TABLE OF CONTENTS

List of Figures

List of Tables

List of Exhibits

Appendices

Abbreviations used in the Report

Ac-ft/yr	Acre-feet per year
BRA	Brazos River Authority
CLCND	Chambers-Liberty Counties Navigation District
COH	City of Houston
GBEP	Galveston Bay Estuary Program
GBF	Galveston Bay Foundation
GBFIG	Galveston Bay Freshwater Inflows Group
GCWA	Gulf Coast Water Authority
MGD	Million gallons per day
MWP	Major Water Provider
RWPG	Regional Water Planning Group
RHWPG	Region H Water Planning Group
SB1	Senate Bill 1 from the 1997 State Legislature
SJRA	San Jacinto River Authority
TNRCC	Texas Natural Resource Conservation Commission
TPWD	Texas Parks and Wildlife Department
TRA	Trinity River Authority
TWDB	Texas Water Development Board
WUG	Water User Group

Water Measurements

Acre-foot (AF) = 43,560 cubic feet = 325,851 gallons
Acre-foot per year (ac-ft/yr) = 325,851 gallons per year = 893 gallons per day
Gallons per minute (gpm) = 1,440 gallons per day = 1.6 ac-ft/yr
Million gallons per day (mgd) = 1,000,000 gallons per day = 1120 ac-ft/yr

County Codes used in the Tables

8	Austin County
20	Brazoria County
36	Chambers County
79	Fort Bend County
84	Galveston County
101	Harris County
145	Leon County
146	Liberty County
157	Madison County
170	Montgomery County
187	Polk County
204	San Jacinto County
228	Trinity County
236	Walker County
237	Waller County

Basin Codes used in the Tables

6	Neches River Basin
7	Neches-Trinity Coastal Basin
8	Trinity River Basin
9	Trinity-San Jacinto Coastal Basin
10	San Jacinto River Basin
11	San Jacinto-Brazos Coastal Basin
12	Brazos River Basin
13	Brazos-Colorado Coastal Basin

REGION H TASK 3 - ANALYSIS OF CURRENT WATER SUPPLIES

Introduction

The available water supply within Region H includes both groundwater and surface water. Groundwater is provided from two major aquifers—the Gulf Coast and the Carrizo-Wilcox; three minor aquifers—the Sparta, Queen City, and Brazos River alluvium. Primary surface water sources are reservoir storage and run-of-river (ROR) supply from the three rivers in the area—the Trinity, the San Jacinto, and the Brazos.

Much of the regional water demand is supplied by surface water. Of the total 1996 water demand, almost 66 percent, or 1,247,360 acre-feet, was supplied by surface water. Surface water supplies are obtained from the Lake Livingston-Wallisville Salt Water Barrier System on the Trinity River; Lakes Conroe and Houston on the San Jacinto River; the Brazos River Authority/Corps of Engineers (BRA/COE) System; run-of-river flows from the Trinity, Brazos, and San Jacinto rivers; the corresponding coastal basins; and some smaller tributaries and reservoirs. Ground water supplies accounted for the remaining 34 percent of the total 1996 water demand predominately supplied by the Gulf Coast aquifer.

As a part of Task 3, the Texas Water Development Board (TWDB) requires the presentation of *Tables 4, 5*, and *6* in accordance with *Exhibit B, "Data and Format Guidelines for SB1 Regional Water Plan – Technical Reports."* *Table 4, "Current Water Supply Sources,"* indicates the amount of water supply that could be obtained during drought of record conditions from each unique supply source currently available to serve the region. *Table 5*, *"Current Water Supplies Available to Region H by City and Category,"* evaluates the current water supplies available to the region for cities and categories of water users for each county/basin, or portion of a county/basin, in the regional water planning area. In most cases, this is represented by existing contracts or rights. *Table 6*, *"Current Water Supplies Available to the RWPG by Major Water Provider of Municipal and Manufacturing Water,"* tabulates the current water supplies available to the major providers of municipal and manufacturing water for each county/basin, or portion of a county/basin, in the regional water planning area. The RWPG designated five major water providers (MWPs) within the region—Brazos River Authority (BRA), City of Houston (COH), Gulf Coast Water Authority (GCWA), San Jacinto River Authority (SJRA), and Trinity River Authority (TRA). An additional table, *Table 5A*, was compiled as requested by the RWPG. *Table 5A* is identical to *Table 5* except in *Table 5A*, it is assumed that existing water supply contracts included in *Table 5* will be renewed at the current contract amounts and extended through the planning period. The tables and the detailed methodology associated with compiling the tables are included in *Appendix A*.

Some of the information contained within this Task 3 report was based on information published in the *Task 1 – Description of the Region*. For a complete and detailed list of sources, see *Appendix A – References* in the Task 1 report.

Task 3.1 Identification of Groundwater Sources[1]

Groundwater Aquifers

As presented in the Task 1 report, groundwater resources in Region H consist of two major aquifers and three minor aquifers. The two major aquifers are the Gulf Coast aquifer and the Carrizo-Wilcox aquifer with the Gulf Coast aquifer furnishing by far the most groundwater within the region. There are also three minor aquifers present: the Sparta, Queen City and Brazos River alluvium aquifers.

The Carrizo-Wilcox aquifer is the main aquifer in the northern part of Region H in Leon County and the north part of Madison County. The aquifer is composed of, in ascending order, the Wilcox Group and the Carrizo Formation. Because they are hydraulically connected, they are considered one aquifer. The Wilcox Group is composed of alternating beds of sand, sandy clay, and clay with locally interbedded gravel, silt, clay, and lignite. The Carrizo Formation is a uniform, well sorted sand that contains a few very thin beds of clay with the aquifer dipping downward to the southeast at about 70 to 100 feet per mile. The Carrizo-Wilcox aquifer supplies groundwater for domestic, municipal, manufacturing, and agricultural uses in Leon and Madison counties. *Exhibit 1, Major Groundwater Aquifers*, provides a map showing the location of the aquifer.

The Gulf Coast aquifer consists of four general water-producing units. The shallowest is the Chicot aquifer followed by the Evangeline aquifer, the Jasper aquifer and the Catahoula Formation. The Chicot and Evangeline aquifers are the more prolific water producing units in the Gulf Coast aquifer followed by the Jasper aquifer and the Catahoula Formation. The aquifer extends from the Gulf Coast to approximately 100 to 120 miles inland, in Walker and Trinity counties. The units are composed of alternating beds of sand, silt, and clay, and at deeper depths shale can occur at and below the base of the Evangeline aquifer. Formation beds vary in thickness, composition; areal extent and individual beds normally cannot be traced over extended distances. Total aquifer sand thickness varies and can be as great as several hundred feet. The Gulf Coast aquifer supplies ground water for domestic, municipal, manufacturing, and agricultural uses in Austin, Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, Polk, San Jacinto, Trinity, Walker, and Waller counties.

The Queen City Formation is a minor aquifer that occurs in central and southeast Leon County and in Madison County. The Queen City Formation is composed of sand and loosely cemented sandstone with interbedded shale layers occurring throughout. The Queen City Formation ranges in thickness from 250 feet to 400 feet with approximately 60 to 70 percent of the total thickness being sand according to Texas Water Commission Bulletin 6513, "Availability and Quality of Ground Water in Leon County, Texas, 1965" (Bulletin 6513). Groundwater is provided by the Queen City Formation for domestic, municipal, industrial and agricultural uses in Leon and Madison counties.

The Sparta Formation is another minor aquifer that occurs in southeast Leon county, all of Madison County, northwest Walker County, and northeast Trinity County. The Sparta Formation consists of sand and interbedded clay, with the lower portion of the aquifer containing massive unconsolidated sands with a few layers of shale. The Sparta Formation ranges in thickness from 200 to 300 feet in Leon County (Bulletin 6513) and Madison County. Groundwater from the aquifer is provided for

[1] The information in this section of the Task 3 report was provided by LBG-Guyton Associates.

domestic, municipal, and agricultural uses in Leon County and for domestic, municipal, manufacturing, and agricultural uses in Madison County.

The Brazos River alluvium is the third minor aquifer in the region. The Brazos River alluvium occurs in the floodplain and terrace deposits of the Brazos River in Austin, Fort Bend and Waller Counties as shown on *Exhibit 2, Minor Groundwater Aquifers*. The Quaternary alluvial sediments consist of clay, silt, sand, and gravel according to Texas Water Development Board Report 345 "Aquifers of Texas," (1995) with the more permeable sand and gravel in the lower part of the aquifer. The saturated thickness of the sediment is as much as 85 feet with a width of the alluvium that ranges from less than 1 mile to approximately 7 miles according to Report 345. The Brazos River alluvium supplies groundwater for domestic and agricultural purposes in Fort Bend and Waller counties. In Austin County, it supplies groundwater for domestic, manufacturing and agricultural uses.

Recharge to the two major and three minor aquifers is principally from the infiltration of precipitation and stream flow on the outcrops, see *Exhibit 3, Aquifer Outcrop Areas*. Part of the water infiltrates to the zone of saturation and then moves downdip through the aquifers, while large amounts of precipitation on the outcrops are rejected recharge and become runoff. Average annual precipitation in Region H ranges from about 40 inches per year in the northern section to about 50 to 54 inches in the southeastern section.

Groundwater Use Overview

According to the Texas Water Development Board (TWDB) Region H pumped approximately 653,279 acre-feet of groundwater in 1996. Groundwater in the region is used for domestic, municipal, manufacturing, steam-electric power cooling and agricultural purposes. The majority of the water is used for municipal purposes. Municipal usage accounts for approximately 73 percent or 475,910 acre-feet of the water pumped. Municipal pumpage consists of water used for cities and communities, parks, campgrounds and water districts. Agricultural usage accounts for approximately 16 percent or 103,279 acre-feet of the groundwater pumped. Major agricultural crops include rice, soybean, corn, cotton and hay. Cattle are the principle livestock raised in the region. Finally, industrial usage represents approximately 11 percent or 74,090 acre-feet of the groundwater – water pumped for manufacturing, mining, steam electric power and other industrial needs. A majority of the overall groundwater usage is in the southern section of the region where more of the population, industrial and agricultural demands exist and where the aquifer is capable of providing large quantities of water for the various uses.

Aquifer Conditions

Groundwater conditions within the region have been favorable and should continue to be favorable for the pumping of substantial quantities of good quality water to help satisfy the multiple water needs. The principal aquifers that will provide the water include the Carrizo-Wilcox in Leon and Madison counties and the Gulf Coast aquifer system in the central and southern sections of the region. Smaller amounts of water can be provided by the Queen City, Sparta, and Brazos River alluvium aquifers with the minor aquifers being particularly important in areas that do not require large quantities of water but desire an adequate supply of water.

Carrizo-Wilcox Aquifer

The Carrizo-Wilcox aquifer was deposited in a manner that resulted in a combined aquifer with a thickness of about 2,000 feet in the very northern section of the region. The Carrizo Sand, the principal water-producing unit of the Carrizo-Wilcox aquifer, is about 100 to 200 feet thick. According to TWDB estimates in the 1997 Texas State Water Plan, the overall availability of water from the Carrizo-Wilcox aquifer in Leon and Madison counties is about 165,900 acre-feet per year. In 1996 only about 3,350 acre-feet of groundwater was pumped from the aquifer in the two counties based on data from the TWDB. Conditions are favorable in the region's northern two counties to develop additional supplies from the Carrizo-Wilcox aquifer. The development should be done in a manner that will properly manage the aquifer and monitor its response to the stress of additional groundwater pumping. Water from the aquifer contains less than 1,000 mg/l of total dissolved solids, but water from the Carrizo Sand can contain elevated levels of iron that require sequestering or treatment for removal for water used for most municipal and industrial purposes.

Gulf Coast Aquifer

The Gulf Coast aquifer was deposited in a manner that resulted in a substantial thickness of sand that contains fresh (good quality) water. The lower unit of the aquifer, Catahoula Sandstone, is screened by wells for the City of Huntsville to the north, and to the south in Galveston County, the Chicot unit is screened in wells used by the City of Galveston. The aquifer is capable of yielding larger quantities of water in the central and southern section of Region H and has been utilized over the past 100 years to provide part of the water supply. The Gulf Coast aquifer has sand thicknesses ranging from about 200 to 500 feet in the central and southern sections of the region with the sand thickness containing fresh water decreasing within about 30 to 40 miles of the Gulf Coast.

The pumpage of large quantities of water in the southern part of the region has caused the aquifer potentiometric head to decline from 50 to about 450 feet in parts of the area. Subsidence of significant proportions has occurred in parts of Harris and Galveston Counties resulting in the gradual reduction and shift in areal extent of groundwater pumping to the west over the past 25 years. Subsidence is discussed in the next section of this report.

Digital groundwater flow models have been developed over the past 25 years for the Chicot and Evangeline aquifers in the southern part of Region H to help assess the groundwater resources. The most recent digital model was developed by the US Geological Survey with a report regarding the model currently in review.

Queen City and Sparta Aquifers

The Queen City and Sparta aquifers occur in the northern part of the region and are capable of providing some water in Leon, Madison, Trinity, and Walker counties. Estimated overall availability from the aquifers is about 25,800 acre-feet per year based on groundwater supply data from the TWDB 1997 Texas State Water Plan. Water availability estimates from the Queen City and Sparta aquifers are about 12,500, 11,100, 245 and 2,035 acre-feet per year in Leon, Madison, Trinity and Walker Counties, respectively. The two aquifers are composed of sands that can provide small to moderate quantities of water to wells. The water transmitting capabilities of the aquifers is limited but adequate for meeting smaller demands (pumping rates of 50 to 500 gpm). The aquifers contain water with less than 1,000 mg/l of total dissolved solids to depths that range from about 800 to 1,000 feet. Pumping from the two aquifers in Leon, Madison, Trinity, and Walker counties in 1996 was about 3,950 acre-feet based on data from the TWDB.

Brazos River Alluvium

The Brazos River alluvium is a shallow aquifer that is about one mile to seven miles wide in a corridor along the Brazos River in Waller, Austin, and Fort Bend counties. The aquifer normally is not greater than about 100 feet deep with wells mostly constructed to provide water for irrigation of row crops and hay. The aquifer may contain water with total dissolved solids that approach 1,000 mg/l with the water having high total hardness due to the amounts of calcium, magnesium and sulfate it contains. Based on estimates from the TWDB in the 1997 Texas State Water Plan, the overall availability of water from the Brazos River alluvium in Austin, Waller and Fort Bend counties is about 41,500 acre-feet per year with pumpage in 1996 estimated at 12,321 acre-feet per year by the TWDB. The aquifer should continue to be able to provide water for use along the Brazos River.

Subsidence Effects

Subsidence has occurred principally in Harris, Galveston, Brazoria, Fort Bend and Chambers counties as the result of the withdrawal of large quantities of groundwater from the Chicot and Evangeline aquifers. Studies and reports prepared by the US Geological Survey and the Harris-Galveston Coastal Subsidence District (HGCSD) show that about 9 plus feet of subsidence occurred in a small part of the Houston Ship Channel area with lesser amounts away from the channel area. In the City of Katy, total subsidence through 1995 is estimated to be about 1.5 feet. In the City of Rosenberg in Fort Bend County, estimated subsidence also is about 1.5 feet through 1995. The HGCSD has developed regulatory plans that have been updated through the years. Groundwater pumping in Harris and Galveston counties has decreased over the past 23 years as additional surface water was utilized and less groundwater was pumped.

A regulatory plan adopted by the HGCSD in 1999 prescribes general areal pumpage limits for the next three decades until 2030. The regulatory plan pumping requirements were used in estimating the availability of groundwater within the Harris and Galveston counties area with the estimate of groundwater availability in 2010 being 363,000 acre-feet per year and decreasing to 211,904 acre-feet per year by 2030. The HGCSD regulatory plan essentially segments Harris and Galveston counties into geographic regions and mandates reduction of groundwater supplies per a scheduled reduction timeline. Water users located within the southeast portion of Harris County and all of Galveston County must currently receive no more than 10 percent of their total water supply from groundwater. This limit will exist throughout the Region H planning period. The remainder of Harris County is segmented within two other regulatory regions. Water users within Regulatory Area 2, which comprises the central portion of the county, must receive no more than 20 percent of their water supply from groundwater as of year 2000. Groundwater users within the remainder of Harris County, within HGCSD Regulatory Area 3, can receive only 70 percent of their water supplies from groundwater by year 2010, 30 percent of their water as groundwater by year 2020, and only 20 percent of their water supply from groundwater by year 2030. These regulatory limitations affect all of the WUGs (except irrigation for agricultural purposes and livestock uses) within Harris and Galveston counties by year 2010, causing a continuing decrease in the availability of groundwater in these two counties over time.

The Fort Bend Subsidence District is scheduled to enact a groundwater regulatory plan within the next few years to further discharge its duties. The plan also probably will include pumping limits as needed to control subsidence within the District.

Groundwater Availability in Fort Bend and Montgomery Counties

Groundwater pumpage in Fort Bend County has been increasing over the past ten years from about 69,000 acre-feet per year in 1990 to about 74,500 and 85,000 acre-feet per year in 1996 and 1998, respectively, based on data provided by the Fort Bend Subsidence District. Groundwater availability for the county was estimated by the TWDB at about 55,581 acre-feet per year from the Gulf Coast aquifer. Region H investigated the availability of groundwater in the county and performed simulations using the groundwater flow model developed for the Chicot and Evangeline aquifers by the HGCSD. The data from the model show that groundwater pumping could be increased from its present level up to about 91,500 acre-feet per year with a small resulting water-level decline of 20 feet occurring in a limited part of the county. Over the past 10 years static water levels within the county in observation wells have been stable or showed a slight water-level recovery in east, south, and west Fort Bend County. In the northern section of Fort Bend County there has been about 25 feet of water-level decline over the past 10 years in some Evangeline aquifer screened wells (refer to *Figures 1* through *4*). Based on the results of the model runs and well water-level data, groundwater availability from the Gulf Coast aquifer in Fort Bend County is estimated at 91,548 acre-feet per year. Groundwater availability in Fort Bend County may be adjusted in the future as the Fort Bend Subsidence District develops its regulatory management plan.

The Gulf Coast aquifer provides groundwater to Montgomery County with the Jasper aquifer the principal source for about three-quarters of the county and the Chicot and Evangeline aquifers providing water in the southeast and very southern portion of the county. The TWDB estimated groundwater availability from the Gulf Coast aquifer at about 39,997 acre-feet per year. Pumpage within the county was about 41,683 and 40,925 acre-feet per year in 1996 and 1997, respectively, based on data from the TWDB. Pumpage is concentrated in the central and southern portions of the county along the Interstate Highway 45 corridor, around Lake Conroe, and in the southeastern portion of the county north of the City of Humble.

The outcrop of the upper Jasper aquifer encompasses about 520 square miles in the northern portion of Montgomery County extending into Grimes and Walker counties. If recharge to the aquifer is two inches per year, there would be a minimum of about 55,000 acre-feet per year of recharge. Recharge also occurs on the outcrop of the Evangeline and Chicot aquifers within Montgomery County. The estimated availability of groundwater within Montgomery County for the Gulf Coast aquifer is about 55,000 acre-feet per year. Past pumpage and subsequent aquifer response to pumpage show that the development of additional groundwater will cause additional potentiometric head decline in wells. Groundwater pumpage should be spread throughout the county to take advantage of developing water in areas where aquifer conditions are favorable but where the demand has not developed for the water, which is principally in the western and eastern portions of the county away from the Interstate Highway 45 corridor area.

Public Supply Groundwater Usage

Region H relied on groundwater to provide approximately 60 percent or 475,910 acre-feet of the municipal water supply in 1996. Austin, Leon, Liberty, Madison and Montgomery counties relied on groundwater to supply essentially 100 percent of the domestic and municipal demand. *Figure 5* gives the amount of groundwater pumped for municipal purposes for each county in the region. Within the region, Harris County accounted for the most municipal groundwater usage in 1996 with 328,791 acre-feet. The next highest demands are Fort Bend County with 46,007 acre-feet,

Montgomery County with 38,430 acre-feet and Brazoria County with 22,901 acre-feet. Municipal users represent cities and communities, parks, campgrounds and any water districts.

Cities with populations of 1,000 or greater and county-other users that rely on groundwater for at least part of their overall supply are identified in *Table 5* with a source code of 01 based on the source of their water supply. The amount of groundwater projected to be available to the users can vary through the planning period depending on the demand for water by a user and whether surface water is needed or available in future years to satisfy part of the demand.

Existing and Planned Groundwater Systems

Groundwater systems provide water to most of the cities, towns, and county-other users within the region. Wells that provide water to the cities over 1,000 population and county-wells will require refurbishing and replacing as they reach the end of their useful life. Storage facilities will require maintenance and periodic refurbishing. Additional wells and storage facilities will be needed for certain cities or county-other users identified in the following paragraphs. The estimated needs for additional facilities for the cities and county-other users were developed based on a review of data provided by the TWDB, TNRCC, and the cities and county-other users.

Liberty County

The City of Cleveland has three wells with an estimated combined capacity of about 1,100 gallons per minute (gpm). With a demand of 1,915 acre-feet per year or 1,197 gpm by 2030, it is estimated that the City should construct an additional well by 2030 with a capacity of at least 300 gpm to supplement its current well capacity and possibly add about 0.5 million gallons of ground storage.

The City of Liberty has three wells with an estimated combined capacity of about 1,100 to 1,400 gpm. With estimated demand of 2,105 acre-feet per year by 2010 or an average of 1,315 gpm, the City should have adequate well capacity through 2010. Demand is projected to reach 2,694 acre-feet per year by 2050 or an average of about 1,684 gpm. After 2010, it is estimated that the City should drill an additional well with a capacity of at least 400 gpm to provide additional water to the City system.

Walker County

Walker County has a number of rural water supply corporations and Texas Department of Criminal Justice facilities that have water demands classified as county-other. Based on review of information provided in data from the TWDB, the estimated pumping capacity of these facilities is about 4,300 acre-feet per year or about 2,687 gpm. Estimated water demand in 2000 for this user group is about 5,309 acre-feet per year with demand projected to increase to 5,977 acre-feet per year by 2050. The approximately 668 acre-feet per year of increase in demand, if met with groundwater, will require wells and probably ground storage facilities be constructed in the county. Data show that wells drilled for water supply corporations normally provide about 80 to 150 gpm with the average about 115 gpm. With 668 acre-feet per year of additional demand equaling about 418 gpm, it would require four additional wells at about 105 gpm each. It also is estimated that about 0.5 million gallons of ground storage capacity could be required for the additional supply facilities of about 418 gpm. Construction of wells and ground storage should occur gradually through the decades as the demand for water increases in various areas of the county.

Waller County

The Town of Brookshire has an estimated water demand of 762 acre-feet in 2000, 1,013 in 2010 and 2,060 acre-feet by 2050. Available data show that two small, older wells drilled in the 1950s and one newer well are in use as of 1996 with an estimated capacity of about 1,100 acre-feet per year or about 688 gpm. It is estimated that after 2010, the Town of Brookshire could need to drill an additional water well to provide about 960 acre-feet per year or 600 gpm. Sands are available for screening in the Evangeline aquifer to construct a well with a pumping rate of 600 gpm.

The City of Hempstead had three operational wells as of 1996 with an estimated capacity of about 1,200 gpm. One of the wells was drilled in 1956. It is estimated that by about 2030 the City could require one additional well to provide water to the system with the demand for water being 851 acre-feet per year in 1996 and projected to increase to 1,405 acre-feet per year by 2050. The well should provide a minimum of a few hundred gallons per minute.

The Town of Prairie View and Prairie View A&M University had an estimated combined usage of 1,323 acre-feet in 1990. Demand for water in that area is projected to increase to 3,092 acre-feet per year by 2050. The combined present pumping capacity of the wells is about 2,470 acre-feet per year, thus it is estimated by about 2030 that the area could need additional pumping rate capacity of about 620 acre-feet per year or about 390 gpm. An additional 0.5 million gallons of ground storage also could be needed for the water system as the user demand for water on the system increases.

Industrial Groundwater Usage

In 1996, Region H relied on groundwater to provide approximately 11 percent of the water used for industrial purposes, which accounted for approximately 74,090 acre-feet of the groundwater used in Region H. Industrial consumption represents water that is used for manufacturing, mining and steam electric power. *Figure 6* shows the amount of groundwater used for industrial purposes for each county in the region. Within the region Harris County accounted for the most industrial groundwater usage in 1996 with 38,541 acre-feet. The next highest users were Liberty with 9,015 acre-feet, Fort Bend with 8,901 acre-feet, and Chambers with 8,178 acre-feet.

Agricultural Groundwater Usage

In 1996, Region H relied on groundwater to provide approximately 27 percent of the water used for agricultural purposes. This equaled approximately 16 percent or 103,279 acre-feet of the total groundwater used in the region. Agricultural usage represents water that is used for livestock purposes and irrigation of crops. The main agricultural crops in the region include rice, cotton, and soybeans in the south and corn, cotton, and hay in the north. Cattle are the principle livestock raised. *Figure 7* shows the amount of groundwater used for agricultural purposes for each county in the region. Within the region, Fort Bend County accounted for the most agricultural groundwater usage in 1996 with 34,709 acre-feet. The next highest user is Waller County with 23,532 acre-feet followed by Harris County with 16,038 acre-feet.

Groundwater Drought Susceptibility

The aquifers within Region H generally have low transmissivity rates, and are less susceptible to drought because the static water levels do not fluctuate drastically during a severe drought. In general, Region H water suppliers have established drought triggers for their groundwater systems as

a function of system capacity (pumps, storage, etc.) as opposed to other regions where static aquifer groundwater levels are used as drought triggers.

Groundwater Availability Summary

Groundwater has been an important water resource within Region H for the past 100 years. The major Carrizo-Wilcox and Gulf Coast aquifers and minor Sparta, Queen City, and Brazos River alluvium aquifers should continue providing an important water resource to the region to be used in combination with surface water to help satisfy the regional water demand. Water of good quality continues to be available from the aquifers and should continue in the future with prudent management of the resource. Subsidence issues were taken into consideration when estimating future groundwater availability within Harris and Galveston counties. The groundwater availability data given in *Table 4, "Current Water Sources,"* and *Table 5, "Current Water Supplies Available to Region H by City and Category,"* as a part of the overall water resources, provide quantitative numbers of the amount of the resource estimated to be available in Region H.

Task 3.2 Identification of Surface Water Sources

As stated in the Task 1 report, surface water sources in Region H consist of reservoir storage and run-of-river supply for the three rivers in the area, the Trinity, the San Jacinto and the Brazos. The supply information presented in Task 1 is based on the Trans-Texas Water Program *Phase I Report* (1994), *Planning Information Update* (1996), and *Water for Texas* (1997). Since the publication of these documents, additional data gathering and evaluations were performed by the engineering consulting team to more completely investigate the supplies of Region H, rendering new insight and information regarding those supplies. This information was used to arrive at the current supplies that will be considered for the remainder of the planning effort. Major refinements of the Task 1 data include determination of the amount of water available from the lower Brazos run-of-river supply and the addition of reliable coastal basin and tributary supplies. A map showing major surface water sources that serve Region H is included as *Exhibit 4*. A map showing the approximate service areas for the current regional water providers is included on *Exhibit 5*.

Available Surface Water

Table 1 below summarizes the surface water supply sources currently available to Region H based on the information gathered to compile *Table 4, "Current Water Sources."*

The total supply available from each source currently being used to serve Region H is included in *Table 4*, *"Current Water Sources,"* in *Appendix A*. In general, *Table 4* indicates the maximum amount of water supply that could be obtained during drought of record (DOR) conditions from each unique supply source. The information in *Table 4* was compiled from existing contracts and water rights in Region H, existing water availability modeling results for various supply sources, review of previous reports and contact with actual providers and contracting entities. A detailed explanation of the information in *Table 4* and how it was obtained can be found in *Appendix A-Table 4 Methodology*. Not all of the sources listed in *Table 4* are actually available to Region H. With regard to this issue, the TWDB Executive Administrator issued this guidance:

> *If multiple RWPGs plan on utilizing water from the same reservoir to meet future demands, it is imperative that the firm yield reported for the reservoir in question be*

consistent across all planning decades for all affected regions in Table 4. RWPGs shall report existing reservoirs physically located within their region in Table 4, as well as reservoirs located in a different region if those supplies are available to the region.

Table 1: Current Surface Water Supply Sources Available for Use in Region H

Basin/Reservoir/Run-of-River	Current Year 2000 Available Yield (acre-feet/year)
Trinity Basin	
Lake Livingston/Wallisville	1,321,279
Run-of-River and Big Ditch	185,320
Other Tributaries, Local Supplies and Reservoirs	60,859
San Jacinto River Basin	
Lake Houston	168,000
Lake Conroe	99,950
Lewis Creek	6,300
Run-of-River and Local Supplies	56,352
Brazos River Basin	
BRA/COE System[2]	137,293
Run-of-River and Local Supplies	505,364
Coastal Basins	89,307
Sam Rayburn Reservoir and Neches Basin Supplies	6,202
Total Existing Surface Water Supply Available to Serve Region H	**2,636,226**

Thus, *Table 4* lists the entire firm yields of each of the upper Brazos River reservoirs jointly owned by BRA and COE, even though only a small portion of those sources is available to Region H, via long term contractual commitments. By the same rationale, *Table 4* considers that the surface water supplies of the Trinity River Authority are common between regions, and therefore, these Trinity River supplies have been shown in *Table 4*.

Surface Water Drought Susceptibility

Within this report, the surface water reservoir and run-of-river supplies represent firm yield and reliable quantities, respectively. The five Major Water Providers in Region H maintain Drought Contingency Plans prepared under provision of the Texas Administrative Code, Section 30, Chapter 288 for their respective shares of these supplies. These drought plans are summarized in Appendix D. While each major provider utilizes unique criteria to define drought stages, their drought contingency plans use a common methodology. A first stage trigger is used to initiate customer notification systems and voluntary use reductions. A second stage trigger is used to initiate mandatory use reductions. Finally, a third stage trigger is used to initiate additional use reductions and/or the suspension of service to some customers. The drought triggers established by the Major Water Providers are included in Appendix D.

[2] This amount is based on current contracts within Region H. The total yield of the BRA/COE system is 736,016 ac-feet/yr.

Surface Water Conveyance Systems

Region H contains a number of raw surface water conveyance systems (pipelines, canals, and pump stations). The conveyance systems mainly lie in the coastal river basins in the southern counties of Region H. The main canal systems belong to the City of Houston, Coastal Water Authority (CWA), the Gulf Coast Water Authority (GCWA), the Trinity River Authority (TRA), the Lower Neches Valley Authority (LNVA), the Chocolate Bayou Water Company, the San Jacinto River Authority (SJRA), the Chambers-Liberty Counties Navigation Districts, and Dow Chemical. The information in this section was gathered from each of the entities listed above and the Trans-Texas Water Program Phase I Report for the Southeast Area. These systems are shown on *Exhibit 6*.

The 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, the Cedar Point Lateral, the Lake Houston pump station, and the West Canal. The Trinity River pump station near Liberty has an existing capacity of 723 mgd and an ultimate design capacity of 1,300 mgd. The main canal runs westerly from the Trinity River pump station about 22 miles to the Lynchburg Reservoir (north of the Houston Ship Channel). The total capacity of the canal is approximately 1,300 mgd from the Trinity River Pump Station to the Cedar Point Lateral. Downstream of the Cedar Point Lateral, the canal has a capacity of 1,100 mgd. The Lynchburg Reservoir has an impoundment capacity of 4,600 acre-feet. The Cedar Point Lateral, with a design capacity of 230 mgd, is located about 8 miles southwest of the Trinity River pump station and diverts water from the main canal southward. The Lake Houston pump station diverts water from Lake Houston into the CWA west canal, which travels southwesterly until it terminates at the City of Houston East Water Purification Plant. The CWA distribution system consists of pressure pipelines that start at the Lynchburg Reservoir with the Lynchburg pump station and extend southwest about 10 miles to the Bayport Industrial complex and eastward along State Highway 225 conveying raw water to industrial users.

The GCWA system consists of three main canals that deliver water from the Brazos River to Fort Bend, Brazoria, and Galveston Counties: the American Canal, the Briscoe Canal, and the Galveston Canal System. The American Canal runs parallel to State Highway 6 southeasterly from the Brazos River lift station (the Shannon Plant, which is 12 miles north of Rosenberg) to Alvin, Texas. The Briscoe Canal runs southeasterly from the Brazos River pump station (the Briscoe Plant, which is 6 miles west of Arcola) to Alvin and then to an industrial complex in southern Brazoria County. The American Canal is connected to the Briscoe Canal by a lateral called “Lateral 10” just west of Manvel. The Galveston Canal System extends from the old Briscoe system southeast of Alvin to the GCWA reservoir (4 miles east of Dickinson). The Galveston Canal System connects to the American Canal 6 miles east of Alvin. GCWA has three pump stations, the Shannon Plant with a total capacity of 347 mgd, the Briscoe Plant with a total capacity of 302.4 mgd, and the American Canal’s second lift station located at Sugar Land with a total capacity of 225 mgd.

The Dayton Canal is a small system that serves Liberty County. The canal, which is off the Trinity River, extends about 20 miles west of the river and has an estimated capacity of 90 mgd.

The Devers canal system currently delivers irrigation water easterly from the Trinity River to customers in Liberty and Chambers Counties. The main canal system is 81 miles with 125 miles of laterals. Due to the flat grade of the main canal the flow can be reversed to flow westerly. The system contains two pump stations. The first one on the Devers main canal at the Trinity River has a

total name plate capacity of 295 mgd, and the second pump station (near State Highway 563) has a total capacity of 274 mgd.

The Lower Neches Valley Authority System diverts water from the Neches River and Pine Island Bayou and delivers it to customers in Jefferson County and farmers in Chambers and Liberty Counties. The LNVA canal consists of two main canals, the Neches Main and the BI Main. After the junction of the two main canals, the Neches Main travels southwesterly until the Nolte Canal branches off traveling westward into Liberty County. At this point the Neches Main turns and extends southward into Chambers County. The Nolte Canal and the end of the Neches Main are the only sections of the LNVA canal system that extend into Region H. The capacity of the Nolte Canal upstream of the check structure is 130 mgd, and 36 mgd downstream from the check.

The Chocolate Bayou Water Company has a distribution system that can be divided into two sections. The Juliff section, also known as the old South Texas Water system, which transports water from the Juliff pump station on the Brazos River near the Fort Bend-Brazoria County boundary, and the Chocolate Bayou Canal section, which transports water from Chocolate Bayou near Liverpool. The Juliff section has two main canals (the North Canal and the Main Canal) and the Angleton Lateral. This section provides irrigation water to rice farmers and some industrial water to Brazoria County. The Chocolate Bayou Canal section has its main pump station on Chocolate Bayou, but there are additional pump stations on Mustang Bayou and Halls Bayou as well. This section also provides irrigation and industrial water to Brazoria County.

The San Jacinto River Authority provides raw surface water from a point at the Lake Houston dam through its canal system and SJRA's Highlands Reservoir to a point just north of the Houston Ship Channel, providing service to the industrial customers in eastern Harris County.

The Chambers-Liberty Counties Navigation District canal system diverts water from the Trinity River just south of Anahuac Lake. The canal travels easterly and branches to the north and south along the length of the main canal to serve the City of Anahuac and irrigators in Chambers County.

The Dow Chemical canal in Brazoria County diverts water from Oyster Creek near Lake Jackson. From there the canal travels parallel to the Brazos River into the Dow complex just north of Freeport. Exiting the Dow complex, a drainage canal transports water to the Gulf.

Previously Studied Potential Reservoir Sites

Part of the Task 3 analysis includes the identification of reservoir sites of unique value, based on the definition given in the Texas Water Code §16.053(e)(5). In this portion of the analysis, previously studied proposed reservoir sites planned to serve Region H were identified and presented to the RWPG. Using information provided in existing studies and reports, a summary table was prepared listing expected yields, total and unit costs, and a brief discussion of potential issues of concern regarding each proposed reservoir. This information is included in *Appendix B*. The RWPG reviewed the information in *Appendix B* and elected to identify any reservoirs of unique value during the evaluation of water supply management strategies to be performed in Task 5.

Legal and Regulatory Constraints

A number of legal (institutional) and regulatory factors affect water planning, development, and usage within the Region H area. The most notables of these factors are surface water rights,

groundwater conservation districts, interbasin transfer rules, wastewater return flow impacts, environmental flows, and the newly created North Harris County Regional Water Authority.

All of the water that is included in the analysis of surface water supplies for Region H is water that is obtained under a water right issued through the Texas Natural Resources Conservation Commission (TNRCC), or a predecessor agency of the TNRCC. The major water providers have a substantial portion of the rights available to the region, and these major providers contract to supply water obtained under those rights to various water user groups.

Two groundwater conservation districts exist within the Region H area. These districts are the Harris-Galveston Coastal Subsidence District and the Fort Bend Subsidence District. Each district enacts and enforces groundwater regulations within their respective counties. The specific rules regulating the use of groundwater use was described in the previous section titled "Subsidence Effects." The HGCSD has adopted rules that will limit the availability of groundwater within Harris and Galveston counties. It is anticipated that the Fort Bend Subsidence District will likewise adopt rules that limit future groundwater withdrawals.

The Brown-Lewis bill (formally Senate Bill 1) included restrictions on the interbasin transfer of water. These rules mandate that water supplies obtained by a receiving basin become junior to all other rights in existence within the originating basin of the transfer. This rule applies to all future permits associated with interbasin transfer. As illustrated within this report, a significant quantity of water currently supplied within Region H occurs via interbasin transfer. Some of the water delivered by all of the major water providers occurs through some type of interbasin transfer. The most significant of these are the City of Houston and SJRA transfers of Trinity River water into the San Jacinto watershed and the BRA and GCWA transfers of Brazos River water into the San Jacinto-Brazos Coastal basin. It is anticipated that new interbasin transfers will be needed to support growth within and throughout Region H, particularly to the San Jacinto and San Jacinto-Brazos basins where the largest amounts of population growth are occurring. Current limitations on interbasin transfers will affect the development of future water resource management strategies.

The use of wastewater reuse and reclamation is a water management strategy that is growing in usage within the Texas water industry. Wastewater reuse is the reuse of wastewater prior to its discharge into a receiving stream of the state. These reused quantities can be used for irrigation, manufacturing, mining, and steam electric power and limited municipal purposes (landscaping, etc.) Wastewater reclamation, however, can affect the reliability of existing surface water rights. In particular, within Region H, one of the greatest potential areas of reuse is within Harris and Montgomery counties upstream of Lake Houston. Significant reuse of these flows will, however, affect the water rights of the SJRA and City of Houston associated with their San Jacinto River water rights. While reuse should be investigated as a viable water management strategy, particular analysis must be performed to minimize the impact of existing surface water rights.

Currently, while water rights for environmental uses can be adopted, it is not the norm within Texas water law to do so. Environmental water releases are routinely enacted, as a result of a mitigative measure associated with development of a water supply project. Adoption of a water right for an environmental beneficial use has not occurred. Several reasons for this situation include the lack of definition in terms of supporting data on environmental needs of rivers, streams and bays. Also, the cost associated with development or procurement of environmental rights has not historically occurred. As discussed herein, environmental water uses are benefiting Region H economically.

Additionally, a number of agencies and interest groups (GBFIG and others) have been trying for many years to resolve the historical issues associated with the lack of development of environmental water rights. A new provision under the Texas Water Code establishes the Texas Water Trust within the Texas Water Bank. Existing water rights can be placed in the Texas Water Trust to be dedicated to environmental needs, including instream flows, water quality, fish and wildlife habitat, or bay and estuary inflows. While no water rights from Region H have yet been placed in the Texas Water Trust, it can be anticipated that it will figure in further efforts to address both the technical and institutional issues associated with environmental water rights within Region H.

During January 2000, a new water management agency, the North Harris County Regional Water Authority (NHCRWA) was created. This entity has the power to develop and supply water within a large geographic region of north Harris County. To date, the NHCRWA has been in the process of adopting administrative functions associated with its creation and has recently begun the process of assessing future water supply strategies for its jurisdictional region. To date, the Region H planning process has not specifically segmented out the NHCRWA region and defined specific management strategies for this entity. Upon completion of the analysis of appropriate water supply methods for the NHCRWA, the Region H water plan should be revised to incorporate the NHCRWA as a WUG, develop the associated data, and assign the determined water management strategies. The NHCRWA should become a part of future water management plans for Region H.

Environmental Uses and Requirements

The Region H RWPG agreed to include information on freshwater inflow needs provided by the Galveston Bay Freshwater Inflows Group (GBFIG), an ad-hoc group of regional water supply agencies, state and federal water agencies, environmentalists, business and recreational interests. The GBFIG recommended and the Region H RWPG formally adopted a set of freshwater inflow needs for Galveston Bay. These needs are summarized in *Table 2A* as contained in the Task 2 report and as reproduced below.

Unique River and Stream Segments

The RHWPG has received information compiled by Texas Parks & Wildlife addressing unique river and stream segments. The segments recommended by the RHWPG as unique are listed in the Task 6 Report.

Navigational Uses

As the governing bodies of the nation's waterways, the US Coast Guard and the Army Corps of Engineers were contacted in an effort to define water requirements and navigational parameters. The US Coast Guard referred to the Texas Natural Resources Code that states if a water body maintains an average width of 30 feet, then it is navigable.

No information has been found that defines minimum water quantity volumes for any particular waterway nor requirements for reservoir releases to maintain minimum flows within a waterway. A search of the TNRCC water rights database indicated that there are no navigation water rights in Region H.

Table 2A: Environmental Water Needs for Galveston Bay

Inflow Scenario	Quantity Needed (acre-feet/year)	Historical Frequency	Target Minimum Frequency
Max H	5.2 million	66%	50%
Min Q	4.2 million	70%	60%
Min Q-Sal	2.5 million	82%	75%
Min Historic	1.8 million	98%	90%

Note: The health and productivity of Galveston Bay must consider the quantity, quality, seasonality (monthly inflows), and location of inflows. It is anticipated that the inflow needs projections will continue to be refined over time. The use of improved data focused on the fisheries production solely from the Galveston Bay system is one example of an anticipated means of refinement.

Scenario Descriptions:

Max H: Modeled inflows recommended for maximum bay and estuary fisheries harvest by Texas Parks & Wildlife Department.

Min Q: Minimum modeled inflow recommended to maintain the bay and estuary fisheries harvest.

Min Q-Sal: Estimated minimum acceptable inflow recommended to maintain the salinity needed for bay and estuary fisheries viability.

Min Historic: Minimum annual inflow calculated for Galveston Bay over the period of record (1941-1990).

The 13th Edition (1996) of the *State of Texas Water Quality Inventory Report* put together by the Texas Natural Resource Conservation Commission divides the Texas rivers basins into various segments. Each segment is described and classified, the designated water uses are identified, and the water quality is determined. This report was used to identify all of the river segments located in Region H along with their associated uses.

The Texas Parks and Wildlife Department conducted an *Analysis of Texas Waterways: A Report on the Physical Characteristics on Rivers, Streams, and Bayous in Texas*. This report identifies the seasonal and restrictive waterways: "those sections of rivers, streams, and bayous… which have been found to contain an insufficient flow of water for recreational use under normal conditions, or for various reasons could not be classified as a major waterway, and would be restricted to seasonal usage" (Analysis of Texas Waterways, TPWD). Using this information the seasonal and restrictive waterways of Region H are shown on *Exhibit* 7.

Recreational Uses

Water-based recreational uses in Region H include activities that are directly dependent upon the region's rivers, streams and reservoirs, such as swimming, boating, fishing and paddle sports, as well as those enhanced by proximity to water sources such as wildlife viewing, camping and hunting, and eco-tourism. There are also economic activities associated with water-based recreation such as marinas, tourist accommodation and services, and other recreation-based businesses. Generally, communities developed adjacent to or near recreational lakes contribute an increased tax base, from which economic benefits can accrue. Positive local tax base impacts in rural communities of Region H have been and can be significant, therefore, reservoir development in these areas has been viewed as an economic benefit for these regions. Recreation water needs and requirements have two distinct components – physical and economic.

The physical component addresses the amount (volume) of water needed to perform various recreational activities. This is strictly a function of the geometry of whatever body of water is being considered and the type of activity that is being investigated.

In order to provide for this need, some stakeholders in water-related recreational activities apply for diversion permits from the TNRCC that allow them to divert water into man-made lakes and ponds dedicated to recreational purposes. A search of the TNRCC water rights database returned 125 records for recreation water rights with stated total diversion of about 10,303 acre-feet per year. Six of these rights account for 7,652 acre-feet per year in authorized diversions. The entity associated with, the location of, and the diversion amount of each of these six is shown in *Table 2*.

Table 2: Major Recreational Water Rights in Region H

Owner	Stream	Diversion (af/yr)
Brazos River Club	Brazos River	3,000
Properties of the Southwest	Log Gully	1,164
US Fish and Wildlife	Big Slough	1,080
C E Zwahr ET AL	Austin Bayou	1,003
George W Maxwell	Cow Island	805
The Woodlands Corporation	Bear Branch	600

The majority of the region's fresh water recreation occurs, not on dedicated recreational lakes, but on water supply reservoirs. The region's water reservoirs provide a broad range of recreational opportunities but were created for a water supply purpose to meet the region's consumptive water demands. While recreation is permitted on most of the region's water supply reservoirs, there are no dedicated recreational water rights protecting volumes for recreational purposes on these reservoirs. There are three water supply reservoirs in Region H that provide a significant portion of the freshwater-related recreational activities that take place in the region. They are Lake Livingston, Lake Conroe, and Lake Houston; with Lake Livingston having the largest capacity and Lake Houston having the smallest capacity.

The economic importance of water-based recreational businesses is illustrated within recent studies that indicate that water-related recreational activities account for a significant portion of the Texas

economy. In 1996, Texas ranked second in the United States in angler expenditures at roughly $2.9 billion, providing more than 80,000 jobs. In the same year, there were an estimated 2.6 million anglers in Texas, with 2.1 million classified as primarily freshwater anglers. Furthermore, one study estimates that in 1997, Texas ranked fifth in the United States in boat ownership with about $302 million in retail boat sales. Texas Parks and Wildlife Department reported in February of 2000 that 617,864 boats are registered in the state, 98 percent of which are used as pleasure craft. Counties in Region H account for nearly one-quarter of these (134,289) and 99 percent of these are registered as pleasure craft. In Texas, the 1991 retail sales for migratory bird hunting was $262,600,000, and the 1991 retail sales for migratory waterfowl hunting was $48,900,000. The 1991 retail sales for non-consumptive bird use was $155,300,000; The 1991 non-consumptive waterfowl use in Texas was $103,600,000. Such statistics demonstrate an economic-driven recreational need for water in Texas.

While there is a direct relationship between water needs and these industries, there are no statistical data available to calculate or quantify that relationship. Although, anecdotal information suggest negative impacts on communities when reservoirs levels decrease, there is no data available to indicate specific reservoir levels required to support boating and fishing activities or how much water is necessary to maintain habitat that supports resident and migratory wildlife. Wildlife viewing had the most quantitative data, yet this data was only available for small pockets of Region H. For instance, High Island is a major birding area, but there is no information that quantifies the number of birds and people that come to the area as a result of the amount of water in the area.

In an effort to better define this aspect of the recreational needs, all state parks and forests, national parks and forests, wildlife refuges, and wildlife management facilities in Region H were identified. Every facility was researched to determine if it provided facilities for camping and picnicking, nature and wildlife viewing, hunting, fishing, and boating and other water sports. Sources include various websites and publications from the Texas Parks and Wildlife Department, National Park Service, USDA Forest Service, US Fish and Wildlife Service, National Wildlife Refuge System, Galveston Bay National Estuary Program, US Army Corps of Engineers, US Historical Society, Great Outdoor Recreation Pages, Recreation.Gov, *1998-1999 Texas Almanac*, various Texas road atlases, and various county and river authority websites. All of this information was compiled into the following three tables contained in *Appendix C*.

1. "Region H-River Segments, Bay and Estuaries" – Lists all of the river basins, river segments, bays and estuaries in the region, and the recreational opportunities associated with each.

2. "Recreation" – Lists all of the national parks, preserves, wildlife refuges, state parks, wildlife management areas, and forests, and the recreational opportunities associated with each.

3. "Region H-River Segments, Bay and Estuaries-Special Features" – Lists all of the lakes and reservoir segments in the region and the recreational opportunities associated with each.

These tables contain data that was available from the entities listed in the scope and other resources found, but they are not complete and lack data for some of the waterways and public recreational areas. *Appendix C* contains a detailed bibliography of all of the sources used for this section. From the table containing the public recreational sites and data obtained from the *Galveston Bay*

Recreational User's Handbook, an exhibit was prepared to illustrate the location and each associated recreational activity for Region H (see *Exhibit* 7). This exhibit also shows the seasonal and restricted waterways. Additional information was acquired from the Houston Canoe Club on areas within the region of importance to paddle sports.

Recreational water needs are currently met through the use of water supply reservoirs, rivers and streams, and Galveston Bay. Economic activities are associated with water-based recreation, hunting, wildlife viewing and eco-tourism, and reflect an additional element in evaluating recreational water needs.

Task 3.3 Total Water Supply

The total amount of water supply currently available to Region H from existing available water sources is 3,687,495 acre-feet per year. Of that, approximately 71 percent is surface water. By the years 2030 and 2050, the available supply is expected to be 3,459,862 acre-feet per year and 3,460,265 acre-feet per year, respectively. *Table 3* below summarizes these current and projected water supplies.

Table 3:

Summary of Water Supply Available for Region H for Study Years 2000, 2030, and 2050

Supply Source	Supply Available (af/yr)		
	Year 2000	Year 2030	Year 2050
Groundwater			
• Gulf Coast Aquifer	816,180	588,266	588,255
• Carrizo-Wilcox Aquifer	168,487	168,479	168,479
• Queen City & Sparta Aquifer	25,320	25,314	25,325
• Brazos River Alluvium	41,282	41,282	41,282
Subtotal GW	1,051,269	823,341	823,341
Surface Water			
• Trinity River Basin	1,567,458	1,567,458	1,567,458
• San Jacinto River Basin	330,602	330,703	330,682
• Brazos River Basin	642,657	642,734	642,843
• Coastal Basins	89,307	89,204	89,465
• Lower Neches Basin	6,202	6,422	6,476
Subtotal SW	2,636,226	2,636,521	2,636,924
Total	**3,687,495**	**3,459,862**	**3,460,265**

This water supply is distributed to each Water User Group (WUG), i.e. each city, each county-other and each non-municipal water use category. This distribution is shown in *Table 5, "Current Water Supplies available to the RWPG by City and Category,"* contained in *Appendix* A.

In *Table 5*, the ground and surface water supply sources available to Region H are assigned to the various WUGs in the region based on contracts and water rights, limitations of conveyance facilities and in some cases, current usage patterns. In general, a thorough search was performed to determine how each WUG obtained its water supply. This required identification of third-party contracts as well as water providers in addition to the major water providers (MWPs). A detailed description of the methodology and information used to compile *Table 5* is contained in *Appendix A*.

About 61 percent of the year 2000 total available Region H supply is allocated to the region through one of the MWPs. The following *Table 7* shows the distribution of the available supply among the providers for study years 2000, 2030 and 2050.

Table 7:

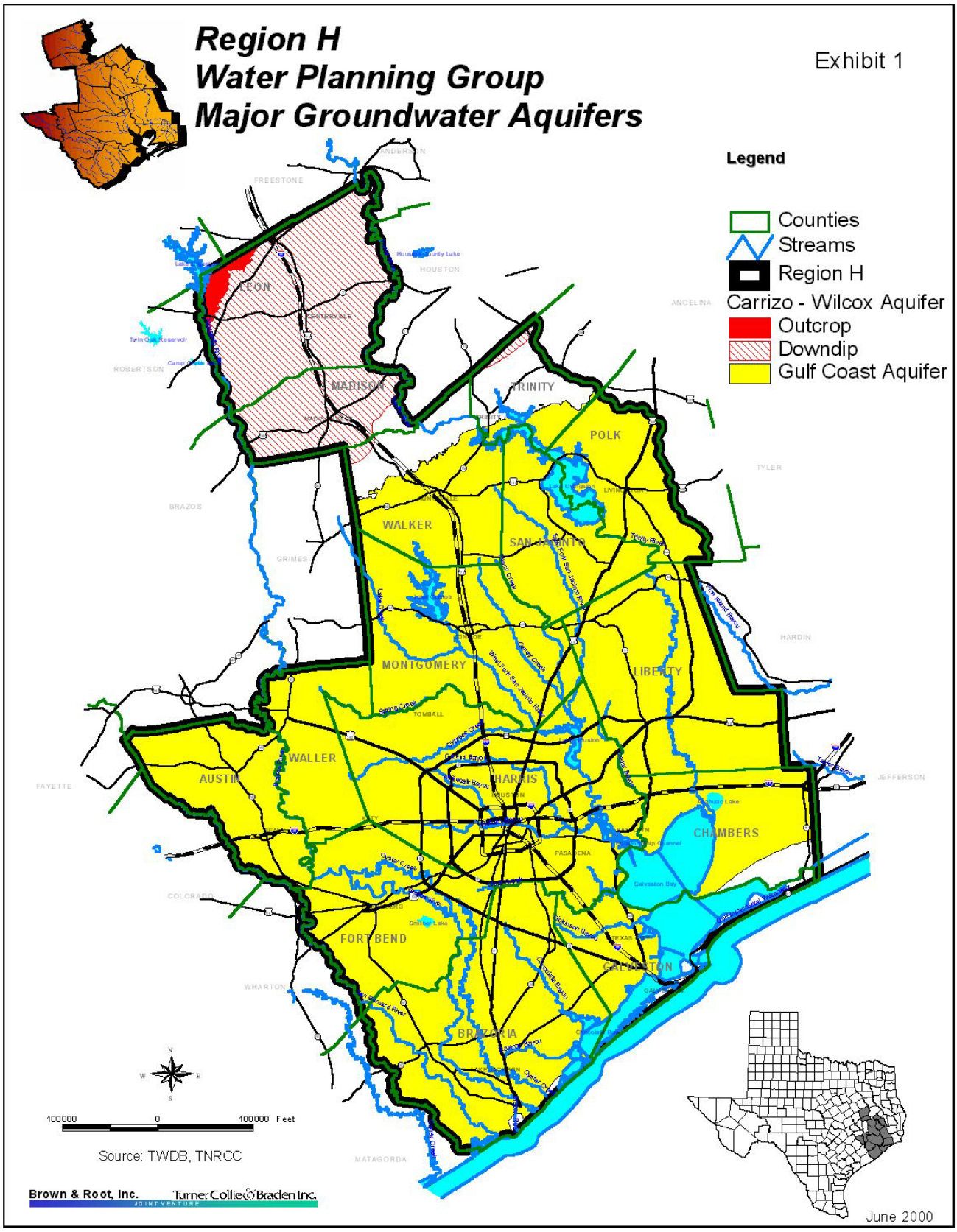
Available Supply by Major Provider within Region H for the Study Years 2000, 2030, and 2050

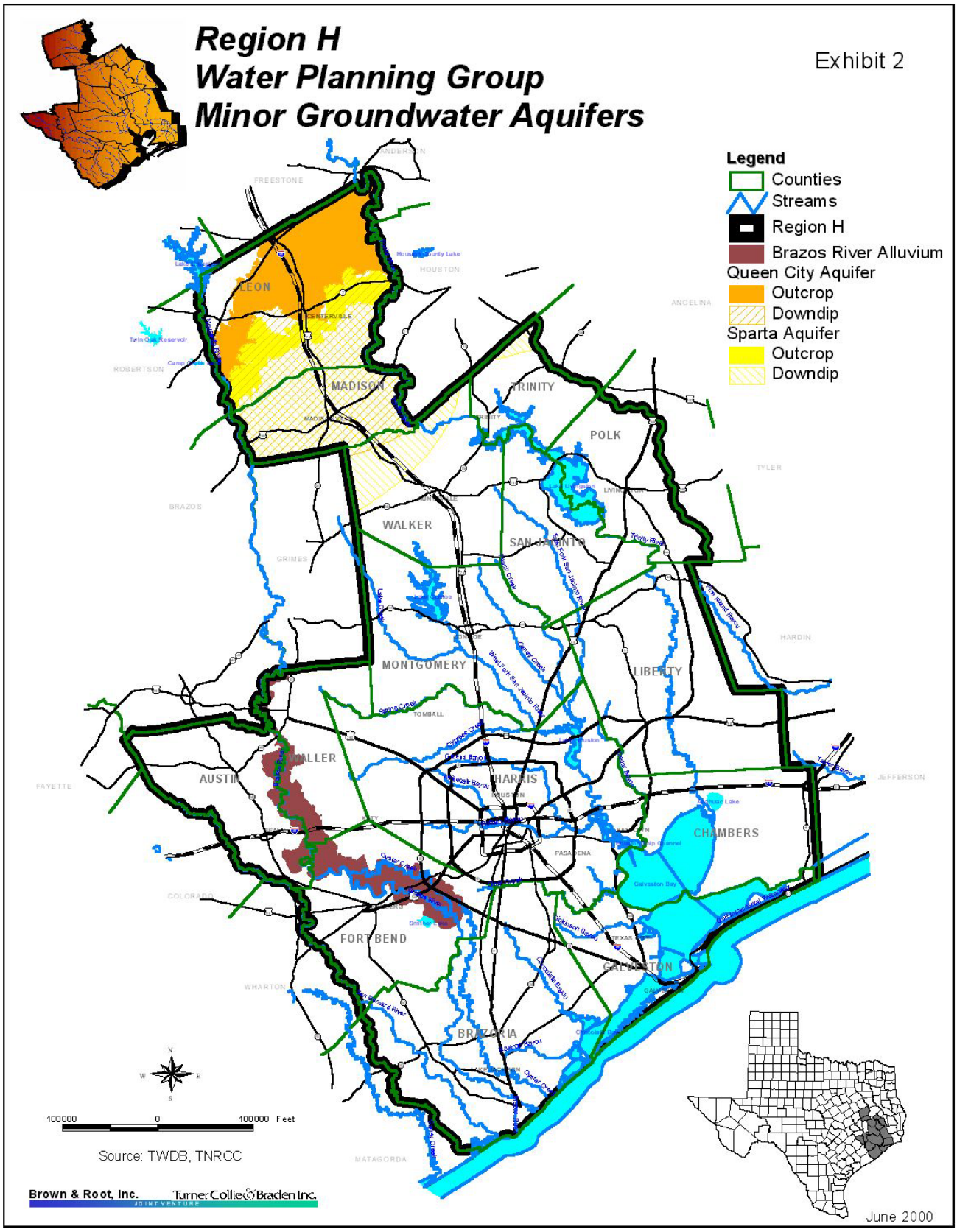
Provider	Supply (af/yr)		
	Year 2000	Year 2030	Year 2050
BRA	104,625	104,625	104,625
City of Houston			
• Groundwater	145,479	100,643	99,345
• Surface Water	1,258,829	1,258,829	1,258,829
GCWA	210,850	210,850	210,850
SJRA			
• Groundwater	12,181	18,001	18,001
• Surface Water	143,921	143,921	143,921
TRA	380,479	380,479	380,479
Other Sources/Providers			
• Groundwater	893,609	704,697	705,995
• Surface Water	537,522	537,817	538,220
Total	**3,687,495**	**3,459,862**	**3,460,265**

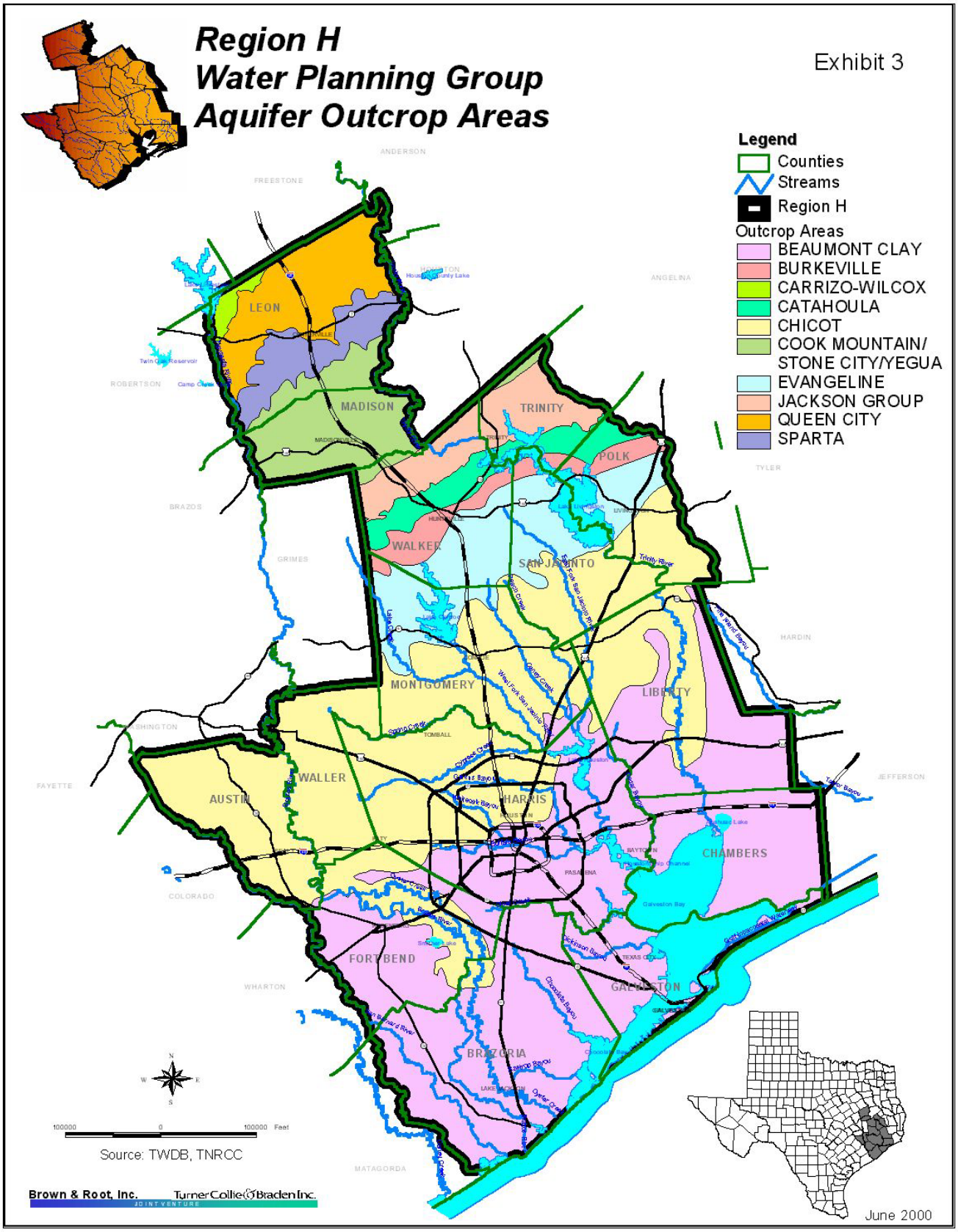
The current and projected available supplies are allocated to each of the five MWPs by source in *Table 6, "Current Water Supplies available to RWPG by Major Provider of Municipal and Manufacturing Water,"* contained in *Appendix* A.

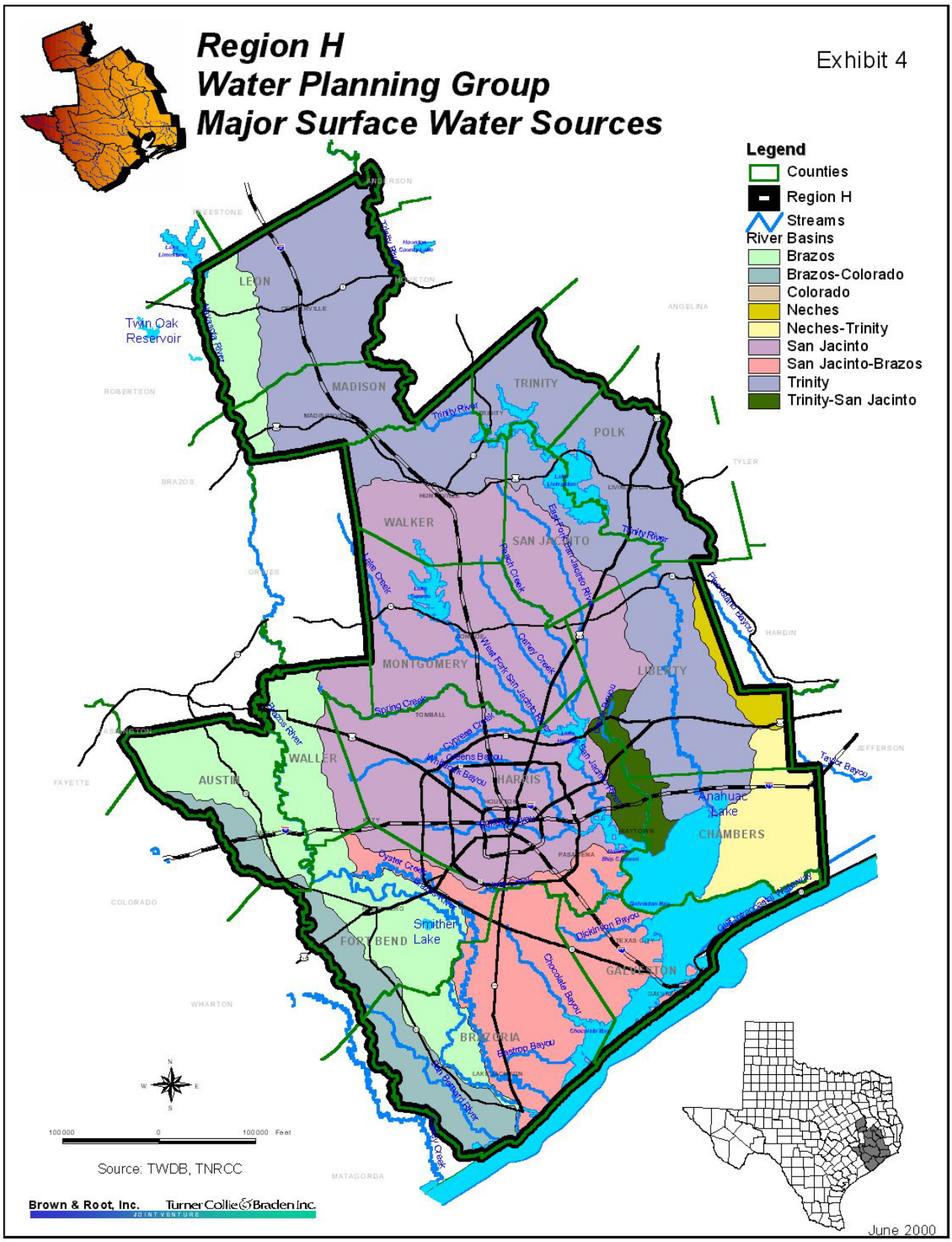
As in *Table 5*, the information used to compile *Table 6* included contracts, water rights, limitations of conveyance facilities, and current usage patterns. As with *Table 5*, the procedure consisted of a thorough iterative evaluation. A description of the methodology and information used to compile *Table 6* is contained in *Appendix A*.

The information on supply described in this Task 3 report was summarized and used in presentations made to the public in four separate public meetings held throughout the region in February 2000. Few public comments were received on the supply data and those comments did not result in any substantive revisions to the data or assumptions used as the basis for the determination of total supply available to Region H.


Region H
Water Planning Group
Major Groundwater Aquifers
Exhibit 1
Legend
Counties
Streams
Region H
Carrizo - Wilcox Aquifer
Outcrop
Downdip
Gulf Coast Aquifer
LEON
MADISON
TRINITY
POLK
WALKER
SAN JACINTO
MONTGOMERY
LIBERTY
WALLER
AUSTIN
HARRIS
CHAMBERS
FORT BEND
GALVESTON
BRAZORIA
FREESTONE
HOUSTON
ANGELINA
ROBERTSON
BRAZOS
GRIMES
TYLER
HARDIN
JEFFERSON
FAYETTE
COLORADO
WHARTON
MATAGORDA
100000 0 100000 Feet
Source: TWDB, TNRCC
Brown & Root, Inc.
Turner Collie & Braden Inc.
JOINT VENTURE
June 2000

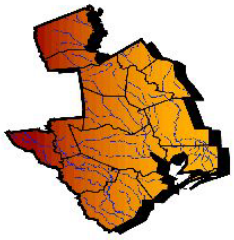

Region H
Water Planning Group
Minor Groundwater Aquifers
Exhibit 2
Legend
Counties
Streams
Region H
Brazos River Alluvium
Queen City Aquifer
Outcrop
Downdip
Sparta Aquifer
Outcrop
Downdip
LEON
MADISON
TRINITY
POLK
WALKER
SAN JACINTO
MONTGOMERY
LIBERTY
AUSTIN
WALLER
HARRIS
CHAMBERS
FORT BEND
GALVESTON
BRAZORIA
FREESTONE
HOUSTON
ANGELINA
ROBERTSON
BRAZOS
GRIMES
TYLER
HARDIN
FAYETTE
JEFFERSON
COLORADO
WHARTON
MATAGORDA
N
W
E
S
100000
0
100000 Feet
Source: TWDB, TNRCC
Brown & Root, Inc.
Turner Collie & Braden Inc.
JOINT VENTURE
June 2000

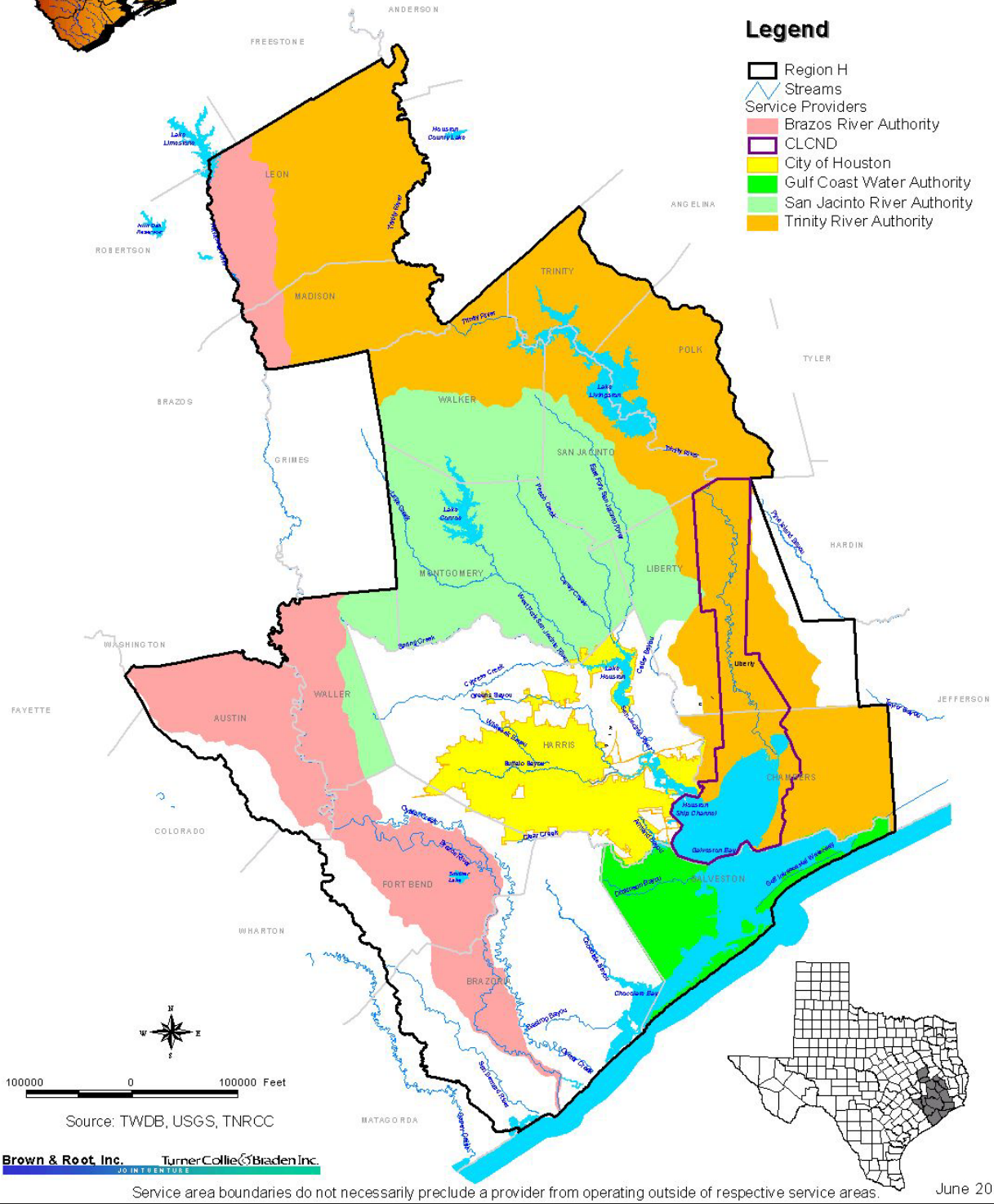

Region H
Water Planning Group
Aquifer Outcrop Areas
Exhibit 3
Legend
Counties
Streams
Region H
Outcrop Areas
BEAUMONT CLAY
BURKEVILLE
CARRIZO-WILCOX
CATAHOULA
CHICOT
COOK MOUNTAIN/
STONE CITY/YEGUA
EVANGELINE
JACKSON GROUP
QUEEN CITY
SPARTA
LEON
MADISON
TRINITY
POLK
WALKER
SAN JACINTO
MONTGOMERY
LIBERTY
WALLER
AUSTIN
HARRIS
CHAMBERS
FORT BEND
GALVESTON
BRAZORIA
ANDERSON
FREESTONE
ANGELINA
ROBERTSON
BRAZOS
GRIMES
HARDIN
WASHINGTON
FAYETTE
JEFFERSON
COLORADO
WHARTON
MATAGORDA
Source: TWDB, TNRCC
Brown & Root, Inc.
Turner Collie & Braden Inc.
JOINT VENTURE
June 2000


Region H
Water Planning Group
Major Surface Water Sources
Exhibit 4
Legend
Counties
Region H
Streams
River Basins
Brazos
Brazos-Colorado
Colorado
Neches
Neches-Trinity
San Jacinto
San Jacinto-Brazos
Trinity
Trinity-San Jacinto
Twin Oak Reservoir
Anahuac Lake
Smither Lake
LEON
MADISON
TRINITY
POLK
WALKER
SAN JACINTO
MONTGOMERY
LIBERTY
WALLER
AUSTIN
HARRIS
CHAMBERS
FORT BEND
BRAZORIA
GALVESTON
ANDERSON
FREESTONE
HOUSTON
ANGELINA
ROBERTSON
BRAZOS
TYLER
GRIMES
HARDIN
WASHINGTON
JEFFERSON
FAYETTE
COLORADO
WHARTON
MATAGORDA
Trinity River
Navasota River
Lake Creek
Peach Creek
East Fork San Jacinto River
West Fork San Jacinto River
Caney Creek
Spring Creek
Cypress Creek
Brays Bayou
Sims Bayou
Greens Bayou
Hunting Bayou
Buffalo Bayou
Clear Creek
Oyster Creek
Dickinson Bayou
Chocolate Bayou
Bastrop Bayou
Taylor Bayou
Pleasure Bayou
Brazos River
Colorado River
100000 0 100000 Feet
Source: TWDB, TNRCC
Brown & Root, Inc.
Turner Collie & Braden Inc.
JOINT VENTURE
June 2000

Region H
Water Planning Group
Regional Water Provider Service Areas

Exhibit 5



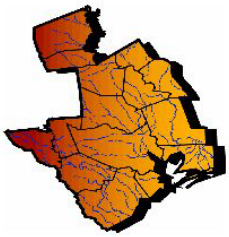


Source: TWDB, USGS, TNRCC

Brown & Root, Inc. Turner Collie & Braden Inc. JOINT VENTURE

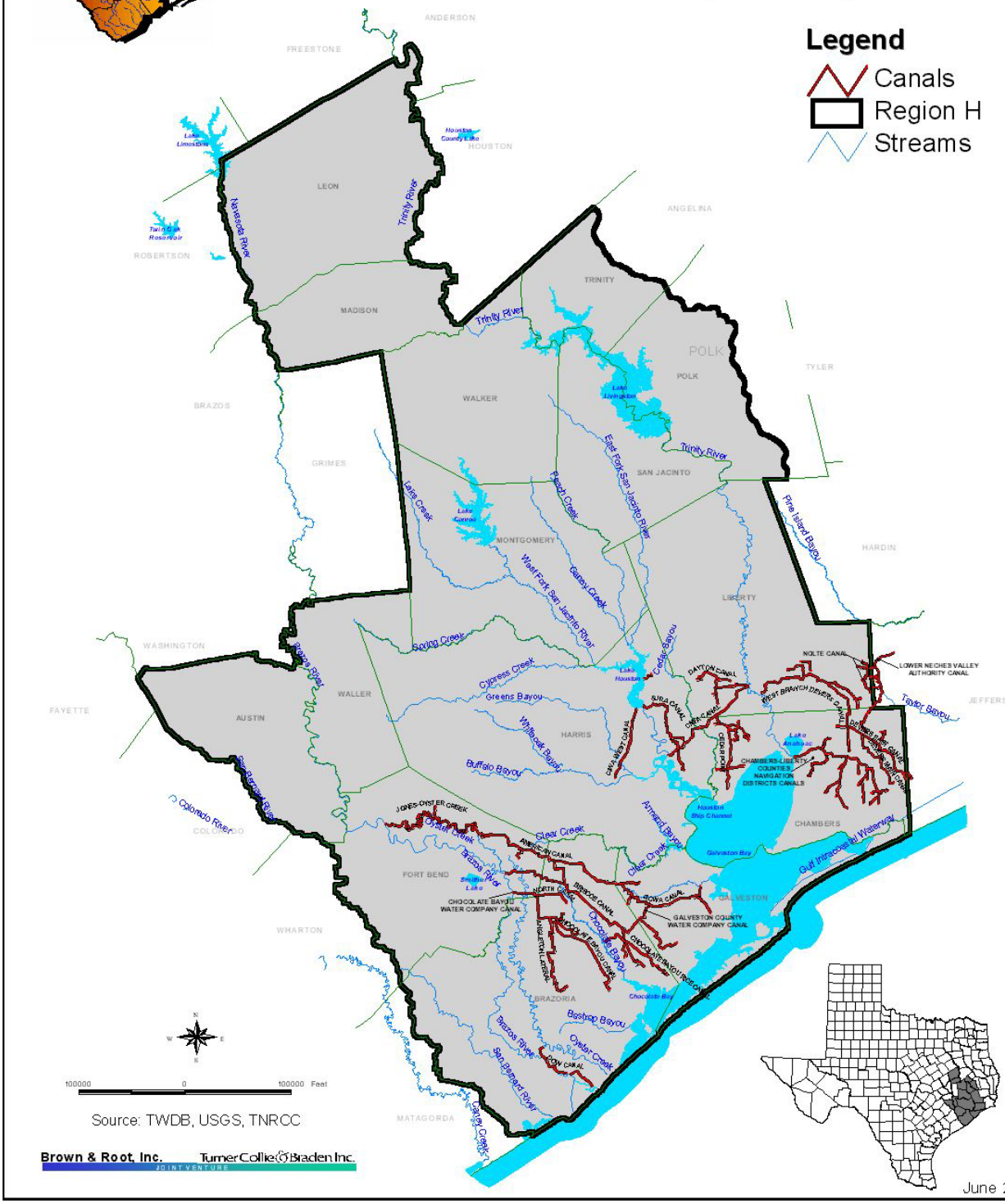
Service area boundaries do not necessarily preclude a provider from operating outside of respective service areas.

June 2000



Region H
Water Planning Group
Raw Surface Water Conveyance Systems

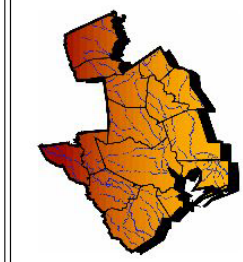
Exhibit 6



Source: TWDB, USGS, TNRCC

Brown & Root, Inc. Turner Collie & Braden Inc. JOINT VENTURE

June 2000



Region H Counties & River Basins

Legend

Counties

River Basins

- 6 - Neches
- 7 - Neches-Trinity
- 8 - Trinity
- 9 - Trinity-San Jacinto
- 10 - San Jacinto
- 11 - San Jacinto-Brazos
- 12 - Brazos
- 13 - Brazos-Colorado
- 14 - Colorado

LEON 145

MADISON 157

TRINITY 228

POLK 187

WALKER 236

SAN JACINTO 204

MONTGOMERY 170

LIBERTY 146

WALLER 237

AUSTIN 008

HARRIS 101

CHAMBERS 036

FORT BEND 079

GALVESTON 084

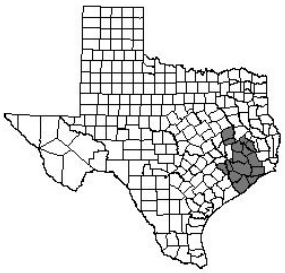
BRAZORIA 020

N

W E

S

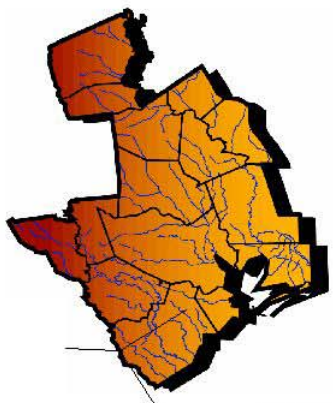
90000 0 90000 180000 Feet



Brown & Root, Inc. Turner Collie & Braden Inc.
JOINT VENTURE

Region H Water Planning Group Recreational Areas

Exhibit 7



Legend

- Seasonal/Restrictive Waterways
- Streams
- Region H
- Counties
- Nature & Wildlife Viewing
- Hunting
- Fishing
- Boating/Watersports
- Camping/Picnicking

ANDERSON
FREESTONE
NACOGDOCHES
LIMESTONE
LEON
ANGELINA
HOUSTON
ROBERTSON
MADISON
TRINITY
POLK
TYLER
JASPER
BRAZOS
WALKER
SAN JACINTO
GRIMES
BURLESON
HARDIN
MONTGOMERY
LIBERTY
WASHINGTON
WALLER
JEFFERSON
AUSTIN
HARRIS
CHAMBERS
COLORADO
FORT BEND
GALVESTON
WHARTON
BRAZORIA
ORDA

Upper Keechi Creek, Big Creek, Navasota River, Steele Creek, Keechi Creek, Buggy Creek, Trinity River, Big Elkhart Creek, Houston County Lake, Hurricane Bayou, Tenthouse Creek, White Rock Creek, Little White Rock Creek, Cochino Bayou, Piney Creek, Neches River, Davy Crockett Nat'l Forest, Lake Livingston, Lake Livingston State Park, Sam Houston Nat'l Forest, Huntsville State Park, Big Thicket Nat'l Preserve, Trinity River NWR, Lake Conroe, W G Jones State Forest, Lake Houston State Park, Sheldon Lake SP/WMA, San Jacinto State Park, Atkinson Island WMA, Anahuac NWR, Candy Cain Abshier WMA, Redfish Reef, Galveston Island State Park, Christmas Bay State Park, Brazoria NWR, Bryan Beach State Park, Peach Point WMA, San Bernard NWR, Varner - Hogg State Park, Brazos Bend State Park, Attwater Prairie Chicken NWR, SFA State Park, Addicks Barker Reservoir, Galveston Bay, Houston Ship Channel

N W E S

100000 0 100000 Feet

Source: TWDB, TNRCC, See Appendix C

Brown & Root, Inc. Turner Collie & Braden Inc.
JOINT VENTURE

June 2000