potential increase in dependable yield of over 240,000 acre-feet per year above current TWDB estimates; however, all of this supply is tied to existing water rights and does not necessarily represent additional supply available to the area.

## 3.4 Comparison of Water Demands to Existing Supplies

Table 3.4 is a comparison of the projected future water demands and the existing available supply in the study area through 2050. A detailed analysis of this

TABLE 3.4

Projected Water Requirements and Existing Supply in the Southeast Area: 2000 - 2050

- Thousands of Acre-Feet per Year -

| | Sabine River Basin | Neches River Basin | Neches-Trinity River Basin | Trinity River Basin | Trinity-San Jacinto River Basin | San Jacinto River Basin | San Jacinto-Brazos River Basin | Brazos River Basin | Total Southeast Area |
|---|---|---|---|---|---|---|---|---|---|
| 2000 | | | | | | | | | |
| Projected Water Demand | 104.1 | 292.4 | 280.6 | 98.4 | 137.6 | 1,051.5 | 493.8 | 441.9 | 2,900. |
| Supplied by Groundwater | 23.3 | 110.5 | 7.8 | 34.3 | 27.5 | 466.4 | 80.7 | 130.5 | 881. |
| Supplied by Surface Water | 80.8 | 181.9 | 272.8 | 64.1 | 110.1 | 585.1 | 413.1 | 311.4 | 2,019. |
| Available In-Basin Surface Supply | 1,190.4 | 846.9 | 0.0 | 1,346.2 | 0.0 | 257.7 | 0.0 | 488.2 | 4,129. |
| Supplied by Reserves | 284.0 | 149.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 433. |
| Resulting Surplus (Deficit) | 825.6 | 515.6 | (272.8) | 1,282.1 | (110.1) | (327.4) | (413.1) | 176.8 | 1,676. |
| 2010 | | | | | | | | | |
| Projected Water Demand | 135.3 | 329.9 | 282.6 | 114.0 | 143.5 | 1,166.3 | 554.3 | 519.7 | 3,245. |
| Supplied by Groundwater | 23.3 | 111.6 | 8.1 | 36.6 | 31.5 | 350.0 | 85.7 | 141.9 | 788. |
| Supplied by Surface Water | 112.1 | 218.3 | 274.5 | 77.4 | 112.0 | 816.3 | 468.6 | 377.8 | 2,457. |
| Available In-Basin Surface Supply | 1,190.4 | 846.9 | 0.0 | 1,346.2 | 0.0 | 257.7 | 0.0 | 487.6 | 4,128. |
| Supplied by Reserves | 284.0 | 149.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 433. |
| Resulting Surplus (Deficit) | 794.3 | 479.2 | (274.5) | 1,268.8 | (112.0) | (558.6) | (468.6) | 109.8 | 1,238. |
| 2020 | | | | | | | | | |
| Projected Water Demand | 162.7 | 368.7 | 285.3 | 137.0 | 152.3 | 1,287.3 | 625.1 | 606.6 | 3,625. |
| Supplied by Groundwater | 23.3 | 112.8 | 8.5 | 38.7 | 37.5 | 291.9 | 91.0 | 156.1 | 759. |
| Supplied by Surface Water | 139.4 | 255.9 | 276.8 | 98.3 | 114.8 | 995.4 | 534.1 | 450.5 | 2,865. |
| Available In-Basin Surface Supply | 1,190.4 | 846.9 | 0.0 | 1,346.2 | 0.0 | 257.7 | 0.0 | 487.1 | 4,128. |
| Supplied by Reserves | 284.0 | 149.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 433. |
| Resulting Surplus (Deficit) | 767.0 | 441.6 | (276.8) | 1,247.9 | (114.8) | (737.7) | (534.1) | 36.6 | 829. |
| 2030 | | | | | | | | | |
| Projected Water Demand | 192.1 | 419.7 | 289.8 | 161.0 | 161.9 | 1,425.7 | 696.7 | 641.8 | 3,988 |
| Supplied by Groundwater | 23.4 | 114.6 | 8.8 | 41.2 | 43.5 | 389.0 | 90.8 | 169.4 | 880. |
| Supplied by Surface Water | 168.7 | 305.1 | 281.0 | 119.8 | 118.4 | 1,036.7 | 605.9 | 472.4 | 3,108 |
| Available In-Basin Surface Supply | 1,190.4 | 846.9 | 0.0 | 1,346.2 | 0.0 | 257.7 | 0.0 | 486.6 | 4,127 |
| Supplied by Reserves | 284.0 | 149.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 433 |
| Resulting Surplus (Deficit) | 737.7 | 392.4 | (281.0) | 1,226.4 | (118.4) | (779.0) | (605.9) | 14.2 | 586 |
| 2040 | | | | | | | | | |
| Projected Water Demand | 223.5 | 470.3 | 293.9 | 174.1 | 170.7 | 1,551.0 | 763.9 | 666.3 | 4,313 |
| Supplied by Groundwater | 23.5 | 116.3 | 9.1 | 43.8 | 49.6 | 385.6 | 90.6 | 181.1 | 899 |
| Supplied by Surface Water | 200.0 | 354.0 | 284.8 | 130.3 | 121.1 | 1,165.4 | 673.3 | 485.2 | 3,414 |
| Available In-Basin Surface Supply | 1,190.4 | 846.9 | 0.0 | 1,346.2 | 0.0 | 257.7 | 0.0 | 486.0 | 4,127 |
| Supplied by Reserves | 284.0 | 149.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 433 |
| Resulting Surplus (Deficit) | 706.4 | 343.5 | (284.8) | 1,215.9 | (121.1) | (907.7) | (673.3) | 0.8 | 279 |
| 2050 | | | | | | | | | |
| Projected Water Demand | 258.4 | 527.1 | 298.1 | 189.4 | 180.3 | 1,689.7 | 841.0 | 698.3 | 4,682 |
| Supplied by Groundwater | 23.6 | 118.3 | 9.4 | 46.7 | 56.0 | 415.7 | 90.4 | 197.3 | 957 |
| Supplied by Surface Water | 234.8 | 408.8 | 288.6 | 142.7 | 124.3 | 1,274.0 | 750.6 | 501.0 | 3,724 |
| Available In-Basin Surface Supply | 1,190.4 | 846.9 | 0.0 | 1,346.2 | 0.0 | 257.7 | 0.0 | 485.4 | 4,12[illegible] |
| Supplied by Reserves | 284.0 | 149.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 43[illegible] |
| Resulting Surplus (Deficit) | 671.6 | 288.7 | (288.6) | 1,203.5 | (124.3) | (1,016.3) | (750.6) | (15.6) | (3[illegible] |

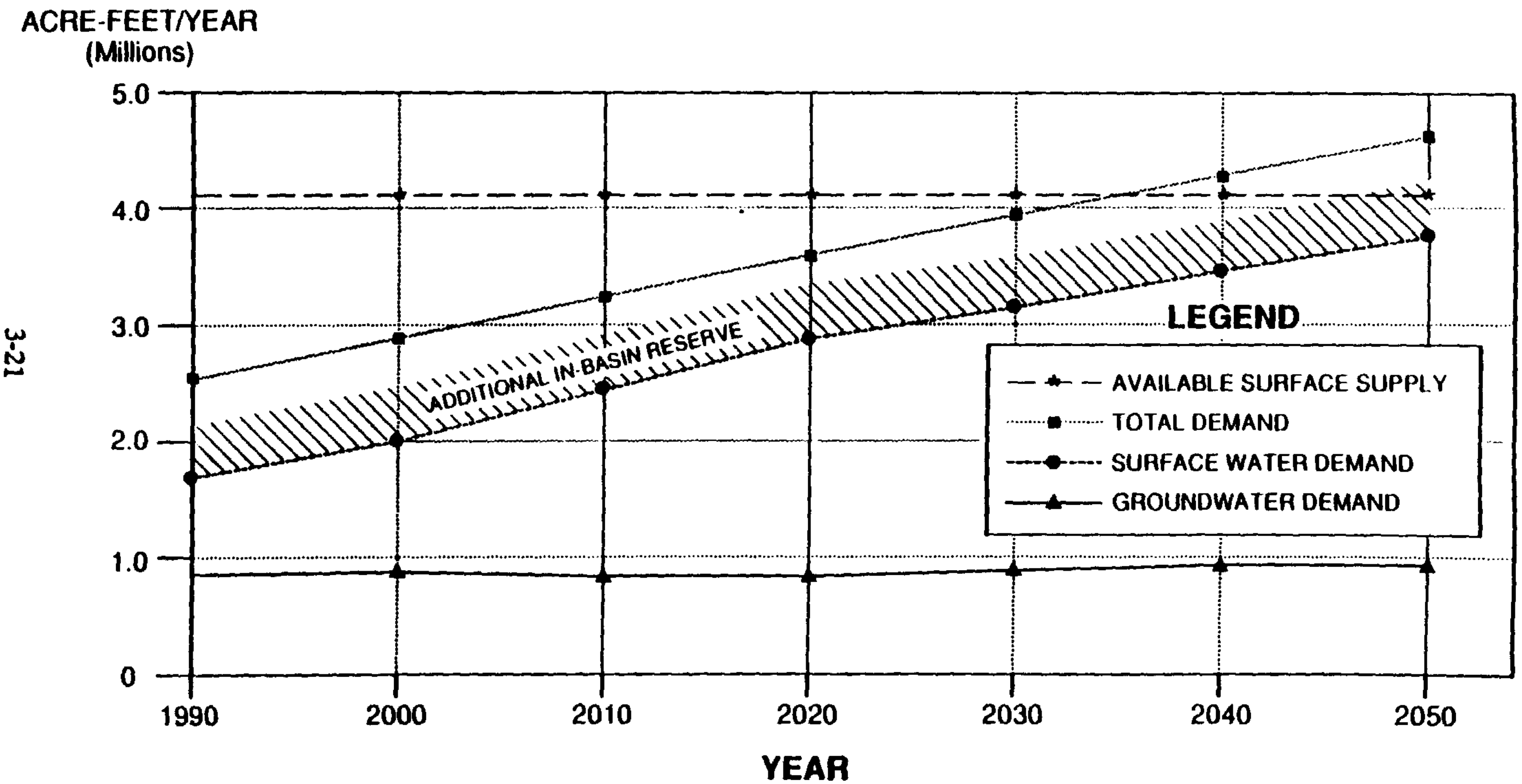
comparison is contained in Appendix L. The comparison assumes no development of new sources and is subdivided by river basins and coastal basins to show approximately where the surpluses and deficits are located. The projected water demands are taken from Table 2.3. The estimates of future groundwater use are from Table 3.2. The predicted surface supply use is a calculated quantity, based on the difference between the total demand and the predicted groundwater use in each area. The available surface water supply values are the combined reservoir yields and run-of-the-river yields shown in previous tables for each basin. The resulting surpluses (or deficits) represent the difference between the available surface supply and the needed additional supply in each basin and for the study area as a whole, as further illustrated in Figure 3.1.

Available groundwater and surface water supplies within the study area are computed based on the methodology used by the TWDB for water planning purposes for the 1990 Texas Water Plan. This methodology was outlined in Section 3.1 and is further explained as follows:

- In areas currently supplied by groundwater, if additional groundwater is available county-wide, then the area is assumed to remain on groundwater.
- If additional groundwater supply is limited on a county-wide basis, then the areas with centralized systems are assumed to convert to surface water if it is available.
- Areas currently using groundwater supplies but experiencing significant water quality problems or declining water tables are also assumed to convert to surface water when it is available.
- Demand areas currently on surface water are assumed to remain on surface water until its availability is exceeded.
- If demands for both existing groundwater and surface water sources are exceeded, additional water sources are assumed to be necessary such as development of remote groundwater sources, new surface water reservoirs, or improved water resource management techniques.

## Figure 3.1

### COMPARISON OF PROJECTED WATER DEMANDS AND EXISTING SUPPLIES in the Southeast Area




G5740.007

In the Sabine River Basin, the Neches River Basin and the Trinity River Basin, the current outlook is that there will be more water available from presently existing sources than will be needed to meet local in-basin demands past the year 2050. On the other hand, the Neches-Trinity, Trinity-San Jacinto and San Jacinto-Brazos coastal basins have no dependable local surface water supplies and only moderate amounts of groundwater. Most of their needs must be met with water from the adjoining major river basins. In the lower Brazos River Basin, where there is presently some surplus water available for export, indications are that the in-basin supply and demand will come to be approximately in balance by the year 2040. The San Jacinto River Basin, in the heart of the Houston metropolitan area, will have requirements that are more and more in excess of the available in-basin supplies.

Therefore, key results of the comparisons contained in Table 3.4 are as follows:

a. The Sabine, Neches and Trinity Basins will have significant water surpluses throughout the entire 50-year period.

b. The Neches-Trinity Coastal Basin will continue to have deficits of around 270,000 to 290,000 acre-feet per year, most of which must come from the Neches Basin through the LNVA canal system or the Trinity Basin from the Livingston/Wallisville System. If the Neches Basin and the adjoining Neches-Trinity coastal area are considered together, no appreciable amount of surplus Neches Basin water remains available for export to other basins.

c. The Houston metropolitan area, as reflected by the figures for the Trinity-San Jacinto, San Jacinto and San Jacinto-Brazos basins, accounts for most of the total water demand in the study area. The total Houston area demands which must be served by surface water will be approximately 1,100,000 acre-feet per year as of 2000 and will increase to nearly 2,150,000 acre-feet per year by 2050.

d. The lower Brazos River Basin shows a surplus of some 175,000 acre-feet per year in 2000. By 2040, there will be almost no surplus Brazos Basin water after meeting local needs.

e. If all of the Trinity River Basin surplus supplies were to be made available to the Houston area (including those supplies currently committed to the areas east of the Trinity), the Houston area would have adequate surface water supplies until approximately the year 2016. At that time, the only other area of significant surface supply currently available to meet the needs of the Houston area is the Sabine River Basin - Toledo Bend Reservoir surplus yield.

f. The study area as a whole will have a substantial surface water surplus of over 2,100,000 acre-feet per year (after meeting all in-basin demands) in the year 2000. As a result of projected growth, that surplus quantity will steadily decrease with time, and less than 400,000 acre-feet per year of surplus surface water will remain in 2050. Since over 400,000 acre-feet per year are currently reserved for additional in-basin uses, a deficit for the study area as a whole results.

It is apparent that if the needs of the Southeast Study Area are to be met and water is also to be available for transfer to the West-Central study area through the Trans-Texas Water Program then additional water management or supply methods must be used by 2050.

## 3.5 Short-Term Needs

Inspection of Table 3-4 indicates that a number of local areas have the potential to experience short-term (immediate) water needs. All of the coastal basin areas and the San Jacinto River basin area have existing water demands currently being met through interbasin transfers. Generally, water is imported to the coastal basins from the nearby major river basins. The current pattern establishes the following relationships between the major river basins and their associated coastal basins.

| Supply Basin | Coastal Demand Basin |
|---|---|
| Neches River | Neches-Trinity |
| Trinity River | Trinity-San Jacinto |
| Brazos River | San Jacinto-Brazos |

In large measure, existing available surface water supplies in the above-referenced river basins are anticipated to be depleted to serve their own in-basin demands and associated coastal demand areas during the study period.

The San Jacinto River Basin is the only major river basin within the study area which is not currently meeting its in-basin surface water needs. Surface water demands in this basin are partially served from the Trinity River through the interbasin transfer of Lake Livingston water via the Coastal Water Authority conveyance system. While this practice will continue to satisfy some regional San Jacinto River Basin demands, those localized areas within the basin which are not served by the Coastal Water Authority system will likely experience water supply problems. One such area has now developed within the northern Harris County and southern Montgomery County area.

Within the northern Harris County area, the future limitations on the use of groundwater required by the Harris Galveston Coastal Subsidence District groundwater management plan will require future importation of surface water from outside of the San Jacinto Basin. All of the available surface water owned by the San Jacinto River Authority has been obligated through long term contracts. Therefore, the SJRA must acquire additional water rights or contract for supplies to provide for any significant future water demand increases within their service area (principally Montgomery County).

The above factors require that the Trans-Texas Water Program be developed to provide for both long and short-term water requirements within the Houston metropolitan area.

# 4.0 WATER MANAGEMENT ALTERNATIVES

The total existing water supply sources available to the Southeast Area fall short of being able to meet the total projected future needs of the TTWP through the year 2050. Also, there is a marked imbalance of supply and demand among the eight basins in the study area; three of the basins show surpluses, and the other five are projected to have greater requirements in the year 2050 than can be supplied from present in-basin sources. Collectively, the areas with deficits are shown to need over 2.2 million additional acre-feet per year by 2050, either from other areas outside their basin boundaries or from in-basin sources that have not yet been developed. Finally, depending upon the ultimate determination of other ongoing studies, as much as 600,000 acre-feet per year of water from the Southeast Area may be needed in the South-Central and West-Central Areas at some future time.

During the next fifty years, Texans will increasingly find that existing water supply capacity will be exceeded by the water demands. Alternative strategies must be evaluated to meet the water supply shortfall projected to occur by year 2050. In general, two types of alternative strategies exist:

- Demand and Resource Management - Methods to make more complete or more effective use of supplies that already exist or reduce the demands.
- Supply Development - Methods to develop new sources of water not previously utilized.

Due to the number of available alternative strategies, decision matrix methodologies must be adopted which provide for the most appropriate, cost-effective solution(s) over time. Alternative selection methods must allow for comparison of alternatives which are not solely defined by their construction cost. Additionally, the non-capital costs of alternatives, including environmental, social, and third-party costs, must be evaluated.

Ten basic alternatives were considered for meeting the total future regional water supply needs of the TTWP through 2050:

- Water conservation
- Wastewater reclamation and reuse
- Existing surface reservoirs
- System operation of existing reservoirs
- Aquifer storage and recovery
- Demineralization
- New groundwater supply
- New surface water supply
- Interbasin transfers
- Contractual transfers

These alternatives fall into several distinct groupings. The first three alternatives (conservation, reclamation and reuse, and existing surface reservoirs) relate mainly to more complete or more effective use of the supplies that already exist. The next two (system operation and aquifer storage and recovery) are techniques for enhancing the productivity of multiple sources of supply and may be applicable either to existing sources or new ones. Three alternatives (demineralization, new groundwater supply, and new surface reservoirs) involve development of new supply sources that have not previously been utilized. Finally, the last two alternatives (interbasin transfers and contractual transfers) do not in themselves gain any additional supply. Rather, they are important mechanisms for minimizing economic and environmental costs, and must be applied in combination with one or more of the other options.

Criteria established by the PMC in the mission statement for the Trans-Texas Water Program include the following:

- Provision of supplies to meet both short-term and long-term needs
- Cost effectiveness
- Sensitivity to environmental considerations

The general advantages and disadvantages of the ten alternatives are discussed in the following paragraphs, with particular emphasis on those criteria.

## 4.1 Water Conservation

Water conservation, in the sense of avoiding waste and using the available supply efficiently, is the most cost effective and environmentally positive measure available to keep supply and demand in balance. Many Texas communities, industries, and agricultural operations have already accomplished significant levels of conservation as the costs and difficulty of obtaining new supply have continued to escalate in recent years.

The projections of future requirements that were derived by the Texas Water Development Board as part of the 1990 Texas Water Plan and were adopted for use in this initial evaluation of the Trans-Texas Water Program incorporate a built-in assumption that there will be major conservation gains in the next few decades. The largest of these in terms of the amount of water that might be saved is associated with municipal use, where the projections assume that there will be a significant decrease in average per capita use by the year 2020. In contrast to the familiar historical upward trend of per capita water use throughout the state, the current planning projections are based on the premise that the average annual rate of municipal water use per person will actually be reduced in the next 25 years and that, after 2020, per capita consumption will hold constant well below present levels. For the Southeast Area as a whole, this degree of conservation saving represents a reduction of the 2050 requirements by nearly 300,000 acre-feet per year in comparison to current levels of per capita use.

In the TWDB water use projections, it is also assumed that future water use for manufacturing, irrigation, and generation of electric energy will reflect improved efficiencies brought about through careful management and application of water-saving technology. Thus, the assumption that substantial future conservation increases can be realized is an integral part of the water requirement projections on which this study is based. Those additional conservation benefits are automatically taken into account when the TWDB projections are used to estimate how much new supply will be needed in the future.

In parallel with the water conservation program, the TWDB and the TNRCC are now requiring that water supply entities throughout Texas develop drought contingency plans. These plans are aimed at (a) holding onto the reductions in per capita use even during critical dry times, when water needs might otherwise escalate so as to eliminate those gains, and (b) minimizing the short-duration peak demand levels during dry weather conditions. With respect to the first of these goals, the drought contingency plans are an integral part of the campaign to lower per capita municipal use. Unless the per capita savings can be maintained during severe droughts, they will not be meaningful in terms of long-term water supply adequacy. The second goal relates to water treatment and delivery capacity rather than to total annual supply. Peak daily and hourly use rates are major factors in the costs of water supply facilities because they define the necessary output capacities of municipal water systems. To the extent that peak demands can be held down through proper planning and management, it will be possible to save capital investment and operate the systems more economically. However, the short-duration peak loads usually do not significantly affect the annual water supply requirements.

One hypothesis suggests that still further decreases in requirements could be realized through more effective techniques and more stringent limitations on water use (a concept sometimes referred to as "enhanced conservation"). The validity of this view has yet to be tested, and additional studies are being planned to provide more data to evaluate this hypothesis.

Several water efficiency regulations have been enacted which will require the future use of low-flow plumbing fixtures in new construction, and require development of specific conservation plans by water suppliers. The federal Energy Policy Act of 1992 establishes uniform water efficiency standards for all toilets, urinals, showerheads and faucets manufactured after January 1994. This regulation is aimed at reducing interior water use. Table 4.1 illustrates these national standards. One study (8) suggests that total indoor water demand for the average household (with current plumbing fixtures installed before 1980) would experience a 34 percent decrease upon implementation of the fixture unit standards in Table 4.1.

The State of Texas has recently enacted two pieces of water use regulations. Texas Bill 587, like the federal Energy Policy Act has specified a set of maximum plumbing fixture standards which are equal to, or more stringent than the national standards. Title 31, Part IX, Chapter 288 of the Texas Water Code requires development and enactment of water conservation plans in conjunction with any regulatory request concerning surface water rights. Both of these above regulations are expected to reduce future per capita water demands.

Water conservation meets each of the mission statement criteria and has been included as a key component of the Trans-Texas Water Program. Water conservation itself cannot eliminate the 2.2 million acre-foot per year shortfall in water demand projected in this study. However, specific conservation practices will be studied in

**TABLE 4.1**

**Federal Water Efficiency Standards for Plumbing Fixtures and Fixture Fittings Required by the U.S. Energy Policy Act of 1992**

| Product | Maximum Water Use | Compliance Date |
|---|---|---|
| Toilets* | | |
| Gravity tank-type | 1.6 gal/flush | 1/1/94 |
| Flushometer tank | 1.6 gal/flush | 1/1/94 |
| Electromechanical hydraulic | 1.6 gal/flush | 1/1/94 |
| Blowout# | 3.5 gal/flush | 1/1/94 |
| Commercial Gravity tank-type, white two piece§ | 3.5 gal/flush | 1/1/94-12/31/96<br>1/1/97 |
| Commercial gravity tank-type, white two piece§ | 1.6 gal/flush | 1/1/97<br>1/1/94 |
| Flushometer valve@ | 1.6 gal/flush | 1/1/94 |
| Urinals#@ | 1.0 gal/flush | |
| Showerheads§ | 2.5 gpm (80 psi) | 1/1/94 |
| Faucets§ | | 1/1/94 |
| Lavatory§ | 2.5 gpm (80 psi) | 1/1/94 |
| Lavatory replacement aerators | 2.5 gpm (80 psi) | 1/1/94 |
| Kitchen | 2.5 gpm (80 psi) | 1/1/94 |
| Kitchen replacement aerators | 2.5 gpm (80 psi) | |
| Metering | 0.25 gal/cycle (80 psi) | |

* Compliance with ASME-ANSI Standards A 112.19.2M-1990 and A112.19.6-1990
\# No data on conversion to lower volume
@ Must bear conspicuous label that states "For Commercial Use Only"
§ Compliance with ASME-ANSI Standard A112.18.1M-1989

further detail in Phase II in order to better assess the projected potential reduction in water demand (300,000 acre-feet per year) which can be achieved and to determine what conservation elements and implementation steps must be initiated to allow that potential to occur.

## 4.2 Wastewater Reclamation and Reuse

Quality criteria for wastewater treatment have become increasingly stringent, until in many respects reclaimed wastewater is often of better quality than the natural runoff from the watershed where it originated. Reclaimed wastewater is commonly returned to lakes and streams that are in turn used as sources of municipal and industrial supply, so that more and more reclaimed water is being used and reused in an indirect manner. Direct return of reclaimed wastewater to a city's water distribution system for immediate potable reuse is not an accepted practice, although it has been tried in a few instances. Uncertainty about the biological safety of the direct approach and especially about the effective control of viruses generally causes communities to favor more indirect forms of potable reuse.

Due to the public health issues associated with more direct forms of potable reuse, that approach should not be pursued further at this time. Non-potable reuse, on the other hand, does offer promise of added benefits. Where appropriate, the TWDB's estimates of future reservoir yields include return flows of reclaimed wastewater that are expected to be present in the surface streams and lakes in future years (1). Thus, those contributions toward indirect reuse are accounted for in the evaluations of existing reservoir supply insofar as they are identifiable at this time.

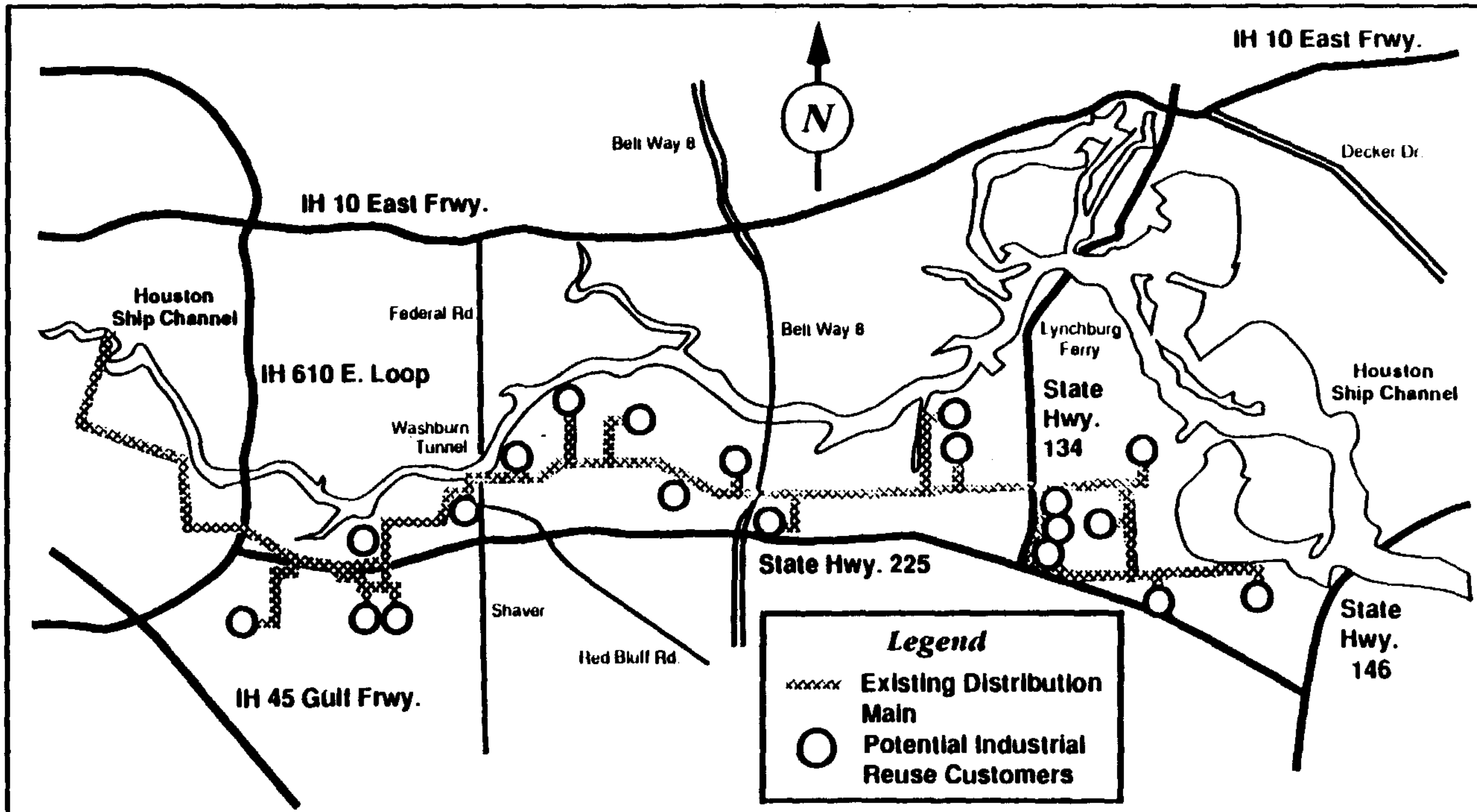
Two recent studies by the City of Houston, *The Houston Water Master Plan (6) and The Feasibility of Wastewater Reuse Study* (27), investigated the feasibility of wastewater reuse. Each study concludes that utilizing reclaimed water as an alternative municipal supply source is not currently economically viable; however, both reports include the recommendation that Houston seek to maximize its future reuse of treated wastewater for industrial purposes.

One area in the Houston SMSA where such water reuse should be given particularly close examination is along Texas Highway 225, south of the Houston Ship Channel, a heavily industrialized area. The industries in this area require significant amounts of process water and cooling water. They are currently supplied with Trinity River water by the Coastal Water Authority (CWA) through the South Channel pipelines and the La Porte area pipeline. Also located in this area is Houston's 69th Street wastewater treatment plant, which produces high-quality effluent and has the capacity to meet much of the need for industrial water. The capacity of the existing wastewater treatment plant is 200 MGD, which is more than the estimated 2030 water needs of the Highway 225 industries. If a meaningful portion of the industrial supply in this area could be shifted from CWA water to use of reclaimed wastewater from the 200 MGD facility (operating at an annual load factor of 75 percent), as much as 168,000 acre-feet per year could be added to the available resources in 2050. A schematic map of the delivery system required for this plan is shown in Figure 4-1.

Significant costs and institutional issues are associated with this alternative; however, reclamation and reuse could potentially meet all the desired criteria established for the TTWP. Major new costs include additional treatment facilities, new transmission and pumping facilities, and additional operation and maintenance. Important issues which must be considered along with this plan are public health, environmental water quality, hydraulics of the distribution system, and numerous legal/regulatory issues such as required permits and public/private contracts. While reclamation and reuse cannot in itself meet the 2.2 million acre-foot per year demand shortfall, this alternative could provide a significant volume of this future demand.

Figure 4.1

**WASTEWATER RECLAMATION & REUSE CONCEPTUAL PLAN: DISTRIBUTION SYSTEM**




**Source:** Houston Water Master Plan

G6186 001

## 4.3 Existing Surface Reservoirs

Five major reservoirs currently in operation or under construction in the study area are indicated to have more yield than will be needed in their own river basins through the year 2050. They are Toledo Bend Reservoir in the Sabine Basin, Sam Rayburn and B.A. Steinhagen Reservoirs in the Neches Basin, and Lake Livingston and the Wallisville Saltwater Barrier in the Trinity Basin. The Wallisville project is now under construction; the others have all been in service for a number of years. Because their yields are more than projected local requirements, these lakes either are now contributing or could potentially contribute significant amounts of water to the areas where requirements exceed the supply. For this reason, each has been considered as a possible source for meeting the identified areas of shortage.

### Lake Livingston/Wallisville

Lake Livingston and the Wallisville salt water barrier have from their early planning stage been intended primarily to benefit the Houston area, and the City of Houston holds 80 percent of the water rights associated with those structures. The Trinity River Authority retains the remaining rights to the system yield; therefore, the entire yield is considered to be available for the Houston area.

### Rayburn/Steinhagen

The system composed of Sam Rayburn Reservoir and B.A. Steinhagen Reservoir has more yield than is projected to be needed in the lower Neches Basin; however, these sources are counted on to supply most of the needs of the adjoining Neches-Trinity Coastal Basin as well. There could be some additional surplus yield available if the Corps of Engineers grants the LNVA a permit to install temporary salt water barriers early in a severe drought period, but this potential is uncertain at this time.

Therefore, none of the surplus yield of this system is currently proposed for use in the TTWP.

**Toledo Bend**

Toledo Bend Reservoir has a large amount of yield in excess of its projected in-basin requirements. The same is true of the half of the Toledo Bend yield that belongs to the State of Louisiana. However, the factors outlined in Chapter 3 limit the availability of Toledo Bend Reservoir yield which can be considered for future interbasin transfer.

Use of the Louisiana share of Toledo Bend raises various economic and institutional issues. Unlike Texas, the State of Louisiana does not have a single agency which regulates the permitting of the state's waters. Each of the regional surface water owners independently regulates its own respective water resources. Therefore, the only agency with authority over the sale of the Louisiana share of Toledo Bend Reservoir is the Sabine River Authority of Louisiana (SRA-LA). However, prior to finalization of any water contracts for the interstate sale of water, statewide impact analyses would potentially be performed by various Louisiana state agencies. In addition, the Governor's Office of Louisiana may review the legal, institutional and financial impacts of the proposed water sale.

Water sales contracts for Toledo Bend Reservoir water within the State of Louisiana are used either to retire the existing debt incurred in the construction of the water supply source or to develop future local projects within the jurisdiction of the water owner (SRA-LA). As such, water supply contracts are generally initiated at the time of immediate water need, and water is not typically reserved for future use unless some immediate payment occurs for that reservation. In order to have a guaranteed use of Louisiana's share of Toledo Bend Reservoir, contractual obligations involving immediate payment for the needed water would therefore likely be required. Since

Texas' share of Toledo Bend Reservoir is an existing available supply for the TTWP, it is reasonable to assume that short-term water needs within Texas would be satisfied with existing Texas supplies prior to the use of Louisiana supplies. Based on the availability of Texas waters to meet short-term demands (as shown in Table 3-4), the immediate payment for water owned by SRA-LA would occur over a 30-to-50-year period prior to its actual use. While securing some part of Louisiana's share of Toledo Bend Reservoir's yield is possible and may be reasonable, it does not appear to be desirable at this time. Future investigation of this alternative is warranted prior to development of any additional water supplies, but this water source is not considered appropriate to meet the 30-to-50-year needs outlined within this phase of the TTWP.

## 4.4 System Operation of Existing Reservoirs

In an area served by multiple sources of water supply, it is generally true that the total amount of dependable yield will be greater if those sources are operated in a coordinated fashion (typically known as system operation) than if they are each operated independently. In the Southeast Area, the most significant opportunity to apply this concept is in the Houston Metropolitan area, which is supplied from several surface water sources and also uses substantial amounts of groundwater.

The underlying concept is that, during a drought period, the amount of water that can be put to beneficial use from a multiple-source system usually can be increased by varying the rates of demand among the several sources based on their respective contents from month to month, rather than holding the diversion rates constant at each source. This is particularly true of surface reservoirs, which tend to vary noticeably in size and in performance characteristics. Those characteristics can be established analytically, and in a given system the lakes that are most likely to incur losses due to evaporation or spills can be reliably identified. By removing water more rapidly from the more loss-prone sources when the system as a whole is relatively full, the total losses can be reduced and the total yield increased.

From a review of the available references, it appears that the amount of potential gain in usable yield due to system operation has not previously been analyzed in complete detail for the Houston sources. Lake Livingston and Lake Wallisville have been envisioned from the outset as being operated as a system, and their estimated yields are based on that approach. Lake Houston and Lake Conroe seem likely to offer the prospect of additional gains that may not yet be fully recognized.

The yields attributed to Lake Houston and Lake Conroe in Table 3.3 are basically consistent with independent operation of those lakes. However, Lake Houston has far less conservation storage per square mile of contributing drainage area than does Lake Conroe. Under conditions comparable to those of the critical drought of record (which lasted from the summer of 1950 to early 1957), Lake Houston would tend to spill repeatedly, while Lake Conroe would not spill at all. By overdrafting Lake Houston (i.e., by diverting at rates greater than its dependable yield) during the early stages of the drought, the loss due to spills could be reduced, and the combined yield of the two lakes could be enhanced appreciably. This alternative also meets each of the mission statement criteria and has been included in the TTWP.

## 4.5 Aquifer Storage and Recovery

Aquifer storage and recovery (ASR) is a form of conjunctive use of groundwater and surface water in which temporarily surplus surface water is at intervals placed in storage in the aquifer. The surplus surface water is first treated to avoid clogging the aquifer and then injected into the ground for subsequent retrieval when needed.

Although this technique has lately received increased attention, it is not a new concept. The City of Lubbock used it to allow full utilization of short-term surface water surpluses in the late 1960's and early 1970's. For over a decade, El Paso has been using a variant of the method, in which the source of the stored water is reclaimed municipal wastewater rather than diversions from a reservoir or a stream (1). The fundamental principle is that water which is not presently needed can, in some cases be placed in an aquifer until it can be taken out and used for beneficial purposes at some later time.

The necessary basic elements of this alternative are (a) a source of surface water supply (or, as in the case of El Paso, suitable reclaimed wastewater) and (b) a groundwater source where the aquifer has proper characteristics for recharge and recovery. If the amount of total supply needed is not too large, it may in some cases be possible to get the surface supply from run-of-the-river diversions without building a reservoir. For greater amounts such as those identified herein, this approach is not normally feasible.

Generally, two forms of groundwater recharge exist:

- Surface techniques - water enters the aquifer from the land surface by infiltration through the surface soil into the unsaturated zone of the aquifer.
- Subsurface techniques - water is injected into the aquifer below grade.

Surface techniques include flooding of recharge zones, ditch and furrow systems, construction of recharge basins, stream channel modification, and stream flow modification. Subsurface techniques consist of utilizing natural openings, pits, and shafts which penetrate into the aquifer, reverse drainage pipe networks, and recharge wells with injection pumps. These techniques are used independently and, in many cases, in conjunction with one another.

Use of surface techniques for ASR is not expected to be feasible in the area of greatest need. Specifically, within the Houston area, the two major aquifers (the Evangeline and the Chicot) are confined by the clayey upper portion of the Chicot

(Beaumont Clay Formation) and the Burkeville confining layer below the Evangeline. The clay portion of the Chicot inhibits infiltration rates, which limits the effective use of surface techniques for the large volumes of identified water need. Surface techniques could be applied to the natural recharge zones of the aquifers (north of the City of Houston); however, this practice would be very expensive due to the cost of the land area required and the transmission facilities needed to convey the water source to the recharge areas. Studies completed as a part of the Houston Water Master Plan (HWMP) identify the natural recharge rate for the Evangeline and Chicot aquifers as a maximum of ten inches per year. Assuming an annual recharge goal of 100,000 acre-feet per year, the amount of land required based on that natural recharge rate would be approximately 120,000 acres. The HWMP further identifies the ratio of evaporation to infiltration in this region as approximately four to one. This means that to recharge 10,000 acre-feet per year, a supply of 50,000 acre-feet per year would be required. Finally, the rate of groundwater movement within the Evangeline and Chicot aquifers is identified as approximately 60 feet per year. Therefore, it would require in excess of 750 years for water injected into the recharge area to migrate into the area of existing groundwater wellfields. Based on these analyses, it was concluded that surface recharge techniques do not appear to be justified.

Within the high demand regions of the Southeast Area, using recharge wells with injection pumps is the most feasible ASR technique. Economically, using recharge wells with injection pumps is more advantageous than other techniques because of the potential to utilize existing groundwater facilities, as explained further below. Outside of the Houston area, other techniques might could be used locally, but only on a small scale.

Traditionally, ASR has been employed to combat seasonal and climatic shortfalls of water supply. Short-term or seasonal peak supplies in excess of the base demand have been injected into aquifers until such time as the base demand equals the peak supplies. ASR has proven to be successful in storing surplus water to meet demands during seasonally dry times and drought periods. However, the value of using ASR techniques to address the long-term needs of the Southeast Area is minimal. Existing surface supplies which provide water for regions of high demand will need to be fully utilized in the near future. Storage of surplus water from these supplies in aquifers may have short-term benefits, but these benefits will disappear as demand increases and existing surpluses decline. Projections included in Table 3-4 indicate that water demands will exceed existing supplies within localized areas of the Houston SMSA by the year 2000. Therefore, ASR of surface water could only be viewed as a short-term measure.

Using reclaimed municipal wastewater, as in El Paso, instead of surplus surface water would increase supplies and have potential long-term benefits; but the costs are expected to outweigh these benefits. Costs associated with the aquifer storage of reclaimed wastewater include the following:

- Injection pretreatment - Although the wastewater would have already undergone primary and secondary treatment at a WWTP, additional treatment would be required to make the water suitable for injection. Additional required treatment would include denitrification, filtration to reduce total suspended solids, and possibly additional chlorination to prevent subsequent bacterial growth.
- Storage facilities - Storage to capture wastewater peaks would likely be necessary.
- Transmission lines - Significant distribution pipelines would be needed to carry the treated water to each injection well.
- Injection pumps and wells - Additional injection pumps and wells may also be needed to deliver the desired volume of reclaimed wastewater into the aquifer.
- Operation and maintenance - Increased costs would be required to both inject water into and extract water out of the aquifer.

Within the City of El Paso, less than 10 percent of the discharged wastewater is subsequently injected into the Hueco Bolson as reclaimed water. While additional supply is created, the cost of a 10 percent return is justified because no other supply source exists. Studies conducted as a part of the HWMP concluded that the cost of injecting reclaimed wastewater was approximately two to three times the cost of injecting treated surface water, and the cost of ASR of treated surface water was more than double the cost of conveying existing remote surface water supplies into the Houston region.

Besides costs, other issues exist which raise questions about the legitimacy of using ASR within the TTWP. The necessity to store treated wastewater in an aquifer can be questioned. Direct reuse of treated wastewater could avoid ASR costs while achieving many of the same benefits. Wastewater reuse as described elsewhere in this document is a viable supply management alternative for nonpotable uses such as for cooling or process water for industrial use. The use of ASR could potentially affect the quality of the aquifer groundwater. These concerns, along with increased costs, make employing ASR techniques in this region on a large scale questionable.

Within the framework of the TTWP, ASR is not a viable alternative to meet the long-term supply problems of the Southeast Area. The high costs and concerns of using ASR to address long-term needs preclude it from further consideration, and it has not been included for further evaluation.

## 4.6 Demineralization

In coastal areas, a demineralization process such as reverse osmosis has the important advantage of a virtually unlimited raw water source - the sea. At many locations around the world, such areas often do not have other alternatives, and desalination is the only feasible way to provide for drinking water needs without bringing the entire potable supply from somewhere else.

Unfortunately, the desalting approach is also expensive. It involves high capital investments and very high costs of maintenance and operation. As a general guideline, the total unit cost of potable water from a large demineralization facility on the seacoast probably will be in the range of $5 to $7 per thousand gallons at today's price levels, in comparison to less than $1.00 per thousand gallons for other conventional supply techniques. This demineralization cost does not include transmission costs to move the treated water any material distance inland and assumes no major additional costs for disposal of the concentrated brine return flow stream that is a by-product of the process.

In some communities, where more traditional water supply sources are available most of the time but are not totally reliable, demineralization facilities have been built as a backup. In such cases, the desalting systems tend not to be operated under normal conditions because the other facilities are much more economical. The demineralization plants are used only during unusually dry periods. They serve to "drought-proof" the over-all supply by making the necessary yield dependable under all conditions. An example of this approach is Santa Barbara, California, where a 6.7 MGD (7,500 acre-foot per year) reverse osmosis plant was constructed in 1992 after an unprecedented drought had threatened to exhaust the city's other sources and leave approximately 190,000 people completely without water (17). This facility is currently the largest operational unit for municipal supply from sea water in the United States. The important point is that in such cases the conventional supply sources will continue to be used even if it means having the desalting plant stand idle, except when the conventional facilities are overtaxed by drought. Under those circumstances, it is clear that a demineralization facility will be built only if the required yield cannot be assured by some other, more customary method.

Demineralization of sea water is also subject to some noticeable environmental difficulties in many instances. The basic process requires approximately 15 to 20 kilowatt-hours of electric energy for each thousand gallons of product water. This is several times the energy consumption associated with more common water treatment techniques. The need for greater amounts of energy means that significant additional electric generating capacity would also be required. The generating capacity, in turn, has its own set of environmental problems, such as control of air pollution, production and delivery of fuel for the plant and provision of cooling water. Salt water desalination results in two output streams - one of usable water and the other of concentrated brine. The brine stream must be disposed of in an environmentally acceptable manner, typically by returning it to the sea some distance offshore via pipeline.

To date, all major urban areas in Texas have found one or more of the other basic water supply alternatives to be preferable to demineralization. This alternative could potentially fill a limited need at some locations along the Texas coast, but the probability of it proving to be the best solution for the large amounts of supply (2.2 million acre-feet per year) required for the TTWP is small. The largest sea water desalination facility anywhere in the world at the present time is about 15 MGD. Due to the above issues, this alternative was not considered for further inclusion in the TTWP.

## 4.7 New Groundwater Supply

Total groundwater pumpage in the Southeast Area was approximately 814,000 acre-feet in 1990. Through analysis of projected future water requirements and groundwater availability county by county, it is estimated that groundwater use in the area will increase to approximately 957,000 acre-feet by 2050.

Estimates by the Texas Water Development Board (15 and 4), based on evaluations of water availability from recharge and aquifer storage, indicate that the total available groundwater supply in the study area as of 2050 will be approximately 1,544,000 acre-feet per year. Although at first glance, this set of numbers would appear to show that as much as 587,000 acre-feet per year of additional groundwater could be developed and used in the area, there are several factors that tend to reduce the actual surplus to a lower amount.

Table 4.2 is a summary of the estimated groundwater availability from the aquifers of the Southeast Area in 2050. Comparison of Tables 3.1, 3.2 and 4.2 shows the following facts concerning opportunities for further development of groundwater:

- Roughly 170,000 acre-feet per year of the unused groundwater yield is identified within the Sparta and Queen City aquifers. Those aquifers are not satisfactory sources of supply, due to problems of water quality and well performance, as reflected by the minor use that is made of them at present. They should not be counted as a significant part of the overall usable resources.

- In the Sabine, Neches and Neches-Trinity basins, moderate volumes of surplus are shown in 2050. Particularly in the Neches Basin, much of the predicted surplus is in the Carrizo-Wilcox aquifer at the northern edge of the area, rather than in the Gulf Coast aquifer where most of the need is concentrated.

- The Trinity Basin shows a significant surplus. Here again, most of the unused supply is in the Carrizo-Wilcox formation, about 100 miles away from the demand centers.

- The Houston metropolitan area is located primarily in the Trinity-San Jacinto coastal basin, the San Jacinto River Basin, and the San Jacinto-Brazos coastal basin. Groundwater in these basins is almost all from the Gulf Coast aquifer, and the problem of subsidence exists throughout most of the area. Within the Houston SMSA, the largest water demand center in the study area, there is no appreciable amount of available surplus groundwater. Current and projected groundwater withdrawal exceeds availability.

- The groundwater surplus in the Brazos River Basin is mostly associated with the Carrizo-Wilcox aquifer and the Brazos River alluvium. The Carrizo-Wilcox may have some potential, but there are practical limits to what might be achieved. The Brazos alluvium water tends to have high concentrations of dissolved minerals, and that source is more suitable for irrigation than for municipal or industrial use.

If all factors are considered, there is no apparent prospect for significant use of groundwater resources over and above the amounts predicted in Table 3.2 as of the year

**Table 4.2**

**Summary of Estimated Groundwater Availability in the Aquifers of the Southeast Area as of 2050**

**- Acre-Feet per Year -**

| Basin | Gulf Coast Aquifer | Carrizo-Wilcox Aquifer | Brazos Alluvium | Sparta and Queen City | Total |
|---|---|---|---|---|---|
| Sabine Basin | 59,000 | 7,900 | -- | 6,700 | 73,600 |
| Neches Basin | 93,100 | 66,500 | -- | 93,500 | 253,100 |
| Neches-Trinity | 25,500 | -- | -- | -- | 25,500 |
| Trinity Basin | 80,800 | 155,600 | -- | 59,500 | 295,900 |
| Trinity-San Jacinto | 61,100 | -- | -- | -- | 63,100 |
| San Jacinto Basin | 363,800 | -- | -- | -- | 363,800 |
| San Jacinto-Brazos | 77,700 | -- | 1,200 | -- | 78,900 |
| Brazos Basin | 81,700 | 215,900 | 82,700 | 11,900 | 392,200 |
| Total | 842,700 | 495,900 | 83,900 | 171,600 | 1,544,100 |

* Note: Amounts are rounded to 100 acre-feet per year.

2050. It seems probable that groundwater outside the Houston metropolitan area will continue to be used for local needs and/or held in reserve as a cushion for additional needs beyond 2050. In the Houston area itself, there is no indicated groundwater surplus, and restricting groundwater use in that area to levels consistent with acceptable subsidence conditions will continue to be a major challenge. Additional future groundwater supply development (beyond that forecast in Table 3.2) appears inconsistent with the TTWP mission statement criteria, and this component was not included further in the TTWP.

## 4.8 New Surface Water Supply

Construction of one or more new regional surface water reservoirs is a potential alternative for meeting part of the water requirements of the TTWP. In the past, this probably would have been the primary choice. Because of environmental issues and the uncertainty and cost involved in obtaining permits and constructing new reservoirs, this alternative is less promising today. However, there are a number of possibilities for new surface water projects to serve the Southeast Area. Collectively, they could add a substantial amount of new yield.

### Previous Studies

The Houston Water Master Plan contains the most recent comprehensive analysis of surface water supply availability for Southeast Texas, including an evaluation of 33 individual reservoir projects that might conceivably be used for future supply for Houston (6). Those projects are listed in Table 4.3. In its final analysis, the HWMP did not recommend development of any new reservoirs due to one or more of the following reasons:

- Size - Many potential reservoir projects had projected yields of less than 56,000 acre-feet/year and the associated reservoir costs, political issues, and

## TABLE 4.3

## Potential Future Surface Water Supplies

## Evaluated in the Houston Water Master Plan

| Name of Reservoir | Basin | Distance to Houston Miles | Country | Status |
|---|---|---|---|---|
| Lake Conroe | San Jacinto | 50 | Montgomery, Walker | Existing |
| Lake Creek Reservoir | San Jacinto | 30 | Montgomery | Future |
| Spring Creek Lake | San Jacinto | 20 | Harris, Montgomery | Future |
| Lake Houston | San Jacinto | 20 | Harris | Existing |
| Tehuacana Reservoir | Trinity | 160 | Freestone | Future |
| Tennessee Colony Reservoir | Trinity | 160 | Anderson, Freestone | Planned |
| Upper Keechi Reservoir | Trinity | 150 | Leon | Future |
| Big Elkhart Reservoir | Trinity | 130 | Houston | Future |
| Hurricane Bayou Reservoir | Trinity | 130 | Houston | Future |
| Lower Keechi Reservoir | Trinity | 120 | Leon | Future |
| Bedigs Reservoir | Trinity | 50 | Madison, Grimes, Walker | Future |
| Gail Reservoir | Trinity | 90 | Houston | Future |
| Mustang Reservoir | Trinity | 90 | Houston | Future |
| Lake Livingston | Trinity | 60 | Polk, San Jacinto | Existing |
| Caney Reservoir | Trinity | 80 | Trinity | Future |
| Nelson Reservoir | Trinity | 90 | Walker | Future |
| Harmon Reservoir | Trinity | 90 | Walker | Future |
| Long King Reservoir | Trinity | 70 | Polk | Future |
| Wallisville Lake | Trinity | 20 | Liberty, Chambers | Under Const. |
| South Bend Reservoir | Brazos | 380 | Young | Planned |
| Lake Whitney | Brazos | 220 | Hill, Bosque | Existing |
| Caldwell Reservoir | Brazos | 100 | Burleson, Milam | Future |
| Lake Millican | Brazos | 70 | Grimes, Brazos | Planned |
| Neches Reservoir | Neches | 140 | Cherokee, Houston | Future |
| Ponta Reservoir | Neches | 180 | Cherokee, Nacodoches | Future |
| Rockland Reservoir | Neches | 110 | Polk, Tyler | Planned |
| Sam Rayburn Reservoir | Neches | 140 | Angelina, Jasper | Existing |
| B.A. Steinhagen Lake | Neches | 120 | Jasper, Tyler | Existing |
| Tenaha Reservoir | Sabine | 210 | Shelby | Future |
| Toledo Bend Reservoir | Sabine | 160 | Sabine, Shelby | Existing |
| Bon Weir Reservoir | Sabine | 170 | Newton | Future |
| Little Cow Creek Reservoir | Sabine | 170 | Newton | Future |
| Big Cow Creek Reservoir | Sabine | 160 | Newton | Future |

environmental impacts of those reservoirs were deemed in excess of the benefits of the potential water source.

- Environmental - The impacts associated with the loss of large areas of critical habitat of plant and animal species, the loss of wetlands, and other issues resulting from some new reservoir projects construction were deemed excessive.

- Technical - Development of some of the proposed new reservoirs would result in a loss of yield from existing reservoirs or would provide water in areas which already had sufficient surface water supply.

Three surface water projects have received attention recently within or upstream of this study area: the Eastex Reservoir in the upper reaches of the Neches Basin, the proposed permanent Neches salt water barrier, and Allens Creek Reservoir in the lower Brazos Basin. The Eastex project is being planned by the Angelina and Neches River Authority, and a Texas water right permit has been granted. It has an estimated dependable yield of 75,290 acre-feet per year (1), part of which would be needed in the upper Neches Basin. The Neches salt water barrier was initially defined in a Corps of Engineers design memorandum in 1981 (18), and its yield was further studied in 1987 by the Lower Neches Valley Authority (16). The Corps of Engineers is currently updating its studies of the barrier project. Finally, a study of the Allens Creek project was published by the Brazos River Authority in 1989 (19), and the Texas Parks and Wildlife Department has environmental studies of the Allens Creek site in progress at the present time.

Other potential projects of significant scope evaluated in the HWMP include the Bon Wier and Big Cow Reservoirs on the lower Sabine River, Rockland Reservoir on the main stem of the Neches River upstream from Lake B.A. Steinhagen, Lake Bedias in the Trinity Basin, Lake Creek Reservoir in the San Jacinto Basin, and Millican Reservoir in the Brazos Basin.

In general, construction of a major new surface reservoir would cause more environmental impact than a conveyance system to transfer water from an existing reservoir to an area of need. For example, a conveyance system extending from Toledo Bend Reservoir to Lake Houston might disturb approximately 5,000 acres of land, whereas the Rockland Reservoir would inundate an area of 101,100 acres at the top of conservation storage. Due to the environmental problems associated with major surface reservoir projects, that alternative is not judged to be a suitable option for the TTWP at the present time. It is likely that several additional large surface reservoirs will be needed in the Southeast Area over the long term, but it is believed that, in most cases, other options should be pursued first.

There are two surface projects of moderate size that are possible exceptions to this conclusion. They are the proposed permanent salt water barrier on the Neches River and the Allens Creek Reservoir in the Brazos Basin. Based on the Phase I studies, it is concluded that both of those projects could be useful as operating components either at the beginning or early in the development of the TTWP. The permanent salt water barrier may be the only feasible answer to the serious and inter-related issues of hydrology and the environment in the lower Neches Basin. The Allens Creek project is potentially the most suitable source of regulating storage to allow smooth transfer of water from the Southeast Area to the West Central Area. The Neches salt water barrier and Allens Creek Reservoir both have sufficient merit to justify further detailed study within the TTWP and that study is scheduled for Phase II.

The preliminary studies for the permanent salt water barrier on the Neches River and Allens Creek Reservoir conducted for Phase I are described in detail in Appendix M. The results of these studies are summarized briefly below.

**Permanent Neches Salt Water Barrier**

The permanent salt water barrier on the Neches River would provide additional water supply by preventing salt water intrusion during times of low stream flow. This is currently done by temporary barriers on the Neches River and Pine Island Bayou and/or by releases from Lake B.A. Steinhagen when the temporary barriers are not in operation. A 1987 study conducted for the Lower Neches Valley Authority indicated that the permanent salt water barrier would provide 247,000 acre-feet per year of additional dependable water supply by reducing required releases from B.A. Steinhagen and by making it possible to use more of the uncontrolled runoff originating below B.A. Steinhagen (16).

Preliminary studies indicate that the environmental guidelines adopted by the PMC for use in the Phase I of the TTWP would significantly reduce the yield provided by the salt water barrier because most of the runoff originating below B.A. Steinhagen during a drought would be unavailable for water supply due to the instream flow criteria. Under the environmental guidelines, the yield gain due to the permanent barrier would be 156,800 acre-feet per year.

The studies conducted by the LNVA in 1987 and the studies conducted for Phase I of the TTWP are based on the assumption that temporary barriers could be installed on the Neches River whenever they are needed to protect the yield of the Sam Rayburn-B.A. Steinhagen system. If the Corps of Engineers requires that temporary barriers not be installed until storage in the reservoirs is partially depleted, the dependably yield of the existing system would be decreased and the benefits of a permanent barrier would be increased.

A preliminary environmental review of the permanent salt water barrier revealed the following principal findings, based largely on previous work by the Corps of Engineers (18).

- The permanent salt water barrier would improve upstream water quality by preventing salt water intrusion. Water quality downstream from the permanent barrier would be slightly more degraded than at present.

- There would be positive impacts on aquatic and terrestrial habitat upstream from the barrier.

- Wetlands upstream from the barrier would be preserved and enhanced by the prevention of salt water intrusion. Construction of the permanent barrier would permanently alter approximately 67 acres of wetland at the barrier site.

- The freshwater conditions that the permanent barrier would create would improve swimming, boating, hunting, and fishing upstream from the barrier.

- There are 21 state-listed threatened and endangered species in Jefferson County, where the project would be built. The state lists no known occurrences of these species in the immediate project area.

- The Paddlefish is an endangered species being reintroduced into some Texas rivers. The Paddlefish Recovery Plan recommends water quality enhancement for the Neches River, with no immediate plans for reintroducing the species. The permanent saltwater barrier would enhance Paddlefish habitat upstream.

- The project would cause short-term impacts to air quality during construction and provide several positive socio-economic impacts.

**Allens Creek Reservoir**

The Allens Creek project is a surface reservoir located near the mouth of Allens Creek on the west bank of the Brazos River near Wallis. Allens Creek itself has a relatively small watershed, and most of the water available for impoundment in the reservoir would be obtained by diversions from the main stem of the Brazos.

A 1989 yield analysis conducted for the Brazos River Authority indicated that the project would yield 85,000 acre-feet per year with the top of conservation storage at elevation 1180 and with a pumping capacity of 770 cfs for diversions from the Brazos River (19).

The 1989 analysis also showed that the Allens Creek project could provide 120,000 acre-feet per year if it were built for maximum yield, with 2,000 cfs of Brazos River diversion capacity.

As part of the Phase I studies for the TTWP, the yield analysis for the Allens Creek project was updated to account for new water rights granted since 1989 and to determine the effect of the Phase I TTWP environmental guidelines. The studies showed that water rights granted since 1989 would have only a small impact on the yield of Allens Creek. The project would still yield 85,000 acre-feet per year if the Brazos River diversion pumps were increased from 770 cfs to 820 cfs. The Phase I TTWP environmental guidelines would have a much larger impact on project yield. With 820 cfs pumping capacity, the guidelines would decrease the yield from 85,000 acre-feet per year to 57,800 acre-feet per year. However, the project could still yield 85,000 acre-feet per year if the capacity of the diversion pumps were to be increased to 1,900 cfs. The Phase I TTWP environmental guidelines would reduce the maximum yield available from Allens Creek Reservoir from 120,000 acre-feet per year (with 2,000 cfs capacity for diversions from the Brazos) to 105,000 acre-feet per year (with 3,000 cfs capacity for diversions from the Brazos).

Initial environmental investigations of Allens Creek Reservoir produced the following observations.

- The median TDS concentration during the critical low flow period would be about 500 milligrams per liter, with a maximum concentration slightly below 1,000 mg/l.
- The current land use at the site includes farming and pasture, with several large stands of trees. The site provides high quality habitat for a variety of species.
- There are 13 state-listed endangered species with known or probable occurrences in Austin County. Only one, the smooth green snake, is known to occur in the Wallis quadrangle map, in which the proposed reservoir would be located.
- Although there is no National Wetland Inventory map available for the Wallis quadrangle, it is likely that Alligator Hole, in the reservoir site, would be delineated as a wetland.
- The bluff which surrounds the proposed reservoir was used by prehistoric people for habitation and as a cemetery.

- There are no designated bottomland hardwood forest areas in Austin County, and the proposed reservoir would not significantly affect bottomland hardwood forest.

## 4.9 Interbasin Transfers

One strategy expected to provide a significant benefit within Texas is the conveyance of water from its area of origin to areas of need. Movement of water from its original source to the places where it is needed is not a new idea. For many centuries, successful civilizations have used canal and aqueduct systems for that purpose. Such systems are in operation throughout the world. The most notable examples in the United States are in the west, where millions of acre-feet per year are transferred. Existing regional and statewide water conveyance systems in the western U.S. include the California State Water Project, the Central Arizona Project, and the Central Utah Project. Each of these conveyance projects has served as a foundation upon which additional water supply and water management programs have been linked. This concept was identified early in the planning process as a potential solution to the long term needs of the Southeast region.

### Texas Experience

As Texas water law has developed, special significance has been attached to transfers that cross the boundaries of the larger river basins. A pattern of major basin boundaries has come to be recognized, based mainly on the contributing networks of tributaries to the principal rivers and on the points where surface water enters and leaves the state. In granting water rights, the TNRCC and its predecessors have followed the concept that water should not be removed from its basin of origin if such removal would prevent residents of that basin from having enough to meet their own needs in the foreseeable future.

Interbasin transfer has been used successfully for many years to deliver surface water supplies on a regional basis in a number of areas throughout Texas. Some of these systems have been in place for more than 50 years. In addition, numerous small-scale interbasin deliveries of water occur in Texas through the distribution systems of local water districts and rural water supply corporations. While none of these existing Texas systems is of the scale of the California and Colorado River systems of the southwestern states, almost three million acre-feet of water per year are supplied for use in Texas through interbasin transfer. In addition, there have been several proposals for very large-scale interbasin transfer systems to serve various areas of Texas. The first truly comprehensive Texas Water Plan, published by the Texas Water Development Board in 1968, proposed an interbasin system to deliver water from east Texas along the Gulf coast to central and southwest Texas all the way to the Lower Rio Grande Valley and another system was proposed across north Texas all the way to the irrigated agricultural areas of the Texas panhandle and eastern New Mexico (2).

**Southeast Area**

Within the study area there are several existing interbasin transfer systems in operation. Brazos River supplies has been used for many years to serve customers of the Gulf Coast Water Authority in the Brazoria and Galveston County areas of the San Jacinto-Brazos Coastal Basin. Neches supplies are used in the Neches-Trinity coastal basin. Sabine River water is used within the Neches Basin to serve municipal and industrial customers. Finally, the City of Houston, which primarily occupies the San Jacinto River basin, imports a major portion of its surface water supply from the Trinity River via the Coastal Water Authority canal system which serves the City and various industrial users along the Ship Channel.

Each of these interbasin transfer systems provides a water supply where it is needed from an area where a water surplus exists. The TTWP was envisioned to expand the opportunities for this type of water supply solution on a regional scale. One of the clearest discussions of this issue was prepared by the U.S. Water Resources Council. In 1968, the Council published a book entitled *The Nation's Water Resources*, which stated:

> "Water importation is urgently needed in western and in southern coastal parts of the [Texas-Gulf] Region. The feasibility of water transfers within the Region as well as of imports from outside will need to be considered. Coordinated planning will be needed between areas of surplus and of deficiency." (3)

Based on the analysis of available water supplies in the Southeast Area, no combination of available demand management or supply development alternatives offers the prospect of providing adequate additional water supply to meet projected requirements without use of interbasin transfers. Projected year 2050 water demands for the region (4.7 million acre-feet per year) are approximately double the year 1990 demands. This relationship is also true within the Houston SMSA. The magnitude of these demands significantly exceed all existing quantities of local water supplies. Whatever other alternatives are used, it is clear that interbasin transfer must be an important component of the total plan. Large-scale interbasin transfer will require construction of significant new infrastructure facilities but will still meet all the criteria established for the TTWP; therefore, interbasin transfer has been recognized as a primary component of the TTWP. More detail regarding this option is provided in subsequent sections of this report.

## 4.10 Contractual Transfers

Contractual water transfer, as used in this study, refers to the temporary or permanent transfer of water, from one party to another, typically by a contractual arrangement, which may or may not involve exchange of the legal water rights. Opportunities for contractual transfer occur where a given water need can be met from two or more alternative sources and where the source that is currently satisfying that need could also be used somewhere else. In such situations, it may be possible to make better use of the overall supply and/or save costs by changing the sources of supply for the original requirement so as to free the former supply for use elsewhere. In some cases, these transfers may be temporary, to postpone major capital investments. In other instances, they may be permanent. A less complex variation of this condition occasionally arises where water requirements that once existed decrease over a period of time so that the supply becomes available for other uses.

**Evaluation Criteria**

An initial examination of the potential for contractual transfers within the Southeast Area was conducted as a part of Phase I. Evaluation of potential contractual transfers was based on the following criteria:

- Transfers must represent water from a reliable supply source. The contractual transfer of water not backed by dependable yield from rivers or reservoirs will not be considered as a long-term solution in the TTWP.
- A transfer must be agreeable to both the buyer and the seller. The transfer should not impair the required future usage of the seller unless agreed to by the seller.
- Environmental impacts of the transfer must also be considered, including effects of the transfer on groundwater aquifers, if any.

In general, two forms of contractual transfer were evaluated for application to the TTWP in the Southeast Area:

- Conversion of irrigation supplies to municipal or manufacturing uses through contractual agreement between the water rights holder and the purchaser.
- Water "trading" to reduce the cost of existing or planned physical conveyance associated with other water management alternatives.

The following assumptions were used in an initial screening process to identify specific water rights permit holders who might serve as candidates for implementing contractual transfers:

- Permits for 10,000 acre-feet per year and greater were assumed to be large enough to justify further consideration.
- Permits in the southern portions of each basin were targeted because of greater potential for reliability of their supply sources.
- Permits for water use that result in physical conveyance of that water in a west-to-east direction or that divert the water at a location significantly downstream from the storage location.

**Irrigation Transfers**

Irrigation transfers were identified due to the projected long-term decline in irrigation demands. This projected decline could potentially create a surplus of reliable supplies which should be available for contractual transfer. Existing irrigation permits were compared to the corresponding water demands projected in each basin and the existing interbasin transfers. The basins with a potential for significant amounts of surplus irrigation supplies were identified as the Brazos, Neches, Trinity and Sabine Basins. A total of over ten separate permits were identified which currently are in use in these basins and which meet the initial screening criteria. These permits are listed in Table 4.4. The actual amount of water which might eventually be available for further contractual transfer will be estimated in Phase II through further studies and discussions with each entity.

**Conveyance Transfers**

Contractual transfer opportunities involving the "trading" of water supplies were also evaluated during Phase I. These contractual transfers have the potential to reduce the magnitude, or defer the schedule for construction of physical transfer facilities required to implement other water management methods currently being considered. Four specific

**Table 4.4**

**Potential Candidates for Contractual Transfers**

| Basin | County | Permit Holder | Use Type | Permit* (Ac.ft./yr.) |
|---|---|---|---|---|
| Brazos | Fort Bend | Richmond Irrig. Co. (in conjunction with HL&P) | Irrigation | 28,000 |
| Brazos | Fort Bend | Chocolate Bayou Water Co. | Irrigation | 145,000 |
| Brazos | Fort Bend | Gulf Coast Water Auth. | Irrig. & Mfg. | 149,932 |
| Trinity | Chambers | Chambers Liberty Conservation District | Irrigation | 110,000 |
| Trinity | Liberty | Dayton Canal Co. | Irrigation | 38,000 |
| Trinity | Liberty | Trinity Hotel Reserve, Inc. | Irrigation | 47,500 |
| Trinity | Polk | Trinity River Authority | Irrigation | 104,450 |
| Neches | Jefferson | Lower Neches Valley Auth. | Irrigation | 326,360 |
| Sabine | Newton | Sabine River Authority | Irrigation | 50,000 |
| Sabine | Orange | Sabine River Authority | Irrigation | 46,700 |

*This number represents the total amount of water permitted for the use type shown, not the amount that might be available for transfer.

contractual transfer opportunities were identified which warrant further evaluation. Each alternative is outlined further below under the name of the permit holder and source of supply.

Trinity Water Reserve, Inc./Trinity

Existing Trinity River water supplies are physically conveyed by the Trinity Water Reserve, Inc. (TWRI) to the Neches River Basin to provide irrigation water to various agricultural interests. A total supply of 86,000 acre-feet per year (total estimated dependable water rights of the TWRI) could be "traded" for Neches and/or Sabine River supplies. If the contractual transfer were implemented, the 86,000 acre-feet per year of Trinity River supply could be used to meet future water demands within the Houston SMSA. This contractual transfer would require the construction of only small canal system interconnections from the existing LNVA canal system to the TWRI canal system, and if Sabine water were involved, a relatively small extension of canal or pipeline to connect the Sabine's Gulf Coast canal system to the LNVA canal system. Otherwise, all physical water transfer could be accomplished using existing conveyance systems, provided the capacity is available in those systems.

Gulf Coast Water Authority/Brazos

Existing Brazos River water supplies are conveyed via canals and stored within the Gulf Coast Water Authority (GCWA) storage reservoir located in the San Jacinto-Brazos Coastal Basin on State Highway 146 near Texas City. A total of 136,800 acre-feet per year of Brazos River supplies could be "traded" for available Trinity, Neches, and/or Sabine supplies. Replacement water supplies would have to be conveyed to the GCWA reservoir through an expanded Coastal Water Authority (CWA) system. This contractual transfer would require capacity improvements within existing segments of the CWA transmission pipeline system and construction of approximately 10 miles of new pipeline to connect the CWA system into the GCWA reservoir. If the contractual transfer were implemented, the 136,800 acre-feet per year could either be used to meet future demands within the Houston SMSA (potentially on the west side of Houston) or made available to the West-Central or South-Central Area.

City of Houston/San Jacinto

The City of Houston currently owns two-thirds of the water rights in Lake Conroe in the San Jacinto Basin, amounting to 66,666 acre-feet per year of dependable supply. These supplies are currently used at the City's East Water Purification Plant, but are ultimately scheduled to be diverted from Lake Houston for the City's planned Northeast Water Purification Plant. If additional available supplies are physically transferred into Lake Houston from the Trinity, Neches, or Sabine Basins, a contractual transfer can be made to allow the Conroe water to be available for future demands in the northern portion of the San Jacinto Basin. This contractual transfer alternative offers the potential to use existing water supplies from the eastern area to meet near-team needs in the San Jacinto Basin by construction of conveyance facilities for over a relatively short distance between the Trinity River and Lake Houston.

City of Houston and Trinity River Authority/Trinity

Both the City of Houston and the Trinity River Authority have ownership of major supplies created by storage in the Lake Livingston reservoir, a total of almost 1.0 million acre-feet per year of dependable yield. A majority of this supply is dedicated to meeting demands significantly downstream in the Trinity coastal basins or in the City of Houston service area within the lower reaches of the San Jacinto Basin. If water supplies from the Neches and/or Sabine Basins are made available through physical conveyance to the lower basin demand areas, a contractual transfer could potentially be implemented which would allow those equivalent supplies to be traded for Livingston supplies. Consequently, physical transfer of Lake Livingston supplies to the San Jacinto or Brazos Basins would be possible using northern transfer routes out of Lake Livingston. Therefore, additional supplies of Neches/Sabine water could be made available to the northern part of the study area or to West-Central Area without the necessity of physically conveying

Neches/Sabine water to Lake Livingston.

Each of the above contractual transfers offers the opportunity to reduce physical conveyance costs for specific water management alternatives which might be considered in meeting the region's needs. However, each opportunity must be investigated further to better establish the environmental and institutional impacts associated with the proposed contractual transfer and to determine whether it is possible to create adequate benefits for all of the various entities who would be party to the necessary agreements.

### 4.11 Summary of Supply Alternatives

Based upon the analyses conducted during this study, seven of the ten basic alternatives were determined to deserve further consideration; consequently, each has been included in the TTWP to be developed further in Phase II. These water management alternatives include:

- Water conservation
- Reclamation and reuse
- Existing surface reservoirs
- Coordinated reservoir system operation
- New surface water projects
- Interbasin transfers
- Contractual transfers

Each of these alternatives meet the criteria established for the TTWP and may be an important element of the integrated water resources management plan for the Southeast Area. For each water management alternative, specific elements have been identified within the overall management method which will require further detailed study in Phase II.

Three alternatives which were evaluated in Phase I of the TTWP have been eliminated from further consideration. Two alternatives, demineralization and aquifer storage and recovery, are not likely to provide significant contributions to the water supply of the Southeast Area. These alternatives could meet some small local needs, but cannot be expected to be developed extensively in this area during the study period. The third alternative, new groundwater supplies, is expected to provide some new supply in the study area and those new supplies are included in the projections of future uses shown in Tables 3.2 and 3.4. Further groundwater use, beyond the growth already predicted, is not judged to be a viable alternative for meeting future needs in the area of greatest demand - Houston.

# 5.0 EXISTING CONVEYANCE FACILITIES

A potential exists for the use of available capacity in existing raw water system pipelines, canals, and pump stations. This chapter identifies the existing raw water systems within the study area that are believed to have potential use within the Trans-Texas Water Program. The more important of these existing water systems belong to the Sabine River Authority, the Lower Neches Valley Authority, the Trinity Water Reserve, Inc., the Coastal Water Authority, the American Rice Growers Association, and the Galveston County Water Authority.

The existing capacities of these systems are discussed in the following pages and summarized in Tables 5.1 and 5.2. Canal capacities expressed in this report do not include an allowance for seepage losses and evaporation. Information on canal systems in the Gulf Coast region indicates that seepage losses can range from 0 to 60 percent of the water conveyed. The Bureau of Reclamation has recorded canal system losses of their facilities which range from 0.5% to over 3% of flow per mile of canal. The majority of these canal systems are of earthen construction; therefore, seepage is a function of the soil type in the canal location. Seepage can be controlled through lining the canal with an impervious material, and clay is the most cost-effective lining material used in the Gulf Coast area. Canal lining also produces a secondary benefit of increasing the conveyance capacity of the facility. The Trans-Texas Water Program will develop canal system design criteria which include acceptable seepage rates and conveyance capacity parameters for use on both existing canal and new canal construction facilities. Evaporation rates within the Southeast Area range from approximately 40 inches per year at the Louisiana state line to approximately 50 inches per year in western Harris County. Associated precipitation rates range from 55 inches per year in the lower Sabine basin to around 45 inches per year in the lower Brazos basin. Canal systems in the region range from experiencing a net gain of water annually (in locations where precipitation exceeds evaporation) to a net loss of water.

# Table 5.1

## Summary of Existing Water Transfer Facilities in Southeast Area - Pump Stations

### Existing Pump Stations

| Water Transfer System | | Name | Location | Design Capacity (MGD) | (cfs) | Existing Capacity (MGD) | (cfs) | W/ Largest Out of Service (MGD) | (cfs) |
|---|---|---|---|---|---|---|---|---|---|
| Sabine River Authority (SRA): | | SRA P.S. | Sabine River Intake | | | 360.6 | 558.2 | 274.2 | 424.5 |
| Lower Neches Valley Authority (LNVA): | | | | | | | | | |
| | Neches Pump Stations | Lift # 1 | Neches Main | | | 604.8 | 936.2 | | |
| | | Lift # 2 | Neches Main | | | 604.8 | 936.2 | | |
| | BI Pump Stations | Lift # 1 | BI Main | | | 633.6 | 980.8 | | |
| | | Lift # 2 | BI Main | | | 633.6 | 980.8 | | |
| | Combined Capacity | | | | | 1,238.4 | 1,917.0 | 1,080.0 | 1,671.8 |
| | Nolte Canal | Nolte P.S. | Nolte Canal | 129.6 | 200.6 | 86.4 | 133.7 | 43.2 | 66.9 |
| Devers Canal System: | | Lift # 1 | Trinity River | | | 295.2 | 457.0 | 227.5 | 352.2 |
| | | Lift # 2 | Highway 563 | | | 273.6 | 423.5 | 183.3 | 283.7 |
| Coastal Water Authority (CWA): | | CWA P.S. | Trinity River | 1,300.0 | 2,012.4 | 723.0 | 1,119.2 | 625.0 | 967.5 |
| Dayton Canal System: | | Dayton P.S. | Trinity River | 90.7 | 140.4 | 90.7 | 140.4 | 25.9 | 40.1 |
| Galveston County Water Authority (GCWA): | | | | | | | | | |
| | System A | Shannon Plant | Brazos River | | | 347.0 | 537.2 | 203.0 | 314.2 |
| | System A | Lift # 2 | System A | | | 224.6 | 347.7 | 164.2 | 254.2 |
| | System B | Briscoe | Brazos River | | | 302.4 | 468.1 | 201.6 | 312.1 |

## Table 5.2

### Summary of Existing Water Transfer Facilities in Southeast Area - Canals

| Water Transfer System | | Existing Canal Systems Reach | Capacity (MGD) | Capacity (cfs) |
|---|---|---|---|---|
| Sabine River Authority (SRA) | | First 4.5 miles of SRA Canal | 749 | 1,159 |
| Lower Neches Valley Authority (LNVA): | | | | |
| | Nechas Main | Lift #2 to Port Arthur Check | 605 | 936* |
| | BI Main | Lift #2 to Junction | 634 | 981* |
| | Combined Capacity | | 1,239 | 1,917 |
| | Neches Main | Port Arthur Check to Junction | 540 | 836* |
| | Neches Main | Junction to China Check | 556 | 860* |
| | Nolte Canal | Nolte Upstream of Check | 36 | 56 |
| Devers Canal System: | | ****opposite to needed direction of flow **** | | |
| Coastal Water Authority (CWA): | | Trinity to Lynchburg (22 mi) | 1,300 | 2,012 |
| Dayton Canal System: | | Trinity to Cedar Bayou (20 mi) | 91 | 140 |
| Galveston County Water Authority (GCWA): | | **** opposite to needed direction of flow **** | | |

*Operational capacities of the LNVA main canals could be less than the design capacities, depending on the gate operation practices.

Again, design criteria will be developed for the TTWP which will also address evaporation and precipitation effects on the canal system capacity. Figure 5.1 shows the approximate location of these facilities in the study area.

## 5.1 The Sabine River Authority System

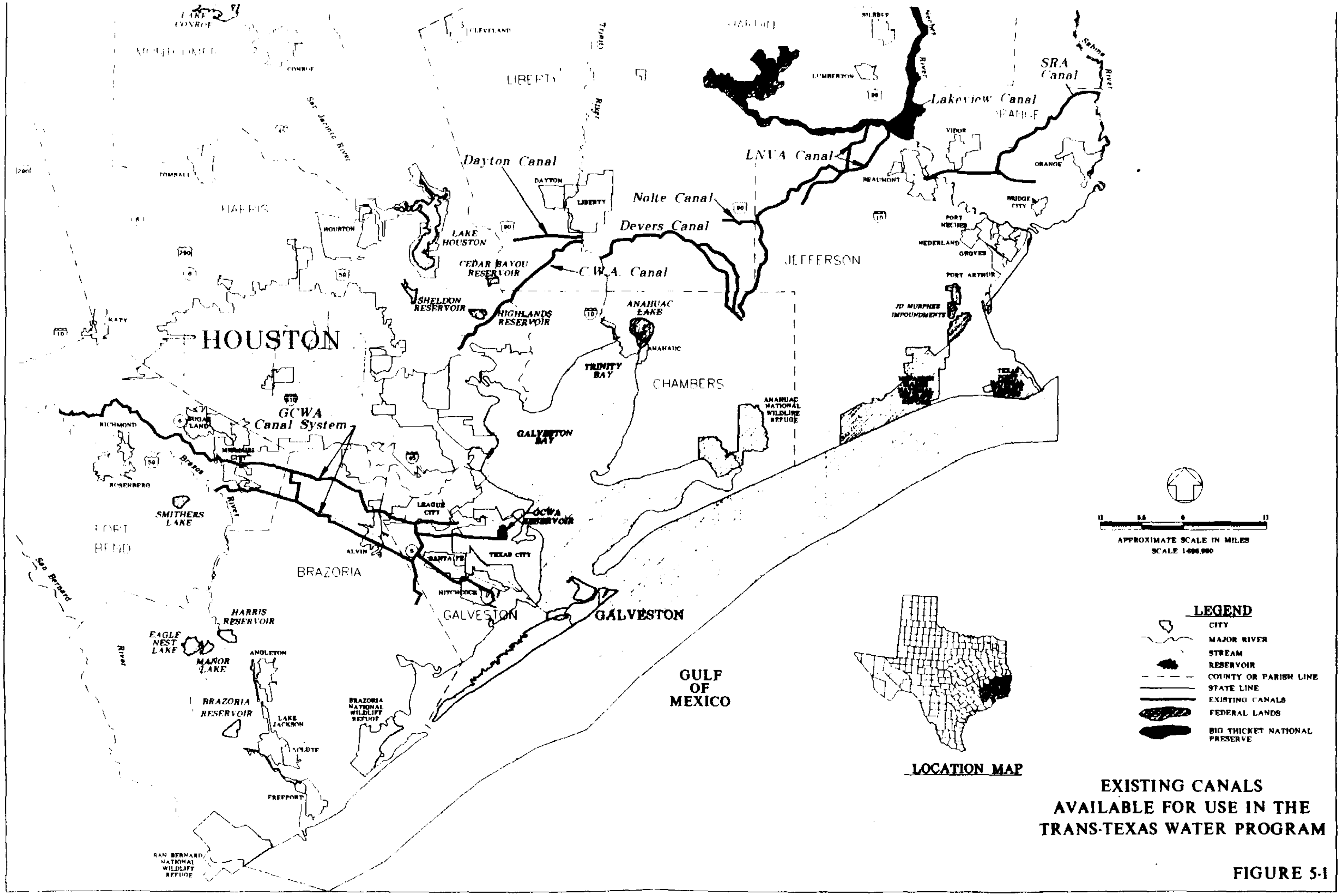
The Sabine River Authority (SRA) owns and operates a canal system which diverts water from the Sabine River and distributes it to water users in Orange County. The diversion pump station has a capacity of 250,400 gallons per minute (GPM) and takes water from the Sabine River northeast of the City of Orange. There are some 75 miles of main canals and laterals to transport the water to the various users.

The pumping facility, which is located on a short intake canal, lifts the water approximately 20 feet into the primary SRA canal. There are four 60,000 GPM horizontal pumps and one 10,400 GPM vertical turbine auxiliary pump, for a total rated capacity of 250,400 GPM, or 361 million gallons per day (MGD). If one of the 60,000 GPM pumps is out of service, the available firm pumping capacity of the system would be 190,400 GPM (274 MGD).

The canal and conveyance facilities of the SRA system consist of 30 miles of main canal, 45 miles of laterals and feeders, and a number of regulating structures to control water levels in the canals.

The first 4.5 miles of the main SRA canal were reviewed for this study, including the main lift station on the intake canal. No gated facilities or checks exist in this segment, but there are three inverted siphons. The calculated capacities of these siphons, based on an assumed one-foot head loss, are:

- Hudson Ditch Siphon - two 96" pipes: 660,000 GPM (950 MGD)
- Ditch 42 - two 96" pipes: 740,000 GPM (1,066 MGD)




**EXISTING CANALS AVAILABLE FOR USE IN THE TRANS-TEXAS WATER PROGRAM**

**FIGURE 5-1**

- Claybar Siphon - two 96" pipes: 520,000 GPM (749 MGD)

The historical pumpage records of the SRA system show that the monthly use reached a maximum value of 3,070 million gallons in July of 1981. This is an average of about 99 MGD (68,800 GPM). Assuming this figure to be the system's peak demand and the available pumping capacity to be 274 MGD, an un-used capacity of 175 MGD (196,200 acre-feet/year) would currently be available.

## 5.2 The Lower Neches Valley Authority System

The Lower Neches Valley Authority (LNVA) diverts raw water from the Neches River and Pine Island Bayou and delivers it to cities, industries and farmers in Jefferson County. Farmers in the eastern parts of Chambers County and Liberty County are also served.

The LNVA has two main canals, known as the Neches Main and the BI Main. The LNVA also owns the Lakeview canal, which carries flow by gravity from the Neches River near the Lakeview Community to the Neches first lift pump station. A second pump station in series, a few miles down the canal, lifts the water to the upper level of the Neches Main canal. The BI canal is also equipped with two pump stations in series to lift water from Pine Island Bayou and raise it to the proper level for gravity flow through the service area.

The combined capacity of the Neches and BI pumping facilities was counted in the review of the LNVA system, as the canals are arranged so that flow can be delivered to all customers from either of the two main diversion points. The total capacity of the primary pumping facilities is approximately 860,000 GPM (1,238 MGD). With one of the largest units (110,000 GPM) out of service, the available firm capacity of the Authority's pumping facilities would be 1,080 MGD.

The portion of the LNVA canal system that could be utilized for water conveyance as part of the Trans-Texas Water Program was divided into the following reaches for the purpose of canal capacity assessment:

| | |
|---|---|
| • Combined capacity of the Neches Main and the BI Main, downstream from their second lift stations | 1,238 MGD |
| • Neches Main from the Port Arthur takeoff to the junction of the two main canals | 540 MGD |
| • Neches Main from the junction to the China check | 556 MGD |
| • Neches Main from the China check to the Nolte Canal takeoff | 426 MGD |

The LNVA also owns the Nolte irrigation system, which takes off from the Neches Main canal and extends westward into the eastern part of Liberty County. The Nolte canal system consists of a 4.3-mile main canal, two laterals which take off to the north, and one lateral to the south. The Nolte canal also includes a check structure with five 36-inch pipes and a pump station with two 30,000 GPM pumps and space for an additional 30,000 GPM pump. The present total rated capacity of the Nolte pump station is 60,000 GPM (86 MGD).

The capacities of the Nolte canal reaches are:

| | |
|---|---|
| • Nolte canal upstream of the check structure | 130 MGD |
| • Nolte canal downstream from the check | 36 MGD |

The historical records of the LNVA system show that pumpage dropped considerably in the 1980-1990 decade. The peak monthly use of the system during that period was 76,448 acre-feet in July 1988, which is equivalent to a monthly average of about 803

MGD. Assuming this figure to be the system's current peak demand and the available pumping capacity to be 1,080 MGD, the remaining un-used capacity in the LNVA pumping system would be about 277 MGD (310,500 acre-feet/year).

### 5.3 Trinity Water Reserve, Inc. (Devers) Canal System

The Devers canal system delivers irrigation water in an easterly direction, from the Trinity River to customers in eastern Liberty County and a small area in Chambers County through 81 miles of main canal and 125 miles of laterals. The slope of the main canal is constructed at a very flat grade, which potentially allows flow to be reversed through the system and occur in a westerly direction. The system includes approximately 900 acre-feet (293 million gallons) of storage capacity in a regulating reservoir, two pumping plants on the main canal and one pumping plant on a lateral. The first pump station on the main Devers canal, located at the Trinity River, has a total name plate capacity of 205,000 GPM (295 MGD), and the second pump station, located near State Highway 563, has a total capacity of 190,000 GPM (274 MGD). The peak monthly water demand for this system is 144 MGD. Using the State Highway 563 pump station as a limiting source, the currently available capacity in the Devers system is 130 MGD (145,700 acre-feet/year).

### 5.4 The Coastal Water Authority Canal

The Coastal Water Authority (CWA) project consists of a main conveyance canal system and a pipeline distribution system. The conveyance system includes the Trinity River pump station, the main canal, the Lynchburg Reservoir and the Cedar Point lateral. The distribution system begins at the southern end of the Lynchburg Reservoir with the Lynchburg pump station and extends in a southwesterly direction approximately ten miles (entirely in pressure pipelines) to the Bayport Industrial complex.

The CWA pump station, on the Trinity River near Liberty, has an existing capacity of 723 MGD, with 10 pumps of varying sizes. The ultimate design capacity of the pump station is 1,300 MGD. The main canal extends westerly 22 miles, from the Trinity River pump station to the Lynchburg Reservoir, which is located on the north side of the Houston Ship Channel, opposite the San Jacinto Monument. The canal is unlined except for a short section near the Interstate Highway 10 siphon, as most of the route is through heavy clay. The total capacity of this canal is over 1,300 MGD. The Lynchburg Reservoir has an impoundment capacity of approximately 1.5 billion gallons, or 4,600 acre-feet.

At a point on the canal about 8 miles southwest of the Trinity River pump station, a check structure diverts a portion of the flow into the Cedar Point lateral system. The design capacity of this lateral system is 230 MGD.

The peak monthly demand of the CWA system has been about 250 MGD during the past 5 years, and there is a gradually increasing trend in annual use. Assuming 250 MGD to be the present demand of the system, this leaves an existing unused firm capacity of 375 MGD (420,400 acre-feet per year). The total available system capacity could be increased to 1,100 MGD (1,233,100 acre-feet per year) by installing the planned additional pumps at the Trinity River Pump Station.

## 5.5 The American Rice Growers Association (Dayton Canal) System

The Dayton Canal, owned by the American Rice Growers Association, is a small system that pumps out of the Trinity River to serve irrigation customers west of the river in Liberty County. The existing Trinity River lift station includes two pumps with a total rating of 63,000 GPM (91 MGD). The canal, which extends about 20 miles west of the Trinity River, is estimated to have an approximate capacity of 90 MGD.

The American Rice Growers Association holds the right to divert 33,000 acre-feet per year (29.5 MGD) from the Trinity River, at a maximum diversion rate of 63,000 GPM. The system also obtains about 5,000 acre-feet per year from a drainage channel known as the Big Ditch, which collects storm runoff from the area. There is currently no unused capacity within this system.

## 5.6 Gulf Coast Water Authority

The Gulf Coast County Water Authority (GCWA), formerly the Galveston County Water Authority, owns a canal system which delivers water from the Brazos River to water users in Fort Bend, Brazoria and Galveston Counties. The GCWA system consists of three primary canals:

- The American Canal (System A) runs in a southeasterly direction parallel to State Highway 6 from the Brazos River lift station (Shannon Plant), which is approximately 12 miles north of the City of Rosenberg, to Alvin, Texas. It connects to the Galveston Canal System about 6 miles east of the City of Alvin.

- The Briscoe Canal (System B) runs from the Brazos River pump station (Briscoe Plant), about six miles west of the City of Arcola, in a southeasterly direction (south of and parallel to State Highway 6) to Alvin and down to the Galveston Bay area.

- The Galveston Canal System extends from the old Briscoe system (System B), southeast of the City of Alvin, to the Galveston County Water Authority Reservoir, located on State Highway 146, about 4 miles east of the City of Dickinson.

- Systems A and B are connected by a lateral known as "Lateral 10", located just west of the City of Manvel.

Three pump stations exist on the GCWA system:

- The Shannon Plant (System A) is located on the Brazos River, approximately 12 miles north of Rosenberg, near Fulshear. The plant operates four pumps with a total capacity of 241,000 GPM (347 MGD).

- System A's second lift station is located at Sugar Land. It operates four pumps with a total capacity of 156,000 GPM (225 MGD).

- The Briscoe Plant is located on the Brazos River, about six miles west of Arcola. It operates three 70,000 GPM pumps, with a total capacity of 210,000 GPM (302.4 MGD).

The canals flow in a generally southeast direction from the Brazos River toward Galveston County. Flow within the natural banks of Jones Creek (a lateral of the Brazos River, used for approximately the first 5 miles of System A) is currently reversed to flow in a southeasterly direction, away from the Brazos River.

The GCWA has water rights which total 237,500 acre-feet per year (212 MGD) for diversions from the Brazos River. The GCWA staff indicates that approximately 78 MGD of average annual demands are currently supplied from the GCWA reservoir. An additional 44 MGD is reserved at the reservoir through an option agreement for use by industrial customers in any given year. In addition, about 60 MGD of uncommitted water is currently available through the GCWA.

# 6.0 INTERBASIN TRANSFER ROUTES

The feasibility of transbasin transfers is an important issue for the Trans-Texas Water Program. As a part of the Phase I investigations, the available transfer route alternatives were given preliminary study and screening. The results are presented in this chapter. A more detailed study of the preferred alternative routes will be included in Phase II.

## 6.1 Route Selection

The following environmental and engineering factors were used in the initial selection of potential conveyance routes to be evaluated in this phase of the TTWP. Each factor was used as a basis for either a quantitative or qualitative comparison of the options, based on data compiled and summarized in Tables 6.1 through 6.4 at the end of this chapter. The initial screening in Phase I is designed to cover the range of reasonable alternatives and to identify the more promising possibilities for further detailed examination in Phase II.

- **Stream and road crossings** - Stream and road crossings are costly and cause hydraulic losses. Stream crossings may also cause environmental damage. In general, the routes should be chosen to limit the number of crossings.

- **Big Thicket Preserve** - Construction within the Big Thicket National Preserve should be entirely avoided if at all possible, due to the highly sensitive environmental nature of the area.

- **Bottomland hardwood areas** - These areas are also environmentally sensitive and should not be used where there is a reasonable alternative. References in this chapter to Priority 1-6 forests refer to rankings in the Texas Bottomland Hardwood Forest Preservation Program (20) and are discussed in greater detail later.

- **Threatened and Endangered Species** - The critical habitat of endangered or threatened species should be completely avoided. The current distribution or present range of populated areas of these species should also be avoided where possible, but that is not as urgent as the critical habitat.

- **Wetlands** - The conveyance facilities should be routed around wetland areas wherever that can be done.
- **Major public recreation areas** - These areas should not be crossed if the facilities will permanently impact the recreational use.
- **Developed urbanized areas** - Such areas should be avoided if open areas are available.
- **Topography** - Insofar as possible, the routes should be located in areas where the topography is suitable for open canals, since the energy requirements to move large volumes of water are much lower for canals than for pipelines.
- **Length** - In general, a short route is better than a long one.
- **Static lift** - It is important to minimize the pumping lift and the number of pump stations required for each segment.
- **Soil characteristics** - To minimize seepage losses, the surface soils should be relatively tight with low infiltration rates.
- **Use of existing facilities** - To economize on construction costs and to minimize environmental impacts, it will be desirable to use the existing conveyance facilities discussed in Section 5.0 where feasible.
- **Use of major stream channels and lakes** - These resources should also be used where available, to avoid unnecessary construction costs and environmental impacts.

Figure 6.1 is a map of the Southeast Study Area, with the identified Trans-Texas conveyance route segment alternatives. The alternative routes are divided into segments and labeled according to the river basins of origin and destination. For example, all alternative routes going from the Sabine River to the Neches River are labeled "SN", and all alternative routes going from the Neches River to the Trinity River are labeled "NT". Across each drainage divide, the alternatives are generally numbered from north to south. For instance, the most northerly transfer path from the Sabine River to the Neches River is labeled "SN-1". (Routes NT-4, NT-5, TS-5 and SB-3 are exceptions; they are additional segments to reach reservoirs and are listed at the end of their respective groups.) Where two segments (a) begin at the same place but divide before reaching their destinations or (b) begin at different points but come together to end at the same place, they are given the same basic

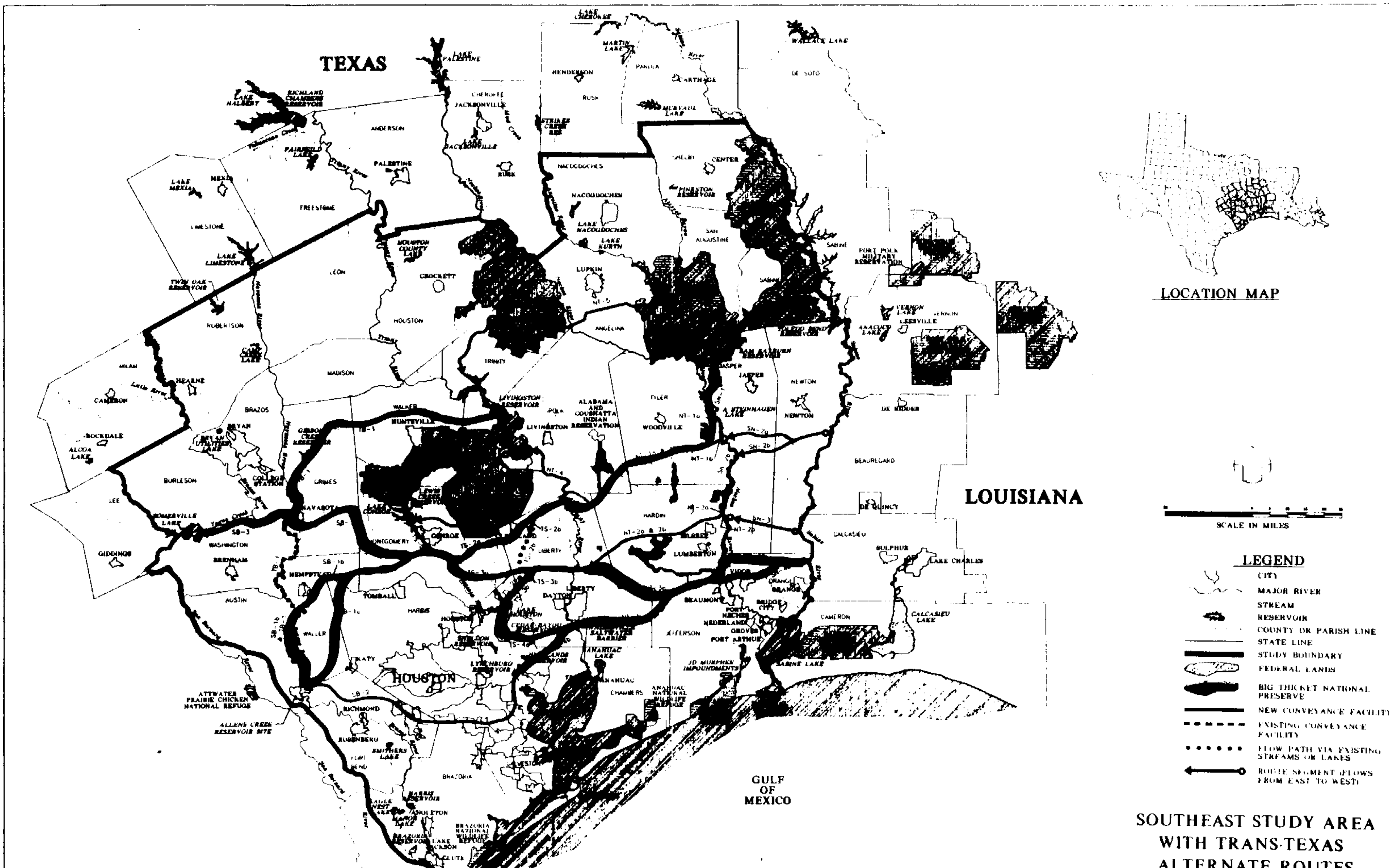

TEXAS
LOUISIANA
LOCATION MAP
GULF OF MEXICO
HOUSTON
SCALE IN MILES
LEGEND
CITY
MAJOR RIVER
STREAM
RESERVOIR
COUNTY OR PARISH LINE
STATE LINE
STUDY BOUNDARY
FEDERAL LANDS
BIG THICKET NATIONAL PRESERVE
NEW CONVEYANCE FACILITY
EXISTING CONVEYANCE FACILITY
FLOW PATH VIA EXISTING STREAMS OR LAKES
ROUTE SEGMENT (FLOWS FROM EAST TO WEST)
SOUTHEAST STUDY AREA WITH TRANS-TEXAS ALTERNATE ROUTES

FIGURE 6.1

number but are distinguished by lower case letters attached to the labels. For example, SN-2a and SN-2b begin at the same point but end in different locations.

Because operation of the conveyance system will be more easily regulated if the water to supply key demand areas can be transferred through storage reservoirs, alternatives were included that could deliver into Lake Livingston, Lake Houston and Lake Conroe. Similarly, alternatives were examined that could deliver into the proposed Allens Creek Reservoir area or Lake Somerville, which are considered the most likely locations for transfer of water from the Southeast Study Area into the West-Central Area.

## 6.2 Sabine River to Neches River

Six separate transfer corridors were identified between the Sabine River and the Neches River:

Segment SN-1: This segment begins at Toledo Bend Reservoir and goes across the watershed divide into Sam Rayburn Reservoir. From there, it travels down the Angelina River to B.A. Steinhagen Lake on the Neches River. It makes good use of existing reservoirs and stream channels and is the only segment which diverts water directly from Toledo Bend Reservoir. This alternative is compatible with any of the segments connecting the Neches River to the Trinity River. It requires a relatively short length of new facilities, but it does have a high static lift.

No urban or Big Thicket areas would be affected by this segment. A Priority 1 bottomland hardwood forest area is located at the northern tip of B.A. Steinhagen Lake, at the confluence of the Angelina and Neches Rivers. Wetlands are located along the Angelina River and at the confluence of the Angelina and Neches. These areas would experience only a minimal increase in water level. Federal and state threatened and endangered species which could be affected by Segment SN-1 are the Bald Eagle, Red-cockaded Woodpecker, and Navasota Ladies'-tresses.

Segment SN-2a: For this segment, water would be diverted from the Sabine River at a point near the town of Bon Wier and would be carried in a canal to the east side of the Neches River near Mount Union. This segment has a high static lift and ends at a point where the next following segment must go under the Big Thicket Preserve in order to avoid surface construction within the preserve. It is one of only two choices that can connect to the segment leading to Lake Livingston (NT-4).

No urban, Big Thicket, or priority bottomland hardwood forest areas would be affected by SN-2a. Sporadic wetlands would be encountered along the route. The Red-cockaded Woodpecker could be affected by the route.

<u>Segment SN-2b</u>: This alternative begins at the same place as SN-2a (Sabine River near Bon Wier) and terminates at the Neches River south of Mount Union. From that point, the Neches River channel is used to transport the water downstream to subsequent diversion points. Use of SN-2b in conjunction with NT-2a would require construction of a pumping facility within the Big Thicket Preserve.

No urban areas would be affected. From where it enters the Neches River to approximately 20 miles downstream where it terminates, the segment runs through wetlands and the Big Thicket. For approximately 10 miles of the reach within the Neches River, the segment is in Priority 2 bottomland hardwood forest. These areas are not expected to be affected by the minor increase in water level. Sporadic wetlands would be affected along the first half of the segment. The Red-cockaded Woodpecker also could be affected.

<u>Segment SN-3</u>: This segment consists of a canal from the Sabine River at Deweyville to the east side of the Neches River near Evadale. The water would be diverted from the Sabine River at a point in southern Newton County. Use of SN-3 in conjunction with NT-2b would involve a tunnel under the Big Thicket Preserve.

No urban or Big Thicket areas would be affected by SN-3. However, it comes within approximately one-half mile of a Priority 2 bottomland hardwood forest area. Sporadic wetlands would be affected along the route. The Red-cockaded Woodpecker might be affected.

<u>Segment SN-4a</u>: The existing SRA canal is used for a short distance on this segment, beginning at the Authority's pump station. The route then leaves the SRA canal and goes due west to the Neches River at Lakeview. Here, the water flows down the Lakeview Canal through the Big Thicket Preserve to the LNVA Neches First Lift. This segment requires only a short distance of new conveyance facilities and utilizes existing facilities that are owned by two of the Trans-Texas Water Program participants (SRA and LNVA). It also has a very low static lift.

A Priority 2 bottomland hardwood forest area is located where SN-4a begins. However, because the route uses an existing channel, the environment should not be seriously affected. Although the segment enters the Neches within the Big Thicket, the tributary stream where the water is released is outside the Preserve. Wetlands would be affected along the route where it does not use an existing canal. On the west side of the Neches, the route uses the existing LNVA Lakeview Canal, which runs in and out of the Big Thicket boundary. However, the Big Thicket would not be affected because the canal already exists. Federal and state threatened and endangered species which could be affected by the route are the Interior Least Tern and the Northern Scarlet Snake.

Segment SN-4b: This segment also begins with the existing SRA facilities and continues using the SRA main canal for a few miles after SN-4a branches off. The destination is the same as SN-4a, but SN-4b goes more to the south and links directly to the LNVA Neches First Lift pump station, in order to avoid the Big Thicket Preserve. This alternative has basically the same advantages as SN-4a.

The Big Thicket would not be affected by this segment. The urban environment north of Vidor would be affected. Where the route begins near the Sabine, the area is a Priority 2 bottomland hardwood forest area. However, because the route uses the existing canal, the environment should not be affected. Wetlands would primarily be affected on the second half of the route where it does not use existing canals. Where the route goes under the Neches in an inverted siphon, wetlands would be affected on both sides of the river. Federal and state threatened and endangered species which might be affected are the Interior Least Tern and the Northern Scarlet Snake.

## 6.3 Neches River to Trinity River

Eight possibilities for transfer routes have been considered between the Neches River and the Trinity River:

Segment NT-1a: This segment picks up where segment SN-1 ends (at B.A. Steinhagen Lake). It travels westward and southward, avoiding isolated areas of the Big Thicket Preserve, and ends at a point just east of the Trinity River near Romayor. This route is compatible with most of the segments crossing the remaining basins. However, the topography is rough and would involve a substantial static lift. The entire length of the segment would require the construction of new facilities, and there are many stream and road crossings. This route or NT-1b or NT-5 must be used if Trans-Texas water is to be transferred into Lake Livingston.

Urban areas, designated bottomland hardwood forest preservation areas, and the Big Thicket would not be affected by this segment. Sporadic wetlands would be affected. Federal and state threatened and endangered species which could be affected include the Interior Least Tern, Bald Eagle, Red-cockaded Woodpecker, Texas Trailing Phlox, and Louisiana Pine Snake.

Segment NT-1b: This segment is essentially the same as NT-1a, except that it begins on the east side of the Neches River, at the end of SN-2a. In order to avoid damaging vegetation inside the Big Thicket Preserve, the initial portion of NT-1b would be constructed by tunneling under the Neches River, starting at a point outside the preserve on the east and going to a point beyond its boundary on the west.

Urban areas and bottomland hardwood preservation areas would not be affected by this segment. At its beginning, the segment crosses the Neches and the Big Thicket, but these areas would be avoided by use of a tunnel. Sporadic wetlands would be affected along the route. Federal and state threatened and endangered species which could be affected by NT-1b include the Interior Least Tern, Bald Eagle, Red-cockaded Woodpecker, Texas Trailing Phlox, and Louisiana Pine Snake.

Segment NT-2a: This segment diverts water from the Neches River near Evadale. This water will have entered the Neches through segment SN-2b. The route travels westward to the east side of the Trinity River between Moss Hill and Hardin.

Sporadic wetlands would be affected by this route. This alternative would require a corridor through the Big Thicket Preserve, so that a pump station could be built on the west side of the Neches. At another point along the way, the distance between the Big Thicket Preserve and a designated bottomland hardwood forest preservation area would leave a very narrow passage for the segment. Federal and state threatened and endangered species which might be affected include the Interior Least Tern, Bald Eagle, Red-cockaded Woodpecker, and Texas Trailing Phlox.

Segment NT-2b: This segment would start at the end of segment SN-3 and would go under the Neches River by tunnel so as to stay entirely below ground and avoid surface disturbance within the Big Thicket Preserve. Throughout most of its length, this segment is identical to NT-2a.

Wetlands would be affected sporadically along the route and on both sides of the Neches, preceding and following the tunnel. The Big Thicket Preserve would be avoided at the Neches by the tunnel. Federal and state threatened and endangered species which might be affected include the Interior Least Tern, Bald Eagle, Red-cockaded Woodpecker, and Texas Trailing Phlox.

Segment NT-3a: This segment begins at the LNVA Neches First Lift, north of Beaumont. It travels through nearly 11 miles of the LNVA's existing Neches Main canal and then by new canal to the east side of the Trinity River between Moss Hill and Hardin. This route avoids surface construction in the Big Thicket Preserve, has a low static lift, and uses existing facilities. The topography is comparatively flat, and it has a relatively low number of stream and road crossings.

Occasional wetlands would be affected along the route. Federal and state threatened and endangered species which might be affected include the Brown Pelican, Interior Least Tern, Bald Eagle, Red-cockaded woodpecker, Navasota Ladies'-tresses, and the Northern Scarlet Snake.

Segment NT-3b: This segment also begins at the LNVA Neches First Lift. It uses almost 23 miles of the existing LNVA Neches Main canal. It then goes by new canal to the Trinity River south of Liberty. This route has the same advantages as NT-3a. It has a shorter length of new canal than NT-3a, and the static lift is very low.

Wetlands would be affected at the end of the segment, where it leaves the existing canal. Federal and state threatened and endangered species which might be affected by NT-3b include the Brown Pelican, Interior Least Tern, Bald Eagle, Red-cockaded Woodpecker, Navasota Ladies'-tresses, Houston Toad, and Northern Scarlet Snake.

Segment NT-4: This segment connects NT-1a and NT-1b to Lake Livingston. It can only be used if either NT-1a or NT-1b is used, and it is the only route other than NT-5 connecting with Lake Livingston. The topography is rough, and there is a high static lift.

Approximately 3/4 of a mile of the Big Thicket National Preserve would be affected at the beginning of the route. The urban area southwest of the town of Livingston would be affected by this segment. Sporadic wetlands would also be crossed. Almost the entire segment is within three designated bottomland hardwood forest areas of Priority 3, 5, and 6. The Whooping Crane, Bald Eagle, and Red-cockaded Woodpecker are the federal and state threatened and endangered species which might be affected.

Segment NT-5: This segment starts at Sam Rayburn Reservoir and ends at Lake Livingston. It leaves the western edge of Sam Rayburn Reservoir in Angelina County and heads west through the Angelina National Forest, passing north of the town of Zavalla. It crosses the Neches River by inverted siphon, then crosses Alabama Creek and the Davy Crockett National Forest. It uses the channel of Little White Rock Creek and then White Rock Creek, which feeds into the northern part of Lake Livingston.

A Priority 1 bottomland hardwood forest area would be crossed at the Neches River. Wetlands would be affected at the Neches River and sporadically along the route. At the existing channel of Little White Rock Creek, wetlands would experience an increased water level. The Red-cockaded Woodpecker and Bald Eagle are the federal and state threatened and endangered species which might be affected.

## 6.4 Trinity River to San Jacinto River

The distance between the Trinity River and the San Jacinto River is short, but the connection between these two basins is of critical importance. Eight possible segments were selected for consideration:

Segment TS-1: This route connects Lake Livingston and Lake Conroe. The topography is very rough, the route crosses the Sam Houston National Forest, the required new facilities distance is long, and the static lift is very high. Despite these drawbacks, this is one of two possible ways to send water into Lake Conroe.

The urban environment in the north Conroe area would be affected by this segment. The Bald Eagle and Red-cockaded Woodpecker are the federal and state threatened and endangered species which might be affected.

Segment TS-2a: This segment begins on the east side of the Trinity River near Romayor and extends to the east side of the San Jacinto River southeast of Conroe. It is compatible with three segments connecting the San jacinto to the Brazos and is one of only two routes which can connect to the segment leading to Lake Somerville (SB-4).

TS-2a would affect the urban environment at Cleveland. Wetlands would be affected on the east side of the West Fork of the San Jacinto and along the entire route. Approximately two miles of Priority 5 bottomland hardwood forest would be affected where the route terminates on the east side of the West Fork of the San jacinto River. The Interior Least Tern, Bald Eagle, and Red-cockaded Woodpecker may be affected.

Segment TS-2b: This segment has the same starting point as TS-2a. After a few miles, it turns southwestward to utilize Marsh Branch and then Luce Bayou to deliver the water to Lake Houston. This route uses 23 miles of existing streams, encounters few major crossings or conflicts and only requires 15 miles of new facilities. One disadvantage is that the static lift is somewhat high.

The segment would pass through wetlands within the existing channels of Tarkington Bayou and Luce Bayou, which would experience increased water levels. Other sporadic wetlands would be affected along the route. The interior Least Tern, Bald Eagle, Red-cockaded Woodpecker, Whooping Crane, and Texas Prairie-Dawn might be affected.

Segment TS-3a: This segment begins on the east side of the Trinity River between Moss Hill and Hardin (where NT-2a, NT-2b and NT-3a end) and travels almost due west to a point on the east side of the San jacinto River below Conroe. This is the only route besides TS-2a that connects to the segment leading to Lake Somerville (SB-4). It requires a long distance of new facilities and has a relatively high static lift.

The segment would affect sporadic wetlands on the east side of the Trinity River and along the route. Priority 1 bottomland hardwood forest would also be affected at the beginning of the route on the east side of the Trinity River, and Priority 5 bottomland hardwood forest would be affected at the end, on the West Fork of the San Jacinto. The Interior Least Tern, Bald Eagle, and Red-cockaded Woodpecker may be affected.

Segment TS-3b: Also beginning on the east side of the Trinity River between Moss Hill and Hardin, this segment travels westward until it reaches Luce Bayou, where the water is released to flow into Lake Houston. This alternative uses 22 miles of existing facilities and requires 11 miles of new facilities. It has a low static lift and few major stream or road crossings.

Sporadic wetlands would be affected on the east side of the Trinity River. Wetlands along Luce Bayou would experience an increase in water level. Priority 1 bottomland hardwood forest would be affected on the east side of the Trinity River, where the segment begins. Federal and state threatened and endangered species which could be affected include the Interior Least Tern, Whooping Crane, Texas

Prairie-Dawn, Bald Eagle, and Red-cockaded Woodpecker.

Segment TS-4a: This segment begins on the east side of the Trinity River, south of Liberty and travels west to Lake Houston. It uses part of the existing Dayton Canal en route and has a low static lift.

No urban areas, wetlands, bottomland hardwood forest, or Big Thicket areas would be affected by the route. Federal and state threatened and endangered species which might be affected include the Interior Least Tern, Whooping Crane, Texas Prairie-Dawn, Bald Eagle, Houston Toad, and Red-cockaded Woodpecker.

Segment TS-4b: This segment begins at the same point as TS-4a but branches at the west side of the Trinity. It uses the existing CWA canal for approximately 22 miles until it reaches Lynchburg Reservoir. The area which this route traverses is heavily urbanized, but it uses an existing canal through the urbanized area.

Environmental effects would be minimal because the entire route is within the existing CWA canal.

Segment TS-5: This segment picks up where TS-1a and TS-3a end, east of the San Jacinto River below Conroe. It basically follows the San Jacinto River upstream to Lake Conroe.

The urban environment of Conroe would be affected. The first approximately 1.5 miles of the segment would affect a Priority 5 bottomland hardwood forest area. Wetlands would be affected sporadically along the route. The Bald Eagle and Red-cockaded Woodpecker are the federal and state threatened and endangered species which may be affected.

## 6.5 San Jacinto River to Brazos River

There are five segments going from the San Jacinto River to the Brazos River.

Segment SB-1a: Three segments (SB-1a, SB-1b, and SB-1c) begin on the east side of the San Jacinto south of Conroe. Route SB-1a travels west, then turns northward just east of the Grimes County line and then goes westward again at a point due east of Navasota. This segment ends on the east side of the Brazos River near the City of Navasota. This route is the only one which connects to the segment leading to Lake Somerville, but it has several disadvantages. The static lift is high, and there are a significant number of road and stream crossings.

Sporadic wetlands would be affected near the San Jacinto River. This segment would affect urban environments at its beginning, south of Conroe, and at its end, south of Navasota. Federal and state threatened and endangered species which might be affected are the Whooping Crane, Bald Eagle, Red-cockaded Woodpecker, Houston Toad, and Navasota Ladies'-tresses.

Segment SB-1b: This segment begins south of Conroe and travels in a generally southwesterly direction to a point where it crosses the watershed divide between the San Jacinto and the Brazos just east of the City of Hempstead. The route goes around the more heavily urbanized sections of the Houston metropolitan area, but conflicts with new urban development will be a significant problem near Conroe. Once the water is in the Brazos River Basin, it would be released into a natural channel, and from there it would flow downstream to points where it would be picked up for transfer farther west.

Sporadic wetlands would be affected at the San Jacinto River, Clear Creek, and along the route. The Whooping Crane, Bald Eagle, Houston Toad, Red-cockaded Woodpecker, and Smooth Green Snake are the federal and state threatened and endangered species which may be affected.

Segment SB-1c: This segment goes in a southwesterly direction from near Conroe to near the City of Wallis, in the Brazos Basin, at the site of the proposed Allens Creek Reservoir.

The segment would affect urban environments at Conroe, Waller, and Brookshire. Like SB-1a and SB-1b, sporadic wetlands would be affected at the San Jacinto where the route starts and along the route. Federal and state threatened and endangered species which might be affected include the Whooping Crane, Bald Eagle, Red-cockaded Woodpecker, and Houston Toad.

Segment SB-2: This segment leaves Lynchburg Reservoir, travels along the southern edge of urbanized Houston, crosses the Brazos River and ends at the site of the proposed Allens Creek Reservoir. It requires 81 miles of new facilities, has a high static lift, passes through heavily urbanized areas, and crosses a large number of roads and streams.

SB-2 would affect wetlands sporadically. It would affect heavily urbanized areas in Baytown, Houston, and Stafford. The federal and state threatened and endangered species which might be affected are the Attwater's Prairie Chicken, Interior Least Tern, Whooping Crane, Texas Prairie-Dawn, Bald Eagle, Houston Toad, and Smooth Green Snake.

Segment SB-3: This is the only segment that goes to Lake Somerville. It begins near Navasota and follows the valley of Yegua Creek to Somerville Dam. The static lift on this route is significant. When all factors are considered, Lake Somerville does not look like as favorable a location as Allens Creek for input of water to the West Central Area.

This segment would affect the urban environment at Navasota. Navasota Ladies'-tresses and the Whooping Crane are the federal and state threatened and endangered species which might be affected.

## 6.6 Trinity River to Brazos River

Segment TB-1: This segment bypasses the San Jacinto Basin and transfers water directly from Lake Livingston into the Brazos Basin. It begins on the west side of Lake Livingston, near U.S. Highway 190 bridge, and goes westward, passing north of Huntsville, to discharge into the headwaters of Gibbons Creek in the Brazos Basin. From there, the water would flow downstream by gravity, to be recovered for transfer to the West-Central Area. The topography along this route is generally hilly, and much of the alignment would not be suitable for canals. The site tentatively selected for the diversion pump station is several miles upstream of the dam, and a location in deeper water may ultimately prove to be necessary. It is not clear that this route will prove to be necessary. It is not clear that this route will prove to be economical. However, when combined with suitable staging and contractual transfers, it might be a desirable alternative for inclusion in the overall plan.

Wetlands and Priority 2 bottomland hardwood forest environments exist along Gibbons Creek and the Navasota River, where the channels would be used by this segment. The increased water level is not expected to affect these environments. Federal and state threatened and endangered species which might be affected include the Red-cockaded Woodpecker, Navasota Ladies'-tresses, Houston Toad, Bald Eagle, Louisiana Pine Snake, and Smooth Green Snake.

## 6.7 Evaluation of Transfer Routes

Based on several of the factors addressed in this section, Table 6.5 was developed to allow evaluation of each proposed route with engineering and environmental criteria. This matrix combines several of the factors used in the initial route selection process to allow an overview of the relative characteristics of the segments.

Table 6.5 presents the results of the preliminary screening process by means of circular symbols for each of eight key categories of comparison. Open circles indicate favorable characteristics; filled-in circles reflect unfavorable conditions; and half-filled circles stand for average conditions. Some of the eight areas of comparison are more important than others, and Table 6.5 is not a precise basis of measurement for the merits of the various segments. It is intended only as an aid to a better understanding of the alternatives and their advantages and disadvantages and selection of alternatives for further consideration in Phase II.

In addition, Table 6.5 is not intended to show the nature of impacts that would occur as a result of the routes, but rather to describe environmental resources which may be affected due to their location along the routes.

The criteria and methodologies used in the matrix include the following:

- **Existing conveyance routes.** Each of the possible routes was examined to determine if existing man-made conveyance facilities could be incorporated to minimize cost and impact to the environment.

- **Engineering design criteria.** This criterion includes static lift, length of route, topography, and soil characteristics.

- **Stream and road crossings.** In addition to the engineering considerations of crossings (cost, hydraulic loss), environmental considerations such as construction impacts on water quality and loss of habitat were considered. Crossings were assessed from USGS quadrangle maps of varying ages, Texas Department of Transportation (TXDOT) County Maps of Texas, and the TXDOT Official Highway Map of Texas.

- **Threatened and endangered species.** The U.S. Fish and Wildlife Service (USFWS) has listed 12 federal threatened or endangered species which are of concern in the Southwest Study Area. They are:

| Common Name | Scientific Name |
|---|---|
| Texas Prairie Dawn | *Hymenoxys texana* |
| Large Fruited Sand Verbena | *Abronia macrocarpa* |
| Navasota Ladies'-tresses | *Spiranthes parksii* |
| Texas Trailing Phlox | *Phlox nivalis var. texensis* |
| White Bladderpod | *Lesquerella pallida* |
| Houston Toad | *Bufo houstonensis* |
| Attwater's Greater Prairie Chicken | *Tympanuchus cupido attwateri* |
| Brown Pelican | *Pelicanus oxidentalus* |
| Interior Least Tern | *Sterna antillarum athalassos* |
| Whooping Crane | *Grus americana* |
| Bald Eagle | *Haliaeetus leucocephalus* |
| Red-cockaded Woodpecker | *Picoides borealis* |

Only the Houston Toad has critical habitat designated by the USFWS within the study area. This habitat is located in Burleson County. While Burleson County is within the study area, none of the route alternatives is in the county.

Information regarding Federal listed threatened and endangered species was available at the county or regional level. A route's potential effect on a species was determined by assigning to the route a numeric score of 0.0, 0.5, or 1.0 for each of the 12 species based on the percent of the route that passed through the region where the species occurred. The scores for each individual species occurring along a route were summed, and the total score for the route was assigned a low, medium or high symbol. The symbols indicate the average effects to species along the whole length of a route.

The Texas Parks and Wildlife Department (TPWD) has listed 38 threatened and endangered species which are known to occur or probably occur in counties within the study area. TPWD also maintains datafiles called element Occurrences of Special Concern, which list species seen at particular locations by county name and topographic map name. These datafiles provide more specific data than the county level data. When state listed threatened and endangered species are evaluated at the topographic map level, only ten of the 38 species remain. They are:

| Common Name | Scientific Name |
|---|---|
| Texas Prairie Dawn | *Hymenoxys texana* |
| Navasota Ladies'-tresses | *Spiranthes parksii* |
| Texas Trailing Phlox | *Phlox nivalis var. texensis* |
| Houston Toad | *Bufo houstonensis* |
| Attwater's Greater Prairie Chicken | *Tympanuchus cupido attwateri* |
| Bald Eagle | *Haliaeetus leucocephalus* |
| Red-cockaded Woodpecker | *Picoides borealis* |
| Northern Scarlet Snake | *Cemophora coccinea copei* |
| Smooth Green Snake | *Opheodrys vernalis blanchardi* |

Potential effects to the ten state listed threatened and endangered species were evaluated separately from Federal listed species because information was available at the topographic map level, which more specifically defines the location of a species. For each route, all topographic maps on which a species occurred were counted. If two species were located on one topographic map, that map was counted twice. The number of topographic maps with species was divided by the total number of topographic maps on the route to determine the route's average level of effect on the species.

- **Wetlands.** The USFWS' National Wetland Inventory (NWI) maps were consulted to determine where wetlands might be affected by the routes. These maps distinguish between types of wetlands but not wetland quality. The maps are based on aerial photographs. Some areas in the two western basins, Trinity-San Jacinto and San Jacinto-Brazos, do not have NWI maps. As a result, some wetlands may not have been fully accounted for. For each of the 28 routes, a list was compiled which counted every wetland the route crossed and categorized them into approximately two dozen wetland types based on the legends of the NWI maps. The two-dozen wetland types were condensed into seven classes, which were ranked for importance based on Cowardin (26), as discussed below. For each route, the number of occurrences of each class was multiplied by the rank of that class to obtain a class score. The scores for each of the seven classes were then summed to obtain a total score for each route.

  Based on Cowardin (26), the seven wetlands classes were ranked as follows, with a score of 1 for the least important wetland type and a score of 7 for the most important wetland type:

  Unconsolidated Bottom = 1
  Unconsolidated Shore = 2
  Aquatic Bed = 4
  Streambed = 4
  Emergent Wetland = 5
  Scrub-Shrub Wetlands = 6
  Forest Wetland = 7

- **Urban area.** The proximity of a route to developed areas was assessed. Avoidance of developed areas is preferable.

- **Big Thicket National Preserve.** Avoidance of the Big Thicket Preserve is highly desirable. Effects to the Preserve were based on whether a route would go through the Preserve. Preserve boundaries were determined from topographic maps.

- **Bottomland/hardwood forest.** The Texas Bottomland Hardwood Forest Preservation Program Report (20) was consulted to determine where these forests would be affected by the routes. Detailed maps in the report provided the locations of forests ranging from Priority 1 to 6. Priority 1 bottomland hardwood forests are those which were determined by USFWS to be of excellent quality and of high value to the key waterfowl species. Priority 2 represents good quality bottomlands with moderate waterfowl benefits. Priority 3 consists of excellent quality bottomlands with minor waterfowl benefits because of small size, lack of management potential, or other factors. Priority 4 represents moderate quality bottomlands with minor waterfowl benefits. Priority 5 sites are those eliminated from further study because of poor quality and/or no waterfowl benefits, while Priority 6 sites are those recommended for future study.

  Low, medium, and high symbols were based on number of miles of route within a forest and the priority of the forest. If a route avoided hardwood forest completely, the route was given a favorable rating (open circle). An average rating (half-filled circle) was used for routes which crossed up to two miles of forest. An unfavorable designation (closed circle) was used for routes which crossed more than two miles of forest. In addition, high score was used for any route that crossed a Priority 1 or 2 forest, regardless of the number of miles.

Many routes have been designed to use existing natural or man-made channels where possible, as covered in the route descriptions, Sections 6.2-6.6. Where existing channels are used, the environment would not be affected as much as it would in areas where new pipelines or canals would be built. To distinguish these areas, asterisks have been used to indicate that the environmental category (wetlands, Big Thicket, etc.) does exist along a route but would be affected only minimally or not at all by an increase in water level. For example, Route TS-4b is entirely within an existing canal. Endangered species and urban areas exist along the route but would not be affected by the increased water level in the canal. Route SN-2 uses the Neches River where the Neches is surrounded by Big Thicket and bottomland hardwood forest. However, these environments are not likely to be affected by the moderate increase in water level.

Determinations about water level increases will be calculated for Phase II of the project, when the number of potential routes has been reduced. Water level increases in large rivers such as the Neches, Trinity, San Jacinto, and Brazos are not expected to be large relative to the size of the channel. Intermittent creeks and streams in the western portion of the study area may be subject to more pronounced changes as a result of becoming perennial. Use of existing natural or man-made channels is noted in the descriptions of the routes and in the discussions of affected environment.

## 6.8 Conclusions Regarding Preferable Routes

Examination of the summary in Table 6.5 and review of additional details in Tables 6.1 through 6.4 lead to the following conclusions:

- For the first step, from the Sabine Basin to the Neches Basin, the three route segments that originate at the upper and lower ends of the study area (Segments SN-1, SN-4a, and SN-4b) are preferable to the three segments located in the middle reaches of the lower Sabine River. The middle-reach alternatives (SN-2A, SN-2B and SN-3) all would lead to some degree of interference with the Big Thicket National Preserve. The impacts on the Big Thicket would not necessarily occur in the Sabine-to-Neches step itself. Instead, they would be unavoidable in the Neches-to-Trinity step because of the locations at which water must be picked up for the next stages of transfer. In general, the engineering characteristics of the upper and lower segments are also superior to those of the middle segments, leaving no apparent reason to prefer the middle alternatives.

- Among the Neches-to-Trinity segments, three (NT-1b, NT-2a and NT-2b) should be ruled out because of problems with the Big Thicket Preserve. Two of these alternatives would require tunneling under the preserve, and the other would involve construction of a diversion pump station on the west bank of the Neches River within the limits of the preserve.

- Segments NT-1a, NT-3a and NT-3b are clearly the best prospects for more detailed study in the Neches-to-Trinity group. NT-3a would involve the flow of water through existing natural and man-made channels within the Big Thicket Preserve, but it should be possible to use those channels without disturbing the environment.

- Segments NT-4 and NT-5, which would convey water to Lake Livingston, should be ruled out on engineering grounds and because NT-4 crosses a sub-area of the Big Thicket National Preserve. The same practical result as intended to be served by these segments could be achieved by a contractual transfer, in which Trans-Texas water would be discharged into the Trinity River in place of releases from Lake Livingston.

- Of the eight segments in the Trinity-to-San Jacinto group, the comparisons indicate that TS-1, TS-2b, and TS-5 can be eliminated at this stage of the investigation. Segment TS-1, from Lake Livingston to Lake Conroe, is unfavorable from the engineering standpoint and passes through many miles of national forest. Segment TS-2b accomplishes the same purposes as Segment TS-3b but is less direct and involves slightly more severe environmental problems. The remaining segments of this group (TS-2a, TS-3a, TS-3b, TS-4a and TS-4b) all warrant further investigation in Phase II.

- In the San Jacinto-to-Brazos group, Segment SB-2, going around the south edge of Houston, can be dropped from the list of preferable alternatives. It would pass through very difficult conditions and over very costly land, and it would be longer than the northern routes that would serve the same basic purpose. The other four segments in this group (SB-1a, SB-1b, SB-1c and SB-3) should be retained on the list of alternatives for additional study.

- Segment TB-1, from Lake Livingston to the Brazos Basin, should also be examined further. It is in some ways basically different from the other alternatives considered, and it should be examined carefully as a potentially economical and useful route for transfer of water to the West Central Area.

Of the 28 potential transfer route segments identified in Phase I, 13 were eliminated in the preliminary screening process, and 15 have been indicated as candidates for more detailed evaluation in the next phase. It is apparent at this point that some of the alternatives retained for additional study are stronger prospects than others, particularly when they are viewed in isolation. In many cases, this is the result of the inter-relationships of groups of segments as components of overall routes. Basically, the alternatives under consideration make up three distinct routes for movement of Trans-Texas water. The northern route goes from Toledo Bend Reservoir to the San Jacinto Basin near Conroe and thence to the Brazos Basin. Two southern routes would both begin at the Sabine River Authority's existing diversion facilities. One route would go from there to the Trinity near Moss Hill and then through southern Montgomery County and westward to the Brazos Basin. The other route would cross the Trinity near Liberty and use the CWA canal facilities to deliver water to the southeast part of the Houston area but would not provide for direct transfer of water into the Brazos Basin. A fourth route option was also considered that is less coherent than the first three but would potentially achieve the same ends. It involves transfer of water from Lake Livingston into the Brazos Basin in exchange for delivery of water from the Southeast Area to offset the loss of Livingston water that would otherwise go to the Houston area.

In order to keep open a full range of options at this stage of the investigation, alternatives were also kept on the list that would allow delivery of water from the West Central Area through both Allens Creek Reservoir and Lake Somerville. Similarly, alternatives were retained that involved both the transfer of Southeast Area water into the Trinity or the Brazos for subsequent re-diversion farther downstream.

Thus, keeping a full degree of flexibility regarding the possible eventual choice of preferred system configuration has caused some segments that involve obvious difficulties to be recommended for inclusion in the Phase II analysis. This was believed to be desirable so as not to narrow the scope of study prematurely.

Table 6.1
TRANS-TEXAS WATER PROGRAM
CHARACTERISTICS OF ALTERNATIVE TRANSMISSION ROUTE SEGMENTS
DISTANCES AND TOPOGRAPHY

| | | Approximate Distances in Miles | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | New Pipeline | New Canal | Total New Facilities | Existing Facilities | Existing Streams | Existing Lakes | Total Overal Distance | Topography Characteristics |
| **Sabine River to Neches River** | | | | | | | | | |
| SN-1 | Toledo Bend to Sam Rayburn to B.A. Steinhagen Dam | 0 | 18 | 18 | 0 | 23.5 | 14.5 | 56 | Rough |
| SN-2a | Sabine @ Bon Wier to east side of Neches near Mt. Union | 0 | 27.5 | 27.5 | 0 | 0 | 0 | 27.5 | OK |
| SN-2b | Sabine @ Bon Wier to Neches so. of Mt. Union to downstream nr Evadale | 0 | 28 | 28 | 0 | 17 | 0 | 45 | OK |
| SN-3 | Sabine @ Deweyville to east side of Neches near Evadale | 0 | 24 | 24 | 0 | 0 | 0 | 24 | OK |
| SN-4a | Sabine @ SRA to Neches @ Lakeview to LNVA Neches First Lift | 0 | 18.5 | 18.5 | 11.5 | 0 | 0 | 30 | OK |
| SN-4b | Sabine @ SRA to LNVA Neches First Lift | 0 | 15 | 15 | 15 | 0 | 0 | 30 | OK |
| **Neches River to Trinity River** | | | | | | | | | |
| NT-1a | Steinhagen Dam to east of Trinity River near Romayor | 0 | 55 | 59 | 0 | 0 | 0 | 55 | Rough |
| NT-1b | East side of Neches near Mt. Union to east of Trinity near Romayor | 3 | 53 | 59 | 0 | 0 | 0 | 56 | Rough |
| NT-2a | Neches River near Evadale to east of Trinity near Moss Hill | 0 | 44 | 44 | 0 | 0 | 0 | 44 | OK |
| NT-2b | East of Neches nr Evadale to east of Trinity near Moss Hill | 5 | 41 | 46 | 0 | 0 | 0 | 46 | OK |
| NT-3a | LNVA Neches First Lift to east of Trinity near Moss Hill | 0 | 31.5 | 31.5 | 10.5 | 0 | 0 | 42 | OK |
| NT-3b | LNVA Neches First Lift to east of Trinity south of Liberty | 0 | 22 | 22 | 22.5 | 0 | 0 | 44.5 | OK |
| NT-4 | East of Trinity River near Romayor to Lake Livingston | 0 | 25 | 25 | 0 | 0 | 0 | 25 | Rough |
| NT-5 | Sam Rayburn Reservoir to Lake Livingston | 5 | 52 | 57 | 0 | 18 | 0 | 75 | Rough |
| **Trinity River to San Jacinto River** | | | | | | | | | |
| TS-1 | Lake Livingston to Lake Conroe | 0 | 48 | 48 | 0 | 0 | 0 | 48 | Very Rough |
| TS-2a | East of Trinity near Romayor to West Fork San Jacinto below Conroe | 3 | 40 | 43 | 0 | 0 | 0 | 43 | OK |
| TS-2b | East of Trinity near Romayor to Lake Houston | 3 | 12 | 15 | 0 | 22.5 | 7.5 | 45 | OK |
| TS-3a | East of Trinity near Moss Hill to West Fork San Jacinto below Conroe | 5 | 38 | 43 | 0 | 0 | 0 | 43 | OK |
| TS-3b | East of Trinity near Moss Hill to Lake Houston | 5 | 6 | 11 | 0 | 14.5 | 7.5 | 33 | OK |
| TS-4a | East of Trinity south of Liberty to Lake Houston | 3 | 10 | 13 | 8 | 2 | 3 | 26 | OK |
| TS-4b | East of Trinity south of Liberty to Lynchburg Reservoir | 3 | 0 | 3 | 22 | 0 | 0 | 25 | OK |
| TS-5 | East of San Jacinto below Conroe to Lake Conroe | 0 | 12 | 12 | 0 | 0 | 0 | 12 | Rough |
| **San Jacinto River to Brazos River** | | | | | | | | | |
| SB-1a | West Fork San Jacinto below Conroe to E. of Brazos near Navasota | 5 | 55 | 60 | 0 | 0 | 0 | 60 | OK |
| SB-1b | West Fork San Jacinto below Conroe to Brazos Basin east of Hempstead | 5 | 36 | 41 | 0 | 0 | 0 | 41 | OK |
| SB-1c | West Fork San Jacinto below Conroe to Allens Creek Res. | 10 | 59 | 69 | 0 | 0 | 0 | 69 | OK |
| SB-2 | Lynchburg Reservoir to Allens Creek Res. | 5 | 76 | 81 | 0 | 0 | 0 | 81 | OK |
| SB-3 | Brazos River near Navasota to Lake Somerville | 5 | 22 | 27 | 0 | 0 | 0 | 27 | OK |
| **Trinity River to Brazos River** | | | | | | | | | |
| TB-1 | Lake Livingston to Gibbons Creek Reservoir | 0 | 55 | 55 | 0 | 0 | 0 | 55 | Very Rough |

Table 6.2
TRANS-TEXAS WATER PROGRAM
CHARACTERISTICS OF ALTERNATIVE TRANSMISSION ROUTE SEGMENTS
KEY CRITERIA

| | | Critical Habitat* | Big Thicket | Urban Areas | Effects on Wetlands | Major Recreation Areas |
|---|---|---|---|---|---|---|
| **Sabine River to Neches River** | | | | | | |
| SN-1 | Toledo Bend to Sam Rayburn to B.A. Steinhagen Dam | | | No | Moderate | National Forests |
| SN-2a | Sabine @ Bon Wier to east side of Neches near Mt. Union | | | No | Moderate | Big Thicket |
| SN-2b | Sabine @ Bon Wier to Neches south of Mt. Union to downstream near Evadale | Uses River Running Thru | No | Moderate | Big Thicket | |
| SN-3 | Sabine @ Deweyville to east side of Neches near Evadale | | | No | Moderate | Big Thicket |
| SN-4a | Sabine @ SRA to Neches @ Lakeview to LNVA Neches First Lift | Uses Canal Running Thru | No | High | Big Thicket | |
| SN-4b | Sabine @ SRA to LNVA Neches First Lift | | | Some | High | None |
| **Neches River to Trinity River** | | | | | | |
| NT-1a | Steinhagen Dam to east of Trinity River near Romayor | | | No | Moderate | |
| NT-1b | East side of Neches near Mt. Union to east of Trinity near Romayor | | Crosses with tunnel | No | Moderate | |
| NT-2a | Neches River near Evadale to east of Trinity near Moss Hill | | Pump Station | No | Moderate | |
| NT-2b | East of Neches near Evadale to east of Trinity near Moss Hill | | Crosses with tunnel | No | High | |
| NT-3a | LNVA Neches First Lift to east of Trinity near Moss Hill | | | No | Moderate | |
| NT-3b | LNVA Neches First Lift to east of Trinity south of Liberty | | | No | Moderate | |
| NT-4 | East of Trinity River near Romayor to Lake Livingston | | Crosses | No | Moderate | Lake Livingston |
| NT-5 | Sam Rayburn Reservoir to Lake Livingston Rayburn | | | No | Moderate | L. Liv. & Sam |
| **Trinity River to San Jacinto River** | | | | | | |
| TS-1 | Lake Livingston to Lake Conroe | | | No | Low | Lakes Liv. & Conroe |
| TS-2a | East of Trinity near Romayor to West Fork San Jacinto below Conroe | | | Some | High | |
| TS-2b | East of Trinity near Romayor to Lake Houston | | | No | Moderate | Lake Houston |
| TS-3a | East of Trinity near Moss Hill to West Fork San Jacinto below Conroe | | | No | Moderate | |
| TS-3b | East of Trinity near Moss Hill to Lake Houston | | | No | Moderate | Lake Houston |
| TS-4a | East of Trinity south of Liberty to Lake Houston | | | No | Low | Lake Houston |
| TS-4b | East of Trinity south of Liberty to Lynchburg Reservoir | | | Center | Low | |
| TS-5 | East of San Jacinto below Conroe to Lake Conroe | | | Heavy | Moderate | Lake Conroe |
| **San Jacinto River to Brazos River** | | | | | | |
| SB-1a | West Fork San Jacinto below Conroe to E. of Brazos near Navasota | | | Heavy | Low | |
| SB-1b | West Fork San Jacinto below Conroe to Brazos Basin east of Hempstead | | | Heavy | Moderate | |
| SB-1c | West Fork San Jacinto below Conroe to Allens Creek Res. | | | Heavy | Moderate | |
| SB-2 | Lynchburg Reservoir to Allens Creek Res. | | | Heavy | Moderate | |
| SB-3 | Brazos River near Navasota to Lake Somerville | | | Some | Low | Lake Somerville |
| **Trinity River to Brazos River** | | | | | | |
| TB-1 | Lake Livingston to Gibbons Creek Reservoir | | | No | Moderate | |

* None of the route segments intersect the critical habitat of any endangered species. See Section 6.6 for information concerning the present population areas of endangered species.

Table 6.3
TRANS-TEXAS WATER PROGRAM
CHARACTERISTICS OF ALTERNATIVE TRANSMISSION ROUTE SEGMENTS
PUMPING LIFTS

| | | Approx. Beginning Elevation (msl) | Approx. Divide Elevation (msl) | Approx. Delivery Elevation (msl) | Static Lift (feet) | Number of Pump Stations |
|---|---|---|---|---|---|---|
| **Sabine River to Neches River** | | | | | | |
| SN-1 | Toledo Bend to Sam Rayburn to B.A. Steinhagen Dam | 172 | 250 | 83 | 78 | 2 |
| SN-2a | Sabine @ Bon Wier to east side of Neches near Mt. Union | 65 | 160 | 100 | 95 | 2 |
| SN-2b | Sabine @ Bon Wier to Neches south of Mt. Union to downstream near Evadale | 65 | 105 | 35 | 40 | 1 |
| SN-3 | Sabine @ Deweyville to east side of Neches near Evadale | 20 | 55 | 35 | 35 | 1 |
| SN-4a | Sabine @ SRA to Neches @ Lakeview to LNVA Neches First Lift | 20 | 30 | 20 | 10 | 1 |
| SN-4b | Sabine @ SRA to LNVA Neches First Lift | 20 | 30 | 25 | 10 | 1 |
| **Neches River to Trinity River** | | | | | | |
| NT-1a | Steinhagen Dam to east of Trinity River near Romayor | 83 | 200 | 75 | 117 | 3 |
| NT-1b | East side of Neches near Mt. Union to east of Trinity near Romayor | 100 | 200 | 75 | 100 | 2 |
| NT-2a | Neches River near Evadale to east of Trinity near Moss Hill | 35 | 90 | 50 | 55 | 1 |
| NT-2b | East of Neches nr Evadale to east of Trinity near Moss Hill | 35 | 90 | 50 | 55 | 1 |
| NT-3a | LNVA Neches First Lift to east of Trinity near Moss Hill | 20 | 75 | 50 | 55 | 1 |
| NT-3b | LNVA Neches First Lift to east of Trinity south of Liberty | 20 | 50 | 30 | 30 | 1 |
| NT-4 | East of Trinity River near Romayor to Lake Livingston | 75 | 131 | 131 | 56 | 1 |
| NT-5 | Sam Rayburn Reservoir to Lake Livingston | 164 | 300 | 131 | 136 | 3 |
| **Trinity River to San Jacinto River** | | | | | | |
| TS-1 | Lake Livingston to Lake Conroe | 131 | 300 | 201 | 169 | 3 |
| TS-2a | East of Trinity near Romayor to West Fork San Jacinto below Conroe | 100 | 170 | 125 | 70 | 2 |
| TS-2b | East of Trinity near Romayor to Lake Houston | 100 | 170 | 44 | 70 | 2 |
| TS-3a | East of Trinity near Moss Hill to West Fork of San Jacinto below Conroe | 50 | 110 | 125 | 75 | 2 |
| TS-3b | East of Trinity near Moss Hill to Lake Houston | 50 | 60 | 44 | 10 | 1 |
| TS-4a | East of Trinity south of Liberty to Lake Houston | 30 | 55 | 44 | 25 | 1 |
| TS-4b | East of Trinity south of Liberty to Lynchburg Reservoir | 30 | 50 | 0 | 20 | 1 |
| TS-5 | East of San Jacinto below Conroe to Lake Conroe | 125 | 201 | 201 | 76 | 2 |
| **San Jacinto River to Brazos River** | | | | | | |
| SB-1a | West Fork San Jacinto below Conroe to E. of Brazos near Navasota | 125 | 350 | 200 | 225 | 5 |
| SB-1b | West Fork San Jacinto below Conroe to Brazos Basin east of Hempstead | 125 | 255 | 200 | 130 | 3 |
| SB-1c | West Fork San Jacinto below Conroe to Allens Creek Res. | 125 | 255 | 125 | 130 | 3 |
| SB-2 | Lynchburg Reservoir to Allens Creek Res. | 0 | 145 | 125 | 145 | 3 |
| SB-3 | Brazos River near Navasota to Lake Somerville | 225 | 250 | 238 | 100 | 2 |
| **Trinity River to Brazos River** | | | | | | |
| TB-1 | Lake Livingston to Gibbons Creek Reservoir | 131 | 385 | 260 | 254 | 5 |

Table 6.4
TRANS-TEXAS WATER PROGRAM
CHARACTERISTICS OF ALTERNATIVE TRANSMISSION ROUTE SEGMENTS
STREAM CROSSINGS AND CONFLICTS

| | | Divided Highway Crossings | Major Road Crossings | Minor Road & Railroad Crossings | Major Stream Crossings | Minor Stream Crossings |
|---|---|---|---|---|---|---|
| **Sabine River to Neches River** | | | | | | |
| SN-1 | Toledo Bend to Sam Rayburn to B.A. Steinhagen Dam | None | None | 10 | None | 2 |
| SN-2a | Sabine @ Bon Wier to east side of Neches near Mt. Union | None | 1 | 16 | 4 | None |
| SN-2b | Sabine @ Bon Wier to Neches south of Mt. Union to downstream near Evadale | None | 1 | 12 | 4 | 2 |
| SN-3 | Sabine @ Deweyville to east side of Neches near Evadale | None | 2 | 4 | 1 | 1 |
| SN-4a | Sabine @ SRA to Neches @ Lakeview to LNVA Neches First Lift | None | 5 | 5 | 2 | 4 |
| SN-4b | Sabine @ SRA to LNVA Neches First Lift | None | 6 | 11 | 3 | 4 |
| **Neches River to Trinity River** | | | | | | |
| NT-1a | Steinhagen Dam to east of Trinity River near Romayor | None | 3 | 22 | 4 | 13 |
| NT-1b | East side of Neches near Mt. Union to east of Trinity near Romayor | None | 3 | 20 | 5 | 11 |
| NT-2a | Neches River near Evadale to east of Trinity near Moss Hill | None | 4 | 19 | 4 | 2 |
| NT-2b | East of Neches nr Evadale to east of Trinity near Moss Hill | None | 4 | 19 | 5 | 2 |
| NT-3a | LNVA Neches First Lift to east of Trinity near Moss Hill | None | 4 | 11 | 3 | 2 |
| NT-3b | LNVA Neches First Lift to east of Trinity south of Liberty | 1 | 3 | 19 | 11 | 3 |
| NT-4 | East of Trinity River near Romayor to Lake Livingston | 1 | None | 10 | 1 | 2 |
| NT-5 | Sam Rayburn Reservoir to Lake Livingston | 1 | 2 | 12 | 4 | 13 |
| **Trinity River to San Jacinto River** | | | | | | |
| TS-1 | Lake Livingston to Lake Conroe | 1 | 1 | 24 | 5 | 7 |
| TS-2a | East of Trinity near Romayor to West Fork San Jacinto below Conroe | None | 5 | 12 | 6 | 2 |
| TS-2b | East of Trinity near Romayor to Lake Houston | None | 1 | 9 | 1 | 1 |
| TS-3a | East of Trinity near Moss Hill to West Fork San Jacinto below Conroe | 1 | 3 | 12 | 6 | 2 |
| TS-3b | East of Trinity near Moss Hill to Lake Houston | None | 1 | 4 | 2 | None |
| TS-4a | East of Trinity south of Liberty to Lake Houston | 1 | 2 | 5 | 1 | 2 |
| TS-4b | East of Trinity south of Liberty to Lynchburg Reservoir | 1 | 3 | 8 | 6 | 3 |
| TS-5 | East of San Jacinto below Conroe to Lake Conroe | 1 | 1 | 3 | None | 4 |
| **San Jacinto River to Brazos River** | | | | | | |
| SB-1a | West Fork San Jacinto below Conroe to E. of Brazos near Navasota | 1 | 6 | 25 | 3 | 9 |
| SB-1b | West Fork San Jacinto below Conroe to Brazos Basin east of Hempstead | 1 | None | 23 | 2 | 8 |
| SB-1c | West Fork San Jacinto below Conroe to Allens Creek Res. | 2 | 6 | 32 | 2 | 15 |
| SB-2 | Lynchburg Reservoir to Allens Creek Res. | 6 | 11 | 43 | 6 | 14 |
| SB-3 | Brazos River near Navasota to Lake Somerville | None | 1 | 9 | 2 | 3 |
| **Trinity River to Brazos River** | | | | | | |
| TB-1 | Lake Livingston to Gibbons Creek Reservoir | None | 4 | 22 | None | 10 |

# TABLE 6.5 AFFECTED ENVIRONMENT

* Environment Would Experience Increased Water Level in Existing Natural or Man-made Channel
○ Low or Favorable Conditions
◒ Medium or Average Conditions
● High or Unfavorable Conditions

| | | Existing Conveyance Routes | Engineering Design Criteria | Stream & Road Crossings | Federal Threatened & Endangered Species | State Threatened & Endangered Species | Wetlands | Urban Areas | Big Thicket | Bottomland Hardwood Forest |
|---|---|---|---|---|---|---|---|---|---|---|
| | SABINE RIVER TO NECHES RIVER | | | | | | | | | |
| SN-1 | Toledo Bend to Sam Rayburn to B.A. Steinhagen Dam | ● | ◒ | ○ | ◒ | ● | ◒ * | ○ | ○ | ○ * |
| SN-2a | Sabine ● Bon Wier to east side of Neches near Mt. Union | ● | ◒ | ◒ | ○ | ○ | ◒ | ○ | ○ | ○ |
| SN-2b | Sabine ● Bon Wier to Neches south of Mt. Union to downstream near Evadale | ● | ◒ | ◒ | ○ | ○ | ◒ * | ○ | ○ * | ● * |
| SN-3 | Sabine ● Deweyville to east side of Neches near Evadale | ● | ◒ | ○ | ○ | ○ | ◒ | ○ | ○ | ● |
| SN-4a | Sabine ● SRA to Neches ● Lakeview to LNVA Neches First Lift | ◒ | ○ | ◒ | ○ | ○ | ● * | ○ | ○ * | ○ * |
| SN-4b | Sabine ● SRA to LNVA Neches First Lift | ○ | ○ | ● | ○ | ○ | ● * | ◒ | ○ | ○ * |
| | NECHES RIVER TO TRINITY RIVER | | | | | | | | | |
| NT-1a | Steinhagen Dam to west of Trinity River near Romayor | ● | ◒ | ● | ○ | ● | ◒ | ○ | ○ | ○ |
| NT-1b | East side of Neches near Mt. Union to west of Trinity near Romayor | ● | ◒ | ● | ○ | ● | ◒ | ○ | ○ | ○ |
| NT-2a | Neches River near Evadale to east of Trinity between Moss Hill and Hardin | ● | ◒ | ● | ◒ | ◒ | ◒ | ○ | ● | ○ |
| NT-2b | East of Neches near Evadale to east of Trinity between Moss Hill and Hardin | ● | ◒ | ◒ | ◒ | ◒ | ● | ○ | ○ | ○ |
| NT-3a | LNVA Neches First Lift to east of Trinity between Moss Hill and Hardin | ◒ | ○ | ◒ | ◒ | ◒ | ◒ | ○ | ○ | ○ |
| NT-3b | LNVA Neches First Lift to east of Trinity south of Liberty and Dayton | ○ | ○ | ◒ | ◒ | ◒ | ◒ | ○ | ○ | ○ |
| NT-4 | Romayor to Lake Livingston | ● | ● | ○ | ◒ | ○ | ◒ | ○ | ● | ● |
| NT-5 | Sam Rayburn to Livingston | ● | ◒ | ◒ | ○ | ○ | ◒ * | ○ | ○ | ● |

# TABLE 6.5, cont. AFFECTED ENVIRONMENT

* Environment Would Experience Increased Water Level in Existing Natural or Man-made Channel
○ Low or Favorable Conditions
◐ Medium or Average Conditions
● High or Unfavorable Conditions

| | | Existing Conveyance Routes | Engineering Design Criteria | Stream & Road Crossings | Federal Threatened & Endangered Species | State Threatened & Endangered Species | Wetlands | Urban Areas | Big Thicket | Bottomland Hardwood Forest |
|---|---|---|---|---|---|---|---|---|---|---|
| | TRINITY RIVER TO SAN JACINTO RIVER | | | | | | | | | |
| TS-1 | Lake Livingston to Lake Conroe | ● | ● | ● | ◐ | ◐ | ○ | ○ | ○ | ○ |
| TS-2a | Romayor to SE of Conroe | ● | ◐ | ◐ | ◐ | ◐ | ● | ◐ | ○ | ◐ |
| TS-2b | Romayor to Lake Houston | ● | ◐ | ○ | ◐ | ○ | ◐* | ○ | ○ | ○ |
| TS-3a | Moss Hill to SE of Conroe | ● | ◐ | ◐ | ◐ | ○ | ◐ | ○ | ○ | ● |
| TS-3b | Moss Hill to Lake Houston | ● | ○ | ○ | ◐ | ○ | ◐* | ○ | ○ | ● |
| TS-4a | Liberty to Lake Houston | ◐ | ○ | ○ | ◐ | ◐ | ○ | ○ | ○ | ○ |
| TS-4b | Liberty to Lynchburg Reservoir | ○ | ○ | ○* | ○* | ○* | ○ | ○* | ○ | ○ |
| TS-5 | SE of Conroe to Lake Conroe | ● | ● | ○ | ○ | ○ | ◐ | ● | ○ | ◐ |
| | SAN JACINTO RIVER TO BRAZOS RIVER | | | | | | | | | |
| SB-1a | West Fork San Jacinto below Conroe to east of Brazos near Navasota | ● | ◐ | ◐ | ◐ | ◐ | ○ | ● | ○ | ○ |
| SB-1b | West Fork San Jacinto below Conroe to Hempstead | ● | ◐ | ◐ | ○ | ○ | ◐* | ● | ○ | ○ |
| SB-1c | West Fork San Jacinto below Conroe to Allens Creek Area | ● | ◐ | ● | ◐ | ○ | ◐ | ● | ○ | ○ |
| SB-2 | San Jacinto ● Lynchburg Reservoir to Allens Creek Area | ● | ● | ● | ● | ◐ | ◐ | ● | ○ | ○ |
| SB-3 | Brazos River near Navasota to Lake Somerville | ● | ◐ | ○ | ○ | ○ | ○ | ◐ | ○ | ○ |
| | TRINITY RIVER TO BRAZOS RIVER | | | | | | | | | |
| TB-1 | Lake Livingston to Brazos Basin near Gibbons Creek Reservoir | ● | ● | ○ | ◐ | ◐ | ◐* | ○ | ○ | ○* |

# 7.0 SUMMARY AND RECOMMENDATIONS

Phase I of the TTWP was designed to initiate and provide conceptual planning for a comprehensive program to meet the water supply needs for the Southeast Area. This section of the report summarizes the findings of the Phase I investigations and presents a summary of the recommended activities to be conducted during Phase II. The conceptual planning completed for the TTWP is based on a methodology which manages existing demands and water resources to the maximum reasonable extent. The conceptual plan developed during Phase I is expected to accomplish the following primary objectives:

- Allow regional water management practices to extend the useful life of available supplies while minimizing environmental impacts.
- Provide a sufficient supply of water to areas of need by use of large-scale interbasin transfers.
- Meet both short-term and long-term water needs of the region.

## 7.1 Planning Information

### Project Description

The Southeast Area is a 32-county region extending from the Sabine River to the Brazos River along the Texas Gulf Coast as shown in Figure 1.1. The TTWP has been divided into five sequential phases and the initial two phases have been authorized. Phase I covers conceptual planning and Phase II is to consist of feasibility planning and environmental studies. Later phases will include permitting, engineering design, and construction of any required facilities, as appropriate. The Sabine River Authority is serving as the lead local project sponsor for the Southeast Area, along with the San Jacinto and Brazos River Authorities and the City of

Houston. This group has begun a comprehensive program of public and agency involvement, including the organization of a Technical Advisory Committee with over 50 participants. The Texas Water Development Board (TWDB) serves as the lead state sponsor with the cooperation of the Texas Natural Resources Conservation Commission (TNRCC) and Texas Parks and Wildlife Department (TPWD). TWDB coordinates this project with similar efforts currently underway in two other regions, the South-Central and West-Central Areas, which include the Cities of Corpus Christi and San Antonio, respectively.

**Water Demand Projections**

Population and water demand projections through 2050 were compiled based on studies by the TWDB. Generally, the TWDB projections compare favorably with previous studies and other data developed for the area. The population for the study area is projected to almost double during the period from 1990 to 2050. Water demand is projected to increase from approximately 2.5 million acre-feet per year in 1990 to nearly 4.7 million acre-feet per year in 2050. These water demand projections are categorized by types of use (industrial, agricultural, municipal, etc.) and subdivided by areas of demand (both river basin and county). The overall TTWP Policy Management Committee (PMC) has developed scenarios for transfers from the Southeast Area to the South-Central and/or West-Central Areas. These scenarios call for year 2050 transfers of (a) 600,000 acre-feet per year, (b) 300,000 acre-feet per year, or (c) no transfer. With a transfer of 600,000 acre-feet per year, potential future demand for water supplies in the Southeast Area would total approximately 5.3 million acre-feet per year.

## Existing Water Resource Management

There are currently several regional management activities for water resources in the study area. Local groundwater management programs were created to address subsidence problems in Harris, Galveston, and Fort Bend Counties. These programs involve a substantial conversion from groundwater use to surface water use. The State of Texas maintains a permitting system for surface water diversions and interbasin transfers to protect the public and regulate use of surface waters. Various individual water users in the area have long-term contracts with water rights holders to insure a dependable supply of surface water for their needs. Finally, as a result of recent federal and state legislation, there is increased emphasis throughout the study area on water conservation practices to improve the efficient use of water, including the recycling of industrial cooling and process waters.

## Existing Water Supplies

Major aquifers in the study area supplied a total groundwater use of 814,000 acre-feet per year in 1990, approximately 80% of which was used in the Houston area. This use is projected to increase to approximately 958,000 acre-feet per year in 2050, with a majority of the increase occurring outside of the Houston area.

As shown below, five major reservoirs are currently in operation or under construction in the study area with supplies which exceed the current demands. The Wallisville project is under construction, and the others have all been in service for a number of years. Because their yields are more than the projected local requirements, these reservoirs either are now contributing or could potentially contribute significant amounts of water to those areas where requirements exceed the supply.

| Basin | Reservoir | Estimated 2050 Yield (Acre-Feet Per Year) |
|---|---|---|
| Sabine | Toledo Bend (Texas Share) | 1,043,300 |
| Neches | Sam Rayburn and B.A. Steinhagen | 664,300 |
| Trinity | Livingston and Wallisville Salt Water Barrier | 1,154,700 |
| | Total | 2,862,300 |

Most of the major river basins within the study area also have an appreciable amount of uncontrolled drainage area downstream of any impoundment. Consequently, there are significant run-of-river yields available for dependable use.

Estimated Run-of-the-River Yields
(Acre-Feet per Year)

| | |
|---|---|
| Sabine River | 147,100 |
| Neches River | 137,700 |
| Trinity River | 180,300 |
| Brazos River | 211,000 |
| Total | 676,100 |

**Comparison of Supply and Demand**

Table 7.1 is a comparison of projected future water demands in 2050 and the existing available supply in the study area. The comparison assumes no development of new sources other than the increased groundwater use projected by the TWDB (see Table 3.2). The demands are subdivided by river and coastal basins to show approximately where surpluses and deficits are located. Without additional gains in supply, the sources available to the Southeast Area would fall short of being able to meet the maximum potential future needs of the TTWP through the year 2050. Also, there is a marked imbalance of supply and demand among the eight basins in the study area. Three of the basins show surpluses, and the other five are projected to have greater requirements in the year 2050 than can be supplied from present in-basin sources. Collectively, the areas with deficits are shown to need over 2.2 million

## TABLE 7.1

**Projected Water Requirements and Existing Supply in the Southeast Area: 2050**

**- Thousands of Acre-Feet per Year -**

| | Sabine River Basin | Neches River Basin | Neches-Trinity River Basin | Trinity River Basin | Trinity-San Jacinto River Basin | San Jacinto River Basin | San Jacinto-Brazos River Basin | Brazos River Basin | Total Southeast Area |
|---|---|---|---|---|---|---|---|---|---|
| 2050 | | | | | | | | | |
| Projected Water Demand | 258.4 | 527.1 | 298.1 | 189.4 | 180.3 | 1,689.7 | 841.0 | 698.3 | 4,682.3 |
| Supplied by Groundwater | 23.6 | 118.3 | 9.4 | 46.7 | 56.0 | 415.7 | 90.4 | 197.3 | 957.4 |
| Supplied by Surface Water | 234.8 | 408.8 | 288.6 | 142.7 | 124.3 | 1,274.0 | 750.6 | 501.0 | 3,724.8 |
| Available In-Basin Surface Supply | 1,190.4 | 846.9 | 0.0 | 1,346.2 | 0.0 | 257.7 | 0.0 | 485.4 | 4,126.6 |
| Supplied by Reserves | 284.0 | 149.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 433.4 |
| Resulting Surplus (Deficit) | 671.6 | 288.7 | (288.6) | 1,203.5 | (124.3) | (1,016.3) | (750.6) | (15.6) | (31.6) |

n:\data\engineer\[illegible]\demands\table7_1
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additional acre-feet per year by 2050, either from other areas outside their basin boundaries or from in-basin sources that have not yet been developed.

## 7.2 Water Management Alternatives

In Phase I of the TTWP, the magnitude of water needs for the region were established and an initial screening of potential water management methods capable of meeting those needs was completed. Ten basic alternative methods were considered. Seven of the ten supply methods were determined to deserve further consideration and are proposed for inclusion in Phase II of the TTWP.

- Water conservation
- Wastewater reclamation and reuse
- Existing surface reservoirs
- System operation
- New surface water projects
- Interbasin transfer
- Contractual transfers

Each of these methods meets the criteria established for the TTWP and would be a significant element of the overall water management plan for the area. However, none of these potential water management methods, taken individually, are capable of meeting the projected water supply shortfalls for the combined Southeast, West-Central and South-Central Areas. Long-term water demands can only be met through combined use of demand and resource management methods and supply development methods.

Two alternative methods which were evaluated in Phase I, demineralization and aquifer storage and recovery, are not likely to provide significant contributions to the water supply of the Southeast Area. These techniques could meet small local needs, but are not expected to be developed extensively in this area during the study period. Both methods have been successfully used in other regions as short-term drought management solutions, but neither offers the long-term sustained benefits necessary for the TTWP. A third method, new groundwater supplies, is expected to be limited to expansion of existing well fields currently in use and these new groundwater supplies are included in the projections of future uses; however, further groundwater use beyond the amount projected is not judged to be a viable alternative for meeting future needs in the area.

Interbasin transfer of developed water supplies must be the foundation of the TTWP in the Southeast Area. Future available sources of water supply will exist mostly outside of the Houston demand area. A successful method must be developed to convey new supplies into the areas of water need. A secondary benefit of developing extensive interbasin transfer is that additional resource management and demand management methods, such as reservoir systems operation and contractual transfer, can be developed on a larger regional scale, thereby providing increased system flexibility, yield and reliability. Due to the importance of interbasin transfer, potential route alternatives were analyzed in more detail as a part of the Phase I studies.

## 7.3 Interbasin Transfer Route Analysis

### Existing Facilities

In Phase I, existing conveyance systems were analyzed to determine their potential for future expanded use. A number of surface water conveyance systems currently operate in the Southeast Area. As shown in Figure 5.1, the more important of these systems belong to the following entities:

- Sabine River Authority
- Lower Neches Valley Authority
- Trinity Water Reserve, Inc.
- Coastal Water Authority
- American Rice Growers Association
- Galveston County Water Authority

Except for the Trinity Water Reserve, Inc. and Gulf Coast Water Authority Canal systems, the predominant direction of conveyance of surface water is from east to west. All of the systems are predominantly unlined earthen canals with low head diversion pumps located at the rivers and some intermediate pumping.

**Alternate Routes**

Figure 6.1 shows the alternative conveyance routes which were investigated to provide interbasin transfer of supplies for the Southeast Area. The alternative routes were divided into segments, each labeled according to the river basins of origin and destination. By combining these segments, potential interbasin transfer routes can be created. Each segment was evaluated through a screening process which considered the following typical factors:

- Existing conveyance routes - ability to use existing facilities to reduce cost and environmental impacts.
- Engineering design criteria - factors such as topography, length of route, amount of lift, soil characteristics, etc.
- Stream and road crossings - number and size.
- Threatened and endangered species - occurrence in area or proximity to critical habitat.
- Wetlands - general distribution along the proposed route.

- Urban areas - interference with developed areas.
- Big Thicket Preserve - degree of encroachment.
- Bottomland hardwood forest - impact on areas designated for protection in the *Texas Bottomland Hardwood Forest Preservation Program* (20).

Based on this preliminary screening process, the following segments were recommended for further analysis in Phase II of TTWP:

| | |
|---|---|
| Segment SN-1 | Toledo Bend Reservoir to Sam Rayburn Reservoir |
| Segment SN-4a | SRA to LNVA Neches First Lift via Lakeview |
| Segment SN-4b | SRA to LNVA Neches First Lift Direct |
| Segment NT-1a | Lake Steinhagen to Trinity near Romayor |
| Segment NT-3a | LNVA to Trinity near Moss Hill |
| Segment NT-3b | LNVA to Trinity near Liberty |
| Segment TS-2a | Trinity near Romayer to West Fork San Jacinto below Conroe |
| Segment TS-3a | Trinity near Moss Hill to West Fork San Jacinto below Conroe |
| Segment TS-3b | Trinity Near Moss Hill to Lake Houston |
| Segment TS-4a | Liberty to Lake Houston |
| Segment TS-4b | Liberty to Lynchberg Reservoir |
| Segment SB-1a | San Jacinto below Conroe to Brazos near Navasota |
| Segment SB-1b | San Jacinto below Conroe to Brazos Basin near Hempsted |
| Segment SB-1c | San Jacinto below Conroe to Allens Creek Area |
| Segment SB-3 | Brazos near Navasota to Lake Somerville |
| Segment TB-1 | Lake Livingston to Gibbons Creek in the Brazos Basin |

## 7.4 Phase II - Additional Studies

Phase II of the TTWP for the Southeast Area will include more detailed studies of potential water supply methods. These studies will evaluate the potential benefits (yield, water savings, etc.), the environmental impacts, and the costs associated with each method. This information will be used to develop a final conceptual plan for the Southeast Area, including project phasing to meet short-term and long-term water needs. The following sections of this report provide an outline of the proposed Phase II studies.

### Water Conservation

Revised water conservation estimates for the Southeast Area will be developed during Phase II of the TTWP based on the recently enacted interior water use plumbing standards codified within the U.S. Energy Policy Act of 1992 and Texas Senate Bill 587. Because the Houston SMSA is the principal water demand center within the Southeast Area, a specific investigation of the potential for enhanced water conservation within the Houston SMSA is also proposed. The following water conservation tasks are planned:

- Create a "baseline" water use profile for both the entire Southeast Area and the Houston SMSA. Define water use and projected conservation savings which should occur based on existing conservation regulations and programs by category of use (residential, commercial/retail, manufacturing, industrial, irrigation, power, mining, and livestock) for years 1990 through 2050, in ten-year increments.

- Determine the potential for "enhanced" water conservation within the Houston SMSA based on cost/benefit analysis techniques for the following water efficient best management practices:

  - Residential plumbing retrofit
  - Incentive programs for toilet replacement
  - Landscaping standards for new development
  - Water audits for large landscaped areas
  - Water audits for institutional, commercial, and industrial users
  - Cost-based rate structures

- Determine the range of potential aggregate water savings for each study period.

- Assist the Southeast PMC with evaluation of the implementation issues associated with the potential water conservation procedures resulting from this study.

- Prepare a memorandum report describing the conservation studies and giving conclusions and recommendations.

**Wastewater Reclamation**

Use of reclaimed wastewater by the City of Houston as a raw water supply source for some of the Coastal Water Authority (CWA) industrial water customers has the potential to be a successful wastewater reclamation alternative and be an important part of the TTWP. Additional study to assess the specific viability of this alternative as a long-term water management method is proposed for Phase II. The analysis will require investigation of public health, environmental, institutional, and engineering considerations as outline below:

- Determine the projected industrial cooling and process water demands of the CWA customers.
- Analyze the hydraulic potential of using available reclaimed wastewater effluent for the industrial water supply of these customers. Create an implementation schedule for conversion to the alternative sources over the course of the study period.
- Prepare a conceptual facility plan (storage reservoirs, treatment facilities, transfer pump station, and transmission mains) which will utilize existing CWA facilities where possible.
- Determine the necessary reclaimed wastewater quality for industrial cooling water and any potential process uses.
- Determine the reclaimed wastewater treatment process or processes necessary to provide the necessary quality.
- Determine the instream flow and water quality impacts to Buffalo Bayou of the proposed program.
- Analyze the capital and operation and maintenance costs associated with the proposed program.
- Examine the impacts of the proposed program on delivery of raw surface water to the City of Houston's East Water Purification Plant (EWPP). Confirm that the necessary long-term EWPP surface water supply can be delivered through existing conveyance facilities.

- Prepare a memorandum report describing the wastewater reclamation and reuse studies, outlining the conceptual facility plan and costs, and giving conclusions and recommendations.

**Coordinated System Operation**

Because of its multiple sources of water supply, the Houston SMSA is the most likely candidate for system operation in the Southeast Area. The Trinity River reservoirs, Lake Livingston and Wallisville, have always been considered as a system, and their permits are based on system operation. Lake Conroe and Lake Houston, in the San Jacinto Basin, are permitted as individual projects, and it is anticipated that system operation could increase their combined yield significantly.

Water supplies for the Houston area can also be coordinated across river basin lines by combined system operation of the Trinity Basin and San Jacinto Basin projects. The opportunities for such coordination will be greater when an interbasin conveyance linkage is built to allow delivery of Trinity River water into the San Jacinto Basin. The potential for coordinated operation of Lake Livingston, Wallisville, Lake Conroe, and Lake Houston will also be studied. The development of system operation studies includes the following steps:

- Review available hydrologic data, including reservoir inflows, evaporation, and area-capacity relationships.
- Develop additional data, if needed.
- Conduct operation studies of individual sources without system operation to determine yield, reservoir elevations, and downstream flows.
- Identify approaches to system operation which are likely to offer the most benefit in terms of increased yield.
- Develop a computer model of the system.
- Conduct a operation studies to determine the potential gain in yield with system operation.

- Review the impact of system operation on yield, downstream flows, and reservoir elevations.
- Analyze the potential environmental, social, and economic impacts of system operation.
- Consider the permits and operational changes needed to achieve the benefits of system operation.
- Prepare a memorandum report describing the system operation studies and conclusions and recommendations regarding incorporation of system operation into the TTWP for the Southeast Area.

**New Surface Water Projects**

Phase II of the TTWP for the Southeast Area will include additional investigations of Allens Creek Reservoir and the Neches River Salt Water Barrier.

Allens Creek Reservoir

The Phase I studies for Allens Creek Reservoir have established the yield of the project. Phase II studies will concentrate on environmental and cost issues. Specific study items include the following:

- Meet with the TPWD and the TWDB to review the on-going environmental studies of the Allens Creek site.
- Make a field reconnaissance of the Allens Creek site to investigate wetlands, wildlife habitat, endangered species, and other factors.
- Extend the hydrology for Allens Creek Reservoir to cover a 50-year period of record, rather than the critical period alone.
- Conduct a water quality analysis for the 50-year period of record to determine average and drought water quality in the reservoir.
- Develop an updated cost estimate for the Allens Creek project, including estimated costs for mitigation of environmental impacts and archaeology.

- Analyze the benefits of operating Allens Creek Reservoir as a balancing reservoir in the Trans-Texas system.

- Conduct a preliminary analysis of the impact of Allens Creek Reservoir on instream flows and inflows to bays and estuaries.

- Conduct a preliminary analysis of the impact of Allens Creek Reservoir on wetlands, terrestrial habitat, fisheries, endangered species, cultural resources, and other factors.

- Prepare a memorandum report on Allens Creek Reservoir outlining the studies and recommendations. Present the memorandum report to the TAC and the PMC.

Neches River Salt Water Barrier

For the Neches River salt water barrier, Phase II studies will include additional investigation of yield, as well as environmental studies. Specific study items include the following:

- Meet with the Lower Neches Valley Authority to consider the results of their on-going hydrologic studies.

- Meet with the U.S. Army Corps of Engineers, to review their on-going investigations of the Neches salt water barrier. Obtain available information on cost, environmental impacts, and other factors.

- Meet with interested individuals and agencies to discuss the potential development of the permanent Neches salt water barrier. Input will be sought from the following:

    - Members of the TAC for the Southeast Area
    - The Texas Natural Resources Conservation Commission
    - The Texas Parks and Wildlife Department
    - The U.S. Fish and Wildlife Service
    - The National Marine Fisheries Service
    - Big Thicket National Preserve (National Park Service)
    - The Lower Neches Valley Authority
    - The Texas Water Development Board
    - The U.S. Army Corps of Engineers

- Make a field reconnaissance of the Neches salt water barrier site to investigate wetlands, wildlife habitat, endangered species, and other factors.

- Develop or obtain from the Corps of Engineers an updated cost estimate for the permanent Neches salt water barrier project, including estimated cost for mitigation of environmental impacts and archaeology.

- Conduct a preliminary analysis of the impact of the Neches salt water barrier on instream flows and inflows to bays and estuaries.

- Conduct a preliminary analysis of the impact of the permanent Neches salt water barrier on wetlands, terrestrial habitat, fisheries, endangered species, cultural resources, and other factors.

- Prepare a memorandum report on the permanent Neches salt water barrier outlining the studies and recommendations. Present the memorandum report to the TAC and the PMC.

**Interbasin Transfers**

Within the Southeast Area, the major water needs are in the Houston SMSA and the major supplies are east of Houston in the Trinity, Neches, and Sabine Basins. In particular, the Sabine has more available water than any other basin. Phase II of the TTWP for the Southeast Area will include additional investigations of conveyance from the Sabine Basin to the Houston area and on to the Brazos Basin for possible delivery farther west. Delivery from the Brazos River to the Houston area is also a possibility, especially if the South-Central and West-Central Areas are found not to need water from the Southeast Area.

A first step in performing conveyance route studies will be additional screening of potential routes on the basis of environmental and engineering criteria. This screening will allow selection of two potential routes requiring detailed analysis for each segment of the transfer. More detailed environmental and engineering analysis will then be conducted to select the preferred routes. Specific elements of the Phase II studies for interbasin transfer include the following:

- Conduct a field reconnaissance of the potential routes selected for more detailed analysis in Phase II, as listed in Section 6.

- Refine the selected routes to minimize environmental impacts.

- Meet with agencies and other interested parties to review environmental and engineering concerns with the routes. Input will be sought from:

  - Members of the TAC for the Southeast Area
  - The Texas Natural Resources Conservation Commission
  - The Texas Parks and Wildlife Department
  - The U.S. Fish and Wildlife Service
  - The National Marine Fisheries Service
  - Big Thicket National Preserve (National Park Service)
  - The U.S. Forest Service
  - River Authorities
  - The Texas Water Development Board
  - The U.S. Army Corps of Engineers

- Meet with the South-Central and West-Central Program Management Committees and consultants to discuss the location of transfers out of the Southeast Area, if any.

- Review available data on geologic conditions, soils, and topography.

- Develop reconnaissance level construction and operation cost estimates for the segments.

- Develop screening criteria for selection of up to two routes for each segment for detailed environmental analysis.

- Screen potential routes for each segment, recommend two routes per segment for detailed analysis, and prepare a memorandum report with the recommendations.

- Review the memorandum report with the TAC and the PMC for the Southeast Area.

- Perform additional field reconnaissance of the routes selected for detailed analysis, including investigations of wetlands, wildlife habitat, endangered species, conflicts with development, and other factors.

- Attend additional meetings with agencies and other interested parties to review environmental and engineering concerns with the routes.

- Refine the routes to minimize environmental impacts and improve associated engineering characteristics.

- Analyze the water quality impacts of diversions for each of the proposed segments.
- Analyze the fisheries impacts of the proposed diversions and routes.
- Analyze the impact of diversions for each of the proposed routes on in-stream uses of water.
- Analyze impacts to threatened and endangered species along each route.
- Analyze terrestrial habitat loss and impact on wildlife resources along each route.
- Analyze the impact of each route on wetlands and navigable waters of the U.S.
- Analyze the impact of each route on known historical and archaeological sites.
- Develop more refined estimates for construction and operation costs of each route.
- Prepare a draft report outlining the findings of these studies and make a preliminary recommendation of a preferred route for each segment.
- Review the report with the TAC the PMC and obtain PMC approval of a preferred route, and submit a final report.

**Contractual Transfers**

Two types of contractual transfers have been identified which may allow a better or more economical use of existing available supplies. The first type involves a contractual transfer of water currently permitted for irrigation to a different category of use. In some areas, irrigation demands are projected to decrease and the contractual transfer may simply serve to re-allocate the supply currently serving those existing agricultural users to municipal or manufacturing use. In other areas, a prospective user may be able to offer a contractual transfer which would provide for reduced irrigation demands during critical periods. Both opportunities will be investigated more fully. Specific large irrigation permits have been identified which may be candidates for this conversion of use through contractual transfer.

The second type of contractual transfer identified is designed to reduce conveyance costs associated with other water management options under consideration. Four specific opportunities involving possible large-scale contractual transfers associated with interbasin transfers have been selected for further study.

The elements of work associated with both types of contractual are similar and are outlined below.

- Analyze each specific opportunity for contractual transfer in the study area to identify any new conveyance facilities needed, potential environmental impacts of the transfer, and institutional issues which will require resolution. Evaluate the general costs associated with each feasible alternative.

- Recommend those contractual transfer alternatives which remain promising for inclusion in the program and develop preliminary plans for implementation including identification of specific contract entities and terms, schedule of activities, and resulting volumes of supplies made available by the transfer.

- Prepare a memorandum report summarizing the findings and recommendations for PMC and TAC review.

**Water Supply Program**

After evaluation of the alternative water management methods, an overall water supply program will be formulated for the Southeast Area which incorporates the appropriate elements to achieve an integrated resource management approach. The cumulative impacts of the recommended actions will need to be evaluated and schedules for implementation of the program developed, as appropriate. Those tasks are summarized below under each of the major activities planned for this stage of the program.

Environmental Studies

- Develop a preliminary analysis of the potential water quality impacts of various alternatives and use the information to aid in the selection of a proposed program. Analyze the impact of the proposed program on water quality.

- Conduct a preliminary review of treatability concerns for the water delivered from the proposed program.

- Conduct a preliminary analysis that the impacts of interbasin transfers would have on the aquatic species in the receiving basin.

- Analyze the impact of the proposed program on stream flows, reservoir levels, and instream water uses.

- Present the overall impacts of the proposed program on wetlands, wildlife habitat, endangered and threatened species, fisheries, cultural resources, and recreation.

- Prepare a memorandum report on the environmental studies and present the report to the PMC and TAC for review.

Estuary Studies

- Use existing models developed by the TWDB to analyze the impacts of potential diversions for the TTWP and the resulting changes in flow patterns on Sabine Lake and Galveston Bay. Compare the impacts of various alternatives and use the information to aid in the selection of a proposed program.

- Collect data on salinity, intensive inflow surveys, and U.S.G.S. flow records for Galveston Bay and Sabine Lake.

- Determine the impact on the aquatic community of Galveston Bay and Sabine Lake of freshwater inflows resulting from the recommended program.

- Determine the impacts of the recommended program on salinity, sediments, circulation, freshwater inflow, fisheries, the nutrient budget and flow regime in Galveston Bay and Sabine Lake.

- Prepare a memorandum report on the estuary studies and present the report to the TAC and PMC for review.

Program Selection

- Based on the information developed through the individual studies described above, recommend an overall water supply program for the Southeast Area, including up to three possible levels of deliveries to the West-Central and South-Central Areas.

- Prepare a memorandum report explaining the recommendations. Present the memorandum report to the TAC and the PMC for review and comments, followed by selection of a recommended program by the PMC.

Preliminary Implementation Studies

- Review the institutional and legal concerns in the implementation of the proposed program:

  - Recommend institutional arrangements for the program.
  - Outline the requirements for environmental and regulatory permits to construct and operate the program.
  - Provide a summary of land and right-of-way acquisition requirements for the program.
  - Outline the necessary long-term contractual commitments required for the program, including water purchase agreements, facility usage agreements, operation and maintenance agreements, etc.

- Make a more detailed evaluation of cost and financing issues, including a cost estimate for the proposed program, development of operation and maintenance cost estimates, a preliminary project financing plan, and proposed pricing policies for the water to be made available through the program.

- Develop an implementation plan and schedule for the program, including options for phasing and a schedule of project development.

- Prepare a memorandum report outlining the implementation plan and details for TAC and PMC review.

- Prepare a detailed work plan for Phase III of the TTWP for the Southeast Area, including scope, schedule and budgets for any required permitting and preliminary design of facilities.

- Prepare an overall report describing the studies done in Phase II and the findings and recommendations from those studies. Present the report to the TAC and PMC. Revise and finalize the report after receiving comments.

# APPENDIX A

## List of References

## APPENDIX A

## LIST OF REFERENCES


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(28) California Department of Water Resources, *Draft. California Water Plan Updata,* Vol. 1., November 1993

# APPENDIX B

## Summary of Previous Studies

Appendix B

Freese and Nichols, Inc., Consulting Engineers, *Preliminary Feasibility Study, Interbasin Water Transfer From the Sabine River to the San Jacinto River Authority Service Areas*, November 1989.

The purpose of this study was to determine the general physical and financial feasibility of transferring water from the Sabine River to the San Jacinto River Authority service area using existing facilities, as feasible, to minimize capital expenditures and delivery costs. Four system capacity scenarios were analyzed: 75 MGD, 100 MGD, 200 MGD and 300 MGD. Two destinations, Lake Houston and Highlands Reservoir, were considered. Scenarios for piping water under or dropping water into the Trinity River were also studied. Estimated costs for all of the above scenarios are below. The routes determined to be feasible are labeled as route "A" on the map included in this appendix.

| | Estimated Delivery Costs (cents/1000 gallons) | | | |
|---|---|---|---|---|
| | 75 MGD | 100 MGD | 200 MGD | 300 MGD |
| Sabine to Lake Houston (Pipe Under Trinity) | 35.6 | 31.4 | 23.5 | 21.3 |
| Sabine to Lake Houston (Drop Into Trinity) | 32.4 | 28.2 | 21.3 | 19.1 |
| Sabine to Highlands Res. (Pipe Under Trinity) | 35.0 | 30.7 | - | - |
| Sabine to Highlands Res. (Drop Into Trinity) | 27.9 | 24.9 | - | - |

Wayne Smith & Associates, Inc., *Feasibility Study, Interbasin Transfer, Sabine to San Jacinto*, 1987.

The purpose of this study was to determine the availability, transport and treatability of Sabine surface waters for transport to the San Jacinto River as a source of future water supply to the Greater Houston Area. Wayne Smith & Assoc. determined that transport of Sabine water to Lake Houston should consist of a combination open channel/pipeline conveyance system over a general routing from north of Deweyville on the Sabine to Luce Bayou on Lake Houston (route "B" on the map included in this appendix). Three capacity scenarios were studied: 100 MGD, 300 MGD, and 600 MGD. The cost of conveyance of the Sabine was estimated and is shown below.

| | 100 MGD | 300 MGD | 600 MGD |
|---|---|---|---|
| Estimated Cost of Conveyance (cents/1000 gallons) | 81 | 40 | 33 |

The quality of the Sabine water was found to be of approximately the same quality as Lake Houston water and should cost about the same as the current treatment of Lake Houston water (17.5 - 22.5 cents/1000 gallons).

Pate Engineering, Inc., *San Jacinto River Authority, Water Resources Development Plan*, May 1988.

The purpose of this study was to define a plan that a) addresses the water supply needs of the rapidly urbanizing service area of the San Jacinto River Authority (SJRA) and b) provides guidance for implementing specific water resources projects within the SJRA service area. The recommended water supply development plan for supplying the long term needs of the SJRA service area included maximum utilization of available groundwater in combination with existing and proposed in-basin surface water supplies to provide a predictable cost effective supply through the year 2030 and beyond. Plan components included the continued use of groundwater both local and remote combined with about 92 MGD of surface water supplied by Lake Conroe, and two proposed reservoirs, Spring Creek Lake and Lake Creek. Although this recommendation does not include interbasin transfer, the study did have interbasin transfer from Toledo Bend as one of the alternatives. The route covered in this alternative is listed as route "E" on the map in this appendix.

Metcalf & Eddy, *Houston Water Master Plan, Appendix M, Detailed Evaluation of Alternatives.* November, 1989.

The purpose of the Houston Water Master Plan (HWMP) is to identify the most promising alternatives for supplying water to the Houston metropolitan area through the year 2030 and to develop a plan for implementation of that alternative. Included in the plan are identification of a regional surface water service area, definition of the facilities required to provide water to that service area, and the costs associated with each alternative. Appendix M is one of two technical appendices which documents the detailed evaluation of alternative plans.

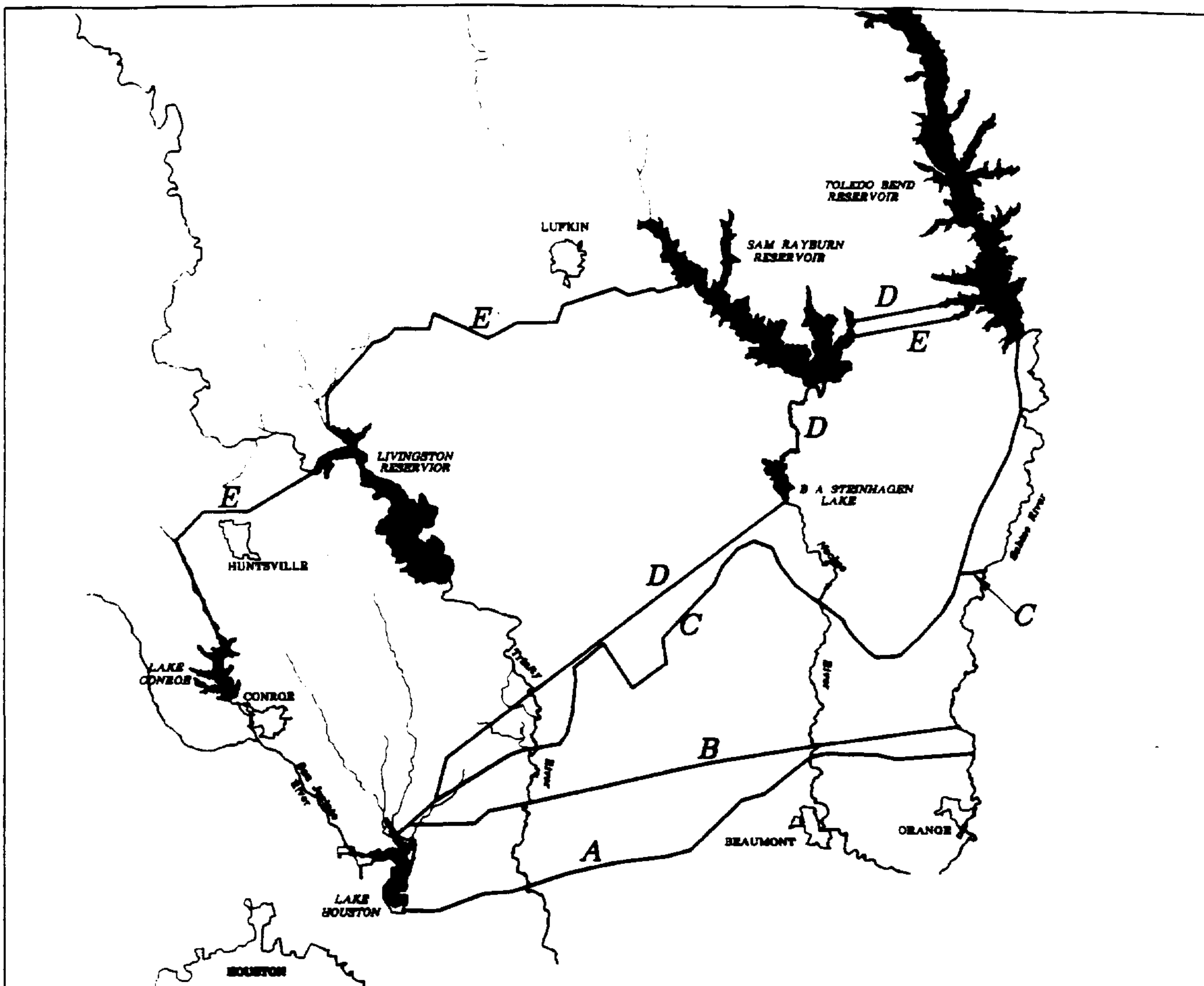
Four water supply alternatives were evaluated from technical, environmental, legal, institutional and financial perspectives. These were (1) Western, (2) Eastern/Toledo Bend, (3) Eastern/Wallisville and (4) Eastern/Salt Water Barrier. The conveyance facilities associated with the Eastern/Toledo Bend alternative are shown as Route D on Figure B.1. The other three alternatives rely principally on expansion of existing conveyance facilities.

The Eastern Wallisville alternative was recommended for selection. The principal factors underlying this choice were: a) The flexibility in plan implementation afforded by allowing the maximum use of local resources before importation of a relatively expensive alternative surface water supply (Toledo Bend Reservoir); b) Wallisville Reservoir is an approved and permitted federal project, and; c) being federally funded, Wallisville Reservoir will provide the least expensive source of new surface water.

Actions which are necessary to implement the recommended alternative included:

- Implementation of an aggressive water conservation program
- Development of new groundwater supplies
- Construction of Wallisville Reservoir
- Expansion of existing and construction of new water treatment and conveyance facilities
- Construction of new storage facilities

*Bon Weir Project*, Texas Basin Project, Bureau of Reclamation, Published 1985 (10).




LOCATION MAP

**FIGURE B-1**
**ALTERNATIVE ROUTES FROM PREVIOUS STUDIES**

NOTE: THIS IS ONLY A SCHEMATIC,
NOT A DETAILED DRAWING

**LEGEND**

- CITY
- MAJOR RIVER
- STREAM
- RESERVOIR

ROUTE A. FREESE & NICHOLS INC., CONSULTING ENGINEERS, ***PRELIMINARY FEASIBILITY STUDY, INTERBASIN WATER TRANSFER FROM THE SABINE RIVER TO THE SAN JACINTO RIVER AUTHORITY SERVICE AREA,*** NOVEMBER 1989.

ROUTE B. WAYNE SMITH & ASSOCIATES, INC., ***FEASIBILITY STUDY, INTERBASIN TRANSFER, SABINE TO SAN JACINTO,*** 1987.

ROUTE C BUREAU OF RECLAMATION, ***BON WEIR PROJECT, PART OF THE TEXAS BASINS PROJECT, TEXAS,*** MARCH 1985.

ROUTE D METCALF & EDDY, ***HOUSTON WATER MASTER PLAN, APPENDIX M, DETAILED EVALUATION OF ALTERNATIVES,*** NOVEMBER 1989.

ROUTE E PATE ENGINEERING, INC. ***SAN JACINTO RIVER AUTHORITY, WATER RESOURCES DEVELOPMENT PLAN,*** MAY 1988

# APPENDIX C

## Phase I Work Plan and Guidelines

## PHASE I

Phase I, Project Initiation/Conceptual Planning, includes the following major elements:

- Agency/Public Coordination
- Program Formulation
- Conceptual Planning
- Contract Administration

For purposes of the Program, the Southeast Area study area will consist of the 35 Texas counties which exist within the Brazos, San Jacinto, Trinity, Neches, and Sabine River basins and which are included within the Southeast Texas and Upper Gulf Coast Region defined in the amended 1990 Texas Water Plan.

### 1.0 AGENCY/PUBLIC COORDINATION

This initial task is designed to establish the administrative, management and technical, organizational committee framework for the southeast portion of the Program.

1.1 Policy Management Committee

1.1.1 The Policy Management Committee (PMC) will coordinate policy, technical, and informational matters associated with the Program and approve project reports. This task consists of attending six (6) PMC meetings and monitoring the program progress during Phase I.

1.2 Technical Advisory Committee

1.2.1 Assist the Southeast Area sponsors to establish the Technical Advisory Committees (TAC's) and attend up to five (5) meetings.

### 2.0 PROGRAM FORMULATION

2.1 Goals and Objectives

Assist the Policy Management Committee and Technical Advisory Committees to establish goals and objectives for the Program.

2.2 Issues Development

2.2.1 Collect information from existing studies and reports from the TWDB, TWC, TPWD, City of Houston, SJRA, SRA, TRA, BRA, LNVA, COE, the Bureau of

Reclamation, and others regarding issues of concern associated with development of major water resources projects within southeastern Texas.

2.2.2 Prepare separate "work papers" which investigate and compile potential questions, data needs, resource needs, and assessment methods for the following five issue areas: Engineering, Environmental, Institutional, Legal, and Financial.

**2.3 Issues Implementation Plan**

2.3.1 Facilitate discussion of each work paper issue before the Policy Management Committee and Technical Advisory Committees.

2.3.2 Formulate a Program issue action plan which will be implemented during subsequent phases.

**3.0 CONCEPTUAL PLANNING**

**3.1 Southeast Area Population, Water Demands and Supplies**

3.1.1 Collect information from the TWDB and other studies regarding the location and nature (water quality, quantity, etc.) of existing and projected water demand within the study area. Assess demand for study years 2000, 2010, 2020, 2030, 2040, and 2050 on a gross basis (municipal, industrial, agricultural, and irrigation) within each river basin study area using TWDB high numbers with conservation.

3.1.2 Using the existing and proposed water supply sources identified in the amended 1990 Texas Water Plan, summarize existing data on ground and surface water availability in the study area for each basin. Tabulate major water supply contracts, interbasin transfers, existing reuse projects, groundwater management plans, instream flow commitments and adjudicated water rights within the study area. Using the appropriate environmental and regulatory guidelines as adopted by the PMC and attached as Attachment 1 to this Exhibit A, recalculate availability of the water supplies and then tabulate existing and future water surpluses and shortages in each basin.

3.2 **South–Central Area Population, Water Demands and Supplies**

3.2.1 Collect general information from the TWDB and other agency studies regarding existing and projected water demands within the South–Central Area of the Trans–Texas Water Program. This study area is defined as the portions of the Colorado, Guadalupe, San Antonio, Nueces, and Lavaca river basins contained within the South Texas and Lower Gulf Coast, and South Central Texas regions of the amended 1990 Texas Water Plan. For purposes of the Program, computation of population and water demand for the entire above described region will be aggregated in total for study years 2000, 2010, 2020, 2030 2040, and 2050.

3.2.2 Collect and summarize general information on available water supplies in the South–Central Area from data supplied by TWDB. Compute the gross total water deficit for the South–Central Area which could potentially be supplied by interbasin transfers from the Southeast area.

3.3 **Existing Conveyance Facilities**

3.3.1 Collect information on existing conveyance facilities which could be used to meet water transfer needs in the Southeast planning area. Information to be collected includes ownership, condition (including estimated channel loss rate), conveyance capacity, and availability for alternative uses.

3.4 **Toledo Bend Reservoir–Louisiana Supply**

3.4.1 Identity the institutional and financial issues related to purchasing water supplies which are currently owned by the State of Louisiana within the Toledo Bend Reservoir for further use in Texas.

3.5 **Alternative Water Supply Plans**

3.5.1 Using supply sources and environmental guidelines identified in Task 3.1.2, create conceptual water supply transfer plans for the Sabine, Trinity, Neches, Brazos, and San Jacinto river watersheds which satisfy the projected 50–year water shortages within each basin, the South–Central Area, and the specific short–term needs within the San Jacinto River basin. The plans will consider existing water supplies within the Southeast Area study area and, if possible, the State of Louisiana. Supply transfers will be proposed to link the five river basins with conveyance facilities and consider the basins as a system for both physical conveyance and water transfers to meet identified water shortages.

3.6 Report Preparation

3.6.1 Prepare a report including Executive Summary, which outlines the work completed for the above tasks and submit deliverables as follows:

a. Draft – 40 copies (15 copies to TWDB and one copy to each PMC members).

b. Final – 75 copies, double-sided on recycled paper (15 copies to TWDB and 5 copies to each PMC member).

c. Executive Summary – 100 copies (50 copies to TWDB and one copy to each PMC member).

d. Camera ready copy of final report, including Executive Summary

e. Graphical report data in digital format if available in that media.

4.0 CONTRACT ADMINISTRATION

4.1 Program Coordination

Attend up to six (6) project status meetings and provide technical input, as required, to coordinate the work efforts and results of the Southeast Area and South–Central Area projects.

4.2 Progress Reports

4.2.1 Prepare six (6) monthly progress reports and monthly billings which summarize the work completed through each work period. The monthly progress report will contain the following information:

- Four major Phase I task names and description.
- Total manhours and cost budgeted for each major task.
- Percent of the tasks completed.
- Dollar value of the percent of the tasks completed.
- Total tasks completed, indicating the percent of and dollar value of the project completed as reflected in totals of all vouchers submitted.
- Description of the work to be completed in the next reporting period.

4.2.2 Prepare and update schedules, budgets, and the work plan, as required, to illustrate the project status.

PHASE II

Phase II – Feasibility Studies includes the following major elements:

- Committee assistance
- Planning studies
- Environmental studies
- Estuary analysis
- Preliminary implementation studies
- Contract administration

1.0 COMMITTEE ASSISTANCE

This initial task is designed to allow further coordination between all appropriate agencies and potential participants in the project. Proposed meetings would be early enough in the work effort to allow adjustment to study efforts if warranted.

1.1 Meetings

1.1.1 Attend up to eighteen (18) Policy Management Committee and eighteen (18) Technical Advisory Committee meetings to discuss plans for diversions from the Sabine River to the west, to review the proposed approach to the work, parameters for system design, environmental permitting processes, etc.

1.2 Meetings Support

1.2.1 Develop exhibits, graphics, technical data, etc. to support the Policy Management Committee and Technical Advisory Committee meetings referenced in Task 1.1.1.

2.0 PLANNING STUDIES

The purpose of this task is to collect and review available data on water demand, available supplies and water quality. An analysis of the data will be conducted to establish the general project parameters.

2.1 Water Demands

2.1.1 Disaggregate the water demands compiled in Phase I for specific municipal, industrial, agricultural, and irrigation users in the lower Sabine River, Trinity River, Neches River, Brazos River, and San Jacinto River basins during the next 50–year period.

2.1.2 Acquire data on existing water conservation measures and plans of the Sabine River Authority, the San Jacinto River Authority, Trinity River Authority, Neches River Authority, Brazos River Authority, the City of Houston and other potential participants in the project.

2.1.3 Assess potential program elements and benefits which could result from implementation of water conservation (reuse, retrofit, etc.) initiatives in Texas since completion of the 1990 Texas Water Plan. Revise updated water demand projections in Task 2.1.1 considering the future effects of recently adopted conservation measures which have included passage of Senate Bill 587, revised irrigation practices, etc.

2.1.4 Update, as necessary, future (50–year period) water demand projections for each major water user.

**2.2 Water Rights**

2.2.1 Acquire data on the firm yield of Toledo Bend Reservoir.

2.2.2 Acquire data on existing or planned water supplies of specific users (other than Toledo Bend Reservoir) within the five southeastern river basins.

2.2.3 Acquire data on existing water rights of specific users in the lower Sabine, Neches, Trinity, Brazos, and San Jacinto River basins.

2.2.4 Determine the quantity of surface water required to meet future unserved water demands identified in Tasks 2.1.4.

2.2.5 Recommend revisions to existing water rights permits as appropriate to meet identified needs.

2.2.6 Determine necessary contract and permit amendments required to implement water rights recommendations.

**2.3 Supply Alternatives**

2.3.1 Develop additional supply alternatives based on information collected following development of the Phase I alternatives. Compile all of the alternatives.

**2.4 Water Quality**

2.4.1 Acquire existing data on water quality and treatability of Sabine River water.

2.4.2 Acquire data on water quality and treatability of water which may be mixed with Sabine River water in delivery, including Neches, Trinity, Brazos, and San Jacinto River water.

2.4.3 Acquire data on existing water treatment processes at the City of Houston's East and Southeast Surface Water Treatment Plants and other existing surface water treatment plants.

2.4.4 Using available literature, propose a conceptual treatment process for Sabine River water and for mixtures of Sabine River and Neches, Trinity, Brazos, and San Jacinto River waters.

2.4.5 Determine preliminary conceptual process modifications, if required, at the existing surface water treatment plants for Sabine River water and all of the potential water mixtures. Include a planning grade estimate of costs to modify existing facilities, if required, for all of the above water mixtures. Develop a program of detailed treatability studies to be performed in Phase III.

**2.5 Planning Studies Report**

2.5.1 Prepare and submit a report in accordance with the deliverables outlined in Task 3.6.1 in Phase I which summarizes the analysis methods, background data, assumptions, and findings of the above studies.

**3.0 ENVIRONMENTAL STUDIES**

The purpose of the environmental studies provided herein shall be to provide factual information for use in meeting the requirements of the National Environmental Policy Act and other federal and state laws for permits and approvals for the Project.

The engineer shall solicit input on methodologies to be used in the environmental studies from the TWDB, TWC, COE, TPWD, Bureau of Reclamation, City of Houston and SJRA.

**3.1 Meetings**

3.1.1 Attend up to ten additional coordination meetings with governmental agencies and other interested parties which have special interest in the environmental aspects of the project. These meetings would consist of discussions of the proposed project approach, major project elements, etc., and would be designed to elicit further discussions of concerns, questions or comments regarding the project.

3.1.2 Document results of all meetings and issue summaries of comments, etc.

3.2 **Environmental Baseline**

3.2.1 Collect existing environmental data for:

- Topographic maps
- Geological data
- Meteorological data
- Water quantity and quality data
- Air quality data

3.2.2 Collect and identify data on:

- Federal lands and collect management plans along routes
- Wetlands along routes
- Endangered species and critical habitat areas along routes
- Historical and archaeological sites along routes

3.2.3 Collect and characterize data on:

- Terrestrial ecosystems
- Aquatic ecosystems

3.3 **Environmental Analysis**

Prepare an environmental analysis assessment. Some non–intensive field investigation is included in this assessment.

3.3.1 Project Purpose and Needs. This element will consist of information developed in the Planning Studies task to establish the purpose and need for the project and will include the following elements:

3.3.1.1 Water needs, current and future.

3.3.1.2 Present water supply.

3.3.1.3 Potential new supplies.

3.3.1.4 Conservation measures.

3.3.1.5 Environmental needs based on the adopted environmental guidelines.

3.3.2 <u>Conceptual Engineering</u>. This element will create a prototypical project suitable to convey required water demands. This prototypical project will be applied to each route alternative to comparatively assess each route.

3.3.2.1 Based on required water volumes and generally accepted facility design criteria, prepare typical section schematics for canals, pump stations, pipelines and associated appurtenances capable of conveying the determined flows.

3.3.2.2 Determine the need and capacity, if required, of terminal storage facilities for Sabine River water for each alternative.

3.3.2.3 Using the potential conveyance routes identified in Task 2.3.1, and the typical section schematics of Task 3.3.2.1, determine a specific infrastructure project for each conveyance route.

3.3.2.4 Determine the conveyance capacity of existing canal pipeline and pump station facilities which may be used in alternative alignments and determine required additional typical facilities if existing facilities can not convey necessary water supplies.

3.3.2.5 Prepare standardized unit costs for those facilities outlined in Tasks 3.3.2.3 and 3.3.2.4.

3.3.3 <u>Environmental Impacts</u>. This element will analyze the environmental impacts of alternative conveyance routes.

3.3.3.1 Analyze the impacts of interbasin water transfers on water quality of Trinity River, Neches River, San Jacinto River, Brazos River, canals, and other receiving bodies of water. Analyze effect of releases during different flow conditions, and discuss effects of increased flows in canals.

3.3.3.2 Analyze water quality during drought conditions, and during normal operating conditions.

3.3.3.3 Present a preliminary analysis of fisheries impacts.

3.3.3.4 Analyze the impacts of interbasin transfers on aquatic species. Determine dominant and rare species for each river basin; analyze water quality impacts on important species (salinity, DO, etc.); address other interbasin transfers within State, historically and presently, and discuss biological impacts of species transfer.

3.3.3.5 Analyze impacts on in–stream uses (boating, fishing, canoeing, public water supply, irrigation, etc.).

3.3.3.6 Discuss impacts to endangered and threatened species along each route.

3.3.3.7 Analyze terrestrial habitat loss; impact on wildlife resources.

3.3.3.8 Determine impacts to wetlands and navigable waters.

3.3.3.9 Assess impact of project on identified historical/archaeological sites.

3.3.4 Conveyance Alternatives. Analyze conveyance alternatives for screening. Appropriate alignments and project configurations will be identified. Alignments with excessive environmental impacts will be eliminated from further study. Preferred alternative(s) will be identified.

3.3.4.1 Establish screening criteria in cooperation with the PMC.

3.3.4.2 Propose rankings for each alternative based on the approved criteria.

3.3.4.3 Recommend the desirable alternatives for further analysis based on environmental and engineering factors.

3.3.5 Report Preparation. This element will document the above findings.

3.3.5.1 Prepare and submit, in accordance with the deliverables outlined in Task 3.6.1 in Phase I, an environmental analysis report which documents the above findings.

**4.0 ESTUARY IMPACT ANALYSIS**

**4.1 Sabine Lake**

4.1.1 Data Collection. Historical data generated from automated samples of salinity, intensive inflow surveys, and U.S.G.S. flow records will be collected.

4.1.2 Correlation Analysis. Correlation and regression analysis will be used to define the flow/salinity relationships and to analyze varying freshwater flow regimes.

4.1.3 Impacts. Determine the impact of decreased freshwater inflows resulting from various alternative routes on Sabine Lake within the aquatic community in the lake.

**4.2 Galveston Bay**

4.2.1 Data Collection. Obtain the TWDB's calibrated hydrodynamic and water quality model of Galveston Bay, U.S.G.S. flow data, and any appropriate studies from the Galveston Bay National Estuary Program.

4.2.2 Model Analysis. Calibrate the TWDB model based on flow and water quality data determined in the Planning Studies and Environmental Studies portions of this project.

4.2.3 Impacts. Determine the impacts resulting from various alternative routes on salinity, sediments, freshwater inflow, fisheries, the nutrient budget, flow regime and circulation.

**4.3 Study Report**

4.3.1 Prepare and submit, in accordance with the deliverables outlined in Task 3.6.1 in Phase I, an estuary analysis report which document the above findings.

5.0 PRELIMINARY IMPLEMENTATION STUDIES

**5.1 Institutional/Legal Issues**

This element will determine, compare, and contrast legal issues and requirements of the preferred route alternatives.

5.1.1 Construction-Related Legal Requirements. Three categories of legal issues will be analyzed to support construction of the project:

- Environmental/Regulatory Permits.
- Utility/Construction Easements.
- Land/ROW Acquisition

5.1.1.1 Environmental/Regulatory Permits – A comprehensive listing of the specific regulatory permits will be established, with anticipated schedules and coordination steps likely to be required for each permit.

5.1.1.2 Utility/Construction Easements – An initial list of highway, railroad, pipeline, or other utility crossings which require a permit or licensing agreement will be developed for each route alternative. The typical procedures and schedules for permit approval will be described.

5.1.1.3 Land/ROW Acquisition – A summary of the expected property acquisition requirements for the entire project will be developed, showing approximate number and size of parcels along each route. Based on these approximate numbers, recommendations will be developed for schedule, budgets, and specific specialists to be used in the acquisition process.

5.1.2 Long-Term Contractual Requirements. Sponsors and users of the conveyance project must also establish necessary contractual agreements governing the project.

5.1.2.1 Water Purchase Agreements – Each user of the raw water purchased from this conveyance system will require a long-term contract for that water. Alternative institutional arrangements necessary for executing water purchase agreements will be identified and qualitatively evaluated. Key issues to be resolved in the purchase agreements will also be identified.

5.1.2.2 Existing Facility Usage Agreements – Existing facilities proposed to be included in the project will require a formal contract governing usage including, but not limited to, identification of liabilities for operation and maintenance, cost recovery, and resolution of conflicts during joint use (if any). An outline of these issues for each specific facility will be developed.

5.1.2.3 Operation and Maintenance Agreements – New facilities may also require operation or maintenance agreements between owners and users, depending on the institutional arrangements adopted for this project. If so, preliminary outlines of the issues for each agreement will be developed under this task.

5.2 **Financing/Cost Issues**

Based upon the expected capital costs and contingencies for the project developed in previous elements of the program, more detailed evaluation of financing and cost data will be required for the implementation plan as follows:

5.2.1 Implementation Costs. Based upon the unit cost established in the conceptual engineering phase during Task 3.3.2, develop the project cost associated with implementing the recommended preferred alternatives including:

- Facility Capital Costs.
- Engineering, surveying, and related technical services.
- Legal, financial, and special consulting services.
- Land and easement acquisition.
- Water rights and changes in treatment costs.
- Permitting and environmental mitigation.

5.2.2 Estimate of Operation and Maintenance Costs. Based on the final recommended plan, an initial estimate of all significant O&M costs expected for the project will be developed, including:

- Pump operation, maintenance and replacement.
- Energy costs.
- Canal maintenance and repairs.
- Staff requirements for routine maintenance.
- Emergency repairs.
- Salvage value estimates for major components.

5.2.3 Preliminary Financing Plan. The services of an expert financial consultant shall be obtained to establish a preliminary financing plan tailored to meet the project requirements and serve the individual project participants. Working closely with the sponsors, end users, and TWDB, a preliminary plan will be developed to address the various needs of the participants.

5.2.4 Pricing Policies. The recommended unit cost for the delivered water will be calculated based on the various factors established in Tasks 5.2.1 and 5.2.2 and a cost–allocation formula will be developed for the proposed participants in the project. If reserve capacity is provided in the conveyance system, the issue of future costs for subsequent users will be addressed. Several alternative financing scenarios will be identified for further evaluation.

5.3 Schedule/Phasing Issues

An overall schedule for the entire project will be proposed including:

- Options for project phasing.
- Preconstruction schedule.

5.3.1 Options for Project Phasing. Based on cost and financing considerations, options for construction phasing of the project will be investigated. The advantages and disadvantages associated with phasing will be outlined and the impact on the project schedule and costs identified.

5.3.2 Preconstruction Schedule. An evaluation will be made of the projected schedule for subsequent permitting and design phases of the project including resolution of environmental/regulatory requirements. An implementation schedule with milestone events will be developed to provide project guidance through subsequent phases.

5.4 <u>Phase III Work Plan</u>

5.4.1 Develop a detailed work plan for Phase III for the Southeastern Area of the Trans-Texas Water Program.

5.5 <u>Report Preparation</u>

5.5.1 Prepare a report summarizing all pertinent information developed for this element of the program in accordance with Task 3.6.1 in Phase I.

6.0 CONTRACT ADMINISTRATION

6.1 <u>Program Coordination</u>

Attend up to eighteen (18) project status meetings and provide technical input, as required, to coordinate the work efforts and results of the Southeast Area and South-Central Area projects.

6.2 <u>Progress Reports</u>

6.2.1 Prepare up to eighteen (18) monthly progress reports and monthly billings which summarize the work completed through each work period. The monthly progress report will contain the following information:

- Major Phase II task names and description.
- Total manhours and cost budgeted for individual tasks, including TWDB and Contractor portions.
- Percent of the tasks completed.
- Dollar value of the percent of the tasks completed.
- Total tasks completed, indicating the percent of and dollar value of the project completed as reflected in totals of all State Vouchers submitted.

6.2.2 Prepare and update schedules, budgets, and the work plan, as required, to illustrate the project status.

# ATTACHMENT 1

## TRANSTEXAS WATER PROGRAM
## ENVIRONMENTAL ASSESSMENT

**Water Quality**

Preliminary water quality impact assessment of affected State waters must include evaluation of water quality standards attainment, chemical and biological compatibility of mixed waters, coastal salt water intrusion, and nutrients for compliance with drinking water standards. The recommended methodology, if any, for each analysis is given as follows:

1. Water Quality Standards Attainment

   A. Chloride, Sulfate, Total Dissolved Solids--Mass balance these constituents under a 7-day, 2-year, low flow (7Q2) condition to insure that the Standards are not violated.

   B. Dissolved Oxygen--If any interbasin transfer scenarios result in a reduction of a river's 7Q2, or if the baseflow is significantly reduced during spring spawning months (defined as the first half of the year when water temperatures are 63°-73°F in TWC Rule 307.7.(b)3. Aquatic Life), then simplified mathematical modeling must be performed to evaluate compliance with the Standard. Basic modeling assumptions are listed below:

      - Summer Analysis
        Headwater--7Q2 flow conditions
        Temperature--average of the three
        hottest months, plus one standard deviation, from the closest USGS station with water temperature data
        Discharges--full permitted effluent
        flow and quality
        BOD--compute BODu = $BOD_{5\ day} \times 2.3$
        $K_n$--nitrification rate = 0.30/day
        $K_d$--BOD oxidation rate = 0.10/day
        Reaeration--use Texas equation

      - Spring Spawning Analysis
        Same as above, except
        Headwaters--10th percentile monthly
        low flow conditions
        Temperature--90th percentile monthly
        high temperature conditions

   C. pH--No recommended method.

   D. Temperature--Mass balance temperature to insure compliance with the maximum temperature criteria, as well as the "rise over ambient" Standard.

   E. Fecal Coliform--No recommended method.

2. Chemical and Biological Compatibility of Waters

A. Formation of precipitates, etc.--No recommended method.

B. Introduction of exotic plants and animals--No recommended method.

3. Salt Water Intrusion

A. Migration of coastal salt wedge and effect of intrusion up tidal rivers--No recommended method.

B. Effect on water supply operations--No recommended method.

C. Effect on freshwater marshes/wetlands--No recommended method.

4. Nutrients

A. Potable water limits--Determine compliance with Drinking Water Standards.

B. Potential for nuisance aquatic vegetation--No recommended method.

## Instream Flows

A relatively rapid assessment of instream flow needs to maintain downstream fish and wildlife habitats affected by the TransTexas Water Program can be performed by using the TPWD-modified Tennant's Method (Lyons 1979), which is based on a fixed percentage of median (50th percentile) monthly flows. At any point in a river basin intercepted by the TransTexas Water Program, streamflows must be passed downstream in an amount up to 60% of the median monthly flows from March through September, and 40 % of the median monthly flows from October through February. Streamflows above these monthly flow limits are to be considered available for other beneficial uses and interbasin transfer. Water stored in existing reservoirs will not be allocated to instream uses and released downstream to make up for normal flows below the specified limits.

## Freshwater Inflows to Bays and Estuaries

For preliminary planning purposes, the freshwater inflow needs of the bays and estuaries can be conservatively estimated as a function of selected central tendency values. The typical bi-modal distribution of monthly rainfall runoff during the historical period is enhanced by requiring the pass through of normal inflows up to the mean (arithmetic average) monthly flow in May-June and September-October, while the minimum maintenance needs are satisfied with inflows up to the median (50th percentile) monthly flow in the remaining months of the year. Water stored in existing reservoirs will not be allocated to bay and estuary uses and released downstream to make up for normal flows below the specified limits.

## New Reservoirs

Existing reservoirs that could potentially contribute to the TransTexas Water Program will be evaluated as to the effects on downstream flows and freshwater inflows to bays and estuaries under their existing state and federal permits which authorize their current operations, while any new reservoirs involved in the Program's future water storage and distribution system will be considered to operate such that they pass through impounded streamflows up to the mean (arithmetic average) monthly flow in April-June and August-October, and median (50th percentile) streamflows in the remaining months of the year, as long as reservoir capacity is above 60%. When reservoir capacity is below 60%, the water management operations will recognize drought contingency by passing through up to the median daily flow of the stream observed during the historical drought of record. The analysis will be repeated at 40% and 80% capacity thresholds to demonstrate a range of feasible solutions for operating any new reservoirs.

# APPENDIX D

## Membership of Southeast Area TAC

# *Technical Advisory Committee*
# Southeast Study Area
# *Trans-Texas Water Program*

**Policy Management Committee**
Sabine River Authority, Chair
City of Houston
San Jacinto River Authority
Brazos River Authority
Texas Water Development Board
Texas Natural Resource Conservation Commission
Texas Parks and Wildlife Department
Coastal Coordination Council

**State and Federal Agencies:**
- National Park Service
- National Marine Fisheries Service
- Texas Department of Agriculture
- Texas General Land Office
- U.S. Army Corps of Engineers
- U.S. Bureau of Reclamation
- U.S. Environmental Protection Agency, Region VI
- U.S. Fish and Wildlife Service
- U.S. Geological Survey

**Local and Regional Agencies:**
- Angelina and Neches River Authority
- Association of Water Board Directors
- City of Beaumont
- Chambers County Judge
- Chambers-Liberty Counties Navigation District
- Coastal Water Authority
- Devers Canal System
- Fort Bend County Subsidence District
- Galveston Bay National Estuary Program
- Gulf Coast Water Authority
- Hardin County, Pct. 4
- Harris County Judge
- Harris-Galveston Coastal Subsidence District
- Houston-Galveston Area Council of Governments
- Jefferson County Judge
- Liberty County Judge
- Lower Neches Valley Authority
- Orange County Judge
- Polk County Judge
- South East Texas Regional Planning Commission
- Texas Farm Bureau
- Trinity River Authority
- TWCA Irrigation/Drainage District Panel

**Environmental and Public Interest Groups:**
- Audubon Society - Houston
- Big Thicket Conservation Association
- Citizens Environmental Coalition
- Clean Air and Water Incorporated
- Coalition Advocating a Safe Environment
- Galveston Bay Foundation
- Greater Houston Partnership - Environmental Committee
- Gulf Coast Conservation Association
- League of Women Voters
- Sierra Club - Golden Triangle Chapter
- Sierra Club - Houston Chapter
- Sportsman Conservationists of Texas
- Texas Committee on Natural Resources

**Other:**
- Dupont Sabine River Works
- Houston Lighting and Power Company
- Art Spencer
- Texas Chemical Council

# APPENDIX E

## Meetings of the PMC and TAC

# APPENDIX E

## Summary of PMC Meetings

At the first PMC meeting on October 15, 1992, the committee laid the foundation for the project. The PMC agreed upon the purpose or "mission statement" which is on page 1.4 of this report. After that there was a brief description of the PMC and its role. They voted to adopt the structure of the PMC that has been presented in this report. The committee agreed on a consensus (no voiced opposition) method of decision-making. They agreed on the duties of the PMC which are:

a) Coordinate policy matters associated with the study,

b) Approve study parameters,

c) Approve draft and final reports, and

d) Appoint Technical Advisory Committees (TAC's) for the TTWP.

At the meeting the PMC also adopted environmental guidelines for the program which are in Appendix C. The PMC discussed and agreed upon the structure and role of the TAC's as presented in this report. Dennis Crowley of the TWDB was identified as the Project Manager of the TTWP. Following that there were comments from both regional PMC's concerning the expected involvement of the City of Houston, the City of San Antonio, and the Lower Colorado River Authority (LCRA) in the program.

The next meeting of the PMC was held on December 9, 1992. During this meeting the Committee prepared a statement which reflected an agreement between the membership to be objective, work for the advancement of the Project as a whole, and not take advantage of their PMC membership to advance the agenda of their respective agencies or organizations. There were also project status reports and reports on TAC membership and organization from both the Southeast and the South-Central

Study Areas. There was also discussion on the process of coordinating the work among the consulting firms.

Another PMC meeting was held on April 27, 1993. A major issue in this meeting was the involvement of the U.S. Bureau of Reclamation in the TTWP. The Bureau has been authorized by the federal government to conduct an "Edward Aquifer Regional Water Resources Management Study" in cooperation with state and local agencies. A major concern was the unnecessary duplication of work in the Bureau study and the TTWP. Therefore the PMC made a motion to support the participation of the Bureau in the Program. There was also some discussion of the environmental guidelines for the project. At that time the Texas Water Development Board staff was having on-going discussions of that issue. Also, status reports were given by the TAC's.

Summary of the TAC Meeting

At the Southeast TAC meeting many questions arose about the financing of the project. Phases I and II are being funded by the Sabine River Authority (SRA) (by a loan from the TWDB), the City of Houston, and the San Jacinto River Authority (SJRA). It is anticipated that the users or beneficiaries of the project will ultimately bear the cost of the project, including these preliminary studies. There could also be some participation by the state and by the federal government (mainly through the Bureau of Reclamation). There were also some questions concerning the economic criteria established in choosing the alternatives (i.e. will the "least-cost" or "cost-benefit" method be used?). Answers indicated that these methods were not entirely appropriate for the TTWP, since there are many other concerns -- environment, public opinion, etc. The question also arose of whether public environmental interest groups should have to pay for protecting the environment from the effects of the project. Answers indicate that this should not be the case, but these groups could pay for enhancement of the environment. There was also a question of whether desalination would be a cheaper and a more environmentally favorable alternative than conveyance systems. Desalination will be considered. Some preliminary cost estimates have been obtained indicating the desalination treatment alone (not including transmission system costs or environmental issues associated with the process) would cost about $7 per thousand gallons. This is compared to $1 per thousand gallons for conventional water treatment. Based on past studies, the cost of conveyance is expected to be far less than the cost of desalination.

Several TAC members suggested that increased conservation efforts might eliminate the need for a project such as the TTWP. The members were assured that this was not the case. The demand projections for the project were developed using the TWDB's high-case scenario population forecast with conservation efforts in place.

Several questions were asked concerning the sponsorship and the institutional structure of the project, most of which have already been addressed in this report. One member asked why the Trinity River Authority (TRA) was not a project sponsor. A representative of the TRA said that they had no major role to play in the project, but they were serving as advisors and were very interested.

Many of the members were interested in the amount of public involvement which would take place throughout the different phases of the project. The TAC was assured that there will be adequate opportunity for public input through the TAC meetings, TAC correspondence and some public meetings held by the PMC where the purpose will be to solicit public input and increase public awareness of the program. There was also the matter of whether or not the project would ultimately be put to a vote of the people. A TWDB representative said that depends on the form of state financial participation, if any.

Another concern was the "ambitious" time schedule of the project. Representatives from the City of Houston indicated that this schedule was needed because they project that Houston will need additional water by the year 2010. The year 2000 had been mentioned previously as the earliest possible date that a part of the work might be completed, but it is probably not a realistic date.

The TAC was informed that Toledo Bend is the major water supply under consideration at this time, but there are still other possible options. No sources of water supply are being ruled out at this time, but currently available sources will be more attractive and probably will be used before any new reservoir projects are seriously considered. It may be possible to buy some of Louisiana's 50% of Toledo Bend's yield. This brought up the question of Louisiana's involvement in the project. Louisiana representatives have been contacted regarding inter-state agreements for additional water supplies and will be periodically briefed on the status of the project.

# MEMORANDUM TO FILE

From: Southeast Area Program Management Committee

Prepared by: Tom Gooch

Date: April 22, 1993

Project: Trans-Texas Water Program, Southeast Area

Subject: Summary of the First Technical Advisory Committee Meeting, April 13, 1993, Days Inn, Houston, Texas

1. Attachment 1 is a copy of the registration sheet for the meeting. Those in attendance were given the following items:

   - A Texas Water Development Board (TWDB) map showing projected water availability in 2040 with no new facilities.
   - "Water for Texas - Trans-Texas Water Program, Overall Program Description."
   - A Trans-Texas Water Program Southeast Area Comment Form.
   - A packet which included the agenda for the meeting, a description of the role of the Technical Advisory Committee (TAC), a list of TAC membership, and a TAC contact list (Attachment 2).
   - Consultant's Scope of Services for Phase 1 and Phase 2.
   - *Southeast Area Program Issues* document.

2. Sam Collins of the Sabine River Authority (SRA) gave an overview of the Trans-Texas Program and the purpose of the meeting. He asked those in attendance to hold their questions for the end and introduced SRA, San Jacinto River Authority (SJRA), TWDB, and City of Houston representatives. He described the Policy Management Committee (PMC) and introduced representatives of Brown and Root and Freese and Nichols. He then asked those in attendance to introduce themselves.

Five river authorities, 5 federal agencies, 4 state agencies, 6 environmental groups, 3 development-oriented organizations, 3 regional agencies, 2 cities, 3 counties, and 6 private companies were represented.

3. Albert Gray of SRA discussed the role of the TAC. He indicated that they would be asked to review technical material and provide comments, preferably in writing. They are not a voting group.

4. Mike Personett of the TWDB reviewed the organization and background of the Trans-Texas Water Program. It is an outgrowth of TWDB planning efforts, which show 4 areas with a long-term deficit in water supply:

   - Southeast (Houston)
   - South-Central (Austin, San Antonio, Corpus Christi)
   - Lower Rio Grande Valley
   - El Paso/Juarez

   TWDB projects that the population will essentially double statewide and in these population areas by 2040, and water needs will also double.

   The Trans-Texas Water Program could meet the needs of two of the four water-short areas - Southeast and South-Central. The program will look at ways to share water, including water wheeling as well as physical transfers. TWDB shows surpluses in the Sabine, Neches, and Colorado basins, with shortages in other basins.

   Mr. Personett discussed the phases of the Trans-Texas Water Program:

   Phase I - Conceptual planning and initial screening
   Phase II - Focused look at screened alternatives
   Phase III - Preliminary design and permitting
   Phase IV - Property acquisition and design
   Phase V - Construction and start-up

   Mr. Personett also described the management structure for the Trans-Texas Water Program - overall direction by a Policy Management Committee (PMC), with regional PMCs and regional TACs.

5. Bruce Moulton of the Texas Water Commission then reviewed the environmental criteria for the Trans-Texas Water Program. The major environmental concerns include:

- Water quality
- Instream flows
- Freshwater inflows to bays and estuaries
- New reservoirs

He reviewed the criteria set by the agencies. He indicated that the criteria are conservative - further study may lead to less stringent requirements.

6. David Parkhill of Brown and Root then reviewed the scope of the Phase I and II studies. He provided an overview of the program issues paper, which covers the following areas:

   - Engineering
   - Environmental
   - Financial
   - Legal
   - Institutional

   The schedule was presented, and it calls for completion of Phase I by mid July, to be followed immediately by Phase II.

7. Albert Gray of SRA asked that written comments on the issues document be returned by April 28. He said that copies of the document would be mailed to TAC members not represented at the meeting.

8. <u>QUESTIONS:</u>

   The members of the TAC then asked questions and gave suggestions. A summary of the questions and comments and of the responses follows.

a. (Glenn Phillips, Texas Eastman) *TWDB lists four areas of water shortage. What about the Ogallala?* <u>Personett.</u> TWDB now projects continued declines in irrigated acreage and in water use per acre on the high plains.

b. (Saul Aronow, Golden Triangle Sierra Club) *Are the goals of the subsidence districts to phase out ground water use realistic enough to provide good data for this study?* <u>Parkhill.</u> The subsidence district has recently completed a revision of its numbers, and the district is comfortable with the numbers.

c. (Janice Bezanson, Texas Committee on Natural Resources) *Nothing in what you have* *presented to date establishes economic criteria for the project. Should there be such? Do you intend to use cost-benefit analysis?* Parkhill. We do not propose to use a traditional cost-benefit analysis. Although there is incentive to supply water at a reasonable cost, it is not feasible to go only with the least-cost approach. We have to balance environmental and other considerations with cost.

d. *What criteria will be used to select among routes?* Parkhill. Cost and environmental impacts will be considered. Personett. What is being done for this project is "integrated resource planning," looking at the whole picture.

e. (Birna Foley, Galveston Bay Foundation) *You have talked about providing low cost water to the people. What is the focus of this effort? Who will bear the cost of water transfers, users or the state?* Personett. This is to be explored. Certainly the user will bear the primary share of the costs. There could be some participation by the state, especially on the front end. *I want to discourage unrealistically low costs, which discourage conservation.*

f. *You have said that Phase I and Phase II are now financed. What do they cost and how are they financed?* Collins. The SRA has received a loan from the TWDB for $700,000, the City of Houston is contributing $300,000, and the SJRA is contributing $100,000.

g. *Is there a plan for federal government sponsorship/participation?* Collins. They are on the TACs and will have input.

h. *Am I correct that there are three sponsors?* Collins. Yes, there are three sponsors in the Southeast Area - SRA, Houston, and SJRA.

i. (Glenn Phillips, Texas Eastman) *Who owns the water in Toledo Bend Reservoir?* Collins. The yield of the project is split between Texas and Louisiana in accordance with the financial investment - 50-50. We might buy some water from Louisiana. *Does Louisiana have concerns on the environmental impact of the project?* Collins. They do.

j. *Are mechanisms to address the cumulative impacts of the project in place?* Parkhill. That will be done as part of the environmental process.

k. (Glenn Phillips, Texas Eastman) *Will this project ultimately come up for a vote of the people?* Personett. There will be state input through the permitting process. Whether or not there is a state vote depends on the form of state financial participation, if any.

l. (Saul Aronow, Golden Triangle Sierra Club) *Is any of the water dedicated to irrigation use?* Parkhill. We will attempt to meet all needs. *Will there be a differential in costs for irrigation and municipal use?* Parkhill. We do not intend to interfere with existing contracts.

m. (Jim Kachtick, Greater Houston Partnership) *Why is the Trinity River Authority not a project sponsor?* Danny Vance, TRA. We had no major role to play in the project, but we are serving as advisors, and we are very interested.

n. (Julian Coghill, Jefferson County Drainage District) *Are any other states doing projects like this, and can we learn from them?* Personett. Yes, and there is a lot to learn. We plan to pay more attention to the environment and to avoid some of the turmoil we are now seeing in California. We also hope to use experience and information from the Bureau of Reclamation.

o. (Mike Kieslich, Corps of Engineers) *Is there a public involvement/project scoping element in the program?* Parkhill. This TAC process and meetings with the agencies will be avenues for seeking public input. The formal NEPA process will occur in Phase III. *I would suggest that you expand scoping efforts early in the process.* Moulton. That was also recommended in the South-Central area. *If you cover all the questions that interest the public up front, you may avoid having to repeat your work.*

p. *You said that the yield of Toledo Bend is split. Is there a mechanism to determine control of flows through the reservoir?* Collins. The Sabine River Compact. *Will you consider environmental impacts in Louisiana?* Parkhill. Yes.

q. (Janice Bezanson, Texas Committee on Natural Resources) *To return to the economic question, I have found that the least cost alternative also usually also has the least environmental impact. You should consider the least cost methodology. For example, would paying to implement conservation measures be cheaper?* Personett. We will be looking at an enhanced conservation scenario. Enhanced conservation is not likely to eliminate projects, but we expect it to change the timing and scale. Demand reduction is an integral part of our planning effort.

r. (Gary Neighbors, Angelina-Neches River Authority) *What are the supply source alternatives under consideration?* Parkhill. The book is open right now. Any alternative is possible, including buying Louisiana's share of the Toledo Bend yield.

s. (Mike Kieslich, Corps of Engineers) *What is driving the schedule? It seems very ambitious. Can it be adjusted?* Settle. The City of Houston sees a need for some additional water by the year 2010 or so. Given the time required to develop water supplies, we are starting a little late, and we want to get going.

t. (Rafael Ortega, Harris County) *What project or segment of the project do you expect to have built by the year 2000?* Parkhill. The year 2000 was mentioned as the earliest possible date that a part of the work might be completed. It is probably not a realistic date.

u. *Please elaborate on the concept of public interest group participation.* Parkhill. The idea is that interest groups may want to pay to get environmental benefits. Perhaps someone would want to use capacity in the canal in the early years to deliver water for environmental purposes. Personett. This kind of thing has been done in California.

v. (Mike Kieslich, Corps of Engineers) *Will the feasibility studies look at the impact of changes in freshwater inflows to Galveston Bay?* Parkhill. We plan to use the TWC model in Galveston Bay. We will look at the impact of the proposed actions. Moulton. TWC has its Galveston Bay model on the front burner. We hope to have a lot of information by early next year. *The modelling time required to simulate the bay's hydrodynamics is tremendous.* Moulton. The regulatory agencies will be monitoring the study, and we won't let the consultants get away with murder. At this time, we are looking for a fatal flaw in any plan.

w. *Returning to public interest group participation, I think that the need for environmental groups to purchase water for environmental purposes in California is the result of past poor planning. With proper planning, public interest groups should not have to pay to protect the environment.* Parkhill. Payments might be for environmental enhancement.

x. (Saul Aronow, Golden Triangle Sierra Club) *The Bureau of Reclamation recently abandoned its last reservoir project in Texas. Will the study attempt to resurrect old reservoir projects?* Jim Adams of the SJRA indicated that the project was not abandoned, but set aside for lack of current local interest. Parkhill. We do not rule out any sources. At this time, we expect that currently available sources will be more attractive and will be used first.

y. (Bill Jackson, National Marine Fisheries) *Given the environmental impacts and costs of other sources of supply, what about desalination? It will have to be looked at along* *the coast.* Parkhill. We plan to look at all alternatives. Based on studies done in the past, we expect the cost of conveyance to be far less than the cost of desalination. *I would like to see those studies.* Personett. Desalination has very high energy costs and environmental impacts. Disposal of concentrated brine is one problem. It is being done in parts of the state.

z. *How often will this group meet?* Gray. We expect to meet 4 or 5 times over the next two years. We expect to do most of our work by correspondence.

aa. (Rafael Ortega, Harris County) *What will happen to the PMC as you move to subsequent phases - will the same people be in charge?* Gray. We will reevaluate the role and structure of the PMC after Phase II.

ab. (Glenn Phillips, Texas Eastman) *You spoke of a doubling of population. Are you considering the environmental impacts of such large population increases?* Parkhill. We are using the detailed population estimates from TWDB, looking for the most realistic projections we can get. We do not plan to control population growth by the water supply. Personett. We are looking at high growth, dry year needs. We can adjust the plan if growth changes from the projections. In general, TWDB projections are in the middle to low end of the range of projections.

TRANS-TEXAS WATER PROGRAM
Southeast Area

REGISTRATION FORM

| | Name | Organization | Address | Phone Number | Title |
|---|---|---|---|---|---|
| 1. | S.A. Webb | City of Beaumont | P.O. 3827 - 77706 | 409 866 0023 | Dir Water Utilities |
| 2. | James Stewart | Houston Audubon | 519 Pine Edge Dr The Woodlands 77380 | 713/292-1888 | VP Sci & Res. |
| 3. | John Thompson | Polk County | Polk County Courthouse | 409-327-8113 | County Judge |
| 4. | DANNY F. VANCE | TRINITY RIVER AUTH. | P.O. BOX 60 ARL., TX 76004 | 817-467-4343 | GEN. MGR. |
| 5. | A.T. Hebert, Jr | Lower Neches Valley Auth | P.O. Drawer 3464 Beaumont 77704 | 409 892-4011 | Gen. Mgr. |
| 6. | SAUL ARONOW | Golden Triangle Sierra Club | 5590 FRIST 77708 BEAUMONT TX | 409-892-9141 | ?? |
| 7. | Janice Bezanson | Tx Cmte on Natural Resources | 601 Westlake Dr Austin 78746 | 512-327-4119 | Issues Coordinator |
| 8. | Cindy Loeffler | TPWD | 3000 S. IH35 Austin 78704 | 512 448 4313 | Inflow Implementation Coord |
| 9. | Mark Jordan | Texas Water Commission | PO Box 13087 Austin TX 78711 | (512)475-2201 | Director, Water Policy Div. |
| 10. | Joe Broadus | USGS-Houston | 2320 LaBranch St Houston TX 77004 | (713)750-1655 | Subdistrict Chief |
| 11. | Birna Foley | Galveston Bay Found | 17324-A Highway 3 Webster TX | (713)332-3381 | Special Projects Coord |
| 12. | STEVE DAVIES | HL&P Co. | PO Box 1700 H, T 77251 | 713/945-8196 | DIV. MGR. |
| 13. | Andrew Sipocz | Texas Parks & Wildlife | P.O. Box 8 Seabrook TX 77586 | 713/474-2811 | Assessment Biologist |
| 14. | LANCE ROBINSON | TPWD-COASTAL FISHERIES | P.O. BOX 8, SEABROOK TX 77586 | 713/474-2811 | Galv. Bay Ecosystem Ldr |
| 15. | Bill JACKSON | NOAA/NMFS | 4700 Ave U, GALV TX 77551 | 409/766-3699 | Fisheries Specialist |
| 16. | Melvin Swoboda | DuPont | | | |
| 17. | | | | | |
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TRANS-TEXAS WATER PROGRAM
Southeast Area

REGISTRATION FORM

| | Name | Organization | Address | Phone Number | Title |
|---|---|---|---|---|---|
| 1. | Mike Kieslich | Corps of Engineers | P.O. Box 1229 Galveston, TX 77553 | 409/766-3071 | Chief, Project Management Branch |
| 2. | Mary Gillette | League of Women Voters | 1021 Omar, Houston 770[illegible] | 713-864-[illegible] | |
| 3. | Bruce Moulton | TX Water Comm. | PO BOX 13087 Austin 78711 | 512/463-8208 | |
| 4. | Art Spencer | | 3629 Brittany Pt. Arthur 77642 | 409 962-82[illegible] | |
| 5. | Richard Diehl | A.W.B.D. | 4913 Park Dickinson TX 77539 | | |
| 6. | Richard Strahan | Nat'l Park Service | 3785 Milam; Beaumont 77701 | (409) 839-2689 | Chief - Resources |
| 7. | Gary Neighbors | [illegible] Neches River [illegible] | PO Box 387, [illegible] 75901 | 409 632 7795 | Gen Mgr. |
| 8. | Jerry Berry | Coastal Water Auth | 1200 Smith St, Suite 2260 Houston Tx. | (713) 424-1322 | Operations Manager |
| 9. | Tom Ray | Brazos River Auth. | PO Box 7555 Waco 76714 | 817/776-1441 | |
| 10. | Chuck Settle | City of Houston | P.O. Box 1562 Houston 77251 | (713) 754-0658 | |
| 11. | Rafael Ortega | Harris Co | 1500 CityWest Blvd | 713 266-6[illegible]00 | |
| 12. | Oscar Nelson | Chambers Co | Box 939 Anahuac, TX | 409 267 8295 | Co. Judge |
| 13. | | | | | |
| 14. | | | | | |
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TRANS-TEXAS WATER PROGRAM
Southeast Area

REGISTRATION FORM

| | Name | Organization | Address | Phone Number | Title |
|---|---|---|---|---|---|
| 1. | Carl Masterson | Houston-Galveston Area Council | PO Box 22777 Hou TX 77227-2777 | 713 993 4561 | Sr. Environmental planner |
| 2. | Glenn Phillips | Texas Eastman Div Eastman Chemicals Co | Box 7444 Longview, Tx 75607 | 903-2375346 | Sr. Engineer Assoc. |
| 3. | H.E. (Ike) Barrett | San Jacinto River Authority | P.O. Box 329, Conroe, Tx. 77305 | 409/588-1111 | Manager Surface Water Operations |
| 4. | Tom Gooch | Freese & Nichols | ~~[illegible]~~ 4055 International Pkwy, Fort Worth, TX. 76109 | 817/735-7300 | Principal |
| 5. | JULIAN COGHILL | JEFF CO DRAIN DIST. COMMISSION'R & TWCA | 5239 LAKESIDE DR. PT ARTHUR | (409) 982-0704 | Commissioner |
| 6. | JACK W. TATUM | SRA | | | |
| 7. | B. D. King III | USFWS | 17629 El Camino Real, Hous | 713-286-8282 | Chief, Fed. Proj. |
| 8. | Paul M. Glass | Trinity Water Reserve, Inc | P.O. Box 463, Devers, TX 77538 | (409) 549-7575 | President |
| 9. | DENNIS CROWLEY | TWDB | | 512-463-7976 | |
| 10. | MIKE PERSONETT | TWDB | | | DIRECTOR, LOCAL & REGIONAL ASSISTANCE DIVISION |
| 11. | JIM KACHTICK | GREATER HOUSTON PARTNERSHIP (OXY CHEM) | 5 GREENWAY PLAZA SUITE 2400 HOUSTON, TEX. 77046 | 713/623-7602 | MGR - ENV, SOUTHERN REGION |
| 12. | David C. Berkshire | Big Thicket Cons. Assoc. | 9713 Mariposa Houston, TX 77025 | (713) 667-7881 | Treasurer |
| 13. | C.L. BOGAN | BRAZOS River Board | | | |
| 14. | | | | | |
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TRANS-TEXAS WATER PROGRAM
Southeast Area

REGISTRATION FORM

| Name | Organization | Address | Phone Number | Title |
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A GOVERNMENTAL AGENCY
OF THE
State of Texas
409-746-2192
FAX # 409-746-3780

# SABINE RIVER AUTHORITY of Texas

P. O. BOX 579
ORANGE, TEXAS
77630

March 25, 1993

TO: Technical Advisory Committee (TAC) Members
Trans-Texas Water Program (TTWP)

FROM: Sabine River Authority

SUBJECT: Initial Meeting of the Technical Advisory Committee for the Southeast Study Area of the Trans-Texas Water Program

DATE: April 13, 1993
10:00 a.m.

LOCATION: Days Inn (I-10 East/Mercury Drive)
10155 East Freeway
Houston, Texas
(See Attached Map)

AGENDA:

1. Introduction of Membership
2. Role of the TAC
3. Organization/Background of the TTWP
4. Discussion of Environmental Criteria
5. Scope of Studies for the Southeast Study Area of the TTWP
6. Presentation and Discussion of Issues Papers Concerning the TTWP
7. Schedule of Milestone Events for the TTWP
8. Other Business
9. Adjournment (the meeting will begin promptly at 10:00 a.m. and will continue until completed - hopefully by around noon)

If you should have any questions or need any additional information, please feel free to contact the Sabine River Authority, as follows:

Albert J. Gray .................. Development Manager
Jack W. Tatum ................ Development Coordinator
Jim Brown ........................ Administrative Assistant
Bambi Granger ................ Development Branch Secretary
Phone (409) 746-2192.

Very truly yours,

Albert J. Gray

Albert J. Gray
Development Manager

*April 13, 1993*

# ROLE OF THE SOUTHEAST TECHNICAL ADVISORY COMMITTEE
# TRANS-TEXAS WATER PROGRAM

- The purposes of the Trans-Texas Water Program (TTWP) Southeast Technical Advisory Committee (TAC) are to (1) review and comment on the information produced in the Southeast Study Area; (2) provide socio/economic, engineering and environmental advice to the program sponsor (Sabine River Authority of Texas) and the Policy Management Committee (PMC); and (3) serve as a vehicle for public information and input.

- The TAC will identify and discuss socio/economic, engineering and environmental issues related to the TTWP. The goal of this discussion process will be to identify areas of agreement and disagreement regarding the adequacy and reliability of the data used in the Southeast Study Area.

- In order that each TAC Member's views concerning the Southeast Study Area are properly considered, written comments should be provided to the Sabine River Authority of Texas.

- There will be no voting in the sense of defining a single set of recommendations or conclusions of the TAC. Instead, the full extent of agreement and disagreement (as reflected in written comments from the TAC) will be recorded by the Sabine River Authority for input into the TTWP for the Southeast Study Area.

- Meetings of the TAC will be open to the public.

**Trans-Texas Water Program**
**Southeast Technical Advisory Committee Membership**
**December, 1993**

1 Sabine River Authority (Chair)*
2 Texas Water Development Board*
3 Texas Parks and Wildlife Department*
4 Texas Water Commission
5 Texas General Land Office
6 U.S. Fish and Wildlife Service
7 U.S. Environmental Protection Agency (will not participate-available for technical questions
8 U.S. Corps of Engineers
9 U.S. Bureau of Reclamation
10 National Park Service
11 National Marine Fisheries Service
12 Galveston Bay National Estuary Program
13 City of Houston (Houston)*
14 San Jacinto River Authority (SJRA)*
15 Lower Neches Valley Authority (LNVA)
16 Trinity River Authority
17 Brazos River Authority (BRA)
18 Coastal Water Authority
19 Gulf Coast Water Authority
20 Harris-Galveston Coastal Subsidence District and Fort Bend County Subsidence District
21 South East JTexas Regional Planning C9ommission (One member representing local entities)
22 Houston-Galveston Area Council of Governments (One member representing local entities)
23 County Judge: Orange County
24 County Judge: Jefferson County
25 County Judge: Chambers County
26 County Judge: Liberty County
27 County Judge: Harris County
28 Chambers-Liberty Counties Navigation District
29 Representative of TWCA Irrigation/Drainage District Panel
30 Devers Canal System
31 Association of Water Board Directors
32 Texas Farm Bureau
33 Houston Chapter Sierra Club
34 Golden Triangle Sierra Club
35 Galveston Bay Foundation
36 Sportsman Conservationists of Texes
37 Big Thicket Conservation Association
38 Houston Audubon Society
39 Texas Committee on Natural Resources
40 Citizens Environmental Coalition
41 Gulf Coast Conservation Association
42 Clean Air & Water, Inc.
43 League of Women Voters of Texas
44 Member Appointed by SRA (Dupont Sabine River Works)
45 Member Appointed by Houston (Greater Houston Partnership - Environmental Committee)
46 Member Appointed by SJRA (Texas Chemical Council)
47 Member Appointed by LVNA (Mr. Art Spencer)
48 Member Appointed by TRA (County Judge: Polk County)
49 One Member to be Nominated by BRA
50 One Member to be Nominated by GCWA
51 City of Beaumont
52 Angelina & Neches River Authority (ANRA)
53 Coalition Advocating a Safe Environment
54 Houston Lighting and Power Company

N:JR1341\Phaseone\Freese\ADCOMM

55 U.S. Geological Survey
56 Texas Department of Agriculture
57 County Judge: Hardin County

**Trans-Texas Water Program**
**Southeast Technical Advisory Committee**
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**SOUTHEAST AREA TECHNICAL ADVISORY COMMITTEE**
**INITIAL MEETING**
**COMMENTS, QUESTIONS AND RESPONSES**

The following is a summary and compilation of the various questions and suggestions offered by the members of the TAC at the April 13, 1993 meeting and the subsequently written comments received by Mr. Albert Gray of the Sabine River Authority. This information has been summarized from notes taken at the April 13, 1993 TAC meeting and is not intended to be a complete nor thorough summary of the questions and responses. The summary is intended to reflect a general record of the discussion which occurred.

**Questions and Comments**

Glenn Phillips, Texas Eastman
* "TWDB lists four areas of water shortage. What about the Ogallala?"

Mike Personett, Texas Water Development Board - TWDB now projects continued declines in irrigated acreage and in water use per acre on the high plains.

Saul Aronow, Golden Triangle Sierra Club
* Are the goals of the subsidence districts to phase out ground water use realistic enough to provide good data for this study?

David Parkhill, Brown & Root - The subsidence district has recently completed a revision of its projections, and the district is comfortable with the numbers.

Janice Bezanson, Texas Committee on Natural Resources
* Nothing in what you have presented to date establishes economic criteria for the project. Should there be such? Do you intend to use cost-benefit analysis?

David Parkhill - We do not propose to use a traditional cost-benefit analysis. Although there is incentive to supply water at a reasonable cost, it is not feasible to go only with the least-cost approach. We have to balance environmental and other considerations with cost.

Question from Audience
* What criteria will be used to select among routes?

David Parkhill - Cost and environmental impacts will be considered.

Mike Personett - What is being done for this project is sometimes called "integrated resource planning," which requires looking at the whole picture.

Birna Foley, Galveston Bay Foundation

* You have talked about providing low cost water to the people. What is the focus of this effort: Who will bear the cost of water transfers, users or the state:
Mike Personett - This is to be explored. Certainly the user will bear the primary share of the costs. There could be some participation by the state, especially on the front end.
Birna Foley - I want to discourage unrealistically low costs, which discourage conservation.

Question from Audience
* You have said that Phase I and Phase II are now financed. What do they cost and how are they financed?
Sam Collins, Sabine River Authority - The SRA has received a loan from the TWDB for $700,000, the City of Houston is contributing $300,000, and the SJRA is contributing $100,000.

Question from Audience
* Is there a plan for federal government sponsorship/participation?
Sam Collins - They are on the TACs and will have input.

Question from Audience
* Am I correct that there are three sponsors?
Sam Collins - Yes, there are three sponsors in the Southeast Area - SRA, Houston, and SJRA.

Glenn Phillips, Texas Eastman
* Who owns the water in Toledo Bend Reservoir?
Sam Collins - The yield of the project is split between Texas and Louisiana in accordance with the financial investment - 50-50. We might buy some water from Louisiana.
* Does Louisiana have concerns on the environmental impact of the project?
Sam Collins - They do.

Representative, Texas Department of Parks and Wildlife
* Are mechanisms to address the cumulative impacts of the project in place?
David Parkhill - That will be done as part of the environmental process.

Glenn Phillips, Texas Eastman
* Will this project ultimately come up for a vote of the people?
Mike Personett - There will be state input through the permitting process. Whether or not there is a state vote depends on the form of state financial participation, if any.

Saul Aronow, Golden Triangle Sierra Club
* Is any of the water dedicated to irrigation use?
David Parkhill - We will attempt to meet all needs.

* Will there be a differential in costs for irrigation and municipal use?
David Parkhill - We do not intend to interfere with existing contracts.

Jim Kachtick, Greater Houston Partnership
* Why is the Trinity River Authority not a project sponsor?
Danny Vance, Trinity River Authority - We had no major role to play in the project, but we are serving as advisors, and we are very interested.

Julian Coghill, Jefferson County Drainage District
* Are any other states doing projects like this, and can we learn from them?
Mike Personett - Yes, and there is a lot to learn. We plan to pay more attention to the environment and to avoid some of the turmoil we are now seeing in California. We also hope to use experience and information from the Bureau of Reclamation.

Mike Kieslich, Corps of Engineer
* Is there a public involvement/project scoping element in the program?
David Parkhill - This TAC process and meetings with the agencies will be avenues for seeking public input. The formal NEPA process will occur in Phase III.
* I would suggest that you expand scoping efforts early in the process. If you cover all the questions that interest the public up front, you may avoid having to repeat your work.
Bruce Moulton, Texas Water Commission - That was also recommended in the South-Central area.

Question from Audience
* You said that the yield of Toledo Bend is split. Is there a mechanism to determine control of flows through the reservoir?
Sam Collins - The Sabine River Compact.
* Will you consider environmental impacts in Louisiana?
David Parkhill - Yes.

Janice Bezanson, Texas Committee on Natural Resources
* To return to the economic question, I have found that the least cost alternative also usually also has the least environmental impact. You should consider the least cost methodology. For example, would paying to implement conservation measures be cheaper?
Mike Personett - We will be looking at an enhanced conservation scenario. Enhanced conservation is not likely to eliminate projects, but we expect it to change the timing and scale. Demand reduction is an integral part of our planning effort.

Gary Neighbors, Angelina-Neches River Authority

* What are the supply source alternatives under consideration?
David Parkhill - The book is open right now. Any alternative is possible, including buying Louisiana's share of the Toledo Bend yield.

Mike Kieslich, Corps of Engineers
* What is driving the schedule? It seems very ambitious. Can it be adjusted?
Chuck Settle, City of Houston
* The City of Houston sees a need for some additional water by the year 2010 or so. Given the time required to develop water supplies, we are starting a little late, and we want to get going.

Rafael Ortega, Harris County
* What project or segment of the project do you expect to have built by the year 2000?
David Parkhill - The year 2000 was mentioned as the earliest possible date that a part of the work might be completed. It is probably not a realistic date.

Question from Audience
* Please elaborate on the concept of public interest group participation.
David Parkhill - The idea is that interest groups may want to pay to get environmental benefits. Perhaps someone would want to use capacity in the canal in the early years to deliver water for environmental purposes.
Mike Personett - This kind of thing has been done in California.

Mike Kieslich, Corps of Engineers
* Will the feasibility studies look at the impact of changes in freshwater inflows to Galveston Bay?
David Parkhill - We plan to use the TWC model in Galveston Bay. We will look at the impact of the proposed actions.
Bruce Moulton - TWC has its Galveston Bay model on the front burner. We hope to have a lot of information by early next year.
* The modelling time required to simulate the bay's hydrodynamics is tremendous. Will your TWDB model be adequate?
Bruce Moulton - The regulatory agencies will be monitoring this study, and we won't let the consultants get away with murder. At this time, we are looking for a fatal flaw in any plan.

Question from Audience
* Returning to public interest group participation, I think that the need for environmental groups to purchase water for environmental purposes in California is the result of past poor planning. With proper planning, public interest groups should not have to pay to protect the environment.
David Parkhill - Payments might be for environmental enhancement.

Saul Aronow, Golden Triangle Sierra Club

* The Bureau of Reclamation recently abandoned its last reservoir project in Texas. Will the study attempt to resurrect old reservoir projects?

Jim Adams, San Jacinto River Authority - The project was not abandoned, but set aside for lack of current local interest.

David Parkhill - We do not rule out any sources. At this time, we expect that currently available sources will be more attractive and will be used first.

Bill Jackson, National Marine Fisheries

* Given the environmental impacts and costs of other sources of supply, what about desalination? It will have to be looked at along the coast.

David Parkhill - We plan to look at all alternatives. Based on studies done in the past, we expect the cost of conveyance to be far less than the cost of desalination.

Mike Personett - Desalination has very high energy costs and environmental impacts. Disposal of concentrated brine is one environmental problem, but it is being done in some parts of the state.

Question from Audience

* How often will this group meet?

Albert Gray, Sabine River Authority - We expect to meet 4 or 5 times over the next two years. We expect to do most of our work by correspondence.

Rafael Ortega, Harris County

* What will happen to the PMC as you move to subsequent phases - will the same people be in charge?

Albert Gray - We will reevaluate the role and structure of the PMC after Phase II.

Glenn Phillips, Texas Eastman

* You spoke of a doubling of population. Are you considering the environmental impacts of such large population increases?

David Parkhill - We are using the detailed population estimates from TWDB, looking for the most realistic projections we can get. We do not plan to control population growth by the water supply.

Mike Personett - We are looking at high growth, dry year needs. We can adjust the plan if growth changes from the projections. In general, TWDB projections are in the middle to low end of the range of projections.

**The following questions or comments were submitted in writing following the first TAC meeting.**

Mike Kieslich, U.S. Army Engineer, District Galveston

* "I suggest that material to be presented at the meeting be mailed to the TAC members beforehand so that we can be better prepared to contribute at the meetings."
<u>Response</u> - Meeting materials will be provided to the TAC members before the next meeting.

* "I suggest that questions be allowed at the end of each presentation..."
<u>Response</u> - The amount of information to be presented to the TAC dictated the program format. At the first meeting, a significant amount of material and issues were to be presented. We believe the importance of providing the TAC with all necessary material in the time allowed warranted this format. Future meeting formats may be revised to provide individual discussion on each topic.

* "Shouldn't representatives from Louisiana be involved in the TAC?"
<u>Response</u> - Louisiana representatives have been contacted regarding inter-state agreements for additional water supplies for the Trans-Texas project. Louisiana representatives will be periodically briefed on the status of the project.

* "How is economic feasibility of the alternatives to be determined?"
<u>Response</u> - The evaluation of conveyance alternatives will be based upon consideration of a wide range of factors including the costs to provide water, the economic impacts of water development and the environmental concerns associated with each alternative. After alternatives are developed for further study, detailed costs for capital investment and O&M will be developed for each alternative. Economic feasibility will be determined by each prospective project participant.

* "Recommend a public involvement program be undertaken to solicit comments and concerns from the general public and environmental community so that all important issues are covered in the EIS."
<u>Response</u> - Public involvement is encouraged through the agencies and organizations represented in the TAC. In addition, the Policy Management Committee will host additional public meetings to solicit public input and increase public awareness of the program. The schedule for these meetings has not yet been determined. In subsequent phases, the federal NEPA process will be strictly followed.

* "Completion of Phase II by August 1994 seems very ambitious given the environmental questions that will likely arise. Have all agencies agreed to the "scope" of environmental studies required?"
<u>Response</u> - The City of Houston anticipates a need for additional water supply by approximately the year 2010. Developing water supplies to meet the time frame requires an "ambitious" schedule.

The participants of the TTWP are in agreement with the environmental scope of work as presented to the TAC. Other agencies will be consulted during subsequent project phases and the scope will be adjusted to address additional questions.

* "Is desalination being considered as an alternative in addition to transfers from other basins?"
Response - We plan to look at many alternatives including desalination.

* "Is beneficial uses of the materials to be dredged from the canals being considered?"
Response - The use of spoil associated with construction of pipelines or canals has not yet been thoroughly investigated. The intent of the project will be to minimize the environmental consequences of spoil disposal.

* "Are cumulative environmental impacts being considered?"
Response - Yes, Phase II environmental analysis will consider impacts on the environment resulting from construction, water diversion and alteration in flows for rivers, lakes and bays in the study area over a 50-year time horizon. Cumulative impacts will be more thoroughly evaluated during Phase III.

Wayne Stupka, Coalition Advocating a Safe Environment

* "These meetings should be held when persons holding other jobs can attend."
Response -Your comment on scheduling TAC meeting times after normal business hours is appreciated and will be considered as future meetings are scheduled.

* "It is my opinion that our river basin's growth is highly dependent on our water supply and it seems we are jeopardizing our future by giving our water away. A 50 year use analysis can be very misleading and should not be the basis for what could be a monumental environmental and economic disaster."
Response - One of the primary tasks in Phase I of the Trans-Texas Water Program is to determine where surplus water supplies may exist over the next 50 years. This process will require that projected water supplies and demand for that time period be calculated for each of the river basins in the study area. The identification of surplus supply available for transfer under TTWP will only be made where supply exceeds future water needs of each river basin. Phase II of the program will examine the economic and environmental benefits and costs of the proposed conveyance alternatives.

B.D. King, U.S. Fish and Wildlife Services

* The Corps of Engineers Waterways Experiment Station in Vicksburg, Mississippi has developed a comprehensive three-dimensional model of the Galveston Bay estuary for use in assessing plans for the expansion of navigation channels. This model exceeds the capability, reliability and utility of the TWDB model, and should be used in lieu of the State's model in the assessment of impacts related to the Trans-Texas Project."
Response - We have contacted the Corps of Engineers regarding the Vicksburg, Mississippi Waterways Experiment Station's 3-D model being developed for the Galveston Bay estuary. After consultation with the staffs of the Corps of Engineers - Galveston District, and the Texas Water Development Board, it was determined that three dimensional modeling techniques are not necessary for the Trans-Texas Water Program. The Trans-Texas Water Program and the project for which this 3-D model is being developed are significantly different in scope and nature. The TTWP will propose no construction in areas adjacent to or immediately upstream of Galveston Bay. None of the alternative conveyance routes being developed should result in impacts requiring three-dimensional modeling.

* "The need for new reservoirs may be reduced by implementing a program for renovating existing reservoirs to restore original capacities ... by the removal and beneficial use of sediments which have accumulated in reservoirs since their original construction. The storage capacities thus regained may be sufficient to negate the need for new reservoirs, at least over the short term (20-30 years)."
Response - It is not anticipated that new reservoir construction will be necessary within the Southeast Area of the Trans-Texas Water Program. The program will maximize the efficient use of existing reservoir and conveyance facilities. TWDB supply projections indicate that there should be no significant decrease in reservoir capacity due to sedimentation within the time horizon of this program. Preliminary analysis of supply yield data demonstrate that capacity losses predicted in Lakes within the study area are insignificant in relation to the overall water demands. The total program area supply of 4,154,750 ac-ft/yr (in 1990) will be reduced by 47,650 ac-ft/yr or approximately 1.0% over the 50 year time period.

* "Public meetings should be held as soon as possible in all areas influenced by the proposed project."
Response - The Policy Management Committee will host public meetings to solicit input and increase public awareness of the program. The schedule of these meetings has not yet been determined.

* "This option for recapture of portions of project costs related to environmental protection or mitigation should not be pursued,

due to questions of equity. ...These costs should be borne solely by the project beneficiaries."

Response - Reference was made at the TAC meeting of situations where public interests groups had paid for environmental enhancements under a California project. Environmental concerns are an integral component of the Trans-Texas Water Program. An integrated planning approach should produce a project which accounts for environmental needs in the planning phase and avoids the need to remediate environmental impacts in the future. It is anticipated that users of the TTWP will ultimately bear the costs of the system. It is not anticipated that any public interest group would be asked to "pay to protect" any environmental resource.

* " The section entitled "New Reservoirs" states, in part, that "When reservoir capacity is 60%, the water management operations will recognize drought contingency by passing through up to the median daily flow of the stream observed during the historical drought of record". This drought was unusually severe; most estimates of its recurrence interval indicate that it was a once in 300 year drought. The specification of such an extreme drought ... as the standard to which flows would be held in times of shortage is unnecessarily constraining, and would result in unjustified increases in the frequency of such environmental impacts in the water sheds over the life of the project. The "standard drought" which triggers this flow release criterion should be defined as a drought having a 50-year recurrence interval rather that 300 years, commensurate with the anticipated life of the project."

Response - The environmental guidelines in Appendix 3 of the Program Issues document were developed as a preliminary approach to assessing environmental issues. The most stringent criteria were selected for the feasibility study to provide the greatest protection for sensitive environmental concerns. The agencies which have reviewed the preliminary guidelines have agreed that, during the study phase of the project, it was necessary to fully understand the "worst case" situations. This particular standard will only be considered in the development of new reservoirs. As currently envisioned, no new reservoir construction is anticipated within the Southeast Area of the Trans-Texas Water Program.

Birna Foley, Galveston Bay Foundation

* "Conservation - Effects of conservation measures should be carefully determined, with the recognition that a strong continuing education program may have significant impact."

Response - Trans-Texas Water Program demand projections have been developed using the Texas Water Development Board's high-case scenario population forecast with conservation efforts in place. In the development of the TTWP it is necessary to establish realistic projections for both supply and demand. The TTWP will address conservation issues including the concept of "enhanced conservation." The project is using demand projections which reflect the state's goal of increased conservation.

* "Financial methods used in Western states to rectify environmental problems in those states are probably not applicable to Texas. The Texas plan must seek to avoid the problems that Western states have encountered from water planning done decades ago, particularly the environmental problems such as inadequate instream flows and freshwater inflow to bays and estuaries."
Response - Environmental concerns are an integral part of the Trans-Texas Water Program. This integrated approach should produce a project which accounts for environmental needs in the planning phase and avoids the costs of ameliorating environmental problems in the future. Appendix 3 of the Southeast Area Program Issues details the environmental guidelines to be used in the planning phase of the program.

* "The financial, social, and environmental benefits of not doing a project such as Wallisville should be factored into the value of the Trans-Texas Water Program."
Response - The Environmental Assessment in Phase II of the Trans-Texas Water Program will examine the socio-economic and environmental impacts of the conveyance route alternatives developed by the program. This assessment will include an analysis of the "no action" alternative which will examine the consequences of relying on existing sources of supply to provide necessary water for the project area in the future.

The Honorable Oscar Nelson, County Judge, Chambers County

* "The presentations were very informative and helped me get a handle on the tasks ahead. [I] was disappointed that so many questions seemed to indicate the questioner wanted instant results"
Response - We appreciate your comments. The meeting was intended to encourage questions and comments from people who will be affected by the program. TAC members voicing their concerns in this early stage of the planning process will assure a better program at its completion.

# APPENDIX F

## TWDB Population Projections

## BRAZOS BASIN - POPULATION DATA

| COUNTY | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| AUSTIN | 16,961 | 19,039 | 20,862 | 22,485 | 23,891 | 25,196 | 26,572 |
| BRAZORIA | 13,547 | 15,058 | 16,449 | 17,728 | 18,882 | 20,348 | 21,928 |
| BRAZOS | 121,862 | 147,780 | 182,853 | 220,045 | 258,968 | 287,901 | 320,067 |
| BURLESON | 13,625 | 16,713 | 19,683 | 23,522 | 25,795 | 27,932 | 30,246 |
| FORT BEND | 62,855 | 86,784 | 112,342 | 139,329 | 164,317 | 180,052 | 197,294 |
| GRIMES | 13,397 | 16,517 | 18,817 | 21,446 | 24,316 | 25,902 | 27,591 |
| LEON | 2,285 | 2,870 | 3,116 | 3,311 | 3,512 | 3,682 | 3,860 |
| MADISON | 652 | 671 | 714 | 745 | 775 | 790 | 805 |
| ROBERTSON | 15,511 | 16,340 | 16,791 | 17,257 | 17,658 | 18,096 | 18,545 |
| WALLER | 17,716 | 20,818 | 25,073 | 28,902 | 33,897 | 35,815 | 37,842 |
| WASHINGTON | 26,062 | 30,443 | 34,269 | 37,969 | 41,531 | 44,587 | 47,868 |
| BASIN TOTAL | 304,473 | 373,033 | 450,969 | 532,739 | 613,542 | 670,301 | 732,618 |

## NECHES BASIN - POPULATION DATA

| COUNTY | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| ANGELINA | 69,884 | 76,234 | 83,083 | 88,736 | 94,895 | 101,025 | 107,551 |
| HARDIN | 41,278 | 49,091 | 56,600 | 64,676 | 73,406 | 84,561 | 97,411 |
| HOUSTON | 4,558 | 4,826 | 4,893 | 5,043 | 5,167 | 5,268 | 5,371 |
| JASPER | 19,765 | 22,298 | 23,840 | 25,728 | 28,248 | 29,667 | 31,157 |
| JEFFERSON | 55,745 | 58,322 | 62,337 | 64,632 | 66,821 | 68,558 | 70,340 |
| LIBERTY | 1,875 | 2,298 | 2,697 | 3,179 | 3,640 | 4,156 | 4,745 |
| NACOGDOCHES | 54,753 | 64,274 | 73,582 | 83,561 | 96,717 | 108,694 | 122,154 |
| NEWTON | 13 | 13 | 13 | 12 | 12 | 12 | 12 |
| ORANGE | 26,196 | 29,579 | 32,162 | 34,046 | 36,601 | 40,553 | 44,932 |
| POLK | 8,318 | 10,665 | 12,339 | 13,878 | 16,394 | 17,831 | 19,394 |
| SABINE | 2,812 | 3,035 | 3,260 | 3,431 | 3,431 | 3,396 | 3,361 |
| SAN AUGUSTINE | 7,214 | 7,507 | 7,912 | 8,235 | 8,700 | 8,905 | 9,115 |
| SHELBY | 1,939 | 1,993 | 2,085 | 2,131 | 2,179 | 2,205 | 2,231 |
| TRINITY | 3,779 | 4,467 | 5,245 | 5,824 | 6,248 | 6,642 | 7,061 |
| TYLER | 16,646 | 18,043 | 20,180 | 23,011 | 25,343 | 26,585 | 27,888 |
| BASIN TOTAL | 314,775 | 352,645 | 390,228 | 426,123 | 467,802 | 508,058 | 552,724 |

## NECHES-TRINITY BASIN - POPULATION DATA

| COUNTY | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| CHAMBERS | 7,642 | 8,348 | 11,327 | 14,513 | 17,004 | 18,836 | 20,865 |
| GALVESTON | 3,074 | 3,460 | 3,576 | 4,019 | 4,897 | 5,901 | 7,111 |
| JEFFERSON | 183,652 | 190,370 | 204,114 | 211,414 | 218,364 | 223,884 | 229,544 |
| LIBERTY | 84 | 112 | 139 | 172 | 205 | 243 | 288 |
| BASIN TOTAL | 194,452 | 202,290 | 219,156 | 230,118 | 240,470 | 248,864 | 257,808 |

## SABINE BASIN - POPULATION DATA

| COUNTY | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| JASPER | 11,337 | 12,550 | 13,424 | 14,500 | 15,937 | 16,740 | 17,583 |
| NEWTON | 13,556 | 13,872 | 13,955 | 13,970 | 14,106 | 14,251 | 14,397 |
| ORANGE | 54,313 | 59,635 | 65,952 | 71,752 | 78,947 | 87,071 | 96,031 |
| SABINE | 6,774 | 7,448 | 8,095 | 8,539 | 8,487 | 8,365 | 8,245 |
| SAN AUGUSTINE | 785 | 793 | 807 | 819 | 835 | 843 | 851 |
| SHELBY | 20,095 | 21,071 | 22,479 | 23,173 | 23,899 | 24,293 | 24,693 |
| BASIN TOTAL | 106,860 | 115,369 | 124,712 | 132,753 | 142,211 | 151,563 | 161,801 |

## SAN JACINTO BASIN - POPULATION DATA

| COUNTY | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| FORT BEND | 45,204 | 76,633 | 101,873 | 128,527 | 153,174 | 168,732 | 185,870 |
| GRIMES | 3,649 | 4,654 | 5,436 | 6,328 | 7,303 | 7,842 | 8,421 |
| HARRIS | 2,496,331 | 2,895,781 | 3,264,121 | 3,614,478 | 3,976,374 | 4,284,483 | 4,616,466 |
| LIBERTY | 14,974 | 19,578 | 25,032 | 30,525 | 36,366 | 41,538 | 47,446 |
| MONTGOMERY | 182,201 | 241,640 | 329,972 | 424,918 | 529,107 | 611,888 | 707,620 |
| SAN JACINTO | 7,479 | 9,512 | 11,970 | 14,630 | 17,262 | 18,648 | 20,145 |
| WALKER | 15,536 | 17,139 | 20,433 | 23,622 | 27,347 | 30,286 | 33,541 |
| WALLER | 5,674 | 7,452 | 9,458 | 11,014 | 13,182 | 14,034 | 14,941 |
| BASIN TOTAL | 2,771,048 | 3,272,389 | 3,768,295 | 4,254,042 | 4,760,115 | 5,177,451 | 5,634,450 |

## SAN JACINTO-BRAZOS BASIN - POPULATION DATA

| COUNTY | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| BRAZORIA | 150,868 | 175,750 | 205,735 | 232,090 | 255,767 | 284,099 | 315,569 |
| FORT BEND | 105,264 | 154,881 | 205,283 | 258,521 | 307,952 | 338,903 | 372,965 |
| GALVESTON | 214,325 | 249,454 | 294,556 | 339,070 | 388,332 | 421,538 | 457,583 |
| HARRIS | 234,922 | 286,524 | 336,563 | 385,053 | 433,616 | 484,365 | 541,053 |
| BASIN TOTAL | 705,379 | 866,609 | 1,042,137 | 1,214,734 | 1,385,667 | 1,528,905 | 1,687,171 |

## TRINITY BASIN - POPULATION DATA

| COUNTY | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| CHAMBERS | 4,204 | 4,645 | 6,043 | 7,903 | 9,496 | 10,711 | 12,081 |
| GRIMES | 1,782 | 2,272 | 2,654 | 3,089 | 3,566 | 3,829 | 4,111 |
| HARDIN | 42 | 52 | 63 | 75 | 87 | 102 | 120 |
| HOUSTON | 16,817 | 17,451 | 17,627 | 18,018 | 18,346 | 18,612 | 18,882 |
| LEON | 10,380 | 12,558 | 13,452 | 14,183 | 14,936 | 15,579 | 16,250 |
| LIBERTY | 35,172 | 43,045 | 50,938 | 59,577 | 68,301 | 78,172 | 89,470 |
| MADISON | 10,279 | 10,706 | 11,328 | 11,791 | 12,239 | 12,461 | 12,687 |
| POLK | 22,369 | 28,579 | 33,027 | 37,189 | 43,891 | 47,711 | 51,863 |
| SAN JACINTO | 8,893 | 10,975 | 13,432 | 15,966 | 18,443 | 19,747 | 21,143 |
| TRINITY | 7,666 | 8,855 | 9,991 | 10,846 | 11,467 | 12,002 | 12,562 |
| WALKER | 35,381 | 44,330 | 54,145 | 63,645 | 74,742 | 83,499 | 93,282 |
| BASIN TOTAL | 152,985 | 183,468 | 212,700 | 242,282 | 275,514 | 302,425 | 332,451 |

## TRINITY-SAN JACINTO BASIN - POPULATION DATA

| COUNTY | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| CHAMBERS | 8,242 | 9,439 | 11,367 | 13,864 | 16,075 | 17,938 | 20,017 |
| HARRIS | 86,946 | 109,572 | 124,121 | 137,730 | 151,690 | 166,292 | 182,300 |
| LIBERTY | 621 | 836 | 1,037 | 1,290 | 1,535 | 1,820 | 2,158 |
| BASIN TOTAL | 95,809 | 119,847 | 136,525 | 152,884 | 169,300 | 186,050 | 204,474 |

# APPENDIX G

## Houston Water Master Plan and H-GAC Population Projections

# HOUSTON WATER MASTER PLAN

## APPENDIX H

FINAL DRAFT

## WATER DEMANDS

MAY 1986

PROJECT NO. [illegible]

Metcalf & Eddy

TABLE 2-4. POPULATION PROJECTIONS BY MDA

| MDA | 1985 | 1990 | 2000 | 2010 | 2020 | 2030 |
|---|---|---|---|---|---|---|
| 1 | 19788 | 21123 | 20720 | 20843 | 21080 | 21822 |
| 2 | 133271 | 137234 | 136189 | 134341 | 131919 | 130477 |
| 3 | 106373 | 109936 | 114119 | 118465 | 120434 | 123334 |
| 4 | 41048 | 42790 | 44128 | 46280 | 47568 | 49697 |
| 5 | 92465 | 99187 | 96606 | 95231 | 93068 | 91743 |
| 6 | 63353 | 65882 | 64058 | 62851 | 61722 | 61268 |
| 7 | 51028 | 56726 | 60995 | 65448 | 68931 | 72629 |
| 8 | 58939 | 60518 | 59786 | 59850 | 60010 | 60342 |
| 9 | 73034 | 81558 | 91216 | 91950 | 91920 | 90888 |
| 10 | 19584 | 20431 | 21669 | 23073 | 24431 | 26337 |
| 11 | 105306 | 112938 | 116912 | 122342 | 127652 | 132366 |
| 12 | 108564 | 118133 | 114976 | 112059 | 109450 | 107316 |
| 13 | 158013 | 170408 | 178317 | 179262 | 176088 | 172845 |
| 14 | 105648 | 114114 | 121793 | 120762 | 119887 | 118838 |
| 15 | 94559 | 106199 | 108570 | 111426 | 113619 | 116384 |
| 16 | 89268 | 92252 | 96993 | 94324 | 91672 | 89589 |
| 17 | 107422 | 119279 | 137494 | 154167 | 165774 | 175954 |
| 18 | 30593 | 32098 | 35641 | 40078 | 43623 | 48048 |
| 19 | 9655 | 11419 | 17860 | 25684 | 33108 | 42227 |
| 20 | 73945 | 85422 | 104527 | 119510 | 127260 | 130775 |
| 21 | 29737 | 36076 | 56677 | 74397 | 90732 | 99034 |
| 22 | 42922 | 48745 | 66779 | 84976 | 101022 | 114319 |
| 23 | 5326 | 5458 | 5725 | 6119 | 6515 | 7063 |
| 24 | 190693 | 240618 | 306423 | 344035 | 352391 | 344915 |
| 25 | 25292 | 36843 | 61514 | 81880 | 96030 | 99475 |
| 26 | 93899 | 114334 | 162561 | 207517 | 224689 | 241381 |
| 27 | 95172 | 128770 | 173061 | 236452 | 278796 | 308422 |
| 28 | 18825 | 23829 | 36727 | 51898 | 63986 | 77893 |
| 29 | 21095 | 25620 | 38954 | 55034 | 67787 | 83446 |
| 30 | 1599 | 1745 | 2437 | 3296 | 4115 | 5136 |
| 31 | 68466 | 86863 | 164001 | 244850 | 303252 | 360673 |
| 32 | 32630 | 44183 | 72338 | 105724 | 131356 | 159029 |
| 33 | 30096 | 38741 | 64880 | 94016 | 114279 | 128758 |
| 34 | 89879 | 108405 | 114211 | 174710 | 216976 | 254371 |
| 35 | 43282 | 50530 | 66670 | 83030 | 93704 | 104828 |

TABLE 2-4. POPULATION PROJECTIONS BY MOA (continued)

| MOA | 1985 | 1990 | 2000 | 2010 | 2020 | 2030 |
|---|---|---|---|---|---|---|
| 36 | 13474 | 16202 | 20358 | 24820 | 28905 | 33823 |
| 37 | 13529 | 15549 | 20726 | 25750 | 30177 | 35625 |
| 38 | 155556 | 173450 | 198825 | 229894 | 249080 | 273472 |
| 39 | 13339 | 14441 | 15354 | 16618 | 17342 | 18203 |
| 40 | 17932 | 18199 | 17425 | 16684 | 15991 | 15330 |
| 41 | 611 | 651 | 639 | 649 | 661 | 686 |
| 42 | 7480 | 7716 | 8012 | 8429 | 8854 | 9487 |
| 43 | 71087 | 78186 | 92849. | 109163 | 119870 | 129998 |
| 44 | 21362 | 24103 | 32939 | 43785 | 54088 | 66803 |
| 45 | 15224 | 17196 | 23923 | 32115 | 39865 | 49399 |
| 46 | 51587 | 58291 | 73754 | 92497 | 108369 | 123599 |
| 47 | 78029 | 80128 | 115669 | 150428 | 183235 | 220911 |
| 48 | 87501 | 87219 | 104566 | 123478 | 139252 | 156744 |
| 49 | 31569 | 31114 | 37660 | 45721 | 53328 | 62786 |
| 50 | 133747 | 144247 | 235566 | 342367 | 423641 | 492165 |
| 51 | 52165 | 54291 | 74367 | 97846 | 116605 | 137872 |
| 52 | 6187 | 6274 | 17308 | 19816 | 22160 | 25031 |
| 53 | 6692 | 7230 | 10955 | 15533 | 19896 | 25295 |
| 54 | 18276 | 18738 | 24751 | 32201 | 39292 | 48092 |
| 55 | 44344 | 50580 | 132277 | 164610 | 192999 | 227869 |
| 56 | 33016 | 34194 | 43407 | 54871 | 65777 | 79376 |
| 57 | 28229 | 34390 | 49196 | 67307 | 84481 | 105619 |
| 58 | 59280 | 63063 | 82872 | 106831 | 128559 | 155199 |
| 59 | 36518 | 40311 | 59451 | 82724 | 104728 | 131711 |
| 60 | 24569 | 26729 | 34820 | 44740 | 54111 | 65694 |
| 61 | 7700 | 8415 | 9520 | 10942 | 12291 | 14008 |
| 62 | 10838 | 14171 | 18159 | 23079 | 27742 | 33531 |
| 63 | 52253 | 74867 | 108111 | 148024 | 183741 | 225659 |
| 64 | 78607 | 89739 | 107875 | 127043 | 144608 | 166240 |
| 65 | 65080 | 86377 | 87420 | 95841 | 101505 | 107276 |
| TOTALS: | 3566550 | 4024468 | 4994281 | 5999686 | 6745999 | 7489115 |

# HOUSTON WATER MASTER PLAN

## APPENDIX M

## DETAILED EVALUATION OF ALTERNATIVES


Metcalf & Eddy

with

Ekistics Corporation


Prepared for the City of Houston

Department of Public Works

Water Division Project Number 8891

November 1989

## REVISIONS TO HWMP BASE DATA INCORPORATED IN APPENDIX M

Information contained in the HWMP technical appendices presenting base data were affected not only by public comment but also by the passage of time during the planning process. In order to use current and accurate input data for this long-range planning process, some changes to previous work have been made. These changes are described below.

Population and Employment Growth. The Houston area experienced unprecedented growth during the sixties, seventies, and the early eighties. The mid 1980s, however, brought recession and a struggle to regain a positive growth path. Although an optimistic growth projection is considered the conservative (and correct) approach to long range water supply planning, growth projections prepared at the beginning of this project (Appendix D), which served as the basis for water demand projections, are now considered to be too optimistic. To accommodate this fact without beginning the master plan work anew, a strategy of delaying projected growth for five years was adopted. As a result, water demands originally projected for 1990 will now be expected in 1995, for 1995 in 2000, and so on throughout the planning period. The year 2030, with revised water demands, has been retained as the end of the planning period.

Water Demand Projections. Water demands based on the original population and employment growth projections were documented in Appendix H. Table 1 presents water demands for the three service areas considered in previous work: the Eight-County area, the Harris County plus Houston Extraterritorial Jurisdiction (ETJ) area, and Harris County. These water demands reflect the

# H-GAC Estimates and Projections

# Population/Employment Estimates and Projections for the H-GAC 8-County Region (at the Census Tract Level)

## For the years 1970, 1980, 1985, 1989, 1990, 1996, and 2010

Houston-Galveston Area Council (H-GAC)
Data Services Department
3555 Timmons Lane
Houston, Texas 77027
Tel (713) 627 3200 Fax (713) 621 8129



June 1992

# APPENDIX N

## Public & Agency Comments

## POPULATION, HOUSEHOLDS, AND HOUSING UNITS ESTIMATES AND PROJECTIONS FOR THE H-GAC 8-COUNTY REGION

| COUNTY | POP70 | POP80 | POP85 | POP89 | POP90 | POP96 | POP10 |
|---|---|---|---|---|---|---|---|
| HARRIS | 1738265 | 2409544 | 2723888 | 2831192 | 2818293 | 3120821 | 3717000 |
| BRAZORIA | 108169 | 169587 | 188953 | 187309 | 191707 | 214897 | 300000 |
| FORT BEND | 51957 | 130846 | 187855 | 212473 | 225421 | 265267 | 356000 |
| WALLER | 14285 | 19798 | 23757 | 25094 | 23297 | 27093 | 45000 |
| MONTGOMERY | 49479 | 128487 | 164941 | 176698 | 182201 | 216842 | 317000 |
| LIBERTY | 33015 | 47088 | 56014 | 54744 | 52726 | 55730 | 95000 |
| CHAMBERS | 12187 | 18538 | 19003 | 19289 | 20088 | 22705 | 33000 |
| GALVESTON | 169812 | 195940 | 215386 | 219166 | 217399 | 242264 | 305000 |
| REGION | 2177169 | 3119828 | 3579797 | 3725965 | 3731132 | 4165619 | 5168000 |

| COUNTY | HHLD70 | HUNITS70 | HHLD80 | HUNITS80 | HHLD85 | HUNITS85 | HHLD89 | HUNITS89 |
|---|---|---|---|---|---|---|---|---|
| HARRIS | 539893 | 587830 | 869880 | 984577 | 981444 | 1208723 | 1044570 | 1565974 |
| BRAZORIA | 30520 | 34334 | 53907 | 60458 | 60192 | 73131 | 59609 | 74120 |
| FORT BEND | 13813 | 14877 | 39840 | 43162 | 57704 | 68177 | 65449 | 75060 |
| WALLER | 3647 | 4386 | 5726 | 6718 | 7068 | 8902 | 7727 | 8786 |
| MONTGOMERY | 14892 | 18336 | 41487 | 49899 | 53299 | 65663 | 57010 | 68972 |
| LIBERTY | 10479 | 12607 | 16227 | 19806 | 19289 | 26230 | 19383 | 21430 |
| CHAMBERS | 3773 | 4239 | 6248 | 7289 | 6406 | 7646 | 6709 | 7469 |
| GALVESTON | 53004 | 61886 | 69284 | 82945 | 75669 | 99830 | 79217 | 104419 |
| REGION | 670021 | 738495 | 1102599 | 1254854 | 1261071 | 1558302 | 1339674 | 1926230 |

**SOURCE:**

This printed report is a consolidation of the following H-GAC publications:

1) "1985/2010 Estimates of Population and Employment";
2) "1988 Estimates of Employment, 13 Counties by Census Tract";
3) "1996 Population/Employment Forecasts";
4) "1989 Population, 8 Counties";
5) Other sources, like H-GAC machine-readable files, etc.

**IMPORTANT NOTE:** All 1990 data is based on census preliminary reports, and may differ from actual 1990 census data released at later dates.

Houston-Galveston Area Council (H-GAC)
Data Services Department
3555 Timmons Ln.
Houston, TX 77027
Tel. (713) 627 3200
Fax (713) 621 8129

# APPENDIX H

## TWDB Water Demand Forecasts for the Southeast Study Area

## SABINE BASIN
## TOTAL WATER DEMANDS IN ACRE-FEET/YEAR

| YEAR | COUNTY | | | | | | BASIN TOTAL |
|---|---|---|---|---|---|---|---|
| | JASPER | NEWTON | ORANGE | SABINE | SAN AUGUST. | SHELBY | |
| 1990 | 1,676 | 4,113 | 71,041 | 1,134 | 225 | 5,676 | 83,865 |
| 2000(1) | 1,860 | 4,345 | 84,629 | 1,262 | 3,524 | 5,756 | 101,376 |
| 2000(2) | 2,292 | 4,868 | 86,276 | 1,545 | 3,551 | 6,462 | 104,994 |
| 2000(3) | 1,776 | 4,261 | 84,235 | 1,212 | 3,519 | 5,621 | 100,624 |
| 2000(4) | 2,193 | 4,767 | 85,819 | 1,486 | 3,546 | 6,289 | 104,100 |
| 2010(1) | 1,975 | 4,389 | 115,162 | 1,346 | 4,291 | 6,212 | 133,375 |
| 2010(2) | 2,437 | 4,919 | 116,988 | 1,654 | 4,319 | 6,964 | 137,281 |
| 2010(3) | 1,793 | 4,206 | 114,239 | 1,236 | 4,281 | 5,909 | 131,664 |
| 2010(4) | 2,222 | 4,703 | 115,972 | 1,522 | 4,308 | 6,612 | 135,339 |
| 2020(1) | 2,112 | 4,425 | 142,005 | 1,405 | 5,049 | 6,601 | 161,597 |
| 2020(2) | 2,611 | 4,962 | 143,993 | 1,728 | 5,077 | 7,376 | 165,747 |
| 2020(3) | 1,815 | 4,160 | 140,565 | 1,239 | 5,034 | 6,130 | 158,943 |
| 2020(4) | 2,267 | 4,643 | 142,349 | 1,531 | 5,060 | 6,830 | 162,680 |
| 2030(1) | 2,292 | 4,483 | 170,402 | 1,401 | 5,821 | 7,045 | 191,444 |
| 2030(2) | 2,840 | 5,028 | 172,588 | 1,725 | 5,850 | 7,846 | 195,877 |
| 2030(3) | 1,926 | 4,165 | 168,589 | 1,217 | 5,803 | 6,480 | 188,180 |
| 2030(4) | 2,409 | 4,658 | 170,522 | 1,508 | 5,829 | 7,203 | 192,129 |
| 2040(1) | 2,397 | 4,538 | 200,688 | 1,388 | 6,702 | 7,503 | 223,216 |
| 2040(2) | 2,973 | 5,093 | 203,103 | 1,707 | 6,731 | 8,317 | 227,924 |
| 2040(3) | 1,956 | 4,173 | 198,447 | 1,177 | 6,681 | 6,855 | 219,289 |
| 2040(4) | 2,478 | 4,660 | 200,630 | 1,465 | 6,708 | 7,589 | 223,530 |
| 2050(1) | 2,507 | 4,597 | 234,263 | 1,375 | 7,720 | 8,039 | 258,501 |
| 2050(2) | 3,113 | 5,162 | 236,931 | 1,689 | 7,749 | 8,866 | 263,510 |
| 2050(3) | 1,987 | 4,184 | 231,533 | 1,139 | 7,696 | 7,307 | 253,847 |
| 2050(4) | 2,549 | 4,666 | 233,994 | 1,423 | 7,724 | 8,052 | 258,408 |

NOTES:

(1) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS
(2) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS
(3) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION
(4) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION

NECHES BASIN
TOTAL WATER DEMANDS IN ACRE-FEET/YEAR

| | COUNTY | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | ANGEL-INA | HARDIN | HOUS-TON | JASPER | JEFFER-SON | LIBERTY | NACOG-DOCHES | NEWTON | ORANGE | POLK | SABINE | SAN AUGUST. | SHELBY | TRINITY | TYLER | BASIN TOTAL |
| 1990 | 37,467 | 12,496 | 1,366 | 60,990 | 94,470 | 7,892 | 12,973 | 8 | 4,751 | 2,226 | 2,214 | 1,680 | 514 | 727 | 2,380 | 242,154 |
| 2000(1) | 45,737 | 14,817 | 1,537 | 76,114 | 105,735 | 7,957 | 15,105 | 6 | 5,690 | 2,979 | 2,884 | 1,599 | 547 | 912 | 2,987 | 284,606 |
| 2000(2) | 47,768 | 16,587 | 1,669 | 77,096 | 106,679 | 8,028 | 17,509 | 6 | 6,398 | 3,362 | 2,988 | 1,879 | 616 | 1,001 | 3,666 | 295,252 |
| 2000(3) | 45,183 | 14,486 | 1,504 | 75,956 | 105,346 | 7,939 | 14,558 | 6 | 5,497 | 2,898 | 2,864 | 1,550 | 535 | 877 | 2,863 | 282,062 |
| 2000(4) | 47,177 | 16,197 | 1,630 | 76,904 | 106,238 | 8,008 | 16,920 | 6 | 6,180 | 3,266 | 2,965 | 1,823 | 600 | 961 | 3,521 | 292,396 |
| 2010(1) | 49,720 | 15,942 | 1,533 | 87,973 | 119,986 | 8,007 | 17,143 | 4 | 5,971 | 3,344 | 3,266 | 1,670 | 558 | 1,032 | 8,300 | 324,449 |
| 2010(2) | 51,929 | 17,980 | 1,666 | 89,017 | 121,013 | 8,090 | 19,894 | 4 | 6,738 | 3,785 | 3,378 | 1,967 | 630 | 1,136 | 9,066 | 336,293 |
| 2010(3) | 48,563 | 15,134 | 1,467 | 87,627 | 119,114 | 7,967 | 15,977 | 3 | 5,553 | 3,164 | 3,222 | 1,562 | 532 | 952 | 8,020 | 318,857 |
| 2010(4) | 50,633 | 17,039 | 1,594 | 88,600 | 120,089 | 8,046 | 18,512 | 4 | 6,275 | 3,575 | 3,326 | 1,839 | 600 | 1,044 | 8,736 | 329,912 |
| 2020(1) | 52,961 | 17,152 | 1,549 | 94,292 | 137,061 | 8,069 | 19,339 | 2 | 6,121 | 3,669 | 3,615 | 1,727 | 564 | 1,122 | 18,676 | 365,919 |
| 2020(2) | 55,315 | 19,475 | 1,687 | 95,407 | 138,127 | 8,166 | 22,461 | 3 | 6,930 | 4,165 | 3,733 | 2,037 | 638 | 1,237 | 19,546 | 378,927 |
| 2020(3) | 51,171 | 15,841 | 1,448 | 93,738 | 135,736 | 8,003 | 17,398 | 2 | 5,487 | 3,387 | 3,549 | 1,565 | 523 | 993 | 18,224 | 357,065 |
| 2020(4) | 53,281 | 17,944 | 1,572 | 94,739 | 136,698 | 8,089 | 20,181 | 3 | 6,216 | 3,834 | 3,656 | 1,844 | 590 | 1,094 | 18,991 | 368,732 |
| 2030(1) | 59,907 | 18,449 | 1,565 | 108,774 | 151,861 | 8,130 | 22,167 | 1 | 6,456 | 4,125 | 3,960 | 1,809 | 569 | 1,188 | 28,992 | 417,953 |
| 2030(2) | 62,417 | 21,084 | 1,706 | 109,980 | 152,963 | 8,239 | 25,778 | 2 | 7,323 | 4,708 | 4,078 | 2,138 | 645 | 1,311 | 29,949 | 432,321 |
| 2030(3) | 57,675 | 16,786 | 1,443 | 108,096 | 150,276 | 8,044 | 19,594 | 1 | 5,684 | 3,737 | 3,885 | 1,608 | 521 | 1,028 | 28,414 | 406,792 |
| 2030(4) | 59,936 | 19,157 | 1,571 | 109,158 | 151,264 | 8,141 | 22,814 | 2 | 6,439 | 4,262 | 3,991 | 1,904 | 589 | 1,144 | 29,281 | 419,653 |
| 2040(1) | 67,726 | 20,159 | 1,579 | 125,144 | 168,364 | 8,197 | 24,870 | 1 | 6,959 | 4,455 | 4,330 | 1,845 | 573 | 1,249 | 34,166 | 469,617 |
| 2040(2) | 70,392 | 23,215 | 1,724 | 126,407 | 169,497 | 8,320 | 28,924 | 2 | 7,921 | 5,090 | 4,447 | 2,183 | 649 | 1,380 | 35,172 | 485,323 |
| 2040(3) | 65,072 | 18,038 | 1,438 | 124,333 | 166,577 | 8,089 | 21,735 | 1 | 5,966 | 4,009 | 4,244 | 1,613 | 516 | 1,064 | 33,500 | 456,195 |
| 2040(4) | 67,461 | 20,789 | 1,568 | 125,468 | 167,582 | 8,202 | 25,348 | 2 | 6,850 | 4,581 | 4,350 | 1,917 | 585 | 1,180 | 34,387 | 470,270 |
| 2050(1) | 76,652 | 22,108 | 1,596 | 144,035 | 186,891 | 8,272 | 27,954 | 1 | 7,515 | 4,816 | 4,740 | 1,882 | 577 | 1,314 | 39,349 | 527,702 |
| 2050(2) | 79,484 | 25,652 | 1,745 | 145,358 | 188,056 | 8,411 | 32,505 | 2 | 8,582 | 5,508 | 4,856 | 2,229 | 653 | 1,453 | 40,406 | 544,901 |
| 2050(3) | 73,538 | 19,432 | 1,436 | 143,083 | 184,896 | 8,138 | 24,162 | 1 | 6,268 | 4,305 | 4,644 | 1,618 | 511 | 1,102 | 38,589 | 511,721 |
| 2050(4) | 76,062 | 22,622 | 1,568 | 144,294 | 185,918 | 8,269 | 28,215 | 2 | 7,296 | 4,928 | 4,749 | 1,930 | 581 | 1,217 | 39,496 | 527,148 |

NOTES: (1) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS
(2) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS
(3) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION
(4) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION

## NECHES-TRINITY BASIN
## TOTAL WATER DEMANDS IN ACRE-FEET/YEAR

| YEAR | COUNTY | | | | BASIN TOTAL |
|---|---|---|---|---|---|
| | CHAMBERS | GALVES-TON | JEFFER-SON | LIBERTY | |
| 1990 | 80,900 | 946 | 266,080 | 12,920 | 360,846 |
| 2000(1) | 66,263 | 854 | 199,642 | 11,723 | 278,482 |
| 2000(2) | 66,494 | 909 | 202,971 | 11,726 | 282,100 |
| 2000(3) | 66,208 | 831 | 198,394 | 11,723 | 277,156 |
| 2000(4) | 66,437 | 885 | 201,600 | 11,725 | 280,647 |
| 2010(1) | 66,647 | 841 | 202,663 | 11,716 | 281,867 |
| 2010(2) | 66,961 | 897 | 206,280 | 11,720 | 285,858 |
| 2010(3) | 66,475 | 797 | 199,862 | 11,714 | 278,848 |
| 2010(4) | 66,765 | 849 | 203,299 | 11,717 | 282,630 |
| 2020(1) | 67,064 | 866 | 206,393 | 11,709 | 286,032 |
| 2020(2) | 67,469 | 929 | 210,149 | 11,714 | 290,261 |
| 2020(3) | 66,751 | 790 | 202,200 | 11,705 | 281,446 |
| 2020(4) | 67,111 | 848 | 205,580 | 11,710 | 285,249 |
| 2030(1) | 67,390 | 946 | 211,398 | 11,702 | 291,436 |
| 2030(2) | 67,865 | 1,023 | 215,284 | 11,708 | 295,880 |
| 2030(3) | 66,985 | 837 | 206,357 | 11,698 | 285,877 |
| 2030(4) | 67,407 | 903 | 209,829 | 11,702 | 289,841 |
| 2040(1) | 67,623 | 1,061 | 215,786 | 11,703 | 296,173 |
| 2040(2) | 68,148 | 1,154 | 219,776 | 11,710 | 300,788 |
| 2040(3) | 67,131 | 909 | 210,003 | 11,697 | 289,740 |
| 2040(4) | 67,609 | 995 | 213,561 | 11,703 | 293,868 |
| 2050(1) | 67,887 | 1,199 | 220,334 | 11,709 | 301,128 |
| 2050(2) | 68,467 | 1,311 | 224,431 | 11,717 | 305,925 |
| 2050(3) | 67,294 | 995 | 213,788 | 11,700 | 293,778 |
| 2050(4) | 67,835 | 1,105 | 217,433 | 11,709 | 298,082 |

NOTES:

(1) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS
(2) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS
(3) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION
(4) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION

TRINITY BASIN
TOTAL WATER DEMANDS IN ACRE-FEET/YEAR

| YEAR | COUNTY | | | | | | | | | | | BASIN TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CHAM-BERS | GRIMES | HARDIN | HOUS-TON | LEON | LIBERTY | MAD-ISON | POLK | SAN JACINTO | TRINITY | WALKER | |
| 1990 | 41,464 | 471 | 5 | 4,878 | 3,569 | 63,487 | 3,130 | 3,591 | 1,206 | 1,558 | 6,807 | 130,166 |
| 2000(1) | 15,970 | 674 | 21 | 4,608 | 3,621 | 42,314 | 3,472 | 4,283 | 1,668 | 1,603 | 14,472 | 92,706 |
| 2000(2) | 16,091 | 753 | 23 | 5,051 | 3,870 | 43,480 | 4,023 | 5,276 | 2,056 | 1,906 | 17,542 | 100,071 |
| 2000(3) | 15,940 | 656 | 21 | 4,491 | 3,522 | 42,001 | 3,395 | 4,064 | 1,584 | 1,538 | 14,138 | 91,350 |
| 2000(4) | 16,058 | 732 | 23 | 4,923 | 3,767 | 43,116 | 3,931 | 5,025 | 1,960 | 1,828 | 17,084 | 98,447 |
| 2010(1) | 16,189 | 720 | 19 | 4,634 | 3,729 | 44,741 | 3,601 | 4,843 | 1,967 | 1,771 | 26,828 | 109,042 |
| 2010(2) | 16,346 | 812 | 21 | 5,081 | 3,992 | 46,120 | 4,184 | 5,990 | 2,442 | 2,101 | 30,613 | 117,702 |
| 2010(3) | 16,102 | 681 | 18 | 4,405 | 3,543 | 43,982 | 3,427 | 4,362 | 1,759 | 1,623 | 25,980 | 105,882 |
| 2010(4) | 16,243 | 768 | 20 | 4,824 | 3,787 | 45,292 | 3,976 | 5,435 | 2,203 | 1,929 | 29,522 | 113,999 |
| 2020(1) | 16,493 | 774 | 15 | 4,696 | 3,813 | 47,227 | 3,703 | 10,370 | 2,275 | 5,166 | 38,642 | 133,174 |
| 2020(2) | 16,698 | 881 | 18 | 5,154 | 4,087 | 48,837 | 4,309 | 11,661 | 2,839 | 5,519 | 43,119 | 143,122 |
| 2020(3) | 16,325 | 708 | 14 | 4,342 | 3,535 | 46,000 | 3,447 | 9,614 | 1,938 | 4,937 | 37,270 | 128,130 |
| 2020(4) | 16,506 | 805 | 16 | 4,758 | 3,771 | 47,416 | 3,983 | 10,774 | 2,445 | 5,250 | 41,264 | 136,988 |
| 2030(1) | 16,771 | 831 | 13 | 4,752 | 3,910 | 49,740 | 3,804 | 16,208 | 2,577 | 8,528 | 50,176 | 157,310 |
| 2030(2) | 17,016 | 955 | 16 | 5,218 | 4,194 | 51,584 | 4,434 | 17,732 | 3,227 | 8,896 | 55,462 | 168,734 |
| 2030(3) | 16,546 | 748 | 11 | 4,329 | 3,566 | 48,147 | 3,498 | 15,169 | 2,143 | 8,248 | 48,378 | 150,783 |
| 2030(4) | 16,764 | 859 | 13 | 4,753 | 3,826 | 49,767 | 4,053 | 16,538 | 2,712 | 8,588 | 53,093 | 160,966 |
| 2040(1) | 17,019 | 864 | 13 | 4,797 | 3,996 | 52,397 | 3,859 | 21,688 | 2,736 | 11,883 | 51,388 | 170,640 |
| 2040(2) | 17,296 | 997 | 16 | 5,269 | 4,292 | 54,507 | 4,500 | 23,345 | 3,431 | 12,264 | 57,310 | 183,227 |
| 2040(3) | 16,743 | 765 | 10 | 4,306 | 3,601 | 50,388 | 3,505 | 20,492 | 2,227 | 11,562 | 49,193 | 162,792 |
| 2040(4) | 16,996 | 885 | 13 | 4,736 | 3,869 | 52,310 | 4,071 | 21,988 | 2,853 | 11,900 | 54,477 | 174,098 |
| 2050(1) | 17,287 | 899 | 15 | 4,843 | 4,085 | 55,385 | 3,916 | 27,207 | 2,908 | 16,878 | 52,728 | 186,150 |
| 2050(2) | 17,600 | 1,042 | 18 | 5,321 | 4,394 | 57,799 | 4,568 | 29,008 | 3,651 | 17,272 | 59,361 | 200,035 |
| 2050(3) | 16,951 | 783 | 11 | 4,283 | 3,637 | 52,880 | 3,513 | 25,836 | 2,317 | 16,513 | 50,076 | 176,801 |
| 2050(4) | 17,244 | 912 | 15 | 4,719 | 3,913 | 55,153 | 4,090 | 27,470 | 3,004 | 16,849 | 55,994 | 189,364 |

NOTES: (1) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS
(2) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS
(3) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION
(4) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION

TRINITY-SAN JACINTO BASIN
TOTAL WATER DEMANDS IN ACRE-FEET/YEAR

| YEAR | COUNTY | | | BASIN TOTAL |
|---|---|---|---|---|
| | CHAMBERS | HARRIS | LIBERTY | |
| 1990 | 12,549 | 91,268 | 22,098 | 125,915 |
| 2000(1) | 14,466 | 103,534 | 18,375 | 136,375 |
| 2000(2) | 14,651 | 105,524 | 18,397 | 138,572 |
| 2000(3) | 14,399 | 102,675 | 18,368 | 135,442 |
| 2000(4) | 14,582 | 104,631 | 18,390 | 137,603 |
| 2010(1) | 16,106 | 107,787 | 19,227 | 143,120 |
| 2010(2) | 16,334 | 110,057 | 19,254 | 145,645 |
| 2010(3) | 15,940 | 105,944 | 19,210 | 141,094 |
| 2010(4) | 16,154 | 108,135 | 19,237 | 143,526 |
| 2020(1) | 18,048 | 114,763 | 20,086 | 152,897 |
| 2020(2) | 18,334 | 117,283 | 20,121 | 155,738 |
| 2020(3) | 17,757 | 111,905 | 20,059 | 149,721 |
| 2020(4) | 18,010 | 114,179 | 20,089 | 152,278 |
| 2030(1) | 20,885 | 121,090 | 20,944 | 162,919 |
| 2030(2) | 21,223 | 123,863 | 20,985 | 166,071 |
| 2030(3) | 20,511 | 117,598 | 20,908 | 159,017 |
| 2030(4) | 20,808 | 120,103 | 20,944 | 161,855 |
| 2040(1) | 22,797 | 127,695 | 21,809 | 172,301 |
| 2040(2) | 23,173 | 130,703 | 21,858 | 175,734 |
| 2040(3) | 22,337 | 123,495 | 21,763 | 167,595 |
| 2040(4) | 22,680 | 126,210 | 21,807 | 170,697 |
| 2050(1) | 25,060 | 134,726 | 22,759 | 182,546 |
| 2050(2) | 25,479 | 137,989 | 22,818 | 186,285 |
| 2050(3) | 24,501 | 129,722 | 22,701 | 176,924 |
| 2050(4) | 24,896 | 132,665 | 22,754 | 180,315 |

NOTES:

(1) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS
(2) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS
(3) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION
(4) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION

SAN JACINTO BASIN
TOTAL WATER DEMANDS IN ACRE-FEET/YEAR

| YEAR | COUNTY | | | | | | | | BASIN TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| | FORT BEND | GRIMES | HARRIS | LIBERTY | MONT-GOMERY | SAN JACINTO | WALKER | WALLER | |
| 1990 | 21,900 | 822 | 699,177 | 3,045 | 34,590 | 1,062 | 2,735 | 23,000 | 786,331 |
| 2000(1) | 21,498 | 1,172 | 893,173 | 4,793 | 43,680 | 1,434 | 3,468 | 17,170 | 986,388 |
| 2000(2) | 23,512 | 1,334 | 971,991 | 5,178 | 53,127 | 1,767 | 4,270 | 17,420 | 1,078,599 |
| 2000(3) | 20,941 | 1,136 | 872,697 | 4,639 | 41,731 | 1,360 | 3,346 | 17,113 | 962,963 |
| 2000(4) | 22,871 | 1,292 | 948,299 | 5,012 | 50,868 | 1,681 | 4,116 | 17,355 | 1,051,494 |
| 2010(1) | 26,671 | 1,253 | 1,006,784 | 5;615 | 56,537 | 1,726 | 4,019 | 17,167 | 1,119,772 |
| 2010(2) | 29,330 | 1,442 | 1,095,987 | 6,102 | 69,422 | 2,143 | 4,992 | 17,478 | 1,226,896 |
| 2010(3) | 25,182 | 1,174 | 960,443 | 5,210 | 51,155 | 1,538 | 3,698 | 17,019 | 1,065,419 |
| 2010(4) | 27,663 | 1,350 | 1,044,544 | 5,667 | 63,187 | 1,928 | 4,616 | 17,306 | 1,166,261 |
| 2020(1) | 32,432 | 1,346 | 1,130,421 | 6,415 | 70,498 | 2,040 | 4,554 | 17,251 | 1,264,957 |
| 2020(2) | 35,770 | 1,565 | 1,229,309 | 7,012 | 87,076 | 2,550 | 5,692 | 17,612 | 1,386,586 |
| 2020(3) | 29,792 | 1,211 | 1,057,453 | 5,733 | 61,015 | 1,728 | 4,035 | 17,017 | 1,177,984 |
| 2020(4) | 32,800 | 1,410 | 1,146,650 | 6,260 | 75,575 | 2,189 | 5,045 | 17,334 | 1,287,263 |
| 2030(1) | 37,835 | 1,450 | 1,256,755 | 7,273 | 85,804 | 2,353 | 5,156 | 17,490 | 1,414,116 |
| 2030(2) | 41,802 | 1,703 | 1,365,559 | 7,984 | 106,449 | 2,954 | 6,485 | 17,918 | 1,550,854 |
| 2030(3) | 34,247 | 1,278 | 1,164,562 | 6,379 | 72,345 | 1,947 | 4,473 | 17,170 | 1,302,401 |
| 2030(4) | 37,822 | 1,507 | 1,262,719 | 7,007 | 90,939 | 2,470 | 5,654 | 17,550 | 1,425,668 |
| 2040(1) | 41,485 | 1,510 | 1,374,089 | 8,033 | 98,126 | 2,523 | 5,649 | 17,581 | 1,548,996 |
| 2040(2) | 45,849 | 1,783 | 1,491,276 | 8,858 | 122,002 | 3,172 | 7,130 | 18,036 | 1,698,106 |
| 2040(3) | 37,162 | 1,308 | 1,265,146 | 6,942 | 81,765 | 2,041 | 4,827 | 17,214 | 1,416,405 |
| 2040(4) | 41,091 | 1,554 | 1,370,863 | 7,695 | 103,371 | 2,628 | 6,142 | 17,617 | 1,550,961 |
| 2050(1) | 45,566 | 1,579 | 1,503,721 | 8,900 | 112,382 | 2,712 | 6,194 | 17,717 | 1,698,771 |
| 2050(2) | 50,367 | 1,873 | 1,629,937 | 9,857 | 139,995 | 3,412 | 7,844 | 18,200 | 1,861,486 |
| 2050(3) | 40,401 | 1,344 | 1,376,167 | 7,576 | 92,556 | 2,145 | 5,213 | 17,298 | 1,542,700 |
| 2050(4) | 44,718 | 1,608 | 1,490,004 | 8,476 | 117,655 | 2,802 | 6,676 | 17,726 | 1,689,665 |

NOTES:

(1) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS
(2) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS
(3) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION
(4) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION

## SAN JACINTO–BRAZOS BASIN
## TOTAL WATER DEMANDS IN ACRE-FEET/YEAR

| YEAR | COUNTY | | | | BASIN TOTAL |
|---|---|---|---|---|---|
| | BRAZORIA | FORT BEND | GALVES-TON | HARRIS | |
| 1990 | 180,561 | 39,547 | 113,009 | 98,633 | 431,750 |
| 2000(1) | 176,148 | 49,470 | 121,093 | 129,929 | 476,640 |
| 2000(2) | 178,830 | 53,537 | 127,714 | 140,870 | 500,951 |
| 2000(3) | 174,988 | 48,145 | 119,279 | 127,771 | 470,183 |
| 2000(4) | 177,590 | 52,038 | 125,811 | 138,319 | 493,758 |
| 2010(1) | 182,911 | 61,173 | 136,687 | 161,760 | 542,531 |
| 2010(2) | 186,082 | 66,486 | 144,672 | 174,796 | 572,036 |
| 2010(3) | 180,058 | 57,569 | 132,351 | 156,691 | 526,669 |
| 2010(4) | 183,022 | 62,488 | 139,879 | 168,873 | 554,262 |
| 2020(1) | 193,978 | 74,201 | 154,401 | 197,248 | 619,828 |
| 2020(2) | 197,578 | 80,835 | 163,710 | 212,400 | 654,523 |
| 2020(3) | 189,437 | 67,960 | 147,341 | 188,965 | 593,703 |
| 2020(4) | 192,683 | 74,007 | 155,765 | 202,649 | 625,104 |
| 2030(1) | 203,154 | 86,972 | 171,034 | 233,008 | 694,168 |
| 2030(2) | 207,135 | 94,865 | 181,777 | 250,347 | 734,124 |
| 2030(3) | 197,377 | 78,817 | 161,784 | 222,599 | 660,577 |
| 2030(4) | 200,995 | 86,011 | 171,398 | 238,319 | 696,723 |
| 2040(1) | 214,200 | 96,879 | 186,389 | 266,443 | 763,911 |
| 2040(2) | 218,633 | 105,516 | 198,065 | 286,268 | 808,482 |
| 2040(3) | 207,123 | 87,348 | 175,473 | 253,780 | 723,724 |
| 2040(4) | 211,134 | 95,016 | 186,041 | 271,724 | 763,915 |
| 2050(1) | 227,828 | 108,109 | 203,270 | 304,809 | 844,017 |
| 2050(2) | 232,765 | 117,560 | 215,959 | 327,462 | 893,746 |
| 2050(3) | 219,249 | 97,014 | 190,492 | 289,540 | 796,295 |
| 2050(4) | 223,694 | 105,183 | 202,099 | 309,993 | 840,970 |

**NOTES:**

(1) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS
(2) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS
(3) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION
(4) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION

## BRAZOS BASIN
## TOTAL WATER DEMANDS IN ACRE-FEET/YEAR

| | COUNTY | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | AUSTIN | BRAZ-ORIA | BRAZOS | BURLE-SON | FORT BEND | GRIMES | LEON | MADI-SON | ROBERT-SON | WALLER | WASH-INGTON | BASIN TOTAL |
| 1990 | 4,748 | 159,140 | 47,387 | 9,873 | 94,226 | 14,676 | 890 | 251 | 25,504 | 10,419 | 6,387 | 373,501 |
| 2000(1) | 4,837 | 203,043 | 46,419 | 14,293 | 80,358 | 16,025 | 1,111 | 355 | 48,629 | 9,364 | 7,285 | 431,719 |
| 2000(2) | 5,372 | 203,291 | 53,923 | 14,918 | 82,073 | 16,597 | 1,150 | 386 | 49,254 | 10,180 | 8,259 | 445,403 |
| 2000(3) | 4,695 | 202,944 | 45,133 | 14,171 | 79,652 | 15,902 | 1,089 | 350 | 48,501 | 9,195 | 7,065 | 428,697 |
| 2000(4) | 5,209 | 203,184 | 52,404 | 14,778 | 81,268 | 16,457 | 1,127 | 381 | 49,105 | 9,985 | 8,005 | 441,903 |
| 2010(1) | 5,110 | 259,909 | 54,067 | 14,712 | 91,483 | 16,387 | 1,094 | 357 | 50,738 | 10,025 | 7,943 | 511,825 |
| 2010(2) | 5,692 | 260,180 | 63,319 | 15,447 | 93,697 | 17,040 | 1,136 | 390 | 51,395 | 10,996 | 9,039 | 528,331 |
| 2010(3) | 4,793 | 259,690 | 50,663 | 14,411 | 89,542 | 16,113 | 1,053 | 347 | 50,476 | 9,615 | 7,427 | 504,130 |
| 2010(4) | 5,335 | 259,942 | 59,426 | 15,097 | 91,605 | 16,724 | 1,091 | 378 | 51,092 | 10,516 | 8,446 | 519,652 |
| 2020(1) | 5,342 | 322,862 | 61,945 | 15,248 | 95,182 | 21,068 | 1,072 | 358 | 59,420 | 10,691 | 8,575 | 601,763 |
| 2020(2) | 5,965 | 323,155 | 72,986 | 16,128 | 97,927 | 21,812 | 1,117 | 392 | 60,106 | 11,826 | 9,790 | 621,204 |
| 2020(3) | 4,844 | 322,526 | 56,277 | 14,746 | 91,889 | 20,623 | 1,009 | 343 | 59,033 | 10,016 | 7,753 | 589,059 |
| 2020(4) | 5,402 | 322,792 | 66,280 | 15,540 | 94,393 | 21,295 | 1,046 | 373 | 59,647 | 11,039 | 8,840 | 606,647 |
| 2030(1) | 5,549 | 326,928 | 70,305 | 15,569 | 103,546 | 25,782 | 1,051 | 358 | 68,097 | 11,521 | 9,209 | 637,915 |
| 2030(2) | 6,208 | 327,241 | 83,253 | 16,534 | 106,795 | 26,625 | 1,098 | 393 | 68,814 | 12,851 | 10,538 | 660,350 |
| 2030(3) | 4,948 | 326,509 | 62,807 | 14,939 | 99,288 | 25,210 | 972 | 340 | 67,634 | 10,635 | 8,192 | 621,474 |
| 2030(4) | 5,536 | 326,793 | 74,538 | 15,809 | 102,250 | 25,972 | 1,015 | 371 | 68,284 | 11,815 | 9,381 | 641,764 |
| 2040(1) | 5,752 | 329,718 | 76,387 | 15,872 | 105,409 | 30,327 | 1,059 | 358 | 76,793 | 11,859 | 9,779 | 663,313 |
| 2040(2) | 6,444 | 330,055 | 90,707 | 16,917 | 108,959 | 31,225 | 1,109 | 395 | 77,539 | 13,273 | 11,206 | 687,829 |
| 2040(3) | 5,055 | 329,205 | 67,739 | 15,131 | 100,454 | 29,659 | 968 | 337 | 76,268 | 10,849 | 8,565 | 644,230 |
| 2040(4) | 5,673 | 329,512 | 80,669 | 16,074 | 103,575 | 30,471 | 1,014 | 369 | 76,931 | 12,104 | 9,863 | 666,255 |
| 2050(1) | 5,976 | 332,627 | 83,124 | 16,202 | 107,613 | 37,033 | 1,070 | 360 | 89,786 | 12,216 | 10,400 | 696,406 |
| 2050(2) | 6,702 | 332,990 | 98,961 | 17,334 | 111,492 | 37,989 | 1,123 | 399 | 90,562 | 13,720 | 11,932 | 723,204 |
| 2050(3) | 5,175 | 332,010 | 73,168 | 15,337 | 101,869 | 36,260 | 966 | 336 | 89,196 | 11,073 | 8,968 | 674,358 |
| 2050(4) | 5,825 | 332,341 | 87,420 | 16,359 | 105,154 | 37,125 | 1,015 | 369 | 89,873 | 12,407 | 10,384 | 698,271 |

NOTES: (1) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS

(2) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS

(3) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION

(4) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION

# APPENDIX I

## Summary of Water Rights Permits and Contracts

SABINE BASIN: WATER PERMITS

| WRNUMBER | COUNTY | OWNER NAME | STREAM | USE | AMOUNT |
|---|---|---|---|---|---|
| 004657 | 210 | CITY OF CENTER | MILL | 1 | 1460 |
| 004658A | 176 | SABINE RIVER AUTHORITY | SABINE (1) | 1 | 100000 |
| 004662 | 176 | SABINE RIVER AUTHORITY | SABINE | 1/2 | 100400 |
| | | TOTAL: MUNICIPAL USE | | | 201860 |
| 004659 | 176 | WEIRGATE LUMBER COMPAN | LITTLE COW | 2 | 235 |
| 004664 | 181 | E I DUPONT DE NEMOURS & C | ADAMS BAYOU | 2 | 267000 |
| 004658A | 176 | SABINE RIVER AUTHORITY | SABINE (1) | 2 | 600000 |
| | | TOTAL: INDUSTRIAL USE | | | 867235 |
| 004660 | 176 | TEMPLE-INLAND FOREST PRO | UNNAMED | 3 | 50 |
| 004663 | 181 | J A HEARD ET AL | ORANGE CO DD | 3 | 67 |
| 004662 | 181 | SABINE RIVER AUTHORITY | SABINE | 3 | 46700 |
| 004658A | 176 | SABINE RIVER AUTHORITY | SABINE (1) | 3 | 50000 |
| | | TOTAL: IRRIGATION USE | | | 96817 |
| 004658A | 176 | SABINE RIVER AUTHORITY | SABINE | 5 | (2) |
| | | TOTAL: HYDROELECTRIC USE | | | (2) |
| 004661 | 176 | KIRBY FOREST INDUSTRIES IN | HARVE DAVIS | 7 | 0 |
| | | TOTAL: RECREATION USE | | | 0 |
| | | **TOTAL: SABINE BASIN** | | | **1165912** |

NOTES

1. TOLEDO BEND RESERVOIR SUPPLY
2. NO ANNUAL AMOUNT SPECIFIED; USE OF 21,000 CUBIC-FEET/SECOND

NECHES BASIN: WATER PERMITS

| WRNUMBER | COUNTY | OWNER NAME | STREAM | USE | AMOUNT | NOTES |
|---|---|---|---|---|---|---|
| 004411B | 123 | LOWER NECHES VALLEY AUTHORIT | NECHES & PINE | 1 | 0 | |
| 004402 | 174 | STEPHEN B TUCKER JR ETAL | TONKAWA | 1 | 1 | |
| 004399 | 210 | SHELBY CO FWSD NO 1 | BLACKWATER | 1 | 350 | |
| 004409 | 203 | CITY OF SAN AUGUSTINE | CARRIZO | 1 | 500 | |
| 004404 | 210 | CITY OF CENTER | SANDY | 1 | 3800 | |
| 004411B | 123 | LOWER NECHES VALLEY AUTHORIT | NECHES&PINE | 1 | 4202 | |
| 004864A | 174 | CITY OF NACOGDOCHES | BAYOU LOCO | 1 | 22000 | |
| 004415 | 123 | CITY OF BEAUMONT | NECHES | 1 | 56467 | |
| 004411B | 121 | LOWER NECHES VALLEY AUTHORIT | NECHES&ANGELN | 1 | 110000 | |
| | | TOTAL: MUNICIPAL USE | | | 197320 | |
| 004849 | 174 | STEPHEN F. AUSTIN UNIVERSITY | E FK TERRAPIN | 2 | 0 | |
| 004401 | 174 | GEORGE B FREDERICK ETAL | UNNAMED | 2 | 5 | |
| 005213 | 123 | PD GLYCOL LIMITED PARTNERSHIP | UNNAMED | 2 | 11 | |
| 005206 | 123 | FINA OIL & CHEMICAL COMPANY | NECHES | 2 | 40 | |
| 05091 | 181 | TEXAS EASTERN PRODUCTS PIPELN | NECHES | 2 | 100 | |
| 005027 | 121 | LOUISIANA-PACIFIC CORPORATION | SANDY CR | 2 | 225 | |
| 004433 | 123 | BETHLEHEM STEEL CORP. | NECHES | 2 | 268 | |
| 004412 | 121 | TEXAS PARKS & WILDLIFE | INDIAN | 2 | 811 | |
| 004436 | 123 | INDEPENDENT REFINING CORP. | NECHES | 2 | 2700 | |
| 004384 | 003 | TEMPLE-INLAND FOREST PROD COR | LITTLE CEDAR | 2 | 3000 | |
| 004435 | 123 | UNION OIL OF CALIFORNIA | NECHES | 2 | 4300 | |
| 004196 | 123 | STAR ENTERPRISE | NECHES | 2 | 12900 | |
| 004434 | 123 | MOBIL OIL CORP. | NECHES | 2 | 17922 | |
| 004393 | 003 | CHAMPION INTERNATIONAL CORP | ANGELINA | 2 | 19100 | |
| 004411B | 123 | LOWER NECHES VALLEY AUTHORIT | NECHES&PINE IS | 2 | 51314 | |
| 004186 | 123 | GULF STATES UTILITIES | NECHES RIVER | 2 | 279131 | 1 |
| 004437A | 123 | TEXACO CHEMICAL CO | NECHES | 2 | 434400 | |
| 004411B | 121 | LOWER NECHES VALLEY AUTHORIT | NECHES&ANGELN | 2 | 600000 | |
| 004438 | 181 | GULF STATES UTILITIES CO. | SABINE LAKE | 2 | 1590820 | 2 |
| | | TOTAL: INDUSTRIAL USE | | | 3017047 | |
| 005502 | 003 | A O MCQUEEN | UNNAMED | 3 | 0 | |
| 004386 | 003 | ROBERT L FLOURNOY ETAL | BRUSHY | 3 | 1 | |
| 004395 | 174 | STEPHEN B TUCKER JR ETAL | UNNAMED | 3 | 1 | |
| 003296 | 113 | JAMES ROBERT BLOUNT ET AL | UNNAMED | 3 | 2 | |
| 004862 | 174 | R M KELLERMAN & WIFE | BEECH | 3 | 3 | |
| 004387 | 229 | W C CREWS JR ETAL | GREENWOOD | 3 | 4 | |
| 004115 | 174 | FLORENCE GOODMAN WEBB ET AL | UNNAMED | 3 | 5 | |
| 004279 | 174 | HARRY L & BARBARA GERMAN | UNNAMED | 3 | 7 | |
| 004448 | 174 | CLARENCE M FORE | UNNAMED | 3 | 9 | |
| 004382 | 003 | TEXAS A&M UNIVERSITY | JACK & TRIB | 3 | 9 | |

| | | | | | |
|---|---|---|---|---|---|
| 004869 | 174 | ROBERT W MURPHEY | UNNAMED | 3 | 9 |
| 004396 | 174 | NOLAN BAILEY ALDERS | UNNAMED | 3 | 10 |
| 004430 | 229 | DAVID A. PROVOST ESTATE | BRUSH | 3 | 10 |
| 004269 | 174 | LOUIS G & FRANCES E FEARS | WAFFELOW CREE | 3 | 10 |
| 004401 | 174 | GEORGE B FREDERICK ETAL | NACONICHI&TRIB | 3 | 10 |
| 004406 | 174 | PAT SCOGGINS | BLACK | 3 | 11 |
| 003295 | 113 | BOBBY & JUANICE CUNNINGHAM | UNNAMED | 3 | 20 |
| 003299 | 113 | JOHN A WILKINS | UNNAMED | 3 | 20 |
| 003297 | 113 | E W MARTIN | UNNAMED | 3 | 21 |
| 002054 | 203 | ALVIN V NEWTON | E P AYISH | 3 | 22 |
| 003293 | 113 | W A BROWN | HARMON MILL BR | 3 | 23 |
| 005389 | 003 | DIBOLL, CITY OF | UN/WHITE OK CR | 3 | 30 |
| 003288 | 113 | DEXTER BONNETTE | UNNAMED | 3 | 30 |
| 003294 | 113 | GRADY EDGE ET AL | HARMON MILL BR | 3 | 34 |
| 004872 | 174 | A T MAST | LA NANA | 3 | 34 |
| 004429 | 229 | AUBREY T RAIFORD | SPURLOCK | 3 | 35 |
| 003299 | 113 | JOHN A WILKINS | UNNAMED | 3 | 38 |
| 004873 | 174 | A T MAST | LA NANA | 3 | 42 |
| 004397 | 174 | GRACE F. GILCREASE | MARTIN & TRIB | 3 | 42 |
| 004866 | 174 | W B STRIPLING JR | B LOCO & EVANS | 3 | 47 |
| 004863 | 174 | INTERNATIONAL PAPER CO | BLACK | 3 | 50 |
| 001614 | 174 | JOHN D RICHARDSON | CRAWFORD | 3 | 70 |
| 003287 | 113 | PERNIE BAILEY DRILLING CO | UNNAMED | 3 | 75 |
| 004426 | 229 | BURWELL F BOYKIN | ANDERSON | 3 | 80 |
| 003298 | 113 | GRADY B LAKE JR ET AL | UNNAMED | 3 | 83 |
| 003292 | 113 | DONALD CUNNINGHAM ET AL | UNNAMED | 3 | 83 |
| 003291 | 113 | CHESTER CUNNINGHAM | UNNAMED | 3 | 88 |
| 004380A | 228 | TEMPLE-INLAND FOREST PROD COR | NECHES | 3 | 100 |
| 003290 | 113 | E HUBERT BRIMBERRY | SAN PEDRO CR | 3 | 105 |
| 004403 | 174 | A T MAST JR ETAL | WAFFELOW | 3 | 111 |
| 004865 | 174 | A T MAST JR | B LOCO & TRIB | 3 | 116 |
| 004413 | 121 | TEMPLE-INLAND FOREST PROD COR | INDIAN | 3 | 120 |
| 004414 | 121 | TEXAS FOREST SERVICE | WRIGHT | 3 | 125 |
| 003289 | 113 | NEIL LOWERY | UNNAMED | 3 | 168 |
| 001935 | 113 | THOMAS H SHARTLE | SAN PEDRO | 3 | 185 |
| 004432 | 100 | PINEWOOD MANAGEMENT CORP | L PINE ISLAND | 3 | 200 |
| 004383 | 003 | CROWN COLONY COUNTRY CLUB | UNNAMED | 3 | 200 |
| 004867 | 174 | JOHN C MAST | B LOCO & TRIB | 3 | 214 |
| 004392 | 229 | DAN H BYRAM | BEAN | 3 | 250 |
| 004431 | 146 | JIM BEST | BATISTE | 3 | 354 |
| 005134A | 174 | S B HAYTER TRUST | UNNAMED | 3 | 525 |
| 004411B | 121 | LOWER NECHES VALLEY AUTHORIT | NECHES&ANGELN | 3 | 110000 |
| 004411B | 123 | LOWER NECHES VALLEY AUTHORIT | NECHES&PINE | 3 | 326360 |
| | | TOTAL: IRRIGATION USE | | | 440201 |
| 005013 | 174 | MILLER-COHLMIA TRUSTEES | UNNAMED | 7 | 0 |
| 004419 | 100 | WILDWOOD PROP OWNERS ASSOC | KIMBALL | 7 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| 004425 | 229 | TIMBERLAKES DEVELOPMENT CO. | MAGNUS & TRIB | 7 | 0 |
| 004199 | 229 | JERRY DARRELL CHANCE ET AL | UNNAMED TRIB | 7 | 0 |
| 004390 | 229 | JOHN D STOVER ETAL | UNNAMED | 7 | 0 |
| 004400 | 174 | HOLLY LAKE INC | UNNAMED | 7 | 0 |
| 004423 | 229 | JOSEPH C NICHOLS JR | UNNAMED | 7 | 0 |
| 004398 | 003 | GENE BORDERS | ROCKY | 7 | 0 |
| 004389 | 229 | COLMESNEIL ISD | ONE MILE BR | 7 | 0 |
| 004868 | 174 | LAKE ALAZAN, INC. | ALAZAN | 7 | 0 |
| 004418 | 187 | TEXAS COMM INDIAN AFFAIRS | TOMBIGBEE | 7 | 0 |
| 004394 | 003 | CITY OF LUFKIN | UNNAMED | 7 | 0 |
| 005181 | 187 | WILSON LAKE MAINTENANCE ASSOC | E FK DOUBLE BR | 7 | 0 |
| 004870 | 174 | CITY OF NACOGDOCHES | MILL POND | 7 | 0 |
| 003305 | 113 | TEMPLE-INLAND FOREST PROD COR | CONNER CREEK | 7 | 0 |
| 004871 | 174 | HANSON LAKE CLUB INC | HOYA | 7 | 0 |
| 004388 | 121 | U S FOREST SERVICE | BOYKIN | 7 | 0 |
| 004370 | 113 | EVALINE MOORE | MILES | 7 | 0 |
| 004408 | 203 | ALVIN V NEWTON | UNNAMED | 7 | 0 |
| 004391 | 229 | VIRGINIA HARALSON ETAL | WOLF | 7 | 0 |
| 004385 | 003 | TEMPLE-INLAND FOREST PROD COR | WHITE OAK | 7 | 0 |
| 004427 | 229 | F KENNETH BAILEY | UNNAMED | 7 | 0 |
| 004381 | 228 | TEMPLE-INLAND FOREST PROD COR | OLD R & CEDAR | 7 | 0 |
| 004428 | 229 | MORRIS C CLEMMONS JR | SPURLOCK | 7 | 0 |
| 004422 | 229 | CHESWOOD LAKE CLUB | UNNAMED | 7 | 0 |
| 005222 | 113 | GRAPELAND COUNTRY CLUB | SAN PEDRO CR | 7 | 0 |
| 004417 | 187 | A A WELLS | UNNAMED | 7 | 0 |
| 004416 | 187 | INDIAN SPRINGS LAKE ESTATES | W FK DOUBLE ET | 7 | 0 |
| 003306 | 113 | U S DEPT OF AGRICULTURE FOREST | LEE CREEK | 7 | 0 |
| 004379 | 003 | S W HENDERSON, JR TRUSTEE | OLD RIVER SL | 7 | 0 |
| 004407 | 203 | JOE J FISHER | AYISH BAYOU | 7 | 0 |
| 004405 | 210 | ATTOYAC HUNTING & FISHING CLUB | UNNAMED | 7 | 0 |
| 004420 | 187 | HICKORY SPRINGS POA ETAL | LITTLE HICKORY | 7 | 0 |
| 004595 | 203 | WOODLAND ACRES MAINTENANCE I | TUPELO GUM SLO | 7 | 0 |
| 004848 | 174 | J L DEDMAN | S FK PENN | 7 | 0 |
| 003300 | 113 | TEXAS PARKS & WILDLIFE DEPT | UNNAMED | 7 | 0 |
| 004424A | 229 | JOSIAH WHEAT | L TRUKEY&TRIB | 7 | 0 |
| 004421 | 187 | SAN JACINTO BAPTIST ASSN | UNNAMED | 7 | 0 |
| 004118 | 003 | EXETER INVESTMENT CO ET AL | UNNAMED | 7 | 6 |
| 004380A | 228 | TEMPLE-INLAND FOREST PROD COR | NECHES | 7 | 150 |
| | | TOTAL: RECREATION USE | | | 156 |
| | | TOTAL: NECHES BASIN | | | 3654724 |

NOTES
1. CONSUMPTIVE USE OF 6000 AC-FT/YR
2. CONSUMPTIVE USE OF 17,210 AC-FT/YER; BRACKINSH WATER; COOLING

NECHES-TRINITY BASIN: WATER PERMITS

| WRNUMBER | COUNTY | OWNERNAME | STREAM | USE | AMOUN | NOTES |
|---|---|---|---|---|---|---|
| 004495 | 123 | STAR ENTERPRISE | TAYLOR ETC | 2 | 121 | |
| 004441 | 123 | RICE-CARDEN CORP | P ARTHUR BASIN | 2 | 336 | |
| 004305 | 036 | WILLIAM S EDWARDS | ELM BAYOU | 2 | 1200 | |
| 004304 | 036 | CHARLES T JONES ETAL | EAST BAY BAYO | 2 | 5320 | |
| 004494 | 123 | CHEVRON U.S.A. INC | DD #7 CANAL | 2 | 107787 | 1 |
| | | TOTAL: INDUSTRIAL USE | | | 114764 | |
| 002627 | 036 | W H OETKEN | BATISTE | 3 | 0 | |
| 000853 | 123 | W P H MCFADDIN JR | TAYLORS | 3 | 0 | |
| 000221 | 123 | HERBERT CLUBB | MAYHAW | 3 | 0 | |
| 001615 | 036 | CARL J FITZGERALD | CANE BAYU | 3 | 0 | |
| 000275A | 123 | T A FEARS | MAYHAW | 3 | 0 | |
| 000227 | 123 | J E BROUSSARD ET AL | HILEBRANT | 3 | 0 | |
| 000305 | 123 | H E WINGATE ET AL | TAYLOR | 3 | 0 | |
| 000301 | 123 | GUY DEATON | TAYLOR | 3 | 0 | |
| 000572A | 123 | CLIFFORD MANUEL ET AL | TAYLOR | 3 | 0 | |
| 000452A | 036 | J C JACKSON ESTATE | OYSTER B | 3 | 0 | |
| 000383 | 123 | M HALF CIRCLE RANCH CO | TAYLOR | 3 | 0 | |
| 000615 | 123 | ROBIN A STEINHAGEN | BAYOU DIN | 3 | 0 | |
| 000841A | 123 | LOVELL LAKE CO | TAYLOR | 3 | 0 | |
| 004291 | 036 | JOHN G MIDDLETON, ETAL | E FK DOUBLE | 3 | 43 | |
| 004480 | 123 | CITY OF BEAUMONT | HILLEBRANDT | 3 | 55 | |
| 004463 | 123 | B E QUINN III, ETAL | N FK MAYHAW | 3 | 63 | |
| 004303 | 036 | DON W. LAGOW & WIFE | ONION BAYOU | 3 | 68 | |
| 004491 | 123 | MARVIN DUDLEY | HILLEBRANDT | 3 | 77 | |
| 004467 | 123 | LOLA GILL OWEN ETAL | S FK TAYLOR | 3 | 154 | |
| 004288 | 036 | GENE A NELSON ETAL | E FK DOUBLE | 3 | 204 | |
| 004462 | 123 | BAR C RANCH COMPANY | N FK MAYHAW | 3 | 217 | |
| 004452 | 123 | FARM CREDIT BANK OF TEXAS | S FK MAYHAW | 3 | 242 | |
| 004292 | 036 | DONALD G NELSON, ETAL | BATISTE | 3 | 250 | |
| 004458 | 123 | BAR C RANCH COMPANY | N FK MAYHAW | 3 | 276 | |
| 004445 | 123 | EDWIN A BLUESTEIN JR & WIFE | S FK TAYLOR | 3 | 335 | |
| 004473 | 123 | JIM R & H E WINGATE | S FK TAYLOR | 3 | 336 | |
| 004456 | 123 | DOROTHY NELL WILBER ETAL | N FK MAYHAW | 3 | 350 | |
| 004448 | 123 | HERBERT CLUBB AND SONS, IN | MAYHAW | 3 | 350 | |
| 004446 | 123 | RALPH M SHARPE JR, TRUSTEE | S FK TAYLOR | 3 | 350 | |
| 004290 | 036 | THOMAS L FAHRING, JR | E FK DOUBLE | 3 | 382 | |
| 004289 | 036 | OCTAVIA F STANLEY | E FK DOUBLE | 3 | 382 | |
| 004447 | 123 | JAMES L BROUSSARD ET AL | S FK TAYLOR | 3 | 396 | |
| 004461 | 123 | ROBERT L. SHELLHAMMER & W | N FK MAYHAW | 3 | 397 | |
| 004472 | 123 | JIM R. WINGATE | S FK TAYLOR | 3 | 400 | |
| 004265A | 036 | W J WINZER JR | SPINDLETOP B | 3 | 403 | |
| 004310 | 036 | W. J. WINZER, JR | SPINDLETOP | 3 | 413 | |

| | | | | | |
|---|---|---|---|---|---|
| 004486 | 123 | CARL D. LEVY, TRUSTEE | BAYOU DIN | 3 | 438 |
| 004312A | 036 | JESS MATTHEWS JR ET AL | SPINDLETOP | 3 | 470 |
| 004229 | 123 | PATRICK & MICHAEL PHELAN | UNNAMED | 3 | 480 |
| 004479 | 123 | CHEMICAL WASTE MANAGEME | FISH BOX&TAYL | 3 | 500 |
| 004478 | 123 | SHIRLA HOWARD ETAL | FISH BOX&TAYL | 3 | 500 |
| 004439 | 123 | O D & ROBERT CLUBB | N FK TAYLOR | 3 | 504 |
| 004459 | 123 | B E WILBER | MAYHAW | 3 | 511 |
| 004471 | 123 | HERBERT CLUBB | MAYHAW&SF TA | 3 | 525 |
| 004454 | 123 | RUSSELL & IVO PHEND JR | N FK MAYHAW | 3 | 539 |
| 004464 | 123 | DOROTHY NELL WILBER ETAL | N FK MAYHAW | 3 | 560 |
| 004060 | 123 | ETHEL STEPHENSON | MAYHAW BAYO | 3 | 595 |
| 004465 | 123 | WALTER J CRAWFORD ETAL | S FK MAYHAW | 3 | 600 |
| 004457 | 123 | G A N MCFADDIN ETAL | N FK MAYHAW | 3 | 607 |
| 004469 | 123 | C C WILBER | MAYHAW | 3 | 620 |
| 004294 | 036 | BROWN FOUNDATION, INC | DRAINAGE DITC | 3 | 674 |
| 004297 | 036 | GULF COAST BANK | OYSTER BAYOU | 3 | 675 |
| 004443 | 123 | JIM R WINGATE | N FK TAYLOR | 3 | 700 |
| 004444 | 123 | H E WINGATE ETAL | N FK TAYLOR | 3 | 700 |
| 004488 | 123 | J E BROUSSARD II ETAL | HILLEBRANDT | 3 | 788 |
| 004455 | 123 | BAR C RANCH COMPANY | N FK MAYHAW | 3 | 844 |
| 004300 | 036 | J. C. JACKSON ESTATE | OYSTER BAYOU | 3 | 875 |
| 004293 | 036 | LOUISE BARROW GORTON | UNNAMED | 3 | 880 |
| 004292 | 036 | ELOISE BARROW MEREDITH | UNNAMED | 3 | 880 |
| 004298 | 036 | BROWN BROTHERS FARM | OYSTER BAYOU | 3 | 891 |
| 004492 | 123 | BERNIE BROWN ETAL | RHODAIR GULLY | 3 | 900 |
| 004451 | 123 | JUNKER SPENCER ESTATE | S FK TAYLOR | 3 | 969 |
| 004490 | 123 | HARRY M HEBERT ETAL | HILLEBRANDT | 3 | 1050 |
| 004308 | 036 | L C DEVELLIER | RUSH DITCH | 3 | 1109 |
| 004264A | 036 | W J WINZER JR ET AL | SPINDLETOP B | 3 | 1123 |
| 004485 | 123 | MARGARET TODD ESTATE | BAYOU DIN | 3 | 1138 |
| 004228 | 123 | NOLIA F BOUDREAUX ETAL | SAND GULLY | 3 | 1191 |
| 004291 | 036 | SOLMON WESLEY BARROW ET | UNNAMED | 3 | 1220 |
| 004290A | 036 | DON WESLEY LAGOW ET AL | UNNAMED | 3 | 1220 |
| 005016A | 036 | JOHN M BLACKWELL | SPINDLETOP B | 3 | 1250 |
| 005069 | 123 | RUTH L MACKAN ET AL | PIGNUT GULLEY | 3 | 1250 |
| 004312A | 036 | JESS MATTHEWS JR ET AL | SPINDLETOP | 3 | 1284 |
| 004295 | 036 | JEWEL FITZGERALD | CANE & WILLOW | 3 | 1400 |
| 004474 | 123 | JOHN H. KLEIN ESTATE | TAYLOR | 3 | 1500 |
| 004468 | 123 | B E WILBER ETAL | MAYHAW | 3 | 1551 |
| 004293 | 036 | EDMONDS BROTHERS FARMS | W FK DOUBLE | 3 | 1780 |
| 004450 | 123 | JAMES L BROUSSARD & WIFE | MAYHAW&SF TA | 3 | 1800 |
| 004299 | 036 | OCIE R. JACKSON ETAL | OYSTER BAYOU | 3 | 1834 |
| 004449 | 123 | HERBERT CLUBB AND SONS INC | MAYHAW | 3 | 1862 |
| 004301 | 036 | BARROW RANCHES | ONION BAYOU | 3 | 2000 |
| 004306 | 036 | DOROTHY C MCBRIDE ETAL | ELM BAYOU | 3 | 2100 |
| 004309 | 036 | SPINDLETOP BAYOU FARMS | SPINDLETOP | 3 | 2118 |
| 004304 | 036 | CHARLES T JONES ETAL | EAST BAY BAYO | 3 | 2240 |
| 004314 | 123 | L C RUSSELL ETAL | SAND&ARCENEA | 3 | 2402 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 004466 | 123 | LOLA GILL OWEN ETAL | N FK MAYHAW | 3 | 2475 | |
| 004487 | 123 | JOHN GARDNER NELSON ETAL | HILLEBRANDT | 3 | 2483 | |
| 004453 | 123 | FARM CREDIT BANK OF TEXAS | N FK MAYHAW | 3 | 2550 | |
| 004311A | 036 | JOHN MIDDLETON | SPINDLETOP | 3 | 2700 | |
| 004481 | 123 | J E BROUSSARD II ETAL | HILLEBRANDT | 3 | 2800 | |
| 004271B | 123 | JOE BROUSSARD II PARTN, ET A | MAYHAW BAYO | 3 | 3000 | |
| 004460 | 123 | C C WILBER ETAL | N FK MAYHAW | 3 | 3150 | |
| 004100A | 123 | HARRY HOLLOWAY | WILLOW MARSH | 3 | 3358 | |
| 004484 | 123 | STEINHAGEN BROTHERS | BAYOU DIN | 3 | 3500 | |
| 004489 | 123 | TEXAS RICE LAND COMPANY | JOHNS GULLEY | 3 | 3500 | |
| 004470 | 123 | J H TAYLOR | MAYHAW | 3 | 3805 | |
| 004287 | 036 | W E JENKINS, JR ETAL | E FK DOUBLE | 3 | 4900 | |
| 000216 | 123 | JEFFERSON LAND CO | HILEBRANT | 3 | 5000 | |
| 004482 | 123 | JEFFERSON LAND COMPANY | HILEBRNT&PEVI | 3 | 5000 | |
| 004302 | 036 | U.S.-ANAHUAC NWR-BARROW | ONION BAYOU | 3 | 5932 | |
| 004313 | 123 | BRUCE WILBER PIPKIN ESTATE | SPINDLETOP | 3 | 6365 | |
| 004440 | 123 | JOHN F GAULDING ETAL | N FK TAYLOR | 3 | 7500 | |
| 004476 | 123 | LOVELL LAKE COMPANY | TAYLOR | 3 | 9477 | |
| 004574 | 123 | FARM CREDIT BANK OF TEXAS | MAYHAW BAYO | 3 | 10250 | 2 |
| 004475 | 123 | M HALF CIRCLE RANCH COMPA | TAYLOR | 3 | 12000 | |
| 004477 | 123 | JOE BROUSSARD II ETAL | TAYLOR | 3 | 14416 | |
| 004296 | 036 | U.S. ANAHUAC WILDLIFE REFU | OYSTER BAYOU | 3 | 21000 | |
| | | **TOTAL: IRRIGATION USE** | | | **192951** | |
| 004442 | 123 | CHEVRON U.S.A., INC. | N FK TAYLOR | 4 | 77 | |
| 004390A | 123 | U S DEPARTMENT ENERGY | INTRACOASTAL | 4 | 117291 | 3 |
| | | **TOTAL: MINING USE** | | | **117368** | |
| 004422 | 123 | U S DEPT OF INTERIOR | WILD COW BAY | 7 | 0 | |
| 005059 | 036 | JERE RUFF | UNNAMED | 7 | 30 | |
| | | **TOTAL: RECREATION USE** | | | **30** | |
| 004307 | 036 | TRINITY BAY CONSERVATION D | ELM BAYOU | 8 | 0 | |
| 004296 | 036 | U.S. ANAHUAC WILDLIFE REFU | OYSTER BAYOU | 8 | 0 | |
| 005317 | 123 | JEFFERSON CO NAVIGATION DI | TAYLOR BAYOU | 8 | 0 | |
| 004493 | 123 | TEXAS PARKS & WILDLIFE DEP | BIG HILL | 8 | 7000 | |
| | | **TOTAL: FLOOD CONTROL USE** | | | **7000** | |
| | | **TOTAL: NECHES-TRINITY BASIN** | | | **432113** | |

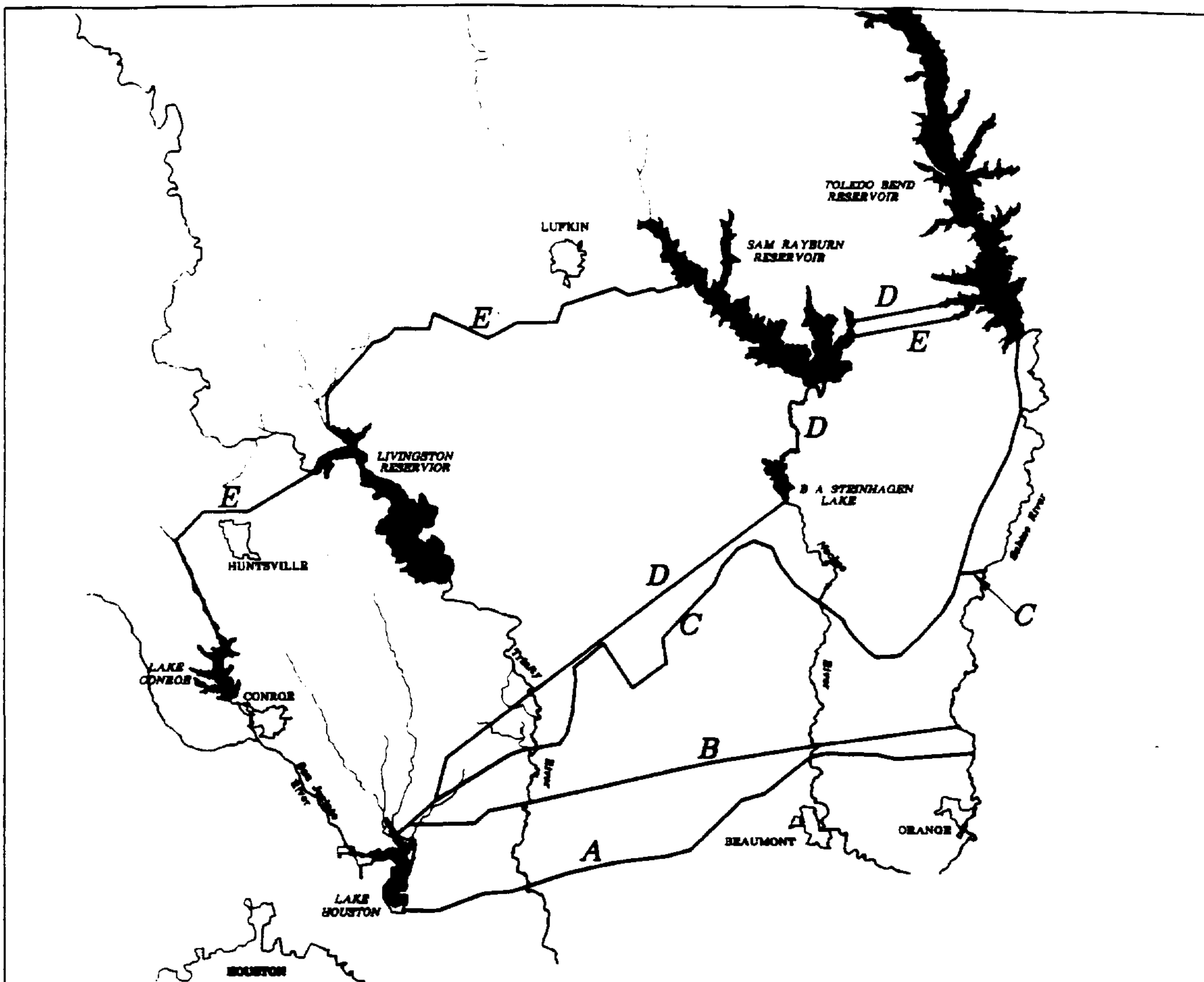
NOTES
1. CONSUMPTIVE USE OF 480 AC-FT/YR
2. EXPIRES 12/31/95
3. BRACKISH WATER

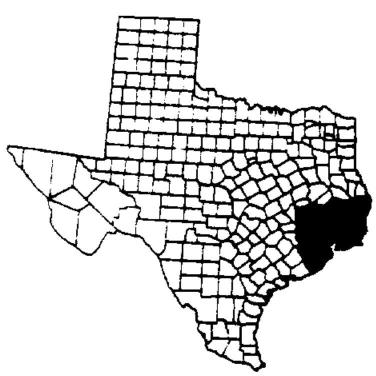
TRINITY BASIN: WATER PERMITS

| WRNUMBER | COUNTY | OWNER NAME | STREAM | USE | AMOUNT | NOTES |
|---|---|---|---|---|---|---|
| 004261 | 146 | CITY OF HOUSTON | TRINITY | 1 | 0 | |
| 004279 | 036 | CHAMBERS-LIBERTY COS ND | TRINITY ETAL | 1 | 2147 | |
| 005097 | 113 | HOUSTON CO WCID 1 | LITTLE ELKHAR | 1 | 3500 | |
| 004261 | 036 | CITY OF HOUSTON | TRINITY | 1 | 10000 | |
| 004248 | 036 | TRINITY RIVER AUTHORITY | TRINITY | 1 | 10000 | |
| 004248 | 187 | TRINITY RIVER AUTHORITY | TRINITY | 1 | 40000 | |
| 004261 | 187 | CITY OF HOUSTON | TRINITY | 1 | 444000 | |
| | | TOTAL: MUNICIPAL USE | | | 509647 | |
| 004285 | 146 | CHARLES & PAUL HAIDUSEK | WHITES | 2 | 0 | |
| 005318 | 145 | NORTHWESTERN RESOURCES CO | UNNAMED | 2 | 130 | |
| 004250 | 236 | TEXAS PARKS & WILDLIFE DEPT | HARMON | 2 | 1200 | |
| 005271 | 146 | TRINITY WATER RESERVE, INC. | TRINITY | 2 | 4000 | |
| 004248 | 036 | TRINITY RIVER AUTHORITY | TRINITY | 2 | 11600 | |
| 004261 | 036 | CITY OF HOUSTON | TRINITY | 2 | 28000 | |
| 004279 | 036 | CHAMBERS-LIBERTY COS ND | TRINITY ETAL | 2 | 30000 | |
| 004261 | 036 | CITY OF HOUSTON | TRINITY & OLD | 2 | 31600 | |
| 004248 | 187 | TRINITY RIVER AUTHORITY | TRINITY | 2 | 207150 | |
| 004261 | 187 | CITY OF HOUSTON | TRINITY | 2 | 458800 | |
| | | TOTAL: INDUSTRIAL USE | | | 772480 | |
| 001790 | 187 | PAUL LAURENT | BLACK | 3 | 0 | |
| 001923A | 113 | M L & M H KNOX | HURRICANE | 3 | 0 | |
| 004258 | 228 | C. J. RICHARDSON & WIFE | UNNAMED | 3 | 3 | |
| 005090 | 113 | E S DARSEY & WIFE | UNNAMED | 3 | 5 | |
| 004238 | 145 | RAY SIMPSON & WIFE | UNNAMED | 3 | 6 | |
| 005093 | 113 | CHARLES WENDELL WARNER ET | UNNAMED | 3 | 9 | |
| 005098 | 113 | WADE L. PENNINGTON | UNNAMED | 3 | 20 | |
| 005094 | 113 | WADE L PENNINGTON | UNNAMED | 3 | 20 | |
| 004253 | 236 | ROBERT D. JAMESON | L CAROLINA | 3 | 20 | |
| 005095 | 113 | JUDY ELAINE GOAR | UNNAMED | 3 | 40 | |
| 005087 | 113 | BEN H CAUDLE ETAL | UNNAMED | 3 | 43 | |
| 005083 | 145 | MRS A P VAN WINKLE ETAL | BUFFALO & TRIB | 3 | 50 | |
| 005096 | 113 | C D CHEATHAM JR ETAL | CANEY & TRIB | 3 | 51 | |
| 004233 | 113 | M. H. KNOX & WIFE | HURRICANE & | 3 | 65 | |
| 004230 | 113 | ELSIE ANNE EAKIN | UNNAMED | 3 | 67 | |
| 005086 | 113 | WILLIE BEDFORD CASKEY | CHAFFIN | 3 | 70 | |
| 005088 | 113 | HENRY C BROWN ESTATE ETAL | BIG ELKHART | 3 | 80 | |
| 004232 | 113 | SPRING CREEK COUNTRY CLUB | SPRING CREEK | 3 | 81 | |
| 005091 | 113 | ARWINE SKIDMORE ESTATE | UNNAMED | 3 | 83 | |

| | | | | | |
|---|---|---|---|---|---|
| 005092 | 113 | JAMES KENT DAILEY ESTATE | UNNAMED | 3 | 84 |
| 004254 | 113 | ERNEST MARIETTA & WIFE | UNNAMED | 3 | 88 |
| 005089 | 113 | ERNEST E HUFF | UNNAMED | 3 | 88 |
| 004231 | 113 | BISON DEVELOPMENT CO. | HAMMOND | 3 | 100 |
| 004284 | 146 | STEPHEN & LOUIS MECHE | WHITES | 3 | 104 |
| 004256 | 228 | WESTWOOD SHORES, INC. | UNNAMED | 3 | 150 |
| 005075 | 113 | JOHN A MCCALL, ET AL | TRINITY&QUALE | 3 | 170 |
| 004234 | 113 | O. O. BROWN, TRUSTEE ETAL | TRINITY & TRIB | 3 | 170 |
| 004282 | 146 | L B MAXWELL ETAL | UNNAMED | 3 | 172 |
| 005085 | 145 | C W KENNEDY III ETAL | U KEECHI/TRIN | 3 | 175 |
| 004249 | 236 | TEXAS DEPT. OF CORRECTIONS | TURKEY | 3 | 179 |
| 004281 | 146 | JACK STOESSER ETAL | COW ISLAND | 3 | 232 |
| 004086 | 113 | ALICANTE CORPORATION N V | HURRICANE | 3 | 339 |
| 004235 | 113 | GRADY B. LAKE, JR. | TRINITY | 3 | 353 |
| 004280 | 146 | GEORGE W MAXWELL | COW ISLAND | 3 | 395 |
| 004285 | 146 | CHARLES & PAUL HAIDUSEK | WHITES | 3 | 440 |
| 005076 | 113 | RLG REALTY HOLDINGS LTD | TRINITY | 3 | 500 |
| 005061A | 113 | JOHN W KLEIN | LTL ELKHART C | 3 | 500 |
| 004283 | 146 | JOHN I LOVELL & A REESE BROW | NF LONG ISLAN | 3 | 640 |
| 004240 | 157 | TEXAS DEPT. OF CORRECTIONS | TRINITY & TRIB | 3 | 701 |
| 004286 | 036 | JETT HANKAMER & SONS | WHITES | 3 | 710 |
| 004241 | 113 | TEXAS DEPT. OF CORRECTIONS | TRINITY & TRIB | 3 | 961 |
| 005061A | 113 | JOHN W KLEIN | BIG ELKHART CR | 3 | 1000 |
| 004239 | 113 | SEVEN J STOCK FARM, INC. | TRINITY | 3 | 1240 |
| 004269 | 146 | TRINITY PLANTATION, INC ETAL | MENARD | 3 | 1932 |
| 002640 | 146 | PRICE & ELLEN DANIEL TRUSTEE | JOSIE BAYOU | 3 | 2400 |
| 004261 | 036 | CITY OF HOUSTON | TRINITY & OLD | 3 | 13400 |
| 004248 | 036 | TRINITY RIVER AUTHORITY | TRINITY | 3 | 30000 |
| 004277 | 146 | DAYTON CANAL CO. | TRINITY ETAL | 3 | 38000 |
| 005271 | 146 | TRINITY WATER RESERVE, INC. | TRINITY | 3 | 47500 |
| 004248 | 187 | TRINITY RIVER AUTHORIY | TRINITY | 3 | 104450 |
| 004279 | 036 | CHAMBERS-LIBERTY COS ND | TRINITY ETAL | 3 | 110000 |
| | | TOTAL: IRRIGATION USE | | | 357886 |
| 004279 | 036 | CHAMBERS-LIBERTY COS ND | TRINITY ETAL | 4 | 800 |
| 005271 | 146 | TRINITY WATER RESERVE, INC. | TRINITY | 4 | 7000 |
| | | TOTAL: MINING USE | | | 7800 |
| 004263 | 187 | WIGGINS LAND CO. | UNNAMED | 7 | 0 |
| 004268 | 146 | EILEEN FOWLER, ATTORNEY, ET | MILL | 7 | 0 |
| 004244 | 093 | DARRELL R. HALL | ROCKY | 7 | 0 |
| 004262 | 187 | THE NATURE CONSERVANCY | UNNAMED | 7 | 0 |
| 004276 | 146 | PRICE & ELLEN DANIEL, TRUSTEE | LAKE BAYOU | 7 | 0 |
| 004260 | 204 | MITCHELL DEVELOPMENT CORP. | UNNAMED | 7 | 0 |
| 004243 | 157 | CITY OF MADISONVILLE ETAL | TOWN | 7 | 0 |
| 004259 | 204 | HOWARD T. HARSTAD | SCHOFIELD | 7 | 0 |

*Bon Weir Project*, Texas Basin Project, Bureau of Reclamation, Published 1985 (10).



LOCATION MAP

## FIGURE B-1
## ALTERNATIVE ROUTES FROM PREVIOUS STUDIES

NOTE: THIS IS ONLY A SCHEMATIC, NOT A DETAILED DRAWING

LEGEND

- CITY
- MAJOR RIVER
- STREAM
- RESERVOIR

ROUTE A. FREESE & NICHOLS INC., CONSULTING ENGINEERS, ***PRELIMINARY FEASIBILITY STUDY, INTERBASIN WATER TRANSFER FROM THE SABINE RIVER TO THE SAN JACINTO RIVER AUTHORITY SERVICE AREA,*** NOVEMBER 1989.

ROUTE B. WAYNE SMITH & ASSOCIATES, INC., ***FEASIBILITY STUDY, INTERBASIN TRANSFER, SABINE TO SAN JACINTO,*** 1987.

ROUTE C BUREAU OF RECLAMATION, ***BON WEIR PROJECT, PART OF THE TEXAS BASINS PROJECT, TEXAS,*** MARCH 1985.

ROUTE D METCALF & EDDY, ***HOUSTON WATER MASTER PLAN, APPENDIX M, DETAILED EVALUATION OF ALTERNATIVES,*** NOVEMBER 1989.

ROUTE E PATE ENGINEERING, INC. ***SAN JACINTO RIVER AUTHORITY, WATER RESOURCES DEVELOPMENT PLAN,*** MAY 1988

# APPENDIX C

## Phase I Work Plan and Guidelines

## PHASE I

Phase I, Project Initiation/Conceptual Planning, includes the following major elements:

- Agency/Public Coordination
- Program Formulation
- Conceptual Planning
- Contract Administration

For purposes of the Program, the Southeast Area study area will consist of the 35 Texas counties which exist within the Brazos, San Jacinto, Trinity, Neches, and Sabine River basins and which are included within the Southeast Texas and Upper Gulf Coast Region defined in the amended 1990 Texas Water Plan.

### 1.0 AGENCY/PUBLIC COORDINATION

This initial task is designed to establish the administrative, management and technical, organizational committee framework for the southeast portion of the Program.

1.1 Policy Management Committee

1.1.1 The Policy Management Committee (PMC) will coordinate policy, technical, and informational matters associated with the Program and approve project reports. This task consists of attending six (6) PMC meetings and monitoring the program progress during Phase I.

1.2 Technical Advisory Committee

1.2.1 Assist the Southeast Area sponsors to establish the Technical Advisory Committees (TAC's) and attend up to five (5) meetings.

### 2.0 PROGRAM FORMULATION

2.1 Goals and Objectives

Assist the Policy Management Committee and Technical Advisory Committees to establish goals and objectives for the Program.

2.2 Issues Development

2.2.1 Collect information from existing studies and reports from the TWDB, TWC, TPWD, City of Houston, SJRA, SRA, TRA, BRA, LNVA, COE, the Bureau of

Reclamation, and others regarding issues of concern associated with development of major water resources projects within southeastern Texas.

2.2.2 Prepare separate "work papers" which investigate and compile potential questions, data needs, resource needs, and assessment methods for the following five issue areas: Engineering, Environmental, Institutional, Legal, and Financial.

**2.3 Issues Implementation Plan**

2.3.1 Facilitate discussion of each work paper issue before the Policy Management Committee and Technical Advisory Committees.

2.3.2 Formulate a Program issue action plan which will be implemented during subsequent phases.

**3.0 CONCEPTUAL PLANNING**

**3.1 Southeast Area Population, Water Demands and Supplies**

3.1.1 Collect information from the TWDB and other studies regarding the location and nature (water quality, quantity, etc.) of existing and projected water demand within the study area. Assess demand for study years 2000, 2010, 2020, 2030, 2040, and 2050 on a gross basis (municipal, industrial, agricultural, and irrigation) within each river basin study area using TWDB high numbers with conservation.

3.1.2 Using the existing and proposed water supply sources identified in the amended 1990 Texas Water Plan, summarize existing data on ground and surface water availability in the study area for each basin. Tabulate major water supply contracts, interbasin transfers, existing reuse projects, groundwater management plans, instream flow commitments and adjudicated water rights within the study area. Using the appropriate environmental and regulatory guidelines as adopted by the PMC and attached as Attachment 1 to this Exhibit A, recalculate availability of the water supplies and then tabulate existing and future water surpluses and shortages in each basin.

3.2 **South–Central Area Population, Water Demands and Supplies**

3.2.1 Collect general information from the TWDB and other agency studies regarding existing and projected water demands within the South–Central Area of the Trans–Texas Water Program. This study area is defined as the portions of the Colorado, Guadalupe, San Antonio, Nueces, and Lavaca river basins contained within the South Texas and Lower Gulf Coast, and South Central Texas regions of the amended 1990 Texas Water Plan. For purposes of the Program, computation of population and water demand for the entire above described region will be aggregated in total for study years 2000, 2010, 2020, 2030 2040, and 2050.

3.2.2 Collect and summarize general information on available water supplies in the South–Central Area from data supplied by TWDB. Compute the gross total water deficit for the South–Central Area which could potentially be supplied by interbasin transfers from the Southeast area.

3.3 **Existing Conveyance Facilities**

3.3.1 Collect information on existing conveyance facilities which could be used to meet water transfer needs in the Southeast planning area. Information to be collected includes ownership, condition (including estimated channel loss rate), conveyance capacity, and availability for alternative uses.

3.4 **Toledo Bend Reservoir–Louisiana Supply**

3.4.1 Identity the institutional and financial issues related to purchasing water supplies which are currently owned by the State of Louisiana within the Toledo Bend Reservoir for further use in Texas.

3.5 **Alternative Water Supply Plans**

3.5.1 Using supply sources and environmental guidelines identified in Task 3.1.2, create conceptual water supply transfer plans for the Sabine, Trinity, Neches, Brazos, and San Jacinto river watersheds which satisfy the projected 50–year water shortages within each basin, the South–Central Area, and the specific short–term needs within the San Jacinto River basin. The plans will consider existing water supplies within the Southeast Area study area and, if possible, the State of Louisiana. Supply transfers will be proposed to link the five river basins with conveyance facilities and consider the basins as a system for both physical conveyance and water transfers to meet identified water shortages.

3.6 Report Preparation

3.6.1 Prepare a report including Executive Summary, which outlines the work completed for the above tasks and submit deliverables as follows:

a. Draft – 40 copies (15 copies to TWDB and one copy to each PMC members).

b. Final – 75 copies, double-sided on recycled paper (15 copies to TWDB and 5 copies to each PMC member).

c. Executive Summary – 100 copies (50 copies to TWDB and one copy to each PMC member).

d. Camera ready copy of final report, including Executive Summary

e. Graphical report data in digital format if available in that media.

4.0 CONTRACT ADMINISTRATION

4.1 Program Coordination

Attend up to six (6) project status meetings and provide technical input, as required, to coordinate the work efforts and results of the Southeast Area and South-Central Area projects.

4.2 Progress Reports

4.2.1 Prepare six (6) monthly progress reports and monthly billings which summarize the work completed through each work period. The monthly progress report will contain the following information:

- Four major Phase I task names and description.
- Total manhours and cost budgeted for each major task.
- Percent of the tasks completed.
- Dollar value of the percent of the tasks completed.
- Total tasks completed, indicating the percent of and dollar value of the project completed as reflected in totals of all vouchers submitted.
- Description of the work to be completed in the next reporting period.

4.2.2 Prepare and update schedules, budgets, and the work plan, as required, to illustrate the project status.

PHASE II

Phase II – Feasibility Studies includes the following major elements:

- Committee assistance
- Planning studies
- Environmental studies
- Estuary analysis
- Preliminary implementation studies
- Contract administration

1.0 COMMITTEE ASSISTANCE

This initial task is designed to allow further coordination between all appropriate agencies and potential participants in the project. Proposed meetings would be early enough in the work effort to allow adjustment to study efforts if warranted.

1.1 Meetings

1.1.1 Attend up to eighteen (18) Policy Management Committee and eighteen (18) Technical Advisory Committee meetings to discuss plans for diversions from the Sabine River to the west, to review the proposed approach to the work, parameters for system design, environmental permitting processes, etc.

1.2 Meetings Support

1.2.1 Develop exhibits, graphics, technical data, etc. to support the Policy Management Committee and Technical Advisory Committee meetings referenced in Task 1.1.1.

2.0 PLANNING STUDIES

The purpose of this task is to collect and review available data on water demand, available supplies and water quality. An analysis of the data will be conducted to establish the general project parameters.

2.1 Water Demands

2.1.1 Disaggregate the water demands compiled in Phase I for specific municipal, industrial, agricultural, and irrigation users in the lower Sabine River, Trinity River, Neches River, Brazos River, and San Jacinto River basins during the next 50–year period.

2.1.2 Acquire data on existing water conservation measures and plans of the Sabine River Authority, the San Jacinto River Authority, Trinity River Authority, Neches River Authority, Brazos River Authority, the City of Houston and other potential participants in the project.

2.1.3 Assess potential program elements and benefits which could result from implementation of water conservation (reuse, retrofit, etc.) initiatives in Texas since completion of the 1990 Texas Water Plan. Revise updated water demand projections in Task 2.1.1 considering the future effects of recently adopted conservation measures which have included passage of Senate Bill 587, revised irrigation practices, etc.

2.1.4 Update, as necessary, future (50–year period) water demand projections for each major water user.

**2.2 <u>Water Rights</u>**

2.2.1 Acquire data on the firm yield of Toledo Bend Reservoir.

2.2.2 Acquire data on existing or planned water supplies of specific users (other than Toledo Bend Reservoir) within the five southeastern river basins.

2.2.3 Acquire data on existing water rights of specific users in the lower Sabine, Neches, Trinity, Brazos, and San Jacinto River basins.

2.2.4 Determine the quantity of surface water required to meet future unserved water demands identified in Tasks 2.1.4.

2.2.5 Recommend revisions to existing water rights permits as appropriate to meet identified needs.

2.2.6 Determine necessary contract and permit amendments required to implement water rights recommendations.

**2.3 <u>Supply Alternatives</u>**

2.3.1 Develop additional supply alternatives based on information collected following development of the Phase I alternatives. Compile all of the alternatives.

**2.4 <u>Water Quality</u>**

2.4.1 Acquire existing data on water quality and treatability of Sabine River water.

2.4.2 Acquire data on water quality and treatability of water which may be mixed with Sabine River water in delivery, including Neches, Trinity, Brazos, and San Jacinto River water.

2.4.3 Acquire data on existing water treatment processes at the City of Houston's East and Southeast Surface Water Treatment Plants and other existing surface water treatment plants.

2.4.4 Using available literature, propose a conceptual treatment process for Sabine River water and for mixtures of Sabine River and Neches, Trinity, Brazos, and San Jacinto River waters.

2.4.5 Determine preliminary conceptual process modifications, if required, at the existing surface water treatment plants for Sabine River water and all of the potential water mixtures. Include a planning grade estimate of costs to modify existing facilities, if required, for all of the above water mixtures. Develop a program of detailed treatability studies to be performed in Phase III.

**2.5 <u>Planning Studies Report</u>**

2.5.1 Prepare and submit a report in accordance with the deliverables outlined in Task 3.6.1 in Phase I which summarizes the analysis methods, background data, assumptions, and findings of the above studies.

**3.0 ENVIRONMENTAL STUDIES**

The purpose of the environmental studies provided herein shall be to provide factual information for use in meeting the requirements of the National Environmental Policy Act and other federal and state laws for permits and approvals for the Project.

The engineer shall solicit input on methodologies to be used in the environmental studies from the TWDB, TWC, COE, TPWD, Bureau of Reclamation, City of Houston and SJRA.

**3.1 <u>Meetings</u>**

3.1.1 Attend up to ten additional coordination meetings with governmental agencies and other interested parties which have special interest in the environmental aspects of the project. These meetings would consist of discussions of the proposed project approach, major project elements, etc., and would be designed to elicit further discussions of concerns, questions or comments regarding the project.

3.1.2 Document results of all meetings and issue summaries of comments, etc.

3.2 <u>Environmental Baseline</u>

3.2.1 Collect existing environmental data for:

- Topographic maps
- Geological data
- Meteorological data
- Water quantity and quality data
- Air quality data

3.2.2 Collect and identify data on:

- Federal lands and collect management plans along routes
- Wetlands along routes
- Endangered species and critical habitat areas along routes
- Historical and archaeological sites along routes

3.2.3 Collect and characterize data on:

- Terrestrial ecosystems
- Aquatic ecosystems

3.3 <u>Environmental Analysis</u>

Prepare an environmental analysis assessment. Some non–intensive field investigation is included in this assessment.

3.3.1 <u>Project Purpose and Needs</u>. This element will consist of information developed in the Planning Studies task to establish the purpose and need for the project and will include the following elements:

3.3.1.1 Water needs, current and future.

3.3.1.2 Present water supply.

3.3.1.3 Potential new supplies.

3.3.1.4 Conservation measures.

3.3.1.5 Environmental needs based on the adopted environmental guidelines.

3.3.2 Conceptual Engineering. This element will create a prototypical project suitable to convey required water demands. This prototypical project will be applied to each route alternative to comparatively assess each route.

3.3.2.1 Based on required water volumes and generally accepted facility design criteria, prepare typical section schematics for canals, pump stations, pipelines and associated appurtenances capable of conveying the determined flows.

3.3.2.2 Determine the need and capacity, if required, of terminal storage facilities for Sabine River water for each alternative.

3.3.2.3 Using the potential conveyance routes identified in Task 2.3.1, and the typical section schematics of Task 3.3.2.1, determine a specific infrastructure project for each conveyance route.

3.3.2.4 Determine the conveyance capacity of existing canal pipeline and pump station facilities which may be used in alternative alignments and determine required additional typical facilities if existing facilities can not convey necessary water supplies.

3.3.2.5 Prepare standardized unit costs for those facilities outlined in Tasks 3.3.2.3 and 3.3.2.4.

3.3.3 Environmental Impacts. This element will analyze the environmental impacts of alternative conveyance routes.

3.3.3.1 Analyze the impacts of interbasin water transfers on water quality of Trinity River, Neches River, San Jacinto River, Brazos River, canals, and other receiving bodies of water. Analyze effect of releases during different flow conditions, and discuss effects of increased flows in canals.

3.3.3.2 Analyze water quality during drought conditions, and during normal operating conditions.

3.3.3.3 Present a preliminary analysis of fisheries impacts.

3.3.3.4 Analyze the impacts of interbasin transfers on aquatic species. Determine dominant and rare species for each river basin; analyze water quality impacts on important species (salinity, DO, etc.); address other interbasin transfers within State, historically and presently, and discuss biological impacts of species transfer.

3.3.3.5 Analyze impacts on in–stream uses (boating, fishing, canoeing, public water supply, irrigation, etc.).

3.3.3.6 Discuss impacts to endangered and threatened species along each route.

3.3.3.7 Analyze terrestrial habitat loss; impact on wildlife resources.

3.3.3.8 Determine impacts to wetlands and navigable waters.

3.3.3.9 Assess impact of project on identified historical/archaeological sites.

3.3.4 Conveyance Alternatives. Analyze conveyance alternatives for screening. Appropriate alignments and project configurations will be identified. Alignments with excessive environmental impacts will be eliminated from further study. Preferred alternative(s) will be identified.

3.3.4.1 Establish screening criteria in cooperation with the PMC.

3.3.4.2 Propose rankings for each alternative based on the approved criteria.

3.3.4.3 Recommend the desirable alternatives for further analysis based on environmental and engineering factors.

3.3.5 Report Preparation. This element will document the above findings.

3.3.5.1 Prepare and submit, in accordance with the deliverables outlined in Task 3.6.1 in Phase I, an environmental analysis report which documents the above findings.

**4.0 ESTUARY IMPACT ANALYSIS**

**4.1 Sabine Lake**

4.1.1 Data Collection. Historical data generated from automated samples of salinity, intensive inflow surveys, and U.S.G.S. flow records will be collected.

4.1.2 Correlation Analysis. Correlation and regression analysis will be used to define the flow/salinity relationships and to analyze varying freshwater flow regimes.

4.1.3 Impacts. Determine the impact of decreased freshwater inflows resulting from various alternative routes on Sabine Lake within the aquatic community in the lake.

**4.2 Galveston Bay**

4.2.1 Data Collection. Obtain the TWDB's calibrated hydrodynamic and water quality model of Galveston Bay, U.S.G.S. flow data, and any appropriate studies from the Galveston Bay National Estuary Program.

4.2.2 Model Analysis. Calibrate the TWDB model based on flow and water quality data determined in the Planning Studies and Environmental Studies portions of this project.

4.2.3 Impacts. Determine the impacts resulting from various alternative routes on salinity, sediments, freshwater inflow, fisheries, the nutrient budget, flow regime and circulation.

**4.3 Study Report**

4.3.1 Prepare and submit, in accordance with the deliverables outlined in Task 3.6.1 in Phase I, an estuary analysis report which document the above findings.

**5.0 PRELIMINARY IMPLEMENTATION STUDIES**

**5.1 Institutional/Legal Issues**

This element will determine, compare, and contrast legal issues and requirements of the preferred route alternatives.

5.1.1 Construction-Related Legal Requirements. Three categories of legal issues will be analyzed to support construction of the project:

- Environmental/Regulatory Permits.
- Utility/Construction Easements.
- Land/ROW Acquisition

5.1.1.1 Environmental/Regulatory Permits – A comprehensive listing of the specific regulatory permits will be established, with anticipated schedules and coordination steps likely to be required for each permit.

5.1.1.2 Utility/Construction Easements – An initial list of highway, railroad, pipeline, or other utility crossings which require a permit or licensing agreement will be developed for each route alternative. The typical procedures and schedules for permit approval will be described.

5.1.1.3 Land/ROW Acquisition – A summary of the expected property acquisition requirements for the entire project will be developed, showing approximate number and size of parcels along each route. Based on these approximate numbers, recommendations will be developed for schedule, budgets, and specific specialists to be used in the acquisition process.

5.1.2 Long-Term Contractual Requirements. Sponsors and users of the conveyance project must also establish necessary contractual agreements governing the project.

5.1.2.1 Water Purchase Agreements – Each user of the raw water purchased from this conveyance system will require a long-term contract for that water. Alternative institutional arrangements necessary for executing water purchase agreements will be identified and qualitatively evaluated. Key issues to be resolved in the purchase agreements will also be identified.

5.1.2.2 Existing Facility Usage Agreements – Existing facilities proposed to be included in the project will require a formal contract governing usage including, but not limited to, identification of liabilities for operation and maintenance, cost recovery, and resolution of conflicts during joint use (if any). An outline of these issues for each specific facility will be developed.

5.1.2.3 Operation and Maintenance Agreements – New facilities may also require operation or maintenance agreements between owners and users, depending on the institutional arrangements adopted for this project. If so, preliminary outlines of the issues for each agreement will be developed under this task.

5.2 **Financing/Cost Issues**

Based upon the expected capital costs and contingencies for the project developed in previous elements of the program, more detailed evaluation of financing and cost data will be required for the implementation plan as follows:

5.2.1 Implementation Costs. Based upon the unit cost established in the conceptual engineering phase during Task 3.3.2, develop the project cost associated with implementing the recommended preferred alternatives including:

- Facility Capital Costs.
- Engineering, surveying, and related technical services.
- Legal, financial, and special consulting services.
- Land and easement acquisition.
- Water rights and changes in treatment costs.
- Permitting and environmental mitigation.

5.2.2 Estimate of Operation and Maintenance Costs. Based on the final recommended plan, an initial estimate of all significant O&M costs expected for the project will be developed, including:

- Pump operation, maintenance and replacement.
- Energy costs.
- Canal maintenance and repairs.
- Staff requirements for routine maintenance.
- Emergency repairs.
- Salvage value estimates for major components.

5.2.3 Preliminary Financing Plan. The services of an expert financial consultant shall be obtained to establish a preliminary financing plan tailored to meet the project requirements and serve the individual project participants. Working closely with the sponsors, end users, and TWDB, a preliminary plan will be developed to address the various needs of the participants.

5.2.4 Pricing Policies. The recommended unit cost for the delivered water will be calculated based on the various factors established in Tasks 5.2.1 and 5.2.2 and a cost-allocation formula will be developed for the proposed participants in the project. If reserve capacity is provided in the conveyance system, the issue of future costs for subsequent users will be addressed. Several alternative financing scenarios will be identified for further evaluation.

5.3 Schedule/Phasing Issues

An overall schedule for the entire project will be proposed including:

- Options for project phasing.
- Preconstruction schedule.

5.3.1 Options for Project Phasing. Based on cost and financing considerations, options for construction phasing of the project will be investigated. The advantages and disadvantages associated with phasing will be outlined and the impact on the project schedule and costs identified.

5.3.2 Preconstruction Schedule. An evaluation will be made of the projected schedule for subsequent permitting and design phases of the project including resolution of environmental/regulatory requirements. An implementation schedule with milestone events will be developed to provide project guidance through subsequent phases.

5.4 Phase III Work Plan

5.4.1 Develop a detailed work plan for Phase III for the Southeastern Area of the Trans–Texas Water Program.

5.5 Report Preparation

5.5.1 Prepare a report summarizing all pertinent information developed for this element of the program in accordance with Task 3.6.1 in Phase I.

6.0 CONTRACT ADMINISTRATION

6.1 Program Coordination

Attend up to eighteen (18) project status meetings and provide technical input, as required, to coordinate the work efforts and results of the Southeast Area and South–Central Area projects.

6.2 Progress Reports

6.2.1 Prepare up to eighteen (18) monthly progress reports and monthly billings which summarize the work completed through each work period. The monthly progress report will contain the following information:

- Major Phase II task names and description.
- Total manhours and cost budgeted for individual tasks, including TWDB and Contractor portions.
- Percent of the tasks completed.
- Dollar value of the percent of the tasks completed.
- Total tasks completed, indicating the percent of and dollar value of the project completed as reflected in totals of all State Vouchers submitted.

6.2.2 Prepare and update schedules, budgets, and the work plan, as required, to illustrate the project status.

# ATTACHMENT 1

## TRANSTEXAS WATER PROGRAM
## ENVIRONMENTAL ASSESSMENT

**Water Quality**

Preliminary water quality impact assessment of affected State waters must include evaluation of water quality standards attainment, chemical and biological compatibility of mixed waters, coastal salt water intrusion, and nutrients for compliance with drinking water standards. The recommended methodology, if any, for each analysis is given as follows:

1. Water Quality Standards Attainment

   A. Chloride, Sulfate, Total Dissolved Solids--Mass balance these constituents under a 7-day, 2-year, low flow (7Q2) condition to insure that the Standards are not violated.

   B. Dissolved Oxygen--If any interbasin transfer scenarios result in a reduction of a river's 7Q2, or if the baseflow is significantly reduced during spring spawning months (defined as the first half of the year when water temperatures are 63°-73°F in TWC Rule 307.7.(b)3. Aquatic Life), then simplified mathematical modeling must be performed to evaluate compliance with the Standard. Basic modeling assumptions are listed below:

      - Summer Analysis
        Headwater--7Q2 flow conditions
        Temperature--average of the three
        hottest months, plus one standard deviation, from the closest USGS station with water temperature data
        Discharges--full permitted effluent
        flow and quality
        BOD--compute BODu = $BOD_{5\ day} \times 2.3$
        $K_n$--nitrification rate = 0.30/day
        $K_d$--BOD oxidation rate = 0.10/day
        Reaeration--use Texas equation

      - Spring Spawning Analysis
        Same as above, except
        Headwaters--10th percentile monthly
        low flow conditions
        Temperature--90th percentile monthly
        high temperature conditions

   C. pH--No recommended method.

   D. Temperature--Mass balance temperature to insure compliance with the maximum temperature criteria, as well as the "rise over ambient" Standard.

   E. Fecal Coliform--No recommended method.

2. Chemical and Biological Compatibility of Waters

A. Formation of precipitates, etc.--No recommended method.

B. Introduction of exotic plants and animals--No recommended method.

3. Salt Water Intrusion

A. Migration of coastal salt wedge and effect of intrusion up tidal rivers--No recommended method.

B. Effect on water supply operations--No recommended method.

C. Effect on freshwater marshes/wetlands--No recommended method.

4. Nutrients

A. Potable water limits--Determine compliance with Drinking Water Standards.

B. Potential for nuisance aquatic vegetation--No recommended method.

## Instream Flows

A relatively rapid assessment of instream flow needs to maintain downstream fish and wildlife habitats affected by the TransTexas Water Program can be performed by using the TPWD-modified Tennant's Method (Lyons 1979), which is based on a fixed percentage of median (50th percentile) monthly flows. At any point in a river basin intercepted by the TransTexas Water Program, streamflows must be passed downstream in an amount up to 60% of the median monthly flows from March through September, and 40 % of the median monthly flows from October through February. Streamflows above these monthly flow limits are to be considered available for other beneficial uses and interbasin transfer. Water stored in existing reservoirs will not be allocated to instream uses and released downstream to make up for normal flows below the specified limits.

## Freshwater Inflows to Bays and Estuaries

For preliminary planning purposes, the freshwater inflow needs of the bays and estuaries can be conservatively estimated as a function of selected central tendency values. The typical bi-modal distribution of monthly rainfall runoff during the historical period is enhanced by requiring the pass through of normal inflows up to the mean (arithmetic average) monthly flow in May-June and September-October, while the minimum maintenance needs are satisfied with inflows up to the median (50th percentile) monthly flow in the remaining months of the year. Water stored in existing reservoirs will not be allocated to bay and estuary uses and released downstream to make up for normal flows below the specified limits.

## New Reservoirs

Existing reservoirs that could potentially contribute to the TransTexas Water Program will be evaluated as to the effects on downstream flows and freshwater inflows to bays and estuaries under their existing state and federal permits which authorize their current operations, while any new reservoirs involved in the Program's future water storage and distribution system will be considered to operate such that they pass through impounded streamflows up to the mean (arithmetic average) monthly flow in April-June and August-October, and median (50th percentile) streamflows in the remaining months of the year, as long as reservoir capacity is above 60%. When reservoir capacity is below 60%, the water management operations will recognize drought contingency by passing through up to the median daily flow of the stream observed during the historical drought of record. The analysis will be repeated at 40% and 80% capacity thresholds to demonstrate a range of feasible solutions for operating any new reservoirs.

# APPENDIX D

## Membership of Southeast Area TAC

# *Technical Advisory Committee*
# Southeast Study Area
# *Trans-Texas Water Program*

**Policy Management Committee**
Sabine River Authority, Chair
City of Houston
San Jacinto River Authority
Brazos River Authority
Texas Water Development Board
Texas Natural Resource Conservation Commission
Texas Parks and Wildlife Department
Coastal Coordination Council

**State and Federal Agencies:**
- National Park Service
- National Marine Fisheries Service
- Texas Department of Agriculture
- Texas General Land Office
- U.S. Army Corps of Engineers
- U.S. Bureau of Reclamation
- U.S. Environmental Protection Agency, Region VI
- U.S. Fish and Wildlife Service
- U.S. Geological Survey

**Local and Regional Agencies:**
- Angelina and Neches River Authority
- Association of Water Board Directors
- City of Beaumont
- Chambers County Judge
- Chambers-Liberty Counties Navigation District
- Coastal Water Authority
- Devers Canal System
- Fort Bend County Subsidence District
- Galveston Bay National Estuary Program
- Gulf Coast Water Authority
- Hardin County, Pct. 4
- Harris County Judge
- Harris-Galveston Coastal Subsidence District
- Houston-Galveston Area Council of Governments
- Jefferson County Judge
- Liberty County Judge
- Lower Neches Valley Authority
- Orange County Judge
- Polk County Judge
- South East Texas Regional Planning Commission
- Texas Farm Bureau
- Trinity River Authority
- TWCA Irrigation/Drainage District Panel

**Environmental and Public Interest Groups:**
- Audubon Society - Houston
- Big Thicket Conservation Association
- Citizens Environmental Coalition
- Clean Air and Water Incorporated
- Coalition Advocating a Safe Environment
- Galveston Bay Foundation
- Greater Houston Partnership - Environmental Committee
- Gulf Coast Conservation Association
- League of Women Voters
- Sierra Club - Golden Triangle Chapter
- Sierra Club - Houston Chapter
- Sportsman Conservationists of Texas
- Texas Committee on Natural Resources

**Other:**
- Dupont Sabine River Works
- Houston Lighting and Power Company
- Art Spencer
- Texas Chemical Council

# APPENDIX E

## Meetings of the PMC and TAC

## APPENDIX E

### Summary of PMC Meetings

At the first PMC meeting on October 15, 1992, the committee laid the foundation for the project. The PMC agreed upon the purpose or "mission statement" which is on page 1.4 of this report. After that there was a brief description of the PMC and its role. They voted to adopt the structure of the PMC that has been presented in this report. The committee agreed on a consensus (no voiced opposition) method of decision-making. They agreed on the duties of the PMC which are:

a) Coordinate policy matters associated with the study,

b) Approve study parameters,

c) Approve draft and final reports, and

d) Appoint Technical Advisory Committees (TAC's) for the TTWP.

At the meeting the PMC also adopted environmental guidelines for the program which are in Appendix C. The PMC discussed and agreed upon the structure and role of the TAC's as presented in this report. Dennis Crowley of the TWDB was identified as the Project Manager of the TTWP. Following that there were comments from both regional PMC's concerning the expected involvement of the City of Houston, the City of San Antonio, and the Lower Colorado River Authority (LCRA) in the program.

The next meeting of the PMC was held on December 9, 1992. During this meeting the Committee prepared a statement which reflected an agreement between the membership to be objective, work for the advancement of the Project as a whole, and not take advantage of their PMC membership to advance the agenda of their respective agencies or organizations. There were also project status reports and reports on TAC membership and organization from both the Southeast and the South-Central

Study Areas. There was also discussion on the process of coordinating the work among the consulting firms.

Another PMC meeting was held on April 27, 1993. A major issue in this meeting was the involvement of the U.S. Bureau of Reclamation in the TTWP. The Bureau has been authorized by the federal government to conduct an "Edward Aquifer Regional Water Resources Management Study" in cooperation with state and local agencies. A major concern was the unnecessary duplication of work in the Bureau study and the TTWP. Therefore the PMC made a motion to support the participation of the Bureau in the Program. There was also some discussion of the environmental guidelines for the project. At that time the Texas Water Development Board staff was having on-going discussions of that issue. Also, status reports were given by the TAC's.

Summary of the TAC Meeting

At the Southeast TAC meeting many questions arose about the financing of the project. Phases I and II are being funded by the Sabine River Authority (SRA) (by a loan from the TWDB), the City of Houston, and the San Jacinto River Authority (SJRA). It is anticipated that the users or beneficiaries of the project will ultimately bear the cost of the project, including these preliminary studies. There could also be some participation by the state and by the federal government (mainly through the Bureau of Reclamation). There were also some questions concerning the economic criteria established in choosing the alternatives (i.e. will the "least-cost" or "cost-benefit" method be used?). Answers indicated that these methods were not entirely appropriate for the TTWP, since there are many other concerns -- environment, public opinion, etc. The question also arose of whether public environmental interest groups should have to pay for protecting the environment from the effects of the project. Answers indicate that this should not be the case, but these groups could pay for enhancement of the environment. There was also a question of whether desalination would be a cheaper and a more environmentally favorable alternative than conveyance systems. Desalination will be considered. Some preliminary cost estimates have been obtained indicating the desalination treatment alone (not including transmission system costs or environmental issues associated with the process) would cost about $7 per thousand gallons. This is compared to $1 per thousand gallons for conventional water treatment. Based on past studies, the cost of conveyance is expected to be far less than the cost of desalination.

Several TAC members suggested that increased conservation efforts might eliminate the need for a project such as the TTWP. The members were assured that this was not the case. The demand projections for the project were developed using the TWDB's high-case scenario population forecast with conservation efforts in place.

Several questions were asked concerning the sponsorship and the institutional structure of the project, most of which have already been addressed in this report. One member asked why the Trinity River Authority (TRA) was not a project sponsor. A representative of the TRA said that they had no major role to play in the project, but they were serving as advisors and were very interested.

Many of the members were interested in the amount of public involvement which would take place throughout the different phases of the project. The TAC was assured that there will be adequate opportunity for public input through the TAC meetings, TAC correspondence and some public meetings held by the PMC where the purpose will be to solicit public input and increase public awareness of the program. There was also the matter of whether or not the project would ultimately be put to a vote of the people. A TWDB representative said that depends on the form of state financial participation, if any.

Another concern was the "ambitious" time schedule of the project. Representatives from the City of Houston indicated that this schedule was needed because they project that Houston will need additional water by the year 2010. The year 2000 had been mentioned previously as the earliest possible date that a part of the work might be completed, but it is probably not a realistic date.

The TAC was informed that Toledo Bend is the major water supply under consideration at this time, but there are still other possible options. No sources of water supply are being ruled out at this time, but currently available sources will be more attractive and probably will be used before any new reservoir projects are seriously considered. It may be possible to buy some of Louisiana's 50% of Toledo Bend's yield. This brought up the question of Louisiana's involvement in the project. Louisiana representatives have been contacted regarding inter-state agreements for additional water supplies and will be periodically briefed on the status of the project.

## MEMORANDUM TO FILE

From: Southeast Area Program Management Committee

Prepared by: Tom Gooch

Date: April 22, 1993

Project: Trans-Texas Water Program, Southeast Area

Subject: Summary of the First Technical Advisory Committee Meeting, April 13, 1993, Days Inn, Houston, Texas

1. Attachment 1 is a copy of the registration sheet for the meeting. Those in attendance were given the following items:

   - A Texas Water Development Board (TWDB) map showing projected water availability in 2040 with no new facilities.
   - "Water for Texas - Trans-Texas Water Program, Overall Program Description."
   - A Trans-Texas Water Program Southeast Area Comment Form.
   - A packet which included the agenda for the meeting, a description of the role of the Technical Advisory Committee (TAC), a list of TAC membership, and a TAC contact list (Attachment 2).
   - Consultant's Scope of Services for Phase 1 and Phase 2.
   - *Southeast Area Program Issues* document.

2. Sam Collins of the Sabine River Authority (SRA) gave an overview of the Trans-Texas Program and the purpose of the meeting. He asked those in attendance to hold their questions for the end and introduced SRA, San Jacinto River Authority (SJRA), TWDB, and City of Houston representatives. He described the Policy Management Committee (PMC) and introduced representatives of Brown and Root and Freese and Nichols. He then asked those in attendance to introduce themselves.

Five river authorities, 5 federal agencies, 4 state agencies, 6 environmental groups, 3 development-oriented organizations, 3 regional agencies, 2 cities, 3 counties, and 6 private companies were represented.

3. Albert Gray of SRA discussed the role of the TAC. He indicated that they would be asked to review technical material and provide comments, preferably in writing. They are not a voting group.

4. Mike Personett of the TWDB reviewed the organization and background of the Trans-Texas Water Program. It is an outgrowth of TWDB planning efforts, which show 4 areas with a long-term deficit in water supply:

   - Southeast (Houston)
   - South-Central (Austin, San Antonio, Corpus Christi)
   - Lower Rio Grande Valley
   - El Paso/Juarez

   TWDB projects that the population will essentially double statewide and in these population areas by 2040, and water needs will also double.

   The Trans-Texas Water Program could meet the needs of two of the four water-short areas - Southeast and South-Central. The program will look at ways to share water, including water wheeling as well as physical transfers. TWDB shows surpluses in the Sabine, Neches, and Colorado basins, with shortages in other basins.

   Mr. Personett discussed the phases of the Trans-Texas Water Program:

   Phase I - Conceptual planning and initial screening
   Phase II - Focused look at screened alternatives
   Phase III - Preliminary design and permitting
   Phase IV - Property acquisition and design
   Phase V - Construction and start-up

   Mr. Personett also described the management structure for the Trans-Texas Water Program - overall direction by a Policy Management Committee (PMC), with regional PMCs and regional TACs.

5. Bruce Moulton of the Texas Water Commission then reviewed the environmental criteria for the Trans-Texas Water Program. The major environmental concerns include:

- Water quality
- Instream flows
- Freshwater inflows to bays and estuaries
- New reservoirs

He reviewed the criteria set by the agencies. He indicated that the criteria are conservative - further study may lead to less stringent requirements.

6. David Parkhill of Brown and Root then reviewed the scope of the Phase I and II studies. He provided an overview of the program issues paper, which covers the following areas:

   - Engineering
   - Environmental
   - Financial
   - Legal
   - Institutional

   The schedule was presented, and it calls for completion of Phase I by mid July, to be followed immediately by Phase II.

7. Albert Gray of SRA asked that written comments on the issues document be returned by April 28. He said that copies of the document would be mailed to TAC members not represented at the meeting.

8. <u>QUESTIONS:</u>

   The members of the TAC then asked questions and gave suggestions. A summary of the questions and comments and of the responses follows.

a. (Glenn Phillips, Texas Eastman) *TWDB lists four areas of water shortage. What about the Ogallala?* <u>Personett.</u> TWDB now projects continued declines in irrigated acreage and in water use per acre on the high plains.

b. (Saul Aronow, Golden Triangle Sierra Club) *Are the goals of the subsidence districts to phase out ground water use realistic enough to provide good data for this study?* <u>Parkhill.</u> The subsidence district has recently completed a revision of its numbers, and the district is comfortable with the numbers.

c. (Janice Bezanson, Texas Committee on Natural Resources) *Nothing in what you have* *presented to date establishes economic criteria for the project. Should there be such? Do you intend to use cost-benefit analysis?* Parkhill. We do not propose to use a traditional cost-benefit analysis. Although there is incentive to supply water at a reasonable cost, it is not feasible to go only with the least-cost approach. We have to balance environmental and other considerations with cost.

d. *What criteria will be used to select among routes?* Parkhill. Cost and environmental impacts will be considered. Personett. What is being done for this project is "integrated resource planning," looking at the whole picture.

e. (Birna Foley, Galveston Bay Foundation) *You have talked about providing low cost water to the people. What is the focus of this effort? Who will bear the cost of water transfers, users or the state?* Personett. This is to be explored. Certainly the user will bear the primary share of the costs. There could be some participation by the state, especially on the front end. *I want to discourage unrealistically low costs, which discourage conservation.*

f. *You have said that Phase I and Phase II are now financed. What do they cost and how are they financed?* Collins. The SRA has received a loan from the TWDB for $700,000, the City of Houston is contributing $300,000, and the SJRA is contributing $100,000.

g. *Is there a plan for federal government sponsorship/participation?* Collins. They are on the TACs and will have input.

h. *Am I correct that there are three sponsors?* Collins. Yes, there are three sponsors in the Southeast Area - SRA, Houston, and SJRA.

i. (Glenn Phillips, Texas Eastman) *Who owns the water in Toledo Bend Reservoir?* Collins. The yield of the project is split between Texas and Louisiana in accordance with the financial investment - 50-50. We might buy some water from Louisiana. *Does Louisiana have concerns on the environmental impact of the project?* Collins. They do.

j. *Are mechanisms to address the cumulative impacts of the project in place?* Parkhill. That will be done as part of the environmental process.

k. (Glenn Phillips, Texas Eastman) *Will this project ultimately come up for a vote of the people?* Personett. There will be state input through the permitting process. Whether or not there is a state vote depends on the form of state financial participation, if any.

l. (Saul Aronow, Golden Triangle Sierra Club) *Is any of the water dedicated to irrigation use?* Parkhill. We will attempt to meet all needs. *Will there be a differential in costs for irrigation and municipal use?* Parkhill. We do not intend to interfere with existing contracts.

m. (Jim Kachtick, Greater Houston Partnership) *Why is the Trinity River Authority not a project sponsor?* Danny Vance, TRA. We had no major role to play in the project, but we are serving as advisors, and we are very interested.

n. (Julian Coghill, Jefferson County Drainage District) *Are any other states doing projects like this, and can we learn from them?* Personett. Yes, and there is a lot to learn. We plan to pay more attention to the environment and to avoid some of the turmoil we are now seeing in California. We also hope to use experience and information from the Bureau of Reclamation.

o. (Mike Kieslich, Corps of Engineers) *Is there a public involvement/project scoping element in the program?* Parkhill. This TAC process and meetings with the agencies will be avenues for seeking public input. The formal NEPA process will occur in Phase III. *I would suggest that you expand scoping efforts early in the process.* Moulton. That was also recommended in the South-Central area. *If you cover all the questions that interest the public up front, you may avoid having to repeat your work.*

p. *You said that the yield of Toledo Bend is split. Is there a mechanism to determine control of flows through the reservoir?* Collins. The Sabine River Compact. *Will you consider environmental impacts in Louisiana?* Parkhill. Yes.

q. (Janice Bezanson, Texas Committee on Natural Resources) *To return to the economic question, I have found that the least cost alternative also usually also has the least environmental impact. You should consider the least cost methodology. For example, would paying to implement conservation measures be cheaper?* Personett. We will be looking at an enhanced conservation scenario. Enhanced conservation is not likely to eliminate projects, but we expect it to change the timing and scale. Demand reduction is an integral part of our planning effort.

r. (Gary Neighbors, Angelina-Neches River Authority) *What are the supply source alternatives under consideration?* Parkhill. The book is open right now. Any alternative is possible, including buying Louisiana's share of the Toledo Bend yield.

s. (Mike Kieslich, Corps of Engineers) *What is driving the schedule? It seems very ambitious. Can it be adjusted?* Settle. The City of Houston sees a need for some additional water by the year 2010 or so. Given the time required to develop water supplies, we are starting a little late, and we want to get going.

t. (Rafael Ortega, Harris County) *What project or segment of the project do you expect to have built by the year 2000?* Parkhill. The year 2000 was mentioned as the earliest possible date that a part of the work might be completed. It is probably not a realistic date.

u. *Please elaborate on the concept of public interest group participation.* Parkhill. The idea is that interest groups may want to pay to get environmental benefits. Perhaps someone would want to use capacity in the canal in the early years to deliver water for environmental purposes. Personett. This kind of thing has been done in California.

v. (Mike Kieslich, Corps of Engineers) *Will the feasibility studies look at the impact of changes in freshwater inflows to Galveston Bay?* Parkhill. We plan to use the TWC model in Galveston Bay. We will look at the impact of the proposed actions. Moulton. TWC has its Galveston Bay model on the front burner. We hope to have a lot of information by early next year. *The modelling time required to simulate the bay's hydrodynamics is tremendous.* Moulton. The regulatory agencies will be monitoring the study, and we won't let the consultants get away with murder. At this time, we are looking for a fatal flaw in any plan.

w. *Returning to public interest group participation, I think that the need for environmental groups to purchase water for environmental purposes in California is the result of past poor planning. With proper planning, public interest groups should not have to pay to protect the environment.* Parkhill. Payments might be for environmental enhancement.

x. (Saul Aronow, Golden Triangle Sierra Club) *The Bureau of Reclamation recently abandoned its last reservoir project in Texas. Will the study attempt to resurrect old reservoir projects?* Jim Adams of the SJRA indicated that the project was not abandoned, but set aside for lack of current local interest. Parkhill. We do not rule out any sources. At this time, we expect that currently available sources will be more attractive and will be used first.

y. (Bill Jackson, National Marine Fisheries) *Given the environmental impacts and costs of other sources of supply, what about desalination? It will have to be looked at along* *the coast.* Parkhill. We plan to look at all alternatives. Based on studies done in the past, we expect the cost of conveyance to be far less than the cost of desalination. *I would like to see those studies.* Personett. Desalination has very high energy costs and environmental impacts. Disposal of concentrated brine is one problem. It is being done in parts of the state.

z. *How often will this group meet?* Gray. We expect to meet 4 or 5 times over the next two years. We expect to do most of our work by correspondence.

aa. (Rafael Ortega, Harris County) *What will happen to the PMC as you move to subsequent phases - will the same people be in charge?* Gray. We will reevaluate the role and structure of the PMC after Phase II.

ab. (Glenn Phillips, Texas Eastman) *You spoke of a doubling of population. Are you considering the environmental impacts of such large population increases?* Parkhill. We are using the detailed population estimates from TWDB, looking for the most realistic projections we can get. We do not plan to control population growth by the water supply. Personett. We are looking at high growth, dry year needs. We can adjust the plan if growth changes from the projections. In general, TWDB projections are in the middle to low end of the range of projections.

TRANS-TEXAS WATER PROGRAM
Southeast Area

REGISTRATION FORM

| | Name | Organization | Address | Phone Number | Title |
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| 1. | S.A. Webb | City of Beaumont | P.O. 3827 - 77706 | 409 866 0023 | Dir Water Utilities |
| 2. | James Stewart | Houston Audubon | 519 Pine Edge Dr The Woodlands 77380 | 713/292-7888 | VP Sci & Res. |
| 3. | John Thompson | Polk County | Polk County Courthouse | 409-327-8113 | County Judge |
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| 6. | SAUL ARONOW | Golden Triangle Sierra Club | 5590 FROST BEAUMONT TX 77708 | 409-892-9141 | ?? |
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| 8. | Cindy Loeffler | TPWD | 3000 S. IH35 Austin 78704 | 512 448 4313 | Inflow Implementation Coord |
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| 14. | LANCE ROBINSON | TPWD - COASTAL FISHERIES | P.O. BOX 8, SEABROOK TX 77586 | 713/474-2811 | Galv. Bay Ecosystem Ldr |
| 15. | Bill JACKSON | NOAA/NMFS | 4700 Ave U, GALV TX 77551 | 409/766-3699 | Fisheries Specialist |
| 16. | Melvin Swoboda | DuPont | | | |
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TRANS-TEXAS WATER PROGRAM
Southeast Area

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| 3. | Bruce Moulton | TX Water Comm. | PO BOX 13087 Austin 78711 | 512/463-8208 | |
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| 8. | JERRY BERRY | Coastal Water Auth | 1200 Smith St, Suite 2260 Houston Tx. | (713) 424-1322 | Operations Manager |
| 9. | Tom Ray | Brazos River Auth. | PO Box 7555 WACO 76714 | 817/776-1441 | |
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| 11. | Rafael Ortega | Harris Co | 1500 CityWest Blvd | 713 266-6900 | |
| 12. | Oscar Nelson | Chambers Co | Box 939 Anahuac, TX | 409 267 8295 | Co. Judge |
| 13. | | | | | |
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TRANS-TEXAS WATER PROGRAM
Southeast Area

REGISTRATION FORM

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| 2. | Glenn Phillips | Texas Eastman Div Eastman Chemicals Co | Box 7444 Longview, Tx 75607 | 903-2375346 | Sr. Engineer Assoc. |
| 3. | H.E. (Ike) Barrett | San Jacinto River Authority | P.O. Box 329, Conroe, Tx. 77305 | 409/588-1111 | Manager Surface Water Operations |
| 4. | Tom Gooch | Freese & Nichols | ~~Suite~~ 4055 International Pkwy, Fort Worth, TX. 76109 | 817/735-7300 | Principal |
| 5. | JULIAN COGHILL | JEFF CO DRAIN DIST. COMMISSION'R & TWCA | 5239 LAKESIDE DR. PT ARTHUR | (409) 982-0704 | COMMISSIONER |
| 6 | JACK W. TATUM | SRA | | | |
| 7. | B. D. King III | USFWS | 17629 El Camino Real, Hous. | 713-286-8282 | Chief, Fed. Proj. |
| 8. | Paul M. Glass | Trinity Water Reserve, Inc | P.O. Box 463, Devers, TX 77538 | (409) 549-7575 | President |
| 9. | DENNIS CROWLEY | TWDB | | 512-463-7976 | |
| 10. | MIKE PERSONETT | TWDB | | | DIRECTOR, LOCAL & REGIONAL ASSISTANCE DIVISION |
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| 12. | David C. Berkshire | Big Thicket Cons. Assoc. | 9713 Mariposa Houston, TX 77025 | (713) 667-7881 | |
| 13. | C.L. BOGAN | BRAZOS River Board | | | Treasurer |
| 14. | | | | | |
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| 18. | | | | | |

TRANS-TEXAS WATER PROGRAM
Southeast Area

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A GOVERNMENTAL AGENCY
OF THE
State of Texas
409-746-2192
FAX # 409-746-3780

# SABINE RIVER AUTHORITY of Texas

P. O. BOX 579
ORANGE, TEXAS
77630

March 25, 1993

TO: Technical Advisory Committee (TAC) Members
Trans-Texas Water Program (TTWP)

FROM: Sabine River Authority

SUBJECT: Initial Meeting of the Technical Advisory Committee for the Southeast Study Area of the Trans-Texas Water Program

DATE: April 13, 1993
10:00 a.m.

LOCATION: Days Inn (I-10 East/Mercury Drive)
10155 East Freeway
Houston, Texas
(See Attached Map)

AGENDA:

1. Introduction of Membership
2. Role of the TAC
3. Organization/Background of the TTWP
4. Discussion of Environmental Criteria
5. Scope of Studies for the Southeast Study Area of the TTWP
6. Presentation and Discussion of Issues Papers Concerning the TTWP
7. Schedule of Milestone Events for the TTWP
8. Other Business
9. Adjournment (the meeting will begin promptly at 10:00 a.m. and will continue until completed - hopefully by around noon)

If you should have any questions or need any additional information, please feel free to contact the Sabine River Authority, as follows:

Albert J. Gray .................. Development Manager
Jack W. Tatum ................ Development Coordinator
Jim Brown ........................ Administrative Assistant
Bambi Granger ................ Development Branch Secretary
Phone (409) 746-2192.

Very truly yours,

Albert J. Gray

Albert J. Gray
Development Manager

*April 13, 1993*

# ROLE OF THE SOUTHEAST TECHNICAL ADVISORY COMMITTEE TRANS-TEXAS WATER PROGRAM

- The purposes of the Trans-Texas Water Program (TTWP) Southeast Technical Advisory Committee (TAC) are to (1) review and comment on the information produced in the Southeast Study Area; (2) provide socio/economic, engineering and environmental advice to the program sponsor (Sabine River Authority of Texas) and the Policy Management Committee (PMC); and (3) serve as a vehicle for public information and input.

- The TAC will identify and discuss socio/economic, engineering and environmental issues related to the TTWP. The goal of this discussion process will be to identify areas of agreement and disagreement regarding the adequacy and reliability of the data used in the Southeast Study Area.

- In order that each TAC Member's views concerning the Southeast Study Area are properly considered, written comments should be provided to the Sabine River Authority of Texas.

- There will be no voting in the sense of defining a single set of recommendations or conclusions of the TAC. Instead, the full extent of agreement and disagreement (as reflected in written comments from the TAC) will be recorded by the Sabine River Authority for input into the TTWP for the Southeast Study Area.

- Meetings of the TAC will be open to the public.

**Trans-Texas Water Program**
**Southeast Technical Advisory Committee Membership**
**December, 1993**

1 Sabine River Authority (Chair)*
2 Texas Water Development Board*
3 Texas Parks and Wildlife Department*
4 Texas Water Commission
5 Texas General Land Office
6 U.S. Fish and Wildlife Service
7 U.S. Environmental Protection Agency (will not participate-available for technical questions
8 U.S. Corps of Engineers
9 U.S. Bureau of Reclamation
10 National Park Service
11 National Marine Fisheries Service
12 Galveston Bay National Estuary Program
13 City of Houston (Houston)*
14 San Jacinto River Authority (SJRA)*
15 Lower Neches Valley Authority (LNVA)
16 Trinity River Authority
17 Brazos River Authority (BRA)
18 Coastal Water Authority
19 Gulf Coast Water Authority
20 Harris-Galveston Coastal Subsidence District and Fort Bend County Subsidence District
21 South East JTexas Regional Planning C9ommission (One member representing local entities)
22 Houston-Galveston Area Council of Governments (One member representing local entities)
23 County Judge: Orange County
24 County Judge: Jefferson County
25 County Judge: Chambers County
26 County Judge: Liberty County
27 County Judge: Harris County
28 Chambers-Liberty Counties Navigation District
29 Representative of TWCA Irrigation/Drainage District Panel
30 Devers Canal System
31 Association of Water Board Directors
32 Texas Farm Bureau
33 Houston Chapter Sierra Club
34 Golden Triangle Sierra Club
35 Galveston Bay Foundation
36 Sportsman Conservationists of Texes
37 Big Thicket Conservation Association
38 Houston Audubon Society
39 Texas Committee on Natural Resources
40 Citizens Environmental Coalition
41 Gulf Coast Conservation Association
42 Clean Air & Water, Inc.
43 League of Women Voters of Texas
44 Member Appointed by SRA (Dupont Sabine River Works)
45 Member Appointed by Houston (Greater Houston Partnership - Environmental Committee)
46 Member Appointed by SJRA (Texas Chemical Council)
47 Member Appointed by LVNA (Mr. Art Spencer)
48 Member Appointed by TRA (County Judge: Polk County)
49 One Member to be Nominated by BRA
50 One Member to be Nominated by GCWA
51 City of Beaumont
52 Angelina & Neches River Authority (ANRA)
53 Coalition Advocating a Safe Environment
54 Houston Lighting and Power Company

55 U.S. Geological Survey
56 Texas Department of Agriculture
57 County Judge: Hardin County

**Trans-Texas Water Program**
**Southeast Technical Advisory Committee**
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**SOUTHEAST AREA TECHNICAL ADVISORY COMMITTEE**
**INITIAL MEETING**
**COMMENTS, QUESTIONS AND RESPONSES**

The following is a summary and compilation of the various questions and suggestions offered by the members of the TAC at the April 13, 1993 meeting and the subsequently written comments received by Mr. Albert Gray of the Sabine River Authority. This information has been summarized from notes taken at the April 13, 1993 TAC meeting and is not intended to be a complete nor thorough summary of the questions and responses. The summary is intended to reflect a general record of the discussion which occurred.

**Questions and Comments**

Glenn Phillips, Texas Eastman
* "TWDB lists four areas of water shortage. What about the Ogallala?"
Mike Personett, Texas Water Development Board - TWDB now projects continued declines in irrigated acreage and in water use per acre on the high plains.

Saul Aronow, Golden Triangle Sierra Club
* Are the goals of the subsidence districts to phase out ground water use realistic enough to provide good data for this study?
David Parkhill, Brown & Root - The subsidence district has recently completed a revision of its projections, and the district is comfortable with the numbers.

Janice Bezanson, Texas Committee on Natural Resources
* Nothing in what you have presented to date establishes economic criteria for the project. Should there be such? Do you intend to use cost-benefit analysis?
David Parkhill - We do not propose to use a traditional cost-benefit analysis. Although there is incentive to supply water at a reasonable cost, it is not feasible to go only with the least-cost approach. We have to balance environmental and other considerations with cost.

Question from Audience
* What criteria will be used to select among routes?
David Parkhill - Cost and environmental impacts will be considered.
Mike Personett - What is being done for this project is sometimes called "integrated resource planning," which requires looking at the whole picture.

Birna Foley, Galveston Bay Foundation

* You have talked about providing low cost water to the people. What is the focus of this effort: Who will bear the cost of water transfers, users or the state:
Mike Personett - This is to be explored. Certainly the user will bear the primary share of the costs. There could be some participation by the state, especially on the front end.
Birna Foley - I want to discourage unrealistically low costs, which discourage conservation.

Question from Audience
* You have said that Phase I and Phase II are now financed. What do they cost and how are they financed?
Sam Collins, Sabine River Authority - The SRA has received a loan from the TWDB for $700,000, the City of Houston is contributing $300,000, and the SJRA is contributing $100,000.

Question from Audience
* Is there a plan for federal government sponsorship/participation?
Sam Collins - They are on the TACs and will have input.

Question from Audience
* Am I correct that there are three sponsors?
Sam Collins - Yes, there are three sponsors in the Southeast Area - SRA, Houston, and SJRA.

Glenn Phillips, Texas Eastman
* Who owns the water in Toledo Bend Reservoir?
Sam Collins - The yield of the project is split between Texas and Louisiana in accordance with the financial investment - 50-50. We might buy some water from Louisiana.
* Does Louisiana have concerns on the environmental impact of the project?
Sam Collins - They do.

Representative, Texas Department of Parks and Wildlife
* Are mechanisms to address the cumulative impacts of the project in place?
David Parkhill - That will be done as part of the environmental process.

Glenn Phillips, Texas Eastman
* Will this project ultimately come up for a vote of the people?
Mike Personett - There will be state input through the permitting process. Whether or not there is a state vote depends on the form of state financial participation, if any.

Saul Aronow, Golden Triangle Sierra Club
* Is any of the water dedicated to irrigation use?
David Parkhill - We will attempt to meet all needs.

* Will there be a differential in costs for irrigation and municipal use?
David Parkhill - We do not intend to interfere with existing contracts.

Jim Kachtick, Greater Houston Partnership
* Why is the Trinity River Authority not a project sponsor?
Danny Vance, Trinity River Authority - We had no major role to play in the project, but we are serving as advisors, and we are very interested.

Julian Coghill, Jefferson County Drainage District
* Are any other states doing projects like this, and can we learn from them?
Mike Personett - Yes, and there is a lot to learn. We plan to pay more attention to the environment and to avoid some of the turmoil we are now seeing in California. We also hope to use experience and information from the Bureau of Reclamation.

Mike Kieslich, Corps of Engineer
* Is there a public involvement/project scoping element in the program?
David Parkhill - This TAC process and meetings with the agencies will be avenues for seeking public input. The formal NEPA process will occur in Phase III.
* I would suggest that you expand scoping efforts early in the process. If you cover all the questions that interest the public up front, you may avoid having to repeat your work.
Bruce Moulton, Texas Water Commission - That was also recommended in the South-Central area.

Question from Audience
* You said that the yield of Toledo Bend is split. Is there a mechanism to determine control of flows through the reservoir?
Sam Collins - The Sabine River Compact.
* Will you consider environmental impacts in Louisiana?
David Parkhill - Yes.

Janice Bezanson, Texas Committee on Natural Resources
* To return to the economic question, I have found that the least cost alternative also usually also has the least environmental impact. You should consider the least cost methodology. For example, would paying to implement conservation measures be cheaper?
Mike Personett - We will be looking at an enhanced conservation scenario. Enhanced conservation is not likely to eliminate projects, but we expect it to change the timing and scale. Demand reduction is an integral part of our planning effort.

Gary Neighbors, Angelina-Neches River Authority

* What are the supply source alternatives under consideration?
David Parkhill - The book is open right now. Any alternative is possible, including buying Louisiana's share of the Toledo Bend yield.

Mike Kieslich, Corps of Engineers
* What is driving the schedule? It seems very ambitious. Can it be adjusted?

Chuck Settle, City of Houston
* The City of Houston sees a need for some additional water by the year 2010 or so. Given the time required to develop water supplies, we are starting a little late, and we want to get going.

Rafael Ortega, Harris County
* What project or segment of the project do you expect to have built by the year 2000?
David Parkhill - The year 2000 was mentioned as the earliest possible date that a part of the work might be completed. It is probably not a realistic date.

Question from Audience
* Please elaborate on the concept of public interest group participation.
David Parkhill - The idea is that interest groups may want to pay to get environmental benefits. Perhaps someone would want to use capacity in the canal in the early years to deliver water for environmental purposes.
Mike Personett - This kind of thing has been done in California.

Mike Kieslich, Corps of Engineers
* Will the feasibility studies look at the impact of changes in freshwater inflows to Galveston Bay?
David Parkhill - We plan to use the TWC model in Galveston Bay. We will look at the impact of the proposed actions.
Bruce Moulton - TWC has its Galveston Bay model on the front burner. We hope to have a lot of information by early next year.
* The modelling time required to simulate the bay's hydrodynamics is tremendous. Will your TWDB model be adequate?
Bruce Moulton - The regulatory agencies will be monitoring this study, and we won't let the consultants get away with murder. At this time, we are looking for a fatal flaw in any plan.

Question from Audience
* Returning to public interest group participation, I think that the need for environmental groups to purchase water for environmental purposes in California is the result of past poor planning. With proper planning, public interest groups should not have to pay to protect the environment.
David Parkhill - Payments might be for environmental enhancement.

Saul Aronow, Golden Triangle Sierra Club

* The Bureau of Reclamation recently abandoned its last reservoir project in Texas. Will the study attempt to resurrect old reservoir projects?

Jim Adams, San Jacinto River Authority - The project was not abandoned, but set aside for lack of current local interest.

David Parkhill - We do not rule out any sources. At this time, we expect that currently available sources will be more attractive and will be used first.

Bill Jackson, National Marine Fisheries

* Given the environmental impacts and costs of other sources of supply, what about desalination? It will have to be looked at along the coast.

David Parkhill - We plan to look at all alternatives. Based on studies done in the past, we expect the cost of conveyance to be far less than the cost of desalination.

Mike Personett - Desalination has very high energy costs and environmental impacts. Disposal of concentrated brine is one environmental problem, but it is being done in some parts of the state.

Question from Audience

* How often will this group meet?

Albert Gray, Sabine River Authority - We expect to meet 4 or 5 times over the next two years. We expect to do most of our work by correspondence.

Rafael Ortega, Harris County

* What will happen to the PMC as you move to subsequent phases - will the same people be in charge?

Albert Gray - We will reevaluate the role and structure of the PMC after Phase II.

Glenn Phillips, Texas Eastman

* You spoke of a doubling of population. Are you considering the environmental impacts of such large population increases?

David Parkhill - We are using the detailed population estimates from TWDB, looking for the most realistic projections we can get. We do not plan to control population growth by the water supply.

Mike Personett - We are looking at high growth, dry year needs. We can adjust the plan if growth changes from the projections. In general, TWDB projections are in the middle to low end of the range of projections.

**The following questions or comments were submitted in writing following the first TAC meeting.**

Mike Kieslich, U.S. Army Engineer, District Galveston

* "I suggest that material to be presented at the meeting be mailed to the TAC members beforehand so that we can be better prepared to contribute at the meetings."
<u>Response</u> - Meeting materials will be provided to the TAC members before the next meeting.

* "I suggest that questions be allowed at the end of each presentation..."
<u>Response</u> - The amount of information to be presented to the TAC dictated the program format. At the first meeting, a significant amount of material and issues were to be presented. We believe the importance of providing the TAC with all necessary material in the time allowed warranted this format. Future meeting formats may be revised to provide individual discussion on each topic.

* "Shouldn't representatives from Louisiana be involved in the TAC?"
<u>Response</u> - Louisiana representatives have been contacted regarding inter-state agreements for additional water supplies for the Trans-Texas project. Louisiana representatives will be periodically briefed on the status of the project.

* "How is economic feasibility of the alternatives to be determined?"
<u>Response</u> - The evaluation of conveyance alternatives will be based upon consideration of a wide range of factors including the costs to provide water, the economic impacts of water development and the environmental concerns associated with each alternative. After alternatives are developed for further study, detailed costs for capital investment and O&M will be developed for each alternative. Economic feasibility will be determined by each prospective project participant.

* "Recommend a public involvement program be undertaken to solicit comments and concerns from the general public and environmental community so that all important issues are covered in the EIS."
<u>Response</u> - Public involvement is encouraged through the agencies and organizations represented in the TAC. In addition, the Policy Management Committee will host additional public meetings to solicit public input and increase public awareness of the program. The schedule for these meetings has not yet been determined. In subsequent phases, the federal NEPA process will be strictly followed.

* "Completion of Phase II by August 1994 seems very ambitious given the environmental questions that will likely arise. Have all agencies agreed to the "scope" of environmental studies required?"
<u>Response</u> - The City of Houston anticipates a need for additional water supply by approximately the year 2010. Developing water supplies to meet the time frame requires an "ambitious" schedule.

The participants of the TTWP are in agreement with the environmental scope of work as presented to the TAC. Other agencies will be consulted during subsequent project phases and the scope will be adjusted to address additional questions.

* "Is desalination being considered as an alternative in addition to transfers from other basins?"
Response - We plan to look at many alternatives including desalination.

* "Is beneficial uses of the materials to be dredged from the canals being considered?"
Response - The use of spoil associated with construction of pipelines or canals has not yet been thoroughly investigated. The intent of the project will be to minimize the environmental consequences of spoil disposal.

* "Are cumulative environmental impacts being considered?"
Response - Yes, Phase II environmental analysis will consider impacts on the environment resulting from construction, water diversion and alteration in flows for rivers, lakes and bays in the study area over a 50-year time horizon. Cumulative impacts will be more thoroughly evaluated during Phase III.

Wayne Stupka, Coalition Advocating a Safe Environment

* "These meetings should be held when persons holding other jobs can attend."
Response -Your comment on scheduling TAC meeting times after normal business hours is appreciated and will be considered as future meetings are scheduled.

* "It is my opinion that our river basin's growth is highly dependent on our water supply and it seems we are jeopardizing our future by giving our water away. A 50 year use analysis can be very misleading and should not be the basis for what could be a monumental environmental and economic disaster."
Response - One of the primary tasks in Phase I of the Trans-Texas Water Program is to determine where surplus water supplies may exist over the next 50 years. This process will require that projected water supplies and demand for that time period be calculated for each of the river basins in the study area. The identification of surplus supply available for transfer under TTWP will only be made where supply exceeds future water needs of each river basin. Phase II of the program will examine the economic and environmental benefits and costs of the proposed conveyance alternatives.

B.D. King, U.S. Fish and Wildlife Services

* The Corps of Engineers Waterways Experiment Station in Vicksburg, Mississippi has developed a comprehensive three-dimensional model of the Galveston Bay estuary for use in assessing plans for the expansion of navigation channels. This model exceeds the capability, reliability and utility of the TWDB model, and should be used in lieu of the State's model in the assessment of impacts related to the Trans-Texas Project."
Response - We have contacted the Corps of Engineers regarding the Vicksburg, Mississippi Waterways Experiment Station's 3-D model being developed for the Galveston Bay estuary. After consultation with the staffs of the Corps of Engineers - Galveston District, and the Texas Water Development Board, it was determined that three dimensional modeling techniques are not necessary for the Trans-Texas Water Program. The Trans-Texas Water Program and the project for which this 3-D model is being developed are significantly different in scope and nature. The TTWP will propose no construction in areas adjacent to or immediately upstream of Galveston Bay. None of the alternative conveyance routes being developed should result in impacts requiring three-dimensional modeling.

* "The need for new reservoirs may be reduced by implementing a program for renovating existing reservoirs to restore original capacities ... by the removal and beneficial use of sediments which have accumulated in reservoirs since their original construction. The storage capacities thus regained may be sufficient to negate the need for new reservoirs, at least over the short term (20-30 years)."
Response - It is not anticipated that new reservoir construction will be necessary within the Southeast Area of the Trans-Texas Water Program. The program will maximize the efficient use of existing reservoir and conveyance facilities. TWDB supply projections indicate that there should be no significant decrease in reservoir capacity due to sedimentation within the time horizon of this program. Preliminary analysis of supply yield data demonstrate that capacity losses predicted in Lakes within the study area are insignificant in relation to the overall water demands. The total program area supply of 4,154,750 ac-ft/yr (in 1990) will be reduced by 47,650 ac-ft/yr or approximately 1.0% over the 50 year time period.

* "Public meetings should be held as soon as possible in all areas influenced by the proposed project."
Response - The Policy Management Committee will host public meetings to solicit input and increase public awareness of the program. The schedule of these meetings has not yet been determined.

* "This option for recapture of portions of project costs related to environmental protection or mitigation should not be pursued,

due to questions of equity. ...These costs should be borne solely by the project beneficiaries."

Response - Reference was made at the TAC meeting of situations where public interests groups had paid for environmental enhancements under a California project. Environmental concerns are an integral component of the Trans-Texas Water Program. An integrated planning approach should produce a project which accounts for environmental needs in the planning phase and avoids the need to remediate environmental impacts in the future. It is anticipated that users of the TTWP will ultimately bear the costs of the system. It is not anticipated that any public interest group would be asked to "pay to protect" any environmental resource.

* " The section entitled "New Reservoirs" states, in part, that "When reservoir capacity is 60%, the water management operations will recognize drought contingency by passing through up to the median daily flow of the stream observed during the historical drought of record". This drought was unusually severe; most estimates of its recurrence interval indicate that it was a once in 300 year drought. The specification of such an extreme drought ... as the standard to which flows would be held in times of shortage is unnecessarily constraining, and would result in unjustified increases in the frequency of such environmental impacts in the water sheds over the life of the project. The "standard drought" which triggers this flow release criterion should be defined as a drought having a 50-year recurrence interval rather that 300 years, commensurate with the anticipated life of the project."

Response - The environmental guidelines in Appendix 3 of the Program Issues document were developed as a preliminary approach to assessing environmental issues. The most stringent criteria were selected for the feasibility study to provide the greatest protection for sensitive environmental concerns. The agencies which have reviewed the preliminary guidelines have agreed that, during the study phase of the project, it was necessary to fully understand the "worst case" situations. This particular standard will only be considered in the development of new reservoirs. As currently envisioned, no new reservoir construction is anticipated within the Southeast Area of the Trans-Texas Water Program.

Birna Foley, Galveston Bay Foundation

* "Conservation - Effects of conservation measures should be carefully determined, with the recognition that a strong continuing education program may have significant impact."

Response - Trans-Texas Water Program demand projections have been developed using the Texas Water Development Board's high-case scenario population forecast with conservation efforts in place. In the development of the TTWP it is necessary to establish realistic projections for both supply and demand. The TTWP will address conservation issues including the concept of "enhanced conservation." The project is using demand projections which reflect the state's goal of increased conservation.

* "Financial methods used in Western states to rectify environmental problems in those states are probably not applicable to Texas. The Texas plan must seek to avoid the problems that Western states have encountered from water planning done decades ago, particularly the environmental problems such as inadequate instream flows and freshwater inflow to bays and estuaries."
Response - Environmental concerns are an integral part of the Trans-Texas Water Program. This integrated approach should produce a project which accounts for environmental needs in the planning phase and avoids the costs of ameliorating environmental problems in the future. Appendix 3 of the Southeast Area Program Issues details the environmental guidelines to be used in the planning phase of the program.

* "The financial, social, and environmental benefits of not doing a project such as Wallisville should be factored into the value of the Trans-Texas Water Program."
Response - The Environmental Assessment in Phase II of the Trans-Texas Water Program will examine the socio-economic and environmental impacts of the conveyance route alternatives developed by the program. This assessment will include an analysis of the "no action" alternative which will examine the consequences of relying on existing sources of supply to provide necessary water for the project area in the future.

The Honorable Oscar Nelson, County Judge, Chambers County

* "The presentations were very informative and helped me get a handle on the tasks ahead. [I] was disappointed that so many questions seemed to indicate the questioner wanted instant results"
Response - We appreciate your comments. The meeting was intended to encourage questions and comments from people who will be affected by the program. TAC members voicing their concerns in this early stage of the planning process will assure a better program at its completion.

# APPENDIX F

## TWDB Population Projections

## BRAZOS BASIN - POPULATION DATA

| COUNTY | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| AUSTIN | 16,961 | 19,039 | 20,862 | 22,485 | 23,891 | 25,196 | 26,572 |
| BRAZORIA | 13,547 | 15,058 | 16,449 | 17,728 | 18,882 | 20,348 | 21,928 |
| BRAZOS | 121,862 | 147,780 | 182,853 | 220,045 | 258,968 | 287,901 | 320,067 |
| BURLESON | 13,625 | 16,713 | 19,683 | 23,522 | 25,795 | 27,932 | 30,246 |
| FORT BEND | 62,855 | 86,784 | 112,342 | 139,329 | 164,317 | 180,052 | 197,294 |
| GRIMES | 13,397 | 16,517 | 18,817 | 21,446 | 24,316 | 25,902 | 27,591 |
| LEON | 2,285 | 2,870 | 3,116 | 3,311 | 3,512 | 3,682 | 3,860 |
| MADISON | 652 | 671 | 714 | 745 | 775 | 790 | 805 |
| ROBERTSON | 15,511 | 16,340 | 16,791 | 17,257 | 17,658 | 18,096 | 18,545 |
| WALLER | 17,716 | 20,818 | 25,073 | 28,902 | 33,897 | 35,815 | 37,842 |
| WASHINGTON | 26,062 | 30,443 | 34,269 | 37,969 | 41,531 | 44,587 | 47,868 |
| BASIN TOTAL | 304,473 | 373,033 | 450,969 | 532,739 | 613,542 | 670,301 | 732,618 |

## NECHES BASIN - POPULATION DATA

| COUNTY | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| ANGELINA | 69,884 | 76,234 | 83,083 | 88,736 | 94,895 | 101,025 | 107,551 |
| HARDIN | 41,278 | 49,091 | 56,600 | 64,676 | 73,406 | 84,561 | 97,411 |
| HOUSTON | 4,558 | 4,826 | 4,893 | 5,043 | 5,167 | 5,268 | 5,371 |
| JASPER | 19,765 | 22,298 | 23,840 | 25,728 | 28,248 | 29,667 | 31,157 |
| JEFFERSON | 55,745 | 58,322 | 62,337 | 64,632 | 66,821 | 68,558 | 70,340 |
| LIBERTY | 1,875 | 2,298 | 2,697 | 3,179 | 3,640 | 4,156 | 4,745 |
| NACOGDOCHES | 54,753 | 64,274 | 73,582 | 83,561 | 96,717 | 108,694 | 122,154 |
| NEWTON | 13 | 13 | 13 | 12 | 12 | 12 | 12 |
| ORANGE | 26,196 | 29,579 | 32,162 | 34,046 | 36,601 | 40,553 | 44,932 |
| POLK | 8,318 | 10,665 | 12,339 | 13,878 | 16,394 | 17,831 | 19,394 |
| SABINE | 2,812 | 3,035 | 3,260 | 3,431 | 3,431 | 3,396 | 3,361 |
| SAN AUGUSTINE | 7,214 | 7,507 | 7,912 | 8,235 | 8,700 | 8,905 | 9,115 |
| SHELBY | 1,939 | 1,993 | 2,085 | 2,131 | 2,179 | 2,205 | 2,231 |
| TRINITY | 3,779 | 4,467 | 5,245 | 5,824 | 6,248 | 6,642 | 7,061 |
| TYLER | 16,646 | 18,043 | 20,180 | 23,011 | 25,343 | 26,585 | 27,888 |
| BASIN TOTAL | 314,775 | 352,645 | 390,228 | 426,123 | 467,802 | 508,058 | 552,724 |

## NECHES-TRINITY BASIN - POPULATION DATA

| COUNTY | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| CHAMBERS | 7,642 | 8,348 | 11,327 | 14,513 | 17,004 | 18,836 | 20,865 |
| GALVESTON | 3,074 | 3,460 | 3,576 | 4,019 | 4,897 | 5,901 | 7,111 |
| JEFFERSON | 183,652 | 190,370 | 204,114 | 211,414 | 218,364 | 223,884 | 229,544 |
| LIBERTY | 84 | 112 | 139 | 172 | 205 | 243 | 288 |
| BASIN TOTAL | 194,452 | 202,290 | 219,156 | 230,118 | 240,470 | 248,864 | 257,808 |

## SABINE BASIN - POPULATION DATA

| COUNTY | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| JASPER | 11,337 | 12,550 | 13,424 | 14,500 | 15,937 | 16,740 | 17,583 |
| NEWTON | 13,556 | 13,872 | 13,955 | 13,970 | 14,106 | 14,251 | 14,397 |
| ORANGE | 54,313 | 59,635 | 65,952 | 71,752 | 78,947 | 87,071 | 96,031 |
| SABINE | 6,774 | 7,448 | 8,095 | 8,539 | 8,487 | 8,365 | 8,245 |
| SAN AUGUSTINE | 785 | 793 | 807 | 819 | 835 | 843 | 851 |
| SHELBY | 20,095 | 21,071 | 22,479 | 23,173 | 23,899 | 24,293 | 24,693 |
| BASIN TOTAL | 106,860 | 115,369 | 124,712 | 132,753 | 142,211 | 151,563 | 161,801 |

## SAN JACINTO BASIN - POPULATION DATA

| COUNTY | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| FORT BEND | 45,204 | 76,633 | 101,873 | 128,527 | 153,174 | 168,732 | 185,870 |
| GRIMES | 3,649 | 4,654 | 5,436 | 6,328 | 7,303 | 7,842 | 8,421 |
| HARRIS | 2,496,331 | 2,895,781 | 3,264,121 | 3,614,478 | 3,976,374 | 4,284,483 | 4,616,466 |
| LIBERTY | 14,974 | 19,578 | 25,032 | 30,525 | 36,366 | 41,538 | 47,446 |
| MONTGOMERY | 182,201 | 241,640 | 329,972 | 424,918 | 529,107 | 611,888 | 707,620 |
| SAN JACINTO | 7,479 | 9,512 | 11,970 | 14,630 | 17,262 | 18,648 | 20,145 |
| WALKER | 15,536 | 17,139 | 20,433 | 23,622 | 27,347 | 30,286 | 33,541 |
| WALLER | 5,674 | 7,452 | 9,458 | 11,014 | 13,182 | 14,034 | 14,941 |
| BASIN TOTAL | 2,771,048 | 3,272,389 | 3,768,295 | 4,254,042 | 4,760,115 | 5,177,451 | 5,634,450 |

## SAN JACINTO-BRAZOS BASIN - POPULATION DATA

| COUNTY | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| BRAZORIA | 150,868 | 175,750 | 205,735 | 232,090 | 255,767 | 284,099 | 315,569 |
| FORT BEND | 105,264 | 154,881 | 205,283 | 258,521 | 307,952 | 338,903 | 372,965 |
| GALVESTON | 214,325 | 249,454 | 294,556 | 339,070 | 388,332 | 421,538 | 457,583 |
| HARRIS | 234,922 | 286,524 | 336,563 | 385,053 | 433,616 | 484,365 | 541,053 |
| BASIN TOTAL | 705,379 | 866,609 | 1,042,137 | 1,214,734 | 1,385,667 | 1,528,905 | 1,687,171 |

## TRINITY BASIN - POPULATION DATA

| COUNTY | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| CHAMBERS | 4,204 | 4,645 | 6,043 | 7,903 | 9,496 | 10,711 | 12,081 |
| GRIMES | 1,782 | 2,272 | 2,654 | 3,089 | 3,566 | 3,829 | 4,111 |
| HARDIN | 42 | 52 | 63 | 75 | 87 | 102 | 120 |
| HOUSTON | 16,817 | 17,451 | 17,627 | 18,018 | 18,346 | 18,612 | 18,882 |
| LEON | 10,380 | 12,558 | 13,452 | 14,183 | 14,936 | 15,579 | 16,250 |
| LIBERTY | 35,172 | 43,045 | 50,938 | 59,577 | 68,301 | 78,172 | 89,470 |
| MADISON | 10,279 | 10,706 | 11,328 | 11,791 | 12,239 | 12,461 | 12,687 |
| POLK | 22,369 | 28,579 | 33,027 | 37,189 | 43,891 | 47,711 | 51,863 |
| SAN JACINTO | 8,893 | 10,975 | 13,432 | 15,966 | 18,443 | 19,747 | 21,143 |
| TRINITY | 7,666 | 8,855 | 9,991 | 10,846 | 11,467 | 12,002 | 12,562 |
| WALKER | 35,381 | 44,330 | 54,145 | 63,645 | 74,742 | 83,499 | 93,282 |
| BASIN TOTAL | 152,985 | 183,468 | 212,700 | 242,282 | 275,514 | 302,425 | 332,451 |

## TRINITY-SAN JACINTO BASIN - POPULATION DATA

| COUNTY | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| CHAMBERS | 8,242 | 9,439 | 11,367 | 13,864 | 16,075 | 17,938 | 20,017 |
| HARRIS | 86,946 | 109,572 | 124,121 | 137,730 | 151,690 | 166,292 | 182,300 |
| LIBERTY | 621 | 836 | 1,037 | 1,290 | 1,535 | 1,820 | 2,158 |
| BASIN TOTAL | 95,809 | 119,847 | 136,525 | 152,884 | 169,300 | 186,050 | 204,474 |

# APPENDIX G

## Houston Water Master Plan and H-GAC Population Projections

# HOUSTON WATER MASTER PLAN

## APPENDIX H

FINAL DRAFT

## WATER DEMANDS

MAY 1986

PROJECT NO. 2881

M&E Metcalf & Eddy

TABLE 2-4. POPULATION PROJECTIONS BY MDA

| MDA | 1985 | 1990 | 2000 | 2010 | 2020 | 2030 |
|---|---|---|---|---|---|---|
| 1 | 19788 | 21123 | 20720 | 20843 | 21080 | 21822 |
| 2 | 133271 | 137234 | 136189 | 134341 | 131919 | 130477 |
| 3 | 106373 | 109936 | 114119 | 118465 | 120434 | 123334 |
| 4 | 41048 | 42790 | 44128 | 46280 | 47568 | 49697 |
| 5 | 92465 | 99187 | 96606 | 95231 | 93068 | 91743 |
| 6 | 63353 | 65882 | 64058 | 62851 | 61722 | 61268 |
| 7 | 51028 | 56726 | 60995 | 65448 | 68931 | 72629 |
| 8 | 58939 | 60518 | 59786 | 59850 | 60010 | 60342 |
| 9 | 73034 | 81558 | 91216 | 91950 | 91920 | 90888 |
| 10 | 19584 | 20431 | 21669 | 23073 | 24431 | 26337 |
| 11 | 105306 | 112938 | 116912 | 122342 | 127652 | 132366 |
| 12 | 108564 | 118133 | 114976 | 112059 | 109450 | 107316 |
| 13 | 158013 | 170408 | 178317 | 179262 | 176088 | 172845 |
| 14 | 105648 | 114114 | 121793 | 120762 | 119887 | 118838 |
| 15 | 94559 | 106199 | 108570 | 111426 | 113619 | 116384 |
| 16 | 89268 | 92252 | 96993 | 94324 | 91672 | 89589 |
| 17 | 107422 | 119279 | 137494 | 154167 | 165774 | 175954 |
| 18 | 30593 | 32098 | 35641 | 40078 | 43623 | 48048 |
| 19 | 9655 | 11419 | 17860 | 25684 | 33108 | 42227 |
| 20 | 73945 | 85422 | 104527 | 119510 | 127260 | 130775 |
| 21 | 29737 | 36076 | 56677 | 74397 | 90732 | 99034 |
| 22 | 42922 | 48745 | 66779 | 84976 | 101022 | 114319 |
| 23 | 5326 | 5458 | 5725 | 6119 | 6515 | 7063 |
| 24 | 190693 | 240618 | 306423 | 344035 | 352391 | 344915 |
| 25 | 25292 | 36843 | 61514 | 81880 | 96030 | 99475 |
| 26 | 93899 | 114334 | 162561 | 207517 | 224689 | 241381 |
| 27 | 95172 | 128770 | 173061 | 236452 | 278796 | 308422 |
| 28 | 18825 | 23829 | 36727 | 51898 | 63986 | 77893 |
| 29 | 21095 | 25620 | 38954 | 55034 | 67787 | 83446 |
| 30 | 1599 | 1745 | 2437 | 3296 | 4115 | 5136 |
| 31 | 68466 | 86863 | 164001 | 244850 | 303252 | 360673 |
| 32 | 32630 | 44183 | 72338 | 105724 | 131356 | 159029 |
| 33 | 30096 | 38741 | 64880 | 94016 | 114279 | 128758 |
| 34 | 89879 | 108405 | 114211 | 174710 | 216976 | 254371 |
| 35 | 43282 | 50530 | 66670 | 83030 | 93704 | 104828 |

TABLE 2-4. POPULATION PROJECTIONS BY MOA (continued)

| MOA | 1985 | 1990 | 2000 | 2010 | 2020 | 2030 |
|---|---|---|---|---|---|---|
| 36 | 13474 | 16202 | 20358 | 24820 | 28905 | 33823 |
| 37 | 13529 | 15549 | 20726 | 25750 | 30177 | 35625 |
| 38 | 155556 | 173450 | 198825 | 229894 | 249080 | 273472 |
| 39 | 13339 | 14441 | 15354 | 16618 | 17342 | 18203 |
| 40 | 17932 | 18199 | 17425 | 16684 | 15991 | 15330 |
| 41 | 611 | 651 | 639 | 649 | 661 | 686 |
| 42 | 7480 | 7716 | 8012 | 8429 | 8854 | 9487 |
| 43 | 71087 | 78186 | 92849. | 109163 | 119870 | 129998 |
| 44 | 21362 | 24103 | 32939 | 43785 | 54088 | 66803 |
| 45 | 15224 | 17196 | 23923 | 32115 | 39865 | 49399 |
| 46 | 51587 | 58291 | 73754 | 92497 | 108369 | 123599 |
| 47 | 78029 | 80128 | 115669 | 150428 | 183235 | 220911 |
| 48 | 87501 | 87219 | 104566 | 123478 | 139252 | 156744 |
| 49 | 31569 | 31114 | 37660 | 45721 | 53328 | 62786 |
| 50 | 133747 | 144247 | 235566 | 342367 | 423641 | 492165 |
| 51 | 52165 | 54291 | 74367 | 97846 | 116605 | 137872 |
| 52 | 6187 | 6274 | 17308 | 19816 | 22160 | 25031 |
| 53 | 6692 | 7230 | 10955 | 15533 | 19896 | 25285 |
| 54 | 18276 | 18738 | 24751 | 32201 | 39292 | 48092 |
| 55 | 44344 | 50580 | 132277 | 164610 | 192999 | 227869 |
| 56 | 33016 | 34194 | 43407 | 54871 | 65777 | 79376 |
| 57 | 28229 | 34390 | 49196 | 67307 | 84481 | 105619 |
| 58 | 59280 | 63063 | 82872 | 106831 | 128559 | 155199 |
| 59 | 36518 | 40311 | 59451 | 82724 | 104728 | 131711 |
| 60 | 24569 | 26729 | 34820 | 44740 | 54111 | 65694 |
| 61 | 7700 | 8415 | 9520 | 10942 | 12291 | 14008 |
| 62 | 10838 | 14171 | 18159 | 23079 | 27742 | 33531 |
| 63 | 52253 | 74867 | 108111 | 148024 | 183741 | 225659 |
| 64 | 78607 | 89739 | 107875 | 127043 | 144608 | 166240 |
| 65 | 65080 | 86377 | 87420 | 95841 | 101505 | 107276 |
| TOTALS: | 3566550 | 4024468 | 4994281 | 5999686 | 6745999 | 7489115 |

# HOUSTON WATER MASTER PLAN

# APPENDIX M

# DETAILED EVALUATION OF ALTERNATIVES

Metcalf & Eddy

with

Ekistics Corporation

Prepared for the City of Houston

Department of Public Works

Water Division Project Number 8891

November 1989

## REVISIONS TO HWMP BASE DATA INCORPORATED IN APPENDIX M

Information contained in the HWMP technical appendices presenting base data were affected not only by public comment but also by the passage of time during the planning process. In order to use current and accurate input data for this long-range planning process, some changes to previous work have been made. These changes are described below.

Population and Employment Growth. The Houston area experienced unprecedented growth during the sixties, seventies, and the early eighties. The mid 1980s, however, brought recession and a struggle to regain a positive growth path. Although an optimistic growth projection is considered the conservative (and correct) approach to long range water supply planning, growth projections prepared at the beginning of this project (Appendix D), which served as the basis for water demand projections, are now considered to be too optimistic. To accommodate this fact without beginning the master plan work anew, a strategy of delaying projected growth for five years was adopted. As a result, water demands originally projected for 1990 will now be expected in 1995, for 1995 in 2000, and so on throughout the planning period. The year 2030, with revised water demands, has been retained as the end of the planning period.

Water Demand Projections. Water demands based on the original population and employment growth projections were documented in Appendix H. Table 1 presents water demands for the three service areas considered in previous work: the Eight-County area, the Harris County plus Houston Extraterritorial Jurisdiction (ETJ) area, and Harris County. These water demands reflect the

# H-GAC Estimates and Projections

# Population/Employment Estimates and Projections for the H-GAC 8-County Region (at the Census Tract Level)

## For the years 1970, 1980, 1985, 1989, 1990, 1996, and 2010

Houston-Galveston Area Council (H-GAC)
Data Services Department
3555 Timmons Lane
Houston, Texas 77027
Tel (713) 627 3200 Fax (713) 621 8129



June 1992

# APPENDIX N

# Public & Agency Comments

## POPULATION, HOUSEHOLDS, AND HOUSING UNITS ESTIMATES AND PROJECTIONS FOR THE H-GAC 8-COUNTY REGION

| COUNTY | POP70 | POP80 | POP85 | POP89 | POP90 | POP96 | POP10 |
|---|---|---|---|---|---|---|---|
| HARRIS | 1738265 | 2409544 | 2723888 | 2831192 | 2818293 | 3120821 | 3717000 |
| BRAZORIA | 108169 | 169587 | 188953 | 187309 | 191707 | 214897 | 300000 |
| FORT BEND | 51957 | 130846 | 187855 | 212473 | 225421 | 265267 | 356000 |
| WALLER | 14285 | 19798 | 23757 | 25094 | 23297 | 27093 | 45000 |
| MONTGOMERY | 49479 | 128487 | 164941 | 176698 | 182201 | 216842 | 317000 |
| LIBERTY | 33015 | 47088 | 56014 | 54744 | 52726 | 55730 | 95000 |
| CHAMBERS | 12187 | 18538 | 19003 | 19289 | 20088 | 22705 | 33000 |
| GALVESTON | 169812 | 195940 | 215386 | 219166 | 217399 | 242264 | 305000 |
| REGION | 2177169 | 3119828 | 3579797 | 3725965 | 3731132 | 4165619 | 5168000 |

| COUNTY | HHLD70 | HUNITS70 | HHLD80 | HUNITS80 | HHLD85 | HUNITS85 | HHLD89 | HUNITS89 |
|---|---|---|---|---|---|---|---|---|
| HARRIS | 539893 | 587830 | 869880 | 984577 | 981444 | 1208723 | 1044570 | 1565974 |
| BRAZORIA | 30520 | 34334 | 53907 | 60458 | 60192 | 73131 | 59609 | 74120 |
| FORT BEND | 13813 | 14877 | 39840 | 43162 | 57704 | 68177 | 65449 | 75060 |
| WALLER | 3647 | 4386 | 5726 | 6718 | 7068 | 8902 | 7727 | 8786 |
| MONTGOMERY | 14892 | 18336 | 41487 | 49899 | 53299 | 65663 | 57010 | 68972 |
| LIBERTY | 10479 | 12607 | 16227 | 19806 | 19289 | 26230 | 19383 | 21430 |
| CHAMBERS | 3773 | 4239 | 6248 | 7289 | 6406 | 7646 | 6709 | 7469 |
| GALVESTON | 53004 | 61886 | 69284 | 82945 | 75669 | 99830 | 79217 | 104419 |
| REGION | 670021 | 738495 | 1102599 | 1254854 | 1261071 | 1558302 | 1339674 | 1926230 |

**SOURCE:**

This printed report is a consolidation of the following H-GAC publications:

1) "1985/2010 Estimates of Population and Employment";
2) "1988 Estimates of Employment, 13 Counties by Census Tract";
3) "1996 Population/Employment Forecasts";
4) "1989 Population, 8 Counties";
5) Other sources, like H-GAC machine-readable files, etc.

**IMPORTANT NOTE:** All 1990 data is based on census preliminary reports, and may differ from actual 1990 census data released at later dates.

Houston-Galveston Area Council (H-GAC)
Data Services Department
3555 Timmons Ln.
Houston, TX 77027
Tel. (713) 627 3200
Fax (713) 621 8129

# APPENDIX H

## TWDB Water Demand Forecasts for the Southeast Study Area

## SABINE BASIN
## TOTAL WATER DEMANDS IN ACRE-FEET/YEAR

| YEAR | COUNTY | | | | | | BASIN TOTAL |
|---|---|---|---|---|---|---|---|
| | JASPER | NEWTON | ORANGE | SABINE | SAN AUGUST. | SHELBY | |
| 1990 | 1,676 | 4,113 | 71,041 | 1,134 | 225 | 5,676 | 83,865 |
| 2000(1) | 1,860 | 4,345 | 84,629 | 1,262 | 3,524 | 5,756 | 101,376 |
| 2000(2) | 2,292 | 4,868 | 86,276 | 1,545 | 3,551 | 6,462 | 104,994 |
| 2000(3) | 1,776 | 4,261 | 84,235 | 1,212 | 3,519 | 5,621 | 100,624 |
| 2000(4) | 2,193 | 4,767 | 85,819 | 1,486 | 3,546 | 6,289 | 104,100 |
| 2010(1) | 1,975 | 4,389 | 115,162 | 1,346 | 4,291 | 6,212 | 133,375 |
| 2010(2) | 2,437 | 4,919 | 116,988 | 1,654 | 4,319 | 6,964 | 137,281 |
| 2010(3) | 1,793 | 4,206 | 114,239 | 1,236 | 4,281 | 5,909 | 131,664 |
| 2010(4) | 2,222 | 4,703 | 115,972 | 1,522 | 4,308 | 6,612 | 135,339 |
| 2020(1) | 2,112 | 4,425 | 142,005 | 1,405 | 5,049 | 6,601 | 161,597 |
| 2020(2) | 2,611 | 4,962 | 143,993 | 1,728 | 5,077 | 7,376 | 165,747 |
| 2020(3) | 1,815 | 4,160 | 140,565 | 1,239 | 5,034 | 6,130 | 158,943 |
| 2020(4) | 2,267 | 4,643 | 142,349 | 1,531 | 5,060 | 6,830 | 162,680 |
| 2030(1) | 2,292 | 4,483 | 170,402 | 1,401 | 5,821 | 7,045 | 191,444 |
| 2030(2) | 2,840 | 5,028 | 172,588 | 1,725 | 5,850 | 7,846 | 195,877 |
| 2030(3) | 1,926 | 4,165 | 168,589 | 1,217 | 5,803 | 6,480 | 188,180 |
| 2030(4) | 2,409 | 4,658 | 170,522 | 1,508 | 5,829 | 7,203 | 192,129 |
| 2040(1) | 2,397 | 4,538 | 200,688 | 1,388 | 6,702 | 7,503 | 223,216 |
| 2040(2) | 2,973 | 5,093 | 203,103 | 1,707 | 6,731 | 8,317 | 227,924 |
| 2040(3) | 1,956 | 4,173 | 198,447 | 1,177 | 6,681 | 6,855 | 219,289 |
| 2040(4) | 2,478 | 4,660 | 200,630 | 1,465 | 6,708 | 7,589 | 223,530 |
| 2050(1) | 2,507 | 4,597 | 234,263 | 1,375 | 7,720 | 8,039 | 258,501 |
| 2050(2) | 3,113 | 5,162 | 236,931 | 1,689 | 7,749 | 8,866 | 263,510 |
| 2050(3) | 1,987 | 4,184 | 231,533 | 1,139 | 7,696 | 7,307 | 253,847 |
| 2050(4) | 2,549 | 4,666 | 233,994 | 1,423 | 7,724 | 8,052 | 258,408 |

**NOTES:**

(1) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS
(2) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS
(3) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION
(4) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION

NECHES BASIN
TOTAL WATER DEMANDS IN ACRE-FEET/YEAR

| | COUNTY | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | ANGEL-INA | HARDIN | HOUS-TON | JASPER | JEFFER-SON | LIBERTY | NACOG-DOCHES | NEWTON | ORANGE | POLK | SABINE | SAN AUGUST. | SHELBY | TRINITY | TYLER | BASIN TOTAL |
| 1990 | 37,467 | 12,496 | 1,366 | 60,990 | 94,470 | 7,892 | 12,973 | 8 | 4,751 | 2,226 | 2,214 | 1,680 | 514 | 727 | 2,380 | 242,154 |
| 2000(1) | 45,737 | 14,817 | 1,537 | 76,114 | 105,735 | 7,957 | 15,105 | 6 | 5,690 | 2,979 | 2,884 | 1,599 | 547 | 912 | 2,987 | 284,606 |
| 2000(2) | 47,768 | 16,587 | 1,669 | 77,096 | 106,679 | 8,028 | 17,509 | 6 | 6,398 | 3,362 | 2,988 | 1,879 | 616 | 1,001 | 3,666 | 295,252 |
| 2000(3) | 45,183 | 14,486 | 1,504 | 75,956 | 105,346 | 7,939 | 14,558 | 6 | 5,497 | 2,898 | 2,864 | 1,550 | 535 | 877 | 2,863 | 282,062 |
| 2000(4) | 47,177 | 16,197 | 1,630 | 76,904 | 106,238 | 8,008 | 16,920 | 6 | 6,180 | 3,266 | 2,965 | 1,823 | 600 | 961 | 3,521 | 292,396 |
| 2010(1) | 49,720 | 15,942 | 1,533 | 87,973 | 119,986 | 8,007 | 17,143 | 4 | 5,971 | 3,344 | 3,266 | 1,670 | 558 | 1,032 | 8,300 | 324,449 |
| 2010(2) | 51,929 | 17,980 | 1,666 | 89,017 | 121,013 | 8,090 | 19,894 | 4 | 6,738 | 3,785 | 3,378 | 1,967 | 630 | 1,136 | 9,066 | 336,293 |
| 2010(3) | 48,563 | 15,134 | 1,467 | 87,627 | 119,114 | 7,967 | 15,977 | 3 | 5,553 | 3,164 | 3,222 | 1,562 | 532 | 952 | 8,020 | 318,857 |
| 2010(4) | 50,633 | 17,039 | 1,594 | 88,600 | 120,089 | 8,046 | 18,512 | 4 | 6,275 | 3,575 | 3,326 | 1,839 | 600 | 1,044 | 8,736 | 329,912 |
| 2020(1) | 52,961 | 17,152 | 1,549 | 94,292 | 137,061 | 8,069 | 19,339 | 2 | 6,121 | 3,669 | 3,615 | 1,727 | 564 | 1,122 | 18,676 | 365,919 |
| 2020(2) | 55,315 | 19,475 | 1,687 | 95,407 | 138,127 | 8,166 | 22,461 | 3 | 6,930 | 4,165 | 3,733 | 2,037 | 638 | 1,237 | 19,546 | 378,927 |
| 2020(3) | 51,171 | 15,841 | 1,448 | 93,738 | 135,736 | 8,003 | 17,398 | 2 | 5,487 | 3,387 | 3,549 | 1,565 | 523 | 993 | 18,224 | 357,065 |
| 2020(4) | 53,281 | 17,944 | 1,572 | 94,739 | 136,698 | 8,089 | 20,181 | 3 | 6,216 | 3,834 | 3,656 | 1,844 | 590 | 1,094 | 18,991 | 368,732 |
| 2030(1) | 59,907 | 18,449 | 1,565 | 108,774 | 151,861 | 8,130 | 22,167 | 1 | 6,456 | 4,125 | 3,960 | 1,809 | 569 | 1,188 | 28,992 | 417,953 |
| 2030(2) | 62,417 | 21,084 | 1,706 | 109,980 | 152,963 | 8,239 | 25,778 | 2 | 7,323 | 4,708 | 4,078 | 2,138 | 645 | 1,311 | 29,949 | 432,321 |
| 2030(3) | 57,675 | 16,786 | 1,443 | 108,096 | 150,276 | 8,044 | 19,594 | 1 | 5,684 | 3,737 | 3,885 | 1,608 | 521 | 1,028 | 28,414 | 406,792 |
| 2030(4) | 59,936 | 19,157 | 1,571 | 109,158 | 151,264 | 8,141 | 22,814 | 2 | 6,439 | 4,262 | 3,991 | 1,904 | 589 | 1,144 | 29,281 | 419,653 |
| 2040(1) | 67,726 | 20,159 | 1,579 | 125,144 | 168,364 | 8,197 | 24,870 | 1 | 6,959 | 4,455 | 4,330 | 1,845 | 573 | 1,249 | 34,166 | 469,617 |
| 2040(2) | 70,392 | 23,215 | 1,724 | 126,407 | 169,497 | 8,320 | 28,924 | 2 | 7,921 | 5,090 | 4,447 | 2,183 | 649 | 1,380 | 35,172 | 485,323 |
| 2040(3) | 65,072 | 18,038 | 1,438 | 124,333 | 166,577 | 8,089 | 21,735 | 1 | 5,966 | 4,009 | 4,244 | 1,613 | 516 | 1,064 | 33,500 | 456,195 |
| 2040(4) | 67,461 | 20,789 | 1,568 | 125,468 | 167,582 | 8,202 | 25,348 | 2 | 6,850 | 4,581 | 4,350 | 1,917 | 585 | 1,180 | 34,387 | 470,270 |
| 2050(1) | 76,652 | 22,108 | 1,596 | 144,035 | 186,891 | 8,272 | 27,954 | 1 | 7,515 | 4,816 | 4,740 | 1,882 | 577 | 1,314 | 39,349 | 527,702 |
| 2050(2) | 79,484 | 25,652 | 1,745 | 145,358 | 188,056 | 8,411 | 32,505 | 2 | 8,582 | 5,508 | 4,856 | 2,229 | 653 | 1,453 | 40,406 | 544,901 |
| 2050(3) | 73,538 | 19,432 | 1,436 | 143,083 | 184,896 | 8,138 | 24,162 | 1 | 6,268 | 4,305 | 4,644 | 1,618 | 511 | 1,102 | 38,589 | 511,721 |
| 2050(4) | 76,062 | 22,622 | 1,568 | 144,294 | 185,918 | 8,269 | 28,215 | 2 | 7,296 | 4,928 | 4,749 | 1,930 | 581 | 1,217 | 39,496 | 527,148 |

NOTES: (1) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS
(2) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS
(3) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION
(4) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION

NECHES-TRINITY BASIN
TOTAL WATER DEMANDS IN ACRE-FEET/YEAR

| YEAR | COUNTY | | | | BASIN TOTAL |
|---|---|---|---|---|---|
| | CHAMBERS | GALVES-TON | JEFFER-SON | LIBERTY | |
| 1990 | 80,900 | 946 | 266,080 | 12,920 | 360,846 |
| 2000(1) | 66,263 | 854 | 199,642 | 11,723 | 278,482 |
| 2000(2) | 66,494 | 909 | 202,971 | 11,726 | 282,100 |
| 2000(3) | 66,208 | 831 | 198,394 | 11,723 | 277,156 |
| 2000(4) | 66,437 | 885 | 201,600 | 11,725 | 280,647 |
| 2010(1) | 66,647 | 841 | 202,663 | 11,716 | 281,867 |
| 2010(2) | 66,961 | 897 | 206,280 | 11,720 | 285,858 |
| 2010(3) | 66,475 | 797 | 199,862 | 11,714 | 278,848 |
| 2010(4) | 66,765 | 849 | 203,299 | 11,717 | 282,630 |
| 2020(1) | 67,064 | 866 | 206,393 | 11,709 | 286,032 |
| 2020(2) | 67,469 | 929 | 210,149 | 11,714 | 290,261 |
| 2020(3) | 66,751 | 790 | 202,200 | 11,705 | 281,446 |
| 2020(4) | 67,111 | 848 | 205,580 | 11,710 | 285,249 |
| 2030(1) | 67,390 | 946 | 211,398 | 11,702 | 291,436 |
| 2030(2) | 67,865 | 1,023 | 215,284 | 11,708 | 295,880 |
| 2030(3) | 66,985 | 837 | 206,357 | 11,698 | 285,877 |
| 2030(4) | 67,407 | 903 | 209,829 | 11,702 | 289,841 |
| 2040(1) | 67,623 | 1,061 | 215,786 | 11,703 | 296,173 |
| 2040(2) | 68,148 | 1,154 | 219,776 | 11,710 | 300,788 |
| 2040(3) | 67,131 | 909 | 210,003 | 11,697 | 289,740 |
| 2040(4) | 67,609 | 995 | 213,561 | 11,703 | 293,868 |
| 2050(1) | 67,887 | 1,199 | 220,334 | 11,709 | 301,128 |
| 2050(2) | 68,467 | 1,311 | 224,431 | 11,717 | 305,925 |
| 2050(3) | 67,294 | 995 | 213,788 | 11,700 | 293,778 |
| 2050(4) | 67,835 | 1,105 | 217,433 | 11,709 | 298,082 |

NOTES:

(1) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS
(2) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS
(3) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION
(4) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION

TRINITY BASIN
TOTAL WATER DEMANDS IN ACRE-FEET/YEAR

| YEAR | COUNTY | | | | | | | | | | | BASIN TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CHAM-BERS | GRIMES | HARDIN | HOUS-TON | LEON | LIBERTY | MAD-ISON | POLK | SAN JACINTO | TRINITY | WALKER | |
| 1990 | 41,464 | 471 | 5 | 4,878 | 3,569 | 63,487 | 3,130 | 3,591 | 1,206 | 1,558 | 6,807 | 130,166 |
| 2000(1) | 15,970 | 674 | 21 | 4,608 | 3,621 | 42,314 | 3,472 | 4,283 | 1,668 | 1,603 | 14,472 | 92,706 |
| 2000(2) | 16,091 | 753 | 23 | 5,051 | 3,870 | 43,480 | 4,023 | 5,276 | 2,056 | 1,906 | 17,542 | 100,071 |
| 2000(3) | 15,940 | 656 | 21 | 4,491 | 3,522 | 42,001 | 3,395 | 4,064 | 1,584 | 1,538 | 14,138 | 91,350 |
| 2000(4) | 16,058 | 732 | 23 | 4,923 | 3,767 | 43,116 | 3,931 | 5,025 | 1,960 | 1,828 | 17,084 | 98,447 |
| 2010(1) | 16,189 | 720 | 19 | 4,634 | 3,729 | 44,741 | 3,601 | 4,843 | 1,967 | 1,771 | 26,828 | 109,042 |
| 2010(2) | 16,346 | 812 | 21 | 5,081 | 3,992 | 46,120 | 4,184 | 5,990 | 2,442 | 2,101 | 30,613 | 117,702 |
| 2010(3) | 16,102 | 681 | 18 | 4,405 | 3,543 | 43,982 | 3,427 | 4,362 | 1,759 | 1,623 | 25,980 | 105,882 |
| 2010(4) | 16,243 | 768 | 20 | 4,824 | 3,787 | 45,292 | 3,976 | 5,435 | 2,203 | 1,929 | 29,522 | 113,999 |
| 2020(1) | 16,493 | 774 | 15 | 4,696 | 3,813 | 47,227 | 3,703 | 10,370 | 2,275 | 5,166 | 38,642 | 133,174 |
| 2020(2) | 16,698 | 881 | 18 | 5,154 | 4,087 | 48,837 | 4,309 | 11,661 | 2,839 | 5,519 | 43,119 | 143,122 |
| 2020(3) | 16,325 | 708 | 14 | 4,342 | 3,535 | 46,000 | 3,447 | 9,614 | 1,938 | 4,937 | 37,270 | 128,130 |
| 2020(4) | 16,506 | 805 | 16 | 4,758 | 3,771 | 47,416 | 3,983 | 10,774 | 2,445 | 5,250 | 41,264 | 136,988 |
| 2030(1) | 16,771 | 831 | 13 | 4,752 | 3,910 | 49,740 | 3,804 | 16,208 | 2,577 | 8,528 | 50,176 | 157,310 |
| 2030(2) | 17,016 | 955 | 16 | 5,218 | 4,194 | 51,584 | 4,434 | 17,732 | 3,227 | 8,896 | 55,462 | 168,734 |
| 2030(3) | 16,546 | 748 | 11 | 4,329 | 3,566 | 48,147 | 3,498 | 15,169 | 2,143 | 8,248 | 48,378 | 150,783 |
| 2030(4) | 16,764 | 859 | 13 | 4,753 | 3,826 | 49,767 | 4,053 | 16,538 | 2,712 | 8,588 | 53,093 | 160,966 |
| 2040(1) | 17,019 | 864 | 13 | 4,797 | 3,996 | 52,397 | 3,859 | 21,688 | 2,736 | 11,883 | 51,388 | 170,640 |
| 2040(2) | 17,296 | 997 | 16 | 5,269 | 4,292 | 54,507 | 4,500 | 23,345 | 3,431 | 12,264 | 57,310 | 183,227 |
| 2040(3) | 16,743 | 765 | 10 | 4,306 | 3,601 | 50,388 | 3,505 | 20,492 | 2,227 | 11,562 | 49,193 | 162,792 |
| 2040(4) | 16,996 | 885 | 13 | 4,736 | 3,869 | 52,310 | 4,071 | 21,988 | 2,853 | 11,900 | 54,477 | 174,098 |
| 2050(1) | 17,287 | 899 | 15 | 4,843 | 4,085 | 55,385 | 3,916 | 27,207 | 2,908 | 16,878 | 52,728 | 186,150 |
| 2050(2) | 17,600 | 1,042 | 18 | 5,321 | 4,394 | 57,799 | 4,568 | 29,008 | 3,651 | 17,272 | 59,361 | 200,035 |
| 2050(3) | 16,951 | 783 | 11 | 4,283 | 3,637 | 52,880 | 3,513 | 25,836 | 2,317 | 16,513 | 50,076 | 176,801 |
| 2050(4) | 17,244 | 912 | 15 | 4,719 | 3,913 | 55,153 | 4,090 | 27,470 | 3,004 | 16,849 | 55,994 | 189,364 |

NOTES: (1) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS
(2) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS
(3) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION
(4) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION

TRINITY-SAN JACINTO BASIN
TOTAL WATER DEMANDS IN ACRE-FEET/YEAR

| YEAR | COUNTY | | | BASIN TOTAL |
|---|---|---|---|---|
| | CHAMBERS | HARRIS | LIBERTY | |
| 1990 | 12,549 | 91,268 | 22,098 | 125,915 |
| 2000(1) | 14,466 | 103,534 | 18,375 | 136,375 |
| 2000(2) | 14,651 | 105,524 | 18,397 | 138,572 |
| 2000(3) | 14,399 | 102,675 | 18,368 | 135,442 |
| 2000(4) | 14,582 | 104,631 | 18,390 | 137,603 |
| 2010(1) | 16,106 | 107,787 | 19,227 | 143,120 |
| 2010(2) | 16,334 | 110,057 | 19,254 | 145,645 |
| 2010(3) | 15,940 | 105,944 | 19,210 | 141,094 |
| 2010(4) | 16,154 | 108,135 | 19,237 | 143,526 |
| 2020(1) | 18,048 | 114,763 | 20,086 | 152,897 |
| 2020(2) | 18,334 | 117,283 | 20,121 | 155,738 |
| 2020(3) | 17,757 | 111,905 | 20,059 | 149,721 |
| 2020(4) | 18,010 | 114,179 | 20,089 | 152,278 |
| 2030(1) | 20,885 | 121,090 | 20,944 | 162,919 |
| 2030(2) | 21,223 | 123,863 | 20,985 | 166,071 |
| 2030(3) | 20,511 | 117,598 | 20,908 | 159,017 |
| 2030(4) | 20,808 | 120,103 | 20,944 | 161,855 |
| 2040(1) | 22,797 | 127,695 | 21,809 | 172,301 |
| 2040(2) | 23,173 | 130,703 | 21,858 | 175,734 |
| 2040(3) | 22,337 | 123,495 | 21,763 | 167,595 |
| 2040(4) | 22,680 | 126,210 | 21,807 | 170,697 |
| 2050(1) | 25,060 | 134,726 | 22,759 | 182,546 |
| 2050(2) | 25,479 | 137,989 | 22,818 | 186,285 |
| 2050(3) | 24,501 | 129,722 | 22,701 | 176,924 |
| 2050(4) | 24,896 | 132,665 | 22,754 | 180,315 |

NOTES:

(1) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS
(2) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS
(3) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION
(4) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION

## SAN JACINTO BASIN
## TOTAL WATER DEMANDS IN ACRE-FEET/YEAR

| YEAR | COUNTY | | | | | | | | BASIN TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| | FORT BEND | GRIMES | HARRIS | LIBERTY | MONT-GOMERY | SAN JACINTO | WALKER | WALLER | |
| 1990 | 21,900 | 822 | 699,177 | 3,045 | 34,590 | 1,062 | 2,735 | 23,000 | 786,331 |
| 2000(1) | 21,498 | 1,172 | 893,173 | 4,793 | 43,680 | 1,434 | 3,468 | 17,170 | 986,388 |
| 2000(2) | 23,512 | 1,334 | 971,991 | 5,178 | 53,127 | 1,767 | 4,270 | 17,420 | 1,078,599 |
| 2000(3) | 20,941 | 1,136 | 872,697 | 4,639 | 41,731 | 1,360 | 3,346 | 17,113 | 962,963 |
| 2000(4) | 22,871 | 1,292 | 948,299 | 5,012 | 50,868 | 1,681 | 4,116 | 17,355 | 1,051,494 |
| 2010(1) | 26,671 | 1,253 | 1,006,784 | 5;615 | 56,537 | 1,726 | 4,019 | 17,167 | 1,119,772 |
| 2010(2) | 29,330 | 1,442 | 1,095,987 | 6,102 | 69,422 | 2,143 | 4,992 | 17,478 | 1,226,896 |
| 2010(3) | 25,182 | 1,174 | 960,443 | 5,210 | 51,155 | 1,538 | 3,698 | 17,019 | 1,065,419 |
| 2010(4) | 27,663 | 1,350 | 1,044,544 | 5,667 | 63,187 | 1,928 | 4,616 | 17,306 | 1,166,261 |
| 2020(1) | 32,432 | 1,346 | 1,130,421 | 6,415 | 70,498 | 2,040 | 4,554 | 17,251 | 1,264,957 |
| 2020(2) | 35,770 | 1,565 | 1,229,309 | 7,012 | 87,076 | 2,550 | 5,692 | 17,612 | 1,386,586 |
| 2020(3) | 29,792 | 1,211 | 1,057,453 | 5,733 | 61,015 | 1,728 | 4,035 | 17,017 | 1,177,984 |
| 2020(4) | 32,800 | 1,410 | 1,146,650 | 6,260 | 75,575 | 2,189 | 5,045 | 17,334 | 1,287,263 |
| 2030(1) | 37,835 | 1,450 | 1,256,755 | 7,273 | 85,804 | 2,353 | 5,156 | 17,490 | 1,414,116 |
| 2030(2) | 41,802 | 1,703 | 1,365,559 | 7,984 | 106,449 | 2,954 | 6,485 | 17,918 | 1,550,854 |
| 2030(3) | 34,247 | 1,278 | 1,164,562 | 6,379 | 72,345 | 1,947 | 4,473 | 17,170 | 1,302,401 |
| 2030(4) | 37,822 | 1,507 | 1,262,719 | 7,007 | 90,939 | 2,470 | 5,654 | 17,550 | 1,425,668 |
| 2040(1) | 41,485 | 1,510 | 1,374,089 | 8,033 | 98,126 | 2,523 | 5,649 | 17,581 | 1,548,996 |
| 2040(2) | 45,849 | 1,783 | 1,491,276 | 8,858 | 122,002 | 3,172 | 7,130 | 18,036 | 1,698,106 |
| 2040(3) | 37,162 | 1,308 | 1,265,146 | 6,942 | 81,765 | 2,041 | 4,827 | 17,214 | 1,416,405 |
| 2040(4) | 41,091 | 1,554 | 1,370,863 | 7,695 | 103,371 | 2,628 | 6,142 | 17,617 | 1,550,961 |
| 2050(1) | 45,566 | 1,579 | 1,503,721 | 8,900 | 112,382 | 2,712 | 6,194 | 17,717 | 1,698,771 |
| 2050(2) | 50,367 | 1,873 | 1,629,937 | 9,857 | 139,995 | 3,412 | 7,844 | 18,200 | 1,861,486 |
| 2050(3) | 40,401 | 1,344 | 1,376,167 | 7,576 | 92,556 | 2,145 | 5,213 | 17,298 | 1,542,700 |
| 2050(4) | 44,718 | 1,608 | 1,490,004 | 8,476 | 117,655 | 2,802 | 6,676 | 17,726 | 1,689,665 |

**NOTES:**

(1) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS
(2) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS
(3) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION
(4) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION

## SAN JACINTO–BRAZOS BASIN
## TOTAL WATER DEMANDS IN ACRE-FEET/YEAR

| YEAR | COUNTY BRAZORIA | FORT BEND | GALVES-TON | HARRIS | BASIN TOTAL |
|---|---|---|---|---|---|
| 1990 | 180,561 | 39,547 | 113,009 | 98,633 | 431,750 |
| 2000(1) | 176,148 | 49,470 | 121,093 | 129,929 | 476,640 |
| 2000(2) | 178,830 | 53,537 | 127,714 | 140,870 | 500,951 |
| 2000(3) | 174,988 | 48,145 | 119,279 | 127,771 | 470,183 |
| 2000(4) | 177,590 | 52,038 | 125,811 | 138,319 | 493,758 |
| 2010(1) | 182,911 | 61,173 | 136,687 | 161,760 | 542,531 |
| 2010(2) | 186,082 | 66,486 | 144,672 | 174,796 | 572,036 |
| 2010(3) | 180,058 | 57,569 | 132,351 | 156,691 | 526,669 |
| 2010(4) | 183,022 | 62,488 | 139,879 | 168,873 | 554,262 |
| 2020(1) | 193,978 | 74,201 | 154,401 | 197,248 | 619,828 |
| 2020(2) | 197,578 | 80,835 | 163,710 | 212,400 | 654,523 |
| 2020(3) | 189,437 | 67,960 | 147,341 | 188,965 | 593,703 |
| 2020(4) | 192,683 | 74,007 | 155,765 | 202,649 | 625,104 |
| 2030(1) | 203,154 | 86,972 | 171,034 | 233,008 | 694,168 |
| 2030(2) | 207,135 | 94,865 | 181,777 | 250,347 | 734,124 |
| 2030(3) | 197,377 | 78,817 | 161,784 | 222,599 | 660,577 |
| 2030(4) | 200,995 | 86,011 | 171,398 | 238,319 | 696,723 |
| 2040(1) | 214,200 | 96,879 | 186,389 | 266,443 | 763,911 |
| 2040(2) | 218,633 | 105,516 | 198,065 | 286,268 | 808,482 |
| 2040(3) | 207,123 | 87,348 | 175,473 | 253,780 | 723,724 |
| 2040(4) | 211,134 | 95,016 | 186,041 | 271,724 | 763,915 |
| 2050(1) | 227,828 | 108,109 | 203,270 | 304,809 | 844,017 |
| 2050(2) | 232,765 | 117,560 | 215,959 | 327,462 | 893,746 |
| 2050(3) | 219,249 | 97,014 | 190,492 | 289,540 | 796,295 |
| 2050(4) | 223,694 | 105,183 | 202,099 | 309,993 | 840,970 |

**NOTES:**

(1) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS
(2) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS
(3) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION
(4) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION

**BRAZOS BASIN**
**TOTAL WATER DEMANDS IN ACRE-FEET/YEAR**

| YEAR | COUNTY | | | | | | | | | | | BASIN TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AUSTIN | BRAZ-ORIA | BRAZOS | BURLE-SON | FORT BEND | GRIMES | LEON | MADI-SON | ROBERT-SON | WALLER | WASH-INGTON | |
| 1990 | 4,748 | 159,140 | 47,387 | 9,873 | 94,226 | 14,676 | 890 | 251 | 25,504 | 10,419 | 6,387 | 373,501 |
| 2000(1) | 4,837 | 203,043 | 46,419 | 14,293 | 80,358 | 16,025 | 1,111 | 355 | 48,629 | 9,364 | 7,285 | 431,719 |
| 2000(2) | 5,372 | 203,291 | 53,923 | 14,918 | 82,073 | 16,597 | 1,150 | 386 | 49,254 | 10,180 | 8,259 | 445,403 |
| 2000(3) | 4,695 | 202,944 | 45,133 | 14,171 | 79,652 | 15,902 | 1,089 | 350 | 48,501 | 9,195 | 7,065 | 428,697 |
| 2000(4) | 5,209 | 203,184 | 52,404 | 14,778 | 81,268 | 16,457 | 1,127 | 381 | 49,105 | 9,985 | 8,005 | 441,903 |
| 2010(1) | 5,110 | 259,909 | 54,067 | 14,712 | 91,483 | 16,387 | 1,094 | 357 | 50,738 | 10,025 | 7,943 | 511,825 |
| 2010(2) | 5,692 | 260,180 | 63,319 | 15,447 | 93,697 | 17,040 | 1,136 | 390 | 51,395 | 10,996 | 9,039 | 528,331 |
| 2010(3) | 4,793 | 259,690 | 50,663 | 14,411 | 89,542 | 16,113 | 1,053 | 347 | 50,476 | 9,615 | 7,427 | 504,130 |
| 2010(4) | 5,335 | 259,942 | 59,426 | 15,097 | 91,605 | 16,724 | 1,091 | 378 | 51,092 | 10,516 | 8,446 | 519,652 |
| 2020(1) | 5,342 | 322,862 | 61,945 | 15,248 | 95,182 | 21,068 | 1,072 | 358 | 59,420 | 10,691 | 8,575 | 601,763 |
| 2020(2) | 5,965 | 323,155 | 72,986 | 16,128 | 97,927 | 21,812 | 1,117 | 392 | 60,106 | 11,826 | 9,790 | 621,204 |
| 2020(3) | 4,844 | 322,526 | 56,277 | 14,746 | 91,889 | 20,623 | 1,009 | 343 | 59,033 | 10,016 | 7,753 | 589,059 |
| 2020(4) | 5,402 | 322,792 | 66,280 | 15,540 | 94,393 | 21,295 | 1,046 | 373 | 59,647 | 11,039 | 8,840 | 606,647 |
| 2030(1) | 5,549 | 326,928 | 70,305 | 15,569 | 103,546 | 25,782 | 1,051 | 358 | 68,097 | 11,521 | 9,209 | 637,915 |
| 2030(2) | 6,208 | 327,241 | 83,253 | 16,534 | 106,795 | 26,625 | 1,098 | 393 | 68,814 | 12,851 | 10,538 | 660,350 |
| 2030(3) | 4,948 | 326,509 | 62,807 | 14,939 | 99,288 | 25,210 | 972 | 340 | 67,634 | 10,635 | 8,192 | 621,474 |
| 2030(4) | 5,536 | 326,793 | 74,538 | 15,809 | 102,250 | 25,972 | 1,015 | 371 | 68,284 | 11,815 | 9,381 | 641,764 |
| 2040(1) | 5,752 | 329,718 | 76,387 | 15,872 | 105,409 | 30,327 | 1,059 | 358 | 76,793 | 11,859 | 9,779 | 663,313 |
| 2040(2) | 6,444 | 330,055 | 90,707 | 16,917 | 108,959 | 31,225 | 1,109 | 395 | 77,539 | 13,273 | 11,206 | 687,829 |
| 2040(3) | 5,055 | 329,205 | 67,739 | 15,131 | 100,454 | 29,659 | 968 | 337 | 76,268 | 10,849 | 8,565 | 644,230 |
| 2040(4) | 5,673 | 329,512 | 80,669 | 16,074 | 103,575 | 30,471 | 1,014 | 369 | 76,931 | 12,104 | 9,863 | 666,255 |
| 2050(1) | 5,976 | 332,627 | 83,124 | 16,202 | 107,613 | 37,033 | 1,070 | 360 | 89,786 | 12,216 | 10,400 | 696,406 |
| 2050(2) | 6,702 | 332,990 | 98,961 | 17,334 | 111,492 | 37,989 | 1,123 | 399 | 90,562 | 13,720 | 11,932 | 723,204 |
| 2050(3) | 5,175 | 332,010 | 73,168 | 15,337 | 101,869 | 36,260 | 966 | 336 | 89,196 | 11,073 | 8,968 | 674,358 |
| 2050(4) | 5,825 | 332,341 | 87,420 | 16,359 | 105,154 | 37,125 | 1,015 | 369 | 89,873 | 12,407 | 10,384 | 698,271 |

NOTES: (1) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS
(2) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS
(3) TOTAL USING AVERAGE MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION
(4) TOTAL USING HIGH MUNICIPAL WATER DEMAND PROJECTIONS AND ACCOUNTING FOR FUTURE CONSERVATION

# APPENDIX I

## Summary of Water Rights Permits and Contracts

SABINE BASIN: WATER PERMITS

| WRNUMBER | COUNTY | OWNER NAME | STREAM | USE | AMOUNT |
|---|---|---|---|---|---|
| 004657 | 210 | CITY OF CENTER | MILL | 1 | 1460 |
| 004658A | 176 | SABINE RIVER AUTHORITY | SABINE (1) | 1 | 100000 |
| 004662 | 176 | SABINE RIVER AUTHORITY | SABINE | 1/2 | 100400 |
| | | TOTAL: MUNICIPAL USE | | | 201860 |
| 004659 | 176 | WEIRGATE LUMBER COMPAN | LITTLE COW | 2 | 235 |
| 004664 | 181 | E I DUPONT DE NEMOURS & C | ADAMS BAYOU | 2 | 267000 |
| 004658A | 176 | SABINE RIVER AUTHORITY | SABINE (1) | 2 | 600000 |
| | | TOTAL: INDUSTRIAL USE | | | 867235 |
| 004660 | 176 | TEMPLE-INLAND FOREST PRO | UNNAMED | 3 | 50 |
| 004663 | 181 | J A HEARD ET AL | ORANGE CO DD | 3 | 67 |
| 004662 | 181 | SABINE RIVER AUTHORITY | SABINE | 3 | 46700 |
| 004658A | 176 | SABINE RIVER AUTHORITY | SABINE (1) | 3 | 50000 |
| | | TOTAL: IRRIGATION USE | | | 96817 |
| 004658A | 176 | SABINE RIVER AUTHORITY | SABINE | 5 | (2) |
| | | TOTAL: HYDROELECTRIC USE | | | (2) |
| 004661 | 176 | KIRBY FOREST INDUSTRIES IN | HARVE DAVIS | 7 | 0 |
| | | TOTAL: RECREATION USE | | | 0 |
| | | TOTAL: SABINE BASIN | | | 1165912 |

NOTES

1. TOLEDO BEND RESERVOIR SUPPLY
2. NO ANNUAL AMOUNT SPECIFIED; USE OF 21,000 CUBIC-FEET/SECOND

NECHES BASIN: WATER PERMITS

| WRNUMBER | COUNTY | OWNER NAME | STREAM | USE | AMOUNT | NOTES |
|---|---|---|---|---|---|---|
| 004411B | 123 | LOWER NECHES VALLEY AUTHORIT | NECHES & PINE | 1 | 0 | |
| 004402 | 174 | STEPHEN B TUCKER JR ETAL | TONKAWA | 1 | 1 | |
| 004399 | 210 | SHELBY CO FWSD NO 1 | BLACKWATER | 1 | 350 | |
| 004409 | 203 | CITY OF SAN AUGUSTINE | CARRIZO | 1 | 500 | |
| 004404 | 210 | CITY OF CENTER | SANDY | 1 | 3800 | |
| 004411B | 123 | LOWER NECHES VALLEY AUTHORIT | NECHES&PINE | 1 | 4202 | |
| 004864A | 174 | CITY OF NACOGDOCHES | BAYOU LOCO | 1 | 22000 | |
| 004415 | 123 | CITY OF BEAUMONT | NECHES | 1 | 56467 | |
| 004411B | 121 | LOWER NECHES VALLEY AUTHORIT | NECHES&ANGELN | 1 | 110000 | |
| | | TOTAL: MUNICIPAL USE | | | 197320 | |
| 004849 | 174 | STEPHEN F. AUSTIN UNIVERSITY | E FK TERRAPIN | 2 | 0 | |
| 004401 | 174 | GEORGE B FREDERICK ETAL | UNNAMED | 2 | 5 | |
| 005213 | 123 | PD GLYCOL LIMITED PARTNERSHIP | UNNAMED | 2 | 11 | |
| 005206 | 123 | FINA OIL & CHEMICAL COMPANY | NECHES | 2 | 40 | |
| 05091 | 181 | TEXAS EASTERN PRODUCTS PIPELN | NECHES | 2 | 100 | |
| 005027 | 121 | LOUISIANA-PACIFIC CORPORATION | SANDY CR | 2 | 225 | |
| 004433 | 123 | BETHLEHEM STEEL CORP. | NECHES | 2 | 268 | |
| 004412 | 121 | TEXAS PARKS & WILDLIFE | INDIAN | 2 | 811 | |
| 004436 | 123 | INDEPENDENT REFINING CORP. | NECHES | 2 | 2700 | |
| 004384 | 003 | TEMPLE-INLAND FOREST PROD COR | LITTLE CEDAR | 2 | 3000 | |
| 004435 | 123 | UNION OIL OF CALIFORNIA | NECHES | 2 | 4300 | |
| 004196 | 123 | STAR ENTERPRISE | NECHES | 2 | 12900 | |
| 004434 | 123 | MOBIL OIL CORP. | NECHES | 2 | 17922 | |
| 004393 | 003 | CHAMPION INTERNATIONAL CORP | ANGELINA | 2 | 19100 | |
| 004411B | 123 | LOWER NECHES VALLEY AUTHORIT | NECHES&PINE IS | 2 | 51314 | |
| 004186 | 123 | GULF STATES UTILITIES | NECHES RIVER | 2 | 279131 | 1 |
| 004437A | 123 | TEXACO CHEMICAL CO | NECHES | 2 | 434400 | |
| 004411B | 121 | LOWER NECHES VALLEY AUTHORIT | NECHES&ANGELN | 2 | 600000 | |
| 004438 | 181 | GULF STATES UTILITIES CO. | SABINE LAKE | 2 | 1590820 | 2 |
| | | TOTAL: INDUSTRIAL USE | | | 3017047 | |
| 005502 | 003 | A O MCQUEEN | UNNAMED | 3 | 0 | |
| 004386 | 003 | ROBERT L FLOURNOY ETAL | BRUSHY | 3 | 1 | |
| 004395 | 174 | STEPHEN B TUCKER JR ETAL | UNNAMED | 3 | 1 | |
| 003296 | 113 | JAMES ROBERT BLOUNT ET AL | UNNAMED | 3 | 2 | |
| 004862 | 174 | R M KELLERMAN & WIFE | BEECH | 3 | 3 | |
| 004387 | 229 | W C CREWS JR ETAL | GREENWOOD | 3 | 4 | |
| 004115 | 174 | FLORENCE GOODMAN WEBB ET AL | UNNAMED | 3 | 5 | |
| 004279 | 174 | HARRY L & BARBARA GERMAN | UNNAMED | 3 | 7 | |
| 004448 | 174 | CLARENCE M FORE | UNNAMED | 3 | 9 | |
| 004382 | 003 | TEXAS A&M UNIVERSITY | JACK & TRIB | 3 | 9 | |

| | | | | | |
|---|---|---|---|---|---|
| 004869 | 174 | ROBERT W MURPHEY | UNNAMED | 3 | 9 |
| 004396 | 174 | NOLAN BAILEY ALDERS | UNNAMED | 3 | 10 |
| 004430 | 229 | DAVID A. PROVOST ESTATE | BRUSH | 3 | 10 |
| 004269 | 174 | LOUIS G & FRANCES E FEARS | WAFFELOW CREE | 3 | 10 |
| 004401 | 174 | GEORGE B FREDERICK ETAL | NACONICHI&TRIB | 3 | 10 |
| 004406 | 174 | PAT SCOGGINS | BLACK | 3 | 11 |
| 003295 | 113 | BOBBY & JUANICE CUNNINGHAM | UNNAMED | 3 | 20 |
| 003299 | 113 | JOHN A WILKINS | UNNAMED | 3 | 20 |
| 003297 | 113 | E W MARTIN | UNNAMED | 3 | 21 |
| 002054 | 203 | ALVIN V NEWTON | E P AYISH | 3 | 22 |
| 003293 | 113 | W A BROWN | HARMON MILL BR | 3 | 23 |
| 005389 | 003 | DIBOLL, CITY OF | UN/WHITE OK CR | 3 | 30 |
| 003288 | 113 | DEXTER BONNETTE | UNNAMED | 3 | 30 |
| 003294 | 113 | GRADY EDGE ET AL | HARMON MILL BR | 3 | 34 |
| 004872 | 174 | A T MAST | LA NANA | 3 | 34 |
| 004429 | 229 | AUBREY T RAIFORD | SPURLOCK | 3 | 35 |
| 003299 | 113 | JOHN A WILKINS | UNNAMED | 3 | 38 |
| 004873 | 174 | A T MAST | LA NANA | 3 | 42 |
| 004397 | 174 | GRACE F. GILCREASE | MARTIN & TRIB | 3 | 42 |
| 004866 | 174 | W B STRIPLING JR | B LOCO & EVANS | 3 | 47 |
| 004863 | 174 | INTERNATIONAL PAPER CO | BLACK | 3 | 50 |
| 001614 | 174 | JOHN D RICHARDSON | CRAWFORD | 3 | 70 |
| 003287 | 113 | PERNIE BAILEY DRILLING CO | UNNAMED | 3 | 75 |
| 004426 | 229 | BURWELL F BOYKIN | ANDERSON | 3 | 80 |
| 003298 | 113 | GRADY B LAKE JR ET AL | UNNAMED | 3 | 83 |
| 003292 | 113 | DONALD CUNNINGHAM ET AL | UNNAMED | 3 | 83 |
| 003291 | 113 | CHESTER CUNNINGHAM | UNNAMED | 3 | 88 |
| 004380A | 228 | TEMPLE-INLAND FOREST PROD COR | NECHES | 3 | 100 |
| 003290 | 113 | E HUBERT BRIMBERRY | SAN PEDRO CR | 3 | 105 |
| 004403 | 174 | A T MAST JR ETAL | WAFFELOW | 3 | 111 |
| 004865 | 174 | A T MAST JR | B LOCO & TRIB | 3 | 116 |
| 004413 | 121 | TEMPLE-INLAND FOREST PROD COR | INDIAN | 3 | 120 |
| 004414 | 121 | TEXAS FOREST SERVICE | WRIGHT | 3 | 125 |
| 003289 | 113 | NEIL LOWERY | UNNAMED | 3 | 168 |
| 001935 | 113 | THOMAS H SHARTLE | SAN PEDRO | 3 | 185 |
| 004432 | 100 | PINEWOOD MANAGEMENT CORP | L PINE ISLAND | 3 | 200 |
| 004383 | 003 | CROWN COLONY COUNTRY CLUB | UNNAMED | 3 | 200 |
| 004867 | 174 | JOHN C MAST | B LOCO & TRIB | 3 | 214 |
| 004392 | 229 | DAN H BYRAM | BEAN | 3 | 250 |
| 004431 | 146 | JIM BEST | BATISTE | 3 | 354 |
| 005134A | 174 | S B HAYTER TRUST | UNNAMED | 3 | 525 |
| 004411B | 121 | LOWER NECHES VALLEY AUTHORIT | NECHES&ANGELN | 3 | 110000 |
| 004411B | 123 | LOWER NECHES VALLEY AUTHORIT | NECHES&PINE | 3 | 326360 |
| | | TOTAL: IRRIGATION USE | | | 440201 |
| 005013 | 174 | MILLER-COHLMIA TRUSTEES | UNNAMED | 7 | 0 |
| 004419 | 100 | WILDWOOD PROP OWNERS ASSOC | KIMBALL | 7 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| 004425 | 229 | TIMBERLAKES DEVELOPMENT CO. | MAGNUS & TRIB | 7 | 0 |
| 004199 | 229 | JERRY DARRELL CHANCE ET AL | UNNAMED TRIB | 7 | 0 |
| 004390 | 229 | JOHN D STOVER ETAL | UNNAMED | 7 | 0 |
| 004400 | 174 | HOLLY LAKE INC | UNNAMED | 7 | 0 |
| 004423 | 229 | JOSEPH C NICHOLS JR | UNNAMED | 7 | 0 |
| 004398 | 003 | GENE BORDERS | ROCKY | 7 | 0 |
| 004389 | 229 | COLMESNEIL ISD | ONE MILE BR | 7 | 0 |
| 004868 | 174 | LAKE ALAZAN, INC. | ALAZAN | 7 | 0 |
| 004418 | 187 | TEXAS COMM INDIAN AFFAIRS | TOMBIGBEE | 7 | 0 |
| 004394 | 003 | CITY OF LUFKIN | UNNAMED | 7 | 0 |
| 005181 | 187 | WILSON LAKE MAINTENANCE ASSOC | E FK DOUBLE BR | 7 | 0 |
| 004870 | 174 | CITY OF NACOGDOCHES | MILL POND | 7 | 0 |
| 003305 | 113 | TEMPLE-INLAND FOREST PROD COR | CONNER CREEK | 7 | 0 |
| 004871 | 174 | HANSON LAKE CLUB INC | HOYA | 7 | 0 |
| 004388 | 121 | U S FOREST SERVICE | BOYKIN | 7 | 0 |
| 004370 | 113 | EVALINE MOORE | MILES | 7 | 0 |
| 004408 | 203 | ALVIN V NEWTON | UNNAMED | 7 | 0 |
| 004391 | 229 | VIRGINIA HARALSON ETAL | WOLF | 7 | 0 |
| 004385 | 003 | TEMPLE-INLAND FOREST PROD COR | WHITE OAK | 7 | 0 |
| 004427 | 229 | F KENNETH BAILEY | UNNAMED | 7 | 0 |
| 004381 | 228 | TEMPLE-INLAND FOREST PROD COR | OLD R & CEDAR | 7 | 0 |
| 004428 | 229 | MORRIS C CLEMMONS JR | SPURLOCK | 7 | 0 |
| 004422 | 229 | CHESWOOD LAKE CLUB | UNNAMED | 7 | 0 |
| 005222 | 113 | GRAPELAND COUNTRY CLUB | SAN PEDRO CR | 7 | 0 |
| 004417 | 187 | A A WELLS | UNNAMED | 7 | 0 |
| 004416 | 187 | INDIAN SPRINGS LAKE ESTATES | W FK DOUBLE ET | 7 | 0 |
| 003306 | 113 | U S DEPT OF AGRICULTURE FOREST | LEE CREEK | 7 | 0 |
| 004379 | 003 | S W HENDERSON, JR TRUSTEE | OLD RIVER SL | 7 | 0 |
| 004407 | 203 | JOE J FISHER | AYISH BAYOU | 7 | 0 |
| 004405 | 210 | ATTOYAC HUNTING & FISHING CLUB | UNNAMED | 7 | 0 |
| 004420 | 187 | HICKORY SPRINGS POA ETAL | LITTLE HICKORY | 7 | 0 |
| 004595 | 203 | WOODLAND ACRES MAINTENANCE I | TUPELO GUM SLO | 7 | 0 |
| 004848 | 174 | J L DEDMAN | S FK PENN | 7 | 0 |
| 003300 | 113 | TEXAS PARKS & WILDLIFE DEPT | UNNAMED | 7 | 0 |
| 004424A | 229 | JOSIAH WHEAT | L TRUKEY&TRIB | 7 | 0 |
| 004421 | 187 | SAN JACINTO BAPTIST ASSN | UNNAMED | 7 | 0 |
| 004118 | 003 | EXETER INVESTMENT CO ET AL | UNNAMED | 7 | 6 |
| 004380A | 228 | TEMPLE-INLAND FOREST PROD COR | NECHES | 7 | 150 |
| | | TOTAL: RECREATION USE | | | 156 |
| | | TOTAL: NECHES BASIN | | | 3654724 |

NOTES

1. CONSUMPTIVE USE OF 6000 AC-FT/YR
2. CONSUMPTIVE USE OF 17,210 AC-FT/YER; BRACKINSH WATER; COOLING

NECHES-TRINITY BASIN: WATER PERMITS

| WRNUMBER | COUNTY | OWNERNAME | STREAM | USE | AMOUN | NOTES |
|---|---|---|---|---|---|---|
| 004495 | 123 | STAR ENTERPRISE | TAYLOR ETC | 2 | 121 | |
| 004441 | 123 | RICE-CARDEN CORP | P ARTHUR BASIN | 2 | 336 | |
| 004305 | 036 | WILLIAM S EDWARDS | ELM BAYOU | 2 | 1200 | |
| 004304 | 036 | CHARLES T JONES ETAL | EAST BAY BAYO | 2 | 5320 | |
| 004494 | 123 | CHEVRON U.S.A. INC | DD #7 CANAL | 2 | 107787 | 1 |
| | | TOTAL: INDUSTRIAL USE | | | 114764 | |
| 002627 | 036 | W H OETKEN | BATISTE | 3 | 0 | |
| 000853 | 123 | W P H MCFADDIN JR | TAYLORS | 3 | 0 | |
| 000221 | 123 | HERBERT CLUBB | MAYHAW | 3 | 0 | |
| 001615 | 036 | CARL J FITZGERALD | CANE BAYU | 3 | 0 | |
| 000275A | 123 | T A FEARS | MAYHAW | 3 | 0 | |
| 000227 | 123 | J E BROUSSARD ET AL | HILEBRANT | 3 | 0 | |
| 000305 | 123 | H E WINGATE ET AL | TAYLOR | 3 | 0 | |
| 000301 | 123 | GUY DEATON | TAYLOR | 3 | 0 | |
| 000572A | 123 | CLIFFORD MANUEL ET AL | TAYLOR | 3 | 0 | |
| 000452A | 036 | J C JACKSON ESTATE | OYSTER B | 3 | 0 | |
| 000383 | 123 | M HALF CIRCLE RANCH CO | TAYLOR | 3 | 0 | |
| 000615 | 123 | ROBIN A STEINHAGEN | BAYOU DIN | 3 | 0 | |
| 000841A | 123 | LOVELL LAKE CO | TAYLOR | 3 | 0 | |
| 004291 | 036 | JOHN G MIDDLETON, ETAL | E FK DOUBLE | 3 | 43 | |
| 004480 | 123 | CITY OF BEAUMONT | HILLEBRANDT | 3 | 55 | |
| 004463 | 123 | B E QUINN III, ETAL | N FK MAYHAW | 3 | 63 | |
| 004303 | 036 | DON W. LAGOW & WIFE | ONION BAYOU | 3 | 68 | |
| 004491 | 123 | MARVIN DUDLEY | HILLEBRANDT | 3 | 77 | |
| 004467 | 123 | LOLA GILL OWEN ETAL | S FK TAYLOR | 3 | 154 | |
| 004288 | 036 | GENE A NELSON ETAL | E FK DOUBLE | 3 | 204 | |
| 004462 | 123 | BAR C RANCH COMPANY | N FK MAYHAW | 3 | 217 | |
| 004452 | 123 | FARM CREDIT BANK OF TEXAS | S FK MAYHAW | 3 | 242 | |
| 004292 | 036 | DONALD G NELSON, ETAL | BATISTE | 3 | 250 | |
| 004458 | 123 | BAR C RANCH COMPANY | N FK MAYHAW | 3 | 276 | |
| 004445 | 123 | EDWIN A BLUESTEIN JR & WIFE | S FK TAYLOR | 3 | 335 | |
| 004473 | 123 | JIM R & H E WINGATE | S FK TAYLOR | 3 | 336 | |
| 004456 | 123 | DOROTHY NELL WILBER ETAL | N FK MAYHAW | 3 | 350 | |
| 004448 | 123 | HERBERT CLUBB AND SONS, IN | MAYHAW | 3 | 350 | |
| 004446 | 123 | RALPH M SHARPE JR, TRUSTEE | S FK TAYLOR | 3 | 350 | |
| 004290 | 036 | THOMAS L FAHRING, JR | E FK DOUBLE | 3 | 382 | |
| 004289 | 036 | OCTAVIA F STANLEY | E FK DOUBLE | 3 | 382 | |
| 004447 | 123 | JAMES L BROUSSARD ET AL | S FK TAYLOR | 3 | 396 | |
| 004461 | 123 | ROBERT L. SHELLHAMMER & W | N FK MAYHAW | 3 | 397 | |
| 004472 | 123 | JIM R. WINGATE | S FK TAYLOR | 3 | 400 | |
| 004265A | 036 | W J WINZER JR | SPINDLETOP B | 3 | 403 | |
| 004310 | 036 | W. J. WINZER, JR | SPINDLETOP | 3 | 413 | |

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|---|---|---|---|---|---|
| 004486 | 123 | CARL D. LEVY, TRUSTEE | BAYOU DIN | 3 | 438 |
| 004312A | 036 | JESS MATTHEWS JR ET AL | SPINDLETOP | 3 | 470 |
| 004229 | 123 | PATRICK & MICHAEL PHELAN | UNNAMED | 3 | 480 |
| 004479 | 123 | CHEMICAL WASTE MANAGEME | FISH BOX&TAYL | 3 | 500 |
| 004478 | 123 | SHIRLA HOWARD ETAL | FISH BOX&TAYL | 3 | 500 |
| 004439 | 123 | O D & ROBERT CLUBB | N FK TAYLOR | 3 | 504 |
| 004459 | 123 | B E WILBER | MAYHAW | 3 | 511 |
| 004471 | 123 | HERBERT CLUBB | MAYHAW&SF TA | 3 | 525 |
| 004454 | 123 | RUSSELL & IVO PHEND JR | N FK MAYHAW | 3 | 539 |
| 004464 | 123 | DOROTHY NELL WILBER ETAL | N FK MAYHAW | 3 | 560 |
| 004060 | 123 | ETHEL STEPHENSON | MAYHAW BAYO | 3 | 595 |
| 004465 | 123 | WALTER J CRAWFORD ETAL | S FK MAYHAW | 3 | 600 |
| 004457 | 123 | G A N MCFADDIN ETAL | N FK MAYHAW | 3 | 607 |
| 004469 | 123 | C C WILBER | MAYHAW | 3 | 620 |
| 004294 | 036 | BROWN FOUNDATION, INC | DRAINAGE DITC | 3 | 674 |
| 004297 | 036 | GULF COAST BANK | OYSTER BAYOU | 3 | 675 |
| 004443 | 123 | JIM R WINGATE | N FK TAYLOR | 3 | 700 |
| 004444 | 123 | H E WINGATE ETAL | N FK TAYLOR | 3 | 700 |
| 004488 | 123 | J E BROUSSARD II ETAL | HILLEBRANDT | 3 | 788 |
| 004455 | 123 | BAR C RANCH COMPANY | N FK MAYHAW | 3 | 844 |
| 004300 | 036 | J. C. JACKSON ESTATE | OYSTER BAYOU | 3 | 875 |
| 004293 | 036 | LOUISE BARROW GORTON | UNNAMED | 3 | 880 |
| 004292 | 036 | ELOISE BARROW MEREDITH | UNNAMED | 3 | 880 |
| 004298 | 036 | BROWN BROTHERS FARM | OYSTER BAYOU | 3 | 891 |
| 004492 | 123 | BERNIE BROWN ETAL | RHODAIR GULLY | 3 | 900 |
| 004451 | 123 | JUNKER SPENCER ESTATE | S FK TAYLOR | 3 | 969 |
| 004490 | 123 | HARRY M HEBERT ETAL | HILLEBRANDT | 3 | 1050 |
| 004308 | 036 | L C DEVELLIER | RUSH DITCH | 3 | 1109 |
| 004264A | 036 | W J WINZER JR ET AL | SPINDLETOP B | 3 | 1123 |
| 004485 | 123 | MARGARET TODD ESTATE | BAYOU DIN | 3 | 1138 |
| 004228 | 123 | NOLIA F BOUDREAUX ETAL | SAND GULLY | 3 | 1191 |
| 004291 | 036 | SOLMON WESLEY BARROW ET | UNNAMED | 3 | 1220 |
| 004290A | 036 | DON WESLEY LAGOW ET AL | UNNAMED | 3 | 1220 |
| 005016A | 036 | JOHN M BLACKWELL | SPINDLETOP B | 3 | 1250 |
| 005069 | 123 | RUTH L MACKAN ET AL | PIGNUT GULLEY | 3 | 1250 |
| 004312A | 036 | JESS MATTHEWS JR ET AL | SPINDLETOP | 3 | 1284 |
| 004295 | 036 | JEWEL FITZGERALD | CANE & WILLOW | 3 | 1400 |
| 004474 | 123 | JOHN H. KLEIN ESTATE | TAYLOR | 3 | 1500 |
| 004468 | 123 | B E WILBER ETAL | MAYHAW | 3 | 1551 |
| 004293 | 036 | EDMONDS BROTHERS FARMS | W FK DOUBLE | 3 | 1780 |
| 004450 | 123 | JAMES L BROUSSARD & WIFE | MAYHAW&SF TA | 3 | 1800 |
| 004299 | 036 | OCIE R. JACKSON ETAL | OYSTER BAYOU | 3 | 1834 |
| 004449 | 123 | HERBERT CLUBB AND SONS INC | MAYHAW | 3 | 1862 |
| 004301 | 036 | BARROW RANCHES | ONION BAYOU | 3 | 2000 |
| 004306 | 036 | DOROTHY C MCBRIDE ETAL | ELM BAYOU | 3 | 2100 |
| 004309 | 036 | SPINDLETOP BAYOU FARMS | SPINDLETOP | 3 | 2118 |
| 004304 | 036 | CHARLES T JONES ETAL | EAST BAY BAYO | 3 | 2240 |
| 004314 | 123 | L C RUSSELL ETAL | SAND&ARCENEA | 3 | 2402 |

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|---|---|---|---|---|---|---|
| 004466 | 123 | LOLA GILL OWEN ETAL | N FK MAYHAW | 3 | 2475 | |
| 004487 | 123 | JOHN GARDNER NELSON ETAL | HILLEBRANDT | 3 | 2483 | |
| 004453 | 123 | FARM CREDIT BANK OF TEXAS | N FK MAYHAW | 3 | 2550 | |
| 004311A | 036 | JOHN MIDDLETON | SPINDLETOP | 3 | 2700 | |
| 004481 | 123 | J E BROUSSARD II ETAL | HILLEBRANDT | 3 | 2800 | |
| 004271B | 123 | JOE BROUSSARD II PARTN, ET A | MAYHAW BAYO | 3 | 3000 | |
| 004460 | 123 | C C WILBER ETAL | N FK MAYHAW | 3 | 3150 | |
| 004100A | 123 | HARRY HOLLOWAY | WILLOW MARSH | 3 | 3358 | |
| 004484 | 123 | STEINHAGEN BROTHERS | BAYOU DIN | 3 | 3500 | |
| 004489 | 123 | TEXAS RICE LAND COMPANY | JOHNS GULLEY | 3 | 3500 | |
| 004470 | 123 | J H TAYLOR | MAYHAW | 3 | 3805 | |
| 004287 | 036 | W E JENKINS, JR ETAL | E FK DOUBLE | 3 | 4900 | |
| 000216 | 123 | JEFFERSON LAND CO | HILEBRANT | 3 | 5000 | |
| 004482 | 123 | JEFFERSON LAND COMPANY | HILEBRNT&PEVI | 3 | 5000 | |
| 004302 | 036 | U.S.-ANAHUAC NWR-BARROW | ONION BAYOU | 3 | 5932 | |
| 004313 | 123 | BRUCE WILBER PIPKIN ESTATE | SPINDLETOP | 3 | 6365 | |
| 004440 | 123 | JOHN F GAULDING ETAL | N FK TAYLOR | 3 | 7500 | |
| 004476 | 123 | LOVELL LAKE COMPANY | TAYLOR | 3 | 9477 | |
| 004574 | 123 | FARM CREDIT BANK OF TEXAS | MAYHAW BAYO | 3 | 10250 | 2 |
| 004475 | 123 | M HALF CIRCLE RANCH COMPA | TAYLOR | 3 | 12000 | |
| 004477 | 123 | JOE BROUSSARD II ETAL | TAYLOR | 3 | 14416 | |
| 004296 | 036 | U.S. ANAHUAC WILDLIFE REFU | OYSTER BAYOU | 3 | 21000 | |
| | | **TOTAL: IRRIGATION USE** | | | **192951** | |
| 004442 | 123 | CHEVRON U.S.A., INC. | N FK TAYLOR | 4 | 77 | |
| 004390A | 123 | U S DEPARTMENT ENERGY | INTRACOASTAL | 4 | 117291 | 3 |
| | | **TOTAL: MINING USE** | | | **117368** | |
| 004422 | 123 | U S DEPT OF INTERIOR | WILD COW BAY | 7 | 0 | |
| 005059 | 036 | JERE RUFF | UNNAMED | 7 | 30 | |
| | | **TOTAL: RECREATION USE** | | | **30** | |
| 004307 | 036 | TRINITY BAY CONSERVATION D | ELM BAYOU | 8 | 0 | |
| 004296 | 036 | U.S. ANAHUAC WILDLIFE REFU | OYSTER BAYOU | 8 | 0 | |
| 005317 | 123 | JEFFERSON CO NAVIGATION DI | TAYLOR BAYOU | 8 | 0 | |
| 004493 | 123 | TEXAS PARKS & WILDLIFE DEP | BIG HILL | 8 | 7000 | |
| | | **TOTAL: FLOOD CONTROL USE** | | | **7000** | |
| | | **TOTAL: NECHES-TRINITY BASIN** | | | **432113** | |

NOTES
1. CONSUMPTIVE USE OF 480 AC-FT/YR
2. EXPIRES 12/31/95
3. BRACKISH WATER

TRINITY BASIN: WATER PERMITS

| WRNUMBER | COUNTY | OWNER NAME | STREAM | USE | AMOUNT | NOTES |
|---|---|---|---|---|---|---|
| 004261 | 146 | CITY OF HOUSTON | TRINITY | 1 | 0 | |
| 004279 | 036 | CHAMBERS-LIBERTY COS ND | TRINITY ETAL | 1 | 2147 | |
| 005097 | 113 | HOUSTON CO WCID 1 | LITTLE ELKHAR | 1 | 3500 | |
| 004261 | 036 | CITY OF HOUSTON | TRINITY | 1 | 10000 | |
| 004248 | 036 | TRINITY RIVER AUTHORITY | TRINITY | 1 | 10000 | |
| 004248 | 187 | TRINITY RIVER AUTHORITY | TRINITY | 1 | 40000 | |
| 004261 | 187 | CITY OF HOUSTON | TRINITY | 1 | 444000 | |
| | | TOTAL: MUNICIPAL USE | | | 509647 | |
| 004285 | 146 | CHARLES & PAUL HAIDUSEK | WHITES | 2 | 0 | |
| 005318 | 145 | NORTHWESTERN RESOURCES CO | UNNAMED | 2 | 130 | |
| 004250 | 236 | TEXAS PARKS & WILDLIFE DEPT | HARMON | 2 | 1200 | |
| 005271 | 146 | TRINITY WATER RESERVE, INC. | TRINITY | 2 | 4000 | |
| 004248 | 036 | TRINITY RIVER AUTHORITY | TRINITY | 2 | 11600 | |
| 004261 | 036 | CITY OF HOUSTON | TRINITY | 2 | 28000 | |
| 004279 | 036 | CHAMBERS-LIBERTY COS ND | TRINITY ETAL | 2 | 30000 | |
| 004261 | 036 | CITY OF HOUSTON | TRINITY & OLD | 2 | 31600 | |
| 004248 | 187 | TRINITY RIVER AUTHORITY | TRINITY | 2 | 207150 | |
| 004261 | 187 | CITY OF HOUSTON | TRINITY | 2 | 458800 | |
| | | TOTAL: INDUSTRIAL USE | | | 772480 | |
| 001790 | 187 | PAUL LAURENT | BLACK | 3 | 0 | |
| 001923A | 113 | M L & M H KNOX | HURRICANE | 3 | 0 | |
| 004258 | 228 | C. J. RICHARDSON & WIFE | UNNAMED | 3 | 3 | |
| 005090 | 113 | E S DARSEY & WIFE | UNNAMED | 3 | 5 | |
| 004238 | 145 | RAY SIMPSON & WIFE | UNNAMED | 3 | 6 | |
| 005093 | 113 | CHARLES WENDELL WARNER ET | UNNAMED | 3 | 9 | |
| 005098 | 113 | WADE L. PENNINGTON | UNNAMED | 3 | 20 | |
| 005094 | 113 | WADE L PENNINGTON | UNNAMED | 3 | 20 | |
| 004253 | 236 | ROBERT D. JAMESON | L CAROLINA | 3 | 20 | |
| 005095 | 113 | JUDY ELAINE GOAR | UNNAMED | 3 | 40 | |
| 005087 | 113 | BEN H CAUDLE ETAL | UNNAMED | 3 | 43 | |
| 005083 | 145 | MRS A P VAN WINKLE ETAL | BUFFALO & TRIB | 3 | 50 | |
| 005096 | 113 | C D CHEATHAM JR ETAL | CANEY & TRIB | 3 | 51 | |
| 004233 | 113 | M. H. KNOX & WIFE | HURRICANE & | 3 | 65 | |
| 004230 | 113 | ELSIE ANNE EAKIN | UNNAMED | 3 | 67 | |
| 005086 | 113 | WILLIE BEDFORD CASKEY | CHAFFIN | 3 | 70 | |
| 005088 | 113 | HENRY C BROWN ESTATE ETAL | BIG ELKHART | 3 | 80 | |
| 004232 | 113 | SPRING CREEK COUNTRY CLUB | SPRING CREEK | 3 | 81 | |
| 005091 | 113 | ARWINE SKIDMORE ESTATE | UNNAMED | 3 | 83 | |

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|---|---|---|---|---|---|
| 005092 | 113 | JAMES KENT DAILEY ESTATE | UNNAMED | 3 | 84 |
| 004254 | 113 | ERNEST MARIETTA & WIFE | UNNAMED | 3 | 88 |
| 005089 | 113 | ERNEST E HUFF | UNNAMED | 3 | 88 |
| 004231 | 113 | BISON DEVELOPMENT CO. | HAMMOND | 3 | 100 |
| 004284 | 146 | STEPHEN & LOUIS MECHE | WHITES | 3 | 104 |
| 004256 | 228 | WESTWOOD SHORES, INC. | UNNAMED | 3 | 150 |
| 005075 | 113 | JOHN A MCCALL, ET AL | TRINITY&QUALE | 3 | 170 |
| 004234 | 113 | O. O. BROWN, TRUSTEE ETAL | TRINITY & TRIB | 3 | 170 |
| 004282 | 146 | L B MAXWELL ETAL | UNNAMED | 3 | 172 |
| 005085 | 145 | C W KENNEDY III ETAL | U KEECHI/TRIN | 3 | 175 |
| 004249 | 236 | TEXAS DEPT. OF CORRECTIONS | TURKEY | 3 | 179 |
| 004281 | 146 | JACK STOESSER ETAL | COW ISLAND | 3 | 232 |
| 004086 | 113 | ALICANTE CORPORATION N V | HURRICANE | 3 | 339 |
| 004235 | 113 | GRADY B. LAKE, JR. | TRINITY | 3 | 353 |
| 004280 | 146 | GEORGE W MAXWELL | COW ISLAND | 3 | 395 |
| 004285 | 146 | CHARLES & PAUL HAIDUSEK | WHITES | 3 | 440 |
| 005076 | 113 | RLG REALTY HOLDINGS LTD | TRINITY | 3 | 500 |
| 005061A | 113 | JOHN W KLEIN | LTL ELKHART C | 3 | 500 |
| 004283 | 146 | JOHN I LOVELL & A REESE BROW | NF LONG ISLAN | 3 | 640 |
| 004240 | 157 | TEXAS DEPT. OF CORRECTIONS | TRINITY & TRIB | 3 | 701 |
| 004286 | 036 | JETT HANKAMER & SONS | WHITES | 3 | 710 |
| 004241 | 113 | TEXAS DEPT. OF CORRECTIONS | TRINITY & TRIB | 3 | 961 |
| 005061A | 113 | JOHN W KLEIN | BIG ELKHART CR | 3 | 1000 |
| 004239 | 113 | SEVEN J STOCK FARM, INC. | TRINITY | 3 | 1240 |
| 004269 | 146 | TRINITY PLANTATION, INC ETAL | MENARD | 3 | 1932 |
| 002640 | 146 | PRICE & ELLEN DANIEL TRUSTEE | JOSIE BAYOU | 3 | 2400 |
| 004261 | 036 | CITY OF HOUSTON | TRINITY & OLD | 3 | 13400 |
| 004248 | 036 | TRINITY RIVER AUTHORITY | TRINITY | 3 | 30000 |
| 004277 | 146 | DAYTON CANAL CO. | TRINITY ETAL | 3 | 38000 |
| 005271 | 146 | TRINITY WATER RESERVE, INC. | TRINITY | 3 | 47500 |
| 004248 | 187 | TRINITY RIVER AUTHORIY | TRINITY | 3 | 104450 |
| 004279 | 036 | CHAMBERS-LIBERTY COS ND | TRINITY ETAL | 3 | 110000 |
| | | TOTAL: IRRIGATION USE | | | 357886 |
| 004279 | 036 | CHAMBERS-LIBERTY COS ND | TRINITY ETAL | 4 | 800 |
| 005271 | 146 | TRINITY WATER RESERVE, INC. | TRINITY | 4 | 7000 |
| | | TOTAL: MINING USE | | | 7800 |
| 004263 | 187 | WIGGINS LAND CO. | UNNAMED | 7 | 0 |
| 004268 | 146 | EILEEN FOWLER, ATTORNEY, ET | MILL | 7 | 0 |
| 004244 | 093 | DARRELL R. HALL | ROCKY | 7 | 0 |
| 004262 | 187 | THE NATURE CONSERVANCY | UNNAMED | 7 | 0 |
| 004276 | 146 | PRICE & ELLEN DANIEL, TRUSTEE | LAKE BAYOU | 7 | 0 |
| 004260 | 204 | MITCHELL DEVELOPMENT CORP. | UNNAMED | 7 | 0 |
| 004243 | 157 | CITY OF MADISONVILLE ETAL | TOWN | 7 | 0 |
| 004259 | 204 | HOWARD T. HARSTAD | SCHOFIELD | 7 | 0 |

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|---|---|---|---|---|---|
| 004272 | 204 | LAKE WATERWHEELS PROP OWN | BIG & TRIB | 7 | 0 |
| 004257 | 228 | CORBIN J. ROBERTSON | DADS & TRIBS | 7 | 0 |
| 004242 | 093 | WILLIAM T MORAN ESTATE | ROCKY | 7 | 0 |
| 004255 | 228 | WESTWOOD SHORES, INC. | UNNAMED | 7 | 0 |
| 004460 | 146 | WELDON ALDERS | BIG CANEY CR | 7 | 0 |
| 004252 | 236 | C. T. LOWRIMORE ETAL | UNNAMED | 7 | 0 |
| 004237 | 145 | PEARLAND CONV CENTER INC | YELLOW | 7 | 0 |
| 004251 | 236 | W. J. COBURN | UNNAMED | 7 | 0 |
| 004267 | 187 | ESTATE OF C. J. GERLACH | SALLY | 7 | 0 |
| 004247 | 236 | FRED SELLARS ETAL | BLACK | 7 | 0 |
| 005137 | 145 | TEXAS PARKS & WILDLIFE DEPT | UNNAMED | 7 | 0 |
| 004246 | 236 | E. M. SMITHER CO. | BLACK | 7 | 0 |
| 005081 | 145 | EMMET P CROW JR | BIRCH | 7 | 0 |
| 004245 | 093 | W. T. BRACEWELL | PINE | 7 | 0 |
| 004236 | 145 | TEXAS OLEFINS CO. | UNNAMED | 7 | 0 |
| 004275 | 146 | LAKECROFT, INC. | LONG JOHN | 7 | 0 |
| 004274 | 146 | KNIGHTS FOREST PROP. OWNERS | GREENS | 7 | 0 |
| 004273 | 146 | A. G. SERVICES, INC. | UNNAMED | 7 | 0 |
| 005084 | 145 | WILLIE HARCROW | UNNAMED | 7 | 0 |
| 004278 | 146 | FLOYD A WENZEL & L S SODOLA | UNNAMED | 7 | 0 |
| 004587 | 187 | PROPERTY OWENRS OF ACE TX IN | WILLIAMS CR | 7 | 0 |
| 005026 | 187 | MAINTENANCE COMM OF LAKESI | CROOKED CR | 7 | 0 |
| 004271 | 204 | WOODLAND TRACTS, INC. | UNNAMED | 7 | 0 |
| 004264 | 187 | WIGGINS LAND CO. | DRY | 7 | 0 |
| 004266 | 187 | DIXIE LAND CORP. | UNNAMED | 7 | 0 |
| 004588 | 187 | PROPERTY OWNERS OF ACE TX IN | SPRING BR | 7 | 0 |
| 004265 | 187 | MOZELLE PIXLEY | UNNAMED | 7 | 0 |
| 004009 | 146 | BROOKHILL CORP INC | MEETINGHOUSE | 7 | 36 |
| 004147 | 204 | WIGGINS LAND CO OF TEXAS | UNNAMED | 7 | 41 |
| 004270 | 204 | U.S. FOREST SERVICE | DOUBLE & HENR | 7 | 150 |
| 004102 | 236 | GIBBS BROTHERS AND COMPANY | UNNAMED | 7 | 211 |
| 004335 | 187 | T E DUKE | MENARD/TRINIT | 7 | 400 |
| 005374 | 145 | MATTIE K. CARTER TRUST | UNNAMED TRIB | 7 | 488 |
| 004280 | 146 | GEORGE W MAXWELL | COW ISLAND | 7 | 805 |
| | | TOTAL: RECREATION USE | | | 2131 |
| | | TOTAL: TRINITY BASIN | | | 1649944 |

AMENDED PER JERRY BOYD'S DIRECTIONS 6/1/93

TRINITY-SAN JACINTO BASIN: WATER PERMITS

| WRNUMBER | COUNTY | OWNERNAME | STREAM | USE | AMOUN | NOTES |
|---|---|---|---|---|---|---|
| 003926 | 036 | HOUSTON LIGHTING & POWER CO | CEDAR BAYO | 2 | 30000 | 1 |
| | | TOTAL: INDUSTRIAL | | | 30000 | |
| 003912 | 146 | STOESSER FARMS, INC. | CEDAR BAYOU | 3 | 4 | |
| 003921 | 101 | RICHARD L. SHUMAN | ADLONG DITC | 3 | 60 | |
| 003910 | 146 | ROY A. SEABERG | SALT FLAT DR | 3 | 327 | |
| 003923 | 101 | BILLY E. MURFF | CEDAR BAYOU | 3 | 347 | |
| 003911 | 146 | STOESSER FARMS INC | CEDAR BAYOU | 3 | 525 | |
| 003923 | 101 | BILLY E. MURFF | CEDAR BAYOU | 3 | 607 | |
| 003915 | 101 | ROY A. SEABERG, ETAL | CEDAR BAYOU | 3 | 650 | |
| 003922 | 101 | CEDAR BAYOU, LTD. | CEDAR BAYOU | 3 | 700 | |
| 003922 | 101 | CEDAR BAYOU, LTD. | CEDAR BAYOU | 3 | 800 | |
| 003916 | 146 | MARCELLA B. ZALESKY | COFFEE SLOU | 3 | 881 | |
| 003914 | 101 | ROY A. SEABERG, ETAL | CEDAR BAYOU | 3 | 900 | |
| 003925 | 146 | J.M. FROST, III | HICKORY ISLA | 3 | 1067 | |
| 003919 | 146 | J.M. FROST, III | CEDAR BAYOU | 3 | 1152 | |
| 003913 | 101 | RAY A SEABERG ET AL | CEDAR BAYOU | 3 | 1200 | |
| 003909 | 146 | STOESSER FARMS, INC. | CEDAR BAYOU | 3 | 1402 | |
| 003924 | 036 | W. H. KEENAN, TRUSTEE, ET AL | HICKORY ISLA | 3 | 2133 | |
| 003918 | 146 | W. H. KEENAN, TRUSTEE, ET AL | CEDAR BAYOU | 3 | 2500 | |
| | | TOTAL: IRRIGATION USE | | | 15255 | |
| 003917 | 146 | BRUCE A BERRY, TRUSTEE | COFFEE SLOU | 7 | 0 | |
| 003920 | 146 | JAMES L. ROBERTSON, TRUSTEE | CEDAR BAYOU | 7 | 100 | |
| 002280 | 146 | E F SCHWEIZERHOF | CEDAR | 7 | 184 | |
| | | TOTAL: RECREATION USE | | | 284 | |
| | | TOTAL: TRINITY-SAN JACINTO BASIN | | | 45539 | |

NOTES
1. CONSUMPTIVE USE 14,003 AC-FT/YR

SABINE RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2030 TOTAL | DEMANDS 2030 GW | DEMANDS 2030 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| JASPER | 14,183 | - | 2,409 | 2,322 | 87 | 11,861 | - |
| NEWTON | 28,957 | - | 4,658 | 4,005 | 653 | 24,952 | - |
| ORANGE | 15,089 | - | 170,522 | 15,097 | 155,425 | (8) | - |
| SABINE | 10,408 | - | 1,508 | 60 | 1,448 | 10,348 | - |
| SAN AUGUSTINE | 1,009 | - | 5,829 | 19 | 5,810 | 990 | - |
| SHELBY | 3,899 | - | 7,203 | 1,908 | 5,295 | 1,991 | - |
| BASIN TOTALS | 73,545 | 1,190,400 | 192,129 | 23,411 | 168,718 | 50,134 | 1,021,682 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2040 TOTAL | DEMANDS 2040 GW | DEMANDS 2040 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| JASPER | 14,183 | - | 2,478 | 2,391 | 87 | 11,792 | - |
| NEWTON | 28,957 | - | 4,660 | 4,008 | 652 | 24,949 | - |
| ORANGE | 15,089 | - | 200,630 | 15,097 | 185,533 | (8) | - |
| SABINE | 10,408 | - | 1,465 | 60 | 1,405 | 10,348 | - |
| SAN AUGUSTINE | 1,009 | - | 6,708 | 19 | 6,689 | 990 | - |
| SHELBY | 3,899 | - | 7,589 | 1,908 | 5,681 | 1,991 | - |
| BASIN TOTALS | 73,545 | 1,190,400 | 223,530 | 23,483 | 200,047 | 50,062 | 990,353 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2050 TOTAL | DEMANDS 2050 GW | DEMANDS 2050 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| JASPER | 14,183 | - | 2,549 | 2,462 | 87 | 11,721 | - |
| NEWTON | 28,957 | - | 4,666 | 4,014 | 652 | 24,943 | - |
| ORANGE | 15,089 | - | 233,994 | 15,097 | 218,897 | (8) | - |
| SABINE | 10,408 | - | 1,423 | 60 | 1,363 | 10,348 | - |
| SAN AUGUSTINE | 1,009 | - | 7,724 | 19 | 7,705 | 990 | - |
| SHELBY | 3,899 | - | 8,052 | 1,908 | 6,144 | 1,991 | - |
| BASIN TOTALS | 73,545 | 1,190,400 | 258,408 | 23,560 | 234,848 | 49,985 | 955,552 |

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| | | | | | |
|---|---|---|---|---|---|
| 005257A | 101 | LAKESIDE COUNTRY CLUB | BUFFALO BAYO | 3 | 175 |
| 005336 | 101 | HOUSTON COUNTRY CLUB | BUFFALO BAYO | 3 | 175 |
| 003964 | 101 | LENORA WARREN JORDAN ET AL | ROCK HOLLOW | 3 | 200 |
| 005311A | 101 | BRAE-BURN COUNTRY CLUB | BRAYS BAYOU | 3 | 200 |
| 005209 | 101 | INWOOD FOREST GOLF CLUB LTD | WHITE OAK BAY | 3 | 230 |
| 003941 | 093 | SELECTED LANDS CORP | CANEY | 3 | 300 |
| 003960 | 170 | THE WOODLANDS CORPORATION | UNNAMED | 3 | 310 |
| 005332 | 101 | PINE FOREST COUNTRY CLUB | BEAR CRK | 3 | 378 |
| 003985 | 101 | RIVER OAKS COUNTRY CLUB | BUFFALO | 3 | 460 |
| 004188 | 170 | THE WOODLANDS CORP | BEAR BRANCH | 3 | 500 |
| 003963 | 237 | DAVID N. NELSON ETAL | CYPRESS | 3 | 501 |
| 003959 | 170 | LAKE WOODLANDS PROP OWNERS | PANTHER | 3 | 750 |
| 003983 | 101 | HAROLD & JESSE FREEMAN | BEAR | 3 | 800 |
| 003995 | 101 | TEXAS PARKS & WILDLIFE | CARPENTERS | 3 | 875 |
| 003980 | 101 | ROY A. SEABERG ETAL | SAN JACINTO | 3 | 1600 |
| 003965A | 101 | ALTA G. LONGENBAUGH | CYPRESS | 3 | 2941 |
| 003979 | 146 | DAVE REIDLAND, ETAL | LUCE | 3 | 4999 |
| | | TOTAL: IRRIGATION USE | | | 16038 |
| 004963 | 170 | SAN JACINTO RIVER AUTH ET AL | W F SAN JACINT | 4 | 5500 |
| | | TOTAL: MINING USE | | | 5500 |
| 003950 | 170 | CONROE CREOSOTING CO. | LITTLE CANEY | 7 | 0 |
| 003951 | 170 | MAGNOLIA BEND PROP. OWNERS | OLD BOGGY | 7 | 0 |
| 003939 | 170 | LAKE CONROE FOREST OWNERS AS | RUSH & TRIB | 7 | 0 |
| 003938 | 170 | WEISINGER ESTATE | UNNAMED | 7 | 0 |
| 003975 | 170 | ROYAL FOREST COLONY CLUB INC | UNNAMED | 7 | 0 |
| 003927 | 236 | M. B. ETHEREDGE | MCDONALD | 7 | 0 |
| 003953 | 093 | LAKE WINONA PROP. OWNERS | UNNAMED | 7 | 0 |
| 005408 | 170 | THE WOODLANDS CORP | UN/DECKER BR | 7 | 0 |
| 003929 | 236 | SUNSET LAKE CLUB | MCDONALD | 7 | 0 |
| 003940 | 170 | LAKE FOREST FALLS, INC. | BASE | 7 | 0 |
| 003948 | 170 | SAN JACINTO GIRL SCOUTS | STEWARTS &TRI | 7 | 0 |
| 003949 | 170 | RIVERBROOK COMMUNITY IMP ASS | UNNAMED | 7 | 0 |
| 003935 | 170 | J. S. HULON | UNNAMED | 7 | 0 |
| 003976 | 170 | SPRING LAKE IMPROVEMENT ASSN. | UNNAMED | 7 | 0 |
| 004523A | 170 | J H WILKENFELD TRUSTEE ET AL | UNNAMED | 7 | 0 |
| 003931 | 236 | TEXAS PARKS & WILDLIFE | PRAIRIE ETAL | 7 | 0 |
| 003933A | 170 | LAKE MT PLEASANT SUBD ASSN | UNNAMED | 7 | 0 |
| 003942 | 170 | TRI-LAKE ESTATES PROP. OWNERS | UNNAMED | 7 | 0 |
| 003973 | 170 | ARROWHEAD LAKES PROP. OWNERS | UNNAMED | 7 | 0 |
| 003945 | 170 | DEER LAKE LODGE PROP. OWNERS | UNNAMED | 7 | 0 |
| 003936 | 170 | CAPE CONROE, LTD. | UNNAMED | 7 | 0 |
| 003962 | 237 | GALVESTON-HOUSTON CO. | UNNAMED | 7 | 0 |
| 003956 | 093 | LAKE HOLLYHILL OWNERS ASSN. | UNNAMED | 7 | 0 |
| 003943 | 170 | 177 LAKE ESTATES ASSN., INC. | UNNAMED | 7 | 0 |

NECHES RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2010 TOTAL | DEMANDS 2010 GW | DEMANDS 2010 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| ANGELINA | 30,795 | - | 50,633 | 26,824 | 23,809 | 3,971 | - |
| HARDIN | 29,413 | - | 17,039 | 10,277 | 6,762 | 19,136 | - |
| HOUSTON | 35,844 | - | 1,594 | 596 | 998 | 35,248 | - |
| JASPER | 14,183 | - | 88,600 | 47,887 | 40,713 | (33,704) | - |
| JEFFERSON | 741 | - | 120,089 | 4,786 | 115,303 | (4,045) | - |
| LIBERTY | 1,297 | - | 8,046 | 813 | 7,233 | 484 | - |
| NACOGDOCHES | 72,552 | - | 18,512 | 8,255 | 10,257 | 64,297 | - |
| NEWTON | - | - | 4 | 4 | 0 | (4) | - |
| ORANGE | 3,772 | - | 6,275 | 3,294 | 2,981 | 478 | - |
| POLK | 13,020 | - | 3,575 | 2,821 | 754 | 10,199 | - |
| SABINE | 2,278 | - | 3,326 | 870 | 2,456 | 1,408 | - |
| SAN AUGUSTINE | 10,009 | - | 1,839 | 538 | 1,301 | 9,471 | - |
| SHELBY | 1,300 | - | 600 | 412 | 188 | 888 | - |
| TRINITY | 7,577 | - | 1,044 | 906 | 138 | 6,671 | - |
| TYLER | 30,320 | - | 8,736 | 3,359 | 5,377 | 26,961 | - |
| BASIN TOTALS | 253,101 | 846,900 | 329,912 | 111,642 | 218,270 | 141,459 | 628,630 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2020 TOTAL | DEMANDS 2020 GW | DEMANDS 2020 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| ANGELINA | 30,795 | - | 53,281 | 26,824 | 26,457 | 3,971 | - |
| HARDIN | 29,413 | - | 17,944 | 11,018 | 6,926 | 18,395 | - |
| HOUSTON | 35,844 | - | 1,572 | 588 | 984 | 35,256 | - |
| JASPER | 14,183 | - | 94,739 | 47,887 | 46,852 | (33,704) | - |
| JEFFERSON | 741 | - | 136,698 | 4,786 | 131,912 | (4,045) | - |
| LIBERTY | 1,297 | - | 8,089 | 856 | 7,233 | 441 | - |
| NACOGDOCHES | 72,552 | - | 20,181 | 8,255 | 11,926 | 64,297 | - |
| NEWTON | - | - | 3 | 3 | 0 | (3) | - |
| ORANGE | 3,772 | - | 6,216 | 3,295 | 2,921 | 477 | - |
| POLK | 13,020 | - | 3,834 | 2,948 | 886 | 10,072 | - |
| SABINE | 2,278 | - | 3,656 | 872 | 2,784 | 1,406 | - |
| SAN AUGUSTINE | 10,009 | - | 1,844 | 538 | 1,306 | 9,471 | - |
| SHELBY | 1,300 | - | 590 | 402 | 188 | 898 | - |
| TRINITY | 7,577 | - | 1,094 | 956 | 138 | 6,621 | - |
| TYLER | 30,320 | - | 18,991 | 3,614 | 15,377 | 26,706 | - |
| BASIN TOTALS | 253,101 | 846,900 | 368,732 | 112,842 | 255,890 | 140,259 | 591,010 |

SAN JACINTO-BRAZOS BASIN: WATER PERMITS

| WRNUMBER | COUNTY | OWNER NAME | STREAM | USE | AMOUNT | NOTES |
|---|---|---|---|---|---|---|
| 005169 | 079 | GULF COAST WATER AUTHORITY | JONES CR | 1 | 12000 | |
| 005170 | 079 | FORT BEND COUNTY WCID 1 | JONES & OYSTER | 1 | 18000 | |
| | | TOTAL: MUNICIPAL USE | | | 30000 | |
| 001108F | 079 | AMERICAN CANAL CO | CLEAR CREEK | 2 | 0 | |
| 005358 | 020 | AMOCO CHEMICALS CO. | CHOCOLATE | 2 | 0 | |
| 004534 | 020 | DAVID H SCHULTZ | AUSTIN BAYOU | 2 | 92 | |
| 005064 | 020 | JAY CHARLES SVOBODA | IOWA COLONY DD | 2 | 160 | |
| 005345B | 020 | C E ZWAHR ET AL | AUSTIN | 2 | 192 | |
| 004535 | 020 | ANNA KOLANCY | AUSTIN BAYOU | 2 | 200 | |
| 005256 | 020 | JOHN D VIEMAN ET AL | AUSTIN BAYOU | 2 | 252 | |
| 005352 | 020 | THE RANDOLPH CO. ETAL | AUSTIN | 2 | 1198 | |
| 005350 | 101 | HOUSTON L&P-WEBSTER | CLEAR | 2 | 4440 | |
| 005286 | 084 | TEXAS COPPER CORPORATION | BARGE CANAL | 2 | 25000 | 2 |
| 005363 | 084 | HOUSTON L&P-ROBINSON PLANT | DICKINSON | 2 | 30000 | 3 |
| 005357 | 020 | CHOCOLATE BAYOU WATER CO ET A | CHOCOLATE&TRIB | 2 | 33600 | |
| 005328B | 020 | DOW CHEMICAL CO.-SEE BRAZOS | OYSTER | 2 | 58175 | |
| 005361 | 084 | STERLING CHEMICALS INC | GALVESTON BAY | 2 | 107970 | 2 |
| 005334 | 020 | DOW CHEMICAL COMPANY | FREEPORT CHAN | 2 | 4209000 | 1 |
| | | TOTAL: INDUSTRIAL USE | | | 4470279 | |
| 000734 | 020 | LEWIS H FOLLET | BASTROP | 3 | 0 | |
| 000401 | 020 | W D EVANS ET AL | BASTROP | 3 | 0 | |
| 002002A | 079 | J M FROST III ET AL | OYSTER CREEK | 3 | 0 | |
| 001522 | 020 | A E NOVAK | IOWA COL | 3 | 0 | |
| 000449A | 020 | LYNDON W BING ET AL | AUSTIN | 3 | 0 | |
| 005362 | 084 | CHAPARRAL RECREATION ASSOC. | DICKINSON&TRIB | 3 | 46 | |
| 005359 | 020 | ALVIN GOLF & COUNTRY CLUB | MUSTANG | 3 | 54 | |
| 005336 | 079 | THE LAKES, LIMITED | OYSTER | 3 | 100 | |
| 005230 | 101 | BAYWOOD COUNTRY CLUB | ARMAND BAYOU | 3 | 150 | |
| 005170 | 079 | FORT BEND COUNTY WCID 1 | JONES & OYSTER | 3 | 159 | |
| 005360 | 020 | JAMES SCOPEL | UNNAMED DITCH | 3 | 160 | |
| 005354 | 020 | R T MARSHALL TRUSTEE | WF CHOCOLATE | 3 | 187 | |
| 004535 | 020 | ANNA KOLANCY | AUSTIN BAYOU | 3 | 225 | |
| 005338A | 020 | TEXAS DEPT OF CORRECTIONS | OYSTER | 3 | 300 | |
| 004355 | 020 | J V 3 INC | AUSTIN BAYOU | 3 | 360 | |
| 005342 | 020 | E C STOKLEY TRUSTEE | BASTROP | 3 | 400 | |
| 005348 | 020 | CLEVELAND DAVIS III ETAL | AUSTIN | 3 | 454 | |
| 005400 | 084 | SOUTH SHORE HARBOUR DEV LTD | UN/CLEAR CR | 3 | 539 | |
| 005356 | 020 | J W ISAACS | COUNTY DITCH | 3 | 560 | |
| 005341 | 020 | TOM TIGNER TRUST | BASTROP | 3 | 600 | |
| 004456 | 020 | C F BROWN JR TRUSTEE | FLORES BAYOU | 3 | 657 | |

NECHES RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| | SUPPLY LIMITS | | DEMANDS | | | EXCESS/DEFICIT | |
|---|---|---|---|---|---|---|---|
| | GW | SW | 2050 | | | WATER | |
| COUNTY | AVAIL. | AVAIL. | TOTAL | GW | SW | GW | SW |
| ANGELINA | 30,795 | - | 76,062 | 26,824 | 49,238 | 3,971 | - |
| HARDIN | 29,413 | - | 22,622 | 15,132 | 7,490 | 14,281 | - |
| HOUSTON | 35,844 | - | 1,568 | 580 | 988 | 35,264 | - |
| JASPER | 14,183 | - | 144,294 | 47,887 | 96,407 | (33,704) | - |
| JEFFERSON | 741 | - | 185,918 | 4,786 | 181,132 | (4,045) | - |
| LIBERTY | 1,297 | - | 8,269 | 1,036 | 7,233 | 261 | - |
| NACOGDOCHES | 72,552 | - | 28,215 | 8,255 | 19,960 | 64,297 | - |
| NEWTON | - | - | 2 | 2 | 0 | (2) | - |
| ORANGE | 3,772 | - | 7,296 | 3,295 | 4,001 | 477 | - |
| POLK | 13,020 | - | 4,928 | 3,586 | 1,342 | 9,434 | - |
| SABINE | 2,278 | - | 4,749 | 834 | 3,915 | 1,444 | - |
| SAN AUGUSTINE | 10,009 | - | 1,930 | 538 | 1,392 | 9,471 | - |
| SHELBY | 1,300 | - | 581 | 393 | 188 | 907 | - |
| TRINITY | 7,577 | - | 1,217 | 1,079 | 138 | 6,498 | - |
| TYLER | 30,320 | - | 39,497 | 4,120 | 35,377 | 26,200 | - |
| BASIN TOTALS | 253,101 | 846,900 | 527,148 | 118,347 | 408,801 | 134,754 | 438,099 |

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BRAZOS BASIN: WATER PERMITS

| WRNUMBER | COUNTY | OWNERNAME | STREAM | USE | AMOUNT | NOTES |
|---|---|---|---|---|---|---|
| 005160 | 198 | CAMP COOLEY LTD. | UNNAMED | 1 | 0 | |
| 005167 | 079 | BRAZOS RIVER AUTHORITY | TRIBS & BRAZO | 1 | 0 | |
| 005166 | 079 | BRAZOS RIVER AUTHORITY | BRAZOS | 1 | 0 | |
| 005332A | 020 | U S DEPT OF ENERGY | BRAZOS | 1 | 4 | |
| 005328B | 020 | DOW CHEMICAL CO. | BRAZOS | 1 | 20 | |
| 005328B | 020 | DOW CHEMICAL CO. | BRAZOS | 1 | 3136 | |
| 005165 | 198 | BRAZOS RIVER AUTHORITY | NAVASOTA | 1 | 4000 | |
| 005366 | 020 | BRAZOSPORT WATER AUTHORIT | BRAZOS | 1 | 45000 | |
| 005164 | 239 | BRAZOS RIVER AUTHORITY | YEGUA CR | 1 | 48000 | 1 |
| 005171 | 079 | GULF COAST WATER AUTHORIT | BRAZOS | 1 | 75000 | |
| 005168 | 079 | GULF COAST WATER AUTHORIT | BRAZOS | 1 | 99932 | |
| | | TOTAL MUNICIPAL USE | | | 275092 | |
| 005167 | 079 | BRAZOS RIVER AUTHORITY | TRIB & BRAZOS | 2 | 0 | |
| 005328B | 020 | DOW CHEMICAL CO. | OYSTER | 2 | 0 | |
| 005354 | 093 | TEXAS MUNICIPAL POWER AGEN | UNNAMED TRIB | 2 | 0 | |
| 005326 | 198 | WALNUT CREEK MINING CO | UNNAMED TRIB | 2 | 0 | |
| 005132 | 093 | TEXAS MUNICIPAL POWER AGEN | UNNAMED | 2 | 0 | |
| 001108F | 079 | AMERICAN CANAL CO | BRAZOS | 2 | 0 | |
| 004601A | 008 | ACME BRICK COMPANY | BRAZOS | 2 | 10 | |
| 005280 | 239 | WALDO NIENSTEDT | JERDELLA | 2 | 20 | |
| 005319 | 145 | NORTHWESTERN RESOURCES CO | UNNAMED | 2 | 90 | |
| 005332A | 020 | U S DEPT OF ENERGY | BRAZOS | 2 | 135 | |
| 005271 | 026 | TEXAS A&M UNIVERSITY | MIDDLE & BRA | 2 | 420 | |
| 005148A | 198 | TEXAS-NEW MEXICO POWER CO | DRY BRANCH | 2 | 458 | |
| 005307A | 093 | TEXAS MUNICIPAL POWER AGEN | NAVASOTA | 2 | 6000 | |
| 005328B | 020 | DOW CHEMICAL CO. | BUFFALO CAMP | 2 | 7500 | |
| 005311A | 093 | TEXAS MUNICIPAL POWER AGEN | GIBBONS | 2 | 9740 | |
| 005322B | 079 | CHOCOLATE BAYOU WATER CO | BRAZOS | 2 | 10000 | |
| 005320 | 079 | RICHMOND IRR CO & HL & P | BRAZOS | 2 | 12000 | |
| 005325 | 079 | HOUSTON L&P CO-PARISH | DRY | 2 | 28711 | |
| 005268 | 021 | CITY OF BRYAN | UNNAMED TRIB | 2 | 55708 | |
| 005165 | 198 | BRAZOS RIVER AUTHORITY | NAVASOTA | 2 | 61074 | 2 |
| 005328B | 020 | DOW CHEMICAL COMPANY | BRAZOS | 2 | 85000 | |
| 005328B | 020 | DOW CHEMICAL CO. | BRAZOS | 2 | 150000 | |
| 005298 | 198 | TEXAS UTILITIES ELECTRIC CO. | DUCK | 2 | 1378000 | 3 |
| | | TOTAL: INDUSTRIAL USE | | | 1804866 | |
| 005636 | 008 | HOUSTON L&P | BRAZOS | 3 | 0 | |
| 005276 | 239 | GEORGE W SPRANKLE | UNNAMED | 3 | 2 | |

NECHES-TRINITY BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2040 TOTAL | DEMANDS 2040 GW | DEMANDS 2040 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| CHAMBERS | 19,753 | - | 67,609 | 2,135 | 65,474 | 17,618 | - |
| GALVESTON | 4,400 | - | 995 | 991 | 4 | 3,409 | - |
| JEFFERSON | 2,395 | - | 213,561 | 5,939 | 207,622 | (3,544) | - |
| LIBERTY | 432 | - | 11,703 | 41 | 11,662 | 391 | - |
| BASIN TOTALS | 26,980 | 0 | 293,868 | 9,106 | 284,762 | 17,874 | (284,762) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2050 TOTAL | DEMANDS 2050 GW | DEMANDS 2050 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| CHAMBERS | 19,753 | - | 67,835 | 2,361 | 65,474 | 17,392 | - |
| GALVESTON | 4,400 | - | 1,105 | 1,101 | 4 | 3,299 | - |
| JEFFERSON | 2,395 | - | 217,433 | 5,939 | 211,494 | (3,544) | - |
| LIBERTY | 432 | - | 11,709 | 47 | 11,662 | 385 | - |
| BASIN TOTALS | 26,980 | 0 | 298,082 | 9,448 | 288,634 | 17,532 | (288,634) |

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| | | | | | |
|---|---|---|---|---|---|
| 004471A | 198 | KATHLEEN KELLY | BRAZOS | 3 | 935 |
| 004284A | 021 | ROBERT T & GERALDINE MOORE | BRAZOS | 3 | 962 |
| 004365 | 198 | WESLEY E. ANDERSON ETAL | BRAZOS | 3 | 976 |
| 004580A | 198 | ANDERSON DEVELOPMENT CORP | BRAZOS | 3 | 1000 |
| 004363A | 198 | JOE REISTINO ESTATE | BRAZOS | 3 | 1068 |
| 004579A | 198 | ANDERSON DEVELOPMENT CORP | BRAZOS | 3 | 1200 |
| 005271 | 026 | TEXAS A&M UNIVERSITY | MIDDLE & BRA | 3 | 1200 |
| 004282A | 021 | H H MOORE ET UX | BRAZOS | 3 | 1403 |
| 004398A | 198 | JOE REISTINO ESTATE | BRAZOS | 3 | 1500 |
| 004581A | 198 | ANDERSON DEVELOPMENT CORP | BRAZOS | 3 | 1637 |
| 005236 | 020 | T L SMITH ESTATE | MANOR LAKE | 3 | 2151 |
| 004364A | 198 | THE NORTHERN TRUST CO TRUS | L BRAZOS&BRA | 3 | 3026 |
| 005470 | 198 | THE NORTHERN TRUST CO TRUS | BRAZOS | 3 | 3750 |
| 001549 | 020 | T M SMITH ET AL | EAGLE N L | 3 | 4000 |
| 004283B | 021 | TOM J MOORE FARMS | BRAZOS/BIG C | 3 | 5440 |
| 005320 | 079 | RICHMOND IRR CO & HL & P | BRAZOS | 3 | 28000 |
| 005171 | 079 | GULF COAST WATER AUTHORIT | BRAZOS | 3 | 50000 |
| 005322B | 079 | CHOCOLATE BAYAU WATER CO | BRAZOS | 3 | 145000 |
| | | TOTAL: IRRIGATION USE | | | 271523 |
| 005053 | 093 | TEXAS MUNICIPAL POWER AGEN | UNNAMED | 4 | 0 |
| 005106 | 198 | WALNUT CREEK MINING COMPA | UNNAMED | 4 | 0 |
| 005312 | 093 | TEXAS MUNICIPAL POWER AGEN | BIG BRANCH | 4 | 200 |
| 005332A | 020 | U S DEPT OF ENERGY | BRAZOS | 4 | 52000 |
| | | TOTAL: MINING USE | | | 52200 |
| 005385 | 021 | NANTUCKET LTD | ALUM CR | 7 | 0 |
| 005270 | 021 | LEISURE LAKE, INC | UNNAMED | 7 | 0 |
| 005297 | 198 | CAMP COOLEY LTD | UNNAMED | 7 | 0 |
| 005310 | 021 | CARTER LAKE DEVELOPMENT C | UNNAMED | 7 | 0 |
| 005278 | 239 | K L NIXON | FOURMILE | 7 | 0 |
| 005314 | 021 | WELLBORN OAKS DEVELOPMEN | UNNAMED | 7 | 0 |
| 005281 | 026 | HARRY H BOWERS | UNNAMED | 7 | 0 |
| 005282 | 026 | RUSSELL F WIGGINS | 2ND DAVIDSON | 7 | 0 |
| 005313 | 093 | TEXAS MUNICIPAL POWER AGEN | UNNAMED | 7 | 0 |
| 005301 | 198 | CAMP CREEK WATER CO. | CAMP | 7 | 0 |
| 005318A | 237 | G M BECKER | UNNAMED | 7 | 0 |
| 005306 | 093 | SELECTED LANDS LTD NO 18 | UNNAMED | 7 | 0 |
| 005315 | 093 | NAVASOTA FISHING CLUB INC | UNNAMED | 7 | 0 |
| 005304 | 157 | JOINT TEXAS DIVISION OF ETC | UNNAMED | 7 | 0 |
| 005309 | 021 | CITY OF BRYAN | UNNAMED | 7 | 0 |
| 005302 | 145 | HILLTOP LAKES RESORT CITY | RUNNING & TRI | 7 | 0 |
| 005367 | 198 | BERT WHEELER | BEAR | 7 | 0 |
| 005324 | 079 | MARY D. MYERS | UNNAMED | 7 | 0 |
| 005303 | 145 | CITY OF NORMANGEE | RUNNING | 7 | 0 |
| 005299 | 145 | JAMES DENNISON ETAL | UNNAMED | 7 | 0 |

TRINITY RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2020 TOTAL | DEMANDS 2020 GW | DEMANDS 2020 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| CHAMBERS | 4,233 | - | 16,506 | 3,117 | 13,389 | 1,116 | - |
| GRIMES | 5,321 | - | 805 | 535 | 270 | 4,786 | - |
| HARDIN | | - | 16 | 10 | 6 | (10) | - |
| HOUSTON | 53,767 | - | 4,758 | 2,053 | 2,705 | 51,714 | - |
| LEON | 104,413 | - | 3,771 | 3,101 | 670 | 101,312 | - |
| LIBERTY | 34,577 | - | 47,416 | 19,442 | 27,974 | 15,135 | - |
| MADISON | 47,202 | - | 3,983 | 2,891 | 1,092 | 44,311 | - |
| POLK | 19,530 | - | 10,774 | 2,439 | 8,335 | 17,091 | - |
| SAN JACINTO | 10,935 | - | 2,445 | 1,033 | 1,412 | 9,902 | - |
| TRINITY | 4,286 | - | 5,250 | 604 | 4,646 | 3,682 | - |
| WALKER | 11,640 | - | 41,264 | 3,450 | 37,814 | 8,190 | - |
| BASIN TOTALS | 295,904 | 1,346,220 | 136,988 | 38,675 | 98,313 | 257,229 | 1,247,907 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2030 TOTAL | DEMANDS 2030 GW | DEMANDS 2030 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| CHAMBERS | 4,233 | - | 16,764 | 3,117 | 13,647 | 1,116 | - |
| GRIMES | 5,321 | - | 859 | 590 | 269 | 4,731 | - |
| HARDIN | | - | 13 | 11 | 2 | (11) | - |
| HOUSTON | 53,767 | - | 4,753 | 2,046 | 2,707 | 51,721 | - |
| LEON | 104,413 | - | 3,826 | 3,156 | 670 | 101,257 | - |
| LIBERTY | 34,577 | - | 49,767 | 21,793 | 27,974 | 12,784 | - |
| MADISON | 47,202 | - | 4,053 | 2,940 | 1,113 | 44,262 | - |
| POLK | 19,530 | - | 16,538 | 2,439 | 14,099 | 17,091 | - |
| SAN JACINTO | 10,935 | - | 2,712 | 1,033 | 1,679 | 9,902 | - |
| TRINITY | 4,286 | - | 8,588 | 604 | 7,984 | 3,682 | - |
| WALKER | 11,640 | - | 53,093 | 3,453 | 49,640 | 8,187 | - |
| BASIN TOTALS | 295,904 | 1,346,220 | 160,966 | 41,182 | 119,784 | 254,722 | 1,226,436 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2040 TOTAL | DEMANDS 2040 GW | DEMANDS 2040 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| CHAMBERS | 4,233 | - | 16,996 | 3,117 | 13,879 | 1,116 | - |
| GRIMES | 5,321 | - | 885 | 616 | 269 | 4,705 | - |
| HARDIN | | - | 13 | 13 | 0 | (13) | - |
| HOUSTON | 53,767 | - | 4,736 | 2,028 | 2,708 | 51,739 | - |
| LEON | 104,413 | - | 3,869 | 3,199 | 670 | 101,214 | - |
| LIBERTY | 34,577 | - | 52,310 | 24,336 | 27,974 | 10,241 | - |
| MADISON | 47,202 | - | 4,071 | 2,944 | 1,127 | 44,258 | - |
| POLK | 19,530 | - | 21,988 | 2,440 | 19,548 | 17,090 | - |
| SAN JACINTO | 10,935 | - | 2,853 | 1,033 | 1,820 | 9,902 | - |
| TRINITY | 4,286 | - | 11,900 | 604 | 11,296 | 3,682 | - |
| WALKER | 11,640 | - | 54,477 | 3,456 | 51,021 | 8,184 | - |
| BASIN TOTALS | 295,904 | 1,346,220 | 174,098 | 43,786 | 130,312 | 252,118 | 1,215,908 |

SOUTHEAST AREA
ACTIVE WATER RIGHTS CONTRACTS

SABINE BASIN

| NAME OF OWNER | USE TYPES | DIVERSION POINT | COUNTY | QUANTITY (AC-FT/YR) |
|---|---|---|---|---|
| | | | | |
| City of Hemphill | Municipal | Toledo Bend | Sabine | 1841 |
| Beechwood WSC | Municipal | Toledo Bend | | 81 |
| Huxley | Municipal | Toledo Bend | | 147 |
| Pendleton Utility Corp. | Municipal | Toledo Bend | | 28 |
| City of Hemphill | Municipal | Toledo Bend | Sabine | 1,841 |
| El Camino WS | Municipal | Toledo Bend | | 22 |
| Rose City | Municipal | Toledo Bend | | 110 |
| Miles, Inc. | Industrial | Toledo Bend | | 1,120 |
| Firestone | Industrial | Toledo Bend | | 280 |
| North Star Steel Texas | Industrial | Toledo Bend | | 4,481 |
| Dupont | Industrial | Toledo Bend | | 24,643 |
| A. Schulman | Industrial | Toledo Bend | | 224 |
| Chevron | Industrial | Toledo Bend | | 2,240 |
| Allied | Industrial | Toledo Bend | | 1,120 |
| Gulf States Utilities | Industrial | Toledo Bend | | 12,321 |
| Inland Orange | Industrial | Toledo Bend | | 17,922 |
| Crawfish and Rice | Irrigation | Toledo Bend | | 5,287 |
| | | | | |
| TOTAL | | | | 73,709 |

NECHES BASIN

| NAME OF OWNER | USE TYPES | DIVERSION POINT | COUNTY | QUANTITY (AC-FT/YR) |
|---|---|---|---|---|
| City of Lufkin | Municipal | Neches | Angelina | 28,000 |
| Temple-Inland Forest Prod Corp | Industrial | Neches River | Jasper | 50,000 |
| City of Woodville | Municipal | Neches | Tyler | 5,600 |
| | | | | |
| TOTAL | | | | 83,600 |

TRINITY-SAN JACINTO BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 1990 TOTAL | DEMANDS 1990 GW | DEMANDS 1990 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| CHAMBERS | 2,300 | - | 12,549 | 1,072 | 11,477 | 1,228 | - |
| HARRIS | 56,100 | - | 91,268 | 9,647 | 81,621 | 46,453 | - |
| LIBERTY | 2,161 | - | 22,098 | 6,202 | 15,896 | (4,041) | - |
| BASIN TOTALS | 60,561 | 0 | 125,915 | 16,921 | 108,994 | 43,640 | (108,994) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2000 TOTAL | DEMANDS 2000 GW | DEMANDS 2000 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| CHAMBERS | 2,300 | - | 14,582 | 2,300 | 12,282 | 0 | - |
| HARRIS | 56,100 | - | 104,631 | 23,010 | 81,621 | 33,090 | - |
| LIBERTY | 2,161 | - | 18,390 | 2,161 | 16,229 | 0 | - |
| BASIN TOTALS | 60,561 | 0 | 137,603 | 27,471 | 110,132 | 33,090 | (110,132) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2010 TOTAL | DEMANDS 2010 GW | DEMANDS 2010 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| CHAMBERS | 2,822 | - | 16,154 | 2,822 | 13,332 | 0 | - |
| HARRIS | 56,100 | - | 108,135 | 26,514 | 81,621 | 29,586 | - |
| LIBERTY | 2,161 | - | 19,237 | 2,161 | 17,076 | 0 | - |
| BASIN TOTALS | 61,083 | 0 | 143,526 | 31,497 | 112,029 | 29,586 | (112,029) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2020 TOTAL | DEMANDS 2020 GW | DEMANDS 2020 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| CHAMBERS | 2,822 | - | 18,010 | 2,822 | 15,188 | 0 | - |
| HARRIS | 56,100 | - | 114,179 | 32,558 | 81,621 | 23,542 | - |
| LIBERTY | 2,161 | - | 20,089 | 2,161 | 17,928 | 0 | - |
| BASIN TOTALS | 61,083 | 0 | 152,278 | 37,541 | 114,737 | 23,542 | (114,737) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2030 TOTAL | DEMANDS 2030 GW | DEMANDS 2030 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| CHAMBERS | 2,822 | - | 20,808 | 2,822 | 17,986 | 0 | - |
| HARRIS | 56,100 | - | 120,103 | 38,482 | 81,621 | 17,618 | - |
| LIBERTY | 2,161 | - | 20,944 | 2,161 | 18,783 | 0 | - |
| BASIN TOTALS | 61,083 | 0 | 161,855 | 43,465 | 118,390 | 17,618 | (118,390) |

## ACTIVE WATER RIGHTS CONTRACTS (CONT.)

### SAN JACINTO - BRAZOS BASIN

| NAME OF OWNER | USE TYPES | DIVERSION POINT | COUNTY | QUANTITY (AC-FT/YR) |
|---|---|---|---|---|
| George M Munson | Irrigation | Oyster Cr | Brazoria | 18,000 |
| Imperial Holly Corporation | Industrial | Jones & Oyster | Fort Bend | 18,159 |
| | | | | |
| TOTAL | | | | 36,159 |

### BRAZOS BASIN

| NAME OF OWNER | USE TYPES | DIVERSION POINT | COUNTY | QUANTITY (AC-FT/YR) |
|---|---|---|---|---|
| TX Utilities Electric Co | Industrial | Brazos | Austin | 14,000 |
| Houston L & P Co | Industrial | Brazos | Austin | 83,000 |
| South Texas Water Co | Irrigation | Brazos | Brazoria | 14,550 |
| South Texas Water Co | Industrial | Brazos | Brazoria | 14,560 |
| City of Freeport | Municipal | Brazos | Brazoria | 3,136 |
| South Texas Water Co | Industrial | Brazos | Fort Bend | 45,000 |
| Galveston County Water Auth | Municipal | Brazos | Galveston | |
| Galveston County Water Auth | Industrial | Brazos River | Galveston | 136,518 |
| Texas Municipal Power Agency | Industrial | Navasota | Grimes | 3,600 |
| Houston Lighting & Power Co | Industrial | Navasota | Leon | 12,400 |
| Houston L&P Co | Industrial | Navasota | Robertson | 18,487 |
| TX Utilities Electric Co | Industrial | Navasota | Robertson | 33,013 |
| Radian Corp | Industrial | Brazos | Waller | 45 |
| City of Brenham | Municipal | Yegua Creek | Washington | 1,680 |
| | | | | |
| TOTAL | | | | 379,989 |

There are no Active Water Contracts within the Neches-Trinity and Trinity-San Jacinto Basins

SAN JACINTO RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 1990 TOTAL | DEMANDS 1990 GW | DEMANDS 1990 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| FORT BEND | 11,116 | - | 21,900 | 19,807 | 2,093 | (8,691) | - |
| GRIMES | 5,633 | - | 822 | 568 | 254 | 5,065 | - |
| HARRIS | 258,060 | - | 699,177 | 382,846 | 316,331 | (124,786) | - |
| LIBERTY | 4,322 | - | 3,045 | 3,016 | 29 | 1,306 | - |
| MONTGOMERY | 39,997 | - | 34,590 | 28,198 | 6,392 | 11,799 | - |
| SAN JACINTO | 10,935 | - | 1,062 | 980 | 82 | 9,955 | - |
| WALKER | 10,967 | - | 2,735 | 2,061 | 674 | 8,906 | - |
| WALLER | 22,802 | - | 23,000 | 22,864 | 136 | (62) | - |
| BASIN TOTALS | 363,832 | 257,650 | 786,331 | 460,340 | 325,991 | (96,508) | (68,341) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2000 TOTAL | DEMANDS 2000 GW | DEMANDS 2000 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| FORT BEND | 11,116 | - | 22,871 | 16,115 | 6,756 | (4,999) | - |
| GRIMES | 5,633 | - | 1,292 | 1,038 | 254 | 4,595 | - |
| HARRIS | 258,060 | - | 948,299 | 382,697 | 565,602 | (124,637) | - |
| LIBERTY | 4,322 | - | 5,012 | 4,322 | 690 | 0 | - |
| MONTGOMERY | 39,997 | - | 50,868 | 39,997 | 10,871 | 0 | - |
| SAN JACINTO | 10,935 | - | 1,681 | 1,599 | 82 | 9,336 | - |
| WALKER | 10,967 | - | 4,116 | 3,442 | 674 | 7,525 | - |
| WALLER | 22,802 | - | 17,355 | 17,219 | 136 | 5,583 | - |
| BASIN TOTALS | 363,832 | 249,100 | 1,051,494 | 466,429 | 585,065 | (102,597) | (335,965) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2010 TOTAL | DEMANDS 2010 GW | DEMANDS 2010 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| FORT BEND | 11,116 | - | 27,663 | 15,651 | 12,012 | (4,535) | - |
| GRIMES | 5,633 | - | 1,350 | 1,096 | 254 | 4,537 | - |
| HARRIS | 258,060 | - | 1,044,544 | 265,947 | 778,597 | (7,887) | - |
| LIBERTY | 4,322 | - | 5,667 | 4,322 | 1,345 | 0 | - |
| MONTGOMERY | 39,997 | - | 63,187 | 39,997 | 23,190 | 0 | - |
| SAN JACINTO | 10,935 | - | 1,928 | 1,846 | 82 | 9,089 | - |
| WALKER | 10,967 | - | 4,616 | 3,942 | 674 | 7,025 | - |
| WALLER | 22,802 | - | 17,306 | 17,170 | 136 | 5,632 | - |
| BASIN TOTALS | 363,832 | 243,900 | 1,166,261 | 349,971 | 816,290 | 13,861 | (572,390) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2020 TOTAL | DEMANDS 2020 GW | DEMANDS 2020 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| FORT BEND | 11,116 | - | 32,800 | 15,510 | 17,290 | (4,394) | - |
| GRIMES | 5,633 | - | 1,410 | 1,156 | 254 | 4,477 | - |
| HARRIS | 258,060 | - | 1,146,650 | 207,217 | 939,433 | 50,843 | - |
| LIBERTY | 4,322 | - | 6,260 | 4,322 | 1,938 | 0 | - |
| MONTGOMERY | 39,997 | - | 75,575 | 39,997 | 35,578 | 0 | - |
| SAN JACINTO | 10,935 | - | 2,189 | 2,107 | 82 | 8,828 | - |
| WALKER | 10,967 | - | 5,045 | 4,371 | 674 | 6,596 | - |
| WALLER | 22,802 | - | 17,334 | 17,198 | 136 | 5,604 | - |
| BASIN TOTALS | 363,832 | 238,600 | 1,287,263 | 291,878 | 995,385 | 71,954 | (756,785) |

INTERBASIN TRANSFER
IMPORTS AND EXPORTS: 1990-2050

SABINE BASIN

| IMPORTS | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|---|
| MUNICIPAL | 1637 | 1734 | 1732 | 1717 | 1705 | 1751 | 1797 |
| MANUFACTURING | 964 | 1201 | 1442 | 1723 | 2057 | 2049 | 2041 |
| IRRIGATION | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STEAM POWER | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MINING | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 2601 | 2935 | 3174 | 3440 | 3762 | 3800 | 3838 |
| EXPORTS | | | | | | | |
| MUNICIPAL | 787 | 1024 | 1622 | 2002 | 2627 | 3133 | 3736 |
| MANUFACTURING | 0 | 162 | 47 | 306 | 1158 | 1181 | 1204 |
| IRRIGATION | 0 | 0 | 0 | 0 | 0 | 0 | .0 |
| STEAM POWER | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MINING | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 787 | 1186 | 1669 | 2308 | 3785 | 4314 | 4940 |

NECHES BASIN

| IMPORTS | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|---|
| MUNICIPAL | 994 | 1249 | 1922 | 2314 | 2953 | 3477 | 4099 |
| MANUFACTURING | 0 | 162 | 47 | 306 | 1158 | 1181 | 1204 |
| IRRIGATION | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STEAM POWER | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MINING | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 994 | 1411 | 1969 | 2620 | 4111 | 4658 | 5303 |
| EXPORTS | | | | | | | |
| MUNICIPAL | 26086 | 24781 | 25494 | 27258 | 31393 | 33676 | 36128 |
| MANUFACTURING | 65359 | 73890 | 76865 | 82807 | 88512 | 95149 | 102296 |
| IRRIGATION | 138970 | 102743 | 102743 | 102743 | 102743 | 102743 | 102743 |
| STEAM POWER | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MINING OIL | 262 | 215 | 185 | 156 | 126 | 101 | 81 |
| TOTAL | 230677 | 201629 | 205287 | 212964 | 222774 | 231669 | 241248 |

SAN JACINTO-BRAZOS BASIN - **Ground Water/Surface Water Breakdown**

**(All Units in Acre-feet/Year)**

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 1990 TOTAL | DEMANDS 1990 GW | DEMANDS 1990 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| BRAZORIA | 25,200 | - | 180,561 | 17,298 | 163,263 | 7,902 | - |
| FORT BEND | 17,847 | - | 39,547 | 23,508 | 16,039 | (5,661) | - |
| GALVESTON | 17,600 | - | 113,009 | 7,261 | 105,748 | 10,339 | - |
| HARRIS | 16,830 | - | 98,633 | 28,969 | 69,664 | (12,139) | - |
| BASIN TOTALS | 77,477 | 0 | 431,750 | 77,036 | 354,714 | 441 | (354,714) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2000 TOTAL | DEMANDS 2000 GW | DEMANDS 2000 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| BRAZORIA | 25,200 | - | 177,590 | 14,327 | 163,263 | 10,873 | - |
| FORT BEND | 17,847 | - | 52,038 | 19,976 | 32,062 | (2,129) | - |
| GALVESTON | 17,600 | - | 125,811 | 17,600 | 108,211 | 0 | - |
| HARRIS | 16,830 | - | 138,319 | 28,757 | 109,562 | (11,927) | - |
| BASIN TOTALS | 77,477 | 0 | 493,758 | 80,660 | 413,098 | (3,183) | (413,098) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2010 TOTAL | DEMANDS 2010 GW | DEMANDS 2010 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| BRAZORIA | 25,200 | - | 183,022 | 19,759 | 163,263 | 5,441 | - |
| FORT BEND | 17,847 | - | 62,488 | 19,583 | 42,905 | (1,736) | - |
| GALVESTON | 17,600 | - | 139,879 | 17,600 | 122,279 | 0 | - |
| HARRIS | 16,830 | - | 168,873 | 28,757 | 140,116 | (11,927) | - |
| BASIN TOTALS | 77,477 | 0 | 554,262 | 85,699 | 468,563 | (8,222) | (468,563) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2020 TOTAL | DEMANDS 2020 GW | DEMANDS 2020 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| BRAZORIA | 25,200 | - | 192,683 | 25,200 | 167,483 | 0 | - |
| FORT BEND | 17,847 | - | 74,007 | 19,397 | 54,610 | (1,550) | - |
| GALVESTON | 17,600 | - | 155,765 | 17,600 | 138,165 | 0 | - |
| HARRIS | 16,830 | - | 202,649 | 28,757 | 173,892 | (11,927) | - |
| BASIN TOTALS | 77,477 | 0 | 625,104 | 90,954 | 534,150 | (13,477) | (534,150) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2030 TOTAL | DEMANDS 2030 GW | DEMANDS 2030 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| BRAZORIA | 25,200 | - | 200,995 | 25,200 | 175,795 | 0 | - |
| FORT BEND | 17,847 | - | 86,011 | 19,212 | 66,799 | (1,365) | - |
| GALVESTON | 17,600 | - | 171,398 | 17,600 | 153,798 | 0 | - |
| HARRIS | 16,830 | - | 238,319 | 28,757 | 209,562 | (11,927) | - |
| BASIN TOTALS | 77,477 | 0 | 696,723 | 90,769 | 605,954 | (13,292) | (605,954) |

## TRINITY-SAN JACINTO BASIN

| IMPORTS | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|---|
| MUNICIPAL | 14326 | 16339 | 17149 | 18133 | 19701 | 21521 | 23509 |
| MANUFACTURING | 63897 | 71806 | 76451 | 83156 | 89032 | 95715 | 103936 |
| IRRIGATION | 35842 | 23597 | 23597 | 23597 | 23597 | 23597 | 23597 |
| STEAM POWER | 618 | 618 | 618 | 618 | 1718 | 1718 | 1718 |
| MINING | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 114683 | 112360 | 117815 | 125504 | 134048 | 142551 | 152760 |
| EXPORTS | | | | | | | |
| MUNICIPAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MANUFACTURING | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IRRIGATION | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STEAM POWER | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MINING | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## SAN JACINTO BASIN

| IMPORTS | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|---|
| MUNICIPAL | 209388 | 270520 | 345556 | 427303 | 532701 | 593790 | 661885 |
| MANUFACTURING | 181048 | 213971 | 241251 | 295745 | 321048 | 319464 | 313262 |
| IRRIGATION | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STEAM POWER | 10512 | 10512 | 9312 | 8912 | 0 | 0 | 0 |
| MINING | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 400948 | 495003 | 596119 | 731960 | 853749 | 913254 | 975147 |
| EXPORTS | | | | | | | |
| MUNICIPAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MANUFACTURING | 54150 | 60000 | 60000 | 60000 | 60000 | 60000 | 60000 |
| IRRIGATION | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STEAM POWER | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MINING | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 54150 | 60000 | 60000 | 60000 | 60000 | 60000 | 60000 |

BRAZOS RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| | SUPPLY LIMITS | | DEMANDS | | | EXCESS/DEFICIT | |
|---|---|---|---|---|---|---|---|
| | GW | SW | 1990 | | | WATER | |
| COUNTY | AVAIL. | AVAIL. | TOTAL | GW | SW | GW | SW |
| AUSTIN | 29,522 | - | 4,748 | 3,638 | 1,110 | 25,884 | - |
| BRAZORIA | 10,080 | - | 159,140 | 3,099 | 156,041 | 6,981 | - |
| BRAZOS | 54,770 | - | 47,387 | 42,362 | 5,025 | 12,408 | - |
| BURLESON | 63,398 | - | 9,873 | 8,892 | 981 | 54,506 | - |
| FORT BEND | 46,241 | - | 94,226 | 27,401 | 66,825 | 18,840 | - |
| GRIMES | 14,545 | - | 14,676 | 2,896 | 11,780 | 11,649 | - |
| LEON | 26,103 | - | 890 | 672 | 218 | 25,431 | - |
| MADISON | 11,801 | - | 251 | 148 | 103 | 11,653 | - |
| ROBERTSON | 103,644 | - | 25,504 | 21,364 | 4,140 | 82,280 | - |
| WALLER | 15,180 | - | 10,419 | 9,781 | 638 | 5,399 | - |
| WASHINGTON | 16,903 | - | 6,387 | 2,460 | 3,927 | 14,443 | - |
| BASIN TOTALS | 392,187 | 490,400 | 373,501 | 122,713 | 250,788 | 269,474 | 239,612 |

| | SUPPLY LIMITS | | DEMANDS | | | EXCESS/DEFICIT | |
|---|---|---|---|---|---|---|---|
| | GW | SW | 2000 | | | WATER | |
| COUNTY | AVAIL. | AVAIL. | TOTAL | GW | SW | GW | SW |
| AUSTIN | 29,522 | - | 5,209 | 3,922 | 1,287 | 25,600 | - |
| BRAZORIA | 10,080 | - | 203,184 | 3,099 | 200,085 | 6,981 | - |
| BRAZOS | 54,770 | - | 52,404 | 46,727 | 5,677 | 8,043 | - |
| BURLESON | 63,398 | - | 14,778 | 9,921 | 4,857 | 53,477 | - |
| FORT BEND | 46,241 | - | 81,268 | 29,880 | 51,388 | 16,361 | - |
| GRIMES | 14,545 | - | 16,457 | 3,272 | 13,185 | 11,273 | - |
| LEON | 26,103 | - | 1,127 | 657 | 470 | 25,446 | - |
| MADISON | 11,801 | - | 381 | 203 | 178 | 11,598 | - |
| ROBERTSON | 103,644 | - | 49,105 | 21,895 | 27,210 | 81,749 | - |
| WALLER | 15,180 | - | 9,985 | 8,454 | 1,531 | 6,726 | - |
| WASHINGTON | 16,903 | - | 8,005 | 2,447 | 5,558 | 14,456 | - |
| BASIN TOTALS | 392,187 | 488,200 | 441,903 | 130,477 | 311,426 | 261,710 | 176,774 |

| | SUPPLY LIMITS | | DEMANDS | | | EXCESS/DEFICIT | |
|---|---|---|---|---|---|---|---|
| | GW | SW | 2010 | | | WATER | |
| COUNTY | AVAIL. | AVAIL. | TOTAL | GW | SW | GW | SW |
| AUSTIN | 29,522 | - | 5,335 | 4,048 | 1,287 | 25,474 | - |
| BRAZORIA | 10,080 | - | 259,942 | 3,099 | 256,843 | 6,981 | - |
| BRAZOS | 54,770 | - | 59,426 | 53,749 | 5,677 | 1,021 | - |
| BURLESON | 63,398 | - | 15,097 | 10,240 | 4,857 | 53,158 | - |
| FORT BEND | 46,241 | - | 91,605 | 33,595 | 58,010 | 12,646 | - |
| GRIMES | 14,545 | - | 16,724 | 3,544 | 13,180 | 11,001 | - |
| LEON | 26,103 | - | 1,091 | 669 | 422 | 25,434 | - |
| MADISON | 11,801 | - | 378 | 205 | 173 | 11,596 | - |
| ROBERTSON | 103,644 | - | 51,092 | 21,882 | 29,210 | 81,762 | - |
| WALLER | 15,180 | - | 10,516 | 8,447 | 2,069 | 6,733 | - |
| WASHINGTON | 16,903 | - | 8,446 | 2,446 | 6,000 | 14,457 | - |
| BASIN TOTALS | 392,187 | 487,600 | 519,652 | 141,924 | 377,728 | 250,263 | 109,872 |

**Interbasin Transfers In Southeast Texas**

| Basin Source | Owner | Basin Destination | Acre-Feet/Year |
|---|---|---|---|
| Sabine * | Sabine River Authority | Neches | 100,400 |
| Sabine * | Sabine River Authority | Neches | 5,048 |
| Sabine | City of Dallas | Trinity | 119,950 |
| Sabine | City of Dallas | Trinity | 184,520 |
| Neches * | Star Enterprises | Neches-Trinity | 12,900 |
| Neches * | Angelina & Neches River Authority | Sabine | 2,200 |
| Neches | Athens MWA | Trinity | 8,520 |
| Neches | City of Dallas | Trinity | 114,340 |
| Trinity * | Coastal Water Authority | San Jacinto/San Jacinto-Brasos | 997,700 |
| Trinity * | Galveston County Water Authority | San Jacinto-Brazos | 159,851 |
| Trinity * | Trinity Water Reserves, Inc. | Neches-Trinity | 58,500 |
| Brazos * | Brazos River Authority | San Jacinto/Brazos | 0 |
| Brazos * | Dow Chemical | San Jacinto-Brazos | 58,175 |
| Brazos * | GCWA | San Jacinto | 237,500 |
| Brazos | City of Lampasas | Colorado | 3,760 |
| Red | North Texas MWD | Trinity | 44,840 |
| Red | City of Greenville | Trinity | 6,950 |
| Sulphur | North Texas MWD City of Irving | Trinity | 88,560 |

* Interbasin Transfers within TTWP Southeast Area.

BRAZOS RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| | SUPPLY LIMITS | | DEMANDS | | | EXCESS/DEFICIT | |
|---|---|---|---|---|---|---|---|
| | GW | SW | 2050 | | | WATER | |
| COUNTY | AVAIL. | AVAIL. | TOTAL | GW | SW | GW | SW |
| AUSTIN | 29,522 | - | 5,825 | 4,538 | 1,287 | 24,984 | - |
| BRAZORIA | 10,080 | - | 332,341 | 3,099 | 329,242 | 6,981 | - |
| BRAZOS | 54,770 | - | 87,420 | 54,770 | 32,650 | 0 | - |
| BURLESON | 63,398 | - | 16,359 | 11,502 | 4,857 | 51,896 | - |
| FORT BEND | 46,241 | - | 105,154 | 46,225 | 58,929 | 16 | - |
| GRIMES | 14,545 | - | 37,125 | 4,675 | 32,450 | 9,870 | - |
| LEON | 26,103 | - | 1,015 | 711 | 304 | 25,392 | - |
| MADISON | 11,801 | - | 369 | 207 | 162 | 11,594 | - |
| ROBERTSON | 103,644 | - | 89,873 | 60,663 | 29,210 | 42,981 | - |
| WALLER | 15,180 | - | 12,406 | 8,434 | 3,972 | 6,746 | - |
| WASHINGTON | 16,903 | - | 10,384 | 2,449 | 7,935 | 14,454 | - |
| BASIN TOTALS | 392,187 | 485,400 | 698,271 | 197,273 | 500,998 | 194,914 | (15,598) |

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TRANS-TEXAS WATER PROGRAM - SOUTHEAST STUDY AREA
PROJECTED GROUNDWATER AVAILABILITY BY BASIN

SABINE BASIN

| | | Availability (in Acre-feet) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| County | Aquifer | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| Jasper | Gulf Coast | 14,183 | 14,183 | 14,183 | 14,183 | 14,183 | 14,183 | 14,183 |
| Newton | Gulf Coast | 28,957 | 28,957 | 28,957 | 28,957 | 28,957 | 28,957 | 28,957 |
| Orange | Gulf Coast | 15,089 | 15,089 | 15,089 | 15,089 | 15,089 | 15,089 | 15,089 |
| Sabine | Carrizo-Wilcox | 2,973 | 2,973 | 2,973 | 2,973 | 2,973 | 2,973 | 2,973 |
| | Gulf Coast | 732 | 732 | 732 | 732 | 732 | 732 | 732 |
| | Sparta | 6,703 | 6,703 | 6,703 | 6,703 | 6,703 | 6,703 | 6,703 |
| | | 10,408 | 10,408 | 10,408 | 10,408 | 10,408 | 10,408 | 10,408 |
| San Augustine | Carrizo-Wilcox | 1,009 | 1,009 | 1,009 | 1,009 | 1,009 | 1,009 | 1,009 |
| Shelby | Carrizo-Wilcox | 3,899 | 3,899 | 3,899 | 3,899 | 3,899 | 3,899 | 3,899 |
| TOTAL | | 73,544 | 73,544 | 73,544 | 73,544 | 73,544 | 73,544 | 73,544 |

# APPENDIX M

**Permanent Neches Salt Water Barrier**

In the 1987 study by the Lower Neches Valley Authority (16), the permanent salt water barrier was indicated to provide a gain of 247,000 acre-feet per year in additional dependable supply. Of this amount, 155,700 acre-feet per year were attributed to avoidance of excessive releases from Lake Steinhagen for control of salt water intrusion. The other 91,300 acre-feet per year were associated with increased ability to use uncontrolled runoff originating below Lake Steinhagen.

Appendix C contains a copy of the environmental guidelines adopted by the PMC for use in the Phase I Trans-Texas studies. In the case of the Neches salt water barrier, the criteria outlined in Appendix C would require that significant amounts of runoff from the uncontrolled drainage area below Lake Steinhagen be passed through for maintenance of instream flows. The pass-through requirements would be based on average historical flows in the months of May through June and September through October; for the remainder of the year, they would be based on the historical median daily flows for each month.

Analysis of recorded stream flows from the critical drought of record (July 1953 through February 1957) confirmed the previous findings of the 1987 report with regard to the potential yield benefits of a permanent structure. Because the temporary barriers would unavoidably be breached from time to time, when storms caused flows greater than the sheet piling could withstand, the permanent barrier would save an average of approximately 155,700 acre-feet per year of excess releases from Lake Steinhagen. Those releases would be needed to help hold the salt water downstream from the diversion pump intakes while the temporary barriers were being rebuilt after washouts but would not be required with a

TRANS-TEXAS WATER PROGRAM - SOUTHEAST STUDY AREA
PROJECTED GROUNDWATER AVAILABILITY BY BASIN

NECHES-TRINITY BASIN

| | | Availability (in Acre-feet) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| County | Aquifer | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| Chambers | Gulf Coast | 16,101 | 16,101 | 19,753 | 19,753 | 19,753 | 19,753 | 19,753 |
| Galveston | Gulf Coast | 4,400 | 4,400 | 4,400 | 4,400 | 4,400 | 4,400 | 4,400 |
| Jefferson | Gulf Coast | 2,395 | 2,395 | 2,395 | 2,395 | 2,395 | 2,395 | 2,395 |
| Liberty | Gulf Coast | 432 | 432 | 432 | 432 | 432 | 432 | 432 |
| Orange | Gulf Coast | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | | 23,328 | 23,328 | 26,980 | 26,980 | 26,980 | 26,980 | 26,980 |

in adjacent swamp areas. These areas would no longer be subject to intrusion of salt water and/or water affected by municipal and industrial waste. The area upstream from the permanent barrier would be returned to a dependable freshwater environment, with associated benefits for wildlife. Water quality below the permanent barrier site would be negatively impacted by the barrier and would become slightly more degraded. Approximately 600 acres which are drained by Brakes Bayou above the barrier would not be returned to freshwater (18).

- <u>Barrier Impacts on Aquatic and Terrestrial Habitat</u>
  Positive impacts to habitat would be realized upstream from the permanent barrier, where the aquatic environment would be returned to perennial freshwater. Improvements to cypress-tupelo swamps, upland oak-pine forests, and freshwater marsh would provide improved habitat, spawning, and nursery areas. A portion of the Big Thicket National Preserve is located at the confluence of Pine Island Bayou and the Neches River. This area would no longer be subject to salt water intrusion (18). There would be no significant inundation area associated with the barrier, since the normal operating water levels would remain within the river banks.

- <u>Wetlands Impacts</u>
  Wetlands above the permanent barrier would be preserved and enhanced by the supply of freshwater. Approximately 67 acres of land near the Neches River and Bairds Bayou would be permanently altered by construction of the project (18). According to the National Wetland Inventory maps, this entire area is comprised of wetlands.

- <u>Bottomland Hardwood Forest in the Barrier Area</u>
  According to the Texas Bottomland Hardwood Preservation Program (20), no designated bottomland hardwood forest preservation areas are located in the vicinity of the salt water barrier project. The closest bottomland hardwood forest which is part of the preservation program is on Pine Island Bayou, approximately 20 miles upstream (west) of its confluence with the Neches and beyond the area of project impact. However, bottomland hardwood forest does exist at the site, although it is not in a specifically designated area of the Texas Bottomland Hardwood Preservation Program (19).

- <u>Recreation Impacts</u>
  Swimming, boating, hunting, and fishing would be impacted positively by the additional 16.7 miles of continual freshwater conditions in the Neches and Pine Island Bayou that would be created by the construction of the barrier. Accessibility to upstream areas would be improved by the navigation gate incorporated into the permanent structure, which would alleviate existing problems that occur when the temporary barriers are in place. Access to upstream reaches would be slightly more difficult for boats launched downstream or from the Neches Boat Club (18).

TRANS-TEXAS WATER PROGRAM - SOUTHEAST STUDY AREA
PROJECTED GROUNDWATER AVAILABILITY BY BASIN

TRINITY-SAN JACINTO BASIN

| | | Availability (in Acre-feet) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| County | Aquifer | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| Chambers | Gulf Coast | 2,300 | 2,300 | 2,822 | 2,822 | 2,822 | 2,822 | 2,822 |
| Harris | Gulf Coast | 56,100 | 56,100 | 56,100 | 56,100 | 56,100 | 56,100 | 56,100 |
| Liberty | Gulf Coast | 2,161 | 2,161 | 2,161 | 2,161 | 2,161 | 2,161 | 2,161 |
| TOTAL | | 60,561 | 60,561 | 61,083 | 61,083 | 61,083 | 61,083 | 61,083 |

Additionally, Pine Island Bayou is subject to dissolved oxygen levels below 5 milligrams per liter (mg/l) in the summer, and arsenic, manganese, and mercury levels above the EPA criteria for fresh water. The Paddlefish Recovery Plan further notes that sand and gravel and pipeline dredging also occur in the lower Neches River in the vicinity of and downstream from Pine Island Bayou and in the vicinity of Beaumont.

As a result, the Paddlefish Recovery Program recommends encouraging agencies and municipalities to enhance water quality and habitat of the Neches/Angelina River within the target recovery areas(21). The salt water barrier would enhance water quality of the Neches and Pine Island Bayou, thereby improving the habitat for the paddlefish and protecting it against salt water intrusion. In addition, construction of the permanent barrier would remove the potential of trapping paddlefish on the wrong side of the temporary barriers during their construction.

Federal listed threatened and endangered species for Jefferson County include the Bald Eagle, Brown Pelican, and Interior Least Tern. Jefferson County is migratory and nesting habitat for the Brown Pelican; wintering habitat for the Interior Least Tern; and migratory habitat for the Bald Eagle.

- <u>Air Quality Impacts</u>

  Short-term impacts to air quality are to be expected during construction activities. Standard mitigation measures to reduce dust, such as wetting the construction site, are readily available.

- <u>Socio-Economic Impacts of the Permanent Barrier</u>

  Several positive socio-economic impacts would result from the project. The populace of Beaumont and Jefferson County would be provided with a secure source of fresh water. Local customers of the Lower Neches Valley Authority (LNVA) have indicated that they would be willing to accept rate increases in order to provide the local portion of cost sharing for construction (22). A secure source of fresh water would positively impact business and industrial activity (18).

**Allens Creek Reservoir Project**

The Allens Creek project is basically an off-channel surface reservoir, located at the mouth of Allens Creek on the west bank of the Brazos River near Wallis. Allens Creek itself has a relatively small watershed, and most of the water available

TRANS-TEXAS WATER PROGRAM - SOUTHEAST STUDY AREA
PROJECTED GROUNDWATER AVAILABILITY BY BASIN

SAN JACINTO-BRAZOS BASIN

| | | Availability (in Acre-feet) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| County | Aquifer | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
| Brazoria | Gulf Coast | 25,200 | 25,200 | 25,200 | 25,200 | 25,200 | 25,200 | 25,200 |
| Chambers | Gulf Coast | 1,150 | 1,150 | 1,411 | 1,411 | 1,411 | 1,411 | 1,411 |
| Fort Bend | Brazos River Alluviu | 1,173 | 1,173 | 1,173 | 1,173 | 1,173 | 1,173 | 1,173 |
| | Gulf Coast | 16,674 | 16,674 | 16,674 | 16,674 | 16,674 | 16,674 | 16,674 |
| | | 17,847 | 17,847 | 17,847 | 17,847 | 17,847 | 17,847 | 17,847 |
| Galveston | Gulf Coast | 17,600 | 17,600 | 17,600 | 17,600 | 17,600 | 17,600 | 17,600 |
| Harris | Gulf Coast | 16,830 | 16,830 | 16,830 | 16,830 | 16,830 | 16,830 | 16,830 |
| TOTAL | | 78,627 | 78,627 | 78,888 | 78,888 | 78,888 | 78,888 | 78,888 |

increased to significantly more than 85,000 acre-feet per year by raising the peak diversion capability beyond the levels discussed above. It was found that, without the instream flow limitations adopted for the Phase I Trans-Texas studies, a maximum feasible yield of about 120,000 acre-feet per year could be developed with a diversion capacity of 2,000 cfs. With the instream flow requirements in effect, the maximum feasible yield was indicated to be some 105,000 acre-feet per year with a total diversion capacity of 3,000 cfs. Thus, the instream flow criteria would involve a loss of approximately 15,000 acre-feet per year of ultimate yield and would require the addition of approximately 50 percent more pumping capacity to reach maximum obtainable performance.

From the initial environmental investigations of the Allens Creek project, the following observations were noted:

- Water Quality in Allens Creek Reservoir

  Computer simulation studies of reservoir operation indicated that the Allens Creek project would have a median total dissolved solids (TDS) concentration of approximately 500 milligrams per liter during the years of critical low flow conditions (1954-1957). The maximum TDS concentration during that period was shown to be slightly less than 1,000 mg/l.

- Habitat at the Allens Creek Site

  Land use at the reservoir site includes farming and pasture, with several large stands of trees and associated vegetation. Elm, black willow, hackberry, cedar, soapberry, pecan, poison oak, and ash are located in the forested areas and in the riparian zone also on Allens Creek. A wooded area of approximately 650 acres surrounds Alligator Hole, a small lake in the northeast part of the proposed reservoir pool. The trees around Alligator Hole appear to be frequently flooded. The steady water supply, grain fields, grasses, shrubs and trees provide high quality habitat for a variety of species (19).

- Threatened and Endangered Species at Allens Creek

  The following are the state-listed threatened and endangered species for Austin County, based on the State Endangered Species Data File of 1988. That data file lists known, probable, and possible occurrences of species. Only known and probable occurrences have been considered here.

# APPENDIX L

## Groundwater-Surface Water Demand Distribution

SABINE RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 1990 TOTAL | DEMANDS 1990 GW | DEMANDS 1990 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| JASPER | 14,183 | - | 1,676 | 1,599 | 77 | 12,584 | - |
| NEWTON | 28,957 | - | 4,113 | 3,478 | 635 | 25,479 | - |
| ORANGE | 15,089 | - | 71,041 | 15,097 | 55,944 | (8) | - |
| SABINE | 10,408 | - | 1,134 | 194 | 940 | 10,214 | - |
| SAN AUGUSTINE | 1,009 | - | 225 | 31 | 194 | 978 | - |
| SHELBY | 3,899 | - | 5,676 | 2,121 | 3,555 | 1,778 | - |
| BASIN TOTALS | 73,545 | 1,190,400 | 83,865 | 22,520 | 61,345 | 51,025 | 1,129,055 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2000 TOTAL | DEMANDS 2000 GW | DEMANDS 2000 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| JASPER | 14,183 | - | 2,193 | 2,106 | 87 | 12,077 | - |
| NEWTON | 28,957 | - | 4,767 | 4,099 | 668 | 24,858 | - |
| ORANGE | 15,089 | - | 85,819 | 15,097 | 70,722 | (8) | - |
| SABINE | 10,408 | - | 1,486 | 60 | 1,426 | 10,348 | - |
| SAN AUGUSTINE | 1,009 | - | 3,546 | 19 | 3,527 | 990 | - |
| SHELBY | 3,899 | - | 6,289 | 1,908 | 4,381 | 1,991 | - |
| BASIN TOTALS | 73,545 | 1,190,400 | 104,100 | 23,289 | 80,811 | 50,256 | 1,109,589 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2010 TOTAL | DEMANDS 2010 GW | DEMANDS 2010 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| JASPER | 14,183 | - | 2,222 | 2,135 | 87 | 12,048 | - |
| NEWTON | 28,957 | - | 4,703 | 4,044 | 659 | 24,913 | - |
| ORANGE | 15,089 | - | 115,972 | 15,097 | 100,875 | (8) | - |
| SABINE | 10,408 | - | 1,522 | 60 | 1,462 | 10,348 | - |
| SAN AUGUSTINE | 1,009 | - | 4,308 | 19 | 4,289 | 990 | - |
| SHELBY | 3,899 | - | 6,612 | 1,908 | 4,704 | 1,991 | - |
| BASIN TOTALS | 73,545 | 1,190,400 | 135,339 | 23,263 | 112,076 | 50,282 | 1,078,324 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2020 TOTAL | DEMANDS 2020 GW | DEMANDS 2020 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| JASPER | 14,183 | - | 2,267 | 2,180 | 87 | 12,003 | - |
| NEWTON | 28,957 | - | 4,643 | 3,988 | 655 | 24,969 | - |
| ORANGE | 15,089 | - | 142,349 | 15,097 | 127,252 | (8) | - |
| SABINE | 10,408 | - | 1,531 | 60 | 1,471 | 10,348 | - |
| SAN AUGUSTINE | 1,009 | - | 5,060 | 19 | 5,041 | 990 | - |
| SHELBY | 3,899 | - | 6,830 | 1,908 | 4,922 | 1,991 | - |
| BASIN TOTALS | 73,545 | 1,190,400 | 162,680 | 23,252 | 139,428 | 50,293 | 1,050,972 |

SABINE RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2030 TOTAL | DEMANDS 2030 GW | DEMANDS 2030 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| JASPER | 14,183 | - | 2,409 | 2,322 | 87 | 11,861 | - |
| NEWTON | 28,957 | - | 4,658 | 4,005 | 653 | 24,952 | - |
| ORANGE | 15,089 | - | 170,522 | 15,097 | 155,425 | (8) | - |
| SABINE | 10,408 | - | 1,508 | 60 | 1,448 | 10,348 | - |
| SAN AUGUSTINE | 1,009 | - | 5,829 | 19 | 5,810 | 990 | - |
| SHELBY | 3,899 | - | 7,203 | 1,908 | 5,295 | 1,991 | - |
| BASIN TOTALS | 73,545 | 1,190,400 | 192,129 | 23,411 | 168,718 | 50,134 | 1,021,682 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2040 TOTAL | DEMANDS 2040 GW | DEMANDS 2040 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| JASPER | 14,183 | - | 2,478 | 2,391 | 87 | 11,792 | - |
| NEWTON | 28,957 | - | 4,660 | 4,008 | 652 | 24,949 | - |
| ORANGE | 15,089 | - | 200,630 | 15,097 | 185,533 | (8) | - |
| SABINE | 10,408 | - | 1,465 | 60 | 1,405 | 10,348 | - |
| SAN AUGUSTINE | 1,009 | - | 6,708 | 19 | 6,689 | 990 | - |
| SHELBY | 3,899 | - | 7,589 | 1,908 | 5,681 | 1,991 | - |
| BASIN TOTALS | 73,545 | 1,190,400 | 223,530 | 23,483 | 200,047 | 50,062 | 990,353 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2050 TOTAL | DEMANDS 2050 GW | DEMANDS 2050 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| JASPER | 14,183 | - | 2,549 | 2,462 | 87 | 11,721 | - |
| NEWTON | 28,957 | - | 4,666 | 4,014 | 652 | 24,943 | - |
| ORANGE | 15,089 | - | 233,994 | 15,097 | 218,897 | (8) | - |
| SABINE | 10,408 | - | 1,423 | 60 | 1,363 | 10,348 | - |
| SAN AUGUSTINE | 1,009 | - | 7,724 | 19 | 7,705 | 990 | - |
| SHELBY | 3,899 | - | 8,052 | 1,908 | 6,144 | 1,991 | - |
| BASIN TOTALS | 73,545 | 1,190,400 | 258,408 | 23,560 | 234,848 | 49,985 | 955,552 |

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NECHES RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS | | DEMANDS 1990 | | | EXCESS/DEFICIT WATER | |
|---|---|---|---|---|---|---|---|
| | GW AVAIL. | SW AVAIL. | TOTAL | GW | SW | GW | SW |
| ANGELINA | 30,795 | - | 37,467 | 26,886 | 10,581 | 3,909 | - |
| HARDIN | 29,413 | - | 12,496 | 7,140 | 5,356 | 22,273 | - |
| HOUSTON | 35,844 | - | 1,366 | 656 | 710 | 35,188 | - |
| JASPER | 14,183 | - | 60,990 | 47,887 | 13,103 | (33,704) | - |
| JEFFERSON | 741 | - | 94,470 | 4,786 | 89,684 | (4,045) | - |
| LIBERTY | 1,297 | - | 7,892 | 845 | 7,047 | 452 | - |
| NACOGDOCHES | 72,552 | - | 12,973 | 8,370 | 4,603 | 64,182 | - |
| NEWTON | - | - | 8 | 8 | 0 | (8) | - |
| ORANGE | 3,772 | - | 4,751 | 3,293 | 1,458 | 479 | - |
| POLK | 13,020 | - | 2,226 | 2,021 | 205 | 10,999 | - |
| SABINE | 2,278 | - | 2,214 | 836 | 1,378 | 1,442 | - |
| SAN AUGUSTINE | 10,009 | - | 1,680 | 620 | 1,060 | 9,389 | - |
| SHELBY | 1,300 | - | 514 | 326 | 188 | 974 | - |
| TRINITY | 7,577 | - | 727 | 589 | 138 | 6,988 | - |
| TYLER | 30,320 | - | 2,380 | 2,193 | 187 | 28,127 | - |
| BASIN TOTALS | 253,101 | 846,900 | 242,154 | 106,456 | 135,698 | 146,645 | 711,202 |

| COUNTY | SUPPLY LIMITS | | DEMANDS 2000 | | | EXCESS/DEFICIT WATER | |
|---|---|---|---|---|---|---|---|
| | GW AVAIL. | SW AVAIL. | TOTAL | GW | SW | GW | SW |
| ANGELINA | 30,795 | - | 47,177 | 26,824 | 20,353 | 3,971 | - |
| HARDIN | 29,413 | - | 16,197 | 9,592 | 6,605 | 19,821 | - |
| HOUSTON | 35,844 | - | 1,630 | 612 | 1,018 | 35,232 | - |
| JASPER | 14,183 | - | 76,904 | 47,887 | 29,017 | (33,704) | - |
| JEFFERSON | 741 | - | 106,238 | 4,786 | 101,452 | (4,045) | - |
| LIBERTY | 1,297 | - | 8,008 | 775 | 7,233 | 522 | - |
| NACOGDOCHES | 72,552 | - | 16,920 | 8,255 | 8,665 | 64,297 | - |
| NEWTON | - | - | 6 | 6 | 0 | (6) | - |
| ORANGE | 3,772 | - | 6,180 | 3,294 | 2,886 | 478 | - |
| POLK | 13,020 | - | 3,266 | 2,665 | 601 | 10,355 | - |
| SABINE | 2,278 | - | 2,965 | 862 | 2,103 | 1,416 | - |
| SAN AUGUSTINE | 10,009 | - | 1,823 | 538 | 1,285 | 9,471 | - |
| SHELBY | 1,300 | - | 600 | 412 | 188 | 888 | - |
| TRINITY | 7,577 | - | 961 | 823 | 138 | 6,754 | - |
| TYLER | 30,320 | - | 3,521 | 3,144 | 377 | 27,176 | - |
| BASIN TOTALS | 253,101 | 846,900 | 292,396 | 110,475 | 181,921 | 142,626 | 664,979 |

NECHES RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2010 TOTAL | DEMANDS 2010 GW | DEMANDS 2010 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| ANGELINA | 30,795 | - | 50,633 | 26,824 | 23,809 | 3,971 | - |
| HARDIN | 29,413 | - | 17,039 | 10,277 | 6,762 | 19,136 | - |
| HOUSTON | 35,844 | - | 1,594 | 596 | 998 | 35,248 | - |
| JASPER | 14,183 | - | 88,600 | 47,887 | 40,713 | (33,704) | - |
| JEFFERSON | 741 | - | 120,089 | 4,786 | 115,303 | (4,045) | - |
| LIBERTY | 1,297 | - | 8,046 | 813 | 7,233 | 484 | - |
| NACOGDOCHES | 72,552 | - | 18,512 | 8,255 | 10,257 | 64,297 | - |
| NEWTON | - | - | 4 | 4 | 0 | (4) | - |
| ORANGE | 3,772 | - | 6,275 | 3,294 | 2,981 | 478 | - |
| POLK | 13,020 | - | 3,575 | 2,821 | 754 | 10,199 | - |
| SABINE | 2,278 | - | 3,326 | 870 | 2,456 | 1,408 | - |
| SAN AUGUSTINE | 10,009 | - | 1,839 | 538 | 1,301 | 9,471 | - |
| SHELBY | 1,300 | - | 600 | 412 | 188 | 888 | - |
| TRINITY | 7,577 | - | 1,044 | 906 | 138 | 6,671 | - |
| TYLER | 30,320 | - | 8,736 | 3,359 | 5,377 | 26,961 | - |
| BASIN TOTALS | 253,101 | 846,900 | 329,912 | 111,642 | 218,270 | 141,459 | 628,630 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2020 TOTAL | DEMANDS 2020 GW | DEMANDS 2020 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| ANGELINA | 30,795 | - | 53,281 | 26,824 | 26,457 | 3,971 | - |
| HARDIN | 29,413 | - | 17,944 | 11,018 | 6,926 | 18,395 | - |
| HOUSTON | 35,844 | - | 1,572 | 588 | 984 | 35,256 | - |
| JASPER | 14,183 | - | 94,739 | 47,887 | 46,852 | (33,704) | - |
| JEFFERSON | 741 | - | 136,698 | 4,786 | 131,912 | (4,045) | - |
| LIBERTY | 1,297 | - | 8,089 | 856 | 7,233 | 441 | - |
| NACOGDOCHES | 72,552 | - | 20,181 | 8,255 | 11,926 | 64,297 | - |
| NEWTON | - | - | 3 | 3 | 0 | (3) | - |
| ORANGE | 3,772 | - | 6,216 | 3,295 | 2,921 | 477 | - |
| POLK | 13,020 | - | 3,834 | 2,948 | 886 | 10,072 | - |
| SABINE | 2,278 | - | 3,656 | 872 | 2,784 | 1,406 | - |
| SAN AUGUSTINE | 10,009 | - | 1,844 | 538 | 1,306 | 9,471 | - |
| SHELBY | 1,300 | - | 590 | 402 | 188 | 898 | - |
| TRINITY | 7,577 | - | 1,094 | 956 | 138 | 6,621 | - |
| TYLER | 30,320 | - | 18,991 | 3,614 | 15,377 | 26,706 | - |
| BASIN TOTALS | 253,101 | 846,900 | 368,732 | 112,842 | 255,890 | 140,259 | 591,010 |

NECHES RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2030 TOTAL | DEMANDS 2030 GW | DEMANDS 2030 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| ANGELINA | 30,795 | - | 59,936 | 26,824 | 33,112 | 3,971 | - |
| HARDIN | 29,413 | - | 19,157 | 12,062 | 7,095 | 17,351 | - |
| HOUSTON | 35,844 | - | 1,571 | 584 | 987 | 35,260 | - |
| JASPER | 14,183 | - | 109,158 | 47,887 | 61,271 | (33,704) | - |
| JEFFERSON | 741 | - | 151,264 | 4,786 | 146,478 | (4,045) | - |
| LIBERTY | 1,297 | - | 8,141 | 908 | 7,233 | 389 | - |
| NACOGDOCHES | 72,552 | - | 22,814 | 8,255 | 14,559 | 64,297 | - |
| NEWTON | - | - | 2 | 2 | 0 | (2) | - |
| ORANGE | 3,772 | - | 6,439 | 3,295 | 3,144 | 477 | - |
| POLK | 13,020 | - | 4,262 | 3,235 | 1,027 | 9,785 | - |
| SABINE | 2,278 | - | 3,991 | 864 | 3,127 | 1,414 | - |
| SAN AUGUSTINE | 10,009 | - | 1,904 | 538 | 1,366 | 9,471 | - |
| SHELBY | 1,300 | - | 589 | 401 | 188 | 899 | - |
| TRINITY | 7,577 | - | 1,144 | 1,006 | 138 | 6,571 | - |
| TYLER | 30,320 | - | 29,281 | 3,904 | 25,377 | 26,416 | - |
| BASIN TOTALS | 253,101 | 846,900 | 419,653 | 114,551 | 305,102 | 138,550 | 541,798 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2040 TOTAL | DEMANDS 2040 GW | DEMANDS 2040 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| ANGELINA | 30,795 | - | 67,461 | 26,824 | 40,637 | 3,971 | - |
| HARDIN | 29,413 | - | 20,789 | 13,499 | 7,290 | 15,914 | - |
| HOUSTON | 35,844 | - | 1,568 | 581 | 987 | 35,263 | - |
| JASPER | 14,183 | - | 125,468 | 47,887 | 77,581 | (33,704) | - |
| JEFFERSON | 741 | - | 167,582 | 4,786 | 162,796 | (4,045) | - |
| LIBERTY | 1,297 | - | 8,202 | 969 | 7,233 | 328 | - |
| NACOGDOCHES | 72,552 | - | 25,348 | 8,255 | 17,093 | 64,297 | - |
| NEWTON | - | - | 2 | 2 | 0 | (2) | - |
| ORANGE | 3,772 | - | 6,850 | 3,295 | 3,555 | 477 | - |
| POLK | 13,020 | - | 4,581 | 3,404 | 1,177 | 9,616 | - |
| SABINE | 2,278 | - | 4,350 | 849 | 3,501 | 1,429 | - |
| SAN AUGUSTINE | 10,009 | - | 1,917 | 538 | 1,379 | 9,471 | - |
| SHELBY | 1,300 | - | 585 | 397 | 188 | 903 | - |
| TRINITY | 7,577 | - | 1,180 | 1,042 | 138 | 6,535 | - |
| TYLER | 30,320 | - | 34,387 | 4,010 | 30,377 | 26,310 | - |
| BASIN TOTALS | 253,101 | 846,900 | 470,270 | 116,338 | 353,932 | 136,763 | 492,968 |

NECHES RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| | SUPPLY LIMITS | | DEMANDS 2050 | | | EXCESS/DEFICIT WATER | |
|---|---|---|---|---|---|---|---|
| COUNTY | GW AVAIL. | SW AVAIL. | TOTAL | GW | SW | GW | SW |
| ANGELINA | 30,795 | - | 76,062 | 26,824 | 49,238 | 3,971 | - |
| HARDIN | 29,413 | - | 22,622 | 15,132 | 7,490 | 14,281 | - |
| HOUSTON | 35,844 | - | 1,568 | 580 | 988 | 35,264 | - |
| JASPER | 14,183 | - | 144,294 | 47,887 | 96,407 | (33,704) | - |
| JEFFERSON | 741 | - | 185,918 | 4,786 | 181,132 | (4,045) | - |
| LIBERTY | 1,297 | - | 8,269 | 1,036 | 7,233 | 261 | - |
| NACOGDOCHES | 72,552 | - | 28,215 | 8,255 | 19,960 | 64,297 | - |
| NEWTON | - | - | 2 | 2 | 0 | (2) | - |
| ORANGE | 3,772 | - | 7,296 | 3,295 | 4,001 | 477 | - |
| POLK | 13,020 | - | 4,928 | 3,586 | 1,342 | 9,434 | - |
| SABINE | 2,278 | - | 4,749 | 834 | 3,915 | 1,444 | - |
| SAN AUGUSTINE | 10,009 | - | 1,930 | 538 | 1,392 | 9,471 | - |
| SHELBY | 1,300 | - | 581 | 393 | 188 | 907 | - |
| TRINITY | 7,577 | - | 1,217 | 1,079 | 138 | 6,498 | - |
| TYLER | 30,320 | - | 39,497 | 4,120 | 35,377 | 26,200 | - |
| BASIN TOTALS | 253,101 | 846,900 | 527,148 | 118,347 | 408,801 | 134,754 | 438,099 |

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NECHES-TRINITY BASIN - **Ground Water/Surface Water Breakdown**

**(All Units in Acre-feet/Year)**

| | SUPPLY LIMITS | | DEMANDS | | | EXCESS/DEFICIT | |
|---|---|---|---|---|---|---|---|
| | GW | SW | 1990 | | | WATER | |
| COUNTY | AVAIL. | AVAIL. | TOTAL | GW | SW | GW | SW |
| CHAMBERS | 16,101 | - | 80,900 | 964 | 79,936 | 15,137 | - |
| GALVESTON | 4,400 | - | 946 | 942 | 4 | 3,458 | - |
| JEFFERSON | 2,395 | - | 266,080 | 5,950 | 260,130 | (3,555) | - |
| LIBERTY | 432 | - | 12,920 | 33 | 12,887 | 399 | - |
| BASIN TOTALS | 23,328 | 0 | 360,846 | 7,889 | 352,957 | 15,439 | (352,957) |

| | SUPPLY LIMITS | | DEMANDS | | | EXCESS/DEFICIT | |
|---|---|---|---|---|---|---|---|
| | GW | SW | 2000 | | | WATER | |
| COUNTY | AVAIL. | AVAIL. | TOTAL | GW | SW | GW | SW |
| CHAMBERS | 16,101 | - | 66,437 | 963 | 65,474 | 15,138 | - |
| GALVESTON | 4,400 | - | 885 | 881 | 4 | 3,519 | - |
| JEFFERSON | 2,395 | - | 201,600 | 5,945 | 195,655 | (3,550) | - |
| LIBERTY | 432 | - | 11,725 | 26 | 11,699 | 406 | - |
| BASIN TOTALS | 23,328 | 0 | 280,647 | 7,815 | 272,832 | 15,513 | (272,832) |

| | SUPPLY LIMITS | | DEMANDS | | | EXCESS/DEFICIT | |
|---|---|---|---|---|---|---|---|
| | GW | SW | 2010 | | | WATER | |
| COUNTY | AVAIL. | AVAIL. | TOTAL | GW | SW | GW | SW |
| CHAMBERS | 19,753 | - | 66,765 | 1,291 | 65,474 | 18,462 | - |
| GALVESTON | 4,400 | - | 849 | 845 | 4 | 3,555 | - |
| JEFFERSON | 2,395 | - | 203,299 | 5,942 | 197,357 | (3,547) | - |
| LIBERTY | 432 | - | 11,717 | 29 | 11,688 | 403 | - |
| BASIN TOTALS | 26,980 | 0 | 282,630 | 8,107 | 274,523 | 18,873 | (274,523) |

| | SUPPLY LIMITS | | DEMANDS | | | EXCESS/DEFICIT | |
|---|---|---|---|---|---|---|---|
| | GW | SW | 2020 | | | WATER | |
| COUNTY | AVAIL. | AVAIL. | TOTAL | GW | SW | GW | SW |
| CHAMBERS | 19,753 | - | 67,111 | 1,637 | 65,474 | 18,116 | - |
| GALVESTON | 4,400 | - | 848 | 844 | 4 | 3,556 | - |
| JEFFERSON | 2,395 | - | 205,580 | 5,940 | 199,640 | (3,545) | - |
| LIBERTY | 432 | - | 11,710 | 33 | 11,677 | 399 | - |
| BASIN TOTALS | 26,980 | 0 | 285,249 | 8,454 | 276,795 | 18,526 | (276,795) |

| | SUPPLY LIMITS | | DEMANDS | | | EXCESS/DEFICIT | |
|---|---|---|---|---|---|---|---|
| | GW | SW | 2030 | | | WATER | |
| COUNTY | AVAIL. | AVAIL. | TOTAL | GW | SW | GW | SW |
| CHAMBERS | 19,753 | - | 67,407 | 1,933 | 65,474 | 17,820 | - |
| GALVESTON | 4,400 | - | 903 | 899 | 4 | 3,501 | - |
| JEFFERSON | 2,395 | - | 209,829 | 5,939 | 203,890 | (3,544) | - |
| LIBERTY | 432 | - | 11,702 | 36 | 11,666 | 396 | - |
| BASIN TOTALS | 26,980 | 0 | 289,841 | 8,807 | 281,034 | 18,173 | (281,034) |

NECHES-TRINITY BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2040 TOTAL | DEMANDS 2040 GW | DEMANDS 2040 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| CHAMBERS | 19,753 | - | 67,609 | 2,135 | 65,474 | 17,618 | - |
| GALVESTON | 4,400 | - | 995 | 991 | 4 | 3,409 | - |
| JEFFERSON | 2,395 | - | 213,561 | 5,939 | 207,622 | (3,544) | - |
| LIBERTY | 432 | - | 11,703 | 41 | 11,662 | 391 | - |
| BASIN TOTALS | 26,980 | 0 | 293,868 | 9,106 | 284,762 | 17,874 | (284,762) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2050 TOTAL | DEMANDS 2050 GW | DEMANDS 2050 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| CHAMBERS | 19,753 | - | 67,835 | 2,361 | 65,474 | 17,392 | - |
| GALVESTON | 4,400 | - | 1,105 | 1,101 | 4 | 3,299 | - |
| JEFFERSON | 2,395 | - | 217,433 | 5,939 | 211,494 | (3,544) | - |
| LIBERTY | 432 | - | 11,709 | 47 | 11,662 | 385 | - |
| BASIN TOTALS | 26,980 | 0 | 298,082 | 9,448 | 288,634 | 17,532 | (288,634) |

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TRINITY RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 1990 TOTAL | DEMANDS 1990 GW | DEMANDS 1990 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| CHAMBERS | 3,450 | - | 41,464 | 3,117 | 38,347 | 333 | - |
| GRIMES | 5,321 | - | 471 | 286 | 185 | 5,035 | - |
| HARDIN | | - | 5 | 5 | 0 | (5) | - |
| HOUSTON | 53,767 | - | 4,878 | 2,128 | 2,750 | 51,639 | - |
| LEON | 104,413 | - | 3,569 | 2,899 | 670 | 101,514 | - |
| LIBERTY | 34,577 | - | 63,487 | 9,870 | 53,617 | 24,707 | - |
| MADISON | 47,202 | - | 3,130 | 2,524 | 606 | 44,678 | - |
| POLK | 19,530 | - | 3,591 | 2,413 | 1,178 | 17,117 | - |
| SAN JACINTO | 10,935 | - | 1,206 | 1,033 | 173 | 9,902 | - |
| TRINITY | 4,286 | - | 1,558 | 612 | 946 | 3,674 | - |
| WALKER | 9,347 | - | 6,807 | 3,438 | 3,369 | 5,909 | - |
| BASIN TOTALS | 292,828 | 1,346,220 | 130,166 | 28,325 | 101,841 | 264,503 | 1,244,379 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2000 TOTAL | DEMANDS 2000 GW | DEMANDS 2000 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| CHAMBERS | 3,450 | - | 16,058 | 3,117 | 12,941 | 333 | - |
| GRIMES | 5,321 | - | 732 | 461 | 271 | 4,860 | - |
| HARDIN | | - | 23 | 8 | 15 | (8) | - |
| HOUSTON | 53,767 | - | 4,923 | 2,130 | 2,793 | 51,637 | - |
| LEON | 104,413 | - | 3,767 | 3,097 | 670 | 101,316 | - |
| LIBERTY | 34,577 | - | 43,116 | 15,142 | 27,974 | 19,435 | - |
| MADISON | 47,202 | - | 3,931 | 2,874 | 1,057 | 44,328 | - |
| POLK | 19,530 | - | 5,025 | 2,437 | 2,588 | 17,093 | - |
| SAN JACINTO | 10,935 | - | 1,960 | 1,033 | 927 | 9,902 | - |
| TRINITY | 4,286 | - | 1,828 | 604 | 1,224 | 3,682 | - |
| WALKER | 9,347 | - | 17,084 | 3,445 | 13,639 | 5,902 | - |
| BASIN TOTALS | 292,828 | 1,346,220 | 98,447 | 34,348 | 64,099 | 258,480 | 1,282,121 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2010 TOTAL | DEMANDS 2010 GW | DEMANDS 2010 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| CHAMBERS | 4,233 | - | 16,243 | 3,117 | 13,126 | 1,116 | - |
| GRIMES | 5,321 | - | 768 | 498 | 270 | 4,823 | - |
| HARDIN | | - | 20 | 9 | 11 | (9) | - |
| HOUSTON | 53,767 | - | 4,824 | 2,120 | 2,704 | 51,647 | - |
| LEON | 104,413 | - | 3,787 | 3,117 | 670 | 101,296 | - |
| LIBERTY | 34,577 | - | 45,292 | 17,318 | 27,974 | 17,259 | - |
| MADISON | 47,202 | - | 3,976 | 2,902 | 1,074 | 44,300 | - |
| POLK | 19,530 | - | 5,435 | 2,438 | 2,997 | 17,092 | - |
| SAN JACINTO | 10,935 | - | 2,203 | 1,033 | 1,170 | 9,902 | - |
| TRINITY | 4,286 | - | 1,929 | 604 | 1,325 | 3,682 | - |
| WALKER | 11,640 | - | 29,522 | 3,447 | 26,075 | 8,193 | - |
| BASIN TOTALS | 295,904 | 1,346,220 | 113,999 | 36,603 | 77,396 | 259,301 | 1,268,824 |

TRINITY RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2020 TOTAL | DEMANDS 2020 GW | DEMANDS 2020 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| CHAMBERS | 4,233 | - | 16,506 | 3,117 | 13,389 | 1,116 | - |
| GRIMES | 5,321 | - | 805 | 535 | 270 | 4,786 | - |
| HARDIN | | - | 16 | 10 | 6 | (10) | - |
| HOUSTON | 53,767 | - | 4,758 | 2,053 | 2,705 | 51,714 | - |
| LEON | 104,413 | - | 3,771 | 3,101 | 670 | 101,312 | - |
| LIBERTY | 34,577 | - | 47,416 | 19,442 | 27,974 | 15,135 | - |
| MADISON | 47,202 | - | 3,983 | 2,891 | 1,092 | 44,311 | - |
| POLK | 19,530 | - | 10,774 | 2,439 | 8,335 | 17,091 | - |
| SAN JACINTO | 10,935 | - | 2,445 | 1,033 | 1,412 | 9,902 | - |
| TRINITY | 4,286 | - | 5,250 | 604 | 4,646 | 3,682 | - |
| WALKER | 11,640 | - | 41,264 | 3,450 | 37,814 | 8,190 | - |
| BASIN TOTALS | 295,904 | 1,346,220 | 136,988 | 38,675 | 98,313 | 257,229 | 1,247,907 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2030 TOTAL | DEMANDS 2030 GW | DEMANDS 2030 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| CHAMBERS | 4,233 | - | 16,764 | 3,117 | 13,647 | 1,116 | - |
| GRIMES | 5,321 | - | 859 | 590 | 269 | 4,731 | - |
| HARDIN | | - | 13 | 11 | 2 | (11) | - |
| HOUSTON | 53,767 | - | 4,753 | 2,046 | 2,707 | 51,721 | - |
| LEON | 104,413 | - | 3,826 | 3,156 | 670 | 101,257 | - |
| LIBERTY | 34,577 | - | 49,767 | 21,793 | 27,974 | 12,784 | - |
| MADISON | 47,202 | - | 4,053 | 2,940 | 1,113 | 44,262 | - |
| POLK | 19,530 | - | 16,538 | 2,439 | 14,099 | 17,091 | - |
| SAN JACINTO | 10,935 | - | 2,712 | 1,033 | 1,679 | 9,902 | - |
| TRINITY | 4,286 | - | 8,588 | 604 | 7,984 | 3,682 | - |
| WALKER | 11,640 | - | 53,093 | 3,453 | 49,640 | 8,187 | - |
| BASIN TOTALS | 295,904 | 1,346,220 | 160,966 | 41,182 | 119,784 | 254,722 | 1,226,436 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2040 TOTAL | DEMANDS 2040 GW | DEMANDS 2040 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| CHAMBERS | 4,233 | - | 16,996 | 3,117 | 13,879 | 1,116 | - |
| GRIMES | 5,321 | - | 885 | 616 | 269 | 4,705 | - |
| HARDIN | | - | 13 | 13 | 0 | (13) | - |
| HOUSTON | 53,767 | - | 4,736 | 2,028 | 2,708 | 51,739 | - |
| LEON | 104,413 | - | 3,869 | 3,199 | 670 | 101,214 | - |
| LIBERTY | 34,577 | - | 52,310 | 24,336 | 27,974 | 10,241 | - |
| MADISON | 47,202 | - | 4,071 | 2,944 | 1,127 | 44,258 | - |
| POLK | 19,530 | - | 21,988 | 2,440 | 19,548 | 17,090 | - |
| SAN JACINTO | 10,935 | - | 2,853 | 1,033 | 1,820 | 9,902 | - |
| TRINITY | 4,286 | - | 11,900 | 604 | 11,296 | 3,682 | - |
| WALKER | 11,640 | - | 54,477 | 3,456 | 51,021 | 8,184 | - |
| BASIN TOTALS | 295,904 | 1,346,220 | 174,098 | 43,786 | 130,312 | 252,118 | 1,215,908 |

TRINITY RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2050 TOTAL | DEMANDS 2050 GW | DEMANDS 2050 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| CHAMBERS | 4,233 | - | 17,244 | 3,117 | 14,127 | 1,116 | - |
| GRIMES | 5,321 | - | 912 | 643 | 269 | 4,678 | - |
| HARDIN | | - | 15 | 15 | 0 | (15) | - |
| HOUSTON | 53,767 | - | 4,719 | 2,010 | 2,709 | 51,757 | - |
| LEON | 104,413 | - | 3,913 | 3,243 | 670 | 101,170 | - |
| LIBERTY | 34,577 | - | 55,153 | 27,179 | 27,974 | 7,398 | - |
| MADISON | 47,202 | - | 4,090 | 2,948 | 1,142 | 44,254 | - |
| POLK | 19,530 | - | 27,470 | 2,441 | 25,029 | 17,089 | - |
| SAN JACINTO | 10,935 | - | 3,004 | 1,033 | 1,971 | 9,902 | - |
| TRINITY | 4,286 | - | 16,849 | 604 | 16,245 | 3,682 | - |
| WALKER | 11,640 | - | 55,994 | 3,459 | 52,535 | 8,181 | - |
| BASIN TOTALS | 295,904 | 1,346,220 | 189,363 | 46,692 | 142,671 | 249,212 | 1,203,549 |

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TRINITY-SAN JACINTO BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| | SUPPLY LIMITS | | DEMANDS | | | EXCESS/DEFICIT | |
|---|---|---|---|---|---|---|---|
| | GW | SW | 1990 | | | WATER | |
| COUNTY | AVAIL. | AVAIL. | TOTAL | GW | SW | GW | SW |
| CHAMBERS | 2,300 | - | 12,549 | 1,072 | 11,477 | 1,228 | - |
| HARRIS | 56,100 | - | 91,268 | 9,647 | 81,621 | 46,453 | - |
| LIBERTY | 2,161 | - | 22,098 | 6,202 | 15,896 | (4,041) | - |
| BASIN TOTALS | 60,561 | 0 | 125,915 | 16,921 | 108,994 | 43,640 | (108,994) |

| | SUPPLY LIMITS | | DEMANDS | | | EXCESS/DEFICIT | |
|---|---|---|---|---|---|---|---|
| | GW | SW | 2000 | | | WATER | |
| COUNTY | AVAIL. | AVAIL. | TOTAL | GW | SW | GW | SW |
| CHAMBERS | 2,300 | - | 14,582 | 2,300 | 12,282 | 0 | - |
| HARRIS | 56,100 | - | 104,631 | 23,010 | 81,621 | 33,090 | - |
| LIBERTY | 2,161 | - | 18,390 | 2,161 | 16,229 | 0 | - |
| BASIN TOTALS | 60,561 | 0 | 137,603 | 27,471 | 110,132 | 33,090 | (110,132) |

| | SUPPLY LIMITS | | DEMANDS | | | EXCESS/DEFICIT | |
|---|---|---|---|---|---|---|---|
| | GW | SW | 2010 | | | WATER | |
| COUNTY | AVAIL. | AVAIL. | TOTAL | GW | SW | GW | SW |
| CHAMBERS | 2,822 | - | 16,154 | 2,822 | 13,332 | 0 | - |
| HARRIS | 56,100 | - | 108,135 | 26,514 | 81,621 | 29,586 | - |
| LIBERTY | 2,161 | - | 19,237 | 2,161 | 17,076 | 0 | - |
| BASIN TOTALS | 61,083 | 0 | 143,526 | 31,497 | 112,029 | 29,586 | (112,029) |

| | SUPPLY LIMITS | | DEMANDS | | | EXCESS/DEFICIT | |
|---|---|---|---|---|---|---|---|
| | GW | SW | 2020 | | | WATER | |
| COUNTY | AVAIL. | AVAIL. | TOTAL | GW | SW | GW | SW |
| CHAMBERS | 2,822 | - | 18,010 | 2,822 | 15,188 | 0 | - |
| HARRIS | 56,100 | - | 114,179 | 32,558 | 81,621 | 23,542 | - |
| LIBERTY | 2,161 | - | 20,089 | 2,161 | 17,928 | 0 | - |
| BASIN TOTALS | 61,083 | 0 | 152,278 | 37,541 | 114,737 | 23,542 | (114,737) |

| | SUPPLY LIMITS | | DEMANDS | | | EXCESS/DEFICIT | |
|---|---|---|---|---|---|---|---|
| | GW | SW | 2030 | | | WATER | |
| COUNTY | AVAIL. | AVAIL. | TOTAL | GW | SW | GW | SW |
| CHAMBERS | 2,822 | - | 20,808 | 2,822 | 17,986 | 0 | - |
| HARRIS | 56,100 | - | 120,103 | 38,482 | 81,621 | 17,618 | - |
| LIBERTY | 2,161 | - | 20,944 | 2,161 | 18,783 | 0 | - |
| BASIN TOTALS | 61,083 | 0 | 161,855 | 43,465 | 118,390 | 17,618 | (118,390) |

TRINITY-SAN JACINTO BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| | SUPPLY LIMITS | | DEMANDS | | | EXCESS/DEFICIT | |
|---|---|---|---|---|---|---|---|
| | GW | SW | 2040 | | | WATER | |
| COUNTY | AVAIL. | AVAIL. | TOTAL | GW | SW | GW | SW |
| CHAMBERS | 2,822 | - | 22,680 | 2,822 | 19,858 | 0 | - |
| HARRIS | 56,100 | - | 126,210 | 44,589 | 81,621 | 11,511 | - |
| LIBERTY | 2,161 | - | 21,807 | 2,161 | 19,646 | 0 | - |
| BASIN TOTALS | 61,083 | 0 | 170,697 | 49,572 | 121,125 | 11,511 | (121,125) |

| | SUPPLY LIMITS | | DEMANDS | | | EXCESS/DEFICIT | |
|---|---|---|---|---|---|---|---|
| | GW | SW | 2050 | | | WATER | |
| COUNTY | AVAIL. | AVAIL. | TOTAL | GW | SW | GW | SW |
| CHAMBERS | 2,822 | - | 24,895 | 2,822 | 22,073 | 0 | - |
| HARRIS | 56,100 | - | 132,664 | 51,043 | 81,621 | 5,057 | - |
| LIBERTY | 2,161 | - | 22,755 | 2,161 | 20,594 | 0 | - |
| BASIN TOTALS | 61,083 | 0 | 180,314 | 56,026 | 124,288 | 5,057 | (124,288) |

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SAN JACINTO RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 1990 TOTAL | DEMANDS 1990 GW | DEMANDS 1990 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| FORT BEND | 11,116 | - | 21,900 | 19,807 | 2,093 | (8,691) | - |
| GRIMES | 5,633 | - | 822 | 568 | 254 | 5,065 | - |
| HARRIS | 258,060 | - | 699,177 | 382,846 | 316,331 | (124,786) | - |
| LIBERTY | 4,322 | - | 3,045 | 3,016 | 29 | 1,306 | - |
| MONTGOMERY | 39,997 | - | 34,590 | 28,198 | 6,392 | 11,799 | - |
| SAN JACINTO | 10,935 | - | 1,062 | 980 | 82 | 9,955 | - |
| WALKER | 10,967 | - | 2,735 | 2,061 | 674 | 8,906 | - |
| WALLER | 22,802 | - | 23,000 | 22,864 | 136 | (62) | - |
| BASIN TOTALS | 363,832 | 257,650 | 786,331 | 460,340 | 325,991 | (96,508) | (68,341) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2000 TOTAL | DEMANDS 2000 GW | DEMANDS 2000 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| FORT BEND | 11,116 | - | 22,871 | 16,115 | 6,756 | (4,999) | - |
| GRIMES | 5,633 | - | 1,292 | 1,038 | 254 | 4,595 | - |
| HARRIS | 258,060 | - | 948,299 | 382,697 | 565,602 | (124,637) | - |
| LIBERTY | 4,322 | - | 5,012 | 4,322 | 690 | 0 | - |
| MONTGOMERY | 39,997 | - | 50,868 | 39,997 | 10,871 | 0 | - |
| SAN JACINTO | 10,935 | - | 1,681 | 1,599 | 82 | 9,336 | - |
| WALKER | 10,967 | - | 4,116 | 3,442 | 674 | 7,525 | - |
| WALLER | 22,802 | - | 17,355 | 17,219 | 136 | 5,583 | - |
| BASIN TOTALS | 363,832 | 249,100 | 1,051,494 | 466,429 | 585,065 | (102,597) | (335,965) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2010 TOTAL | DEMANDS 2010 GW | DEMANDS 2010 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| FORT BEND | 11,116 | - | 27,663 | 15,651 | 12,012 | (4,535) | - |
| GRIMES | 5,633 | - | 1,350 | 1,096 | 254 | 4,537 | - |
| HARRIS | 258,060 | - | 1,044,544 | 265,947 | 778,597 | (7,887) | - |
| LIBERTY | 4,322 | - | 5,667 | 4,322 | 1,345 | 0 | - |
| MONTGOMERY | 39,997 | - | 63,187 | 39,997 | 23,190 | 0 | - |
| SAN JACINTO | 10,935 | - | 1,928 | 1,846 | 82 | 9,089 | - |
| WALKER | 10,967 | - | 4,616 | 3,942 | 674 | 7,025 | - |
| WALLER | 22,802 | - | 17,306 | 17,170 | 136 | 5,632 | - |
| BASIN TOTALS | 363,832 | 243,900 | 1,166,261 | 349,971 | 816,290 | 13,861 | (572,390) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2020 TOTAL | DEMANDS 2020 GW | DEMANDS 2020 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| FORT BEND | 11,116 | - | 32,800 | 15,510 | 17,290 | (4,394) | - |
| GRIMES | 5,633 | - | 1,410 | 1,156 | 254 | 4,477 | - |
| HARRIS | 258,060 | - | 1,146,650 | 207,217 | 939,433 | 50,843 | - |
| LIBERTY | 4,322 | - | 6,260 | 4,322 | 1,938 | 0 | - |
| MONTGOMERY | 39,997 | - | 75,575 | 39,997 | 35,578 | 0 | - |
| SAN JACINTO | 10,935 | - | 2,189 | 2,107 | 82 | 8,828 | - |
| WALKER | 10,967 | - | 5,045 | 4,371 | 674 | 6,596 | - |
| WALLER | 22,802 | - | 17,334 | 17,198 | 136 | 5,604 | - |
| BASIN TOTALS | 363,832 | 238,600 | 1,287,263 | 291,878 | 995,385 | 71,954 | (756,785) |

## SAN JACINTO RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2030 TOTAL | DEMANDS 2030 GW | DEMANDS 2030 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| FORT BEND | 11,116 | - | 37,822 | 15,365 | 22,457 | (4,249) | - |
| GRIMES | 5,633 | - | 1,507 | 1,253 | 254 | 4,380 | - |
| HARRIS | 258,060 | - | 1,262,719 | 303,249 | 959,470 | (45,189) | - |
| LIBERTY | 4,322 | - | 7,007 | 4,322 | 2,685 | 0 | - |
| MONTGOMERY | 39,997 | - | 90,939 | 39,997 | 50,942 | 0 | - |
| SAN JACINTO | 10,935 | - | 2,470 | 2,388 | 82 | 8,547 | - |
| WALKER | 10,967 | - | 5,654 | 4,980 | 674 | 5,987 | - |
| WALLER | 22,802 | - | 17,550 | 17,414 | 136 | 5,388 | - |
| BASIN TOTALS | 363,832 | 233,400 | 1,425,668 | 388,968 | 1,036,700 | (25,136) | (803,300) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2040 TOTAL | DEMANDS 2040 GW | DEMANDS 2040 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| FORT BEND | 11,116 | - | 41,091 | 15,221 | 25,870 | (4,105) | - |
| GRIMES | 5,633 | - | 1,554 | 1,300 | 254 | 4,333 | - |
| HARRIS | 258,060 | - | 1,370,863 | 299,230 | 1,071,633 | (41,170) | - |
| LIBERTY | 4,322 | - | 7,695 | 4,322 | 3,373 | 0 | - |
| MONTGOMERY | 39,997 | - | 103,371 | 39,997 | 63,374 | 0 | - |
| SAN JACINTO | 10,935 | - | 2,628 | 2,546 | 82 | 8,389 | - |
| WALKER | 10,967 | - | 6,142 | 5,468 | 674 | 5,499 | - |
| WALLER | 22,802 | - | 17,617 | 17,481 | 136 | 5,321 | - |
| BASIN TOTALS | 363,832 | 228,200 | 1,550,961 | 385,565 | 1,165,396 | (21,733) | (937,196) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2050 TOTAL | DEMANDS 2050 GW | DEMANDS 2050 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| FORT BEND | 11,116 | - | 44,718 | 15,084 | 29,634 | (3,968) | - |
| GRIMES | 5,633 | - | 1,608 | 1,354 | 254 | 4,279 | - |
| HARRIS | 258,060 | - | 1,490,005 | 328,672 | 1,161,333 | (70,612) | - |
| LIBERTY | 4,322 | - | 8,476 | 4,322 | 4,154 | 0 | - |
| MONTGOMERY | 39,997 | - | 117,655 | 39,997 | 77,658 | 0 | - |
| SAN JACINTO | 10,935 | - | 2,803 | 2,721 | 82 | 8,214 | - |
| WALKER | 10,967 | - | 6,676 | 6,002 | 674 | 4,965 | - |
| WALLER | 22,802 | - | 17,726 | 17,590 | 136 | 5,212 | - |
| BASIN TOTALS | 363,832 | 223,000 | 1,689,667 | 415,742 | 1,273,925 | (51,910) | (1,050,925) |

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SAN JACINTO-BRAZOS BASIN - **Ground Water/Surface Water Breakdown**
**(All Units in Acre-feet/Year)**

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 1990 TOTAL | DEMANDS 1990 GW | DEMANDS 1990 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| BRAZORIA | 25,200 | - | 180,561 | 17,298 | 163,263 | 7,902 | - |
| FORT BEND | 17,847 | - | 39,547 | 23,508 | 16,039 | (5,661) | - |
| GALVESTON | 17,600 | - | 113,009 | 7,261 | 105,748 | 10,339 | - |
| HARRIS | 16,830 | - | 98,633 | 28,969 | 69,664 | (12,139) | - |
| BASIN TOTALS | 77,477 | 0 | 431,750 | 77,036 | 354,714 | 441 | (354,714) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2000 TOTAL | DEMANDS 2000 GW | DEMANDS 2000 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| BRAZORIA | 25,200 | - | 177,590 | 14,327 | 163,263 | 10,873 | - |
| FORT BEND | 17,847 | - | 52,038 | 19,976 | 32,062 | (2,129) | - |
| GALVESTON | 17,600 | - | 125,811 | 17,600 | 108,211 | 0 | - |
| HARRIS | 16,830 | - | 138,319 | 28,757 | 109,562 | (11,927) | - |
| BASIN TOTALS | 77,477 | 0 | 493,758 | 80,660 | 413,098 | (3,183) | (413,098) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2010 TOTAL | DEMANDS 2010 GW | DEMANDS 2010 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| BRAZORIA | 25,200 | - | 183,022 | 19,759 | 163,263 | 5,441 | - |
| FORT BEND | 17,847 | - | 62,488 | 19,583 | 42,905 | (1,736) | - |
| GALVESTON | 17,600 | - | 139,879 | 17,600 | 122,279 | 0 | - |
| HARRIS | 16,830 | - | 168,873 | 28,757 | 140,116 | (11,927) | - |
| BASIN TOTALS | 77,477 | 0 | 554,262 | 85,699 | 468,563 | (8,222) | (468,563) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2020 TOTAL | DEMANDS 2020 GW | DEMANDS 2020 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| BRAZORIA | 25,200 | - | 192,683 | 25,200 | 167,483 | 0 | - |
| FORT BEND | 17,847 | - | 74,007 | 19,397 | 54,610 | (1,550) | - |
| GALVESTON | 17,600 | - | 155,765 | 17,600 | 138,165 | 0 | - |
| HARRIS | 16,830 | - | 202,649 | 28,757 | 173,892 | (11,927) | - |
| BASIN TOTALS | 77,477 | 0 | 625,104 | 90,954 | 534,150 | (13,477) | (534,150) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2030 TOTAL | DEMANDS 2030 GW | DEMANDS 2030 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| BRAZORIA | 25,200 | - | 200,995 | 25,200 | 175,795 | 0 | - |
| FORT BEND | 17,847 | - | 86,011 | 19,212 | 66,799 | (1,365) | - |
| GALVESTON | 17,600 | - | 171,398 | 17,600 | 153,798 | 0 | - |
| HARRIS | 16,830 | - | 238,319 | 28,757 | 209,562 | (11,927) | - |
| BASIN TOTALS | 77,477 | 0 | 696,723 | 90,769 | 605,954 | (13,292) | (605,954) |

SAN JACINTO-BRAZOS BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2040 TOTAL | DEMANDS 2040 GW | DEMANDS 2040 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| BRAZORIA | 25,200 | - | 211,134 | 25,200 | 185,934 | 0 | - |
| FORT BEND | 17,847 | - | 95,016 | 19,026 | 75,990 | (1,179) | - |
| GALVESTON | 17,600 | - | 186,041 | 17,600 | 168,441 | 0 | - |
| HARRIS | 16,830 | - | 271,724 | 28,757 | 242,967 | (11,927) | - |
| BASIN TOTALS | 77,477 | 0 | 763,915 | 90,583 | 673,332 | (13,106) | (673,332) |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2050 TOTAL | DEMANDS 2050 GW | DEMANDS 2050 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| BRAZORIA | 25,200 | - | 223,694 | 25,200 | 198,494 | 0 | - |
| FORT BEND | 17,847 | - | 105,183 | 18,848 | 86,335 | (1,001) | - |
| GALVESTON | 17,600 | - | 202,099 | 17,600 | 184,499 | 0 | - |
| HARRIS | 16,830 | - | 309,993 | 28,757 | 281,236 | (11,927) | - |
| BASIN TOTALS | 77,477 | 0 | 840,969 | 90,405 | 750,564 | (12,928) | (750,564) |

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BRAZOS RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 1990 TOTAL | DEMANDS 1990 GW | DEMANDS 1990 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| AUSTIN | 29,522 | - | 4,748 | 3,638 | 1,110 | 25,884 | - |
| BRAZORIA | 10,080 | - | 159,140 | 3,099 | 156,041 | 6,981 | - |
| BRAZOS | 54,770 | - | 47,387 | 42,362 | 5,025 | 12,408 | - |
| BURLESON | 63,398 | - | 9,873 | 8,892 | 981 | 54,506 | - |
| FORT BEND | 46,241 | - | 94,226 | 27,401 | 66,825 | 18,840 | - |
| GRIMES | 14,545 | - | 14,676 | 2,896 | 11,780 | 11,649 | - |
| LEON | 26,103 | - | 890 | 672 | 218 | 25,431 | - |
| MADISON | 11,801 | - | 251 | 148 | 103 | 11,653 | - |
| ROBERTSON | 103,644 | - | 25,504 | 21,364 | 4,140 | 82,280 | - |
| WALLER | 15,180 | - | 10,419 | 9,781 | 638 | 5,399 | - |
| WASHINGTON | 16,903 | - | 6,387 | 2,460 | 3,927 | 14,443 | - |
| BASIN TOTALS | 392,187 | 490,400 | 373,501 | 122,713 | 250,788 | 269,474 | 239,612 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2000 TOTAL | DEMANDS 2000 GW | DEMANDS 2000 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| AUSTIN | 29,522 | - | 5,209 | 3,922 | 1,287 | 25,600 | - |
| BRAZORIA | 10,080 | - | 203,184 | 3,099 | 200,085 | 6,981 | - |
| BRAZOS | 54,770 | - | 52,404 | 46,727 | 5,677 | 8,043 | - |
| BURLESON | 63,398 | - | 14,778 | 9,921 | 4,857 | 53,477 | - |
| FORT BEND | 46,241 | - | 81,268 | 29,880 | 51,388 | 16,361 | - |
| GRIMES | 14,545 | - | 16,457 | 3,272 | 13,185 | 11,273 | - |
| LEON | 26,103 | - | 1,127 | 657 | 470 | 25,446 | - |
| MADISON | 11,801 | - | 381 | 203 | 178 | 11,598 | - |
| ROBERTSON | 103,644 | - | 49,105 | 21,895 | 27,210 | 81,749 | - |
| WALLER | 15,180 | - | 9,985 | 8,454 | 1,531 | 6,726 | - |
| WASHINGTON | 16,903 | - | 8,005 | 2,447 | 5,558 | 14,456 | - |
| BASIN TOTALS | 392,187 | 488,200 | 441,903 | 130,477 | 311,426 | 261,710 | 176,774 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2010 TOTAL | DEMANDS 2010 GW | DEMANDS 2010 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| AUSTIN | 29,522 | - | 5,335 | 4,048 | 1,287 | 25,474 | - |
| BRAZORIA | 10,080 | - | 259,942 | 3,099 | 256,843 | 6,981 | - |
| BRAZOS | 54,770 | - | 59,426 | 53,749 | 5,677 | 1,021 | - |
| BURLESON | 63,398 | - | 15,097 | 10,240 | 4,857 | 53,158 | - |
| FORT BEND | 46,241 | - | 91,605 | 33,595 | 58,010 | 12,646 | - |
| GRIMES | 14,545 | - | 16,724 | 3,544 | 13,180 | 11,001 | - |
| LEON | 26,103 | - | 1,091 | 669 | 422 | 25,434 | - |
| MADISON | 11,801 | - | 378 | 205 | 173 | 11,596 | - |
| ROBERTSON | 103,644 | - | 51,092 | 21,882 | 29,210 | 81,762 | - |
| WALLER | 15,180 | - | 10,516 | 8,447 | 2,069 | 6,733 | - |
| WASHINGTON | 16,903 | - | 8,446 | 2,446 | 6,000 | 14,457 | - |
| BASIN TOTALS | 392,187 | 487,600 | 519,652 | 141,924 | 377,728 | 250,263 | 109,872 |

BRAZOS RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2020 TOTAL | DEMANDS 2020 GW | DEMANDS 2020 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| AUSTIN | 29,522 | - | 5,402 | 4,115 | 1,287 | 25,407 | - |
| BRAZORIA | 10,080 | - | 322,792 | 3,099 | 319,693 | 6,981 | - |
| BRAZOS | 54,770 | - | 66,280 | 54,770 | 11,510 | 0 | - |
| BURLESON | 63,398 | - | 15,540 | 10,683 | 4,857 | 52,715 | - |
| FORT BEND | 46,241 | - | 94,393 | 37,415 | 56,978 | 8,826 | - |
| GRIMES | 14,545 | - | 21,295 | 3,834 | 17,461 | 10,711 | - |
| LEON | 26,103 | - | 1,046 | 671 | 375 | 25,432 | - |
| MADISON | 11,801 | - | 373 | 204 | 169 | 11,597 | - |
| ROBERTSON | 103,644 | - | 59,647 | 30,437 | 29,210 | 73,207 | - |
| WALLER | 15,180 | - | 11,039 | 8,437 | 2,602 | 6,743 | - |
| WASHINGTON | 16,903 | - | 8,840 | 2,446 | 6,394 | 14,457 | - |
| BASIN TOTALS | 392,187 | 487,100 | 606,647 | 156,111 | 450,536 | 236,076 | 36,564 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2030 TOTAL | DEMANDS 2030 GW | DEMANDS 2030 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| AUSTIN | 29,522 | - | 5,536 | 4,249 | 1,287 | 25,273 | - |
| BRAZORIA | 10,080 | - | 326,793 | 3,099 | 323,694 | 6,981 | - |
| BRAZOS | 54,770 | - | 74,538 | 54,770 | 19,768 | 0 | - |
| BURLESON | 63,398 | - | 15,809 | 10,952 | 4,857 | 52,446 | - |
| FORT BEND | 46,241 | - | 102,250 | 41,304 | 60,946 | 4,937 | - |
| GRIMES | 14,545 | - | 25,972 | 4,231 | 21,741 | 10,314 | - |
| LEON | 26,103 | - | 1,015 | 687 | 328 | 25,416 | - |
| MADISON | 11,801 | - | 371 | 207 | 164 | 11,594 | - |
| ROBERTSON | 103,644 | - | 68,284 | 39,074 | 29,210 | 64,570 | - |
| WALLER | 15,180 | - | 11,815 | 8,429 | 3,386 | 6,751 | - |
| WASHINGTON | 16,903 | - | 9,381 | 2,445 | 6,936 | 14,458 | - |
| BASIN TOTALS | 392,187 | 486,600 | 641,764 | 169,447 | 472,317 | 222,740 | 14,283 |

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2040 TOTAL | DEMANDS 2040 GW | DEMANDS 2040 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| AUSTIN | 29,522 | - | 5,673 | 4,386 | 1,287 | 25,136 | - |
| BRAZORIA | 10,080 | - | 329,512 | 3,099 | 326,413 | 6,981 | - |
| BRAZOS | 54,770 | - | 80,669 | 54,770 | 25,899 | 0 | - |
| BURLESON | 63,398 | - | 16,074 | 11,217 | 4,857 | 52,181 | - |
| FORT BEND | 46,241 | - | 103,575 | 43,661 | 59,914 | 2,580 | - |
| GRIMES | 14,545 | - | 30,471 | 4,446 | 26,025 | 10,099 | - |
| LEON | 26,103 | - | 1,014 | 699 | 315 | 25,404 | - |
| MADISON | 11,801 | - | 369 | 207 | 162 | 11,594 | - |
| ROBERTSON | 103,644 | - | 76,931 | 47,721 | 29,210 | 55,923 | - |
| WALLER | 15,180 | - | 12,104 | 8,431 | 3,673 | 6,749 | - |
| WASHINGTON | 16,903 | - | 9,863 | 2,447 | 7,416 | 14,456 | - |
| BASIN TOTALS | 392,187 | 486,000 | 666,255 | 181,084 | 485,171 | 211,103 | 829 |

BRAZOS RIVER BASIN - Ground Water/Surface Water Breakdown
(All Units in Acre-feet/Year)

| COUNTY | SUPPLY LIMITS GW AVAIL. | SUPPLY LIMITS SW AVAIL. | DEMANDS 2050 TOTAL | DEMANDS 2050 GW | DEMANDS 2050 SW | EXCESS/DEFICIT WATER GW | EXCESS/DEFICIT WATER SW |
|---|---|---|---|---|---|---|---|
| AUSTIN | 29,522 | - | 5,825 | 4,538 | 1,287 | 24,984 | - |
| BRAZORIA | 10,080 | - | 332,341 | 3,099 | 329,242 | 6,981 | - |
| BRAZOS | 54,770 | - | 87,420 | 54,770 | 32,650 | 0 | - |
| BURLESON | 63,398 | - | 16,359 | 11,502 | 4,857 | 51,896 | - |
| FORT BEND | 46,241 | - | 105,154 | 46,225 | 58,929 | 16 | - |
| GRIMES | 14,545 | - | 37,125 | 4,675 | 32,450 | 9,870 | - |
| LEON | 26,103 | - | 1,015 | 711 | 304 | 25,392 | - |
| MADISON | 11,801 | - | 369 | 207 | 162 | 11,594 | - |
| ROBERTSON | 103,644 | - | 89,873 | 60,663 | 29,210 | 42,981 | - |
| WALLER | 15,180 | - | 12,406 | 8,434 | 3,972 | 6,746 | - |
| WASHINGTON | 16,903 | - | 10,384 | 2,449 | 7,935 | 14,454 | - |
| BASIN TOTALS | 392,187 | 485,400 | 698,271 | 197,273 | 500,998 | 194,914 | (15,598) |

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# APPENDIX M

## Preliminary Studies: Permanent Salt Water Barrier on the Neches River, Allens Creek Reservoir Project

# APPENDIX M

## Permanent Neches Salt Water Barrier

In the 1987 study by the Lower Neches Valley Authority (16), the permanent salt water barrier was indicated to provide a gain of 247,000 acre-feet per year in additional dependable supply. Of this amount, 155,700 acre-feet per year were attributed to avoidance of excessive releases from Lake Steinhagen for control of salt water intrusion. The other 91,300 acre-feet per year were associated with increased ability to use uncontrolled runoff originating below Lake Steinhagen.

Appendix C contains a copy of the environmental guidelines adopted by the PMC for use in the Phase I Trans-Texas studies. In the case of the Neches salt water barrier, the criteria outlined in Appendix C would require that significant amounts of runoff from the uncontrolled drainage area below Lake Steinhagen be passed through for maintenance of instream flows. The pass-through requirements would be based on average historical flows in the months of May through June and September through October; for the remainder of the year, they would be based on the historical median daily flows for each month.

Analysis of recorded stream flows from the critical drought of record (July 1953 through February 1957) confirmed the previous findings of the 1987 report with regard to the potential yield benefits of a permanent structure. Because the temporary barriers would unavoidably be breached from time to time, when storms caused flows greater than the sheet piling could withstand, the permanent barrier would save an average of approximately 155,700 acre-feet per year of excess releases from Lake Steinhagen. Those releases would be needed to help hold the salt water downstream from the diversion pump intakes while the temporary barriers were being rebuilt after washouts but would not be required with a barriers were being rebuilt after washouts but would not be required with a permanent barrier in place. In addition, the permanent barrier would potentially allow diversion and use of an average of 91,300 acre-feet per year of runoff which originated below Lake Steinhagen during the critical drought period but could not be used with the temporary barriers. The combined benefit would be the sum of the two above amounts, or some 247,000 acre-feet per year.

The savings in releases from Lake Steinhagen would not be affected by the Trans-Texas instream flow criteria, but those requirements would reduce the use of uncontrolled runoff from the watershed below Lake Steinhagen. Studies based on daily flows during the critical period showed that the proposed Trans-Texas instream flow requirements would essentially eliminate the permanent barrier's increased use of flows coming from the drainage area immediately upstream from the lower Neches diversion points. With the Trans-Texas criteria in effect, the total gain in yield attributable to the permanent structure would be approximately 156,800 acre-feet per year, of which all but 1,100 acre-feet per year would be attributable to avoidance of excessive releases from Lake Steinhagen.

It should be kept in mind that, as explained in Section 3.2, the computations of yield for the temporary barriers have so far assumed that they could be installed at the beginning of a critical drought. If the Corps of Engineers requires that the barriers not be installed until the conservation storage in Sam Rayburn Reservoir has been partially depleted, the dependable yield with temporary barriers will be less, and the benefits of a permanent barrier would be greater than indicated here.

Preliminary environmental review of the salt water barrier project indicated the following principal findings:

- <u>Water Quality Impacts of the Permanent Barrier</u>

  The permanent salt water barrier would improve water quality conditions on approximately 16.7 river miles of the Neches River and Pine Island Bayou and in adjacent swamp areas. These areas would no longer be subject to intrusion of salt water and/or water affected by municipal and industrial waste. The area upstream from the permanent barrier would be returned to a dependable freshwater environment, with associated benefits for wildlife. Water quality below the permanent barrier site would be negatively impacted by the barrier and would become slightly more degraded. Approximately 600 acres which are drained by Brakes Bayou above the barrier would not be returned to freshwater (18).

- Barrier Impacts on Aquatic and Terrestrial Habitat
  Positive impacts to habitat would be realized upstream from the permanent barrier, where the aquatic environment would be returned to perennial freshwater. Improvements to cypress-tupelo swamps, upland oak-pine forests, and freshwater marsh would provide improved habitat, spawning, and nursery areas. A portion of the Big Thicket National Preserve is located at the confluence of Pine Island Bayou and the Neches River. This area would no longer be subject to salt water intrusion (18). There would be no significant inundation area associated with the barrier, since the normal operating water levels would remain within the river banks.

- Wetlands Impacts
  Wetlands above the permanent barrier would be preserved and enhanced by the supply of freshwater. Approximately 67 acres of land near the Neches River and Bairds Bayou would be permanently altered by construction of the project (18). According to the National Wetland Inventory maps, this entire area is comprised of wetlands.

- Bottomland Hardwood Forest in the Barrier Area
  According to the Texas Bottomland Hardwood Preservation Program (20), no designated bottomland hardwood forest preservation areas are located in the vicinity of the salt water barrier project. The closest bottomland hardwood forest which is part of the preservation program is on Pine Island Bayou, approximately 20 miles upstream (west) of its confluence with the Neches and beyond the area of project impact. However, bottomland hardwood forest does exist at the site, although it is not in a specifically designated area of the Texas Bottomland Hardwood Preservation Program (19).

- Recreation Impacts
  Swimming, boating, hunting, and fishing would be impacted positively by the additional 16.7 miles of continual freshwater conditions in the Neches and Pine Island Bayou that would be created by the construction of the barrier. Accessibility to upstream areas would be improved by the navigation gate incorporated into the permanent structure, which would alleviate existing problems that occur when the temporary barriers are in place. Access to upstream reaches would be slightly more difficult for boats launched downstream or from the Neches Boat Club (18).

- Threatened and Endangered Species

The following is a summary of state-listed threatened and endangered species for Jefferson County, based on the State Endangered Species Data File of 1988. That data file lists known, probable, and possible occurrences of species within the county. Only the known and probable occurrences have been considered here:

| Common Name | Scientific Name |
|---|---|
| Brown pelican | *Pelicanus oxidentalus* |
| Bald Eagle | *Haliaeetus leucocephalus* |
| Interior Least Tern | *Sterna antillarum athalassos* |
| Red-cockaded Woodpecker | *Picoides borealis* |
| Loggerhead Turtle | *Caretta caretta* |
| Atlantic Green Turtle | *Chelonia mydas* |
| Alligator Snapping Turtle | *Macrochclemys temminckii* |
| Atlantic Ridley Turtle | *Lepidochelys kempi* |
| Leatherback Turtle | *Dermochelys coriacea* |
| Paddlefish | *Polyodon spathula* |
| American Swallow-tailed Kite | *Elanoides forficatus* |
| Arctic Peregrine Falcon | *Falco peregrinus tundrius* |
| Reddish Egret | *Egretta rufescens* |
| Wood Stork | *Mycteria americana* |
| White-faced Ibis | *Plegadis chihi* |
| Piping Plover | *Charadrius melodus* |
| Bachman's Sparrow | *Aimophila aestivalis* |
| Timber Rattlesnake | *Crotalus horridus horridus* |
| Texas Horned Lizard | *Phrynosoma cornutum* |
| Northern Scarlet Snake | *Cemophora coccinea copei* |
| Blue Sucker | *Cycleptus elongatus* |

However, a review of the Texas Parks and Wildlife's 1994 data file of known occurrences of species of special concern for the specific USGS topographic quadrangle for that area revealed no known occurrences of state threatened or endangered species.

The Paddlefish is a threatened and endangered species which is being reintroduced into some Texas rivers, including the Neches basin (21). The target recovery areas include the Neches River near Beaumont and its tributaries, Pine Island Bayou and Village Creek, from and including the intercoastal waterway in Jefferson and Orange counties upstream to Anderson and Cherokee counties. The Paddlefish Recovery Plan does not recommend stocking the Neches River at Beaumont. It discusses concern with water quality in Pine Island Bayou and Village Creek, where occasionally pH values fall below 6.5.

Additionally, Pine Island Bayou is subject to dissolved oxygen levels below 5 milligrams per liter (mg/l) in the summer, and arsenic, manganese, and mercury levels above the EPA criteria for fresh water. The Paddlefish Recovery Plan further notes that sand and gravel and pipeline dredging also occur in the lower Neches River in the vicinity of and downstream from Pine Island Bayou and in the vicinity of Beaumont.

As a result, the Paddlefish Recovery Program recommends encouraging agencies and municipalities to enhance water quality and habitat of the Neches/Angelina River within the target recovery areas(21). The salt water barrier would enhance water quality of the Neches and Pine Island Bayou, thereby improving the habitat for the paddlefish and protecting it against salt water intrusion. In addition, construction of the permanent barrier would remove the potential of trapping paddlefish on the wrong side of the temporary barriers during their construction.

Federal listed threatened and endangered species for Jefferson County include the Bald Eagle, Brown Pelican, and Interior Least Tern. Jefferson County is migratory and nesting habitat for the Brown Pelican; wintering habitat for the Interior Least Tern; and migratory habitat for the Bald Eagle.

- Air Quality Impacts

  Short-term impacts to air quality are to be expected during construction activities. Standard mitigation measures to reduce dust, such as wetting the construction site, are readily available.

- Socio-Economic Impacts of the Permanent Barrier

  Several positive socio-economic impacts would result from the project. The populace of Beaumont and Jefferson County would be provided with a secure source of fresh water. Local customers of the Lower Neches Valley Authority (LNVA) have indicated that they would be willing to accept rate increases in order to provide the local portion of cost sharing for construction (22). A secure source of fresh water would positively impact business and industrial activity (18).

**Allens Creek Reservoir Project**

The Allens Creek project is basically an off-channel surface reservoir, located at the mouth of Allens Creek on the west bank of the Brazos River near Wallis. Allens Creek itself has a relatively small watershed, and most of the water available for impoundment in the reservoir would be obtained by diversions from the main stem of the Brazos.

The yield analysis by the Brazos River Authority in 1989 indicated that the Allens Creek project, with the top of conservation storage at elevation 118.0 and a conservation capacity of 142,892 acre-feet, would produce a firm yield of 85,000 acre-feet per year if its Brazos River diversion pumps had a total capacity of 770 cfs (19). As part of the Phase I work for the Trans-Texas Program, the project yield was re-evaluated, with allowance for new water rights issued in the Brazos Basin since the former studies. It was found that the firm yield of 85,000 acre-feet per year would now require a peak diversion rate of 820 cfs.

Studies were also carried out to determine the impact of the instream flow guidelines adopted by the PMC for purposes of the Trans-Texas Phase I work (see Appendix C). Since there is no major bay system at the mouth of the Brazos River, the applicable Trans-Texas criteria would require that the diversions leave instream flows at least equal to 60 percent of historical median daily flows in the months of March through September and 40 percent of historical median daily flows in the months of October through February.

The criteria further required that monthly inflows from the Allens Creek watershed during the critical drought period either (a) be released entirely or (b) be released to the extent of the median historical flows during the critical period for the given months. It was found that the Trans-Texas instream flow requirements reduced the firm yield to 57,800 acre-feet per year with a diversion capability of 820 cfs, a loss of 27,200 acre-feet per year. However, it was also indicated that a firm yield of 85,000 acre-feet per year could still be obtained, even with the Trans-Texas instream flow limitations, if the diversion pumping capacity were increased to 1,900 cfs.

The studies showed that the firm yield of the Allens Creek project could be increased to significantly more than 85,000 acre-feet per year by raising the peak diversion capability beyond the levels discussed above. It was found that, without the instream flow limitations adopted for the Phase I Trans-Texas studies, a maximum feasible yield of about 120,000 acre-feet per year could be developed with a diversion capacity of 2,000 cfs. With the instream flow requirements in effect, the maximum feasible yield was indicated to be some 105,000 acre-feet per year with a total diversion capacity of 3,000 cfs. Thus, the instream flow criteria would involve a loss of approximately 15,000 acre-feet per year of ultimate yield and would require the addition of approximately 50 percent more pumping capacity to reach maximum obtainable performance.

From the initial environmental investigations of the Allens Creek project, the following observations were noted:

- <u>Water Quality in Allens Creek Reservoir</u>

  Computer simulation studies of reservoir operation indicated that the Allens Creek project would have a median total dissolved solids (TDS) concentration of approximately 500 milligrams per liter during the years of critical low flow conditions (1954-1957). The maximum TDS concentration during that period was shown to be slightly less than 1,000 mg/l.

- <u>Habitat at the Allens Creek Site</u>
  Land use at the reservoir site includes farming and pasture, with several large stands of trees and associated vegetation. Elm, black willow, hackberry, cedar, soapberry, pecan, poison oak, and ash are located in the forested areas and in the riparian zone also on Allens Creek. A wooded area of approximately 650 acres surrounds Alligator Hole, a small lake in the northeast part of the proposed reservoir pool. The trees around Alligator Hole appear to be frequently flooded. The steady water supply, grain fields, grasses, shrubs and trees provide high quality habitat for a variety of species (19).

- <u>Threatened and Endangered Species at Allens Creek</u>
  The following are the state-listed threatened and endangered species for Austin County, based on the State Endangered Species Data File of 1988. That data file lists known, probable, and possible occurrences of species. Only known and probable occurrences have been considered here.

| Common Name | Scientific Name |
|---|---|
| Bald Eagle | *Haliaeetus leucocephalus* |
| Attwater's Greater Prairie Chicken | *Tympanuchus cupido attwateri* |
| Whooping Crane | *Grus americana* |
| Western Smooth Green Snake | *Opheodrys vernalis blanchardi* |
| Houston Toad | *Bufo houstonensis* |
| American Swallow-tailed Kite | *Elanoides forficatus* |
| Arctic Peregrine Falcon | *Falco peregrinus tundrius* |
| White-tailed Hawk | *Buteo albicaudatus* |
| Wood Stork | *Mycteria americana* |
| White-faced Ibis | *Plegadis chihi* |
| Timber Rattlesnake | *Crotalus horridus horridus* |
| Texas Horned Lizard | *Phrynosoma cornutum* |
| Blue Sucker | *Cycleptus elongatus* |

A review of the Texas Parks and Wildlife's 1994 datafile of known occurrences of species of special concern revealed that only the Smooth Green Snake is known to occur within the Wallis quadrangle map area, the location of the proposed reservoir.

- Wetlands at Allens Creek

  There is no National Wetland Inventory map available for the Wallis quadrangle. However, Alligator Hole would likely be delineated as a wetland using approved Corps of Engineers methodology.

- Cultural Resources at Allens Creek

  A large number of archeological sites have been investigated within the area of the proposed reservoir. Analysis of three sites which were intensely excavated indicates that the bluff which would form the perimeter of the proposed reservoir was used by prehistoric people for habitation and as a cemetery (23).

- Bottomland Hardwood Forest at Allens Creek

  Bottomland hardwood forest would not be significantly affected by Allens Creek Reservoir. There is no designated bottomland hardwood forest preservation area in Austin County (20).

- Bay and Estuaries Impact of Allens Creek

  The estuary at the mouth of the Brazos River is not as productive or as extensive as other estuaries along the Texas coast. It does not include a bay area as such. The number of species present in the Matagorda-Brazos estuarine system appears to be large, but the populations are moderate (24). It is characterized by benthic organisms with limited mobility, such as mud shrimp, some echinoids and rarely mollusks (25).