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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

Introduction

The following report chronicles the results of the Region H water planning analysis of water shortages and surpluses. This effort is principally based on a comparison of available reliable water supplies versus projected water demands.

Task 4.1 Compare Water Demand and Water Supply Data

As a part of Task 4, the Texas Water Development Board (TWDB) requires the presentation of *Tables 7* and *8*, located in *Appendix A*. *Table 7* is a comparison of the supplies in *Table 5* (Task 3 Report) as allocated to a specific Water User Group (WUG), versus the established demands of those WUGs represented in *Table 2* (Task 2 Report). *Table 8* is the difference between *Table 6* (Task 3 Report), supply available to major water providers, and *Table 3* (Task 2 Report), the demand on the major water providers. Surpluses and shortages for Region H are shown in *Tables 7* and *8*.

Task 4.2 and 4.3 Identify and Present Surpluses and Shortages in Region H

Table 7, "Comparison of Water Demands with Current Water Supplies in Region H by City and Category"

The attached *Table 7* is a comparison of *Table 5*, Current Water Supplies Available to Region H by City and Category, with the projected demands established by Region H and included in *Table 2*, Water Demand by City and Category. It reflects the water balance for water user groups (WUGs) in Region H. The attached *Table 7A* compares the supplies available to WUGs in Region H as cited in *Table 5A* (which represents supplies available assuming existing contracts are extended through 2050) with the established demands of those WUGs represented in *Table 2*. *Table 7* satisfies the format and methodology required by TWDB in Technical Memorandum No. 3. *Table 7A* meets the requirements of the Region H Water Planning Group (RWPG) for its evaluation of water management strategies because it reflects anticipated contract renewals and extensions by current regional water providers and is therefore a more representative estimate of the Region H shortages.

Demands

The demands represented in *Table 2* increase from 2,248,339 acre-feet per year in the year 2000 to 3,158,793 acre-feet per year in the year 2050. Demand is approximately 44 percent municipal, 32 percent manufacturing, 19 percent agricultural (18 percent irrigation and 1 percent livestock demand), 4 percent steam electric power demand, and 1 percent mining demand.

Supplies

Two estimates of current water supply available to WUGs in Region H were prepared as represented by *Tables 5* and *5A*.

Table 5 meets the TWDB guidelines and includes all current, reliable water supply supported by water rights, permits and/or long-term contracts. In 2000, the total volume of groundwater and surface water through rights/permits/contracts available to WUGs in the region is 3,075,132

acre-feet/year. In 2050, the total amount is reduced to 2,568,257 acre-feet/year as contracts expire across the study period.

Table 5A follows TWDB guidelines (includes all current, reliable water supplies supported by water rights, permits and/or long-term contracts) but extends existing water supply contracts at their current levels throughout the study period. In 2000, the total volume of groundwater and surface water through rights/permits/contracts available to WUGs in the region is 3,075,132 acre-feet/year. In 2050 the total amount is 2,893,273 acre-feet/year. This decrease in water availability is principally a result of groundwater reductions due to implementation of the Harris-Galveston Coastal Subsidence District (HGCSD.)

This supplemental table reflects the Region H RWPG assumption that all existing long-term contracts will be extended through 2050. The Region H RWPG believes it represents a better estimate of shortage in the region and will be used as an additional tool to evaluate potential water management strategies in the Region H area.

Needs for Additional Supplies

Tables 7 and *7A* identify the needs for additional supply and the surpluses for each WUG by county and basin as specified in TWDB Technical Memorandum 3.

Table 7 indicates that Region H has shortages in 11 counties in one or more time periods between 2000 and 2050. These include Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, Polk, San Jacinto, Walker and Waller Counties. Shortages are projected for a total of 70 cities/CDPs, 11 counties in the municipal county-other category, 6 counties in the manufacturing category, 4 counties in the mining category, 3 counties in the irrigation category and 2 in the steam-electric power category. It was assumed without verification of reliability that livestock WUGs would be supplied by local sources. The total quantity of the projected water shortages within Region H (from Table 7) is approximately 1,005,052 acre-feet per year in year 2030 and 1,375,459 acre-feet per year in 2050. The single county with the largest projected shortage is Harris County with over 50 percent of the total regional shortages. The San Jacinto river basin contains approximately 50 percent of the total water shortages for the region.

Table 7A, which assumes the extension of existing water supply contracts, indicates that Region H has shortages in the following 8 counties in at least one of the 2000-2050 decade years: Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller. Shortages are projected for 62 cities/CDPs, 8 counties with municipal county-other shortages, 5 counties with manufacturing shortages, 4 counties with mining shortages, 3 counties with irrigation shortages, and 1 county with steam-electric power shortages. It was assumed without verification of reliability that livestock WUGs would be supplied by local sources. The total quantity of the projected shortages within the region from Table 7A is approximately 497,970 acre-feet per year in year 2030 and 790,059 acre-feet per year in 2050. Again, Harris County and the San Jacinto basin are the areas with the largest shortages within the region.

In an effort to better identify the entities with shortages in Region H two summary tables were constructed from *Table 7* and *7A*. These shortage summary tables contain only the entities in

Region H that have a projected shortage in at least one of the years. These tables are located in *Appendix A* immediately following *Table 7* and *7A*.

Shortages are delineated by basin, and therefore some of the WUGs may show a shortage in one basin and have a surplus in another basin. Management strategies will be used to determine whether the surpluses in one basin can be used to meet the shortages in another for these WUGs.

There are WUGs in *Table 7* with surplus supplies. These surpluses will be considered as they may apply to the management strategies addressed in Task 5.

Table 8, "Comparison of Water Demands with Current Water Supplies by Major Providers of Municipal and Manufacturing Water"
The attached *Table 8* is a comparison of *Table 6*, Current Water Supplies Available to Region H by Major Provider of Municipal and Manufacturing Water, with the projected demands established by Region H and included in *Table 3*, Water Demand by Major Provider of Municipal and Manufacturing Water. It reflects the water balance for major water providers (MWPs) in Region H. The attached *Table 8A* compares the supplies available to MWPs in Region H, as cited in *Table 6*, with the established demands of those MWPs represented in *Table 3A*, assuming existing contracts are extended through 2050. *Table 8* satisfies the format and methodology required by TWDB in Technical Memorandum No. 4. *Table 8A* meets the requirements of the Region H Water Planning Group for its evaluation of water management strategies because it reflects anticipated contract renewals and extensions by current regional water providers and is therefore a more representative estimate of the Region H shortages.

Demands
The demands on the MWPs in Region H were prepared as represented by *Tables 3* and *3A*.

Table 3 meets the TWDB guidelines and includes all current, reliable water supply supported by water rights, permits and/or long-term contracts. The Region H demands represented in *Table 3* decrease from 1,440,468 acre-feet per year in the year 2000 to 918,027 acre-feet per year in the year 2050.

Table 3A follows TWDB guidelines (includes all current, reliable water supplies supported by water rights, permits and/or long-term contracts) but extends existing water supply contracts at their current levels throughout the study period. In 2000 the total demand for groundwater and surface water through rights/permits/contracts with MWPs in Region H is 1,440,468 acre-feet/year. In 2050 the total amount is 1,665,140 acre-feet/year. This supplemental table reflects the Region H WPG assumption that all existing long-term contracts will be extended through 2050. The Region H WPG believes it represents a better estimate of shortage in the region and will be used as an additional tool to evaluate potential water management strategies in the Region H area.

Supplies
The MWP supplies in the region range from 2,256,364 acre-feet per year in 2000 to 2,183,382 acre-feet per year in the year 2050. Of this amount, in the year 2000 approximately 7 percent is groundwater and 93 percent is surface water. In the year 2050 approximately 5 percent is groundwater and 95 percent is surface water.

Needs for Additional Supplies
Tables 8 and *8A* identify the needs for additional supply for each MWP as specified in TWDB Technical Memorandum 4.

Table 8 indicates that the Gulf Coast Water Authority will have a shortage in the year 2000, but all of the other MWPs have adequate supplies to meet their demands. All of the other MWPs are projected to have uncommitted water supplies throughout the planning period.

Table 8A, which assumes the extension of existing water supply contracts, indicates that the Gulf Coast Water Authority will have shortages in every decade, but all of the other MWPs will have adequate supplies to meet their demands.

The projected uncommitted water supply surpluses of the major water providers will be considered as they may apply to the management strategies addressed in Task 5.

Task 4.4 Sub-Regional Supply and Demand

A water allocation method was used to compare water supply versus demand. The counties in the regional planning area were first reviewed to determine the amount of reliance on groundwater in each area. After demands were determined, and the amounts of groundwater available to each county were determined, then the available supplies of groundwater were allocated. Quantities of groundwater were distributed equally throughout each county when groundwater was available. Supply and demand were balanced in this manner so that when systems ran out of water, the shortages were shared somewhat equally for the mid-sized systems and larger. In this way, it was assumed that growth in groundwater short areas occurred on surface water and that the management strategies for those counties were weighted heavily toward finding additional supplies. Growth for existing WUGs was supplied using a combination of existing groundwater capacity and new surface water sources.

Rural
For the rural areas, specific attention was paid to the distribution of groundwater throughout each county. For most of the counties and for all of the rural areas, the distribution of groundwater was sufficiently uniform to allow water providers to increase well capacities as needed and to be able to secure enough additional groundwater to meet their increased demands.

Metropolitan
The largest shortages in Region H are in the county-other portion of the counties with a large urban population. There is a high level of growth expected in the vicinity of existing metropolitan areas, but there is little specific information about the eventual disposition of that growth. Some growth areas may be annexed and served by adjacent municipalities. Some

growth may occur within the jurisdiction of newly formed suppliers, like the North Harris County Regional Water Authority. As a result, there is no way to determine with certainty what available supply may be assigned to this growth; it could be a variety of suppliers. In order to maintain flexibility and accommodate local conditions and constraints, the RWPG did not designate any metropolitan sub-regions to be evaluated. It is expected that as specific information is developed regarding the supply for some of these metropolitan areas, the Regional Planning Group will consider amendments to the plan that clarify the specific distribution of the available supply.

Task 4.5 and 4.6 Impacts of the Surpluses and Shortages Presented to the RWPG

Socioeconomic Impacts

Section 357.7(4) of the rules for implementing Senate Bill 1 require that the social and economic impact of not meeting regional water supply needs be evaluated by the Regional Water Planning Groups. The Texas Water Development Board is required to provide technical assistance, upon request, to complete the evaluations. The Board offered its staff to conduct the required analysis of the impacts of the identified needs for each region, using a common methodological approach for all regions, which will facilitate compiling the regional plans into a State Water Plan. The Region H RWPG submitted a request to TWDB for assistance (see *Appendix B*), and TWDB completed the analysis of the social and economic impacts of not meeting water needs as identified in Region H *Table 7*.

TWDB has stated that the purpose of this element of Senate Bill 1 planning is to give each region an estimate of the potential costs of not acting to meet anticipated needs in each water user group, or conversely, the potential benefit to be gained from devising a strategy to meet a water need. Collectively, adding up all the impacts gives the region a view of the ultimate magnitude of the impacts caused by not meeting every one of the entire list of needs. These summations are a ***very worst-case scenario*** for the region, since the likelihood of not meeting the entire list of needs is virtually nonexistent.

The TWDB analysis assumes the following conditions for each decade modeled:

- Shortages occur in a drought equivalent to the drought-of-record (1950-1956)
- No change in the structural relationship within the regional economy occurs
- No change in technology occurs during this period
- No change in human behavior occurs during this period.

Obviously, the assumption of a prolonged drought during which no water management strategies are devised and applied is unrealistic. Nevertheless, the analysis is useful in illustrating the overall value of applying (or failing to apply) management strategies to meet potential water shortages.

At the request of the Region H RWPG, TWDB replicated its analysis based on Table 7 water needs with an analysis of Table 7A which reflects water needs after extending current water supply contracts through 2050. Region H considers the extension of current water supply contracts a logical first step in any set of water management strategies. Table 7A water needs thus provide a more realistic assessment of water shortages in Region H.

The TWDB used data that connect water use with the economy and the population of the region, to evaluate each negative value in *Table 7 and 7A* for an individual water user group. A negative value in *Table 7 or 7A* indicates an unmet water need. The TWDB staff constructed a regional input-output model to determine socioeconomic impact. The detailed results of the analysis are found in *Tables 9, 9A, 10* and *10A*, included in *Appendix A*. Additional information on the analysis of impacts, including notes on interpreting the results, is provided in *Appendix B*. A more detailed description of the methodology currently is being prepared by TWDB.

The data in *Tables 9.00* through *9.50 (and Tables 9A.00 through 9A.50)* show the impacts on the socioeconomic variables for each water user group by decade, from 2000 (*Tables 9.00 and 9A.00*) through 2050 (*Tables 9.50 and 9A.50*). *Tables 10.00* through *10.50 (and Tables 10A.00 through 10A.50)* correspond to the same decades as for *Table(s) 9*, but provide additional detail on the impact in each river basin where a shortage for a particular water user group occurs in two or more basins. These tables can be used to assess any remaining unmet needs after the management strategies to meet water shortages are determined by the RWPG. The impacts of each unmet, or partially met, need can be added together to determine the remaining economic development costs of not meeting the needs.

Each water user group with a need was evaluated in terms of direct and indirect economic and social impact *on the region* resulting from the shortage. Economic variables chosen by TWDB for this analysis include:

- gross economic output (sales and business gross income),
- employment (number of jobs) and
- personal income (wages, salaries and proprietors net receipts).

Social variables of the analysis are:

- population and
- school enrollments.

Declining populations indicate a depreciation of social services in most, but not every case, while decreasing school enrollment indicates loss of younger cohorts of the population and the possibility of strain on tax bases, when combined with economic losses.

Impacts of Unmet Water Needs for Region H

Under extreme supply limitations (drought-of-record) and with no management strategies in place *(Table 7),* Region H water shortages are projected to be approximately 59,000 acre-feet in 2000, rising to one million acre-feet in 2030 and to 1.38 million acre-feet by 2050. The unmet water needs of the region amount to about 19% of the forecasted demand by 2020, rising to 41% of demand in 2040, and to 43% of demand in 2050. This means that by 2050 the region would be able to supply only 57% of the projected needs unless supply development *or other water management strategies* are implemented. (See *Table 4-1* and *Figure 4-1*.)

To provide some perspective on this estimate of shortage, there are a number of WUGS for whom adequate supplies exist that will not be under contract absent action on their part. Simply extending the current supply contracts of these water user groups' increases the percentage of

regional water needs that can be met to 91% in 2030 and 87% in 2050. Conversely, additional management strategies will need to be defined to fill 9% of the 2030 water demand and 13% of the 2050 water demand.

Economic Growth Limitations

This analysis was performed for both Table 7 and Table 7A water needs to meet both TWDB and Region H RWPG requirements. As a result, companion tables and figures summarizing Tables 9 and 9A and Tables 10 and 10A are provided below. The text description relates to Tables 9 and 10, which do not include the extension of current water supply contracts.

Impact on economic development is measured as the difference between expected future growth (the baseline projection), unrestricted by water shortage, and expected growth, restricted by unmet water needs.

> ***Employment*** – Left entirely unmet, the level of water shortage in 2010 results in 249,000 fewer jobs than would be expected in unrestricted development (without unmet water needs) in 2010. The gap between unrestricted and restricted job growth increases to 1.27 million in 2030,and to 1.84 million jobs that the restricted economy could support in 2050.
>
> ***Population*** – The forecasted population growth of the region would be economically restricted by curtailed potential job creation. This in turn causes both an out-migration of some current population and an expected curtailment of future population growth. Compared to the baseline growth in population, the region could expect 496,000 fewer people in 2010, 2.55 million fewer in 2030 and 3.69 million fewer in 2050. The expected 2050 population under the severe shortage conditions (drought-of-record with no management strategies applied) would be 38% lower than projected in the "most likely" growth forecast for the region.
>
> ***Income*** – The potential loss of economic development in the region amounts to about 8% less income to people in 2010, with the gap growing to 32% less than expected in 2030. By 2050 the region would have 37% less income than is currently projected assuming no restrictions because of unmet water needs.

TABLE 4-1. RELATIONSHIP OF WATER NEEDS AND IMPACTS TO PROJECTIONS WITHOUT CONSTRAINTS, REGION H, 2000 – 2050

WATER

Decade	Projected Demand	Projected Water Shortage	Percent Shortage
	(acre-feet)		
2000	2,248,339	59,028	2.6%
2010	2,424,582	210,357	8.7%
2020	2,604,090	488,085	18.7%
2030	2,772,451	1,005,054	36.3%
2040	2,967,886	1,213,716	40.9%
2050	3,188,793	1,375,458	43.1%

EMPLOYMENT

Decade	Baseline Employment	Employment With Water Shortage	Percent Loss
	(Full Time Equivalent jobs)		
2000	2,249,094	2,185,365	2.8%
2010	2,680,947	2,431,716	9.3%
2020	3,107,046	2,474,846	20.3%
2030	3,633,673	2,364,158	34.9%
2040	4,043,189	2,511,028	37.9%
2050	4,495,943	2,657,962	40.9%

POPULATION

Decade	Baseline Population	Population With Water Shortage	Percent Loss
2000	4,780,084	4,653,284	2.7%
2010	5,692,447	5,196,449	8.7%
2020	6,830,796	5,568,089	18.5%
2030	7,846,384	5,298,503	32.5%
2040	8,838,048	5,763,535	34.8%
2050	9,700,277	6,011,908	38.0%

INCOME

Decade	Baseline Income	Income With Water Shortage	Percent Loss
	(millions, 1999 $)		
2000	91,142	88,604	2.8%
2010	108,643	99,660	8.3%
2020	125,910	103,329	17.9%
2030	147,251	99,705	32.3%
2040	163,846	106,537	35.0%
2050	182,194	114,007	37.4%

TABLE 4-1A. RELATIONSHIP OF WATER NEEDS AND IMPACTS TO PROJECTIONS WITHOUT CONSTRAINTS, REGION H, 2000 - 2050

(Supplemental Analysis of Needs Identified in Table 7A)

WATER

Decade	Projected Demand	Projected Water Shortage	Percent Shortage
	(acre-feet)		
2000	2,248,339	59,028	2.6%
2010	2,424,582	193,932	8.0%
2020	2,604,090	377,557	14.5%
2030	2,772,451	497,972	18.0%
2040	2,967,886	647,960	21.8%
2050	3,188,793	790,058	24.8%

EMPLOYMENT

Decade	Baseline Employment	Employment With Water Shortage	Percent Loss
	(Full Time Equivalent jobs)		
2000	2,249,094	2,185,365	2.8%
2010	2,680,947	2,475,414	7.7%
2020	3,107,046	2,654,562	14.6%
2030	3,633,673	3,013,981	17.1%
2040	4,043,189	3,208,221	20.7%
2050	4,495,943	3,431,918	23.7%

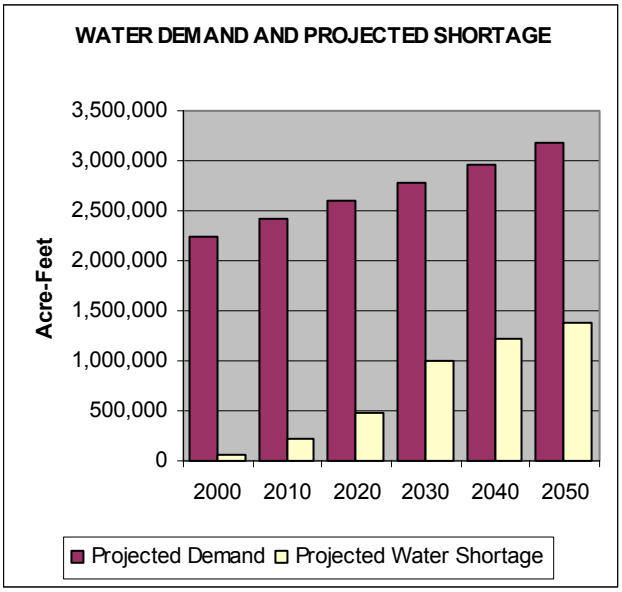
POPULATION

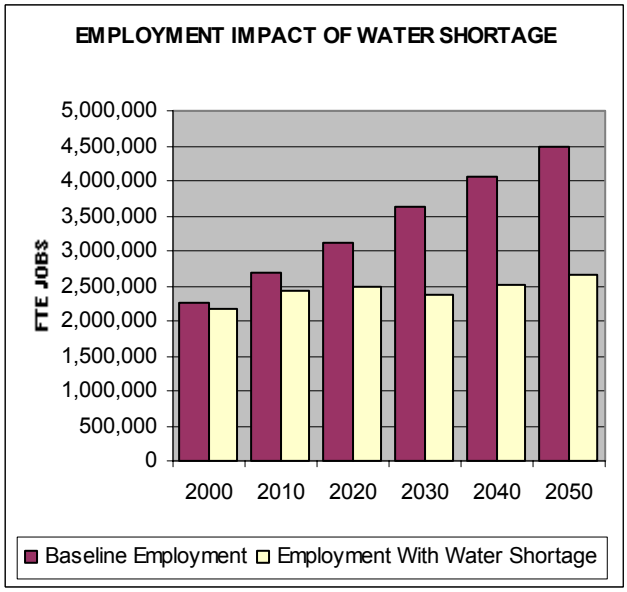
Decade	Baseline Population	Population With Water Shortage	Percent Loss
2000	4,780,084	4,653,284	2.7%
2010	5,692,447	5,283,415	7.2%
2020	6,830,796	5,927,451	13.2%
2030	7,846,384	6,602,075	15.9%
2040	8,838,048	7,162,010	19.0%
2050	9,700,277	7,563,394	22.0%

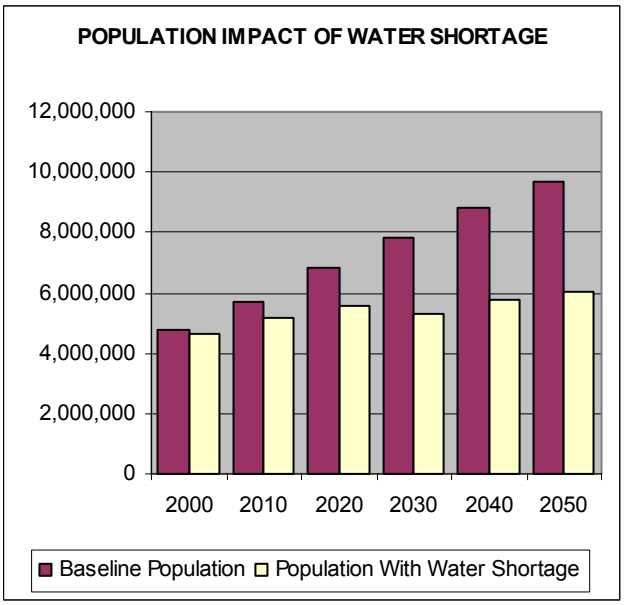
INCOME

Decade	Baseline Income	Income With Water Shortage	Percent Loss
	(millions, 1999 $)		
2000	91,142	88,604	2.8%
2010	108,643	101,097	6.9%
2020	125,910	110,133	12.5%
2030	147,251	125,650	14.7%
2040	163,846	134,365	18.0%
2050	182,194	144,347	20.8%

FIGURE 4-1. SUMMARY OF SOCIO-ECONOMIC IMPACTS OF NOT MEETING WATER NEEDS, REGION H, 2000 – 2050







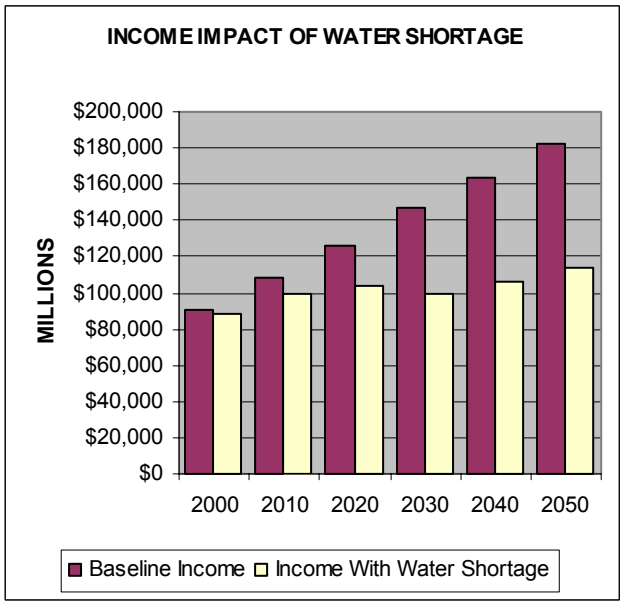
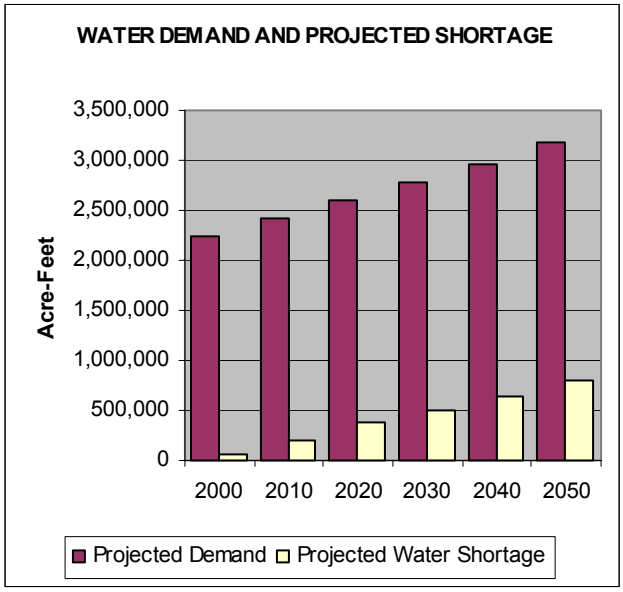
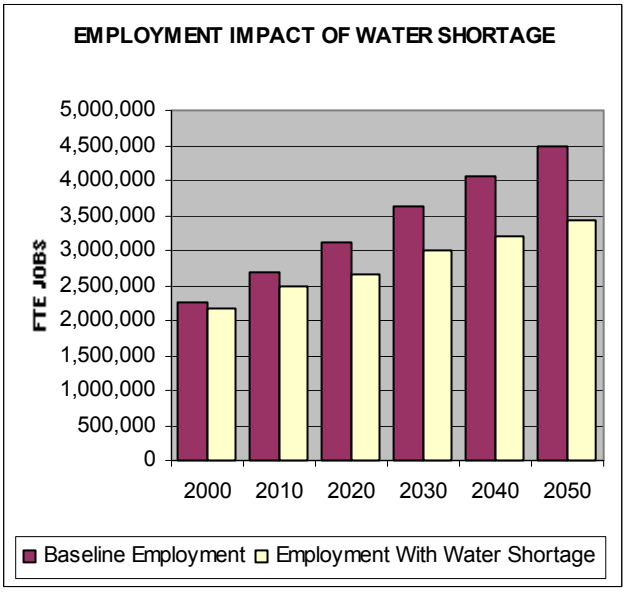
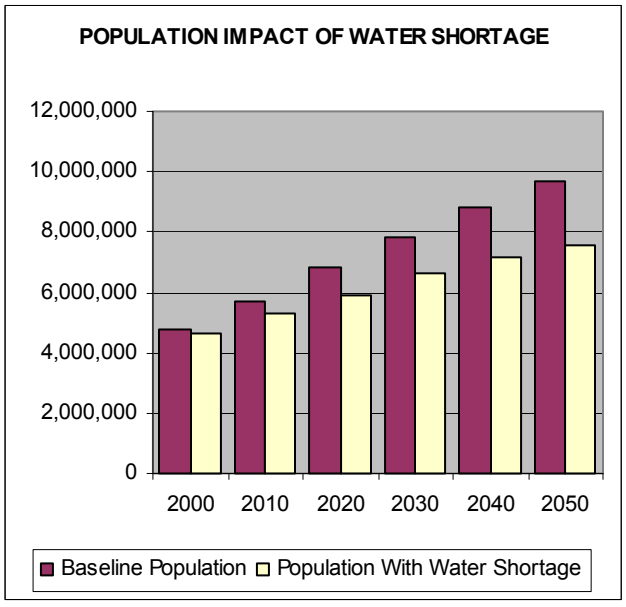


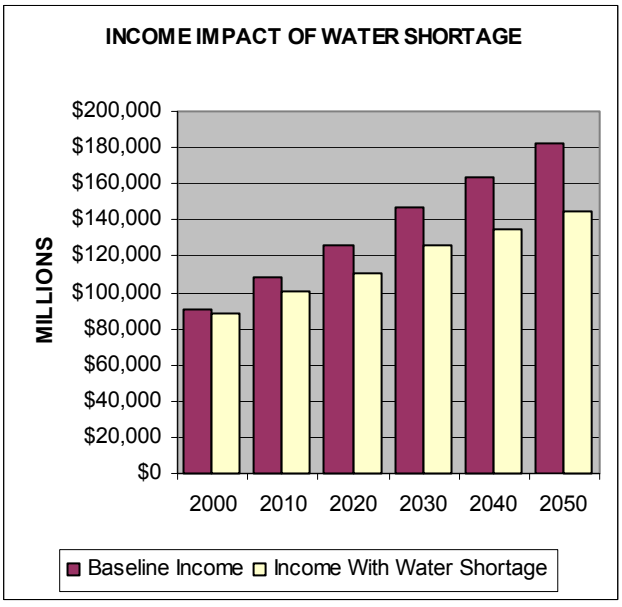
FIGURE 4-1A. SUMMARY OF SOCIO-ECONOMIC IMPACTS OF NOT MEETING WATER NEEDS, REGION H, 2000 - 2050

(Supplemental Analysis of Needs Identified in Table 7A)









Water User Groups with Shortages

The economic and social impact of an unmet water need varies greatly depending on the type of Water User Group for which the shortage is anticipated. On a per acre-foot basis, the largest impacts will generally result from shortages in manufacturing and municipal uses, while shortages for irrigation will typically result in the smallest impact. *Table 4-2* presents the impacts of unmet water needs summarized for each of the six types of Water User Groups.

The vast majority of the economic and social impacts of unmet water needs in Region H result from municipal and manufacturing water shortages. In 2010, municipalities are projected to have unmet needs of 99,000 acre-feet, 47% of the total unmet needs. The economic impacts of this shortage (169,000 jobs, $14.7 billion in output, and $5.4 billion of income) represent approximately 60% of the total impacts. By 2050, projected unmet municipal needs total 565,000 acre-feet (41% of the total) resulting in 1.13 million jobs not created, and reductions of $96.3 billion in potential output and $36.4 billion in potential income.

The impact of not meeting manufacturing needs increases over time. In 2010, manufacturing has projected unmet needs of 59,000 acre-feet, 28% of the total unmet needs. The economic impacts of this shortage include the loss of 80,000 projected jobs (32% of the total employment impact) and $13.3 billion in output (47.5% of the total output impact). In 2050, projected unmet manufacturing needs are 687,000 acre-feet (50% of the total) resulting in 685,000 jobs not created and reduction of $113.8 billion in output (53% of the total output impact).

Shortages are also projected for steam electric generation, mining, and irrigation. The impacts of these needs represent less than 2% of the total impact in any year.

Table 4-2. Summary of Impacts by Decade and Category, Region H, 2000-2050

Category	Decade	Value of Need (acre-feet)	Impact of Need on Employment	Impact of Need on Gross Business Output in 1999 US Dollars (Millions)	Impact of Need on Population	Impact of Need on School Enrollment	Impact of Need on Income in 1999 US Dollars (Millions)	Number of WUGs with Needs
Municipal	2000	-10,258	24,494	2,042.50	48,717	11,771	791.9	17
Manufacturing	2000	-16,277	38,933	6,468.90	77,478	18,689	1,739.90	3
Steam Elec.	2000	0	0	0	0	0	0	0
Mining	2000	-498	106	20.8	219	59	5.1	3
Irrigation	2000	-31,994	195	6.9	386	95	1.9	3
Livestock	2000	0	0	0	0	0	0	0
TOTAL		-59,028	63,729	8,539.00	126,800	30,614	2,538.80	
Municipal	2010	-98,974	168,593	14,678.80	335,522	82,519	5,388.80	72
Manufacturing	2010	-58,891	80,135	13,314.60	159,471	39,250	3,581.20	9
Steam Elec.	2010	-380	109	22.6	217	52	6.2	1
Mining	2010	-371	79	15.5	159	44	3.8	4
Irrigation	2010	-51,740	316	11.1	629	153	3.1	2
Livestock	2010	0	0	0	0	0	0	0
TOTAL		-210,357	249,232	28,042.60	495,998	122,018	8,983.00	
Municipal	2020	-274,414	442,638	38,857.10	883,604	217,130	14,116.60	96
Manufacturing	2020	-171,010	189,133	31,425.10	378,266	92,675	8,452.30	9
Steam Elec.	2020	-380	109	22.6	217	55	6.2	1
Mining	2020	-292	62	12.2	115	38	3	5
Irrigation	2020	-41,989	256	9	505	134	2.5	4
Livestock	2020	0	0	0	0	0	0	0
TOTAL		-488,085	632,200	70,326.00	1,262,707	310,032	22,580.50	
Municipal	2030	-407,407	730,537	63,136.20	1,467,031	363,768	23,397.00	116
Manufacturing	2030	-529,711	532,077	88,406.10	1,066,968	263,534	23,778.30	11
Steam Elec.	2030	-20,380	5,848	1,214.70	11,756	2,926	331	2
Mining	2030	-3,672	785	153.2	1,585	400	37.3	6
Irrigation	2030	-43,883	268	9.4	541	138	2.7	4
Livestock	2030	0	0	0	0	0	0	0
TOTAL		-1,005,054	1,269,515	152,919.60	2,547,881	630,766	47,546.30	
Municipal	2040	-487,998	902,307	77,649.00	1,811,315	443,439	28,931.40	118
Manufacturing	2040	-608,799	608,766	101,148.30	1,220,865	298,486	27,205.50	11
Steam Elec.	2040	-68,980	19,794	4,111.40	39,783	9,756	1,120.40	3
Mining	2040	-4,820	1,031	201.1	2,034	487	49	6
Irrigation	2040	-43,118	263	9.2	516	122	2.6	5
Livestock	2040	0	0	0	0	0	0	0
TOTAL		-1,213,716	1,532,161	183,119.00	3,074,513	752,290	57,308.80	
Municipal	2050	-564,941	1,131,381	96,336.10	2,272,193	563,710	36,378.30	119
Manufacturing	2050	-687,296	684,768	113,776.10	1,372,320	338,323	30,601.90	11
Steam Elec.	2050	-68,980	19,794	4,111.40	39,785	9,896	1,120.40	3
Mining	2050	-8,219	1,757	342.9	3,515	860	83.5	7
Irrigation	2050	-46,022	281	9.9	556	137	2.8	6
Livestock	2050	0	0	0	0	0	0	0
TOTAL		-1,375,458	1,837,981	214,576.50	3,688,369	912,926	68,186.90	

Table 4-2A. Summary of Impacts by Decade and Category, Region H, 2000-2050

(Supplemental Analysis of Needs Identified in Table 7A)

Category	Decade	Value of Need (acre-feet)	Impact of Need on Employment	Impact of Need on Gross Business Output in 1999 US Dollars (Millions)	Impact of Need on Population	Impact of Need on School Enrollment	Impact of Need on Income in 1999 US Dollars (Millions)	Number of WUGs with Needs
Municipal	2000	-10,258	24,494	2,042.51	48,717	11,771	791.8525883	17
Manufacturing	2000	-16,277	38,933	6,468.90	77,478	18,689	1,739.92	3
Steam Elec.	2000	0	0	0	0	0	0	0
Mining	2000	-498	106.477901	20.77904372	219	59	5.06004509	3
Irrigation	2000	-31,994	195.3474643	6.858355675	386	95	1.936390833	3
Livestock	2000	0	0	0	0	0	0	0
TOTAL		-59,028	63,729	8,539.05	126,800	30,614	2,538.76	
Municipal	2010	-84,056	126,436	11,223.18	251,625	61,895	4,019.96	61
Manufacturing	2010	-57,385	78,593	13,058.43	156,402	38,504	3,512.28	8
Steam Elec.	2010	-380	109.0436329	22.64902725	217	52	6.171944058	1
Mining	2010	-371	79.32389816	15.47997032	159	44	3.769631985	4
Irrigation	2010	-51,740	315.9107495	11.0911513	629	153	3.13148001	2
Livestock	2010	0	0	0	0	0	0	0
TOTAL		-193,932	205,533	24,330.82	409,032	100,648	7,545.31	
Municipal	2020	-244,311	341,165	30,666.28	680,728	167,381	10,809.15	79
Manufacturing	2020	-90,585	110,890	18,424.75	221,780	54,336	4,955.64	8
Steam Elec.	2020	-380	109.0436329	22.64902725	217	55	6.171944058	1
Mining	2020	-292	62.4328255	12.18369632	115	38	2.966934069	5
Irrigation	2020	-41,989	256.3742415	9.000914039	505	134	2.541321602	4
Livestock	2020	0	0	0	0	0	0	0
TOTAL		-377,557	452,483	49,134.87	903,345	221,944	15,776.47	
Municipal	2030	-326,116	469,756	42,000.21	942,921	233,463	14,905.62	90
Manufacturing	2030	-129,857	148,876	24,736.24	299,243	74,441	6,653.21	10
Steam Elec.	2030	-380	109	22.65	221	56	6.171944058	1
Mining	2030	-3,360	718.4051154	140.1959577	1,454	366	34.14006326	5
Irrigation	2030	-38,258	233.5939408	8.201131944	470	120	2.315510812	4
Livestock	2030	0	0	0	0	0	0	0
TOTAL		-497,972	619,693	66,907.49	1,244,309	308,446	21,601.46	
Municipal	2040	-396,991	608,377	53,839.92	1,220,633	299,223	19,359.25	92
Manufacturing	2040	-208,526	225,276	37,430.19	452,803	110,556	10,067.46	10
Steam Elec.	2040	-380	109	22.65	217	52	6.17	1
Mining	2040	-4,569	977	190.6414674	1,937	465	46.42438959	5
Irrigation	2040	-37,493	228.9230939	8.037145532	448	106	2.269210824	5
Livestock	2040	0	0	0	0	0	0	0
TOTAL		-647,960	834,968	91,491.44	1,676,038	410,402	29,481.58	
Municipal	2050	-454,730	761,001	66,431.97	1,527,826	378,668	24,306.82	94
Manufacturing	2050	-286,568	300,962	50,005.64	604,930	150,482	13,449.83	10
Steam Elec.	2050	-380	109	22.65	219	53	6.17	1
Mining	2050	-7,983	1,707	333.0905744	3,422	835	81.11313244	6
Irrigation	2050	-40,397	246.6539952	8.659650813	486	120	2.444969209	6
Livestock	2050	0	0	0	0	0	0	0
TOTAL		-790,058	1,064,025	116,802.02	2,136,883	530,158	37,846.38	

Task 4.7 Potential impacts of water shortages on selected economic activities in Region H

Economic Impacts of Water Shortages on Recreational Interests

Recreational Activities Sensitive to Water Supply

One of the distinguishing characteristics of Region H is the abundance of recreational opportunities that enrich the quality of life of its residents. (See Task 3 Report for a discussion of recreational water uses.) Recreation also contributes to attracting tourists and tourist dollars to the region. Some of these recreational activities are associated with water, both freshwater and salt water, and may be sensitive to water supply. The relation to water supply translates through impacts on reservoir levels, instream flows, bay and estuary inflows, water quality, habitat and aesthetics. *Table 4-3* lists recreational activities in Region H and the ways in which those activities are sensitive to water supply.

Table 4-3. Recreational Activities Associated with Water in Region H

Activity	Major Sensitivity to Supply
Boating (Canoe/kayak, sailboats, personal watercraft, power boats)	Reservoir level Instream flow Aesthetics
Swimming	Water quality Reservoir level
Fishing	Reservoir level Instream flow Bay & Estuary inflows Water quality Habitat
Hunting	Habitat
Parks (Camping, hiking, biking, horseback riding)	Aesthetics Habitat
Nature Tourism	Reservoir level Instream flow Bay & Estuary inflows Habitat Aesthetics
Golfing	Course upkeep Aesthetics

Although the major reservoirs in Region H were built and are maintained for municipal and industrial water supply, their existence has spurred the development of recreation related economic activity around their perimeters. In addition, this recreation-oriented development expands the tax base of local jurisdictions located near the reservoirs. Other water bodies similarly provide economic opportunities in recreation support activities.

These activities impact the economy of the region through many paths, some of which are captured under the heading of "commercial activities" in the municipal water user group (WUG) in the preceding socioeconomic analysis of water shortages. Examples of these would be the sale of boating equipment, pier use fees collected by a convenience store or hotel receipts. Others impacts are not accounted for among the WUGs.

Economic Importance of Water Related Recreational Activities to Local and Regional Economies

Nationally, a number of studies discuss the contribution of water-related recreational activities, but few studies quantify the importance of those activities to the regional economy. In 1996, Texas ranked second in the U.S. in angler expenditures at $2.9 billion, providing more than 80,000 jobs. In 1997, Texas ranked fifth in the U.S. in boat ownership with about $302 million in retail boat sales. To provide some estimate of how Region H shares in this economic activity Texas Parks and Wildlife Department reported 617,864 boat registrations for February 2000, 98% of which are used as pleasure craft. Counties in Region H account for 134,289 boats, with 99% used as pleasure craft. If that ratio is indicative of water-related recreational activity in Texas, then about one-fourth of water-related recreational activity in the State occurs in Region H.

Within Region H, a 1995 study by Texas A&M University prepared for the TWDB estimated the positive economic impact of recreational activities in the Trinity-San Jacinto estuary. Using survey and other expenditure data, impacts were estimated as shown in *Table 4-4*.

Table 4-4. Economic Impacts of Recreation Activities, Trinity-San Jacinto Estuary

Economic Impact Variable	Regional Impact	State Impact
Direct Impact ($mil)	421.92	421.92
Output ($mil)	757.69	812.40
Personal Income ($mil)	324.50	331.65
Value-Added ($mil)	491.15	510.94
Employment (jobs)	15,287	16,483

(Source: Table III.6, Tanyeri-Abur, Jones and Jiang, March 1998)

The study noted that it was not possible to develop standard multipliers for recreational activities because these activities are spread across several economic sectors. However, it concluded that "each dollar of tourist and recreationist expenditures resulted in about $1.79 in total output, $0.77 in personal income and $1.16 of value-added in the Trinity San Jacinto estuary regional economy," with "an employment multiplier of about 36 jobs per million dollars of tourist and recreationist expenditures" (Tanyeri-Abur et al, 1998).

A complete picture of the importance of water related recreational activities on the regional economy is not available from current data. The data that are available indicate that water-related recreation is very important to the regional economy and to the state economy.

Recommendations on methods to recognize recreational needs in water resource management planning

These recreational activities (excluding golfing) usually are not traditional "users" of water supply, and so do not show up in an analysis of "shortages" or "unmet needs," particularly when the analysis is restricted to drought-of-record conditions. The Region H Task 3 Report noted six holders of recreational diversion water rights, totaling 7,652 acre-feet per year.

Although some water-related recreational activities, such as boating, appear to benefit most from high reservoir and instream flow levels, many associated with environmental quality or habitat, such as fishing, require varying levels and flows. While water suppliers are accustomed to dealing with seasonal or daily use patterns for their customers, they are less well equipped in their operations to consider seasonal or cyclical environmental water needs or needs of third parties. Based on RWPG discussions and data analysis, the following recommendations are offered for consideration for future water planning.

1. Perform studies of recreational activities that are important to Region H that would define the quantity, timing and location of water supplies necessary to support each activity.

2. Extend regional water planning to consider water needed to support recreational activities (maintain reservoir levels, instream flows, bay and estuary inflows). This task requires analysis of water needs during non-drought conditions.

3. Assist localities to perform economic studies to determine the contribution of water-related recreation to local economies focusing on locational and industry specific socioeconomic impact studies.

Economic impacts on agricultural and nursery industries

Areas where agricultural water supplies are inadequate or under pressure

Region H is projected to have inadequate irrigation water available throughout the 50-year planning period; however, this shortage will result from unmet needs in just three of the region's counties. Under drought-of-record water supply conditions, irrigated agriculture in Brazoria and Waller Counties would be projected to experience water shortages in year 2000 and throughout the planning period. (See *Table 4-5*) Fort Bend County is projected to experience water shortages in the agricultural sector around 2040. This shortage will gradually worsen through the year 2050. The greatest impact under worst case conditions is projected to occur circa 2010 with most of the deficit occurring in Brazoria County. After 2010, the deficit decreases as projected demands decrease in Brazoria County. The deficit then slowly increases through 2050. At all times, Brazoria County accounts for over 85% of the projected agricultural water shortages in Region H. From these figures, it is evident that the impacts resulting from a shortfall of water for agricultural uses in Region H will be confined primarily to Brazoria County.

The impacts of this shortfall are projected to include approximately 186 fewer agriculture jobs in 2000 than are projected to occur if irrigation water needs are met. (See *Table 4-6*). To provide some context, various reports indicate that Brazoria County had 1,097 agricultural jobs in 1997. Agricultural employment will be between 235 to 300 jobs lower than the baseline forecast between 2010 and 2050 if irrigation water needs in Brazoria are not met, with the greatest impact occurring in 2010. These projected water shortages are the result of drought-of-record supply conditions. No management of the water resource is assumed. There is an inherent assumption in the regional planning process that various industries would not employ pro-active short-term water strategies if drought conditions occurred. For these reasons, it is not likely that the projected shortages will be as severe as projected or will occur as soon as indicated. The remaining counties are projected to have sufficient water to meet agricultural demands throughout the planning period.

Table 4-5. Water Deficit for Irrigation Water User Group

in Acre-feet/Year						
County	***2000***	***2010***	***2020***	***2030***	***2040***	***2050***
Brazoria	-30,479	-49,106	-38,872	-40,133	-38,440	-39,750
Fort Bend	0	0	0	0	-101	-632
Waller	-1,515	-2,634	-3,117	-3,750	-4,577	-5,640
Total	-31,994	-51,740	-41,989	-43,883	-43,118	-46,022

Source: *Table 7*

The impact on Brazoria County as a result of foregone agricultural jobs is projected to range from 368 persons in 2000 to almost 600 persons in 2010. Concomitant with these decreased expectations of population growth will be smaller projected school enrollment during this period, ranging in impact from a low of 90 fewer students in the year 2000 to a high of 144 fewer students in 2010.

These impacts to population, employment and income are small when compared to the population, employment and income levels in Brazoria County as a whole, but are severe when compared to those levels in the agricultural sector. The number of jobs projected to be foregone under the worst case scenario in the agricultural sector represents only 0.06% of all jobs in Brazoria County, but between 10 and 30 % of the number of agricultural jobs in 1997. The reduced farm income represents less than 0.1% of the total Brazoria County 1997 payroll, but approximately 31% of the 1997 farm payroll. Additionally, impacts to agricultural workers tend to be more severe since jobs in the agricultural sector often pay lower than jobs in many other sectors. As stated earlier, the likelihood of the above scenario is small. The assumption of year of record drought conditions coupled with no water management planning creates a worse case scenario that is not likely to be realized. Therefore the impacts described above are used only to represent the worst possible case and to provide a basis for evaluating the effect of management strategies.

Table 4-6. Impact of Irrigation Water Shortages on Baseline Forecast Employment, Business Output, Population, School Enrollment and Income.

Decade and County	Value of Need (acre-feet)	Impact of Need on Employ-ment	Impact of Need on Gross Business Output in 1999 US Dollars (Millions)	Impact of Need on Population	Impact of Need on School Enrollment	Impact of Need on Income in 1999 US Dollars (Millions)
Year 2000						
Brazoria County	-30,479	186	6.5	368	90	1.8
Waller County	-1,515	9	0.3	18	5	0.1
Region H	-31,994	195	6.9	386	95	1.9
Year 2010						
Brazoria County	-49,106	300	10.5	597	144	3.0
Waller County	-2,634	16	0.6	32	9	0.2
Region H	-51,740	316	11.1	629	153	3.1
Year 2020						
Brazoria County	-38,872	237	8.3	469	122	2.4
Waller County	-3,117	19	0.7	36	12	0.2
Region H	-41,989	256	9.0	505	134	2.5
Year 2030						
Brazoria County	-40,133	245	8.6	496	126	2.4
Waller County	-3,750	23	0.8	45	12	0.2
Region H	-43,883	268	9.4	541	138	2.7
Year 2040						
Brazoria County	-38,440	235	8.2	464	111	2.3
Fort Bend County	-101	1	0.0	2	0	0.0
Waller County	-4,577	28	1.0	50	11	0.3
Region H	-43,118	263	9.2	516	122	2.6
Year 2050						
Brazoria County	-39,750	243	8.5	485	118	2.4
Fort Bend County	-632	4	0.1	8	2	0.0
Waller County	-5,640	34	1.2	63	17	0.3
Region H	-46,022	281	9.9	556	137	2.8

Source: *Tables 9.00-9.50*

Recommendations on policy or institutional changes that can mitigate impacts on agricultural and nursery industries

In 1990, irrigation use accounted for approximately 500,000 acre-feet or over 25% of the water used in Region H. This amount is projected to decline by 2050 to just over 14% of the water used, although the amount of water used for irrigation is projected to decline by only approximately 29,000 acre-feet. During this period, water used for irrigation in Brazoria County is projected to decline from just over 131,000 acre feet to just under 102,000 acre feet or from just over 33% of water used to just over 20%. Supply in Region H and irrigation supply in Brazoria County is projected to decrease from 3,686,684 acre-feet to 3,459,035 acre-feet and from 91,671 acre-feet to 63,414 acre-feet, respectively.

Balance between water supply and demand can be achieved by reducing demand, increasing supply or both; therefore recommendations to alleviate water shortages include measures to increase supply while reducing demand or reallocating water among existing users. Additionally, the water supply forecasts used for this study assumed that persons or organizations holding water contracts within the Region would not automatically renew these contracts upon expiration. This assumption is likely not correct. Potential methods of meeting projected shortages could include, but are not limited to:

- Extension of current contracts;
- Construction of new water development projects (including interbasin transfers);
- Requiring conservation in other User Groups to free more water for agriculture;
- Development of crop strains that require less water;
- Cultivation of new crops that require less water;
- Requiring conservation measures in agriculture

The use of more efficient irrigation systems and practices, including government assistance to agriculture to develop more efficient irrigation systems, should be considered. Potential measures and the implementation costs (Stansel, 2000) for these methods include:

- Land leveling to eliminate highs and lows in a cut to maintain more uniform water levels- estimated costs range from $100 to $150 per acre.
- Multiple inlets in a field to enhance control of water levels in fields - cost is approximately $2/acre/year
- Reduced levee spacing to reduce the depth of water to flood the entire field within the levee - estimated cost is $0.50/acre/year
- Replacement of field laterals (ditches) with irrigation pipelines to prevent water loss through evaporation, transpiration, and seepage - cost is approximately $10/foot.

Economic impacts on manufacturing

Region H is projected to have inadequate water for manufacturing throughout the 50 year planning period. This shortage will result from unmet needs in six of the 15 constituent counties. Manufacturing in Fort Bend County would already be experiencing water shortages under drought conditions and is projected to experience shortages throughout the planning period (see *Table 4-7*). Brazoria, Galveston, Harris, and Montgomery Counties are projected to experience water shortages under drought conditions starting circa 2010. Chambers County will experience shortages by 2030. These shortages will gradually worsen through the year 2050. A notable increase in the shortfall for Harris County is projected from 2020 to 2030 when the shortage of water available for manufacturing almost quadruples from just over 110,000 acre-feet to just over 430,000 acre-feet. The shortfall in manufacturing water increases with each decade from a total of 16,277 acre-feet in Fort Bend County to a total shortage of over 650,000 acre-feet by 2050 in the six counties with deficits. The projected water shortages are forecast with drought-of-record supply conditions. No management of the water resource is assumed. Again, for these reasons it is not likely that the projected shortages will be as severe as projected and may not occur as soon as indicated. The remaining counties are projected to have sufficient water to meet manufacturing demands throughout the planning period.

Table 4-7. Water Deficit for Manufacturing Water User Group

in Acre-feet/Year						
County	***2000***	***2010***	***2020***	***2030***	***2040***	***2050***
Brazoria	-	-16,853	-30,454	-60,521	-84,042	-107,339
Chambers	-	-	-	-2,361	-2,780	-3,228
Fort Bend	-16,277	-18,185	-19,934	-21,373	-23,862	-26,238
Galveston	-	-879	-5,717	-10,243	-18,832	-27,434
Harris	-	-22,709	-114,447	-434,566	-478,349	-521,830
Montgomery	-	-265	-458	-647	-934	-1,227
Region H Deficit County Total	-16,277	-58,891	-171,010	-529,711	-608,799	-687,296

The greatest impact under worst case conditions is projected to occur in Harris County in terms of the reduction in manufacturing jobs below the baseline forecasts. In terms of proportion of impacts to job growth, Brazoria, Fort Bend, and Montgomery Counties might experience impacts that are at least as severe as those in Harris County.

The impacts of this shortfall are projected to include approximately 680,000 fewer manufacturing jobs in 2050 than would occur if there were not unmet manufacturing water needs. Most of these jobs would have been located in Harris County (see *Table 4-8*). These figures indicate substantial economic impacts resulting from reduced job growth in Region H along with a potential reduction in tax revenue and income levels in the region. The effects of these water shortages on the impacted counties as a result of foregone manufacturing jobs are

projected populations below the baseline forecasts ranging from over 77,000 persons in 2000 to almost 1,400,000 persons in 2050. Concomitant with these decreased expectations of population growth will be smaller projected school enrollment during this period ranging in impact from just over 18,000 fewer students in the year 2000 to over 338,000 fewer students in 2050.

The reduction from the baseline population forecasts in the impacted counties would mean lower tax revenues, lower total wages, lower business output and fewer housing starts. The effects of manufacturing water shortages would be felt throughout the Region H economy, not only in other economic sectors, but in other geographic areas throughout the region, as well.

With the exception of Chambers County, these impacts to population, employment, and income occur in Region H's most populous counties. The projected impacts are substantial when compared to the population, employment, and income levels in each of the counties and in the Region as a whole. The severity of these impacts are magnified when compared to the manufacturing sector, which accounts for approximately 17.4% of the 1997 total employment in the impacted counties. By 2050, the foregone jobs comprise 41% of the number of the total jobs in 1997 in the impacted area, but exceed the number of manufacturing jobs present in 1997 in these counties. The foregone income from manufacturing increases from $1.7 billion dollars in 2000 to over $30 billion in 2050.

Table 4-8. Impact of Manufacturing Water Shortages on Baseline Forecast Employment, Business Output, Population, School Enrollment and Income for Counties with Manufacturing Water Deficits.

Decade and County	Value of Need (acre-feet)	Impact of Need on Employment	Impact of Need on Gross Business Output in 1999 US Dollars (Millions)	Impact of Need on Population	Impact of Need on School Enrollment	Impact of Need on Income in 1999 US Dollars (Millions)
Year 2000						
Fort Bend County	-16,277	38,933	6,468.9	77,478	18,689	1,739.9
Region H Impact Area	-16,277	38,933	6,468.9	77,478	18,689	1,739.9
Year 2010						
Brazoria County	-16,853	13,118	2,179.7	26,107	6,428	586.3
Fort Bend County	-18,185	43,497	7,227.2	86,560	21,314	1,943.9
Galveston County	-879	936	155.6	1,863	449	41.8
Harris County	-22,709	21,933	3,644.2	43,647	10,747	980.2
Montgomery County	-265	650	108.0	1,294	312	29.0
Region H Impact Area	-58,891	80,134	13,314.7	159,471	39,250	3,581.2
Year 2020						
Brazoria County	-30,454	23,706	3,938.7	47,410	11,615	1,059.4
Fort Bend County	-19,934	47,681	7,922.3	95,362	23,364	2,130.8
Galveston County	-5,717	6,088	1,011.6	12,176	2,983	272.1
Harris County	-114,447	110,536	18,365.8	221,072	54,163	4,939.8
Montgomery County	-458	1,123	186.6	2,246	550	50.2
Region H Impact Area	-171,010	189,134	31,425	378,266	92,675	8,452.3
Year 2030						
Brazoria County	-60,521	47,110	7,827.4	94,689	23,555	2,105.3
Chambers County	-2,361	1,635	271.6	3,286	818	73.1
Fort Bend County	-21,373	51,123	8,494.2	102,757	25,562	2,284.6
Galveston County	-10,243	10,908	1,812.4	21,925	5,454	487.5
Harris County	-434,566	419,715	69,736.8	841,121	207,351	18,756.9
Montgomery County	-647	1,587	263.7	3,190	794	70.9
Region H Impact Area	-529,711	532,078	88,406.1	1,066,968	263,534	23,778.3
Year 2040						
Brazoria County	-84,042	65,419	10,869.5	131,490	32,105	2,923.5
Chambers County	-2,780	1,925	319.8	3,869	963	86.0
Fort Bend County	-23,862	57,076	9,483.4	114,722	28,065	2,550.7
Galveston County	-18,832	20,054	3,332.0	40,309	9,826	896.2
Harris County	-478,349	462,002	76,762.9	925,870	226,381	20,646.6
Montgomery County	-934	2,291	380.6	4,605	1,146	102.4
Region H Impact Area	-608,799	608,767	101,148.2	1,220,865	298,486	27,205.4

Year 2050						
Brazoria County	-107,339	83,553	13,882.6	167,942	41,777	3,733.9
Chambers County	-3,228	2,235	371.4	4,492	1,118	99.9
Fort Bend County	-26,238	62,759	10,427.7	126,146	31,380	2,804.7
Galveston County	-27,434	29,214	4,854.0	58,720	14,607	1,305.6
Harris County	-521,830	503,997	83,740.5	1,008,972	247,936	22,523.4
Montgomery County	-1,227	3,009	500.0	6,048	1,505	134.5
Region H Impact Area	-687,296	684,767	113,776.2	1,372,320	338,323	30,602

Source: TWDB *Tables 9.00-9.50*

Other impacts include added expense to manufacturers as they implement measures to meet their water needs. A concern of industry is a lack of water supply reliability (Wade, et al., 1991). This concern has the potential to impact manufacturing growth by causing planned plant expansions to occur outside the impacted region, existing plants to relocate to other areas with reliable water supplies and discouraging new industry from moving into areas with potential water shortages. Wade, et al., 1991 found that industry will implement water conservation projects with costs many times higher than avoided costs to ensure a reliable water supply. As stated earlier, the likelihood of the above scenario is small. The assumption of year of record drought conditions coupled with no water management planning and no renewal of expiring water contracts creates a worse case scenario that is not likely to be realized. Therefore the impacts described above are used only to represent the worst possible case and not the most likely scenario.

Table 4-9. Economic Indicators for Counties with Unmet Manufacturing Water Needs

County	1997 Population	1997 Total Employment	1997 Mfg. Employment	1997 Total Payroll ($1,000)	1997 Mfg. Payroll ($1,000)
Brazoria	191,707	56,732	14,626	$1,657,034	$708,598
Chambers	20,088	5,360	1,536	$184,714	$86,085
Fort Bend	225,421	66,938	12,991	$2,020,264	$537,937
Galveston	217,399	64,513	7,816	$1,586,526	$380,666
Harris	2,818,199	1,511,905	179,830	$51,235,596	$8,199,957
Montgomery	182,201	66,939	7,674	$1,673,405	$269,550
Others	216,765	46,517	7,442	$960,455	$217,349
Region Total	3,871,780	1,818,904	231,915	$59,317,994	$10,400,142

Recommendations on policy or institutional changes that can mitigate impacts on manufacturing

In 1990, manufacturing use accounted for approximately 635,000 acre-feet or over 33% of the water used in Region H. While the amount of water required for manufacturing use is projected to increase to over 1,000,000 acre feet, the percentage of the water demand required for manufacturing within the region is projected to remain relatively constant.

Balance between water supply and demand can be achieved by reducing demand, increasing supply or both; therefore recommendations to alleviate water shortages include measures to increase supply while reducing demand or reallocating water among existing users. Additionally, the water supply forecasts used for this study assumed that persons or organizations holding water contracts within the region would not automatically renew these contracts upon expiration. This assumption is likely not correct. Potential methods of meeting projected shortages could include, but are not limited to:

- Extension of current contracts;
- Construction of new water development projects (including interbasin transfers);
- Requiring conservation in other User Groups to free more water for manufacturing and transfer of water rights from other User Groups to manufacturers;
- Development and implementation of manufacturing processes that require less water;
- Influx of industries that require less water.

Additionally, more efficient use of water by industry will likely be implemented to increase reliability in the water supply and to offset rising water costs (Wade, et. al., 1991). These methods include:

- Replace once through cooling systems with recirculation
- Treatment and reuse of process water

Economic Impacts on Commercial Fishing and Associated Industries

Most of the commercial fisheries in Region H are associated with the Trinity-San Jacinto Estuary (commonly called the Galveston Bay system). The balance of freshwater from rivers (52-54% from the Trinity River; 26-28% from the San Jacinto River) and saltwater from the Gulf of Mexico makes possible an extremely high level of fisheries productivity for Galveston Bay. Galveston Bay has been named an "estuary of national significance" in part because of this productivity. The Bay is the source of approximately 1/3 of Texas' shrimp harvest, 2/3 of the state's oyster harvest and 1/3 of the state's recreational finfish harvest. Seafood harvest by coastal fishermen average more than 100 million lbs/year and virtually all of the coastal fishery species (mollusks, crustaceans, and vertebrate fishes) are estuarine-dependent during at least some important part of their life cycle. (Powell, 1999)

Total impacts on the state's economy from commercial fishing, sport fishing, and other recreational activities has been estimated at about $3.5 billion/year (1994 dollars). The value of that portion associated with Galveston Bay and the Trinity-San Jacinto Estuary is about $1.6 billion/year. (Powell, 1999) These are naturally renewable resources that are free for the harvest or use and don't have to be subsidized, just protected. Without freshwater flows from the rivers to balance saltwater from the Gulf, this productivity is likely to be impaired.

Water Shortage Related Impacts on Commercial Fishing and Associated Industries

Commercial fishing is impacted by the supply of water through instream flows, and bay and estuary inflows. Water supply quantities also affect water quality (including salinity levels) and habitat to support the fisheries. In general, water rights to provide for water needs related to commercial fishing do not exist. Water needs of fish and wildlife are generally accounted for under the public trust function of the State.

Aquaculture, or fish farming, is a special case. In Texas, aquaculture is classified as a manufacturing industry. It is not thought to be a large component of the manufacturing sector, but data to separate aquaculture from other manufacturing are not available to Region H at this time.

Fish and seafood processing facilities associated with commercial fishing would be impacted by water shortages just as any traditional manufacturing water user would. While these facilities individually may consume substantial quantities of water, they do not represent a large portion of total regional manufacturing.

Impacts on Region H of Water Shortages Related to Commercial Fishing

The average value (direct impact) of output from commercial fishing of finfish, shellfish and shrimp in the Trinity-San Jacinto Estuary for the period 1993-1995 is $61.8 million per year. The total regional impact of commercial fishing in the Trinity-San Jacinto Estuary in 1995 was estimated to be $92.1 million, with an employment impact of 1,688 jobs. There is also a direct regional impact of about $42 million from landing of shrimp and fish caught in other waters but landed (sold or processed) in the counties surrounding Galveston Bay. Because of differences in the sources of the data used to develop these estimates of output, they do not appear to be additive. (Tanyeri-Abur et al., 1998)

If water shortages in Region H result in severely curtailing the inflow of freshwater into the Galveston Bay estuary, productivity of the fishery will be impacted through increasing salinities, reduced sediment and nutrients and changed water circulation patterns. Although the exact magnitude of the impact cannot be calculated at this time, the oyster fishery, because oysters are stationary and dependent on salinity levels for protection from predators, will likely be the most severely impacted. If prolonged, increasing salinities will result in loss of some marsh that serves as habitat for juvenile species of fish and shrimp. Bay and gulf fishers and shrimpers would face increased costs in searching for a reduced amount of catch. Seafood processors would likely see reduced amounts of catch offered, but catch from other Gulf areas may be brought in to bay area processors. Reduced harvest would also ultimately impact the distribution system (truckers/rail) and wholesale or retail grocers and restaurants.

Recommendations of Policy or Institutional Changes that can Mitigate Impacts of Water Shortages on Commercial Fishing and Associated Industries

The following recommendations are offered to address water supply concerns for the commercial fishing and its related industries.

1. Support the efforts of Galveston Bay Freshwater Inflows Group efforts to continue studies and develop management strategies for freshwater inflows to the Galveston Bay system that address quantity, quality, timing, and location of inflows while meeting other human water needs.

2. Support the continued efforts of state resource agencies (Texas Water Development Board, Texas Parks and Wildlife Department, Texas Natural Resource Conservation Commission, General Land Office and Texas Department of Health) to monitor stream and bay conditions to provide data to support sound scientific studies of instream and inflow needs.

3. The State of Texas should define regional water planning to consider water needed to support instream flows and bays and estuaries. Looking only at drought-of-record conditions focuses attention toward stored water rather than stream flows.

Socioeconomic Impacts Associated with Ground to Surface Water Conversion and Conjunctive Use Issues

Historically, readily available groundwater in Region H has supported a high level of development. Extensive use of the aquifers in various regions have resulted in subsidence and related impacts including faulting, flooding, and decreased groundwater quality. Subsidence districts have been formed to manage groundwater resources and encourage conversion from groundwater to surface water. These conversion practices have produced:

1. A realization that the cost of water will increase as growth continues within Region H

2. A growing recognition that regionalization of water supplies may serve to produce the least cost water to the end-use customer.

3. Equity issues associated with the development and implementation of future regional water supplies.

Based on these conditions, the most populous areas of Region H are anticipated to incur increased water costs throughout a broader subregional area. If this happens, virtually all of the WUGs within this subregion will incur similar costs for finished treated water. The region will have to work together to minimize the socioeconomic impacts resulting from these anticipated higher water costs.

Citations

Stansel, J. July, 2000. Potential Rice Irrigation Water Conservation Measures, Water Planning Group - Region H (Lower Brazos, Trinity, and San Jacinto Rivers)

Jones, Lonnie L. Texas A&M University. 1999. *Third Party Impacts and Compensation in Water Re-Allocation: The Case of the Edwards Aquifer of Texas*.

North Central Texas Council Of Governments and U.S. Army Corps of Engineers. 1998. Lake Lewisville Use Study (var. doc.).

Tanyeri-Abur, Aysen, Lonnie Jones, and Hong Jiang, TAMU Department of Agricultural Economics for Texas Water Development Board, March 1998. *Economic Impacts of Recreational Activities and Commercial Fishing on the Texas Gulf Coast, Executive Summary.* (31 pp.)

Tanyeri-Abur, Aysen, Lonnie Jones, and Hong Jiang, TAMU Department of Agricultural Economics for Texas Water Development Board, March 1998. *Economic Impacts of Recreational Activities and Commercial Fishing on the Texas Gulf Coast, Trinity-San Jacinto Estuary.* (38 pp.)

Wade, W. W., J. A. Hewitt, and M. T. Nussbaum. 1991. Cost of Industrial Water Shortages. Spectrum Economics, Inc. San Francisco.

Other References

American Sportfishing Association. The Economic Importance of Sport Fishing. Download from Texas Parks and Wildlife Department website, last revised September 3, 1999.

Izaak Walton League of America. Passing the Buck: A Comparison of State Fish and Wildlife Agency Funding and the Economic Value of Wildlife-Associated Recreation. (data for 1996). Download from IWL website, September 15, 1999.

Lipton, Douglas W., et al., USDOC, NOAA Coastal Ocean Program Decision Analysis Series No. 5, June 1995. *Economic Valuation of Natural Resources: A Handbook for Coastal Resource Policymakers.* (131 pp.)

National Society for Park Resources. 1999. *Bibliography of Economic Impacts of Parks, Recreation, Tourism and Open Space.* Website of National Parks and Recreation Association, http://www.nrpa.org/inforctr/biblio.htm, December 1999.

Rylander, Carole Keeton, Texas Comptroller of Public Accounts, The Texas Economy, Regional Outlook, Gulf Coast: Gulf Coast Regional Forecast, (date?). Excerpt from Texas Comptroller of Public Account website, March 13, 2000.

Southwick Associates for International Assn. Of Fish and Wildlife Agencies and the USFWS North American Waterfowl and Wetlands Office, March 1995. *The Economic Contributions of Bird and Waterfowl Recreation in the United States During 1991*.

Tarrant Regional Water District, *Water Management Plan, 1999. Appendix C: Recreation Analysis.* (Contact Wayne P. Owen, Jr., TRWD, 817-335-2491, wowen@trwd.com)

Texas Parks and Wildlife Department (James A. DeLoney, Roxane Eley, Kelly Dziekan), December 1996. *1995 Texas Outdoor Recreation Plan, Assessment and Policy Plan*.

USDA-Forest Service. *Outdoor Recreation in the United States, Results from the National Survey on Recreation and The Environment*. Website of U.S. Forest Service, http://www.fs.fed.us/research/rvur/recreation/publications, December 1999.

USDI-FWS and USDOC-ESA-BOC, March 1993. *1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.*

USDI-FWS and USDOC-ESA-BOC, April 1998. *1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, Texas*.