ESPEY,
HUSTON &
ASSOCIATES, INC.
Engineering & Environmental Consultants

Document No. 890674
EH&A Job No. 11753

BRAZOS VALLEY LONG-RANGE REGIONAL WATER SUPPLY PLANNING STUDY

Prepared for:

City of Bryan
and
City of College Station

Prepared by:

Espey, Huston & Associates, Inc.
P.O. Box 519
Austin, Texas 78767

in association with
R.W. Harden and Associates, Inc.
3409 Executive Center Drive
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STATE OF TEXAS
KEN SCHROEDER
39401
REGISTERED
PROFESSIONAL ENGINEER

Ken Schroeder
8-31-90

August 1990

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WATER SUPPLY PLANNING STUDY

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EXECUTIVE SUMMARY

In April 1989, the cities of Bryan and College Station contracted with the firm of Espey, Huston and Associates, Inc. (EH&A) to conduct a regional water supply planning study for a 5-county area composed of Brazos, Grimes, Leon, Madison, and Robertson Counties. EH&A was joined in this effort by R.W. Harden and Associates, Inc. (RWH&A), consulting hydrologists and geologists. Funding for this study has come from the cities of Bryan and College Station, Texas A&M University, and matching funds from the Texas Water Development Board (TWDB). Although this study evaluates the water demands of the 5-county study area, the central focus of master planning for a regional system has been confined to Brazos County, as set forth by the terms of the TWDB matching planning grant.

Brazos County, with an area of 589 square miles, is the most populous of the 5-county region, where approximately 69% (124,389) of the total regional population resides. Similarly, Brazos County has claimed an equally high proportion (71%) of the municipal water demand within the 5-county study area. The cities of Bryan and College Station (including Texas A&M University) are the most significant municipal communities in Brazos County, generating in 1985 over 93% of the total county-wide municipal water demand.

Since 1970, each of the five counties that comprise the study area has increased in population. Brazos County has led this population growth, more than doubling its population since 1970. With regard to the future population of Brazos County, population growth is expected to continue throughout the study period (1990 - 2020). This forecasted population growth is expected to be fueled in part by increased employment in the high technology and research and development sectors of the local economy that are typically associated with the Texas A&M University system. The industrial manufacturing sectors are also expected to stimulate some growth in the Bryan-College Station area economy.

Historical and projected municipal and manufacturing water demands of the 5-county study area have been evaluated for the period of 1980 - 2020. Water demand projections for the primary study area have been developed from both the Texas Water Development Board and self-reported data provided by Bryan, College Station, and Texas A&M University. Following close coordination and a thorough review of all data, these entities selected a final set of water demand projections from which the regional master plan was developed. These final demand projections were also modelled under a water conservation scenario.

Conducted concurrently with the selection of final water demand projections was an evaluation of the projected water supply deficit for the primary study area. A water supply deficit would be encountered at the point when water demands exceed the capacity of existing facilities. The determination of a supply deficit was based in large part on a conservative estimate of the production capacity of existing ground-water wells that draw from the Simsboro aquifer. This production estimate did not include the capacity of facilities that draw from sources other than the Simsboro aquifer, nor from facilities that would be expected to be phased out of long-term use.

With a base production capacity combined for Bryan, College Station, and Texas A&M University, it was determined that a supply deficit would likely occur within the next decade if no expansions or improvements were made. The combined production capacity for these three entities was conservatively estimated at 30.24 mgd. Table ES-1 provides a summary of the water supply deficits under average day conditions, both with and without the implementation of conservation measures.

In recognition that water demands will exceed the capacity of existing facilities within the next decade, the study team evaluated four alternative sources of water supply. These alternative supplies included both ground-water and surface water sources. Based on an evaluation by RWH&A, the Simsboro aquifer presented the best available ground-water source in terms of both water quality and quantity.

Following a thorough evaluation of fifteen existing and proposed surface water supplies, three surface water alternatives were selected: (1) Lake Somerville, (2) the Brazos River, and (3) the proposed Millican Lake. The selection of the three surface water alternatives was based on a preliminary screening according to several key criteria: sufficient yield, conveyance costs, designated use, and suggestions and recommendations from either the Brazos River Authority or the Trinity River Authority.

Based on the concept of supplementing the capacity of existing facilities through the development of regional facilities, each of the four supply alternatives was comparatively evaluated. Each supply alternative was carried from preliminary engineering design through the estimation of construction costs and annual operations and maintenance costs under both with and without conservation scenarios.

The sizing of facilities and phasing of construction was based on a regional system that would act as wholesale supplier to participating entities in Brazos County. This proposed regional system would supplement the capacities of existing Bryan, College Station, and Texas A&M University facilities. It has been assumed that some flexibility would be inherent in the phasing of construction. Therefore, the initial construction phase has been set to correspond to the milestone year of 2000. A second phase of construction has been assumed to occur in 2010. This second phase would provide sufficient capacity to meet the water demands of the primary study area through 2020.

Based on a comparison of the four water supply alternatives, the study team has recommended the use of ground-water for supply of Brazos County. The ground-water supply alternative is the least-cost alternative in terms of both construction costs and annual operations and maintenance costs. Table ES-2 provides a summary of the facilities and the related construction costs for this alternative under with and without conservation scenarios. These significantly lower construction and operations and maintenance costs likewise translate into the lowest unit costs for treated water.

Although the unit cost of treated water that would be provided by a regional water system would be expected to vary over time, the initial cost per 1000 gallons has been estimated at $2.39 under the without conservation scenario for the year 2000. Assuming the implementation of conservation measures, this unit cost has been estimated at $3.57 per 1000 gallons in 2000.

Although the unit cost (per 1,000 gals.) with conservation is greater than the unit cost without conservation, there is a reduction in water demand and a corresponding reduction in the construction cost with conservation. For the ground water supply, the year 2000 average day water demands would be reduced by 2.7 mgd using conservation. The reduction in water demand will have a corresponding reduction in construction costs of approximately 20% if conservation measures are implemented. Conservation, therefore, provides significant cost savings to users of a regional water supply system.

This report also evaluates the institutional structures available to potentially create, construct, operate, and manage a regional water supply system in Brazos County. The institutional structures that have been examined in this report are:

- Regional System Operated by a Major City or Cities;
- Regional System Operated by the Brazos River Authority;
- Newly-created Water District;
- Newly-created Regional Water Authority.

Each of these structures has certain advantages and disadvantages with respect to such considerations as administration, legal powers, and assurance of accountability to participants in the regional system. The study team has recommended that the regional participants closely examine these options prior to selecting a final institutional arrangement for a regional water system.

The study team has also provided an overview of the options available to finance a regional water supply system. Generally, these include conventional long-term methods such as the issuance of general obligation bonds and/or revenue bonds, as well as use of the funds provided through the Water Development Fund.

Finally, based on the recommendation to continue the use of ground-water, the study team has provided some general guidelines for implementation of the recommended plan. These guidelines also emphasize the need to confirm participation in a regional system, as well as to tailor the sizing and phasing of facilities to optimize the relationship between capital expenditures and the participants' ability to pay.

TABLE ES-1

PROJECTED GROUND-WATER DEFICIT FROM EXISTING FACILITIES
AVERAGE DAY WATER DEMANDS
BRAZOS COUNTY

Item	1990	2000	2010	2020
Average Day Demands				
Municipal[a]	24.918	35.305	42.329	48.437
Manufacturing[a]	0.331	0.449	0.572	0.712
Total Water Demand	25.249	35.754	42.901	49.149
GW Production[b]	30.240	30.240	30.240	30.240
Surplus/(Deficit)	5.0	(5.5)	(12.7)	(18.9)
Average Day Demands with Conservation				
Municipal[c]	24.295	32.657	37.038	41.171
Manufacturing[c]	0.323	0.415	0.501	0.605
Total Water Demand	24.618	33.072	37.538	41.776
GW Production[b]	30.240	30.240	30.240	30.240
Surplus/(Deficit)	5.62	(2.83)	(7.30)	(11.54)

Note: All units in millions of gallons per day.

[a] From Table 3-6.
[b] Estimated reliable ground-water production based on Simsboro aquifer pumpage from Bryan, College Station, and TAMU wellfields.
[c] From Table 3-8.

TABLE ES-2

RECOMMENDED ALTERNATIVE

SIMSBORO GROUND-WATER

Description	Unit	Phase:[1] I Quantity	I Cost	Ic Quantity	Ic Cost	II Quantity	II Cost	IIc Quantity	IIc Cost
Well Field - Pumps, Motor, Well	Wells	16	$7,200,000	13	$5,850,000	4	$1,800,000	3	$1,350,000
Electrical and Instrumentation	Per Well	16	336,000	13	273,000	4	84,000	3	63,000
Lands and Rights-of-Way	Acres	8	80,000	6.5	65,000	2	20,000	1.5	15,000
Well Field Transmission Main	Qmax (mgd)	48.38	2,400,000	39.31	1,700,000	12.10	315,000	09.07	200,000
Lands and Rights-of-Way	Acres @50 R.O.W.	37	185,000	30	150,000	8	40,000	7	35,000
Cooling Towers and Chlorination	Qmax (mgd)	46.39	993,000	36.82	813,000	12.55	284,000	8.75	224,000
Clearwell	Gallons	2.3 million	1,288,000	1.5 million	840,000	800,000	448,000	600,000	336,000
Booster Pump Station	Qmax (mgd)	46.39	1,727,200	36.82	1,403,400	12.55	268,800	8.75	187,400
Lands and Rights-of-Way	Acres	10	50,000	10	50,000	--	--	--	--
Treated Water Transmission Main	Qmax (mgd)	46.39	6,400,000	36.82	5,528,000	--	--	--	--
Lands and Rights-of-Way	Acres	2	20,000	2	20,000	--	--	--	--
SUBTOTAL			$20,679,200		$16,692,400		$3,259,800		$2,410,400
Contingency and Engineering			4,135,800		3,338,500		652,000		482,100
TOTAL CONSTRUCTION COST			$24,815,000		$20,030,900		$3,911,800		$2,892,500

1 Construction Phases

Year	Without Conservation Plan	With Conservation Plan
2000	I	Ic
2010	II	IIc

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1.0 INTRODUCTION

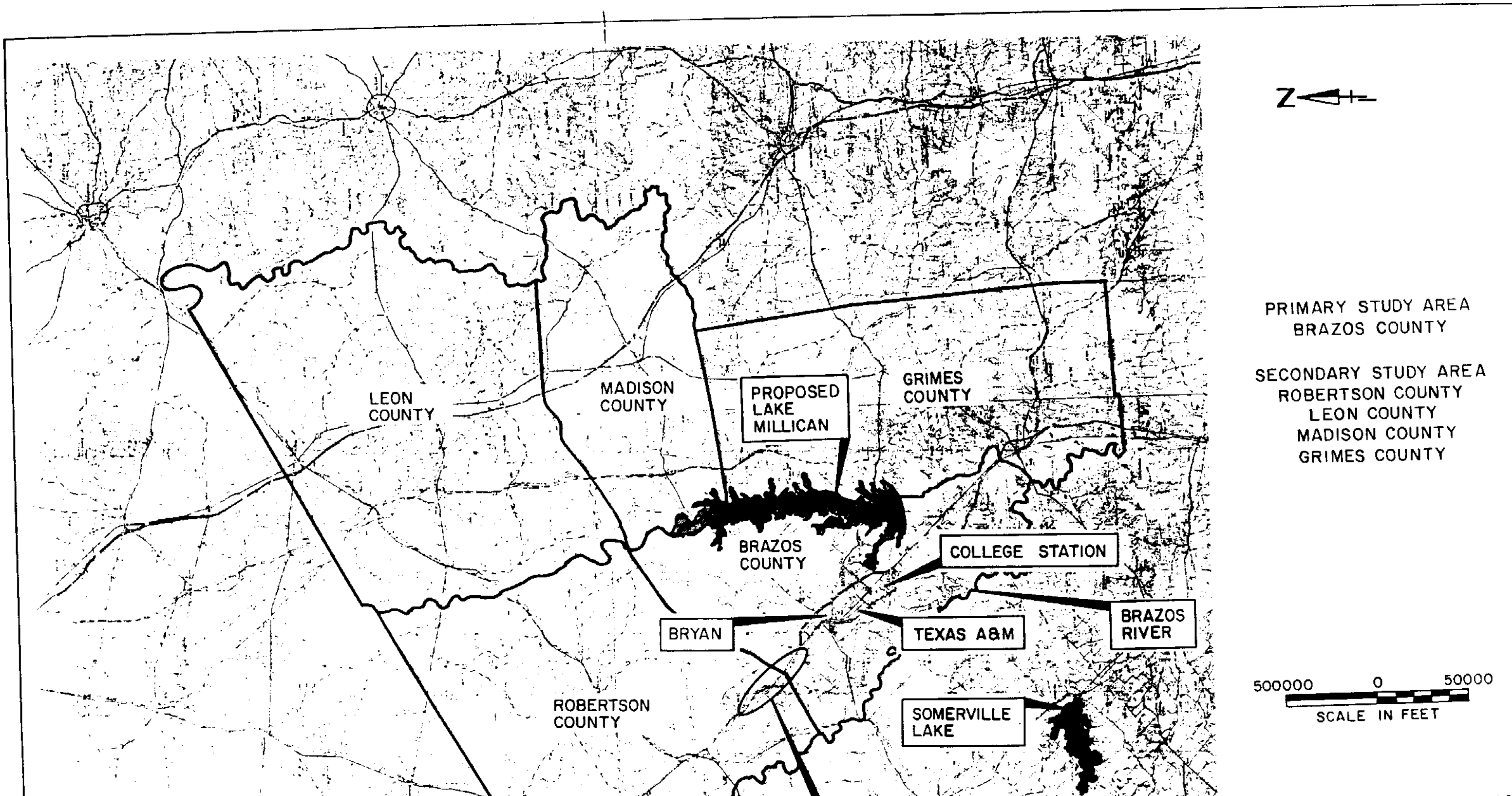
1.1 STUDY BACKGROUND

In April 1989, the cities of Bryan and College Station contracted with the firm of Espey, Huston & Associates, Inc. (EH&A) to conduct a regional water supply planning study for a 5-county area composed of Brazos, Grimes, Leon, Madison, and Robertson counties. EH&A was joined in this undertaking by the firm of R.W. Harden & Associates, Inc., consulting hydrologists and geologists. The cities of Bryan and College Station and Texas A&M University have jointly funded the plan with financial assistance provided by the Texas Water Development Board (TWDB) in the form of a matching planning grant. As defined by the terms of the planning grant, the central focus of this regional water supply plan has been on the primary study area of Brazos County. A secondary study area composed of the remaining four counties has also been evaluated with respect to a regional water system.

Underlying this regional planning effort has been close coordination with local officials and representatives of the cities of Bryan and College Station, Texas A & M University, the Brazos Valley Development Council, and the five counties that compose the study area. In addition, this coordination has extended to the many representatives of the town governments, as well as the many owners and operators of private and cooperative water supply systems throughout the 5-county area. Finally, EH&A has coordinated closely with representatives of the TWDB, drawing extensively from the State's large collection of population and water demand data. EH&A wishes to recognize the contributions of the many individuals that have made this report possible.

1.2 REGIONAL PLANNING AREA DESCRIPTION

The Brazos Valley Water Supply Planning Study encompasses a 5-county region of approximately 3,803 square miles. The study area is composed of Brazos, Grimes, Leon, Madison and Robertson counties as shown in Figure 1-1. Recent estimates (State Data Center, 1989) put the total population of the 5-county area at approximately 180,707 inhabitants, over 60% of whom



SOURCE: USGS 7.5' TOPO QUAD

ESPEY, HUSTON & ASSOCIATES, INC.
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FIGURE 1-1
PRIMARY AND SECONDARY STUDY AREAS

PROJECT NO.

are residents of the twin cities of Bryan and College Station in Brazos County. For the purposes of regional planning, Brazos County has been defined as the primary study area due to the magnitude and concentration of both its population and municipal water demand. The remaining four counties have been defined as the secondary study area because of their generally rural character. Figure 1-2 provides a schematic representation of the regional planning area with divisions among the primary and secondary study areas.

1.2.1 Primary Study Area

Brazos County, with an area of 589 square miles, is defined as a Metropolitan Statistical Area (MSA) by the U.S. Bureau of the Census. As a whole, the county is the most populous of the 5-county region, where approximately 69% (124,389 inhabitants) of the current total regional population resides. Similarly, Brazos County has historically claimed an equally high share of the total municipal water demand for the study area. In 1985, municipal water demand for Brazos County was 71% of the total municipal water demand for the 5-county area.

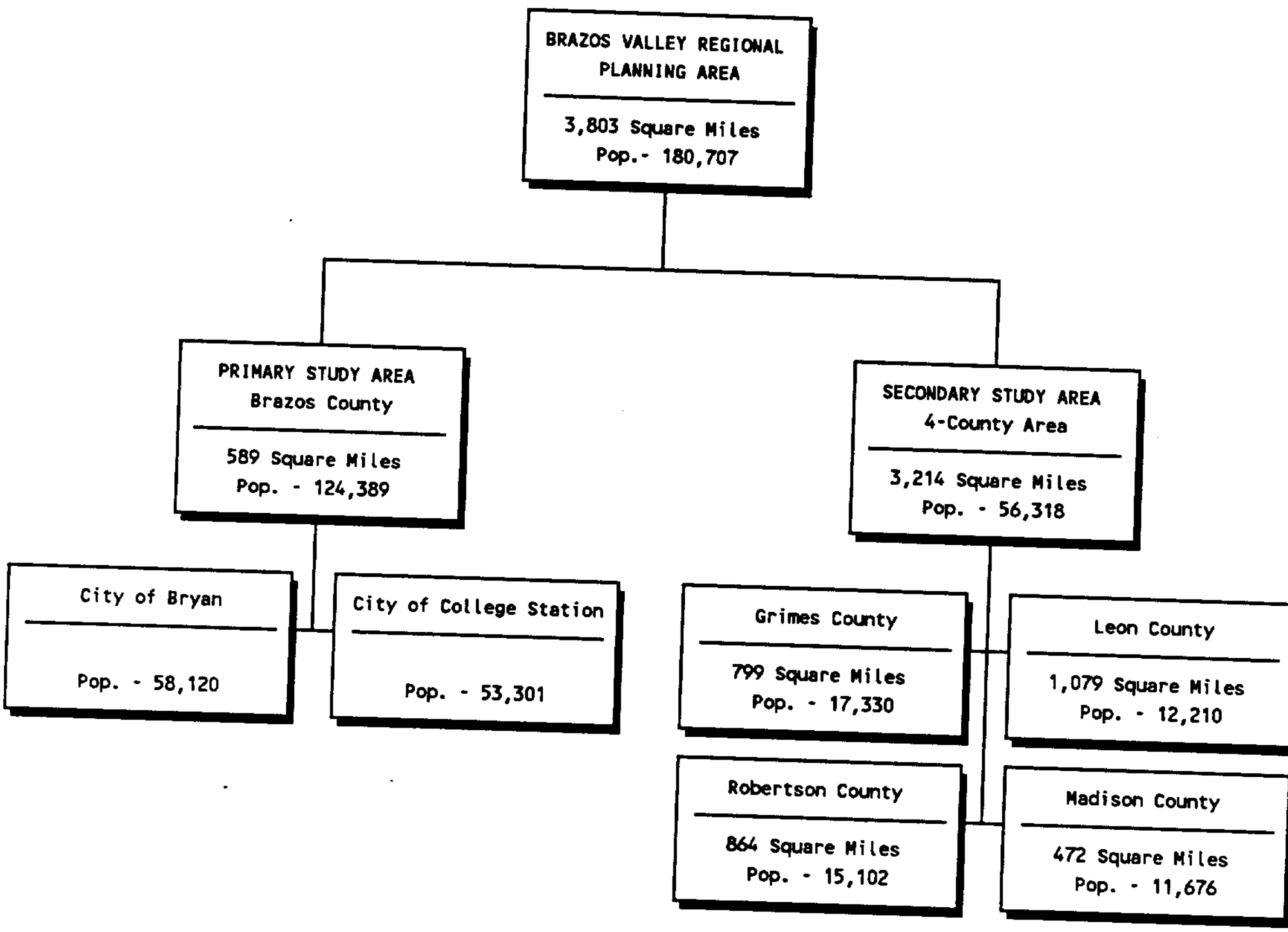
The cities of Bryan and College Station (including Texas A&M University) are the two most significant municipal communities in the county, generating in 1985 over 93% of the total county-wide municipal water demand.

1.2.2 Secondary Study Area

The secondary study area is composed of Grimes, Leon, Madison and Robertson Counties. The total combined area of these counties is approximately 3,214 square miles, with a total estimated population of 56,318 inhabitants. These counties can generally be characterized as rural, with only moderate concentrations of county inhabitants located in small communities.

The City of Navasota (Grimes County) is the largest community within the secondary study area with an estimated population of 6,773. The City of Hearne (Robertson County) is the second largest community within this area, with an estimated population of 5,813.

FIGURE 1-2
REGIONAL PLANNING STUDY AREA
Primary and Secondary Study Areas



1.3 SCOPE OF WORK

Historically, Bryan, College Station, and Texas A & M University have been the largest consumers of municipal water in Brazos County, collectively accounting for over 93% of the total county municipal water usage in 1985. In contrast to the smaller communities located throughout the secondary study area, the urban area of Brazos County is characterized by large municipal demand within a geographically central location. Therefore, this regional water supply plan focuses primarily on the long-range water needs of Brazos County.

Section 2.0 of this report begins with a definition and description of the 5-county study area. This description includes a review of the historical and current trends in population and economic growth for the primary and secondary study areas.

Section 3.0 provides an overview of the methodology and the data sources used to evaluate and develop population and water demand projections for the primary and secondary study area. Key elements of the water demand equation were reviewed in detail: population, per capita usage, peaking factors, and demand reductions through conservation. Finally, an inventory and description of existing water supply, treatment, and storage facilities was developed for the primary study area of Brazos County.

Section 4.0 describes the purposes and potential benefits of the implementation of conservation and drought contingency programs. This section includes a thorough description of the elements of the programs and also a draft water conservation plan and drought contingency plan.

Section 5.0 provides a thorough evaluation of ground-water resources in the study area, including an inventory of aquifers, water quality, and recharge characteristics. This section also evaluates the availability of existing ground-water resources to meet the future demands of the primary study area.

Section 6.0 examines the potential for the use of surface water to supplement existing ground-water supplies. An inventory of existing and proposed surface water resources has been developed and evaluated according to criteria related to available yield, conveyance costs, designated use, and recommendations by managing water authorities.

Section 7.0 describes four regional water supply alternatives that have been developed to meet the future water demands of Brazos County. The first alternative is developed on the assumption that future water needs will be met through the expansion of ground-water facilities. The remaining three alternatives assume future demands will be supplemented through the development of surface water sources. This section includes a detailed description of regional facilities, as well as associated costs.

Section 8.0 provides a comparison of the four regional water supply alternatives. This section includes an estimate and comparison of the unit costs for providing wholesale treated water via a regional water supply system. This section concludes with a recommended source.

Section 9.0 describes the institutional and financial arrangements that are potentially available to construct and operate a regional water supply system.

Section 10.0 provides guidance and recommendations for implementation of a regional water system using the preferred source of water. This section includes a discussion of the construction phases and scheduling of capital improvements.

Section 11.0 includes the overall conclusions pertaining to the development of future water resources for Brazos County.

2.0 REGIONAL SETTING

The 5-county area defined for this study encompasses approximately 3,803 square miles. The majority of the study area is located within the watershed of the Brazos River, with the remainder located within the watershed of the Trinity River. Recent estimates (TDC, 1988) for the 5-county area reveal a population of approximately 180,707 inhabitants. The majority of these inhabitants are located in Brazos County, most of whom reside in the twin cities of Bryan and College Station.

2.1 PHYSICAL

The 5-county area is situated within the vegetative communities of the Blackland Prairie and the Post Oak Savannah associations. The topography of these associations is gently rolling to hilly, with elevations in the study area ranging from approximately 150 to 500 feet above sea level. Land use is variable, ranging from the urbanized areas of Brazos County to the agricultural uses that predominate in the secondary study area. Agricultural uses consist of cultivated lands and native and improved pastures for the grazing of livestock.

The Post Oak Savannah is largely composed of native and improved pastures interspersed by some farmland. The overstory generally consists of post oak and blackjack oak, with an abundant understory of native and introduced species of grass.

The Blackland Prairies consist of generally fertile soils that have historically led to widespread cultivation. The native vegetation is characteristic of true prairies, with blackjack oak and post oak common to areas with medium to light-textured soils.

2.2 INSTITUTIONAL

The overall study area consists of Brazos, Grimes, Madison, Leon and Robertson Counties. Political subdivisions within these counties generally are divided into county and city governments, school districts, special districts, and regional water authorities that serve the public.

In most cases, some overlap of boundaries exists among each of these levels of government, although the enabled powers of each may differ.

In general, the provision of municipal water service is accomplished either through public, quasi-public or private means. Appendix A contains a list of public and private entities that provide water service within the 5-county study area. Included in this list are some local county and city governments that have local decision-making authority, although they do not provide water service.

2.3 ECONOMICS

2.3.1 State of Texas

In spite of numerous contingencies (the recovery of the real estate and financial sector, the price of oil, the success or failure of numerous local, regional, and state initiatives and programs, etc.), there are some long-range patterns in demographics and industrial performance within the state which permit long-term economic forecasting.

Some basic forecasts for future business activity within the state include the following:

- Nominal gross state product will advance at an annual compounded rate of 7.2%. When adjustments are made for anticipated inflation, real output would be expected to expand by 2.7% per year. This pace would slightly exceed projected growth for the nation through 2010 (Texas Economic Publishers, Inc., 1989).

- Personal income will increase by 7.1% per year on a compounded basis, with real gains of 2.5% forecasted.

- Aggregate employment will grow at an annual rate of 1.5%, while population will increase at an annual compounded rate of 1.3%.

among universities in the Southwest and is among the top 20 nationally. Growth potential is substantially enhanced by the 440-acre Texas A & M University Research Park. The park will serve to establish a close relationship between the research capabilities of TAMU and selected industrial and commercial entities engaged in compatible research.

Three additional industrial parks in the Bryan-College Station area offer facilities for light to heavy industry, for research and development, and for high technology industrial growth.

Employment in Brazos County is concentrated in state and local government (42%), trades (23%), services (16%) and manufacturing (7%). Each of these sectors will benefit from continued development of the research and development and industrial parks mentioned above. In conclusion, employment growth should continue at current rates over the short-term, and continue to exceed state levels over the planning period.

Secondary Study Area

The 4-county secondary study area is primarily rural, with no communities larger than 7,000 inhabitants. The covered labor force of these counties is generally employed within the local and state government, trade, services and durable goods manufacturing sectors. To a lesser extent, the construction and the transportation and public utilities sectors contribute to the local economy in terms of both covered employment and earnings. The farming sector has historically made significant contributions to earnings, particularly in Leon and Madison counties, although these contributions are not usually revealed in covered employment statistics.

Lignite mining and energy development projects are both ongoing and planned for the 4-county area and will influence growth to an undetermined extent on both the local area and a larger region.

In most cases, some overlap of boundaries exists among each of these levels of government, although the enabled powers of each may differ.

In general, the provision of municipal water service is accomplished either through public, quasi-public or private means. Appendix A contains a list of public and private entities that provide water service within the 5-county study area. Included in this list are some local county and city governments that have local decision-making authority, although they do not provide water service.

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- Personal income will increase by 7.1% per year on a compounded basis, with real gains of 2.5% forecasted.

- Aggregate employment will grow at an annual rate of 1.5%, while population will increase at an annual compounded rate of 1.3%.

- The services sector will continue to be the leading source of employment expansion, followed by manufacturing.

In general, forecasts reveal an economically healthy and viable future, as the state's economy continues to diversify. Diversification has strengthened the state's national economic interdependencies, decreasing the sensitivity of Texas' economy to local and state business fluctuations.

2.3.2 Planning Area

The following summary will discuss recent trends in population and employment growth, proposed major projects, and local economic development initiatives within the primary and secondary study areas.

Primary Study Area

Recent trends in employment and population growth, coupled with the economic growth potential of the Bryan-College Station area, provide the basis for an optimistic economic forecast for the primary study area. From 1985 to 1989, the civilian labor force has increased in Brazos County by 7.00%, compared to 1.94% for the state (TEC, 1985-89). From August 1988 to August 1989, the Bryan-College Station Metropolitan Statistical Area (MSA) saw a 2.4% increase in employment, adding an estimated 1,200 jobs during the period. Recent unemployment rates are consistently lower than other metropolitan counties.

Similarly, population grew by 2.8% annually from 1985 to 1987, compared to 1.3% annually for the state. Projections by both the TWDB and the TDC call for continued growth, at rates substantially greater than those projected for the state.

Texas A&M University (TAMU) provides the basic foundation for employment and population growth in the Bryan-College Station area. TAMU ranks first in research funding among universities in the Southwest and is among the top 20 nationally. Growth potential is substantially enhanced by the 440-acre Texas A & M University Research Park. The park will serve to establish a close relationship between the research capabilities of TAMU and selected industrial and commercial entities engaged in compatible research.

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Secondary Study Area

The 4-county secondary study area is primarily rural, with no communities larger than 7,000 inhabitants. The covered labor force of these counties is generally employed within the local and state government, trade, services and durable goods manufacturing sectors. To a lesser extent, the construction and the transportation and public utilities sectors contribute to the local economy in terms of both covered employment and earnings. The farming sector has historically made significant contributions to earnings, particularly in Leon and Madison counties, although these contributions are not usually revealed in covered employment statistics.

Lignite mining and energy development projects are both ongoing and planned for the 4-county area and will influence growth to an undetermined extent on both the local area and a larger region.

2.4 HISTORICAL POPULATION

2.4.1 Primary Study Area

In the last two decades, Brazos County has experienced steady population growth, increasing almost 35% from a 1980 population of 93,588 to an estimated 1988 population of 124,389 (TDC, 1989). The twin cities of Bryan and College Station have captured the majority of the county's population growth, increasing by approximately 31% and 43%, respectively, during the same 80-88 period. The 1988 estimated populations of Bryan and College Station are 58,120 and 53,301, respectively, for a combined total population of 111,421. Tables 2-1 and 2-2 provide a summary of historical population trends by county and city for the primary study area.

2.4.2 Secondary Study Area

The 4-county secondary study area has experienced slight to moderate population growth during the last two decades. Since 1980, the collective population of these four counties has increased 17% from 48,476 to an estimated 1988 population of 56,318, resulting in an overall net increase of 7,842 inhabitants. Refer to Table 2-1 for a summary of historical population trend by county. Table 2-2 provides a summary of population for major towns within the secondary study area.

TABLE 2-1

HISTORICAL POPULATION TRENDS BY COUNTY

	1960	1970	1980	1988
Primary Study Area				
Brazos Co.	44,895	57,978	93,588	124,389
Secondary Study Area				
Grimes Co.	12,709	11,855	13,580	17,330
Leon Co.	9,951	8,738	9,594	12,210
Madison Co.	6,749	7,693	10,649	11,676
Robertson Co.	16,157	14,389	14,653	15,102
SUBTOTAL	45,566	42,675	48,476	56,318
5-County Study Area	90,461	100,653	142,064	180,707
State of Texas	9,580,000	11,198,655	14,229,191	16,840,881

	ANNUALIZED COMPOUNDED GROWTH 60-70	70-80	80-88
Primary Study Area			
Brazos Co.	2.59%	4.90%	3.62%
Secondary Study Area			
Grimes Co.	-0.69%	1.37%	3.09%
Leon Co.	-1.29%	0.94%	3.06%
Madison Co.	1.32%	3.30%	1.16%
Robertson Co.	-1.15%	0.18%	0.38%
SUBTOTAL	-0.65%	1.28%	1.89%
Total Study Area	1.07%	3.51%	3.05%
State of Texas	1.57%	2.42%	2.13%

SOURCE: 1960-80, U.S. Bureau of the Census, 1972 and 1982.
1988, Texas State Data Center, 1989.

TABLE 2-2

HISTORICAL POPULATION TRENDS BY CITY

Place	1980	1988	Numerical Change	Percent Change
PRIMARY STUDY AREA				
Bryan	44,337	58,120	13,783	31.09%
College Station	37,272	53,301	16,029	43.01%
SUBTOTAL	83,589	113,409	29,820	35.67%
SECONDARY STUDY AREA				
Bremond	1,025	995	(30)	-2.93%
Buffalo	1,507	2,052	545	36.16%
Calvert	1,732	1,723	(9)	-0.52%
Centerville	799	915	116	14.52%
Franklin	1,349	1,456	107	7.93%
Hearne	5,418	5,813	395	7.29%
Madisonville	3,660	4,174	514	14.04%
Marquez	231	288	57	24.68%
Navasota	5,971	6,773	802	13.43%
Normangee	636	796	160	25.16%
Oakwood	606	745	139	22.94%
SUBTOTAL	22,934	25,730	2,796	12.19%

SOURCE: 1980, U.S. Bureau of the Census, 1982.
1988, Texas State Data Center, 1989.

3.0 POPULATION AND WATER DEMAND PROJECTIONS

3.1 OVERVIEW OF PLANNING METHODOLOGY

The projection of water demand is based in large part on historical trends in population growth, per capita usage characteristics, and water demand from industrial, agricultural, and other land uses that have no direct link to local population. The methodology that is used for this study is one that combines the review and evaluation of best available published data with a thorough cross-referencing of data sources.

This study employs a 30-year planning horizon, beginning in 1990 and spanning to 2020. This period was defined as reasonable in light of the availability and reliability of population and water demand forecasts, as well as the economic life of many public works projects and major capital improvements.

A primary purpose of this study is to evaluate the adequacy of existing and future water supplies to meet short-and long-term regional future water demands. Included in this evaluation is the examination of alternative supplies, in particular, the conversion of selected current ground water uses to surface water. Note that for this analysis, only the municipal and manufacturing water use categories have been included. These two categories best represent the water uses that would have the greatest potential for conversion, assuming economic and technical feasibility. The water demands from other categories (steam electric, mining, irrigation and livestock) have not been used in this analysis for several reasons. The steam electric and mining categories represent either minimal demand or have been assumed to rely on self-developed water supplies. The patterns of agricultural water demand (livestock and irrigation) and the exercise of existing water rights are not expected to significantly change in the study area. In addition, much of this demand is currently met with surface water.

3.2 REVIEW OF PLANNING DATA SOURCES

Within the 5-county study area, water demand has historically been met through supply by a wide variety of entities, including municipalities, investor-owned systems, non-profit water supply corporations, special districts, individual on-site systems, and private agricultural and industrial water supply systems. The Texas Water Development Board (TWDB) has been the clearinghouse for most historical self-reported water usage data within the state and has been relied upon extensively for water demand projections for this study. Additionally, the TWDB projections have been supplemented with data obtained by questionnaire from water suppliers (cities, water supply corporations, etc.).

Population data has been drawn from more diverse sources, including the TWDB and other state and local agencies. The data sources for both water demand and population that have been used in this study are discussed in greater detail in the following sections.

3.2.1 Texas Water Development Board

The TWDB maintains an extensive data base on both historical and projected water demand and population statistics. This data base incorporates self-reported historical data that includes, but is not limited to, ground-water and surface water sources, type of utility, category of water use, population served, and total number of connections. The TWDB projects water demand among the following water use categories: (1) municipal, (2) manufacturing, (3) steam electric, (4) irrigation, (5) mining, and (6) livestock. Much of the data compiled by the TWDB is used in the Texas Water Plan and therefore may be potentially disaggregated into a variety of geographical areas, including cities, counties, and river basins.

In the application of its projection methodology, the TWDB relies on a comprehensive approach that incorporates self-reported population, per capita usage, and non-municipal water usage into a state-wide water demand projection model. For the municipal water use category, population projections are generated under a cohort-component (survival) method under a low and high series. Projections are presented at both the county and city level.

The TWDB population projections serve as the basis for the projection of the municipal water demand category. In its simplest form, municipal water demand is derived by multiplying the projected population of the selected entity by the per capita water usage derived for the same entity. As with population, two per capita usage statistics are derived: an average and a high. Typically, the average per capita statistic represents the historical average of the most recent 10-year period, when available. The high per capita statistic is generally the highest per capita usage recorded during the same period. In all cases, these per capita statistics are applied to the projected low and high series population projections to obtain municipal water demand projections.

Additionally, the TWDB incorporates a conservation component into its municipal water demand projections. This conservation component assumes that if municipal water conservation measures were implemented the per capita usage would decline over time rather than remain constant as in the average and high per capita scenarios previously described.

Finally, the TWDB conducts an extensive program of public input in the development of population and water demand projections. Private and public interests are provided with the opportunity to review and comment on TWDB projections. Public comments and revisions are continually compiled for the updating of the state-wide water demand projection model. The TWDB has recently completed an update of the population and water demand projection model and this study reflects the most current data available.

3.2.2 Texas State Data Center

The Texas State Data Center (TSDC) of the Texas Department of Commerce is a recognized source of population statistics at both the local, county and state level. The reliability of these projections is further strengthened by TSDC's local knowledge (being prepared by the Texas Population Projections Program at Texas A&M University, College Station) and the recent date of preparation and publishing (December, 1988).

The TSDC projections are developed using a cohort-component method that is based on a 1986 update of 1980 US Bureau of the Census Population and Housing statistics. Adjustments to the base population are made for special populations that do not normally exhibit the same demographic characteristics of the local population. These special populations are usually linked with local institutions such as universities, military bases or prisons.

The TSDC projects population by county under three scenarios: 0.0, 0.5, and 1.0. Scenario 0.0 is referred to as the Zero Migration Scenario, and assumes that county inmigration equals outmigration, resulting in population growth by natural increase. Typically, this scenario serves as the base population projection and does not accurately reflect the demographic processes found in all counties. For counties that experienced growth through net inmigration, the Zero Migration Scenario (0.0) results in the lowest population projection of the three scenarios. Likewise, this scenario results in the highest projection for counties that have historically experienced population decline due to net outmigration.

Scenario 1.0 is referred to as the 1970-1980 Migration Scenario, and bases future population projections on the trends in age, sex, and race/ethnicity net migration rates of the high-growth period of the 1970's. This scenario generally results in projections that are highest for counties that have experienced net inmigration during the 1970's, while counties with net outmigration during the same period result in the lowest projections.

Scenario 0.5 is referred to as the Middle-Range Migration Scenario, and generally represents an average of the Zero Migration (0.0) Scenario and the 1970-1980 Migration (1.0) Scenario. The TSDC notes that this scenario best reflects the characteristics of recent (since 1980) population growth at the county and state level, and represents a "most likely scenario" for most counties.

3.2.3 US Bureau of the Census

The Bureau of the Census of the U.S. Department of Commerce is the source of the most comprehensive set of demographic statistics for the entire nation. In addition to conducting the national census each decade, the Bureau also maintains a wide range of population estimates for interim years. County-level population estimates developed by the Census Bureau were reviewed for the 5-county study area, but were generally found to be lower than those developed by the TSDC. This can likely be attributed to slight differences in the population estimation methodology employed by these agencies.

3.2.4 Brazos Valley Development Council

The Brazos Valley Development Council (BVDC) is the local council of governments that, in addition to the 5-county study area, also includes Burleson and Washington counties. The BVDC routinely distributes population projection data compiled from other sources. County-level population projections currently used by the BVDC were prepared by the Texas Department of Health and only extend to the year 2000. The study team reviewed BVDC data and determined that these projections would be of limited value due to the limitations of a year 2000 horizon.

3.2.5 Participant Surveys and Interviews

The study team has coordinated with local officials, utility operators and managers, and city public works staff in order to solicit insight into local patterns of water usage, existing or anticipated utility system deficiencies, and projections of future water demand and population. A survey questionnaire was prepared and distributed by certified mail to approximately 43 public and private entities within the 5-county area, including county governments, cities, water supply corporations and special districts. Thirteen questionnaires were returned, comprising a response rate of approximately 30 percent. Refer to Table 3-1 for a summary of responses. Also refer to Appendix B of this document for a sample copy of the questionnaire.

In addition, the study team has had personal communications with representatives of many local and state agencies concerning this project.

TABLE 3-1

SUMMARY OF QUESTIONNAIRE RESPONSES

BRAZOS VALLEY REGIONAL WATER SUPPLY PLANNING STUDY

Respondent	Type of System	County	Service Area	Source of Supply	'88 Average Day Demand (MGD)	Number of Connections	Interest in Participation	Water Conservation Plan
Fairview Smetana WSC	Non-Profit	Brazos	NW Brazos Co.	City of Bryan	0.058	470	No	No
Twin Creek WSC	Non-Profit	Robertson	E Robertson Co.	GW (2 wells)	0.113	560	No	No
Madison County WSC	Non-Profit	Madison	E Madisonville	GW (2 wells)	0.024	189	Yes	Yes
Wixon WSC	Non-Profit	Brazos	Wixon Valley	GW & Bryan	0.400	1,200	Yes	No
City of Navasota	Municipal	Grimes	City of Navasota	GW (5 wells)	1.000	2,200	No	No
Flo Community WSC	Non-Profit	Leon	Rural Leon Co.	GW (3 wells)	0.146	876	Not Sure	Yes
City of Buffalo	Municipal	Leon	City of Buffalo	GW (3 wells)	0.250	700	No Response	No Response
City of Calvert	Municipal	Robertson	City of Calvert	GW (3 wells)	0.343	773	No Response	No
City of Madisonville	Municipal	Madison	Madisonville	GW (3 wells)	0.680	1,728	Not Sure	No
Carlos WSC	Non-Profit	Grimes	Carlos Area	GW (4 wells)	0.175	565	No Response	Yes
City of Bryan	Municipal	Brazos	Bryan	GW (13 wells)	9.270	16,200	Yes	No
City of College Station	Municipal	Brazos	College Station	GW (4 wells)	6.800	9,767	Yes	No
Texas A&M University	Institutional	Brazos	TAMU	GW (9 wells)	6.130	na	Yes	Irrigation

3.2.6 Local Planning and Engineering Studies

The study team has reviewed and evaluated local planning and engineering reports that have been provided by surveyed cities and institutions. These documents have been used as a means to supplement and cross-reference the published sources.

3.3 POPULATION PROJECTIONS

3.3.1 Primary Study Area

Brazos County

The primary study area of Brazos County has historically experienced moderate but steady population growth over the last three decades. All but one of the county-level projections considered for this study generally indicate a continuation of this trend throughout the 30-year planning period. Table 3-2 summarizes the 1990-2020 population projections by county and by primary and secondary study area.

Figure 3-1 graphically depicts the TWDB and TSDC population projections for Brazos County. At the outset of the projection period (1990), both TWDB High and Low Series projections fall slightly below those developed by the TSDC. However, by the late 1990's this situation is reversed, with both TWDB projections exceeding those of the TSDC until 2020. From 2000 to 2020, the range of county population projections is defined at the high end by the TWDB High Series projections and at the low end by the TSDC 1.0 Scenario.

Across the 30-year period, the TWDB Low Series projections track closely with the TSDC projections, eventually falling roughly midway between the TWDB High Series and TSDC 1.0 Scenario. In addition, at its most divergent point in 2020, the TSDC "Most Likely" Scenario (0.5) is only slightly lower than the TWDB Low Series projection. Although in later years there is considerable variation among the county population projections, both the TWDB and TSDC projections confirm the trend of continued population growth in Brazos County.

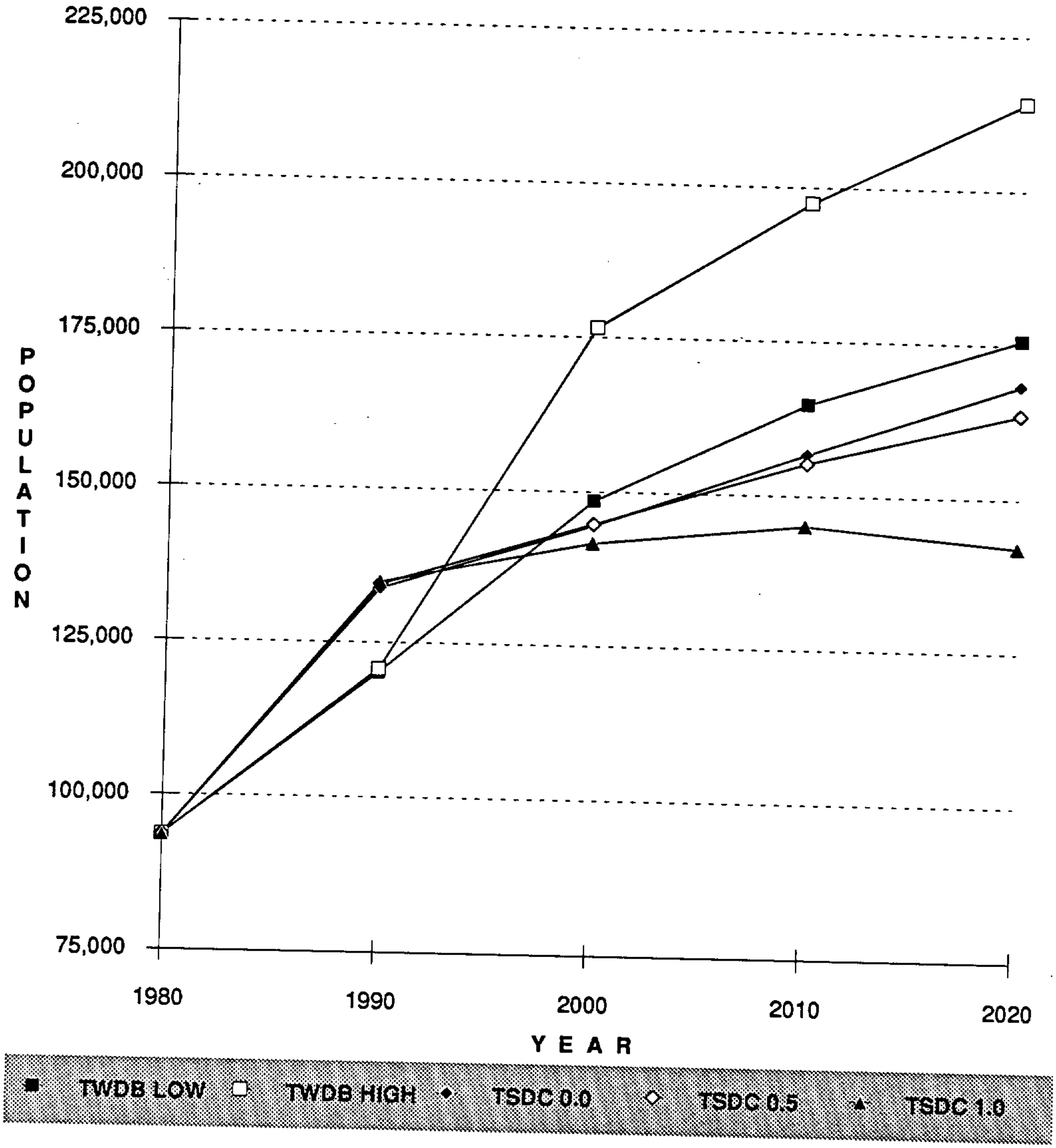
TABLE 3-2

PROJECTED POPULATION COMPARISON

	1980	1990	2000	2010	2020
Primary Study Area					
BRAZOS COUNTY					
TWDB Low Series	93,588	120,188	148,545	164,770	175,694
TWDB High Series	93,588	120,754	176,608	197,376	214,150
TSDC 0.0	93,588	133,765	144,447	156,631	168,307
TSDC 0.5	93,588	134,444	144,693	155,219	163,613
TSDC 1.0	93,588	134,780	141,655	145,081	142,092
Secondary Study Area					
GRIMES COUNTY					
TWDB Low Series	13,580	19,876	23,757	27,233	31,065
TWDB High Series	13,580	20,075	24,996	28,690	32,908
TSDC 0.0	13,580	17,918	19,982	22,765	26,096
TSDC 0.5	13,580	18,560	22,402	27,176	32,850
TSDC 1.0	13,580	19,160	24,634	31,184	38,148
LEON COUNTY					
TWDB Low Series	9,594	12,587	14,533	14,875	15,216
TWDB High Series	9,594	12,807	14,939	15,429	16,785
TSDC 0.0	9,594	12,387	12,779	13,702	14,950
TSDC 0.5	9,594	13,060	15,145	18,017	21,516
TSDC 1.0	9,594	13,684	17,499	22,247	27,329
MADISON COUNTY					
TWDB Low Series	10,649	11,871	12,893	13,661	14,388
TWDB High Series	10,649	12,153	13,289	14,104	15,195
TSDC 0.0	10,649	11,710	12,318	13,232	14,108
TSDC 0.5	10,649	12,317	14,418	17,076	20,035
TSDC 1.0	10,649	12,879	16,818	22,080	27,878
ROBERTSON COUNTY					
TWDB Low Series	14,653	15,627	16,513	17,280	18,449
TWDB High Series	14,653	15,701	16,820	17,852	20,299
TSDC 0.0	14,653	15,865	17,504	19,814	22,687
TSDC 0.5	14,653	15,910	17,556	19,788	22,498
TSDC 1.0	14,653	15,986	17,524	19,177	20,286
SECONDARY SUBTOTAL					
TWDB Low Series	48,476	59,961	67,696	73,069	79,118
TWDB High Series	48,476	60,736	70,044	76,075	85,187
TSDC 0.0	48,476	57,880	62,583	69,513	77,841
TSDC 0.5	48,476	59,847	69,521	82,055	96,899
TSDC 1.0	48,476	61,709	76,475	94,688	113,641
TOTAL STUDY AREA					
TWDB Low Series	142,064	180,149	216,241	237,839	254,812
TWDB High Series	142,064	181,490	246,652	273,451	299,337
TSDC 0.0	142,064	191,645	207,030	226,144	246,148
TSDC 0.5	142,064	194,291	214,214	237,274	260,512
TSDC 1.0	142,064	196,489	218,130	239,769	255,733
STATE OF TEXAS					
TWDB Low Series	14,229,191	17,925,073	20,854,280	23,636,765	26,565,012
TWDB High Series	14,229,191	18,303,462	22,034,172	25,711,412	30,019,490
TSDC 0.0	14,229,191	17,400,293	19,052,863	20,895,095	22,872,225
TSDC 0.5	14,229,191	17,809,286	20,682,019	23,999,093	27,723,601
TSDC 1.0	14,229,191	18,226,855	22,460,425	27,598,050	33,669,910

SOURCE: Texas Water Development Board, 1989.
Texas State Data Center, 1988.

Figure 3-1
County Population Projections
Brazos County



Municipal Population

The twin cities of Bryan and College Station are the two largest municipalities within Brazos County. In the last decade almost 90 percent of the total county population has been resident in these two cities, with the remainder located in rural and suburban areas. Generally, given the trend towards increased growth and urbanization of metropolitan areas, the vast majority of the future Brazos County population would be expected to remain consolidated in Bryan-College Station.

Population projections for Bryan and College Station have been derived from two sources: the TWDB and from data reported by the cities. Following an extensive review by city officials, the self-reported projections were selected as best representing the future population growth of these municipalities. Generally, the self-reported population projections were lower for 1990 than the TWDB projections, but in later years fall approximately midway between the TWDB High and Low Series. Refer to Table 3-3 for a summary of these projections.

3.3.2 Secondary Study Area

The 4-county secondary study area has over the last three decades experienced slight population growth. Population outmigration has in part contributed to periodic decreases in county population for all but Madison County. In 1960, the combined population of the secondary study area was 45,566 inhabitants (US Bureau of the Census, 1972). By 1970, the 4-county population had declined by approximately 6% to 42,675 inhabitants. During the period from 1970 to 1988, all counties generally experienced population growth, although the net increases were slight.

The county population projections developed by both the TWDB and the TSDC assume that population growth will continue at a slight to moderate pace throughout the 30-year planning period. Refer to Table 3-2 for a summary of population projections by county, including a secondary study area subtotal. From the initial "clustering" of TWDB and TSDC data points

TABLE 3-3

PROJECTED POPULATION COMPARISON BY CITY

	1990	2000	2010	2020
City of Bryan				
TWDB Low	62,034	64,123	70,994	74,552
TWDB High	62,327	76,238	85,043	90,870
Self-Reported	56,000	66,345	76,845	81,478
City of College Station				
TWDB Low	47,134	57,326	63,467	66,648
TWDB High	47,356	68,156	76,027	81,236
Self-Reported	44,636	57,926	65,000	74,000

Source: Texas Water Development Board, 1989
Survey Questionnaires

at 1990, the projections moderately diverge. For Grimes, Leon and Madison counties, the high end of the projection range is generally defined by the TSDC 1970-1980 Migration (1.0) Scenario; the low end is generally defined by the TSDC Zero Migration (0.0) Scenario. The range for Robertson County is defined at the high end by both the TWDB High Series and the TSDC Zero Migration (0.0) Scenario, while the low end of the projection range is defined by the TWDB Low Series. Figures 3-2 through 3-6 graphically depict the projected populations of each county and the total secondary study area.

Generally, at the most divergent point (2020), the net difference between the TWDB High and Low Series projections for all secondary study area counties is minimal. Similarly, there is generally a minimal net difference between the TWDB High and Low Series projections and the TSDC Mid-Range (0.5) Scenario throughout the 30-year period for Grimes and Robertson Counties. The net difference among the TWDB projections and the TSDC Mid-Range for Leon and Madison counties is potentially significant, although the differences only become pronounced late in the 30-year planning period.

3.4 MUNICIPAL PER CAPITA DEMAND PROJECTIONS

Population and per capita water usage are the two key components of the equation used to project municipal water demand. The study team has reviewed and evaluated per capita statistics from two sources: the TWDB and participant questionnaires.

The TWDB develops per capita statistics from self-reported data compiled from public and private water suppliers. The TWDB per capita statistics take the form of both a high and an average. The average per capita usage is typically based on the most recent 10-year period for which data is available. The high per capita statistic is typically based on the extreme reported during the same period. Both average and high statistics are developed for most major municipalities within each county.

Figure 3-2
County Population Projections
Grimes County

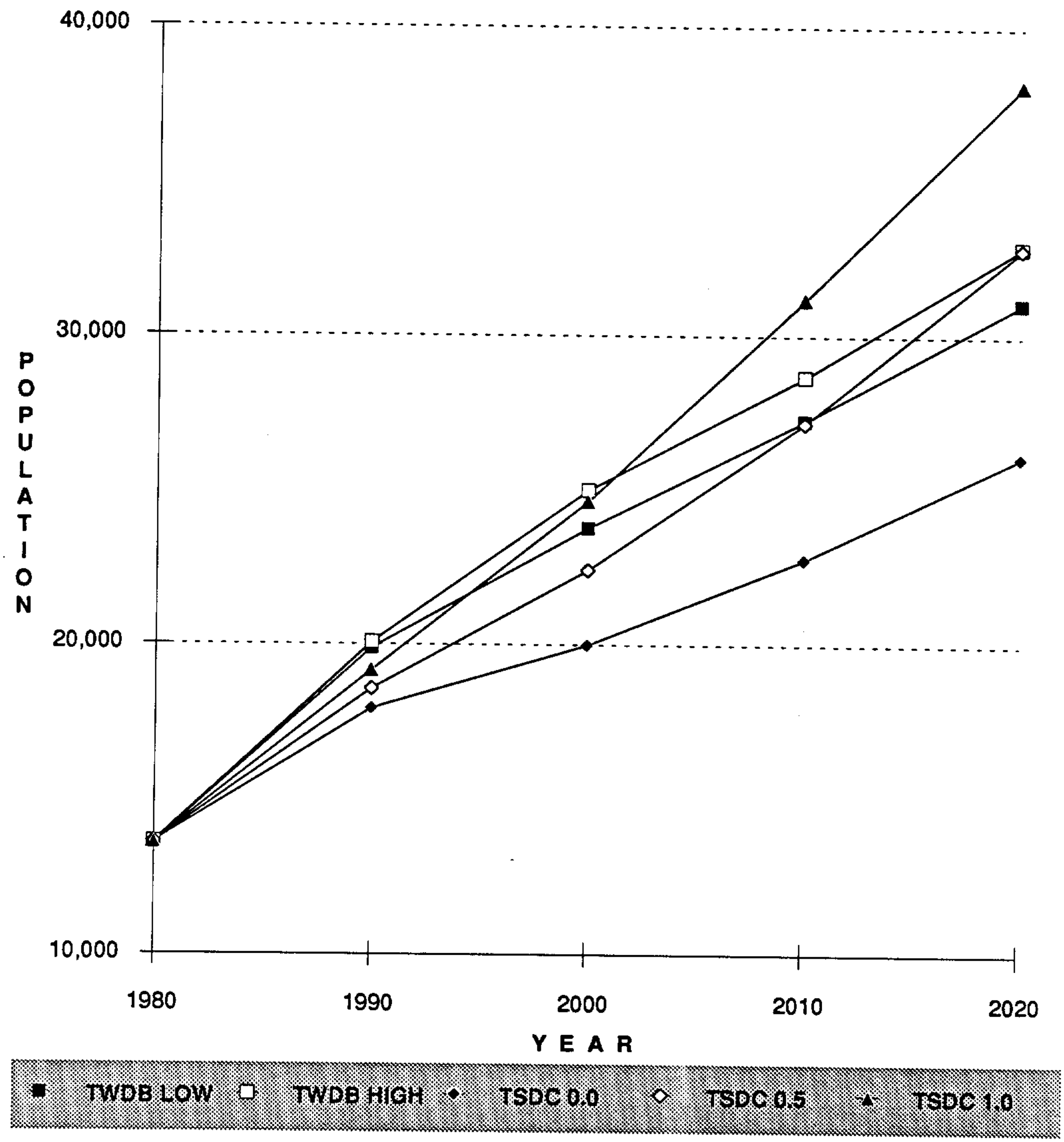


Figure 3-3
County Population Projections
Leon County

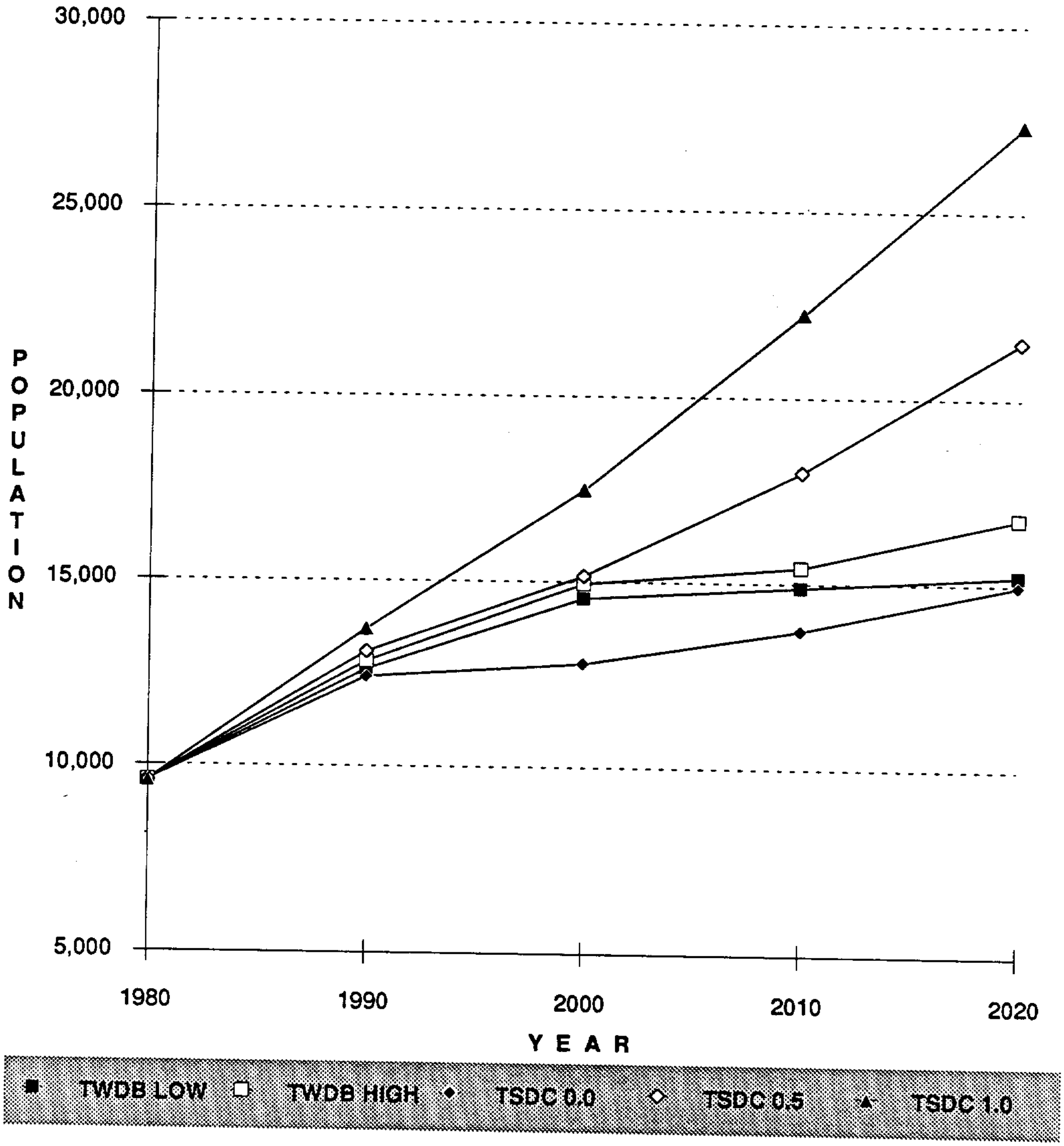


Figure 3–4
County Population Projections
Madison County

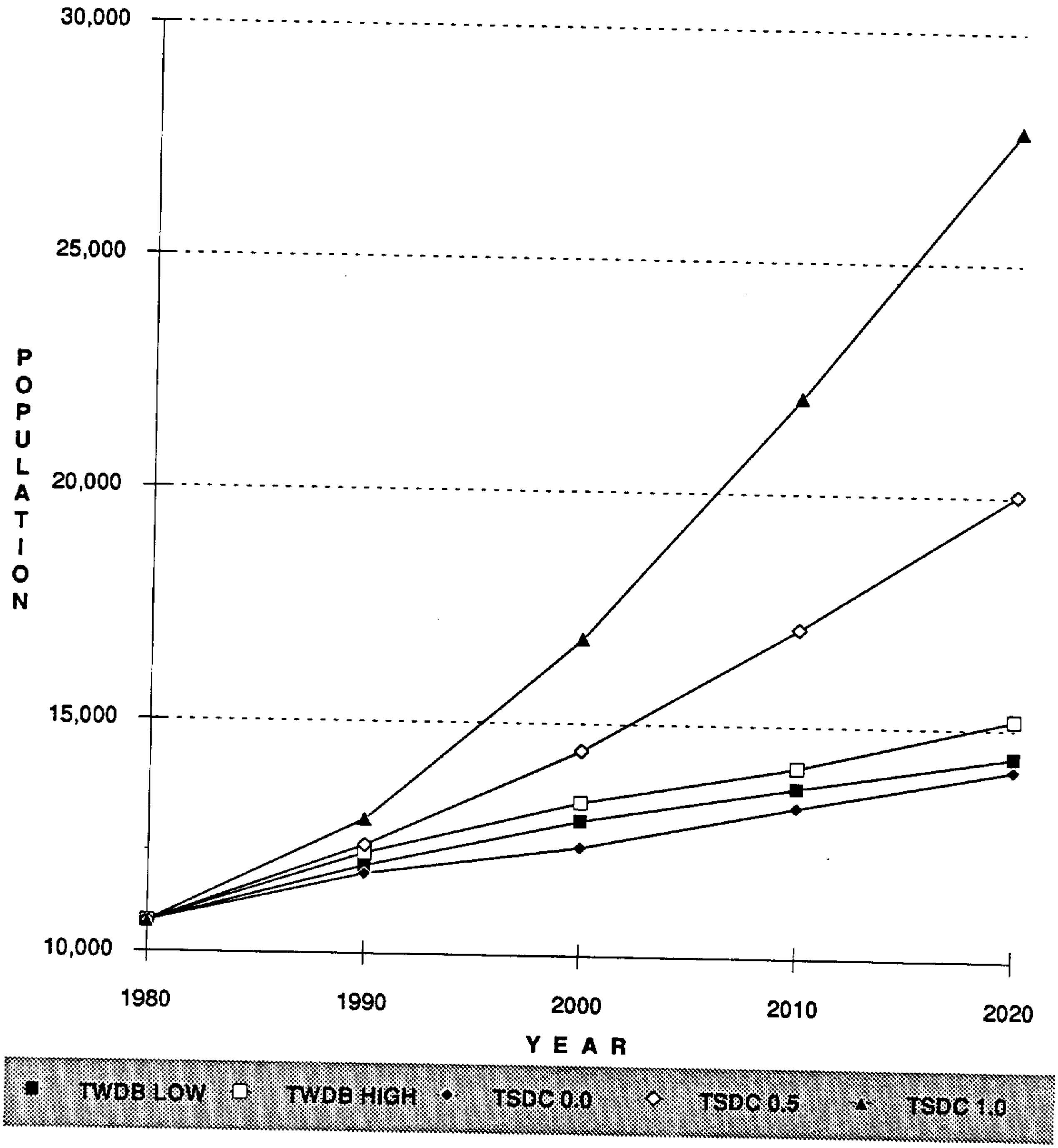


Figure 3-5
County Population Projections
Robertson County

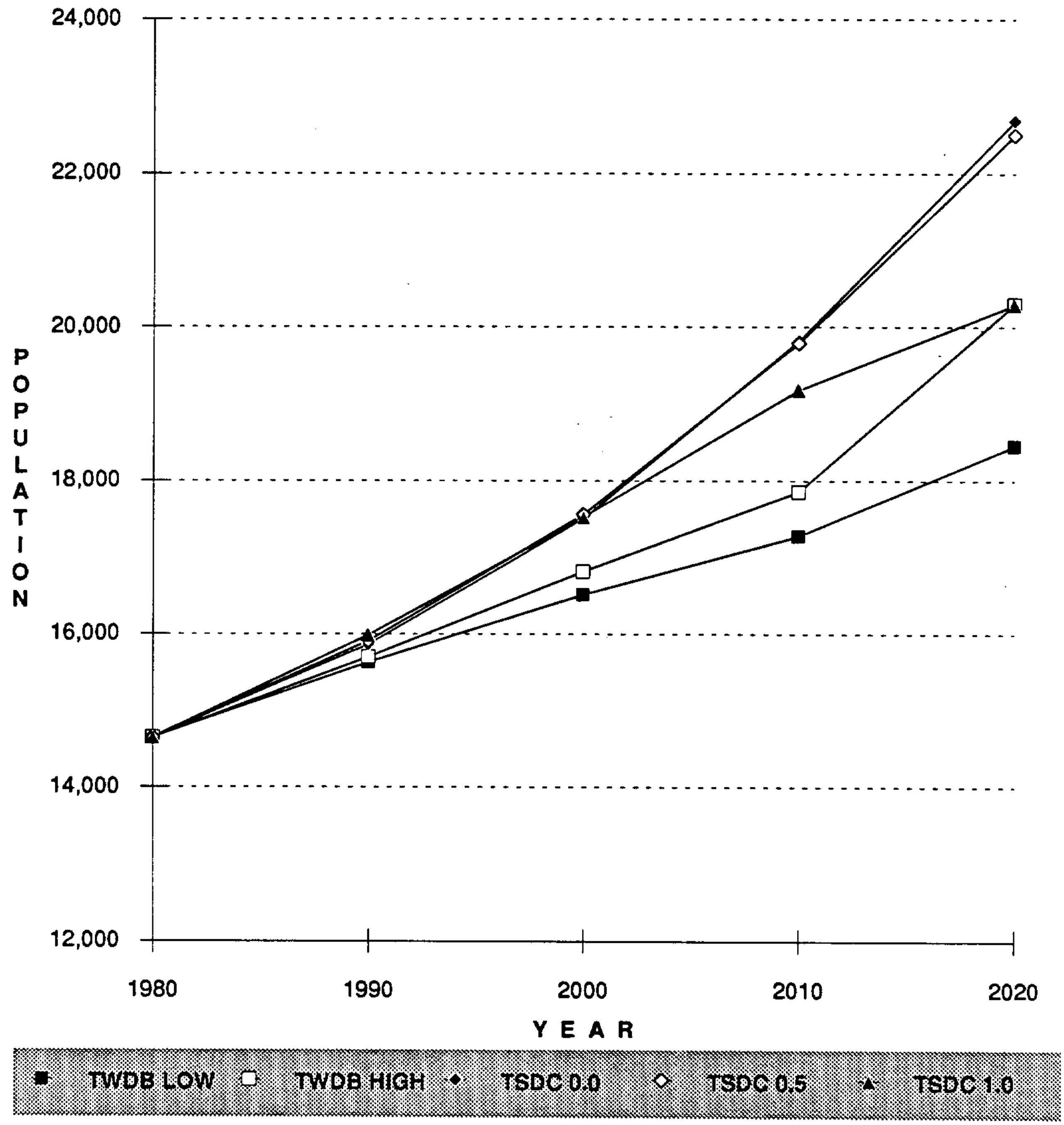
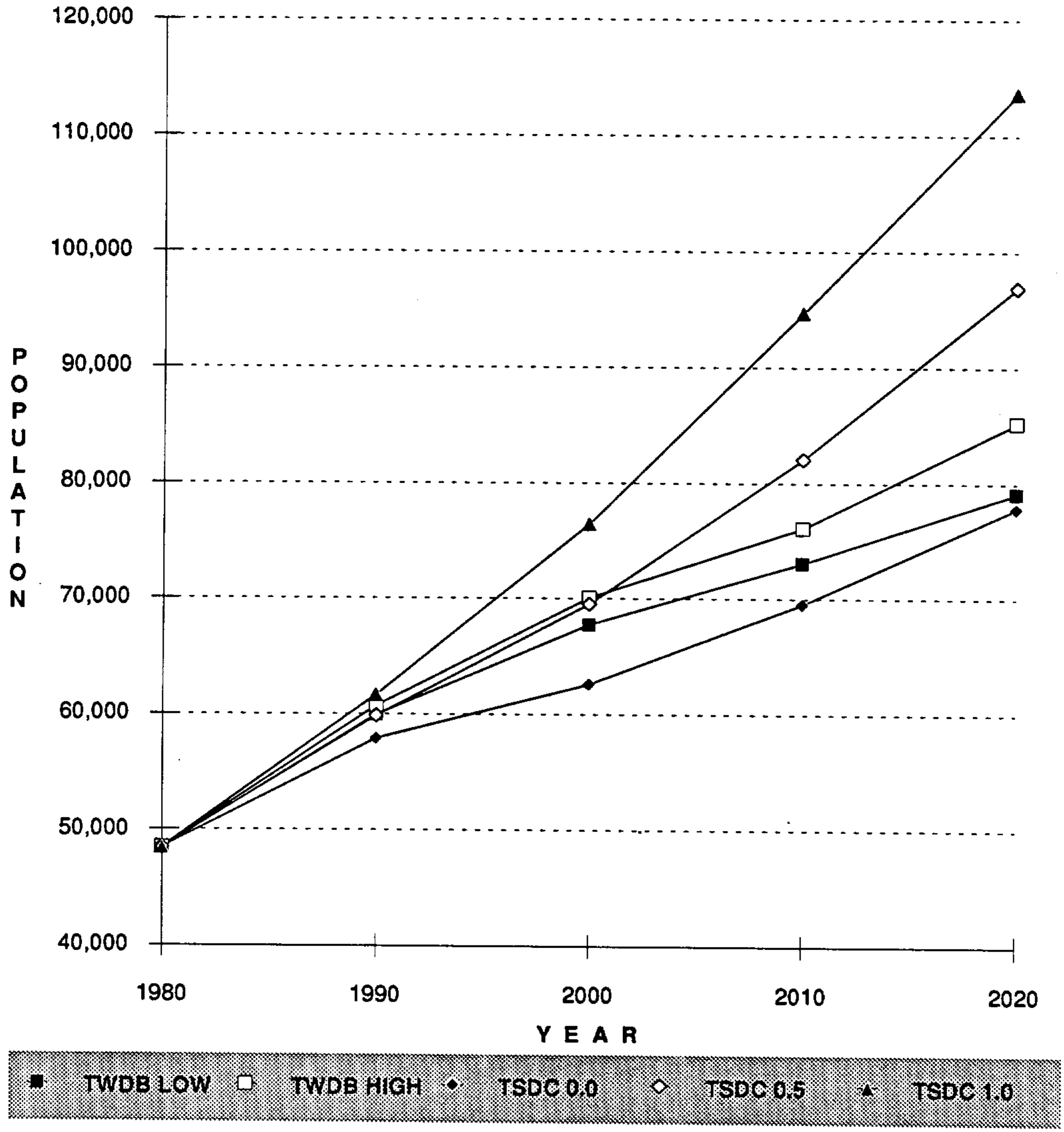


Figure 3–6
County Population Projections
Secondary Study Area



In addition, the TWDB also projects water demand based on the implementation of conservation measures. Assuming conservation, the per capita water demand is assumed to decrease over gradually over time, as opposed to remaining constant.

Based on responses to the survey questionnaire, several cities provided estimates of per capita usage and these have been incorporated into the projection model.

3.4.1 Primary Study Area

There is considerable variation in per capita water usage within Brazos County. A review of historical estimates by the TWDB reveals that rural residents use slightly over 100 gallons per capita, on average, as compared with urban residents who have been estimated to use over 245 gallons per capita on average. TWDB estimates of peak usage are even higher, reaching over 335 gallons per capita for College Station. It should be noted again that the TWDB includes the water usage of Texas A&M University with that of the City of College Station, thus leading to a higher per capita usage. Table 3-4 provides a summary of both historical and projected per capita water usage statistics for both the cities of Bryan and College Station and the rural areas of Brazos County.

3.4.2 Secondary Study Area

Due to the large area and relatively small population dispersed among rural communities, the per capita usage characteristics of the secondary study area have been addressed at the county level. Generally, per capita usage at the county level has been moderate, resulting in a projected range of between 100 and 200 gallons per person per day. Table 3-5 provides a summary of historical and projected per capita usage for the 4-county secondary study area.

3.5 MUNICIPAL AND MANUFACTURING WATER DEMAND PROJECTIONS

As noted previously, water demands within the primary and secondary study areas consist of several general use categories, as defined by the TWDB. These categories are

TABLE 3-4

HISTORICAL AND PROJECTED PER CAPITA MUNICIPAL WATER USAGE
BRAZOS COUNTY

Item	Gallons Per Day					
	1980	1985	1990	2000	2010	2020
Bryan						
Actual	173	145				
TWDB Average			160	160	160	160
With Conservation			156	148	140	136
TWDB High			185	185	185	185
With Conservation			180	171	162	157
Self-Reported [a]			164	164	164	164
College Station						
Actual	233	245				
TWDB Average			266	266	266	266
With Conservation			259	246	233	226
TWDB High			335	335	335	335
With Conservation			327	310	293	285
Self-Reported [a]			161	189	228	248
Other						
Actual	105	104				
TWDB Average			110	110	110	110
With Conservation			107	102	96	94
TWDB High			139	139	139	139
With Conservation			135	128	121	118

[a] Provided by Survey Questionnaire.
SOURCE: TWDB, 1989

TABLE 3-5

HISTORICAL AND PROJECTED MUNICIPAL PER CAPITA WATER USAGE
SECONDARY STUDY AREA

Item	1980	1985	1990	2000	2010	2020
GRIMES COUNTY						
Actual	98	146				
TWDB Average			111	111	111	111
With Conservation			108	103	97	94
TWDB High			140	140	140	140
With Conservation			136	129	122	119
LEON COUNTY						
Actual	129	128				
TWDB Average			127	126	126	125
With Conservation			124	117	111	107
TWDB High			158	158	158	158
With Conservation			154	146	138	133
MADISON COUNTY						
Actual	144	182				
TWDB Average			157	157	157	157
With Conservation			153	145	137	133
TWDB High			198	198	198	198
With Conservation			193	183	173	168
ROBERTSON COUNTY						
Actual	179	133				
TWDB Average			148	149	149	147
With Conservation			144	138	130	125
TWDB High			179	181	181	178
With Conservation			174	167	158	151

SOURCE: TWDB, 1989

municipal, manufacturing, steam electric, irrigation, mining, and livestock uses. For the purposes of this regional study, only the water demands associated with the municipal and manufacturing user classes have been carried forward into the master planning for a potential regional system. Further, master planning has focused only on the municipal and manufacturing water demand associated with the primary study area of Brazos County, although water demand projections for the secondary study area have been evaluated and presented in the following sections.

The water demand projections for the municipal and manufacturing use categories have been developed from the adopted population and per capita usage statistics discussed in previous sections of this report. In the following sections, average day and maximum day water demand projections are presented, including demands under a water conservation scenario.

3.5.1 Average Day Water Demand

3.5.1.1 Primary Study Area

The future water needs of Brazos County will continue to be dominated by the demands of the twin cities of Bryan and College Station, including Texas A&M University. To a much smaller extent, the "other municipal" category has been included to account for the water demands of smaller private water systems located within the county. Based on extensive coordination with representatives of Bryan, College Station and Texas A&M and a thorough review of TWDB data, the water demand projections for Brazos County have been derived largely from self-reported data. Table 3-6 presents projected municipal and manufacturing water demands for Brazos County under average day conditions.

Generally, the average day projections for the county for municipal and manufacturing water usage range from an estimated 25.2 mgd in 1990 to 49.1 mgd in 2020. Based on a comparison with TWDB data, these adopted projections fall below the TWDB high series projections, but above the TWDB low series water demand projections. Refer to Appendix C for a thorough comparison of TWDB and self-reported population, per capita and water demand data.

TABLE 3-6

PROJECTED AVERAGE DAY WATER DEMAND
BRAZOS COUNTY

Item	1990	2000	2010	2020
MUNICIPAL (mgd)				
Bryan [a]	9.184	10.881	12.603	13.362
College Station [a]	7.200	10.959	14.794	18.356
Texas A&M [a]	7.000	9.000	9.900	10.890
Other Municipal [b]	1.535	4.465	5.032	5.828
Municipal Subtotal	24.918	35.305	42.329	48.437
MANUFACTURING [c]	0.331	0.449	0.572	0.712
COUNTY TOTAL (mgd)	25.249	35.754	42.901	49.149

Note: All units in millions of gallons per day.
[a] Self-reported average day water demand.
[b] TWDB high population and high per capita projection.
[c] TWDB high projection.

3.5.1.2 Secondary Study Area

Municipal and manufacturing water demand in the secondary study area is generally evenly divided among Grimes, Leon, Madison, and Robertson counties in 1990, ranging from approximately 2.0 to 2.8 mgd, and totalling 9.9 mgd for the entire area. Future demands under the TWDB high series projections indicate increased water demand, although over the 30-year planning period the net increase is projected at only slightly over 3 mgd. Because of the size of the secondary study area (3,214 square miles) and the rural character of these counties, there is a wide geographic distribution of water demand throughout the area.

Table 3-7 presents a summary of municipal and manufacturing water demand projections for the secondary study area under average day conditions. All projections are based on the TWDB high series projections.

3.5.2 Average Day Water Demand with Conservation

The implementation of water conservation measures would provide participating municipalities with the opportunity to reduce water demands within the primary study area of Brazos County. The TWDB assumes that the demand reductions associated with conservation programs would occur gradually over time, beginning with a 2.5% reduction in 1990 and increasing to a 15% reduction in 2020. The factors of demand reduction used by the TWDB have been applied to both the municipal and manufacturing categories of water demand. Refer to Table 3-8 for a presentation of water demand projections for Brazos County under a water conservation scenario.

3.5.3 Peak Day Water Demand

Seasonal weather patterns are a primary factor contributing to fluctuations in municipal water demand. Certain components of a municipal water supply system are sized according to peak or maximum demands, as opposed to average demands. Peak day demand is

TABLE 3-7

PROJECTED AVERAGE DAY WATER DEMAND
SECONDARY STUDY AREA

Item	1990	2000	2010	2020
MUNICIPAL [a]				
Grimes County	2.778	3.320	3.806	4.341
Leon County	1.994	2.289	2.341	2.376
Madison County	2.346	2.550	2.702	2.842
Robertson County	2.792	2.982	3.128	3.276
Municipal Subtotal	9.910	11.141	11.977	12.835
MANUFACTURING [b]				
Grimes County	0.204	0.271	0.334	0.402
Leon County	0.135	0.112	0.121	0.121
Madison County	0.068	0.080	0.094	0.109
Robertson County	0.020	0.027	0.033	0.041
Manufacturing Subtotal	0.427	0.490	0.582	0.673
COMBINED TOTAL				
Grimes County	2.982	3.591	4.140	4.743
Leon County	2.129	2.401	2.462	2.497
Madison County	2.414	2.630	2.796	2.951
Robertson County	2.812	3.009	3.161	3.317
SECONDARY TOTAL	10.337	11.631	12.559	13.508

Note: All units in millions of gallons per day.
[a] TWDB high population and high per capita projection.
[b] TWDB high series manufacturing demand projections.

TABLE 3-8

PROJECTED AVERAGE DAY WATER DEMAND WITH CONSERVATION

BRAZOS COUNTY

Item	1990	2000	2010	2020
CONSERVATION FACTOR	2.5%	7.5%	12.5%	15.0%
MUNICIPAL (mgd)				
Bryan [a]	8.954	10.065	11.027	11.358
College Station [a]	7.020	10.137	12.945	15.603
Texas A&M [a]	6.496	8.130	8.663	9.257
Other Municipal [b]	1.496	4.130	4.403	4.954
Municipal Subtotal	24.295	32.657	37.038	41.171
MANUFACTURING [c]	0.323	0.415	0.501	0.605
COUNTY TOTAL (mgd)	24.618	33.072	37.538	41.776

Note: All units in millions of gallons per day.
[a] Self-reported average day water demand.
[b] TWDB high population and high per capita projection.
[c] TWDB high projection.

frequently calculated by applying a peaking factor to the average day water demand. In the absence of historical peak-to-average demand statistics, a peaking factor of 2.0 is commonly applied to the average, indicating that the peak day demand is 200% of the average day.

For the purposes of calculating a peak day municipal water demand for Brazos County, EH&A reviewed peaking factors reported by the twin cities of Bryan and College Station, as well as Texas A&M University. Generally, these self-reported peaking factors ranged from 1.99 to 1.57. Following consultation with representatives of Bryan, College Station, and Texas A&M University, the self-reported peaking factors were selected as best representing the historical trends of peak-to-average use. Table 3-9 provides a summary of peaking factors used for calculating the maximum day water demands. Note that a peaking factor of 2.0 has been applied to the "other municipal" demand category. The manufacturing water demand category has not had a peaking factor applied to the average day demand, reflecting the assumption that the water demand of manufacturing industries is not typically related to seasonal use.

3.5.3.1 Primary Study Area

The projected peak day municipal and manufacturing demand of the primary study area of Brazos County is presented in Table 3-9. The demands range from approximately 45.7 mgd in 1990 to 89.2 mgd in 2020. These projections do not assume the adoption or implementation of conservation and/or drought contingency measures.

3.5.3.2 Secondary Study Area

Although master planning of a regional water system has been limited to Brazos County, the projected peak day municipal and manufacturing demands for the secondary study area have been calculated for purposes of comparison. Peak day demands have been conservatively estimated using a peaking factor of 2.0 applied to the average day demand. In 1990 the peak day municipal and manufacturing water demand has been projected to be approximately 20.2 mgd, increasing to 26.3 mgd in 2020. Refer to Table 3-10 for a summary of peak day water demand projections for the secondary study area.

TABLE 3-9

PROJECTED MAXIMUM DAY WATER DEMAND
BRAZOS COUNTY

Item	1990	2000	2010	2020
PEAKING FACTOR				
Bryan [a]	1.85	1.75	1.67	1.73
College Station [a]	1.99	1.99	1.99	1.99
Texas A&M [a]	1.57	1.57	1.57	1.57
Other Municipal [b]	2.00	2.00	2.00	2.00
MAXIMUM DAY WATER DEMAND [c]				
MUNICIPAL				
Bryan [a]	16.990	19.041	21.046	23.117
College Station [a]	14.300	21.798	29.408	36.593
Texas A&M [a]	10.990	14.130	15.543	17.097
Other Municipal [b]	3.069	8.930	10.065	11.655
Municipal Subtotal	45.349	63.899	76.062	88.463
MANUFACTURING [d]	0.331	0.449	0.572	0.712
COUNTY TOTAL (mgd)	45.680	64.348	76.634	89.175

Note: All units in millions of gallons per day.
[a] Self-reported average day water demand.
[b] Assumed peaking factor.
[c] Average day (Table 3-6) times peaking factor.
[d] No peaking factor applied to manufacturing.

TABLE 3-10

PROJECTED MAXIMUM DAY WATER DEMAND
SECONDARY STUDY AREA

Item	1990	2000	2010	2020
MUNICIPAL [a]				
Grimes County	5.556	6.640	7.612	8.682
Leon County	3.988	4.578	4.682	4.752
Madison County	4.692	5.100	5.404	5.684
Robertson County	5.584	5.964	6.256	6.552
Municipal Subtotal	19.820	22.282	23.954	25.670
MANUFACTURING [b]				
Grimes County	0.204	0.271	0.334	0.402
Leon County	0.135	0.112	0.121	0.121
Madison County	0.068	0.080	0.094	0.109
Robertson County	0.020	0.027	0.033	0.041
Manufacturing Subtotal	0.427	0.490	0.582	0.673
COMBINED TOTAL				
Grimes County	5.760	6.911	7.946	9.084
Leon County	4.123	4.690	4.803	4.873
Madison County	4.760	5.180	5.498	5.793
Robertson County	5.604	5.991	6.289	6.593
SECONDARY TOTAL	20.247	22.772	24.536	26.343

Note: All units in millions of gallons per day.
[a] Based on peaking factor of 2.0 applied to average day.
[b] TWDB high projection; no peaking factor applied.

3.5.4 Peak Day Water Demand with Conservation

As discussed previously in Section 3.5.2, the adoption and implementation of water conservation measures would provide the opportunity to reduce water demands within the primary study area of Brazos County. The TWDB assumes that the demand reductions associated with conservation programs would occur gradually over time, beginning with a 2.5% reduction in 1990 and increasing to a 15% reduction in 2020. The factors of demand reduction used by the TWDB have been applied to both the municipal and manufacturing categories of peak day water demand. Refer to Table 3-11 for a presentation of water demand projections for Brazos County under a water conservation scenario.

3.6 INVENTORY OF EXISTING FACILITIES IN PRIMARY STUDY AREA

Water service within the primary study area of Brazos County is delivered through a broad range of existing private and public utility systems. The cities of Bryan and College Station are the largest systems, serving the majority of the county's municipal water needs. The Texas A&M University water system also meets the significant institutional water demand of the university and its research facilities. In addition to the three largest facilities, municipal water demand within the county is met through approximately 24 smaller systems. Table 3-12 presents a list of the existing water supply systems in Brazos County, as reported in the Water Hygiene Inventory, a data base maintained by the Texas Department of Health.

Based on a survey conducted by EH&A and supplemented with data furnished by the Texas Department of Health (TDH), a brief description of the major utility systems found in the primary service area is provided in the following paragraphs:

City of Bryan

The City of Bryan is the largest municipal system within the study area, relying entirely on ground-water sources. Bryan has 13 wells with an existing production capacity of 26.2

TABLE 3-11

PROJECTED MAXIMUM DAY WATER DEMAND WITH CONSERVATION
BRAZOS COUNTY

Item	1990	2000	2010	2020
PEAKING FACTOR				
Bryan [a]	1.85	1.75	1.67	1.73
College Station [a]	1.99	1.99	1.99	1.99
Texas A&M [a]	1.57	1.57	1.57	1.57
Other Municipal [b]	2.00	2.00	2.00	2.00
MAXIMUM DAY WATER DEMAND [c]				
MUNICIPAL				
Bryan [a]	16.566	17.613	18.416	19.649
College Station [a]	13.942	20.163	25.732	31.104
Texas A&M [a]	10.715	13.070	13.600	14.533
Other Municipal [b]	2.992	8.261	8.807	9.907
Municipal Subtotal	44.215	59.107	66.554	75.193
MANUFACTURING [d]	0.323	0.415	0.501	0.605
COUNTY TOTAL (mgd)	44.538	59.522	67.055	75.798

Note: All units in millions of gallons per day.
[a] Self-reported peaking factor.
[b] Assumed peaking factor.
[c] Average day with conservation (Table 3-8) times peaking factor.
[d] No peaking factor applied to manufacturing.

TABLE 3-12

INVENTORY OF EXISTING WATER FACILITIES IN BRAZOS COUNTY

System Name	Number of Connections	Total Production	Total Storage	Ownership	Type of System
Abbate Mobile Home Park	19	0.043	0.000	Investor-owned	Community
Benchley Oaks Subdivision	83	0.065	0.011	Investor-owned	Community
Booger's Bar & Grill	4	0.000	0.001	Investor-owned	Non-community
Brushy Water Supply Corp.	456	0.629	0.182	Trust/Coop	Community
City of Bryan	17,222	26.200	12.000	Municipal	Community
Camp Howdy	24	0.000	0.000	Investor-owned	Non-community
Carousel Mobile Home Park	30	0.016	0.008	Investor-owned	Community
City of College Station	9,466	15.840	13.000	Municipal	Community
Fairview-Smetana WSC	372	0.000	0.284	Trust/Coop	Community
Forest Lake Water System	15	0.052	0.006	Investor-owned	Community
Glenn Oaks Mobile Home Park	55	0.078	0.003	Investor-owned	Community
Handi-Plus No. 18	1	0.000	0.000	Investor-owned	Non-community
Lake Placid Subdivision	25	0.050	0.000	Investor-owned	Community
Lakewood Estates	28	0.030	0.013	Investor-owned	Community
Mara Trailer Park	48	0.022	0.008	Investor-owned	Community
Neeley River Oaks	34	0.104	0.004	Investor-owned	Community
Oakland Lake	25	0.065	0.000	Investor-owned	Community
Porterfield Apartments	18	0.086	0.000	Investor-owned	Community
Ramblewood Mobile Home Park	130	0.063	0.023	Investor-owned	Community
Sheiga Heights	14	0.036	0.000	Investor-owned	Community
Sherwood Heights Water System	74	0.050	0.013	Investor-owned	Community
Smetana Forest	41	0.043	0.006	Investor-owned	Community
Steep Hollow Circle	26	0.042	0.006	Investor-owned	Community
Texas A&M University	1,050	10.418	7.052	State	Community
TAMU - Research Annex	50	2.952	0.996	State	Community
Texas World Speedway	61	0.000	0.150	Investor-owned	Community
Wellborn WSC	1,603	0.027	0.264	Trust/Coop	Community
Wixon WSC	1,214	0.893	0.480	Trust/Coop	Community

SOURCE: Texas Department of Health, Water Hygiene Inventory, 1989.
Survey Questionnaire, EH&A, 1989.

NOTE: Production and Storage Values reported in millions of gallons per day.

mgd. Following chlorine treatment near the wellhead, potable water is conveyed to the city via a 30-inch transmission line. Storage facilities consist of four ground storage tanks and two elevated storage tanks with a total combined capacity of 12 million gallons. Proposed storage expansions by the City of Bryan include an additional 1 million gallon elevated storage tank.

The City of Bryan municipal water system provides retail service to city residents, as well as wholesale service to the Fairview-Smetana Water Supply Corporation.

City of College Station

The City of College Station is the second largest municipal system within the primary study area, also relying entirely on ground-water sources. The City of College Station currently has four wells with a total capacity of approximately 16 mgd. An additional well with an estimated capacity of 4 mgd is scheduled to be placed in service in 1991. Following chlorine treatment near the wellhead, potable water is conveyed from the well field via a 30-inch transmission line to the city distribution system. College Station has three ground storage tanks with a combined capacity of 10 million gallons, as well as two elevated storage tanks with a combined capacity of 3 million gallons. Long-range plans by the city include an additional 2 million gallon elevated storage tank to be placed in service in 1998.

The City of College Station provides retail service to city residents and wholesale service on a limited basis to the Wellborn Water Supply Corporation and the Texas World Speedway.

Texas A&M University

Texas A&M University has an estimated well production capacity of approximately 14 million gallons per day from a total of 10 wells. Transmission lines from the wellfield include 18-inch and 24-inch mains. Campus storage includes a 2 million gallon elevated storage tank and two 2 million gallon ground storage reservoirs. Storage expansions include another 2 million gallon ground storage reservoir proposed in 1990.

The Texas A&M University water system provides service to all facilities within the university complex, as well as limited wholesale service to the Wellborn Water Supply Corporation and the City of College Station.

3.7 EXISTING CAPACITY AND PROJECTION OF SUPPLY DEFICIT

For the purposes of this study, the primary study area will encounter a water supply deficit at the point when future demands exceed the capacity of existing facilities. The current ground-water production capacity of Bryan, College Station, and Texas A&M has been estimated at approximately 30.240 mgd following a review of the existing facilities (see Section 5.0). This current production capacity has been conservatively estimated and is based on certain assumptions that pertain to ground-water sources and the condition of existing facilities.

The first assumption that underlies the estimated 30.240 mgd production capacity pertains to the existing and future sources of ground-water. The majority of recent historical and current ground-water pumpage by the Bryan-College Station area occurs in the Simsboro Aquifer, and this trend is expected to continue into the future, particularly as older wells that currently pump from other aquifers would be expected to be phased out of primary operation. The Simsboro Aquifer, therefore, has been assumed to be the primary and most reliable source of ground-water that would be available to supply the future water demands of the Bryan-College Station area. Given this assumption, only the estimated production of Simsboro wells has been used to derive the total production capacity for the Bryan-College Station area.

A second assumption underlying the estimation of the current ground-water production capacity pertains to the condition of existing facilities. The cities of Bryan and College Station and Texas A&M University have been determined to have a current total of 14 wells that pump from the Simsboro Aquifer. Of these 14, it has been assumed that four of these wells will be phased out of operation, resulting in 10 fully-producing wells from the Simsboro Aquifer. Although the individual production of the 10 wells varies, an average yield of 2,100 gpm

(3.024 mgd/well) has been assumed. For a complete evaluation of the existing ground-water resources, refer to Section 5.0.

Table 3-13 provides a summary of surpluses and deficits under average day demand conditions. This table also includes demands under a conservation scenario. Table 3-14 summarizes the maximum day demands for Brazos County, highlighting projected supply deficits.

TABLE 3-13

PROJECTED GROUND-WATER DEFICIT FROM EXISTING FACILITIES
AVERAGE DAY WATER DEMANDS
BRAZOS COUNTY

Item	1990	2000	2010	2020
Average Day Demands				
Municipal[a]	24.918	35.305	42.329	48.437
Manufacturing[a]	0.331	0.449	0.572	0.712
Total Water Demand	25.249	35.754	42.901	49.149
GW Production[b]	30.240	30.240	30.240	30.240
Surplus/(Deficit)	5.0	(5.5)	(12.7)	(18.9)
Average Day Demands with Conservation				
Municipal[c]	24.295	32.657	37.038	41.171
Manufacturing[c]	0.323	0.415	0.501	0.605
Total Water Demand	24.618	33.072	37.538	41.776
GW Production[b]	30.240	30.240	30.240	30.240
Surplus/(Deficit)	5.62	(2.83)	(7.30)	(11.54)

Note: All units in millions of gallons per day.

[a] From Table 3-6.
[b] Estimated reliable ground-water production based on Simsboro aquifer pumpage from Bryan, College Station, and TAMU wellfields.
[c] From Table 3-8.

TABLE 3-14

PROJECTED GROUND-WATER DEFICIT FROM EXISTING FACILITIES
MAXIMUM DAY WATER DEMANDS
BRAZOS COUNTY

Item	1990	2000	2010	2020
Maximum Day Demands				
Municipal[a]	45.349	63.899	76.062	88.463
Manufacturing[a]	0.331	0.449	0.572	0.712
Total Water Demand	45.680	64.348	76.634	89.175
GW Production[b]	30.240	30.240	30.240	30.240
Surplus/(Deficit)	(15.4)	(34.1)	(46.4)	(58.9)
Maximum Day Demands with Conservation				
Municipal[c]	44.215	59.107	66.554	75.193
Manufacturing[c]	0.323	0.415	0.501	0.605
Total Water Demand	44.538	59.522	67.055	75.798
GW Production[b]	30.240	30.240	30.240	30.240
Surplus/(Deficit)	(14.30)	(29.28)	(36.81)	(45.56)

Note: All units in millions of gallons per day.

[a] From Table 3-9.
[b] Estimated reliable ground-water production based on Simsboro aquifer pumpage from Bryan, College Station, and TAMU wellfields.
[c] From Table 3-11.

4.0 WATER CONSERVATION AND DROUGHT CONTINGENCY PLANS

Water conservation and drought contingency plans have become an integral part of long-range water supply planning on a local, regional and statewide level. In 1985 the 69th Texas Legislature passed House Bill 2 which was subsequently implemented by a constitutional amendment approved by Texas voters on November 5, 1985. One of the provisions of the legislation and constitutional amendment was a requirement that a political subdivision must include water conservation and drought contingency plans as part of an application to the TWDB for financial assistance. The TWDB has adopted rules and guidelines for developing plans for municipal water conservation and for management of water supply problems during prolonged droughts or other periods of emergency.

The scope of this water supply planning study includes the development of a draft water conservation plan and a drought management plan. These draft plans are proposed for the cities of Bryan and College Station (including Texas A&M University) but also could be modified and adapted for other water service providers in the study area.

4.1 WATER CONSERVATION PLAN

4.1.1 Purpose

A water conservation plan is designed to reduce water use through a combination of methods which minimize waste, improve efficiency in the initial use, and encourage reuse wherever possible. There are a number of methods which can be used to reduce the quantity of water used for various functions without necessarily eliminating any uses. These methods accomplish the objective of reduced water usage with a combination of permanent changes to more efficient water-using devices and also in the habits and lifestyles of individual water users.

4.1.2 Goal

The cities of Bryan and College Station have not adopted any form of water conservation program. The cities reported water consumptions during 1988 which equate to an average usage of 173 gallons per capita per day (gpcpd) for Bryan and 159 gpcpd for College Station. The goal of the water conservation plan is to level off the historical trend of increasing per capita water use. Ultimately, per capita usages could be reduced by 5 to 10%, or more, with a well developed and comprehensive plan which is aggressively implemented and enforced.

4.1.3 Potential Benefits

An effective water conservation program can result in significant benefits for a utility and individual customers. Even without an apparent shortage of existing or potential supplies of water, conservation of natural resources is good public policy. Water conservation also will reduce environmental effects such as drawdown of ground-water levels, depletion of aquifers, or reduction in stream flows or reservoir levels.

A water utility can benefit from reductions in average and peak demands with direct cost savings in operations and better levels of service. Capital expenditures for new supply, treatment and distribution facilities can be reduced and deferred. Similar savings in wastewater system operations and capital expenditures can be realized from the expected reduction in wastewater volume.

Individual water customers will realize direct savings in costs from reductions in water and energy usage as a result of changes to conservation habits and more efficient water-using devices. Any extra cost to customers for efficient water-using devices can generally be recovered in a relatively short period. For example, a family reducing usage by 50 gallons a day would realize an annual savings of about $23 at an assumed rate of $1.25 per thousand gallons.

For a utility, a reduction of 10%, or about 15 gpcpd, in the average water usage can equate to a significant savings in water. The annual savings in water requirements would be approximately 300 million gallons and 245 million gallons, respectively, for Bryan and College Station based on the 1990 population estimates.

The water savings which result from repairs of leaks, repairs of inaccurate meters, and reduction of other losses from unauthorized or unmetered uses will produce direct benefits to a utility because lost water does not generate sales revenues.

Water savings by individual customers through conservation habits will initially decrease revenues to the utility. However, the revenues can be replaced as the water becomes available for sale to new customers without the corresponding cost for extra capacity; in effect, conservation is a source of supply.

In summary, the potential benefits from a water conservation plan are maximized when a plan becomes integrated with long-range water planning and also with the overall management and operation of an efficient water system.

4.1.4 Elements of Plan

The TWDB guidelines include nine elements which must be considered in developing a water conservation plan. The specific activities of each element which are feasible and appropriate for the entity and its particular circumstances should be included in the plan.

The nine plan elements to be considered are:

1. Education and Information
2. Plumbing Codes
3. Retrofit Program
4. Water Rate Structure
5. Universal Metering and Meter Maintenance

6. Water Conserving Landscaping
7. Water Audits and Leak Detection
8. Recycling and Reuse
9. Implementation and Enforcement

4.2 DROUGHT CONTINGENCY PLAN

In addition to a water conservation plan, a water utility should also plan for management of water supply problems during prolonged droughts or other periods of emergency. Consumer demands significantly increase during summer drought periods, and extended periods of high usage can cause failures or problems with certain components of the water system. Even during times of average demand, a major breakdown or other disaster could cause a crisis because of a loss of water supply or an inability to treat or deliver sufficient water.

4.2.1 Purpose

A drought contingency plan is designed to significantly reduce water demand during a temporary emergency, using voluntary and/or mandatory procedures that may even prohibit certain water uses during the emergency. The existence of a plan will facilitate a more reasonable, effective, and efficient response to a sudden emergency.

4.2.2 Elements of Plan

The TWDB guidelines list the following six elements to be included in a drought contingency plan:

1. Trigger Conditions
2. Drought Contingency Measures
3. Information and Education
4. Initiation Procedures

5. Termination Notification
6. Means of Implementation

DRAFT WATER CONSERVATION PLAN

I. Education and Information

Several methods will be used to educate and inform water users about the benefits of water conservation and of ways to save water.

A. Initial Program

1. Publish an article in the local newspaper announcing the adoption of the plan, providing information on the availability of details of the plan, and notifying the public of the intent to distribute educational materials.

2. Distribute an initial announcement of the plan, fact sheet, and educational material to existing customers.

3. Maintain a supply of the educational brochures and pamphlets which are available from the TWDB and other sources.

4. Provide a supply of the brochures and pamphlets for distribution at city offices, schools, libraries, and other public places.

5. Provide a packet of the conservation plan fact sheet, brochures and pamphlets to new customers.

B. Long-Term Program

1. Continue the distribution of brochures and pamphlets to new customers and once a year as inserts in water bills.

2. Cooperate with builders, developers, businesses, governmental agencies, schools, and Texas A&M University to develop water conservation exhibits and programs for inclusion at seminars and trade association conventions.

II. Plumbing Codes

Adopt a plumbing code which requires the use of water saving fixtures for all new construction and for replacements in existing structures. The standards that are recommended by the TWDB represent readily available products and technology at a minimal, if any, extra cost over previous standards.

The standards are:

Tank-type toilets	- Maximum 3.5 gallons per flush
Flush valve toilets	- Maximum 3.0 gallons per flush
Tank-type urinals	- Maximum 3.0 gallons per flush
Flush valve urinals	- Maximum 1.0 gallons per flush
Shower heads	- Maximum 3.0 gallons per minute
Lavatory and kitchen faucets	- Maximum 2.75 gallons per minute
Hot water lines	- Insulated
Swimming pools	- Recirculating filtration equipment

Revisions to the standards will be considered and adopted as improved products become available, practical, and economical.

III. Retrofit Program

Provide information through the education program to plumbers and customers about the advantages and availability of retrofit devices for fixtures in existing homes and businesses.

Encourage the voluntary installation and use of low-flow shower heads, faucet aerators, and toilet dams. Encourage local retail stores which sell plumbing supplies to include low water-using fixtures in their inventory.

IV. Water Rate Structure

Consider and evaluate the adoption of a water rate structure which encourages water conservation. Such rate structures include an increasing block rate, a continuously increasing rate, peak or seasonal load rates, and excess use fees. Require a uniform rate structure as a minimum condition of any future contract for sale of water to other utilities.

V. Universal Metering and Meter Maintenance.

Require meters for all water users, including separate meters for each living unit in multi-family complexes and also for all utility, city, and other public facilities.

Establish a meter maintenance program which includes regularly scheduled testing and repairs and replacement as necessary. Meters should be inspected and/or tested for any apparent problem and upon customer complaint for any unusual and significant variation in normal usage. The recommended regular testing schedule is as follows:

Production (master) meters	-	once a year
Meters larger than 1"	-	once a year
Meters 1" or smaller	-	once every ten years

VI. Water Conserving Landscaping

Provide information through the education program to homeowners, home builders, developers, business owners, landscapers, and irrigation contractors about the methods and benefits of water conserving landscaping.

IX. Implementation and Enforcement

The process of developing and adopting a water conservation plan will include the appropriate resolutions, policy statements, city code revisions, and budget allocations necessary to implement the various elements of the program. A program administrator will be responsible for directing the implementation and enforcement of the program and also for monitoring public response and compliance. An annual report will be prepared on the progress, public acceptance, effectiveness, and net benefits of the program.

An acceptable water conservation plan will be required as a condition of a contract between a regional authority and its customer utilities.

DRAFT DROUGHT CONTINGENCY PLAN

I. TRIGGER CONDITIONS

Trigger conditions will be set to indicate the need for drought contingency measures to be put into effect. Trigger conditions will be set for mild, moderate, and severe conditions to indicate the need for the corresponding level of contingency measures.

A. Mild Condition

1. Daily water usage is at or above 90% of the firm capacity of the water system for three consecutive days.

2. Weather conditions, forecasts, and the season of the year indicate a continuing and possibly increasing level of demand on the water system.

B. Moderate Condition

1. Daily water usage is at 100% of the firm capacity of the water system for three consecutive days.

2. Weather conditions, forecasts, and the season of the year indicate a continuing and possibly increasing level of demand on the water system.

C. Severe Condition

1. Daily water usage exceeds the firm capacity of the system for three consecutive days.

2. Weather conditions, forecasts, and the season of the year indicate a continuing and possibly increasing level of demand on the water system.

3. Regardless of recent water usage and drought conditions, there is an impending or actual failure of a major component of the water system which could cause a serious disruption of service to part or all of the service area.

The trigger conditions will be modified when plans and projects for a regional system are finalized.

II. DROUGHT CONTINGENCY MEASURES

Drought contingency measures and an implementation plan will be established for the corresponding levels of trigger conditions. The measures for the second and third levels of severity will include the measures of the preceding level.

A. Mild Condition

1. Advise the public through the news media that the trigger condition has been reached and provide daily updates until the situation has returned to normal.

2. Encourage the public through the news media to voluntarily reduce water consumption by using to the greatest extent possible the suggested steps included in the news release.

3. Advertise and promote a voluntary lawn watering schedule.

B. Moderate Condition

1. Continue the public information program and emphasize the continuing and increasing severity of the problem.

2. Advise the public of a mandatory lawn watering schedule which restricts a customer to off-peak times of a certain day on a recurring schedule.

3. Prohibit ornamental and other non-essential water uses.

4. Encourage industrial and commercial users to stop or modify water usage where possible.

C. Severe Condition

1. Continue the public information program and emphasize the critical nature of the problem.

2. Prohibit all outdoor water uses such as lawn watering, car washing, street and driveway washing, swimming pool filling, and other non-essential uses.

3. Enforce all restrictions and penalize those who fail to comply.

III. INFORMATION AND EDUCATION

After adoption of a drought contingency plan, all customers will be informed of the trigger conditions, corresponding contingency measures, and the means of implementation of the plan. The news media and also letters and brochures for water customers will be used to inform and educate the public upon adoption of a plan. The news media will be used to provide daily information and updates throughout the duration of an emergency.

IV. INITIATION PROCEDURES

Formal written procedures will be established to ensure that the plan will be understood and capable of being implemented almost immediately if necessary. A program administrator will be responsible for beginning notification procedures and advising the public about approaching trigger conditions with sufficient advance notice. All required regulatory ordinances and contract provisions will be established. Notification procedures and press releases will be prearranged and coordinated with all the news media.

V. TERMINATION NOTIFICATION

The news media will be used to inform the public about successful results of the drought contingency plan, improving conditions and the corresponding downgrading of contingency measures, and the termination of the emergency.

VI. MEANS OF IMPLEMENTATION

The drought contingency plan will be implemented and enforced with all necessary and appropriate resolutions, policy statements, ordinances, plumbing code revisions, contract revisions, and budget allocations. A program administrator will be responsible for directing the implementation of the program and monitoring public response and compliance.

5.0 GROUND-WATER RESOURCES

5.1 GENERAL DESCRIPTION

Several aquifers representing substantial ground-water resources exist in parts of the five-county planning area. The Sparta Sand, Queen City Sand, Carrizo Sand and Wilcox Group (composed of the Calvert Bluff, Simsboro and Hooper Formations) are each important water sources in some parts of the five-county area. The Simsboro is by far the most important and currently furnishes water to the three largest users in Brazos County. This study emphasizes the Simsboro Aquifer because of its wide lateral extent and large potential for additional development. The Simsboro is capable of meeting projected future water needs for College Station, Bryan, and Texas A&M University through the year 2020.

Other aquifers including the Sparta, Queen City, Carrizo, Hooper, and Calvert Bluff furnish supplies to numerous, widely-scattered, mostly small users. These aquifers are capable of furnishing additional quantities of water over the northern part of the planning area, and resources are sufficient to meet the small to moderate future water needs of most current users. Some other aquifers exist in the southern part of the planning area, particularly in Grimes County. These include sands in the Yegua, Jackson, Catahoula, and Fleming Formations. Except for the Fleming in southernmost Grimes County, only small amounts of water are reported available from these units. However, because future projected demands in the southern part of the study area are relatively small, these aquifers are probably capable of supplying most of those needs. If well fields are located in southernmost Grimes County in the Fleming, all water demands for Grimes County could likely be met through the year 2020.

5.2 SIMSBORO AQUIFER

5.2.1 Character, Location and Extent

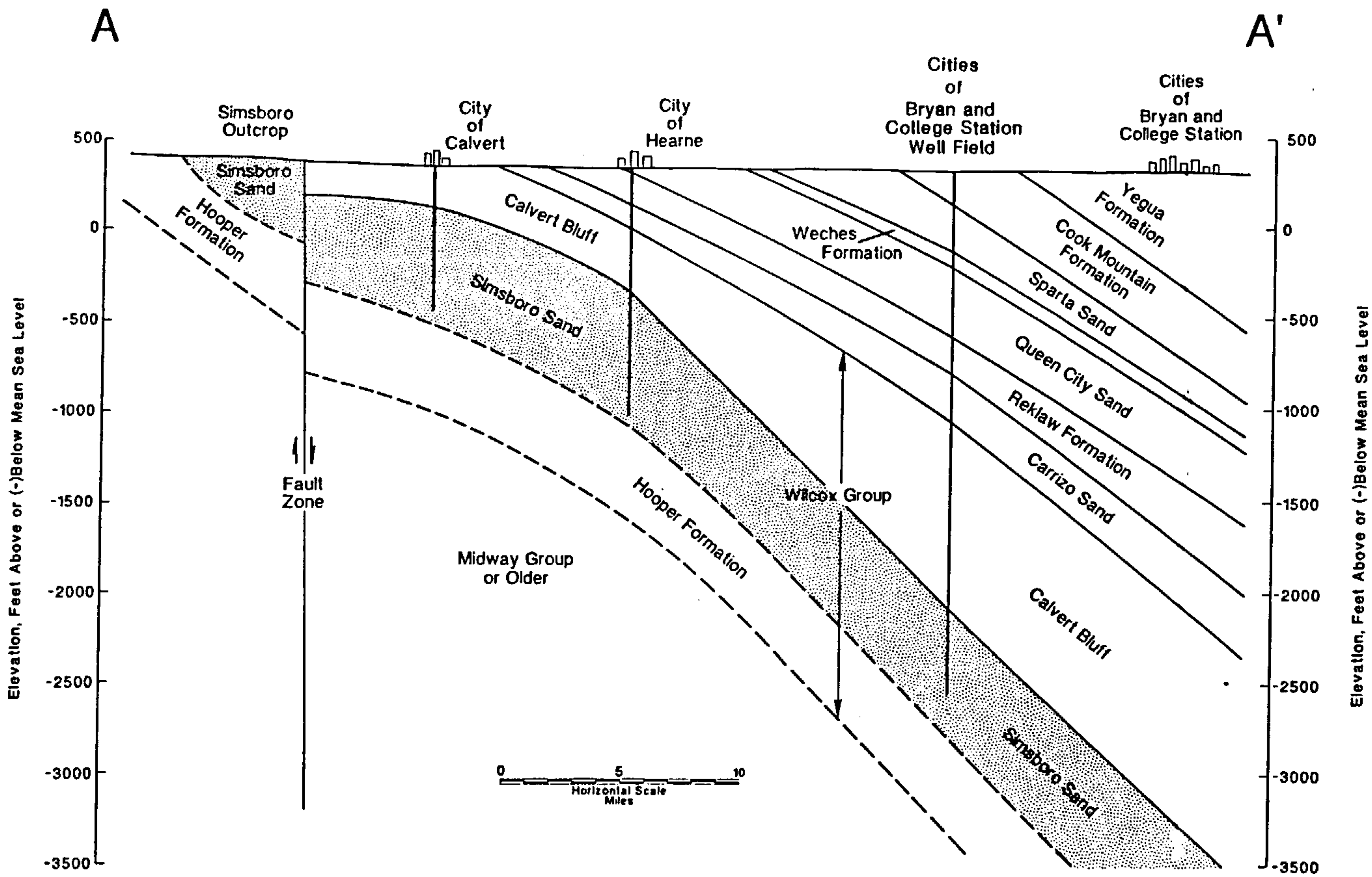
The Wilcox Group is comprised, from shallowest to deepest, of the Calvert Bluff, Simsboro and Hooper Formations. The Simsboro exists throughout the entire five-county area, but comprises an important fresh water aquifer in only the northern half of the study area. Figure 5-1 is a schematic cross section which shows the position and thickness of the more important geologic and water-bearing units, including the Simsboro. The section extends from northern Robertson County to the Bryan-College Station area and passes through the Cities of Calvert and Hearne, and through the City of College Station's well field. Within the five-county area, the Simsboro outcrops at the surface only in the very northwestern corner of Robertson County as shown on Figure 5-2. Elsewhere, the Simsboro outcrop extends across about 150 miles of Central Texas from near Bastrop to beyond Fairfield.

The northwestern extent of the Simsboro Aquifer corresponds to the northwestern edge of the Simsboro outcrop. From the outcrop the Simsboro extends southeast as a thick, consistent sand unit. The Simsboro is thin only in the northwestern part of its outcrop. It thickens downdip to the southeast and is typically 300 to over 600 feet thick. The Simsboro dips to the southeast at an average rate of about 100 feet per mile. Near Calvert, the position of the Simsboro is affected by faulting within the Mexia-Talco Fault System. Coastward, the Simsboro occurs at progressively greater depths, reaching a depth of over 3,000 feet near Bryan. Water-table conditions exist in the sands of the Simsboro in the outcrop area, but artesian conditions exist in all areas downdip to the southeast.

The Simsboro is one of the thickest water-bearing sands in Texas and is typically a massive, thick-bedded zone consisting mostly of fine- to medium-grained, well-sorted sands. The Simsboro contains some, but relatively few, beds of clay and silty clay. Generally in the Bryan-College Station area, the Simsboro consists of over 70 percent of fine- to medium-grained, moderately permeable sand. Screen lengths in wells of Bryan and College Station range from 250 feet to over 450 feet.

The extent of the Simsboro capable of furnishing potable water, up to 1,000 milligrams per liter (mg/l) or less of total dissolved solids content, encompasses only the northern half of the five-county area. Figure 5-2 shows the approximate extent of potable or fresh water in the Simsboro. The fresh/brackish water boundary generally extends from near Bryan to Normangee and into the very southeastern portion of Leon County. The boundary shown on

Figure 5–1
Schematic Cross Section A - A'



Note: Stratigraphic boundaries dashed where inferred.
See Figure 2 for location of Schematic Cross Section A - A'.

Figure 5-2
Extent Of Simsboro Aquifer

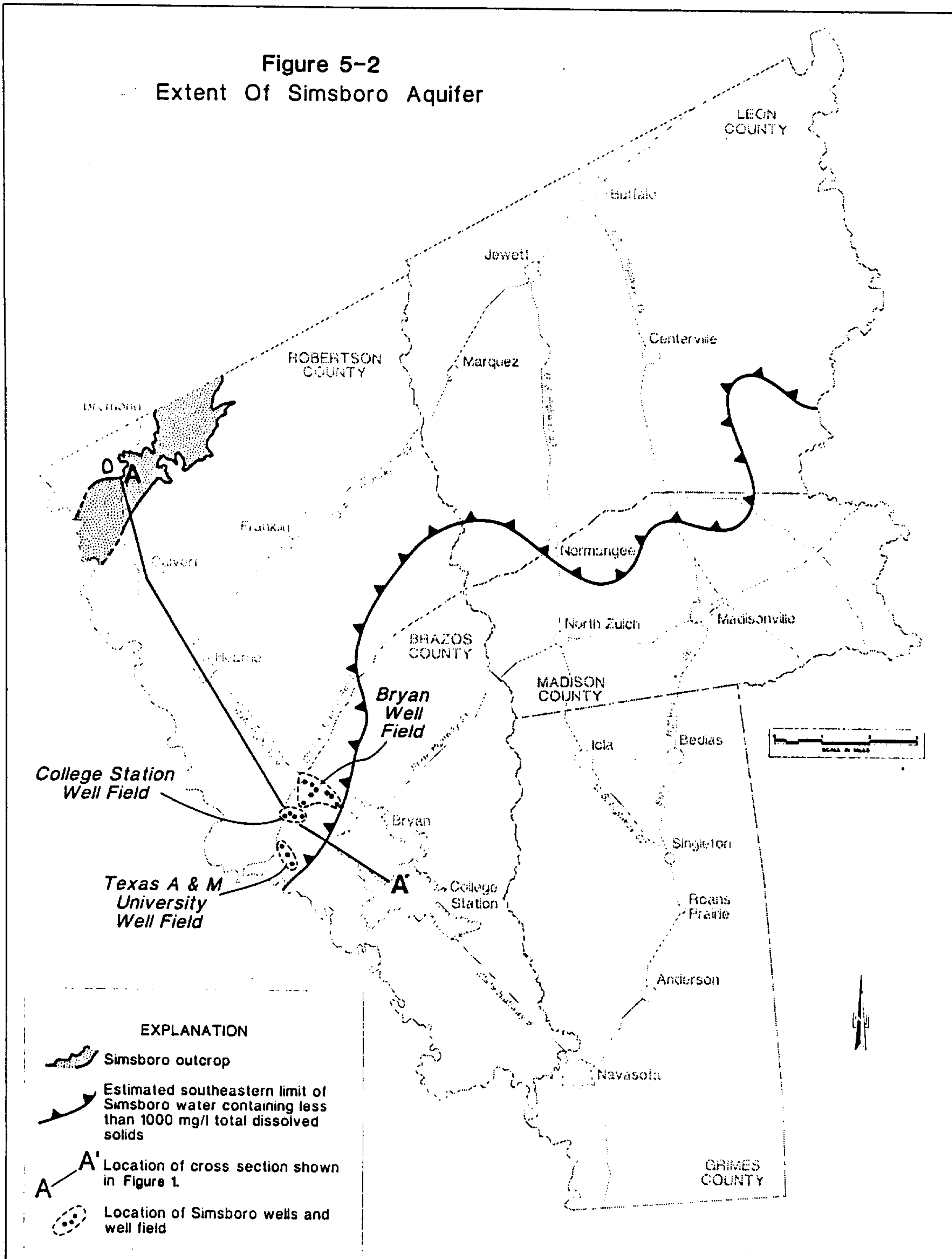


Figure 5-2 is from Texas Water Commission (1989) mappings as modified in the local Bryan-College Station area to reflect site specific data.

5.2.2 Present Use

Included in tables showing water demand projections to 2020 are water use figures for the five-county area for 1980 and 1985. The values reflect both ground water and surface water use, and the only significant surface water use is by a power plant in Grimes County. Virtually all of the other present and past water use in the five-county area has been from ground-water sources.

Table 5-1 provides the 1987 municipal and industrial use from ground-water sources by county. Virtually all use is for municipal purposes with only low amounts used for industrial purposes. Some irrigation use occurs, but virtually all is from shallow alluvial sources located adjacent to the Brazos River. Neither the Simsboro nor the other aquifers addressed herein furnish significant amounts of irrigation pumpage.

Table 5-2 provides the 1987 municipal ground-water use by aquifer and user according to reports to the Texas Water Development Board (1989). The aquifer/formation identifications are those used by the Texas Water Development Board, and they do not always attribute ground-water use to individual aquifers. In cases where a user obtains supplies from two aquifers, the amounts are frequently grouped together and listed in a combined category. For example, nearly all of the City of Bryan's and Texas A&M University's use is from the Simsboro, with only a little being from the Sparta. The listing shows this pumpage under the aquifer heading Wilcox Group/Sparta Sand. There are other small inconsistencies such as the City of Hearne being listed under Carrizo Sand/Wilcox Group when in actuality all of the pumpage is from the Simsboro portion of the Wilcox.

Based on the available records, reports of owners, and estimates of the applicable water-bearing units, the estimated distribution of pumpage by individual aquifer units for 1987 for the five-county area for municipal purposes is as follows:

TABLE 5-1

MUNICIPAL AND INDUSTRIAL GROUND-WATER USED FOR 1987

County	Municipal		Industrial		Total	
	MGD	Ac-Ft	MGD	Ac-Ft	MGD	Ac-Ft
Brazos	20.70	23,188.14	0.05	56.01	20.75	23,244.15
Robertson	2.13	2,381.49	0.03	33.61	2.16	2,415.10
Leon	1.42	1,590.68	0.22	246.44	1.64	1,837.13
Madison	1.35	1,512.27	0.00	0.00	1.35	1,512.27
Grimes	1.48	1,657.90	0.19	212.84	1.67	1,870.73
Total	27.08	30,330.48	0.49	548.90	27.57	30,879.38

SOURCE: Texas Water Development Board, 1989.

MGD is millions of gallons per day.
Ac-Ft is acre-feet.

Table 5-2
Municipal Ground-Water Use By Aquifer For 1987

(Source: Texas Water Development Board, 1989)

Aquifer: Carrizo Sand

User	County	MGD	Ac - Ft
Hilltop Lakes Resort	Leon	0.15863	177.70
City of Oakwood	Leon	0.11911	133.43
City of Normangee	Leon	0.09335	104.58
City of Nordheim	Leon	0.04676	52.38
St. Paul Shiloh-Timesville WSC	Leon	0.03166	35.47

Aquifer: Carrizo Sand/Wilcox Group

User	County	MGD	Ac - Ft
City of Jewett	Leon	0.17634	197.53
FLO WSC	Leon	0.16236	181.88
Robertson County Water Supply Corp.	Robertson	0.12539	140.47
Twin Creek Water Supply Corp.	Robertson	0.09211	103.18
City of Leona	Leon	0.03145	35.24
Wheelock Water Supply Corp.	Robertson	0.01971	22.08
City of Hearne	Robertson	1.20719	1352.30
Leon Homeowners Association	Leon	0.00785	8.80
Lake Limestone Coves	Robertson	0.00673	7.54

Aquifer: Jackson Group

User	County	MGD	Ac - Ft
Carlos Water Supply Corp.	Grimes	0.14750	165.22
City of Shiro	Grimes	0.01501	16.82

Aquifer: Oakville / Lagarto

User	County	MGD	Ac - Ft
Grimes Co. M.U.D. #1	Grimes	0.00115	1.29

Aquifer: Queen City Sand

User	County	MGD	Ac - Ft
City of Centerville	Leon	0.24398	273.31
Flynn Water Supply Corp.	Leon	0.00910	10.19

Aquifer: Sparta Sand

User	County	MGD	Ac - Ft
City of Madisonville	Madison	0.54941	615.44
Midway Water Supply Corp.	Madison	0.02776	31.10
Texas Department of Corrections	Grimes	0.71241	798.04

Table 5-2
Municipal Ground-Water Use By Aquifer For 1987 - Cont'd

Aquifer: *Wilcox Group*

User	County	MGD	Ac - Ft
City of Calvert	Robertson	0.38355	429.65
City of Buffalo	Leon	0.30239	338.74
City of Franklin	Robertson	0.15255	170.88
City of Bremond	Robertson	0.12745	142.77
City of Marquez	Leon	0.04916	55.06
City of New Baden	Robertson	0.00442	4.96
D & S Water Co.	Robertson	0.00345	3.87
City of Calvert	Robertson	0.00203	2.27

Aquifer: *Yegua Fm.*

User	County	MGD	Ac - Ft
Ramblewood MHP	Brazos	0.01200	13.44
North Zulch M.U.D.	Madison	0.05552	62.19
City of Iola	Grimes	0.02077	23.26
Bedias Water System	Grimes	0.02614	29.28

Aquifer: *Catahoula Tuff / Jackson Group*

User	County	MGD	Ac - Ft
City of Anderson	Grimes	0.05031	56.35

Aquifer: *Wilcox Group / Sparta Sand*

User	County	MGD	Ac - Ft
Brushy Water Supply Corp.	Brazos	0.11513	128.97
City of Bryan	Brazos	9.03844	10124.86
Texas A-M Physical Plant Dept.	Brazos	5.56493	6233.84

Aquifer: *Evangeline*

User	County	MGD	Ac - Ft
Dobbins-Plantersville WSC #2	Grimes	0.04365	48.90

Aquifer: *Jasper*

User	County	MGD	Ac - Ft
City of Navasota	Grimes	0.61614	690.20

Aquifer: *Upper Jasper / Evangeline*

User	County	MGD	Ac - Ft
Texas Department of Corrections	Grimes	0.25813	289.16

Table 5-2
Municipal Ground-Water Use By Aquifer For 1987 - Cont'd

Aquifer: *Simsboro Sand*

User	County	MGD	Ac - Ft
City of College Station	Brazos	5.61158	6286.09
Wixon Water Supply Corp.	Brazos	0.29090	325.86

Aquifer: *Other*

User	County	MGD	Ac - Ft
Texas Department of Corrections	Grimes	0.19802	221.82
Dobbins-Plantersville WSC #3	Grimes	0.04314	48.33
Benchley Oaks Subdivision	Brazos	0.02166	24.26
Richards Water System	Grimes	0.02103	23.55
Shadow Lake Subdivision	Grimes	0.01971	22.07
D & S Water Co.	Brazos	0.01471	16.47
Emmett Water Co.	Grimes	0.00879	9.84
H & T Water Supply	Leon	0.00750	8.40
Glenn Oaks MHP	Brazos	0.00747	8.37
Leon I.S.D.	Leon	0.00653	7.32
Roans Prairie WSC	Grimes	0.00612	6.86
D & S Water Co.	Brazos	0.00584	6.54
D & S Water Co.	Brazos	0.00503	5.63
D & S Water Co.	Brazos	0.00419	4.69
West Cedar Creek W.S.	Leon	0.00391	4.37
D & S Water Co.	Brazos	0.00385	4.31
Forest Lake Water System	Brazos	0.00345	3.87
Grassy Creek MHP	Grimes	0.00315	3.53
D & S Water Co.	Brazos	0.00242	2.71
East Cedar Creek Water System	Leon	0.00240	2.69
D & S Water Co.	Brazos	0.00230	2.58
D & S Water Co.	Robertson	0.00136	1.52
Lake Winona Subdivision	Grimes	0.00082	0.92

Aquifer	1987 Municipal Pumpage Ac-ft	Percent of Total Municipal Pumpage
Simsboro	24,758	81
Carrizo	927	3
Queen City	284	1
Hooper and Calvert Bluff	819	3
Sparata	1,742	6
All Others	1,837	6
Total	30,367	100

Over 80 percent of the pumpage is from the Simsboro. Over 23,000 ac-ft was produced from the Simsboro in 1987, of which approximately 20,366 ac-ft, or 87 percent, was by the well fields serving Bryan, College Station and Texas A&M University. Other Simsboro users include Hearne, Calvert, Wixon Water Supply Corp., and several other smaller users scattered over a large area mostly in Robertson County. These smaller users tend to be listed under the Wilcox Group or Carrizo Sand/Wilcox Group in Table 5-2.

Tables 5-3, 5-4, and 5-5 show historical Simsboro pumpage for the Bryan, College Station and Texas A&M University well fields from 1954-1988. Figure 5-3 is a graphic representation of the Simsboro pumpage for these three well fields. The locations of the well fields are shown on Figure 5-2.

5.2.3 Water Quality

Chemical quality of ground water is largely determined by the type of soil and rock through which the water has passed. Consequently, the amounts and kinds of minerals in solution depend on the composition and solubility of the geologic materials. Table 5-6 provides a summary of water quality in the Simsboro Aquifer at various locations in the artesian portion of the aquifer starting immediately downdip of the Simsboro outcrop (Tidwell Prairie Well) in northwest Robertson County and continuing downdip along Highway 6 through Hearne, the

Table 5-3
City of Bryan
Average Monthly And Yearly Simsboro Pumpage - MGD

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY AVG
1954	0.00	0.00	0.00	0.00	0.00	0.26	0.86	0.32	0.23	0.00	0.00	0.00	0.14
1955	0.02	0.03	0.00	0.00	0.05	0.38	1.71	1.25	0.61	1.92	2.78	2.36	0.93
1956	2.56	0.35	0.01	0.04	0.51	1.32	2.59	2.69	3.16	1.26	0.00	0.06	1.21
1957	0.00	0.00	0.00	0.03	0.02	0.79	3.16	1.90	0.37	0.00	0.00	0.00	0.52
1958	0.21	0.03	0.00	0.05	0.43	1.52	1.40	1.93	0.35	0.00	0.00	0.00	0.49
1959	0.25	0.00	0.23	0.16	0.08	0.78	1.38	0.97	0.34	0.00	0.00	0.00	0.35
1960	0.00	0.00	0.00	0.21	0.52	2.49	1.36	1.32	1.57	0.02	0.02	0.19	0.64
1961	0.05	0.00	0.05	0.25	1.72	1.11	0.59	2.06	1.24	0.58	0.12	0.05	0.65
1962	0.16	0.05	0.07	0.22	1.62	1.27	2.84	4.45	1.06	0.86	0.34	0.04	1.08
1963	0.41	0.16	0.46	0.75	1.80	3.13	3.98	5.00	1.91	2.03	0.58	0.54	1.73
1964	0.61	0.41	0.44	0.92	1.96	2.79	4.37	3.13	2.70	1.48	0.77	0.68	1.69
1965	0.83	0.70	0.66	1.42	1.64	3.05	5.04	2.03	3.71	1.91	3.08	3.05	2.26
1966	3.37	3.34	1.61	2.47	1.42	4.48	6.71	4.15	2.17	2.68	2.71	2.43	3.13
1967	2.44	2.21	2.26	2.07	1.49	5.76	5.34	6.20	2.96	2.20	1.84	2.48	3.10
1968	2.29	2.30	3.01	3.07	3.12	2.88	3.96	7.46	4.06	3.72	2.72	4.35	3.58
1969	2.13	3.63	3.72	3.53	4.29	6.28	9.84	7.05	3.95	3.64	4.44	3.46	4.66
1970	4.06	3.50	2.58	3.71	4.58	5.72	8.91	10.54	4.44	4.52	5.19	3.88	5.14
1971	3.06	3.14	5.29	5.58	4.20	7.69	10.31	6.08	5.61	3.82	3.45	2.89	5.09
1972	2.90	2.83	4.37	5.52	5.66	8.31	7.53	7.06	6.67	5.43	3.31	3.15	5.23
1973	3.06	2.84	2.99	3.87 *	5.51	5.31	8.66	7.78	6.54	5.77	5.60	5.03	5.25 *
1974	4.83 *	3.20	4.46	12.57 *	12.78 *	12.02 *	11.11	9.85 *	12.78 *	13.29 *	11.87 *	10.81 *	9.97 *
1975	11.77 *	11.90 *	11.68 *	12.41 *	12.25 *	11.64 *	9.12 *	9.63 *	9.51 *	9.46 *	13.27 *	13.02 *	11.31 *
1976	12.63 *	13.39 *	13.12 *	14.13 *	7.55 *	9.75 *	9.65 *	11.08	8.02	4.55	6.22	5.11 *	9.60 *
1977	23.70 *	5.45	5.31	5.62	6.78	7.95	14.70	11.27	11.00 *	10.15 *	7.28 *	6.02	9.60 *
1978	6.06	6.69 *	7.61 *	5.86 *	7.89 *	10.13 *	12.91	12.13	6.03	12.49 *	6.88 *	12.22 *	8.91 *
1979	7.65 *	3.20	2.90	3.11	3.77	5.06	5.68	5.68	5.53	5.78	4.47	3.46	4.69 *
1980	3.30	3.67	3.76 *	5.25 *	4.07	9.60	12.56	10.77	4.68	6.00	5.28	6.01 *	6.25 *
1981	7.22 *	7.32 *	7.57 *	8.66 *	5.35	6.88	10.60	13.18	10.18	9.14	8.64	7.74	8.54 *
1982	8.44	8.55	8.07	8.08	8.27	11.24	13.47	13.47	11.83	11.24 *	10.61 *	7.74	10.09 *
1983	7.55	7.50	7.55	9.01	9.32	9.86	12.59	11.36	10.23	8.52	7.99	5.76	8.94 *
1984	9.55 *	11.09 *	10.75 *	11.48	10.61	10.00	12.84	12.32	11.67	11.75 *	11.52 *	10.51 *	11.17 *
1985	10.05 *	9.50 *	8.51 *	7.36	7.58	10.82	11.22	15.02	11.34	7.56	6.68	6.66	9.36 *
1986	6.69	6.67	7.87	8.14	9.49 *	10.41 *	13.18	10.73	7.44	6.87	6.26	6.10	8.32 *
1987	5.99	5.77	6.14	8.55	7.59	7.30	10.44	15.19	9.20	8.38	9.21 *	6.37 *	8.34 *
1988	6.12	6.23	6.32	10.21 *	9.41	11.79	11.24	15.90	12.72	12.65 *	10.08 *	8.88 *	10.13 *
1989	8.95 *	8.31 *	6.25	7.97	7.71	8.82	11.20						

* Portion of water used to fill cooling lake

Table 5-4
City of College Station
Average Monthly And Yearly Simsboro Pumpage - MGD

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY AVG
1981									0.08	0.12	0.85	2.46	0.29
1982	3.37	3.74	3.48	2.80	3.30	4.33	5.19	5.98	5.66	5.61	4.67	4.31	4.37
1983	3.63	3.76	3.62	3.25	4.24	4.67	6.04	5.52	6.02	5.74	5.24	4.76	4.71
1984	4.67	4.62	4.72	4.72	6.53	6.10	7.19	7.26	6.75	5.59	4.78	4.21	5.60
1985	4.64	4.98	4.55	3.78	4.75	6.81	7.54	8.93	7.64	5.47	4.94	4.16	5.68
1986	4.36	4.91	5.62	4.76	5.32	4.86	8.23	6.77	5.52	5.13	4.73	4.28	5.37
1987	3.90	4.48	4.47	4.56	5.27	4.53	6.90	9.35	6.37	5.99	5.29	4.34	5.45
1988	4.58	4.42	3.98	3.41	4.16	4.39	4.17	6.05	5.23	4.80	3.57	3.46	4.35
1989	3.41	4.18	4.49	4.02	4.44	4.59	5.47						

Table 5-5
Texas A & M University
Average Monthly And Yearly Simsboro Pumpage - MGD

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY AVG.
1958													0.08*
1959													0.08*
1960													0.08*
1961													0.9
1962													0.9
1963													0.9
1964													0.9
1965						No Monthly Data Available							1.0
1966													1.1
1967													1.1
1968													0.9
1969													0.9
1970													1.72*
1971													1.90*
1972	1.78 *	1.90 *	1.85 *	1.99 *	2.12 *	2.26 *	2.22	2.22	2.47	2.26	2.13	2.01 *	2.10
1973	2.13	2.27	2.22	2.39	2.55	2.72	2.79	2.76	3.46	3.34	2.92	2.41	2.66
1974	2.18	2.64	2.89	2.86	2.83	2.72	3.27	2.97	3.14	2.99	2.59	2.36	2.79
1975	2.61	2.79	2.81	3.19	3.00	3.14	2.76	3.15	3.91	3.53	2.95	2.49	3.03
1976	2.69	1.90	2.95 *	3.35 *	3.15 *	3.30 *	2.90 *	3.31 *	4.11 *	3.71 *	3.10 *	2.61 *	3.09
1977	0.56	3.28	3.03	3.35	3.26	3.55	3.78	4.07	3.97	4.23	4.03	3.55	3.39
1978	3.45	3.83	3.56	4.06	4.11	4.59	4.75	5.10 *	5.40 *	5.04	4.71	4.09	4.39
1979	4.38	4.00	4.85	5.32	4.69	5.37	4.56	4.93	5.37	5.32	4.28	4.11	4.77
1980	3.91	5.04	4.81	5.89	4.77	7.31	5.82	5.88	5.42	4.62	3.65	3.75	5.07
1981	4.56	4.05	1.15	3.81	4.13	4.31	4.95	7.10	7.44	5.98	6.21	4.31	4.83
1982	3.93	4.13	3.75	3.92	3.77	4.33	4.06	3.07	4.29	2.83	1.25	0.88	3.35
1983	2.36	2.63	2.35	3.45	3.19	3.20	3.44	3.30	1.11	0.99	0.56	1.72	2.36
1984	2.60	3.23	2.50	1.12	3.40	4.45	4.01	4.46	4.95	4.05	3.59	2.74	3.42
1985	3.14	3.72	3.43	4.06	3.41	3.86	3.87	4.44	5.26	3.87	3.36	3.00	3.79
1986	2.56	3.47	4.80	3.76	2.92	2.19	4.19	3.67	3.94	3.71	3.24	2.80	3.44
1987	2.75	3.34	2.76	4.08	3.42	4.27	5.89	6.59	6.73	5.31	4.29	3.28	4.39
1988	2.93	3.90	4.30	4.52	4.94	5.44	6.20	6.85	6.04	5.72	4.32	3.94	4.93
1989	3.93	4.47	4.44	5.68	4.99								

* Estimated

Figure 5-3
Annual Simsboro Pumpage By
Bryan, College Station, and Texas A & M University

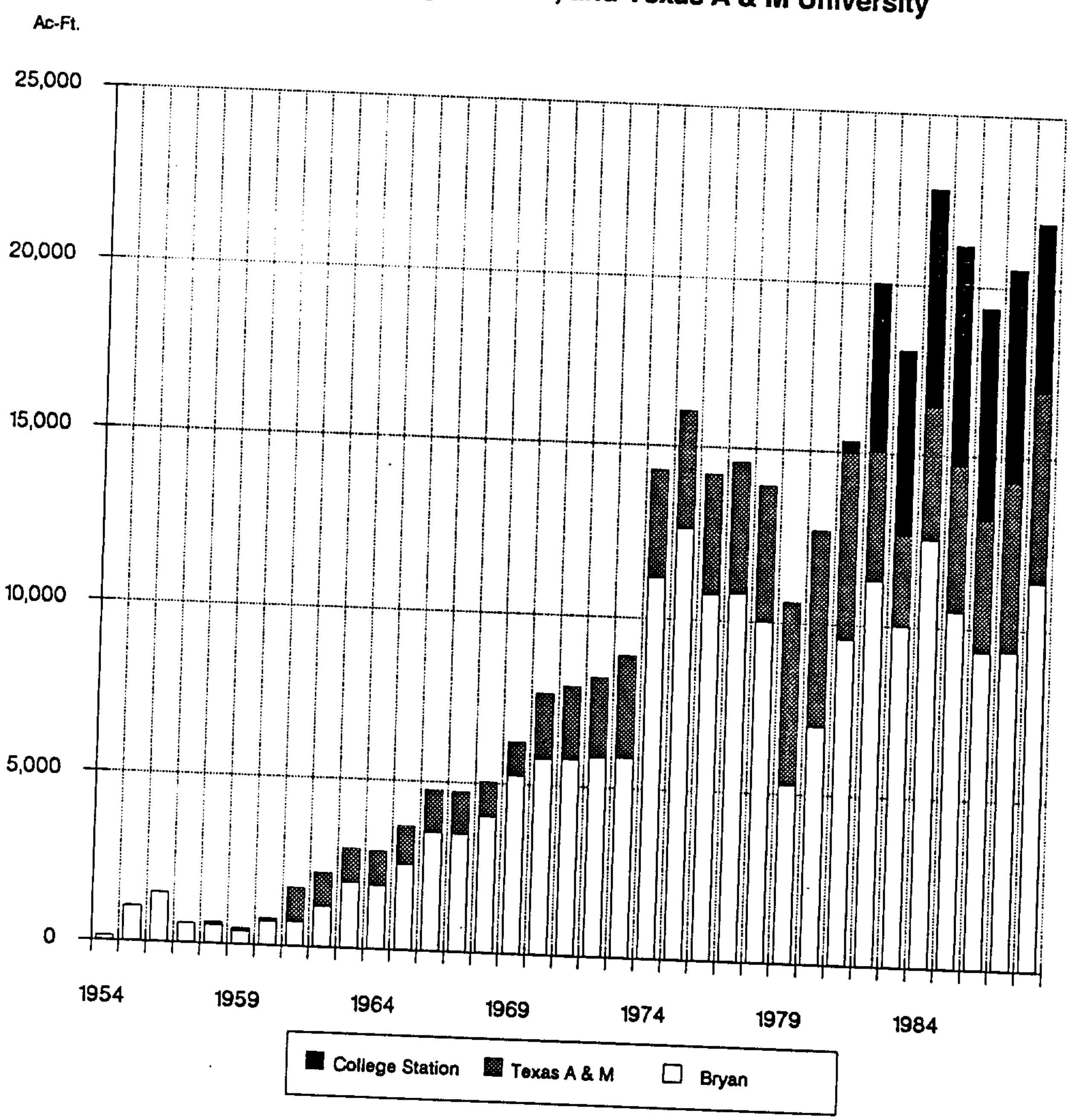


Table 5-6
Chemical Quality Of
Water From Simsboro Wells

	TDH Drinking Water Standards	Tidwell Prairie Well	City of Hearne Well 3	City of College Station Well 1	City of College Station Test Hole
Sample Date	-	3/6/86	2/25/71	9/5/79	8/ - /75
Laboratory	-	IML	TDH	TDH	EW
pH (units)	6.5 - 8.5	7.67	8.5	8.5	7.7
Specific Conductance (umhos/cm)	-	450	702	973	-
Calcium (Ca)	-	65	4	3	32
Magnesium (Mg)	-	8.6	2	1	12
Sodium (Na)	-	38	172	220	2902
Bicarbonate (HCO3)	-	244	394	500	1391
Carbonate (CO3)	-	<1	7	7	0
Sulfate (SO4)	300	40	<4	4	10
Chloride (C)	300	30	44	54	3752
Silica (SiO2)	-	16	18	-	22
Flouride (F)	4.0	<0.01	0.3	0.5	-
Nitrate (NO3)	45	<0.09	<0.4	<0.04	2.5
Iron (Fe)	0.3	0.14	-	0.06	-
Manganese (Mn)	0.05	0.25	-	<0.02	-
Total Alkalinity (CaCO3)	-	200	335	422	-
Total Hardness (CaCO3)	-	260	18	10	-
Total Dissolved Solids (calculated)	1,000	321	441	540	7410

Note: *All concentrations are expressed in mg/l unless specified.*
TDH: Texas Department of Health Laboratory, Austin, Texas
IML: Intermountain Laboratories, College Station, Texas
EW: Edna Wood Laboratory, Houston, Texas

College Station well field, and to the City of College Station, generally along the schematic section shown in Figure 5-1. The City of College Station Test Hole, referenced in Table 5-6, is located approximately at the intersection of University Drive and Texas Avenue. Included on Table 5-6 for comparison purposes are the constituent concentrations for current drinking water standards of the Texas Department of Health.

Generally, water in the Simsboro becomes more mineralized with depth. Some local variations occur, probably due to faulting and varying geochemical processes. Between the outcrop and the Bryan-College Station well fields, mineralization only increases slightly, but rapidly deteriorates between the well fields and the center of College Station. As shown in Table 5-6, the change is from a generally low mineralized water to a highly mineralized unpotable water. As shown on Figure 5-2, the 1,000 mg/l total dissolved solids boundary lies southeast of the Bryan, College Station, and Texas A&M well fields.

Updip of the 1,000 mg/l total dissolved solids boundary, Simsboro water for public supplies typically meets all drinking water standards. The water consists of a sodium bicarbonate water suitable for municipal use. However, on occasion and principally in updip, shallow parts of the aquifer, the water can exceed recommended iron and manganese levels.

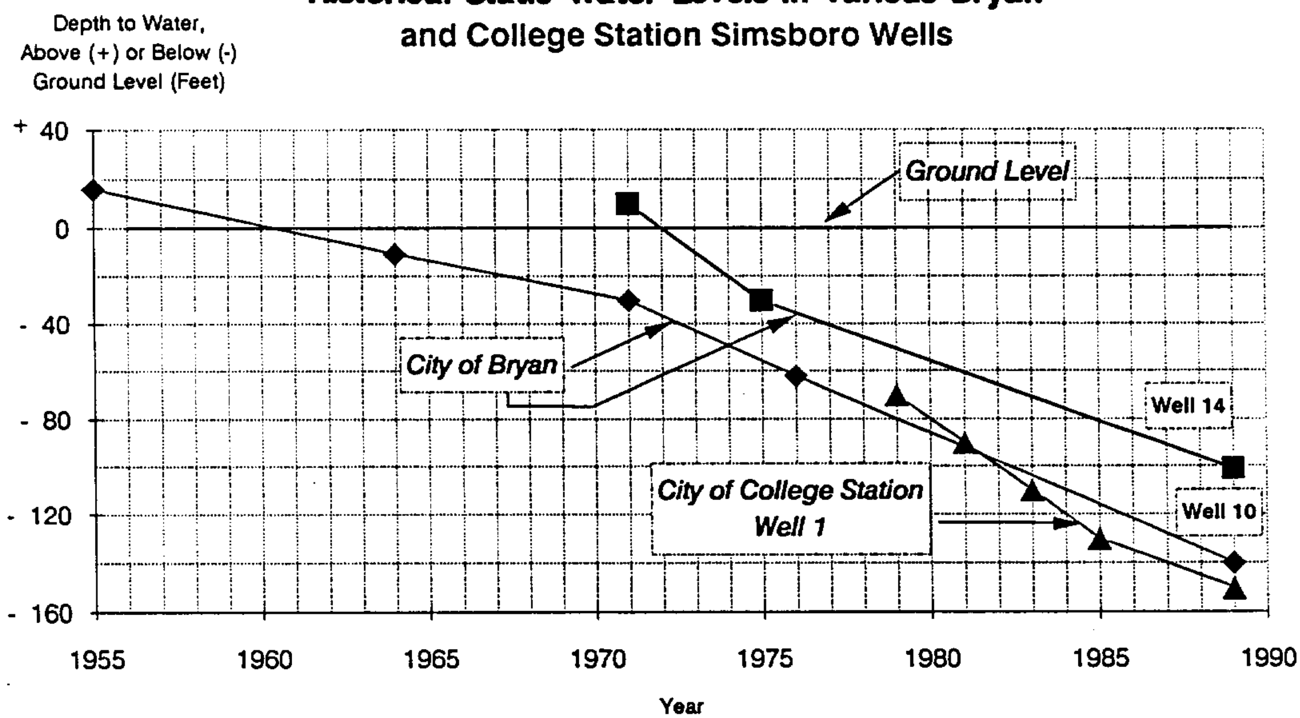
Simsboro water temperature increases in the downdip direction. In the outcrop area in Robertson County the water is about 70 degrees Fahrenheit. Temperature increases with depth to the southeast to about 115 to 120 degrees Fahrenheit at the Bryan-College Station well fields. Forced-draft cooling towers are utilized to treat the water from those well fields.

5.2.4 Water Levels in Wells

When many of the wells of Bryan, College Station and Texas A&M University were drilled, the artesian pressure in the Simsboro was high enough that water levels were above the land surface, and wells would flow. Figure 5-4 depicts the water-level decline through time for various Simsboro wells in the Bryan and College Station well fields. Since the 1950s, water levels have declined and in amounts proportional to pumpage. By the spring of 1966, pumpage had

Figure 5-4

Historical Static Water Levels in Various Bryan and College Station Simsboro Wells



reduced the pressure in Bryans wells so that water levels were below land surface. At that time, static water levels in Texas A&M University's well field were still above land surface primarily due to the relatively low surface elevation at the wells.

Figure 5-4 indicates the general amount of water-level decline which has occurred. From 1954 (when Bryan started pumping from the Simsboro) to date, water levels have declined about 160 feet. By a comparison of Figure 5-4 and the combined pumpage of the Bryan, College Station and Texas A&M University well fields, the amount of water-level decline in relation to pumpage can be approximated. The continued decline in Simsboro water levels is largely due to the continued increase in pumpage in the Bryan-College Station area. If pumpage were to remain constant (no future increases), water levels within a few years would essentially stabilize. Current static water levels are estimated to range from a few tens of feet to about 180 feet below land surface. Pumping levels are typically 50 to 100 feet deeper.

5.2.5 Hydraulic Characteristics

Based on available tests of wells completed in the Simsboro, the hydraulic conductivity of the Simsboro Sand generally ranges from about 100 gpd/sq ft (gallons per day per square foot) to over 350 gpd/sq ft. The lower values are generally representative of the finer sands present in the Simsboro while the higher values generally represent coarser sands.

The relatively high hydraulic conductivities coupled with the thick sands present give rise to high transmissivities for the Simsboro. Locally within the area of Bryan, College Station and Texas A&M University well fields, aquifer tests indicate transmissivities ranging from 90,000 gpd/ft (gallons per day per foot) to 125,000 gpd/ft (Harden, 1977). Such high values indicate a very productive aquifer in the vicinity of the subject well fields. These values are similar to those for the largest, most important aquifers in Texas. Regionally, Simsboro values for transmissivity are probably more typically between 40,000 gpd/ft and 80,000 gpd/ft.

From regional geologic studies and comparisons of actual and computed drawdowns due to past pumping in the Bryan-College Station area, it is known that the long-term, effective transmissivity is not as large as in the vicinity of the Bryan, College Station and Texas A&M University well fields. Somewhat thinner sands exist in other areas, and faulting within the Mexia-Talco Fault System disrupts the continuity of the sands. The result is that more water-level drawdown has occurred in the Bryan, College Station and Texas A&M University well fields from the pumping to date than would be indicated by the local transmissivities measured in the well fields. It has been calculated (Guyton, 1971) (Harden, 1977) that the effective transmissivity after about one weeks pumping is between 50,000 and 60,000 gpd/ft as opposed to the local transmissivities measured in the well fields.

Coefficients of storage for the Simsboro outcrop generally range between .1 and .2 where water-table conditions exist. In downdip areas artesian conditions prevail, and the coefficient of storage generally ranges from .0001 to .001. Based on tests of many wells in the Bryan, College Station, and Texas A&M University well fields, the average storage coefficient is about .00035 (Harden, 1977).

5.2.6 Recharge, Discharge and Movement of Water

The sands of the Simsboro receive recharge in their outcrop areas primarily from precipitation but also from streamflow losses where water tables are below the elevation of creek beds. The mapped recharge area forms a belt one to six miles wide, extending about 150 miles from just south of the Colorado River in Bastrop County to the Trinity River in northeastern Freestone County. The recharge area averages about three miles in width and covers approximately 460 square miles.

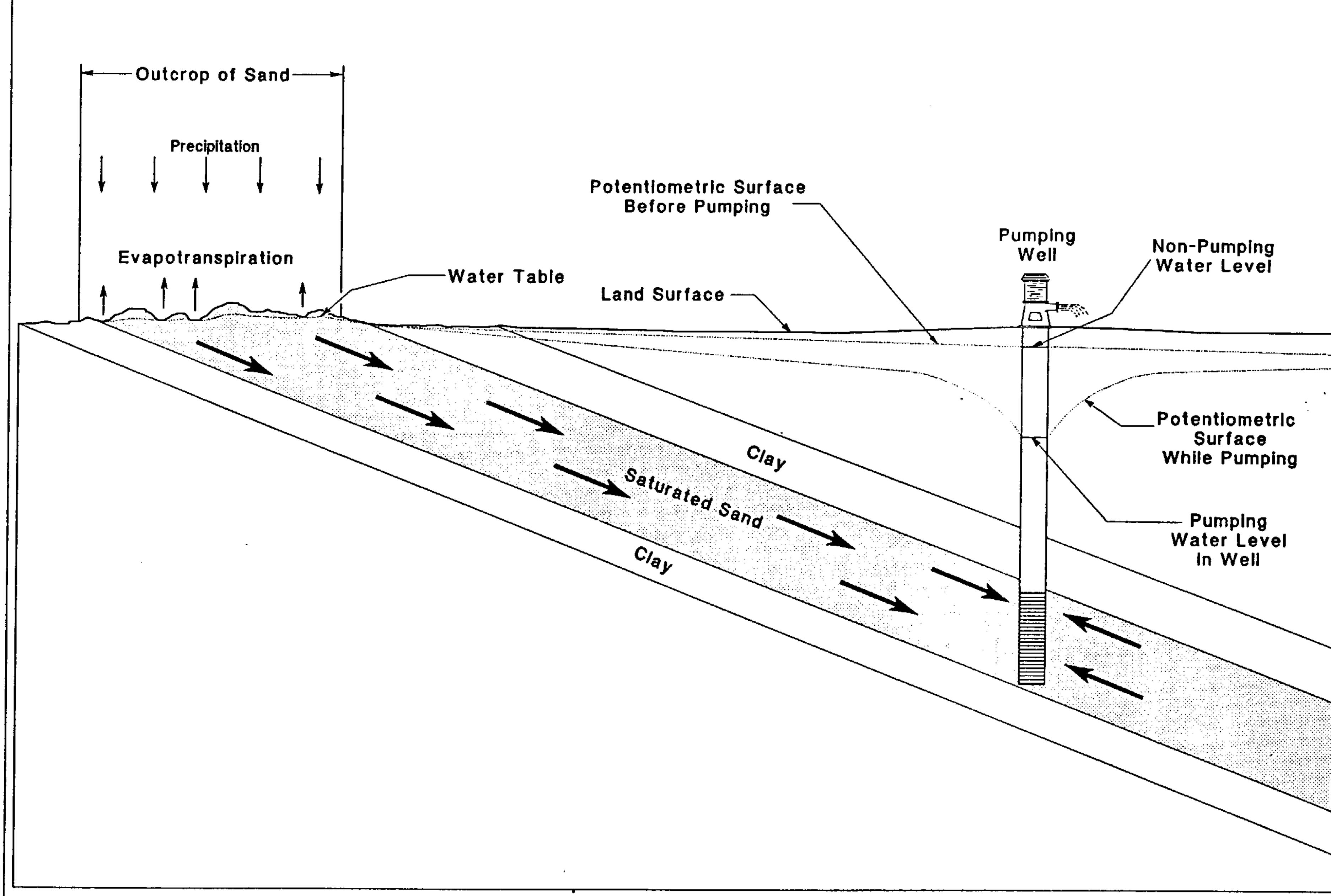
The principal factors influencing the amount of recharge to the Simsboro are the amount and character of precipitation, topography, character of surface materials, type and amount of vegetation, and the ability of subsurface materials to accept recharge and transmit it to areas of discharge. It is virtually impossible to measure the total available recharge directly, but estimates based upon studies in adjacent areas are available (Texas Water Development Board, undated; Cronin and Wilson, 1967). The maximum amount of recharge is estimated to range up to about three to four inches per year which is about 10 percent of the average annual precipitation. Accordingly, over a 460 square mile area, recharge of up to 74,000 to 98,000 acre-feet per year or 66 to 87 mgd (million gallons per day) may be applicable.

While recharge is fairly large, recharge alone is not too important or a limiting factor with respect to the availability of water to wells located in downdip artesian areas because of the large quantities of water in storage in the Simsboro. For example, where water-table conditions exist in the recharge area, the coefficient of storage (amount of water drainable from the sands) is estimated to be between 0.1 and 0.2 based on experience with typical sands. Using a value of 0.15, the amount of water drainable from just the upper 10 feet of saturated sand in the outcrop area amounts to over 440,000 acre-feet. In the upper 50 feet the amount would be five times as large which is equivalent to pumping 67 mgd for 30 years. Thus, large amounts are available for decades from downdip pumping wells with relatively small water-level declines in outcrop areas even without recharge.

At present, a very large percentage of the natural recharge is rejected, and the Simsboro is essentially full to overflowing. Recharged water reaching the water table in outcrop areas moves slowly in the direction of the hydraulic gradient which is from areas of topographic highs towards areas of discharge along the principal stream valleys. Most of the discharge takes place by evapotranspiration in low areas along the principal drainage ways in the outcrop areas. Other discharge occurs by seepage, but these amounts are mostly small. A small part of the recharge also moves down the hydraulic gradient to downdip areas. Under natural conditions and prior to pumping, a small amount moves generally downdip for many miles. Natural ground-water movement rates in the Simsboro are very slow, most probably between about 50 and 200 feet per year.

Pumping from a well changes the local flow pattern so that water moves to the well from all directions. Figure 5-5 is a schematic diagram showing the Simsboro Sand, its recharge area, and the position of the potentiometric surface (defined by the water levels in wells) both prior to pumping and during pumping. Figure 5-5 also shows the cone of depression resulting from pumping, and the movement of water to a well from both updip and downdip directions

Figure 5-5
Cross Section Showing Conditions In Typical Artesian Sand



during pumping. Figure 5-6 shows a plan view of the movement towards a pumping well, and depicts typical flow lines from an outcrop/recharge area.

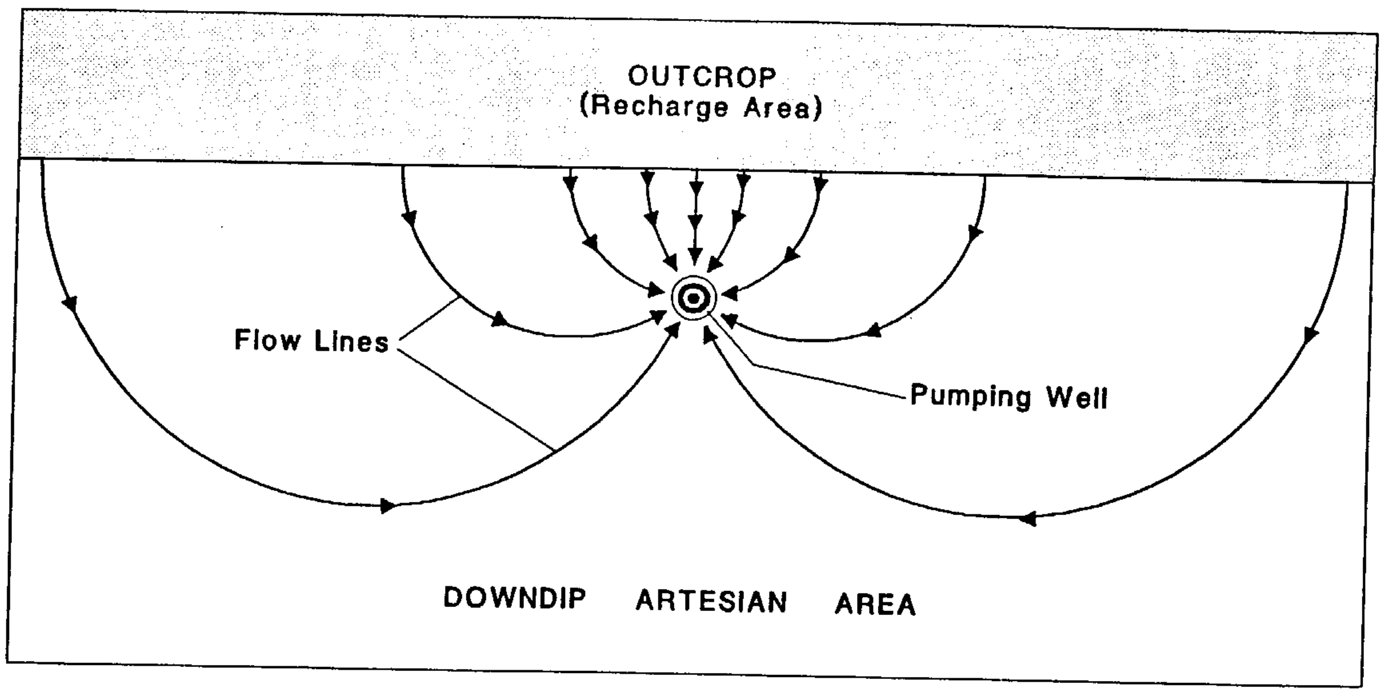
Prior to well development the flow regime in the Simsboro was in a state of equilibrium with the total recharge to the system being equal to the total discharge from seeps and evapotranspiration. Pumping by wells disrupts this equilibrium and causes a withdrawal of water from storage and a concurrent decline of water levels. As water levels fall, natural discharge from the system is reduced, and recharge may be increased. In time, these changes in natural inflow and outflow may be sufficient to balance the withdrawal. If that occurs, a new equilibrium is achieved in which recharge is balanced by the sum of natural outflow and pumpage. Under such conditions depletion of storage no longer occurs. Such an equilibrium, however, is not always possible, especially if the rate of withdrawal is large. Also, it would take tens of feet of lowering of water levels in the outcrop area to capture the water currently being rejected from the Simsboro via evapotranspiration and seeps. However, for the Simsboro and other deep artesian aquifers, if the well pumpage should exceed the reductions in natural outflow which could be achieved and any increases in recharge which could be induced, the wells would continue to furnish water from storage.

Because the outcrop is so extensive and the amount of water in storage is so large, very large developments can be supported with only relatively small, continuing water-level declines. Thus, the present recharge rate, while theoretically important, has little relation to the amount of ground water which is practicable to be developed from deep artesian wells over a period of time -- or even over many decades.

5.2.7 Availability of Water to Meet Demands of the Year 2020

The amount of water capturable by a given well field is a function of the water transmitting capacity of the aquifer, the available drawdown in a given well field, the amount of recharge to the aquifer, and the amount of water in storage in the aquifer. Generally the transmissivity in the artesian portion of the Simsboro Aquifer is quite high, and where sufficient available drawdown is available, large well and well field yields are capable of being developed.

Figure 5-6
Plan View Showing Flow Lines In Typical Artesian Sand



In fact, the Simsboro is one of the most productive aquifers in Texas and is largely undeveloped at present.

Available drawdown is the distance between the static water level and the top of the aquifer (or screen in the well). Generally available drawdown increases to the southeast corresponding to the dip in the formation. This is due to the top of the Simsboro dipping coastward at a much greater rate than the potentiometric surface. Therefore, available drawdowns in the north and northwestern parts of the study area near the Simsboro outcrop are reasonably small, while in downdip areas available drawdown is quite large. Figure 5-1 generally indicates the dip of the top of the Simsboro, and the dramatic increase in available drawdown from northwest to southeast. Near the Simsboro outcrop and near the City of Calvert, available drawdown is reasonably small and generally ranges from just a few tens of feet to about 200 feet. Near the City of Hearne, available drawdown increases several hundred feet, and it continues to increase to the southeast toward the Bryan-College Station well fields.

Near the Simsboro outcrop and within just a few miles downdip of the outcrop, available drawdown limits well yields generally to less than several hundred gallons per minute. Where available drawdown generally exceeds 100 to 200 feet, reasonably large well yields in excess of 1,000 gpm (gallons per minute) can be obtained where thick sands of the Simsboro exist. In the vicinity of the Bryan-College Station well fields, individual well yields are more limited by well and pump diameters than by other factors. Typically, wells have been designed to furnish 1,500 to 3,000 gpm per well which is equivalent to 2.2 to 4.3 mgd per well.

Typical well field yields in the downdip portion of the Simsboro Aquifer are, to date, only a function of the users needs rather than limitations of the Simsboro Aquifer to furnish water. The following table provides the 1987 Simsboro pumpage and number of Simsboro wells in use in 1987 by Bryan, College Station and Texas A&M University:

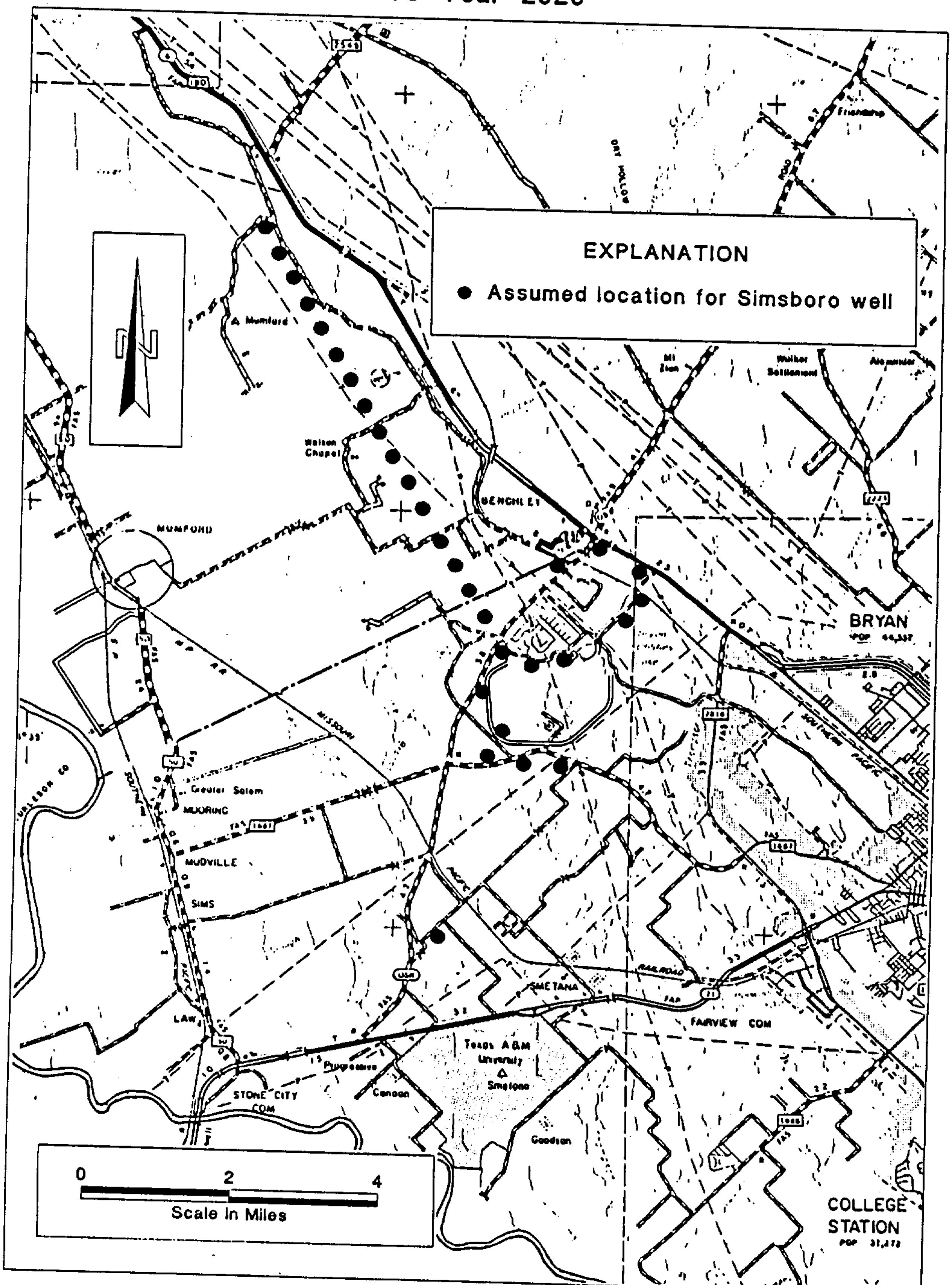
Well Field	Number of Wells	1987 Pumpage (ac-ft)
Bryan	8	9,343
College Station	3	6,105
Texas A&M University	3	4,918

Since 1987, College Station has added one well to its well field. These well field yields are only indicative of municipal water needs of the area and not indicative of the availability of water from the Simsboro. In fact, the Simsboro is capable of furnishing substantially more than the amount of water currently being pumped.

The largest projected future water demand in the five-county area will occur in the primary study area (Brazos County) and will be for the largest present users, Bryan, College Station, and Texas A&M University. Their combined municipal demand is projected to increase from approximately 23.4 mgd in 1990 to approximately 42.6 mgd in year 2020. The increased demand is much too large to be obtained from any of the aquifers present in the planning area, except the Simsboro.

To generally indicate the Simsboros capability to provide increased demand, a hypothetical well field was located in northern Brazos and southern Robertson County and calculations made of future pumping levels. The hypothetical well field was designed to yield up to an average of 49.1 mgd, the total projected demand in Brazos County for 2020. Well spacings were assumed to be at 2,000-foot intervals; individual well yields of 2,100 gpm were assumed. The number of wells required is based on meeting the projected maximum day water demand for Brazos County as furnished earlier in this report. The general layout of the hypothetical well field is shown on Figure 5-7. The conceptual layout includes using 10 of the 14 existing Simsboro wells of Bryan, College Station and Texas A&M University. Additional wells were then added to the well field to meet the estimated future peak daily demands. The wells were added at 2,000-foot spacings along a line extending north toward the City of Hearne. Many other alternative well field layouts would also be possible, but generally should include appropriate well spacings (2,000 feet or more) and well field expansion toward the northwest, away from poorer

Figure 5-7
Conceptual Well Field
To Meet Brazos County Municipal Water Demand
To Year 2020



quality water. Also, actual well field expansion should be based on appropriate test drilling. Table 5-7 shows the results of calculations of future pumping levels and lists the number of wells necessary in five-year increments through year 2020 to meet projected peak demands.

The future pumping levels shown in Table 5-7 were estimated using a computer-assisted mathematical model based on the Theis equation. This mathematical model was developed by the Texas Water Development Board (1973). The calculations are based on a non-leaky artesian solution. The model allows simulation of drawdown (artesian pressure decline) by input of parameters including pumpage, transmissivity, storage coefficient, and boundary conditions by use of image wells. The following hydraulic characteristics were used for the model:

Transmissivity = 100,000 gpd/ft for the first 7 days of any pumping or pumping increase and 55,000 gpd/ft thereafter

Storage Coefficient = .00035

Outcrop = 25 miles from existing Bryan and College Station well fields

Well Yield = 2,100 gpm per well

Pumpage for each five-year period was held constant at the average well field pumpage rate shown in Table 5-7 which is the projected Brazos County demand at the end of the five-year period. For example, during the entire period 1990 to 1995, 30.5 mgd was pumped continuously. This water was pumped from 10 wells each pumping about 2,100 gpm. However, as shown in the table, 19 wells are needed in the well field to meet projected peak daily demands. As water demand increased with time, the number of wells and the pumpage used in the model was increased, as shown in the table.

The average depth of pumping levels shown in Table 5-7 is the calculated average pumping level in the conceptual well field after pumping continuously to the end of the specified period of time. The average depth of the pumping level is based on the computed drawdowns plus an assumed depth of static water level of 100 feet below ground level and also 30 feet of interference drawdown from others. This interference drawdown is based on calculations and

TABLE 5-7

CONCEPTUAL WELL FIELD AND ESTIMATED PUMPING LEVELS

Time Period	Total No. of Wells	Average Well Field Pumpage (MGD)	Well Field Capacity (MGD)	Average Depth of Pumping Level*
1990-1995	19	30.5	57.5	425
1995-2000	22	35.8	66.5	450
2000-2005	24	39.3	72.6	480
2005-2010	26	42.9	78.6	510
2010-2015	28	46.0	84.7	545
2015-2020	30	49.1	90.7	575

* Feet below ground level.

estimates to provide for a few million gallons per day of Simsboro pumpage in Leon County and approximately 20 mgd of pumpage in Robertson County near Calvert, Texas. The pumpage in Robertson County is based on estimated ground-water requirements for power plant and mining purposes. As shown, the estimated average pumping level in 2020 is approximately 575 feet below ground level. During peak water demands, such as during the summer demand, pumping levels will temporarily be lower, while during times of low water demand levels will be higher than those shown. These seasonal water-level fluctuations are mostly unimportant with respect to water availability from the Simsboro.

The results of modeling and the calculations indicate that the Simsboro Aquifer is capable of providing, with some safety factor, all the municipal water requirements for Brazos County including Bryan, College Station, and Texas A&M University. Calculations show that pumping water levels would generally only decline about 350 feet from the present until 2020. With even lower pumping levels, quantities of water in excess of that required to meet projected 2020 demands could be produced.

Typically, the construction of existing Simsboro wells in Bryan/College Station well fields allow high-capacity pumps to be set as deep as 600 to 700 feet below ground level. By modifying and setting pumping equipment in existing wells below pumping levels projected through 2020, existing wells can be used in meeting future projected water requirements. If in some wells, pumping levels fall below the maximum pump setting depth, new wells can be constructed with casings of adequate diameter set sufficiently deeper to provide for 2020 pumping levels or even deeper levels.

5.2.8 Interference Effects From Pumping by Others

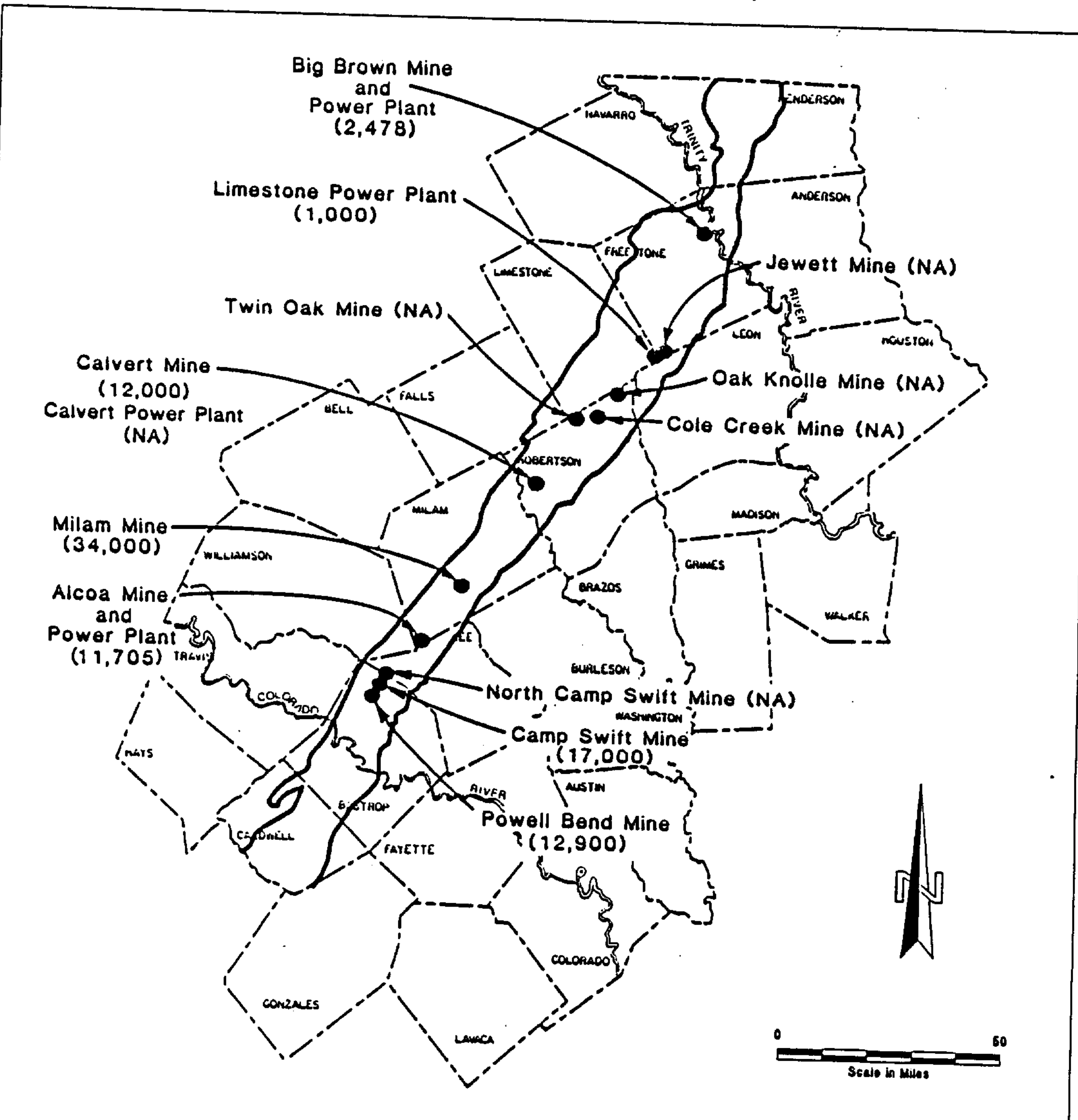
Relative to the Bryan-College Station demand, any potential future development of the Simsboro by others will be mostly for relatively small supplies or at distant locations. No other significant demands are forecast for the entire five-county area. Thus, the potential interference effects on future Bryan-College Station Simsboro developments are not likely to be a limiting factor to those developments. Also, interference on others from Bryan-College Station developments is not likely to be overly significant because of the small projected demand and distant locations. Future projected municipal demands which might logically be obtained from the Simsboro by others are both few and small. Little agricultural development is anticipated, but some moderate to large industrial developments primarily for power plant supplies or in association with lignite mining are anticipated from the Simsboro.

The Texas Water Development Board water use projections provided earlier in this report include projections for future power plant use. Included are 21.4 mgd in 2020 in Robertson County and 10.7 mgd in 2020 for Grimes County. The Robertson County use will likely all be from the Simsboro, and the Grimes County use from surface water sources. Other projections of pumpage from the Carrizo/Wilcox Aquifer for mining and power plant purposes are available (R.W. Harden & Associates, Inc., 1986). Figure 5-8 and Table 5-8 portray these data.

The available data are incomplete and are not necessarily current. Even so, water requirements for individual projects are reported to range from less than 1,000 acre-feet per year to over 30,000 acre-feet per year. In general, several projects are reported to involve withdrawal rates between about 10,000 and 20,000 acre-feet per year. The information appears sufficient to indicate that substantial pumpage will likely occur with some being located in the northern portion of the planning area or in adjoining counties to the southwest. Moreover, the data indicate that nearly all of the pumpage likely will be from the Simsboro with little being from other aquifers. The locations of future potential Simsboro pumping by others appear to be mostly at distances of about 20 to over 70 miles from the Bryan-College Station area. Because of the large distances, no overly large, or limiting, interference effects on potential future Bryan-College Station Simsboro well fields appear likely.

The effect of a well field, producing 20,000 acre-feet per year from the Simsboro, located in northern Robertson County would be between about 20 to 30 feet of interference drawdown on the present Bryan-College Station well fields. Interference of that magnitude, or even substantially larger, will have little impact on the overall availability of water from the Simsboro in northern Brazos and southern Robertson Counties to meet Bryan-College Station use

Figure 5-8
Projected Pumpage From The Carrizo / Wilcox Aquifer For Mining And Power Plant Purposes



EXPLANATION

Twin Oak Mine ●	Approximate location and name of mine or power plant
(12,000)	Maximum projected pumpage (acre-feet per year) NA indicates no projection available
(outcrop boundary symbol)	Boundary of the Carrizo/Wilcox outcrop

DRAFT WATER CONSERVATION PLAN

I. Education and Information

Several methods will be used to educate and inform water users about the benefits of water conservation and of ways to save water.

A. Initial Program

1. Publish an article in the local newspaper announcing the adoption of the plan, providing information on the availability of details of the plan, and notifying the public of the intent to distribute educational materials.

2. Distribute an initial announcement of the plan, fact sheet, and educational material to existing customers.

3. Maintain a supply of the educational brochures and pamphlets which are available from the TWDB and other sources.

4. Provide a supply of the brochures and pamphlets for distribution at city offices, schools, libraries, and other public places.

5. Provide a packet of the conservation plan fact sheet, brochures and pamphlets to new customers.

B. Long-Term Program

1. Continue the distribution of brochures and pamphlets to new customers and once a year as inserts in water bills.

2. Cooperate with builders, developers, businesses, governmental agencies, schools, and Texas A&M University to develop water conservation exhibits and programs for inclusion at seminars and trade association conventions.

II. Plumbing Codes

Adopt a plumbing code which requires the use of water saving fixtures for all new construction and for replacements in existing structures. The standards that are recommended by the TWDB represent readily available products and technology at a minimal, if any, extra cost over previous standards.

The standards are:

Tank-type toilets	- Maximum 3.5 gallons per flush
Flush valve toilets	- Maximum 3.0 gallons per flush
Tank-type urinals	- Maximum 3.0 gallons per flush
Flush valve urinals	- Maximum 1.0 gallons per flush
Shower heads	- Maximum 3.0 gallons per minute
Lavatory and kitchen faucets	- Maximum 2.75 gallons per minute
Hot water lines	- Insulated
Swimming pools	- Recirculating filtration equipment

Revisions to the standards will be considered and adopted as improved products become available, practical, and economical.

III. Retrofit Program

Provide information through the education program to plumbers and customers about the advantages and availability of retrofit devices for fixtures in existing homes and businesses.

Encourage the voluntary installation and use of low-flow shower heads, faucet aerators, and toilet dams. Encourage local retail stores which sell plumbing supplies to include low water-using fixtures in their inventory.

IV. Water Rate Structure

Consider and evaluate the adoption of a water rate structure which encourages water conservation. Such rate structures include an increasing block rate, a continuously increasing rate, peak or seasonal load rates, and excess use fees. Require a uniform rate structure as a minimum condition of any future contract for sale of water to other utilities.

V. Universal Metering and Meter Maintenance.

Require meters for all water users, including separate meters for each living unit in multi-family complexes and also for all utility, city, and other public facilities.

Establish a meter maintenance program which includes regularly scheduled testing and repairs and replacement as necessary. Meters should be inspected and/or tested for any apparent problem and upon customer complaint for any unusual and significant variation in normal usage. The recommended regular testing schedule is as follows:

Production (master) meters	-	once a year
Meters larger than 1"	-	once a year
Meters 1" or smaller	-	once every ten years

VI. Water Conserving Landscaping

Provide information through the education program to homeowners, home builders, developers, business owners, landscapers, and irrigation contractors about the methods and benefits of water conserving landscaping.

The following methods will be promoted:

A. Encourage the use of adapted, low water using plants and grasses for landscaping new homes and sites for commercial, office, and retail development.

B. Encourage the use of drip irrigation systems when possible and other water conserving irrigation systems, with efficient sprinklers and a layout that accommodates prevailing winds.

C. Encourage the use of ornamental fountains that recycle water and use the minimum amount.

D. Encourage nurseries and businesses to offer adapted, low water using plants and grasses and efficient irrigation systems and to promote their use with demonstration projects and advertisement programs.

VII. Water Audits and Leak Detection

Continue monthly records and accounting which compares water production and water delivery. On a regular basis and when otherwise indicated by the apparent water losses, perform investigations to detect and locate major leaks or other sources of lost water. Make repairs and corrective actions as soon as problems are discovered.

VIII. Recycling and Reuse

Evaluate the potential for recycling and reuse of water. Encourage the use of treated effluent for irrigation if it is found to be feasible, environmentally sound, and within the parameters of regulations of the Texas Department of Health and Texas Water Commission.

IX. Implementation and Enforcement

The process of developing and adopting a water conservation plan will include the appropriate resolutions, policy statements, city code revisions, and budget allocations necessary to implement the various elements of the program. A program administrator will be responsible for directing the implementation and enforcement of the program and also for monitoring public response and compliance. An annual report will be prepared on the progress, public acceptance, effectiveness, and net benefits of the program.

An acceptable water conservation plan will be required as a condition of a contract between a regional authority and its customer utilities.

DRAFT DROUGHT CONTINGENCY PLAN

I. TRIGGER CONDITIONS

Trigger conditions will be set to indicate the need for drought contingency measures to be put into effect. Trigger conditions will be set for mild, moderate, and severe conditions to indicate the need for the corresponding level of contingency measures.

A. Mild Condition

1. Daily water usage is at or above 90% of the firm capacity of the water system for three consecutive days.

2. Weather conditions, forecasts, and the season of the year indicate a continuing and possibly increasing level of demand on the water system.

B. Moderate Condition

1. Daily water usage is at 100% of the firm capacity of the water system for three consecutive days.

2. Weather conditions, forecasts, and the season of the year indicate a continuing and possibly increasing level of demand on the water system.

C. Severe Condition

1. Daily water usage exceeds the firm capacity of the system for three consecutive days.

2. Weather conditions, forecasts, and the season of the year indicate a continuing and possibly increasing level of demand on the water system.

3. Regardless of recent water usage and drought conditions, there is an impending or actual failure of a major component of the water system which could cause a serious disruption of service to part or all of the service area.

The trigger conditions will be modified when plans and projects for a regional system are finalized.

II. DROUGHT CONTINGENCY MEASURES

Drought contingency measures and an implementation plan will be established for the corresponding levels of trigger conditions. The measures for the second and third levels of severity will include the measures of the preceding level.

A. Mild Condition

1. Advise the public through the news media that the trigger condition has been reached and provide daily updates until the situation has returned to normal.

2. Encourage the public through the news media to voluntarily reduce water consumption by using to the greatest extent possible the suggested steps included in the news release.

3. Advertise and promote a voluntary lawn watering schedule.

B. Moderate Condition

1. Continue the public information program and emphasize the continuing and increasing severity of the problem.

2. Advise the public of a mandatory lawn watering schedule which restricts a customer to off-peak times of a certain day on a recurring schedule.

3. Prohibit ornamental and other non-essential water uses.

4. Encourage industrial and commercial users to stop or modify water usage where possible.

C. Severe Condition

1. Continue the public information program and emphasize the critical nature of the problem.

2. Prohibit all outdoor water uses such as lawn watering, car washing, street and driveway washing, swimming pool filling, and other non-essential uses.

3. Enforce all restrictions and penalize those who fail to comply.

III. INFORMATION AND EDUCATION

After adoption of a drought contingency plan, all customers will be informed of the trigger conditions, corresponding contingency measures, and the means of implementation of the plan. The news media and also letters and brochures for water customers will be used to inform and educate the public upon adoption of a plan. The news media will be used to provide daily information and updates throughout the duration of an emergency.

IV. INITIATION PROCEDURES

Formal written procedures will be established to ensure that the plan will be understood and capable of being implemented almost immediately if necessary. A program administrator will be responsible for beginning notification procedures and advising the public about approaching trigger conditions with sufficient advance notice. All required regulatory ordinances and contract provisions will be established. Notification procedures and press releases will be prearranged and coordinated with all the news media.

V. TERMINATION NOTIFICATION

The news media will be used to inform the public about successful results of the drought contingency plan, improving conditions and the corresponding downgrading of contingency measures, and the termination of the emergency.

VI. MEANS OF IMPLEMENTATION

The drought contingency plan will be implemented and enforced with all necessary and appropriate resolutions, policy statements, ordinances, plumbing code revisions, contract revisions, and budget allocations. A program administrator will be responsible for directing the implementation of the program and monitoring public response and compliance.

5.0 GROUND-WATER RESOURCES

5.1 GENERAL DESCRIPTION

Several aquifers representing substantial ground-water resources exist in parts of the five-county planning area. The Sparta Sand, Queen City Sand, Carrizo Sand and Wilcox Group (composed of the Calvert Bluff, Simsboro and Hooper Formations) are each important water sources in some parts of the five-county area. The Simsboro is by far the most important and currently furnishes water to the three largest users in Brazos County. This study emphasizes the Simsboro Aquifer because of its wide lateral extent and large potential for additional development. The Simsboro is capable of meeting projected future water needs for College Station, Bryan, and Texas A&M University through the year 2020.

Other aquifers including the Sparta, Queen City, Carrizo, Hooper, and Calvert Bluff furnish supplies to numerous, widely-scattered, mostly small users. These aquifers are capable of furnishing additional quantities of water over the northern part of the planning area, and resources are sufficient to meet the small to moderate future water needs of most current users. Some other aquifers exist in the southern part of the planning area, particularly in Grimes County. These include sands in the Yegua, Jackson, Catahoula, and Fleming Formations. Except for the Fleming in southernmost Grimes County, only small amounts of water are reported available from these units. However, because future projected demands in the southern part of the study area are relatively small, these aquifers are probably capable of supplying most of those needs. If well fields are located in southernmost Grimes County in the Fleming, all water demands for Grimes County could likely be met through the year 2020.

5.2 SIMSBORO AQUIFER

5.2.1 Character, Location and Extent

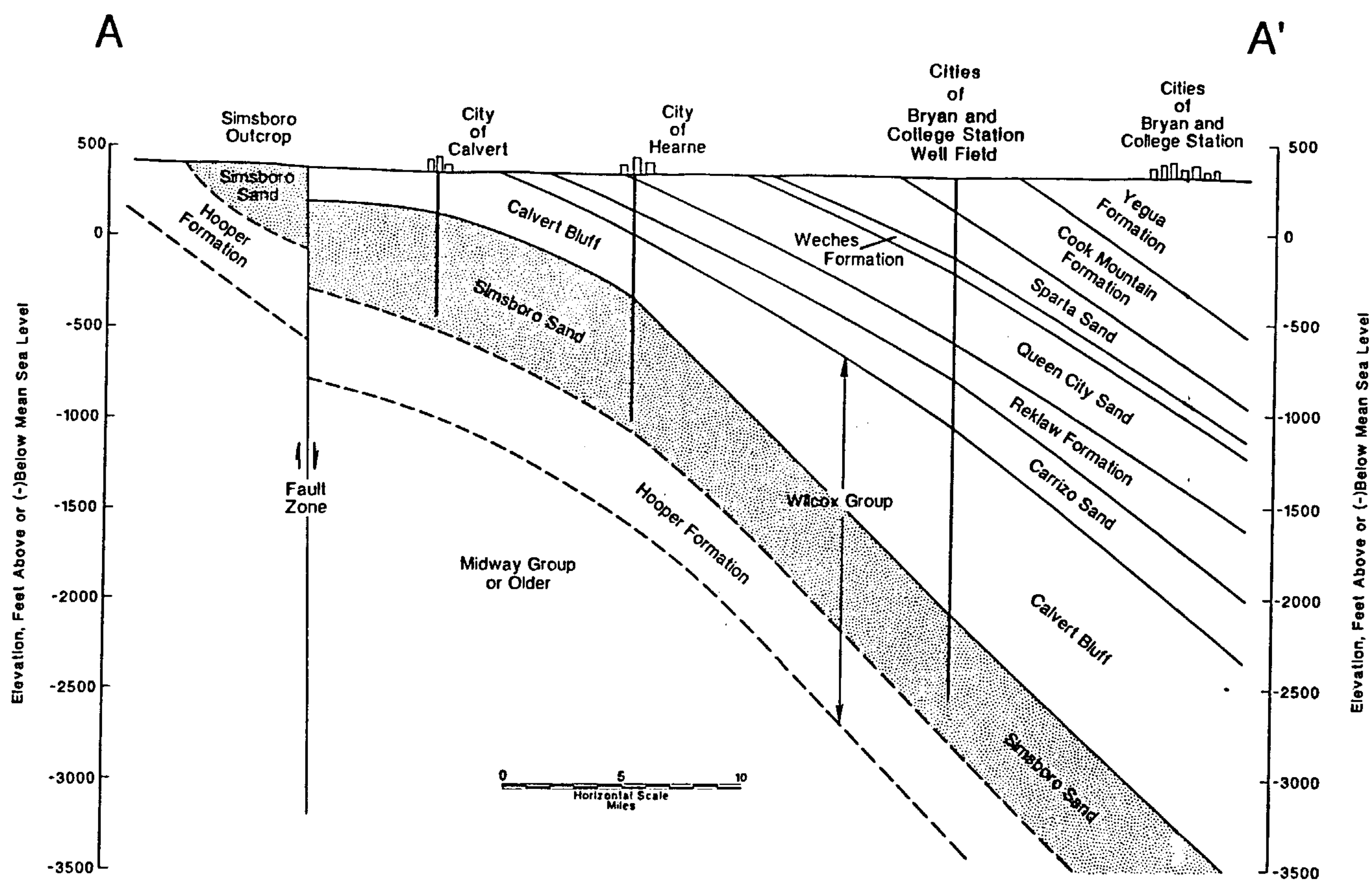
The Wilcox Group is comprised, from shallowest to deepest, of the Calvert Bluff, Simsboro and Hooper Formations. The Simsboro exists throughout the entire five-county area, but comprises an important fresh water aquifer in only the northern half of the study area. Figure 5-1 is a schematic cross section which shows the position and thickness of the more important geologic and water-bearing units, including the Simsboro. The section extends from northern Robertson County to the Bryan-College Station area and passes through the Cities of Calvert and Hearne, and through the City of College Station's well field. Within the five-county area, the Simsboro outcrops at the surface only in the very northwestern corner of Robertson County as shown on Figure 5-2. Elsewhere, the Simsboro outcrop extends across about 150 miles of Central Texas from near Bastrop to beyond Fairfield.

The northwestern extent of the Simsboro Aquifer corresponds to the northwestern edge of the Simsboro outcrop. From the outcrop the Simsboro extends southeast as a thick, consistent sand unit. The Simsboro is thin only in the northwestern part of its outcrop. It thickens downdip to the southeast and is typically 300 to over 600 feet thick. The Simsboro dips to the southeast at an average rate of about 100 feet per mile. Near Calvert, the position of the Simsboro is affected by faulting within the Mexia-Talco Fault System. Coastward, the Simsboro occurs at progressively greater depths, reaching a depth of over 3,000 feet near Bryan. Water-table conditions exist in the sands of the Simsboro in the outcrop area, but artesian conditions exist in all areas downdip to the southeast.

The Simsboro is one of the thickest water-bearing sands in Texas and is typically a massive, thick-bedded zone consisting mostly of fine- to medium-grained, well-sorted sands. The Simsboro contains some, but relatively few, beds of clay and silty clay. Generally in the Bryan-College Station area, the Simsboro consists of over 70 percent of fine- to medium-grained, moderately permeable sand. Screen lengths in wells of Bryan and College Station range from 250 feet to over 450 feet.

The extent of the Simsboro capable of furnishing potable water, up to 1,000 milligrams per liter (mg/l) or less of total dissolved solids content, encompasses only the northern half of the five-county area. Figure 5-2 shows the approximate extent of potable or fresh water in the Simsboro. The fresh/brackish water boundary generally extends from near Bryan to Normangee and into the very southeastern portion of Leon County. The boundary shown on

Figure 5-1
Schematic Cross Section A - A'



Note: Stratigraphic boundaries dashed where inferred.
See Figure 2 for location of Schematic Cross Section A - A'.

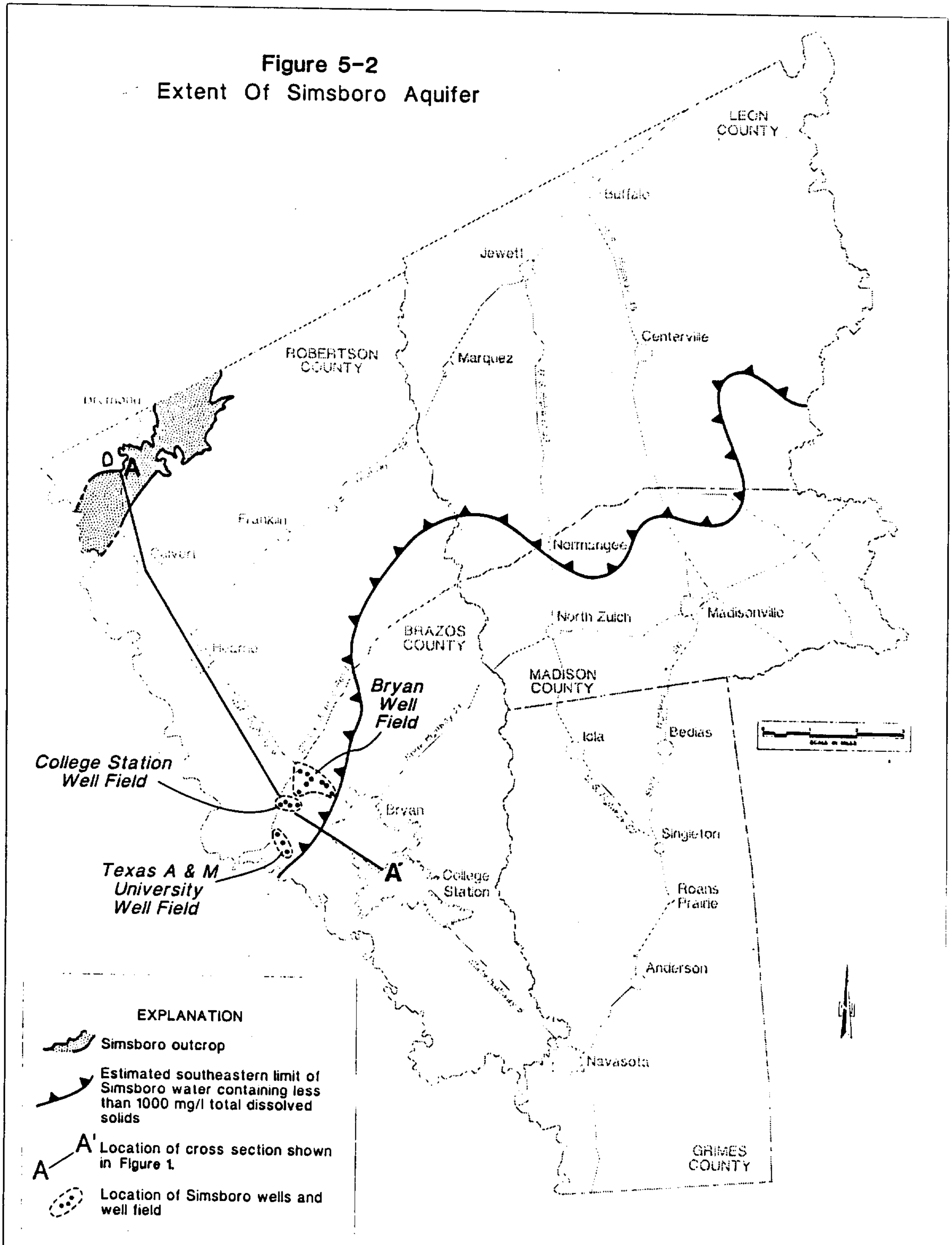


Figure 5-2
Extent Of Simsboro Aquifer

Figure 5-2 is from Texas Water Commission (1989) mappings as modified in the local Bryan-College Station area to reflect site specific data.

5.2.2 Present Use

Included in tables showing water demand projections to 2020 are water use figures for the five-county area for 1980 and 1985. The values reflect both ground water and surface water use, and the only significant surface water use is by a power plant in Grimes County. Virtually all of the other present and past water use in the five-county area has been from ground-water sources.

Table 5-1 provides the 1987 municipal and industrial use from ground-water sources by county. Virtually all use is for municipal purposes with only low amounts used for industrial purposes. Some irrigation use occurs, but virtually all is from shallow alluvial sources located adjacent to the Brazos River. Neither the Simsboro nor the other aquifers addressed herein furnish significant amounts of irrigation pumpage.

Table 5-2 provides the 1987 municipal ground-water use by aquifer and user according to reports to the Texas Water Development Board (1989). The aquifer/formation identifications are those used by the Texas Water Development Board, and they do not always attribute ground-water use to individual aquifers. In cases where a user obtains supplies from two aquifers, the amounts are frequently grouped together and listed in a combined category. For example, nearly all of the City of Bryan's and Texas A&M University's use is from the Simsboro, with only a little being from the Sparta. The listing shows this pumpage under the aquifer heading Wilcox Group/Sparta Sand. There are other small inconsistencies such as the City of Hearne being listed under Carrizo Sand/Wilcox Group when in actuality all of the pumpage is from the Simsboro portion of the Wilcox.

Based on the available records, reports of owners, and estimates of the applicable water-bearing units, the estimated distribution of pumpage by individual aquifer units for 1987 for the five-county area for municipal purposes is as follows:

TABLE 5-1

MUNICIPAL AND INDUSTRIAL GROUND-WATER USED FOR 1987

County	Municipal		Industrial		Total	
	MGD	Ac-Ft	MGD	Ac-Ft	MGD	Ac-Ft
Brazos	20.70	23,188.14	0.05	56.01	20.75	23,244.15
Robertson	2.13	2,381.49	0.03	33.61	2.16	2,415.10
Leon	1.42	1,590.68	0.22	246.44	1.64	1,837.13
Madison	1.35	1,512.27	0.00	0.00	1.35	1,512.27
Grimes	1.48	1,657.90	0.19	212.84	1.67	1,870.73
Total	27.08	30,330.48	0.49	548.90	27.57	30,879.38

SOURCE: Texas Water Development Board, 1989.

MGD is millions of gallons per day.
Ac-Ft is acre-feet.

Table 5-2
Municipal Ground-Water Use By Aquifer For 1987
(Source: Texas Water Development Board, 1989)

Aquifer: *Carrizo Sand*

User	County	MGD	Ac - Ft
Hilltop Lakes Resort	Leon	0.15863	177.70
City of Oakwood	Leon	0.11911	133.43
City of Normangee	Leon	0.09335	104.58
City of Nordheim	Leon	0.04676	52.38
St. Paul Shiloh-Timesville WSC	Leon	0.03166	35.47

Aquifer: *Carrizo Sand/Wilcox Group*

User	County	MGD	Ac - Ft
City of Jewett	Leon	0.17634	197.53
FLO WSC	Leon	0.16236	181.88
Robertson County Water Supply Corp.	Robertson	0.12539	140.47
Twin Creek Water Supply Corp.	Robertson	0.09211	103.18
City of Leona	Leon	0.03145	35.24
Wheelock Water Supply Corp.	Robertson	0.01971	22.08
City of Hearne	Robertson	1.20719	1352.30
Leon Homeowners Association	Leon	0.00785	8.80
Lake Limestone Coves	Robertson	0.00673	7.54

Aquifer: *Jackson Group*

User	County	MGD	Ac - Ft
Carlos Water Supply Corp.	Grimes	0.14750	165.22
City of Shiro	Grimes	0.01501	16.82

Aquifer: *Oakville / Lagarto*

User	County	MGD	Ac - Ft
Grimes Co. M.U.D. #1	Grimes	0.00115	1.29

Aquifer: *Queen City Sand*

User	County	MGD	Ac - Ft
City of Centerville	Leon	0.24398	273.31
Flynn Water Supply Corp.	Leon	0.00910	10.19

Aquifer: *Sparta Sand*

User	County	MGD	Ac - Ft
City of Madisonville	Madison	0.54941	615.44
Midway Water Supply Corp.	Madison	0.02776	31.10
Texas Department of Corrections	Grimes	0.71241	798.04

Table 5-2
Municipal Ground-Water Use By Aquifer For 1987 - Cont'd

Aquifer: ***Wilcox Group***

User	County	MGD	Ac - Ft
City of Calvert	Robertson	0.38355	429.65
City of Buffalo	Leon	0.30239	338.74
City of Franklin	Robertson	0.15255	170.88
City of Bremond	Robertson	0.12745	142.77
City of Marquez	Leon	0.04916	55.06
City of New Baden	Robertson	0.00442	4.96
D & S Water Co.	Robertson	0.00345	3.87
City of Calvert	Robertson	0.00203	2.27

Aquifer: ***Yegua Fm.***

User	County	MGD	Ac - Ft
Ramblewood MHP	Brazos	0.01200	13.44
North Zulch M.U.D.	Madison	0.05552	62.19
City of Iola	Grimes	0.02077	23.26
Bedias Water System	Grimes	0.02614	29.28

Aquifer: ***Catahoula Tuff / Jackson Group***

User	County	MGD	Ac - Ft
City of Anderson	Grimes	0.05031	56.35

Aquifer: ***Wilcox Group / Sparta Sand***

User	County	MGD	Ac - Ft
Brushy Water Supply Corp.	Brazos	0.11513	128.97
City of Bryan	Brazos	9.03844	10124.86
Texas A-M Physical Plant Dept.	Brazos	5.56493	6233.84

Aquifer: ***Evangeline***

User	County	MGD	Ac - Ft
Dobbins-Plantersville WSC #2	Grimes	0.04365	48.90

Aquifer: ***Jasper***

User	County	MGD	Ac - Ft
City of Navasota	Grimes	0.61614	690.20

Aquifer: ***Upper Jasper / Evangeline***

User	County	MGD	Ac - Ft
Texas Department of Corrections	Grimes	0.25813	289.16

Table 5-2
Municipal Ground-Water Use By Aquifer For 1987 - Cont'd

Aquifer: *Simsboro Sand*

User	County	MGD	Ac - Ft
City of College Station	Brazos	5.61158	6286.09
Wixon Water Supply Corp.	Brazos	0.29090	325.86

Aquifer: *Other*

User	County	MGD	Ac - Ft
Texas Department of Corrections	Grimes	0.19802	221.82
Dobbins-Plantersville WSC #3	Grimes	0.04314	48.33
Benchley Oaks Subdivision	Brazos	0.02166	24.26
Richards Water System	Grimes	0.02103	23.55
Shadow Lake Subdivision	Grimes	0.01971	22.07
D & S Water Co.	Brazos	0.01471	16.47
Emmett Water Co.	Grimes	0.00879	9.84
H & T Water Supply	Leon	0.00750	8.40
Glenn Oaks MHP	Brazos	0.00747	8.37
Leon I.S.D.	Leon	0.00653	7.32
Roans Prairie WSC	Grimes	0.00612	6.86
D & S Water Co.	Brazos	0.00584	6.54
D & S Water Co.	Brazos	0.00503	5.63
D & S Water Co.	Brazos	0.00419	4.69
West Cedar Creek W.S.	Leon	0.00391	4.37
D & S Water Co.	Brazos	0.00385	4.31
Forest Lake Water System	Brazos	0.00345	3.87
Grassy Creek MHP	Grimes	0.00315	3.53
D & S Water Co.	Brazos	0.00242	2.71
East Cedar Creek Water System	Leon	0.00240	2.69
D & S Water Co.	Brazos	0.00230	2.58
D & S Water Co.	Robertson	0.00136	1.52
Lake Winona Subdivision	Grimes	0.00082	0.92

Aquifer	1987 Municipal Pumpage Ac-ft	Percent of Total Municipal Pumpage
Simsboro	24,758	81
Carrizo	927	3
Queen City	284	1
Hooper and Calvert Bluff	819	3
Sparata	1,742	6
All Others	1,837	6
Total	30,367	100

Over 80 percent of the pumpage is from the Simsboro. Over 23,000 ac-ft was produced from the Simsboro in 1987, of which approximately 20,366 ac-ft, or 87 percent, was by the well fields serving Bryan, College Station and Texas A&M University. Other Simsboro users include Hearne, Calvert, Wixon Water Supply Corp., and several other smaller users scattered over a large area mostly in Robertson County. These smaller users tend to be listed under the Wilcox Group or Carrizo Sand/Wilcox Group in Table 5-2.

Tables 5-3, 5-4, and 5-5 show historical Simsboro pumpage for the Bryan, College Station and Texas A&M University well fields from 1954-1988. Figure 5-3 is a graphic representation of the Simsboro pumpage for these three well fields. The locations of the well fields are shown on Figure 5-2.

5.2.3 Water Quality

Chemical quality of ground water is largely determined by the type of soil and rock through which the water has passed. Consequently, the amounts and kinds of minerals in solution depend on the composition and solubility of the geologic materials. Table 5-6 provides a summary of water quality in the Simsboro Aquifer at various locations in the artesian portion of the aquifer starting immediately downdip of the Simsboro outcrop (Tidwell Prairie Well) in northwest Robertson County and continuing downdip along Highway 6 through Hearne, the

Table 5-3
City of Bryan
Average Monthly And Yearly Simsboro Pumpage - MGD

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY AVG
1954	0.00	0.00	0.00	0.00	0.00	0.26	0.86	0.32	0.23	0.00	0.00	0.00	0.14
1955	0.02	0.03	0.00	0.00	0.05	0.38	1.71	1.25	0.61	1.92	2.78	2.36	0.93
1956	2.56	0.35	0.01	0.04	0.51	1.32	2.59	2.69	3.16	1.26	0.00	0.06	1.21
1957	0.00	0.00	0.00	0.03	0.02	0.79	3.16	1.90	0.37	0.00	0.00	0.00	0.52
1958	0.21	0.03	0.00	0.05	0.43	1.52	1.40	1.93	0.35	0.00	0.00	0.00	0.49
1959	0.25	0.00	0.23	0.16	0.08	0.78	1.38	0.97	0.34	0.00	0.00	0.00	0.35
1960	0.00	0.00	0.00	0.21	0.52	2.49	1.36	1.32	1.57	0.02	0.02	0.19	0.64
1961	0.05	0.00	0.05	0.25	1.72	1.11	0.59	2.06	1.24	0.58	0.12	0.05	0.65
1962	0.16	0.05	0.07	0.22	1.62	1.27	2.84	4.45	1.06	0.86	0.34	0.04	1.08
1963	0.41	0.16	0.46	0.75	1.80	3.13	3.98	5.00	1.91	2.03	0.58	0.54	1.73
1964	0.61	0.41	0.44	0.92	1.96	2.79	4.37	3.13	2.70	1.48	0.77	0.68	1.69
1965	0.83	0.70	0.66	1.42	1.64	3.05	5.04	2.03	3.71	1.91	3.08	3.05	2.26
1966	3.37	3.34	1.61	2.47	1.42	4.48	6.71	4.15	2.17	2.68	2.71	2.43	3.13
1967	2.44	2.21	2.26	2.07	1.49	5.76	5.34	6.20	2.96	2.20	1.84	2.48	3.10
1968	2.29	2.30	3.01	3.07	3.12	2.88	3.96	7.46	4.06	3.72	2.72	4.35	3.58
1969	2.13	3.63	3.72	3.53	4.29	6.28	9.84	7.05	3.95	3.64	4.44	3.46	4.66
1970	4.06	3.50	2.58	3.71	4.58	5.72	8.91	10.54	4.44	4.52	5.19	3.88	5.14
1971	3.06	3.14	5.29	5.58	4.20	7.69	10.31	6.08	5.61	3.82	3.45	2.89	5.09
1972	2.90	2.83	4.37	5.52	5.66	8.31	7.53	7.06	6.67	5.43	3.31	3.15	5.23
1973	3.06	2.84	2.99	3.87 *	5.51	5.31	8.66	7.78	6.54	5.77	5.60	5.03	5.25 *
1974	4.83 *	3.20	4.46	12.57 *	12.78 *	12.02 *	11.11	9.85 *	12.78 *	13.29 *	11.87 *	10.81 *	9.97 *
1975	11.77 *	11.90 *	11.68 *	12.41 *	12.25 *	11.64 *	9.12 *	9.63 *	9.51 *	9.46 *	13.27 *	13.02 *	11.31 *
1976	12.63 *	13.39 *	13.12 *	14.13 *	7.55 *	9.75 *	9.65 *	11.08	8.02	4.55	6.22	5.11 *	9.60 *
1977	23.70 *	5.45	5.31	5.62	6.78	7.95	14.70	11.27	11.00 *	10.15 *	7.28 *	6.02	9.60 *
1978	6.06	6.69 *	7.61 *	5.86 *	7.89 *	10.13 *	12.91	12.13	6.03	12.49 *	6.88 *	12.22 *	8.91 *
1979	7.65 *	3.20	2.90	3.11	3.77	5.06	5.68	5.68	5.53	5.78	4.47	3.46	4.69 *
1980	3.30	3.67	3.76 *	5.25 *	4.07	9.60	12.56	10.77	4.68	6.00	5.28	6.01 *	6.25 *
1981	7.22 *	7.32 *	7.57 *	8.66 *	5.35	6.88	10.60	13.18	10.18	9.14	8.64	7.74	8.54 *
1982	8.44	8.55	8.07	8.08	8.27	11.24	13.47	13.47	11.83	11.24 *	10.61 *	7.74	10.09 *
1983	7.55	7.50	7.55	9.01	9.32	9.86	12.59	11.36	10.23	8.52	7.99	5.76	8.94 *
1984	9.55 *	11.09 *	10.75 *	11.48	10.61	10.00	12.84	12.32	11.67	11.75 *	11.52 *	10.51 *	11.17 *
1985	10.05 *	9.50 *	8.51 *	7.36	7.58	10.82	11.22	15.02	11.34	7.56	6.68	6.66	9.36 *
1986	6.69	6.67	7.87	8.14	9.49 *	10.41 *	13.18	10.73	7.44	6.87	6.26	6.10	8.32 *
1987	5.99	5.77	6.14	8.55	7.59	7.30	10.44	15.19	9.20	8.38	9.21 *	6.37 *	8.34 *
1988	6.12	6.23	6.32	10.21 *	9.41	11.79	11.24	15.90	12.72	12.65 *	10.08 *	8.88 *	10.13 *
1989	8.95 *	8.31 *	6.25	7.97	7.71	8.82	11.20						

* Portion of water used to fill cooling lake

Table 5-4
City of College Station
Average Monthly And Yearly Simsboro Pumpage - MGD

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY AVG
1981									0.08	0.12	0.85	2.46	0.29
1982	3.37	3.74	3.48	2.80	3.30	4.33	5.19	5.98	5.66	5.61	4.67	4.31	4.37
1983	3.63	3.76	3.62	3.25	4.24	4.67	6.04	5.52	6.02	5.74	5.24	4.76	4.71
1984	4.67	4.62	4.72	4.72	6.53	6.10	7.19	7.26	6.75	5.59	4.78	4.21	5.60
1985	4.64	4.98	4.55	3.78	4.75	6.81	7.54	8.93	7.64	5.47	4.94	4.16	5.68
1986	4.36	4.91	5.62	4.76	5.32	4.86	8.23	6.77	5.52	5.13	4.73	4.28	5.37
1987	3.90	4.48	4.47	4.56	5.27	4.53	6.90	9.35	6.37	5.99	5.29	4.34	5.45
1988	4.58	4.42	3.98	3.41	4.16	4.39	4.17	6.05	5.23	4.80	3.57	3.46	4.35
1989	3.41	4.18	4.49	4.02	4.44	4.59	5.47						

Table 5-5
Texas A & M University
Average Monthly And Yearly Simsboro Pumpage - MGD

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY AVG.
1958													0.08*
1959													0.08*
1960													0.08*
1961													0.9
1962													0.9
1963													0.9
1964													0.9
1965						No Monthly Data Available							1.0
1966													1.1
1967													1.1
1968													0.9
1969													0.9
1970													1.72*
1971													1.90*
1972	1.78 *	1.90 *	1.85 *	1.99 *	2.12 *	2.26 *	2.22	2.22	2.47	2.26	2.13	2.01 *	2.10
1973	2.13	2.27	2.22	2.39	2.55	2.72	2.79	2.76	3.46	3.34	2.92	2.41	2.66
1974	2.18	2.64	2.89	2.86	2.83	2.72	3.27	2.97	3.14	2.99	2.59	2.36	2.79
1975	2.61	2.79	2.81	3.19	3.00	3.14	2.76	3.15	3.91	3.53	2.95	2.49	3.03
1976	2.69	1.90	2.95 *	3.35 *	3.15 *	3.30 *	2.90 *	3.31 *	4.11 *	3.71 *	3.10 *	2.61 *	3.09
1977	0.56	3.28	3.03	3.35	3.26	3.55	3.78	4.07	3.97	4.23	4.03	3.55	3.39
1978	3.45	3.83	3.56	4.06	4.11	4.59	4.75	5.10 *	5.40 *	5.04	4.71	4.09	4.39
1979	4.38	4.00	4.85	5.32	4.69	5.37	4.56	4.93	5.37	5.32	4.28	4.11	4.77
1980	3.91	5.04	4.81	5.89	4.77	7.31	5.82	5.88	5.42	4.62	3.65	3.75	5.07
1981	4.56	4.05	1.15	3.81	4.13	4.31	4.95	7.10	7.44	5.98	6.21	4.31	4.83
1982	3.93	4.13	3.75	3.92	3.77	4.33	4.06	3.07	4.29	2.83	1.25	0.88	3.35
1983	2.36	2.63	2.35	3.45	3.19	3.20	3.44	3.30	1.11	0.99	0.56	1.72	2.36
1984	2.60	3.23	2.50	1.12	3.40	4.45	4.01	4.46	4.95	4.05	3.59	2.74	3.42
1985	3.14	3.72	3.43	4.06	3.41	3.86	3.87	4.44	5.26	3.87	3.36	3.00	3.79
1986	2.56	3.47	4.80	3.76	2.92	2.19	4.19	3.67	3.94	3.71	3.24	2.80	3.44
1987	2.75	3.34	2.76	4.08	3.42	4.27	5.89	6.59	6.73	5.31	4.29	3.28	4.39
1988	2.93	3.90	4.30	4.52	4.94	5.44	6.20	6.85	6.04	5.72	4.32	3.94	4.93
1989	3.93	4.47	4.44	5.68	4.99								

* Estimated

Figure 5-3
Annual Simsboro Pumpage By
Bryan, College Station, and Texas A & M University

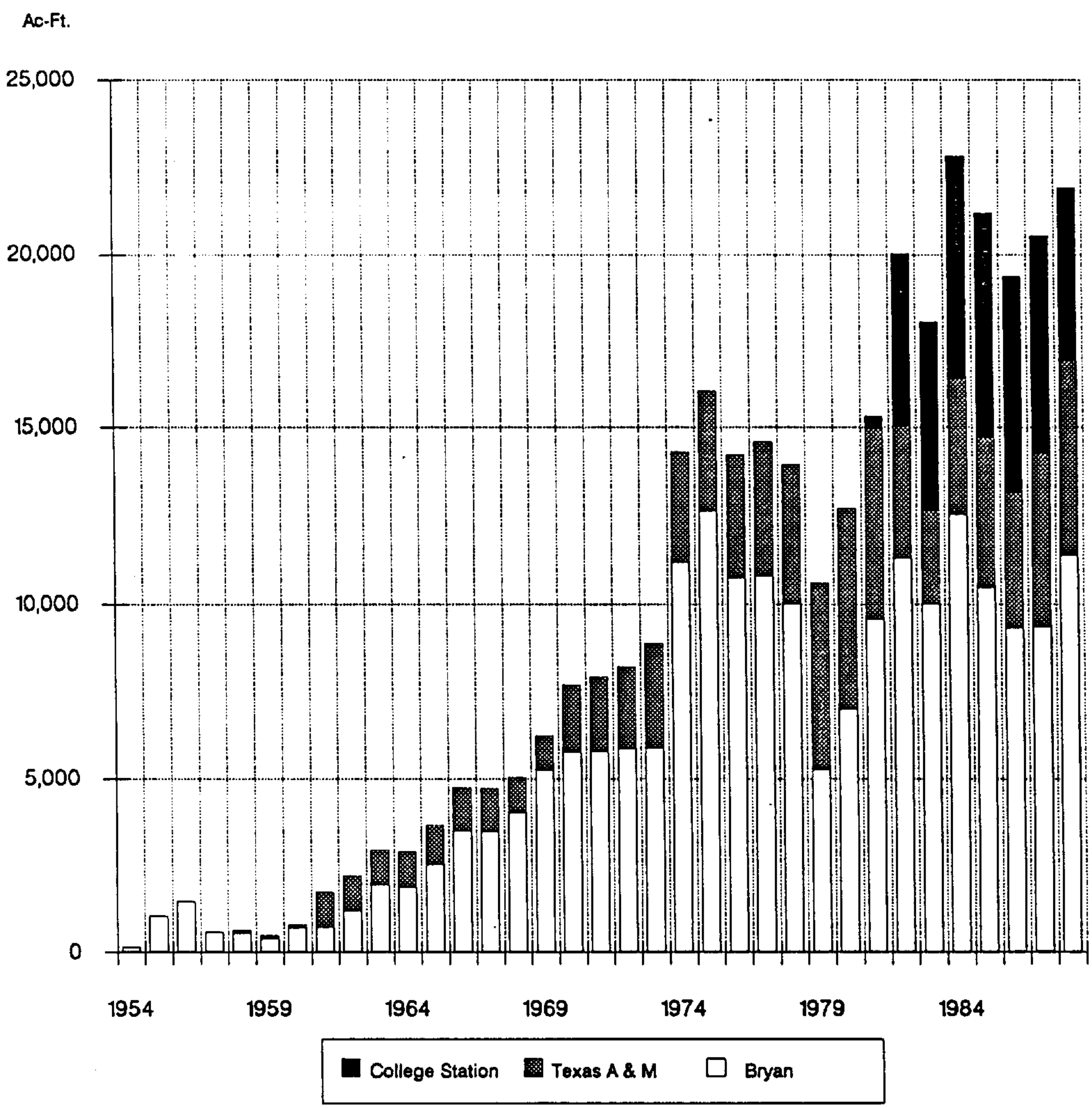


Table 5-6
Chemical Quality Of
Water From Simsboro Wells

	TDH Drinking Water Standards	Tidwell Prairie Well	City of Hearne Well 3	City of College Station Well 1	City of College Station Test Hole
Sample Date	-	3/6/86	2/25/71	9/5/79	8/ - /75
Laboratory	-	IML	TDH	TDH	EW
pH (units)	6.5 - 8.5	7.67	8.5	8.5	7.7
Specific Conductance (umhos/cm)	-	450	702	973	-
Calcium (Ca)	-	65	4	3	32
Magnesium (Mg)	-	8.6	2	1	12
Sodium (Na)	-	38	172	220	2902
Bicarbonate (HCO3)	-	244	394	500	1391
Carbonate (CO3)	-	<1	7	7	0
Sulfate (SO4)	300	40	<4	4	10
Chloride (C)	300	30	44	54	3752
Silica (SiO2)	-	16	18	-	22
Flouride (F)	4.0	<0.01	0.3	0.5	-
Nitrate (NO3)	45	<0.09	<0.4	<0.04	2.5
Iron (Fe)	0.3	0.14	-	0.06	-
Manganese (Mn)	0.05	0.25	-	<0.02	-
Total Alkalinity (CaCO3)	-	200	335	422	-
Total Hardness (CaCO3)	-	260	18	10	-
Total Dissolved Solids (calculated)	1,000	321	441	540	7410

Note: *All concentrations are expressed in mg/l unless specified.*
TDH: Texas Department of Health Laboratory, Austin, Texas
IML: Intermountain Laboratories, College Station, Texas
EW: Edna Wood Laboratory, Houston, Texas

College Station well field, and to the City of College Station, generally along the schematic section shown in Figure 5-1. The City of College Station Test Hole, referenced in Table 5-6, is located approximately at the intersection of University Drive and Texas Avenue. Included on Table 5-6 for comparison purposes are the constituent concentrations for current drinking water standards of the Texas Department of Health.

Generally, water in the Simsboro becomes more mineralized with depth. Some local variations occur, probably due to faulting and varying geochemical processes. Between the outcrop and the Bryan-College Station well fields, mineralization only increases slightly, but rapidly deteriorates between the well fields and the center of College Station. As shown in Table 5-6, the change is from a generally low mineralized water to a highly mineralized unpotable water. As shown on Figure 5-2, the 1,000 mg/l total dissolved solids boundary lies southeast of the Bryan, College Station, and Texas A&M well fields.

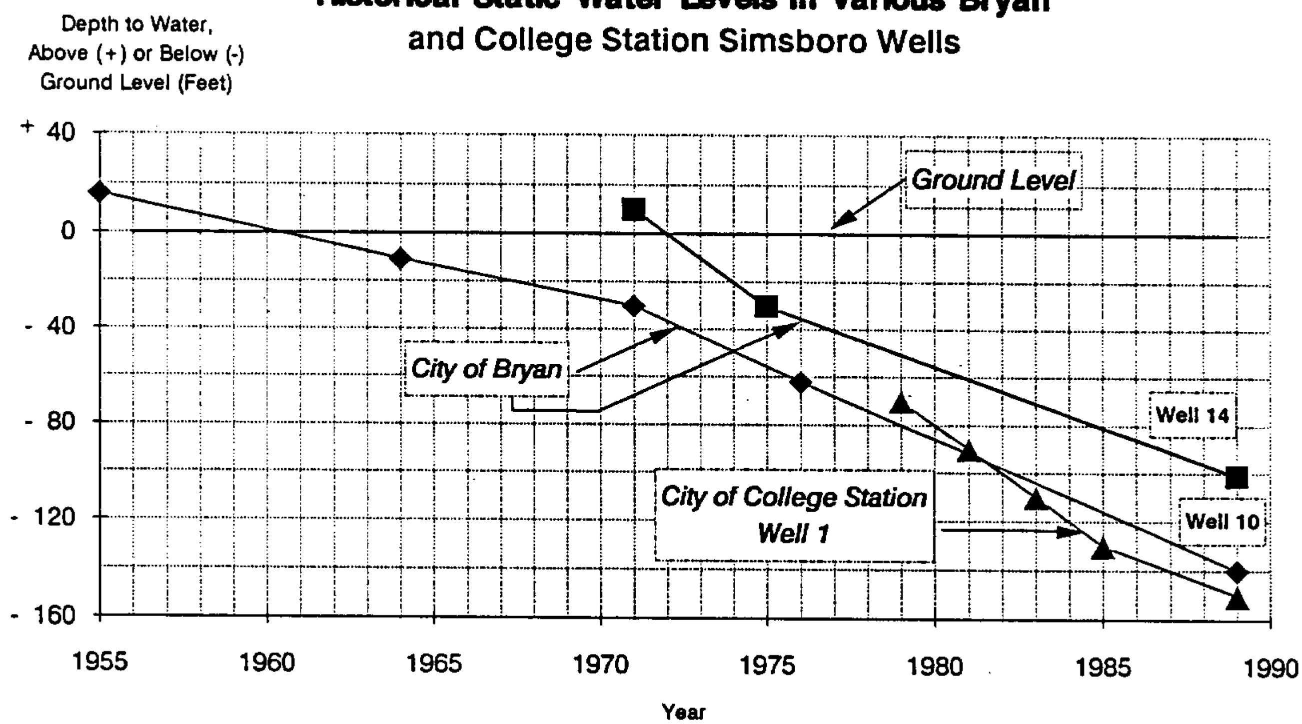
Updip of the 1,000 mg/l total dissolved solids boundary, Simsboro water for public supplies typically meets all drinking water standards. The water consists of a sodium bicarbonate water suitable for municipal use. However, on occasion and principally in updip, shallow parts of the aquifer, the water can exceed recommended iron and manganese levels.

Simsboro water temperature increases in the downdip direction. In the outcrop area in Robertson County the water is about 70 degrees Fahrenheit. Temperature increases with depth to the southeast to about 115 to 120 degrees Fahrenheit at the Bryan-College Station well fields. Forced-draft cooling towers are utilized to treat the water from those well fields.

5.2.4 Water Levels in Wells

When many of the wells of Bryan, College Station and Texas A&M University were drilled, the artesian pressure in the Simsboro was high enough that water levels were above the land surface, and wells would flow. Figure 5-4 depicts the water-level decline through time for various Simsboro wells in the Bryan and College Station well fields. Since the 1950s, water levels have declined and in amounts proportional to pumpage. By the spring of 1966, pumpage had

Figure 5-4
Historical Static Water Levels In Various Bryan
and College Station Simsboro Wells



reduced the pressure in Bryans wells so that water levels were below land surface. At that time, static water levels in Texas A&M University's well field were still above land surface primarily due to the relatively low surface elevation at the wells.

Figure 5-4 indicates the general amount of water-level decline which has occurred. From 1954 (when Bryan started pumping from the Simsboro) to date, water levels have declined about 160 feet. By a comparison of Figure 5-4 and the combined pumpage of the Bryan, College Station and Texas A&M University well fields, the amount of water-level decline in relation to pumpage can be approximated. The continued decline in Simsboro water levels is largely due to the continued increase in pumpage in the Bryan-College Station area. If pumpage were to remain constant (no future increases), water levels within a few years would essentially stabilize. Current static water levels are estimated to range from a few tens of feet to about 180 feet below land surface. Pumping levels are typically 50 to 100 feet deeper.

5.2.5 Hydraulic Characteristics

Based on available tests of wells completed in the Simsboro, the hydraulic conductivity of the Simsboro Sand generally ranges from about 100 gpd/sq ft (gallons per day per square foot) to over 350 gpd/sq ft. The lower values are generally representative of the finer sands present in the Simsboro while the higher values generally represent coarser sands.

The relatively high hydraulic conductivities coupled with the thick sands present give rise to high transmissivities for the Simsboro. Locally within the area of Bryan, College Station and Texas A&M University well fields, aquifer tests indicate transmissivities ranging from 90,000 gpd/ft (gallons per day per foot) to 125,000 gpd/ft (Harden, 1977). Such high values indicate a very productive aquifer in the vicinity of the subject well fields. These values are similar to those for the largest, most important aquifers in Texas. Regionally, Simsboro values for transmissivity are probably more typically between 40,000 gpd/ft and 80,000 gpd/ft.

From regional geologic studies and comparisons of actual and computed drawdowns due to past pumping in the Bryan-College Station area, it is known that the long-term, effective transmissivity is not as large as in the vicinity of the Bryan, College Station and Texas A&M University well fields. Somewhat thinner sands exist in other areas, and faulting within the Mexia-Talco Fault System disrupts the continuity of the sands. The result is that more water-level drawdown has occurred in the Bryan, College Station and Texas A&M University well fields from the pumping to date than would be indicated by the local transmissivities measured in the well fields. It has been calculated (Guyton, 1971) (Harden, 1977) that the effective transmissivity after about one weeks pumping is between 50,000 and 60,000 gpd/ft as opposed to the local transmissivities measured in the well fields.

Coefficients of storage for the Simsboro outcrop generally range between .1 and .2 where water-table conditions exist. In downdip areas artesian conditions prevail, and the coefficient of storage generally ranges from .0001 to .001. Based on tests of many wells in the Bryan, College Station, and Texas A&M University well fields, the average storage coefficient is about .00035 (Harden, 1977).

5.2.6 Recharge, Discharge and Movement of Water

The sands of the Simsboro receive recharge in their outcrop areas primarily from precipitation but also from streamflow losses where water tables are below the elevation of creek beds. The mapped recharge area forms a belt one to six miles wide, extending about 150 miles from just south of the Colorado River in Bastrop County to the Trinity River in northeastern Freestone County. The recharge area averages about three miles in width and covers approximately 460 square miles.

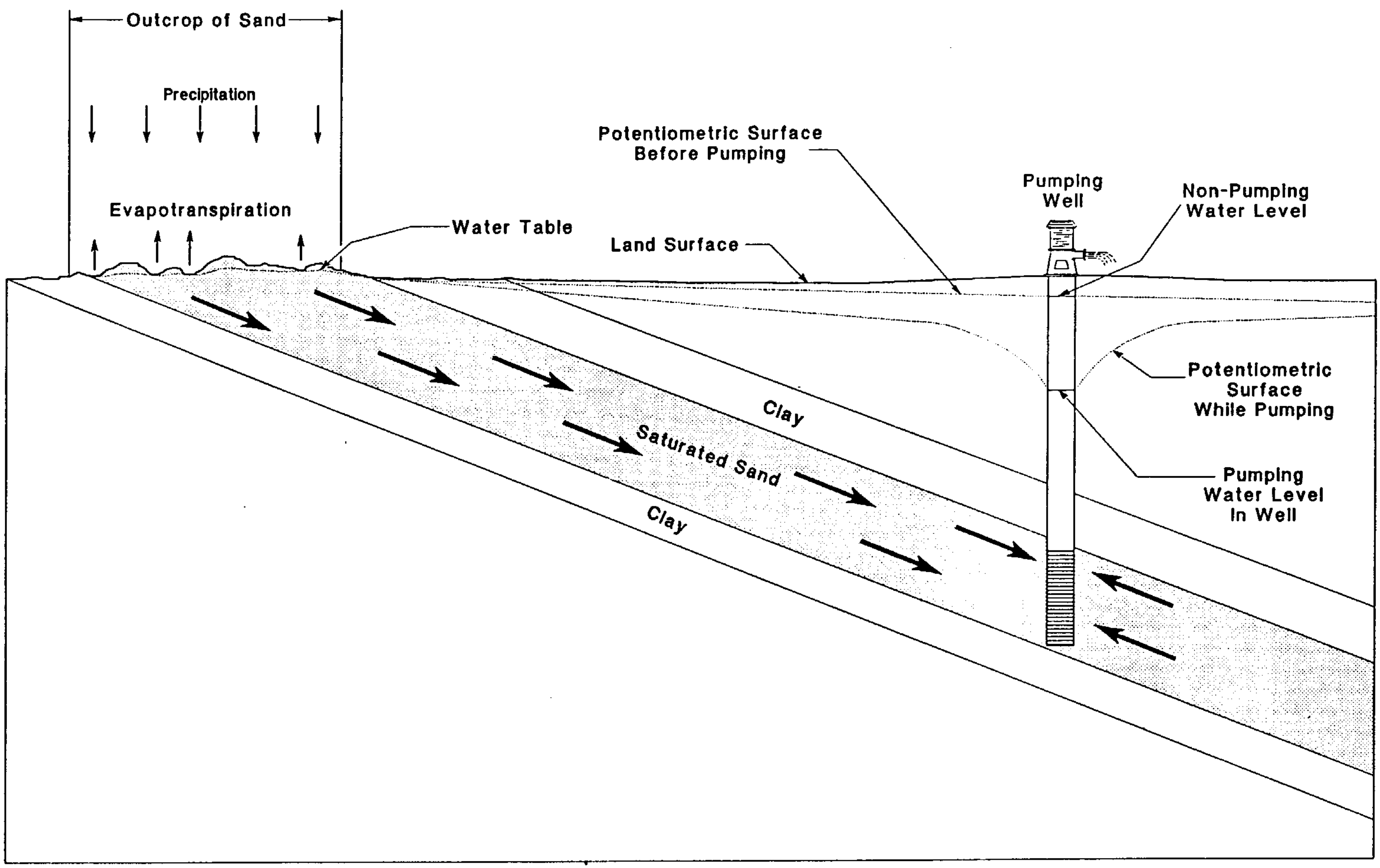
The principal factors influencing the amount of recharge to the Simsboro are the amount and character of precipitation, topography, character of surface materials, type and amount of vegetation, and the ability of subsurface materials to accept recharge and transmit it to areas of discharge. It is virtually impossible to measure the total available recharge directly, but estimates based upon studies in adjacent areas are available (Texas Water Development Board, undated; Cronin and Wilson, 1967). The maximum amount of recharge is estimated to range up to about three to four inches per year which is about 10 percent of the average annual precipitation. Accordingly, over a 460 square mile area, recharge of up to 74,000 to 98,000 acre-feet per year or 66 to 87 mgd (million gallons per day) may be applicable.

While recharge is fairly large, recharge alone is not too important or a limiting factor with respect to the availability of water to wells located in downdip artesian areas because of the large quantities of water in storage in the Simsboro. For example, where water-table conditions exist in the recharge area, the coefficient of storage (amount of water drainable from the sands) is estimated to be between 0.1 and 0.2 based on experience with typical sands. Using a value of 0.15, the amount of water drainable from just the upper 10 feet of saturated sand in the outcrop area amounts to over 440,000 acre-feet. In the upper 50 feet the amount would be five times as large which is equivalent to pumping 67 mgd for 30 years. Thus, large amounts are available for decades from downdip pumping wells with relatively small water-level declines in outcrop areas even without recharge.

At present, a very large percentage of the natural recharge is rejected, and the Simsboro is essentially full to overflowing. Recharged water reaching the water table in outcrop areas moves slowly in the direction of the hydraulic gradient which is from areas of topographic highs towards areas of discharge along the principal stream valleys. Most of the discharge takes place by evapotranspiration in low areas along the principal drainage ways in the outcrop areas. Other discharge occurs by seepage, but these amounts are mostly small. A small part of the recharge also moves down the hydraulic gradient to downdip areas. Under natural conditions and prior to pumping, a small amount moves generally downdip for many miles. Natural ground-water movement rates in the Simsboro are very slow, most probably between about 50 and 200 feet per year.

Pumping from a well changes the local flow pattern so that water moves to the well from all directions. Figure 5-5 is a schematic diagram showing the Simsboro Sand, its recharge area, and the position of the potentiometric surface (defined by the water levels in wells) both prior to pumping and during pumping. Figure 5-5 also shows the cone of depression resulting from pumping, and the movement of water to a well from both updip and downdip directions

Figure 5-5
Cross Section Showing Conditions In Typical Artesian Sand



during pumping. Figure 5-6 shows a plan view of the movement towards a pumping well, and depicts typical flow lines from an outcrop/recharge area.

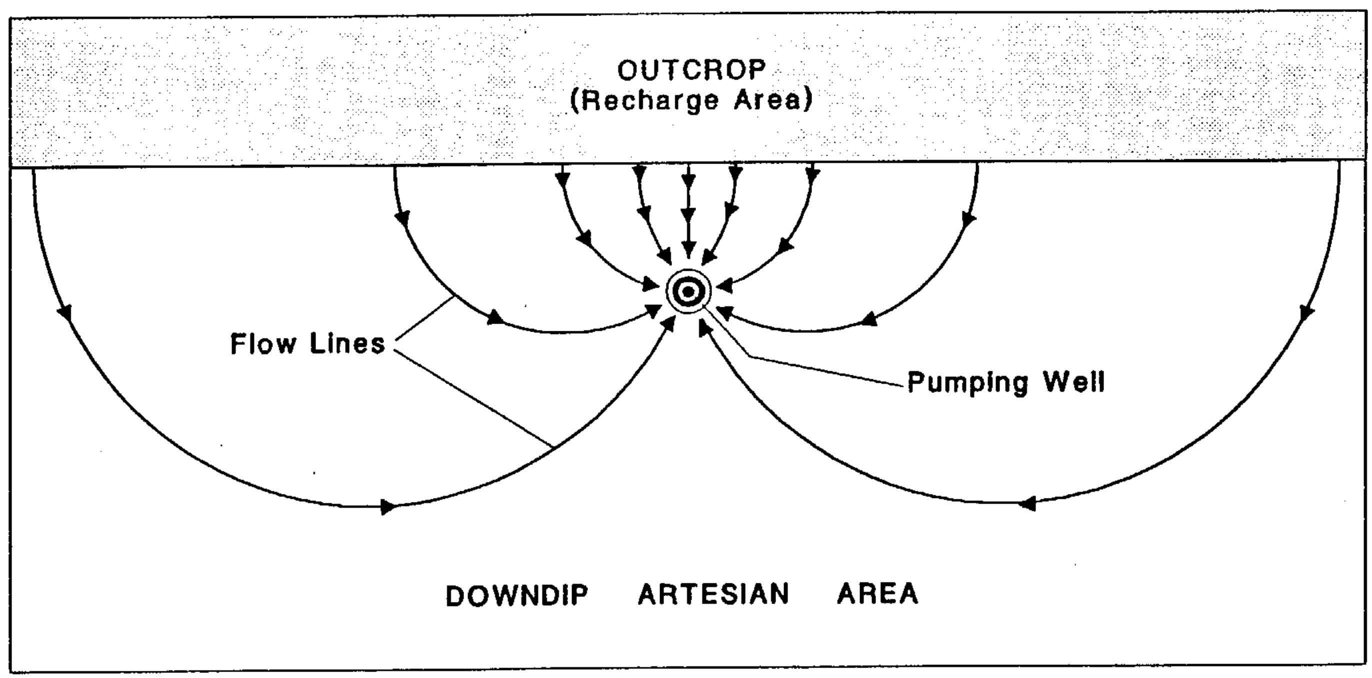
Prior to well development the flow regime in the Simsboro was in a state of equilibrium with the total recharge to the system being equal to the total discharge from seeps and evapotranspiration. Pumping by wells disrupts this equilibrium and causes a withdrawal of water from storage and a concurrent decline of water levels. As water levels fall, natural discharge from the system is reduced, and recharge may be increased. In time, these changes in natural inflow and outflow may be sufficient to balance the withdrawal. If that occurs, a new equilibrium is achieved in which recharge is balanced by the sum of natural outflow and pumpage. Under such conditions depletion of storage no longer occurs. Such an equilibrium, however, is not always possible, especially if the rate of withdrawal is large. Also, it would take tens of feet of lowering of water levels in the outcrop area to capture the water currently being rejected from the Simsboro via evapotranspiration and seeps. However, for the Simsboro and other deep artesian aquifers, if the well pumpage should exceed the reductions in natural outflow which could be achieved and any increases in recharge which could be induced, the wells would continue to furnish water from storage.

Because the outcrop is so extensive and the amount of water in storage is so large, very large developments can be supported with only relatively small, continuing water-level declines. Thus, the present recharge rate, while theoretically important, has little relation to the amount of ground water which is practicable to be developed from deep artesian wells over a period of time -- or even over many decades.

5.2.7 Availability of Water to Meet Demands of the Year 2020

The amount of water capturable by a given well field is a function of the water transmitting capacity of the aquifer, the available drawdown in a given well field, the amount of recharge to the aquifer, and the amount of water in storage in the aquifer. Generally the transmissivity in the artesian portion of the Simsboro Aquifer is quite high, and where sufficient available drawdown is available, large well and well field yields are capable of being developed.

Figure 5-6
Plan View Showing Flow Lines In Typical Artesian Sand



In fact, the Simsboro is one of the most productive aquifers in Texas and is largely undeveloped at present.

Available drawdown is the distance between the static water level and the top of the aquifer (or screen in the well). Generally available drawdown increases to the southeast corresponding to the dip in the formation. This is due to the top of the Simsboro dipping coastward at a much greater rate than the potentiometric surface. Therefore, available drawdowns in the north and northwestern parts of the study area near the Simsboro outcrop are reasonably small, while in downdip areas available drawdown is quite large. Figure 5-1 generally indicates the dip of the top of the Simsboro, and the dramatic increase in available drawdown from northwest to southeast. Near the Simsboro outcrop and near the City of Calvert, available drawdown is reasonably small and generally ranges from just a few tens of feet to about 200 feet. Near the City of Hearne, available drawdown increases several hundred feet, and it continues to increase to the southeast toward the Bryan-College Station well fields.

Near the Simsboro outcrop and within just a few miles downdip of the outcrop, available drawdown limits well yields generally to less than several hundred gallons per minute. Where available drawdown generally exceeds 100 to 200 feet, reasonably large well yields in excess of 1,000 gpm (gallons per minute) can be obtained where thick sands of the Simsboro exist. In the vicinity of the Bryan-College Station well fields, individual well yields are more limited by well and pump diameters than by other factors. Typically, wells have been designed to furnish 1,500 to 3,000 gpm per well which is equivalent to 2.2 to 4.3 mgd per well.

Typical well field yields in the downdip portion of the Simsboro Aquifer are, to date, only a function of the users needs rather than limitations of the Simsboro Aquifer to furnish water. The following table provides the 1987 Simsboro pumpage and number of Simsboro wells in use in 1987 by Bryan, College Station and Texas A&M University:

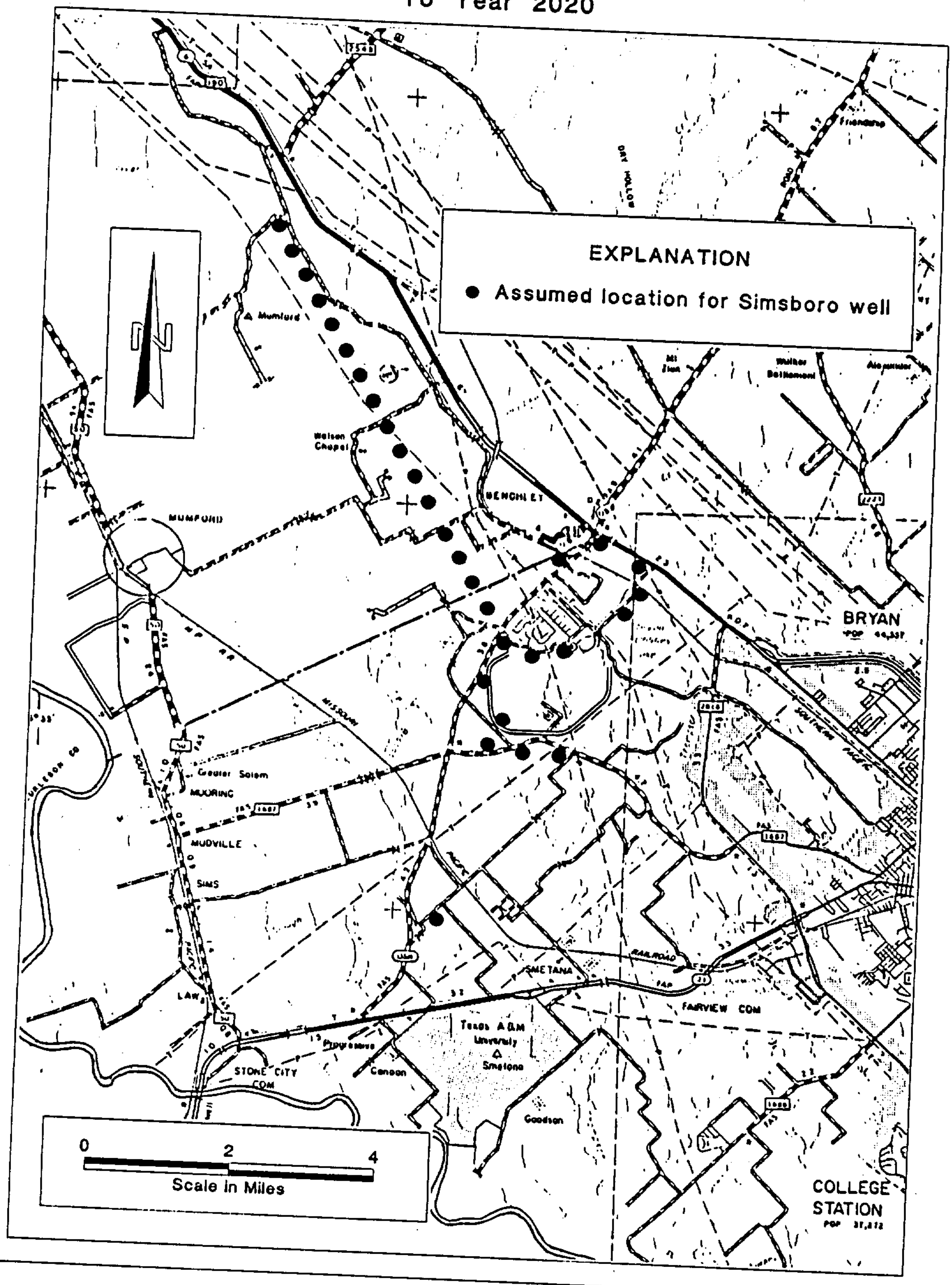
Well Field	Number of Wells	1987 Pumpage (ac-ft)
Bryan	8	9,343
College Station	3	6,105
Texas A&M University	3	4,918

Since 1987, College Station has added one well to its well field. These well field yields are only indicative of municipal water needs of the area and not indicative of the availability of water from the Simsboro. In fact, the Simsboro is capable of furnishing substantially more than the amount of water currently being pumped.

The largest projected future water demand in the five-county area will occur in the primary study area (Brazos County) and will be for the largest present users, Bryan, College Station, and Texas A&M University. Their combined municipal demand is projected to increase from approximately 23.4 mgd in 1990 to approximately 42.6 mgd in year 2020. The increased demand is much too large to be obtained from any of the aquifers present in the planning area, except the Simsboro.

To generally indicate the Simsboros capability to provide increased demand, a hypothetical well field was located in northern Brazos and southern Robertson County and calculations made of future pumping levels. The hypothetical well field was designed to yield up to an average of 49.1 mgd, the total projected demand in Brazos County for 2020. Well spacings were assumed to be at 2,000-foot intervals; individual well yields of 2,100 gpm were assumed. The number of wells required is based on meeting the projected maximum day water demand for Brazos County as furnished earlier in this report. The general layout of the hypothetical well field is shown on Figure 5-7. The conceptual layout includes using 10 of the 14 existing Simsboro wells of Bryan, College Station and Texas A&M University. Additional wells were then added to the well field to meet the estimated future peak daily demands. The wells were added at 2,000-foot spacings along a line extending north toward the City of Hearne. Many other alternative well field layouts would also be possible, but generally should include appropriate well spacings (2,000 feet or more) and well field expansion toward the northwest, away from poorer

Figure 5-7
Conceptual Well Field
To Meet Brazos County Municipal Water Demand
To Year 2020



quality water. Also, actual well field expansion should be based on appropriate test drilling. Table 5-7 shows the results of calculations of future pumping levels and lists the number of wells necessary in five-year increments through year 2020 to meet projected peak demands.

The future pumping levels shown in Table 5-7 were estimated using a computer-assisted mathematical model based on the Theis equation. This mathematical model was developed by the Texas Water Development Board (1973). The calculations are based on a non-leaky artesian solution. The model allows simulation of drawdown (artesian pressure decline) by input of parameters including pumpage, transmissivity, storage coefficient, and boundary conditions by use of image wells. The following hydraulic characteristics were used for the model:

Transmissivity = 100,000 gpd/ft for the first 7 days of any pumping or pumping increase and 55,000 gpd/ft thereafter

Storage Coefficient = .00035

Outcrop = 25 miles from existing Bryan and College Station well fields

Well Yield = 2,100 gpm per well

Pumpage for each five-year period was held constant at the average well field pumpage rate shown in Table 5-7 which is the projected Brazos County demand at the end of the five-year period. For example, during the entire period 1990 to 1995, 30.5 mgd was pumped continuously. This water was pumped from 10 wells each pumping about 2,100 gpm. However, as shown in the table, 19 wells are needed in the well field to meet projected peak daily demands. As water demand increased with time, the number of wells and the pumpage used in the model was increased, as shown in the table.

The average depth of pumping levels shown in Table 5-7 is the calculated average pumping level in the conceptual well field after pumping continuously to the end of the specified period of time. The average depth of the pumping level is based on the computed drawdowns plus an assumed depth of static water level of 100 feet below ground level and also 30 feet of interference drawdown from others. This interference drawdown is based on calculations and

TABLE 5-7

CONCEPTUAL WELL FIELD AND ESTIMATED PUMPING LEVELS

Time Period	Total No. of Wells	Average Well Field Pumpage (MGD)	Well Field Capacity (MGD)	Average Depth of Pumping Level*
1990-1995	19	30.5	57.5	425
1995-2000	22	35.8	66.5	450
2000-2005	24	39.3	72.6	480
2005-2010	26	42.9	78.6	510
2010-2015	28	46.0	84.7	545
2015-2020	30	49.1	90.7	575

* Feet below ground level.

estimates to provide for a few million gallons per day of Simsboro pumpage in Leon County and approximately 20 mgd of pumpage in Robertson County near Calvert, Texas. The pumpage in Robertson County is based on estimated ground-water requirements for power plant and mining purposes. As shown, the estimated average pumping level in 2020 is approximately 575 feet below ground level. During peak water demands, such as during the summer demand, pumping levels will temporarily be lower, while during times of low water demand levels will be higher than those shown. These seasonal water-level fluctuations are mostly unimportant with respect to water availability from the Simsboro.

The results of modeling and the calculations indicate that the Simsboro Aquifer is capable of providing, with some safety factor, all the municipal water requirements for Brazos County including Bryan, College Station, and Texas A&M University. Calculations show that pumping water levels would generally only decline about 350 feet from the present until 2020. With even lower pumping levels, quantities of water in excess of that required to meet projected 2020 demands could be produced.

Typically, the construction of existing Simsboro wells in Bryan/College Station well fields allow high-capacity pumps to be set as deep as 600 to 700 feet below ground level. By modifying and setting pumping equipment in existing wells below pumping levels projected through 2020, existing wells can be used in meeting future projected water requirements. If in some wells, pumping levels fall below the maximum pump setting depth, new wells can be constructed with casings of adequate diameter set sufficiently deeper to provide for 2020 pumping levels or even deeper levels.

5.2.8 Interference Effects From Pumping by Others

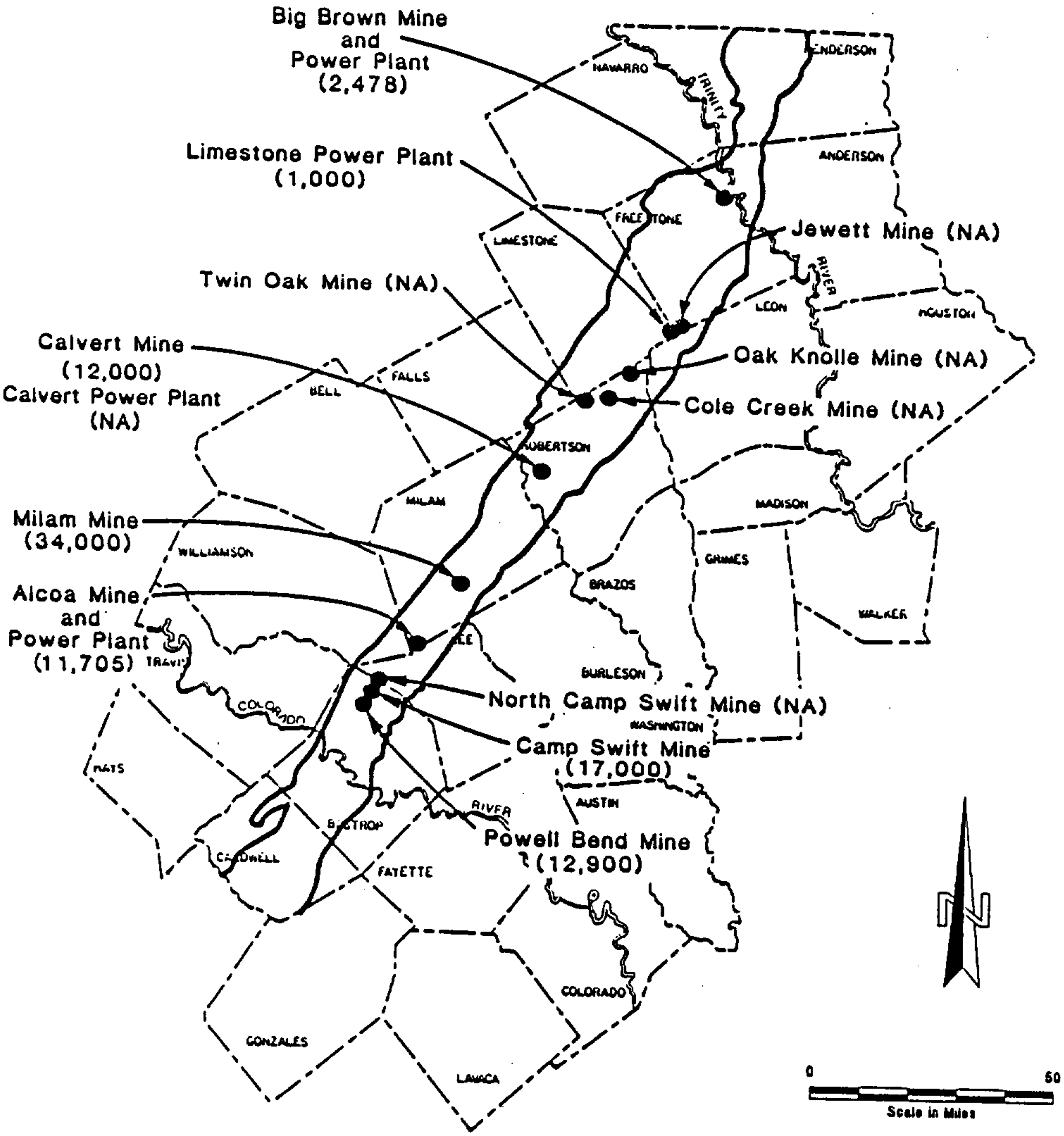
Relative to the Bryan-College Station demand, any potential future development of the Simsboro by others will be mostly for relatively small supplies or at distant locations. No other significant demands are forecast for the entire five-county area. Thus, the potential interference effects on future Bryan-College Station Simsboro developments are not likely to be a limiting factor to those developments. Also, interference on others from Bryan-College Station developments is not likely to be overly significant because of the small projected demand and distant locations. Future projected municipal demands which might logically be obtained from the Simsboro by others are both few and small. Little agricultural development is anticipated, but some moderate to large industrial developments primarily for power plant supplies or in association with lignite mining are anticipated from the Simsboro.

The Texas Water Development Board water use projections provided earlier in this report include projections for future power plant use. Included are 21.4 mgd in 2020 in Robertson County and 10.7 mgd in 2020 for Grimes County. The Robertson County use will likely all be from the Simsboro, and the Grimes County use from surface water sources. Other projections of pumpage from the Carrizo/Wilcox Aquifer for mining and power plant purposes are available (R.W. Harden & Associates, Inc., 1986). Figure 5-8 and Table 5-8 portray these data.

The available data are incomplete and are not necessarily current. Even so, water requirements for individual projects are reported to range from less than 1,000 acre-feet per year to over 30,000 acre-feet per year. In general, several projects are reported to involve withdrawal rates between about 10,000 and 20,000 acre-feet per year. The information appears sufficient to indicate that substantial pumpage will likely occur with some being located in the northern portion of the planning area or in adjoining counties to the southwest. Moreover, the data indicate that nearly all of the pumpage likely will be from the Simsboro with little being from other aquifers. The locations of future potential Simsboro pumping by others appear to be mostly at distances of about 20 to over 70 miles from the Bryan-College Station area. Because of the large distances, no overly large, or limiting, interference effects on potential future Bryan-College Station Simsboro well fields appear likely.

The effect of a well field, producing 20,000 acre-feet per year from the Simsboro, located in northern Robertson County would be between about 20 to 30 feet of interference drawdown on the present Bryan-College Station well fields. Interference of that magnitude, or even substantially larger, will have little impact on the overall availability of water from the Simsboro in northern Brazos and southern Robertson Counties to meet Bryan-College Station use

Figure 5-8
Projected Pumpage From The Carrizo / Wilcox Aquifer For Mining And Power Plant Purposes



EXPLANATION

Approximate location and name of mine or power plant

(12,000) Maximum projected pumpage (acre-feet per year) NA indicates no projection available

Boundary of the Carrizo/Wilcox outcrop

TABLE 5-8

SUMMARY OF PROJECTED PUMPAGE FROM CARRIZO/WILCOX AQUIFER
FOR MINING AND POWER PLANT PURPOSES

Project	County	Projected Maximum Withdrawal Ac-Ft/Yr	Formation**	Source
*Powell Bend Mine	Bastrop	12,900	S	HSI Consultants, Inc. 1981
Camp Swift Mine	Bastrop	17,000	S	U.S. Environmental Protection Agency, 1980
North Camp Swift Mine	Bastrop and Lee	No Data		
*Alcoa - Sandow Mine	Milam and Lee	10,600	S/CB	Hall Southwest Water Consultants, Inc, 1985b
*Alcoa Power Plant	Milam	1,105	S	Texas Water Development Board, 1984
Milam Mine	Milam	34,000		Texas Public Utilities Commission, 1982
*Calvert Mine	Robertson	12,000	S	Phillips Coal Company, 1986
*Calvert Power Plant	Robertson	No Data		
Cole Creek Mine	Robertson	No Data		
*Twin Oak Mine	Robertson and Limestone	No Data		
Oak Knolle Mine	Robertson and Limestone	No Data		
*Jewett Mine	Leon and Freestone	No Data		
*Limestone Power Plant	Limestone and Freestone	1,000	S	U.S. Environmental Protection Agency, 1981
*Big Brown Mine	Freestone	2,400	CB	Hall Southwest Water Consultants, Inc, 1985a
*Big Brown Power Plant	Freestone	78	S	Texas Water Development Board, 1984

SOURCE: R.W. Harden & Associates, Inc., 1986

* Existing project or project with permitting in progress
** Formation code: S - Simsboro, CB - Calvert Bluff

through year 2020. Basically, only lifting costs would be increased slightly. Such developments would also not appreciably change gradients near fresh/brackish water boundaries, and so would not appreciably affect intrusive movement of poor quality water.

From a water quality standpoint, it is unlikely that mining operations in Robertson or adjoining counties will be of any real significance to future well developments in the Simsboro. This is especially true with respect to any future well field developments by Bryan, College Station and Texas A&M University. This is because of the distant locations and because the lignite being mined typically is interbedded with thick deposits of silt and clay and tends to be separated from the Simsboro (and other significant water-bearing units). Degradation of water quality in aquifers adjacent to the lignite tends to be precluded by these natural silt/clay barriers to ground-water movement. While mine drainage sometimes has the potential to be of poorer quality than some natural ground waters, whether that quality would be of any importance would depend on local conditions.

Regardless, the travel of any poor quality water which might result from mining operations or other sources would be limited by low ground-water movement rates. For example, the Bryan-College Station area is about 20-25 miles from the nearest mining operations in northern Robertson County, and typical Simsboro ground-water movement rates are only 100 to 200 feet per year. Thus, 20 miles is equivalent to a travel time of 528 to 1,056 years. Mining operations which are miles away should be of little concern to future Simsboro developments chosen to meet 2020 demands. For similar reasons, any other type of contamination in outcrop recharge areas should not be a concern in planning 2020 supplies from well fields located at even moderate distances from these recharge areas.

5.2.9 Effects of Pumping On Fresh Water/Brackish Water Interface

At present, pumpage from aquifers in the five-county area is either relatively small or the distances from pumping wells to the location of poor quality water (the fresh water/brackish water interface) is typically large. Under such circumstances, there is no likelihood of the poor quality water moving into existing fresh water wells. Similarly, future encroachment of this poor quality water is unlikely unless there is development of heavy pumping close to areas where the poor quality water is located. Only under such conditions can the poor quality water be drawn into wells.

Pumping can affect the position of the fresh water/brackish water interface. This is because the original slope of the potentiometric surface from the outcrop to downdip areas of the aquifer is small and because the cone of depression caused by heavy pumping can be relatively deep and can extend over wide areas. Under such conditions, the cone of depression results in a gradient from the fresh water/brackish water interface towards the pumping well field. For example, in the case of the Simsboro, flow lines to the pumping wells originate in the outcrop. However, they do not go straight to the wells because of the radial nature of the flow to wells. Some of the flow lines pass by on either side of the wells and then turn and come back to the wells from the direction of the fresh water/brackish water interface. Depending on well location, some of the flow lines can actually pass from the outcrop into the area containing the poor quality water and then turn and move toward pumping wells. This circumstance causes the fresh water/brackish water interface to move, quite slowly, toward the pumping wells. This situation would be the most severe if the pumping were very large and were located very close to the fresh water/brackish water interface.

Currently, the cone of depression as a result of pumping from the Simsboro by Bryan, College Station, and Texas A&M University is undoubtedly causing some movement of the fresh/brackish water interface toward the well fields. However, there is no indication from chemical analyses that the water from any of the wells is increasing in mineralization. The following listing shows the concentration of some of the major constituents from early and recent analyses of water from the City of Bryan's Simsboro Well 10. This well is closest to the fresh water/brackish water interface of all the Bryan, College Station, and Texas A&M University Simsboro wells and has been utilized for the longest time. Bryan's Well 10 would be expected to be one of the first wells to show an increase in mineralization if noticeable encroachment of poor quality water were occurring.

Month/Year	3/54	12/87
Total Dissolved Solids, mg/l	775	774
Chloride, mg/l	75	66
Sulfate, mg/l	2	.13
Bicarbonate, mg/l	659	617
Sodium, mg/l	318	307

From inception of Simsboro pumping by the City of Bryan in 1954 and through the development of the Texas A&M University and the City of College Stations Simsboro supplies, no deterioration of water quality has been observed in Well 10 or any of the other Simsboro wells. However, it is possible that given enough time there will be a noticeable increase. It should be anticipated that the first increases will occur in those wells closest to the poor quality water. The process is very, very slow, however, because of the large amounts of water in storage in the Simsboro, the large distance to the fresh water/brackish water interface, and because the water moves radially to the centers of pumping from all directions. As a result, it takes many years for water to move any great distance.

The amount of water in storage in the Simsboro is on the order of 76,800 acre-feet per square mile or 25 billion gallons per square mile. This is equal to pumping for one year at the rate of 68 mgd. Using this value and geometry, approximations can be made of the number of years for water to move to wells fields from any distance. Five examples are shown below using various distances, pumping rates, and assuming a porosity of 30 percent for the Simsboro.

	Well Field Pumping Rate	Distance to Brackish Water	Time Required For Brackish Water To Move To Well Field
Example A	2 mgd	1 mile	108 years
Example B	20 mgd	2 miles	43 years
Example C	60 mgd	4 miles	57 years
Example D	60 mgd	8 miles	230 years
Example E	120 mgd	10 miles	179 years

The existing Simsboro well fields of Bryan, College Station and Texas A&M University collectively represent a condition somewhere between Examples A and B. If the full projected 2020 demand for Brazos County were developed from the Simsboro at a distance of four to eight miles from brackish water, a condition somewhere between Examples C and D would be applicable.

In summary, only very large developments located close to poor quality water can draw in poor quality water, or even cause much lateral movement of the fresh water/brackish water interface except over long time periods. Also, any change in water quality is normally slow. If monitoring of water quality is done, there is a long lead time available to relocate wells or to otherwise deal with the situation. With proper location of future well fields, the threat of brackish water encroachment should not be a limiting factor in ground-water development to meet 2020 demands.

5.3 OTHER AQUIFERS

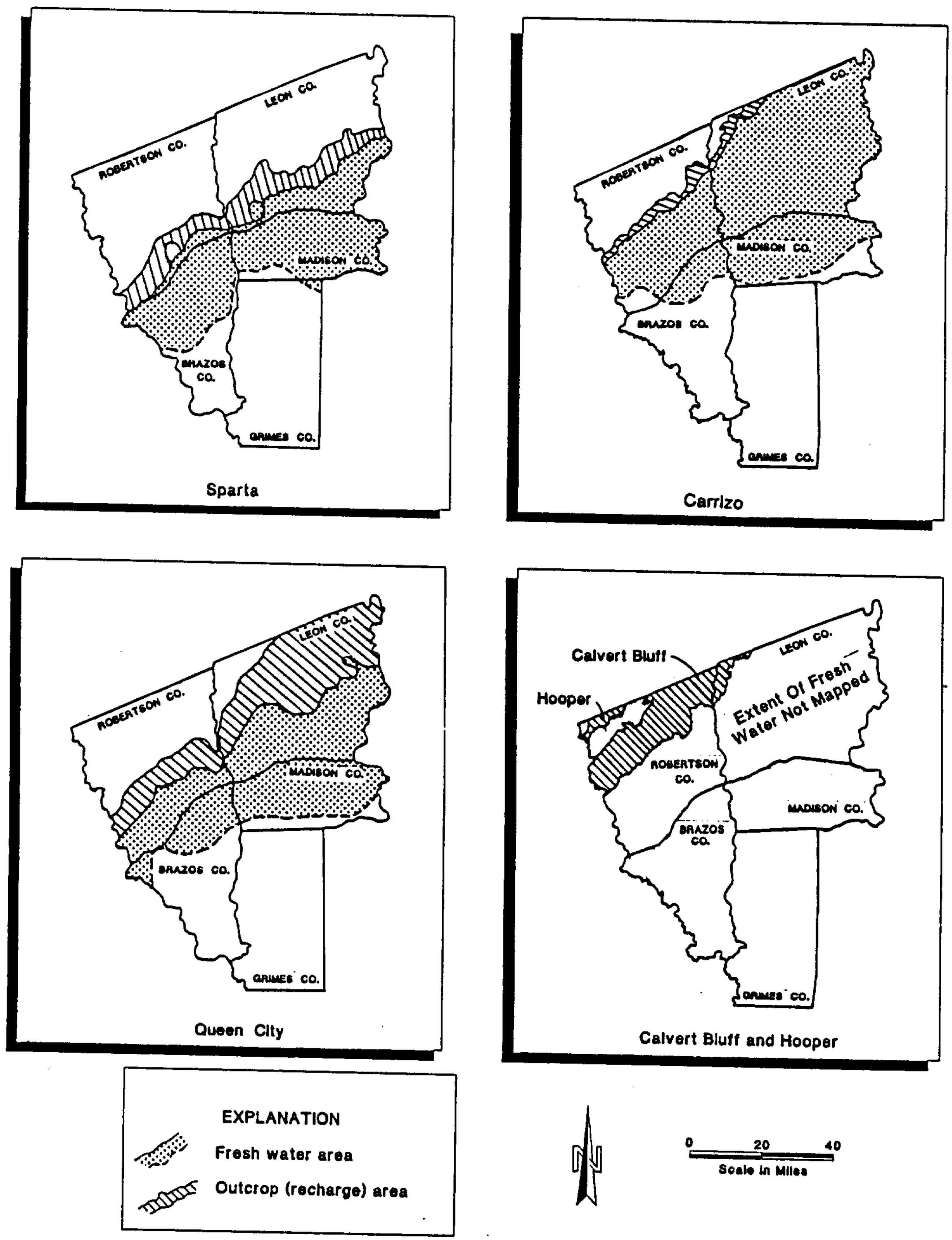
5.3.1 Introduction

Several other aquifers in addition to the Simsboro are located in the five-county area and are included in the scope of this study. From shallowest to deepest they are the Sparta, Queen City, Carrizo, Calvert Bluff, and Hooper. Although these other aquifers are capable of meeting water requirements for some of the smaller municipal and industrial users, they are not nearly as important quantitatively as the Simsboro and are also not likely to be important factors in any regional integration of supplies.

5.3.2 Location

Figure 5-1 shows the relative vertical position and extent of the Sparta, Queen City, Carrizo, Calvert Bluff and Hooper Aquifers. Figure 5-9 shows the lateral extent. The northwest boundary of each of the aquifers is at the northwest boundary of its outcrop area. The downdip or southeastern extent of each aquifer is the southeastern extent of fresh water (up to 1,000 mg/l

Figure 5-9
Location Of Sparta, Queen City, Calvert Bluff And Hooper Aquifers



total dissolved solids content). Each aquifer dips from northwest to southeast generally at a rate of approximately 100 feet per mile. The Sparta is the shallowest, and it overlies the Queen City. The Carrizo Sand directly overlies the Wilcox Group which is composed of the Calvert Bluff, Simsboro, and Hooper Formations. Each aquifer is of importance in only about the northern half of the five-county area or less. The downdip boundaries of fresh water as shown on Figure 5-9 are from Texas Water Commission (1989) mappings.

5.3.3 Present Use

Industrial and municipal use of ground water within the five county study area is small (Table 5-1), except for use by Bryan, College Station and Texas A&M University. Table 5-2 shows the 1987 ground-water use by municipal users by aquifer as reported by the Texas Water Development Board (1989). This information indicates the total distribution of municipal ground-water pumpage in the five-county area and the number and size of current municipal users.

To better evaluate the importance of the individual aquifers to present users, the available information was distributed according to the total amount of use from each aquifer. The distribution is:

Aquifer	1987 Municipal Pumpage Ac-ft	Percent of Total Municipal Pumpage
Simsboro	24,758	81
Carrizo	927	3
Queen City	284	1
Hooper and Calvert Bluff	819	3
Sparata	1,742	6
All Others	1,837	6
Total	30,367	100

Less than 6,000 acre-feet of ground-water pumpage occurred for municipal use from the Sparta, Queen City, Carrizo, Calvert Bluff, Hooper, and other aquifers in the five-county area in 1987. About 1,700 acre-feet was from the Sparta, most of which was from Texas A&M University's Sparta well field. The remainder was produced by over 40 small municipal users scattered over the five-county area. Most of the users produced less than 200 acre-feet in 1987. Moderate users include the City of Centerville in Leon County, the City of Madisonville in Madison County, Texas Department of Corrections in Grimes County, the City of Buffalo in Leon County, and the City of Navasota in Grimes County.

In the general vicinity of the Cities of Bryan and College Station, and their respective well fields, the only aquifers capable of furnishing potable water are the Sparta Sand and Simsboro Sand. Water in the Sparta within Bryan-College Station proper is mineralized with total dissolved solid concentrations in excess of 2,000 mg/l. However, to the west mineralization is lower, and both Bryan and Texas A&M have developed well supplies from the Sparta having total dissolved solids content of about 300 mg/l. The City of College Station has never developed any Sparta supplies.

The City of Bryan has an older well field in the Sparta which is not currently used, except on occasion to meet peak summer demands. Texas A&M University is the only major user of the Sparta in the Bryan-College Station area. In 1987 about three percent of their total pumpage was from the Sparta. The remaining pumpage was from the Simsboro. The Texas A&M University Sparta well field coupled with the earlier Bryan pumpage from the Sparta, virtually resulted in full development of the Sparta (Guyton, 1971), so any significant future ground-water development could only be from the Simsboro.

The City of College Station used one Queen City production well located within the City. The water was of moderately high mineralization, (about 1,700 mg/l total dissolved solids content) and was mixed with Simsboro water. In 1987 the City of College Station produced only about 0.5 percent of their total pumpage from the Queen City. In recent years this Queen City well has been little used.

5.3.4 Availability of Water to Meet Demands of the Year 2020

The northern half of the five-county planning area is endowed with significant ground-water resources which could be utilized to meet water demand through 2020. Six aquifers are present including the Sparta, Queen City, Carrizo, Calvert Bluff, Simsboro, and Hooper. Each can furnish significant additional supplies to present users from expanded or properly-located well fields. In many areas the extent of the aquifers overlaps, and potential users of small supplies will have some options with respect to which zones can be utilized. Local water quality and available well yield likely will dictate choices.

To generally evaluate the potential availability of water from the six aquifers, some typical hydraulic and common characteristics of the aquifers and larger-capacity wells are presented in Table 5-9. Included are typical values which can be used to compare transmissivity, well screen length, and well yield for the different aquifers. The source of the information is primarily published reports which has been supplemented by information from owners and experience in evaluating or developing water supplies from each of the aquifers.

The transmissivity values shown in Table 5-9 represent the typical maximums which can be expected where wells screen the full sand thicknesses commonly present in those areas which have been developed by wells or in those areas considered more favorable for development. Other factors being equal the availability of water from the aquifers is proportional to their transmissivity. It can be seen that the Simsboro is overwhelmingly the most important, however other units have significant availability of water, especially in relation to the widely-scattered and small projected 2020 demand for those small to moderate users in the planning area.

Table 5-9 also shows typical well screen lengths for high-capacity wells completed in the aquifers as well as typical well yields for high-capacity wells. The last column in Table 5-9 ranks the estimated availability of ground water from the aquifers. The numbers are comparative only and reflect the relative quantitative potential of the aquifers. For example, the Queen City, Hooper, and Calvert are considered to have the least water available and to be about equal, with the Sparta considered to have about twice the availability that the Calvert Bluff, Hooper or Queen

TABLE 5-9

TYPICAL AQUIFER VALUES

Aquifer	Transmissivity (gpd/ft)	Well Screen Length (ft)	Well Yield (gpm)	Estimated Relative Water Availability
Sparta	12,000	<100	500	2X
Queen City	<10,000	<100	250	1X
Carrizo	25,000	100	1,000	4X
Calvert Bluff	<10,000	<100	250	1X
Simsboro	100,000	300+	2,400	16X
Hooper	<10,000	<100	250	1X

City has. The Carrizo is considered to have about twice the availability that the Sparta has. The Simsboro is considered to have about four times the availability that the Carrizo has in as much as the Simsboros transmissivity is about four times larger.

Within Robertson, Leon, and Madison counties, future municipal demands are not significantly larger than existing ground-water pumpage. Also, users are widely scattered and have little interference effects on one another. It is judged from Table 5-9 and the amounts of the projected 2020 demand that all small and moderate users will likely be able to obtain future amounts from the same sources which they are currently using or from nearby well fields in available aquifers. The same is likely true for projected industrial demands which are all small (except for Robertson County). The projected industrial use for Robertson County will be from the Simsboro, and the amount is considered available from local well fields.

In southern Brazos County and in Grimes County some other aquifers exist. These include sands of the Yegua Formation, Jackson Group, Catahoula Formation, and Fleming Formation. Evaluations of these aquifers are outside the scope of this study. However, some estimates of availability for Grimes County are given in Baker, et al (1974). They are:

Aquifer	Amount
Yegua	3.5 mgd
Jackson	2.2 mgd
Catahoula	4.5 mgd
Fleming	36 mgd

The values are relatively small excepting for the Fleming. The Fleming is present only in southernmost Grimes County. Both the current and projected demand in the southern part of the planning area are also small. This suggests the aquifers probably are capable of supplying most of those needs, especially if some well fields were located in the Fleming.

5.4 GROUND-WATER RECHARGE ENHANCEMENT AS A SOURCE OF WATER

A variety of methods have been used to artificially recharge aquifers in order to maintain or augment the natural supply. However, artificial recharge methods are generally not applicable to supplementing the type of storage/transmission system present in either the Simsboro or the other aquifers considered herein.

Artificial recharge is defined as augmenting the natural movement of water into underground formations by some method of construction, by spreading of water, or by artificially changing natural conditions. (Todd, 1959) A variety of methods have been used including water spreading via basins, stream channels, ditches, flooding and irrigation. Other techniques employ pits or recharge wells. In addition, sometimes wells are located specifically near surface water bodies and pumped to induce recharge. The particular methods used are governed by local geohydrologic conditions, the quantity of water available to be recharged and the use of the recharged water. In many situations, recharge projects also assist to overcome local problems such as progressive lowering of ground-water levels or brackish water intrusion. Of course, adequate amounts of water must be available in order to place water underground for future use. Common sources include storm runoff collected for subsequent recharge, treated wastewater, or importation of distant surface water sources.

Water spreading techniques or artificially changing natural conditions in outcrops of the water-bearing formations are generally not applicable to the Simsboro or other regional aquifers. At present, the recharge areas of all of the aquifers are full to overflowing. Water levels in outcrop areas adjacent to major stream valleys are a few to several tens of feet higher than the adjacent stream valleys. Thus, any amounts recharged would not benefit downdip areas where wells are located but would only serve to increase natural discharge in outcrop areas. With current water levels, recharging in outcrop areas would do little to increase storage and would not affect transmission to wells in downdip areas.

Recharging in downdip artesian areas could only be accomplished by wells. Recharging via wells is normally done to combat adverse conditions such as brackish water intrusion or progressively declining water levels in addition to maintaining or augmenting the supply. No progressive declines of water levels, excepting those caused by pumpage increases, are occurring in the study area. Also, no troublesome brackish water intrusion is occurring, and there is no lack of overall supply. Recharging via wells in the artesian portion of the aquifers, especially in the Simsboro, would only serve to raise water levels (artesian pressures) and lessen pumping levels in adjacent well fields with the amount being related to the locations and amounts recharged. The net benefit would only be small reductions in lifting costs. At present, lifting costs are essentially an unimportant part of ground-water development costs, and the large capital and operating expenses associated with recharge wells certainly would be an uneconomical way to raise water levels. Furthermore, there would have to be a source for the water used to recharge with that source being large in quantity and of good quality. No such source which could not more economically be utilized directly is available.

6.0 SURFACE WATER RESOURCES

6.1 GENERAL DESCRIPTION

Municipal and manufacturing water demands within the primary study area are currently met exclusively from ground-water sources. However, in the future it is to be expected that the demand for water in the primary study area will exceed the capacity of existing well facilities. The development of surface water supplies represents an alternative course of action to the expansion of existing ground-water supplies. The following sections describe the existing and proposed surface water resources that may be available to supplement the future municipal water demands of Brazos County that would not be met by ground-water sources. Refer to Table 6-1 for a summary of existing and proposed reservoirs.

6.2 EXISTING RESOURCES

6.2.1 Brazos River

The Brazos River is the primary source of a basin-wide water supply system managed by the Brazos River Authority (BRA). In addition to the management of the Brazos River, the BRA manages 11 water supply reservoirs throughout the basin. The BRA reports that a long-term water supply capable of providing over 45 mgd is currently available from the Brazos River near College Station (see Appendix D for BRA's letter of recommendation). This quantity is well in excess of the projected deficiencies that would occur if no new ground-water supplies were developed to meet future water demands. The river is located approximately 5 miles to the southwest of the Bryan-College Station area.

While water quality within the Brazos River is generally satisfactory for water supply, the BRA reports some problems with elevated salt concentrations, particularly during periods of low flow. Because of the available water rights and the close proximity to the Bryan-College Station area, the Brazos River has been carried forward as a potential source of water supply for the primary study area.

TABLE 6-1

EXISTING AND PROPOSED SURFACE WATER RESOURCES

Name	County Location	Status	Basin	Approximate Distance to B-CS	Yield	
					ac-ft/yr	mgd
Brazos River	Brazos					
Lake Somerville	Burleson, Lee, Washington	Existing	Brazos	5 mi	ND	ND
Lake Limestone	Limestone, Robertson, leon	Existing	Brazos	23 mi	31,136	27.8
Twin Oak Reservoir	Robertson	Existing	Brazos	45 mi	65,500	58.5
Gibbons Creek Reservoir	Grimes	Existing	Brazos	35 mi	ND	ND
Lake Livingston	Polk, San Jacinto	Existing	Brazos	12 mi	ND	ND
Lake Conroe	Montgomery	Existing	Trinity	65 mi	1,288,000	1,149.8
Camp Creek Lake	Robertson	Existing	San Jacinto	45 mi	100,600	89.8
Millican Lake	Grimes, Brazos	Existing	Brazos	26 mi	2,600	2.3
Bedias Reservoir	Madison, Grimes, Walker	Proposed	Brazos	3-5 mi	252,000	225.0
Lake Navasota	Robertson	Proposed	Trinity	25 mi	109,758	98.0
Caldwell Reservoir	Burleson, Milam	Proposed	Brazos	22 mi	231,600	206.7
Brazos Coal Lake	Brazos	Proposed	Brazos	16 mi	97,438	87.0
		Proposed	Brazos 10 mi	ND	1.8	

SOURCES: Brazos River Authority, Personal Correspondence, 1990. See Appendix D
Trinity River Authority, Personal Correspondence, 1990. See Appendix D
Metcalf & Eddy, Houston Water Master Plan, 1985.

ND - No Data

11753/890674

6.2.2 Lake Somerville

Lake Somerville is a multi-purpose reservoir located in Burleson County, approximately 23 miles to the southwest of College Station. With a surface area of approximately 11,460 acres, Lake Somerville has a total capacity of 160,110 ac-ft and a 2020 estimated yield of 37,900 ac-ft. The BRA notes a current available yield of 31,136 ac-ft/yr, or approximately 27.8 mgd, from Lake Somerville. See Appendix D for BRA's letter of recommendation. This yield exceeds the projected deficiencies that have been identified if no new ground-water development occurs.

Water quality from Lake Somerville is excellent for water supply. This source has been carried forward as a potential source of water supply for the primary study area of Brazos County.

6.2.3 Lake Limestone

Lake Limestone is located on the Navasota River approximately 45 miles north of the City of Bryan. This reservoir was constructed and is operated by the BRA. Lake Limestone currently supplies make-up water for off-channel cooling lakes that serve the lignite-fueled steam electric power plants located in the area. The lake has a total estimated capacity of 225,400 ac-ft and an estimated yield of approximately 65,500 ac-ft/yr, or approximately 58.5 mgd. Although Lake Limestone has some available water rights, this source has been eliminated for consideration due to the high costs that would be associated with transmission from the reservoir to the Bryan-College Station area.

6.2.4 Twin Oak Reservoir

The Twin Oak Reservoir is located in Robertson County, approximately 35 miles to the north of the Bryan-College Station area. This 2,330 surface acre reservoir is operated by the Texas Utilities Generating Company (TUGCO) and provides cooling water for the lignite-fueled steam electric power plant located in the area. Based on this single purpose use and distance from Bryan-College Station, this reservoir has been eliminated as a potential source of water supply for the primary study area.

6.2.5 Gibbons Creek Reservoir

Gibbons Creek Reservoir is owned and operated by the Texas Municipal Power Agency for the sole purpose of providing cooling water for a lignite-fueled steam electric power plant. This reservoir was eliminated for consideration as a potential source of water for the primary study area for this reason.

6.2.6 Lake Livingston

Lake Livingston is a multi-purpose reservoir located in the Trinity River Basin approximately 65 miles to the east of the Bryan-College Station area. This reservoir is operated by the Trinity River Authority. See Appendix D for TRA's letter of recommendation. Although the TRA has indicated that sufficient water rights exist to meet the future water demands of the primary study area, it has been assumed that this source would not be economically feasible in light of the high costs associated with conveyance.

6.2.7 Lake Conroe

Lake Conroe is located in the San Jacinto River Basin approximately 45 miles to the southeast of the Bryan-College Station area. Although this reservoir may have some available yield for allocation, it has been eliminated for consideration as a viable source of water supply due to the high costs of transmission from the lake to the twin cities area.

6.2.8 Camp Creek Lake

Camp Creek Lake is located in Robertson County approximately 26 miles to the north of the cities of Bryan and College Station. This lake has a total capacity of approximately

8,550 ac-ft and is used primarily for recreation. Because of its small size and its distance from the Bryan-College Station area, this surface water option has been eliminated from consideration as a potential source of water supply.

6.3 PROPOSED RESOURCES

6.3.1 Millican Lake

Millican Lake is a planned multi-purpose reservoir that has been proposed for construction on the Navasota River in portions of Brazos, Grimes, Leon, Madison and Robertson counties. At its closest point, the site would be located several miles to the east of the cities of Bryan and College Station. This proposed reservoir would be constructed and operated by the BRA, and would have an estimated total storage capacity of approximately 1,973,000 ac-ft, and an available reservoir yield of approximately 248,600 ac-ft/yr, the equivalent of 222 mgd. Although still in the planning stages, this reservoir was suggested by BRA and has been carried forward as a potentially viable water supply option for Brazos County. See Appendix D for BRA's letter of recommendation.

6.3.2 Bedias Reservoir

The proposed Bedias Reservoir has been studied by the Trinity River Authority (TRA) and the Bureau of Reclamation as a potential municipal supply for the Houston area and local areas. See Appendix D for TRA's letter of recommendation. As proposed, the 17,000 surface acre Bedias Reservoir would be located in portions of Madison, Grimes, and Walker counties and have a projected yield of approximately 76 mgd. In the absence of firm commitments from users, however, the TRA halted all planning for this potential project in early 1988. If constructed, the proposed reservoir would be located in the Trinity River basin approximately 25 miles from the Bryan-College Station area. Because of the high costs associated with transmission of water from the Trinity River basin to the Brazos River basin, this proposed reservoir has been eliminated for consideration as a viable source of water supply.

6.3.3 Lake Navasota

Lake Navasota is a proposed water supply project on the Navasota River that has been under joint study by the US Army Corps of Engineers and the BRA. The proposed location in Robertson and Leon Counties would be approximately 22 miles from Bryan-College Station. As currently planned, Lake Navasota would have a total capacity of approximately 1,384,900 ac-ft and a yield of approximately 231,600 ac-ft/yr. In light of the distance from the Bryan-College Station area, this alternative has been eliminated from consideration as a viable surface water source for Brazos County.

6.3.4 Caldwell Reservoir

The proposed Caldwell Reservoir has been reviewed for feasibility by a number of entities including the Corps of Engineers and is currently under study by the BRA as a potential source of water supply. The proposed reservoir would be located in Burleson and Milam counties. The damsite is proposed on Cedar Creek west of FM 1362, near Goodwill, approximately 8 miles northeast of Caldwell. Projected yields of this reservoir are approximately 97,438 ac-ft/yr, or approximately 87 mgd. The reservoir would be developed from stormflow down Cedar Creek, and because of the small size of the reservoir it would need to be supplemented by unregulated high flows directly from the Brazos River. Because of its location to the primary study area, Caldwell Reservoir is a potentially viable surface water source and was suggested by BRA. See Appendix D. However, because supplementary flows from the Brazos River were necessary with an additional cost for conveyance, direct pumpage from the Brazos River as discussed in Section 6.2.1 was considered in lieu of pumpage from Caldwell Reservoir.

6.3.5 Brazos Coal Lake

The Brazos Coal Lake is a proposed reservoir that is in the early stages of planning by a private developer. Proposed for location in Brazos County on Peach Creek, a tributary of the Navasota River, approximately 10 miles south of College Station, this lake would have an estimated surface area of approximately 1,500 to 2,500 acres. As planned, a primary purpose of this lake would be to serve as an amenity feature for surrounding land development. The yield of this proposed lake has been estimated at approximately 1.8 mgd. In light of the size and available yield, this project was eliminated for consideration as a surface water alternative for Brazos County.

6.3.6 Upper Keechi Creek Reservoir

The Upper Keechi Creek reservoir is a potential project located in the Trinity River basin. As planned, this potential project would be located in Leon County and would have an estimated firm yield of 25 mgd. This surface water alternative has been eliminated from consideration due to distance-related conveyance costs.

6.4 SURFACE WATER RESOURCES SCREENING PROCESS

Based on the wide range of existing and proposed surface water resources potentially available to serve Brazos County, EH&A conducted a screening of these resources in order to select alternatives for master planning of a regional system. This screening process consisted of an evaluation of each of the previously described surface water alternatives according to several general criteria:

- Sufficient and Available Yield;
- Distance-related Conveyance Costs;
- Designated Use; and,
- Recommendation or suggested consideration by BRA and TRA.

Where possible, EH&A gave consideration to the use of existing resources over proposed. However, in several cases the economic costs of conveyance, for example, would be expected to be prohibitively high, resulting in the consideration of proposed projects situated in closer proximity to the Bryan-College Station area. In the screening of proposed reservoirs, EH&A did not attempt to evaluate the technical, economic, or political feasibility of these projects. Instead, all proposed projects were generally assumed to have an equal probability of construction.

Based on a screening of the surface water alternatives noted in Table 6-1, EH&A identified three potential sources of surface water for the Bryan-College Station area. Table 6-2 provides a screening matrix of the existing and proposed surface water resources considered for the master planning of a regional water supply system.

6.5 RECOMMENDED SURFACE WATER ALTERNATIVES

Based on a screening of all surface water resources with potential to supplement the existing ground-water supplies in the primary study area, EH&A selected three alternatives. These alternatives are: 1) the Brazos River, 2) Lake Somerville, and 3) Lake Millican. Although Lake Millican is a proposed project, this alternative was selected because of its high yield and close proximity to the Bryan-College Station area. The Lake Millican alternative was also suggested by the BRA.

TABLE 6-2

PRELIMINARY SCREENING MATRIX

Resource	Screening Criteria				Status	
	Sufficient Yield	Conveyance Costs	Designated Use	Recommendations	Eliminated	Retained
EXISTING:						
Brazos River	●	●	●	●		■
Lake Somerville	●	●	●	●		■
Lake Limestone	●	○	●	-	■	
Twin Oak Reservoir	○	○	○	-	■	
Gibbons Creek Res.	○	●	○	-	■	
Lake Livingston	●	○	●	-	■	
Lake Conroe	●	○	●	-	■	
Camp Creek Lake	○	○	●	-	■	
PROPOSED						
Millican Lake	●	●	●	●		■
Bedias Reservoir	●	○	●	●	■	
Lake Navasota	●	○	●		■	
Caldwell Reservoir	●	○	●	●	■	
Brazos Coal Lake	○	○	○	-	■	
Upper Keechi Creek Reservoir	●	○	●	●	■	

● Favorable.
○ Unfavorable.

7.0 RECOMMENDED ALTERNATIVE SOURCES

7.1 GENERAL

The purpose of this section is to describe the selected water resources and the methodology used to evaluate the alternatives for a regional water supply for the primary study area. The water demands for the study period have been identified and can be found in Section 3.0, Population and Water Demand Projections. This section will identify four alternative sources selected to meet the expected water demands, describe the necessary improvements and the associated cost of those improvements for each alternative, and develop a reasonable determination of the unit cost of raw water.

In general, three surface water resources and the Simsboro Aquifer wells have been selected. This section provides an economic comparison of each resource. The surface water improvements will consist of intake facilities, pump station, raw water transmission mains, treatment facilities, booster pump stations and treated water transmission mains. The ground water improvements will consist of a well field, well field transmission main, cooling towers, booster pump station and treated water transmission mains. The design of each alternative has been developed using the following criteria:

- Because surface water alternatives are being compared to ground water alternatives, all reservoir alternatives assume the reservoir is in place. Estimated reservoir construction costs were not considered, and the technical, economic, and political feasibility and probability of proposed reservoirs were not evaluated in detail. The cost to purchase water from reservoirs was obtained from the Brazos River Authority at $85.00 per acre-foot. See Appendix D.

- Alternatives were developed for a regional water supply system. Additional facilities to distribute and store water for individual participants in the regional supply system were not considered. Therefore, the cost for regional facilities terminates prior to the individual delivery facility. The cost to convey water from the regional system to smaller municipalities and water supply corporations is discussed in Section 8.0, Comparison of Alternatives.

- Alternative water sources and the necessary facilities were developed only for the primary study area.

- The alternatives assume that throughout the planning period a total of 10 existing Simsboro wells will remain in use. As described in Section 3.7 and Section 5.0, these wells each are assumed to have a capacity of 2,100 gpm, for a total of 30.24 mgd of demand to be supplied by the existing wells throughout the study period. Two construction phases have been considered. The first phase is in the year 2000, with construction meeting the demands for the year 2010. The second phase will be in the year 2010 and will meet the demands for the year 2020. Demands prior to the year 2000 will be met by the existing wells. Ten year construction intervals provide sufficient time to study, plan, permit, design and construct each phase. Conservation factors were applied to each construction phase to develop parallel construction costs. Table 7-1 describes each of the construction phases and the year of construction, the conservation factor being applied to the demands, and the demands used for design.

TABLE 7-1

CONSTRUCTION PHASES

Construction Year	Demand Year	Project[1] Phase	Conservation Factor Applied	Total Demands[2] Q Max-Day mgd	Q Average-Day mgd
2000	2010	I	N/A	46.39	12.66
2000	2010	Ic	12.5%	36.81	7.30
2010	2020	II	N/A	58.94	18.91
2010	2020	IIc	15.0%	45.56	11.54

[1]Phase with subscript "c" have Conservation Factors applied.
[2]Brazos County demands assume 10 existing wells at flow of 2,100 gpm per well, or 30.24 mgd maintained throughout life of study period. See Section 3.0 for demand descriptions.

7.2 GROUND-WATER ALTERNATIVE

7.2.1 Simsboro Aquifer Wells

7.2.1.1 General

The proposed water supply source for Alternative No. 1 is from a well field located in the Simsboro Aquifer north of Bryan. Section 5.0 of this report discusses the feasibility of using well fields to meet the demands of the primary study area. Table 5-7 and Figure 5-7 describe the quantity and location of a well field. Section 5.0 also describes the effects of a well field upon the Simsboro Aquifer. Specifically, it was determined that a well field used to meet the year 2020 demands will provide good quality drinking water with a minimal potential for salt water intrusion and with acceptable projected declines in pumping levels.

This section will describe the design of the improvements used to develop a ground-water supply system and the conveyance facilities used to transfer raw and treated water to the regional delivery points. To develop the costs associated with Alternative No. 1, design assumptions described in Section 5.0 were utilized to determine the engineering requirements of the ground-water system. These assumptions are as follows:

1. Ten existing Simsboro wells were maintained throughout the study period. Although there are more wells existing currently, it is assumed that some of these wells will become ineffective.

2. All wells, both existing and proposed, are assumed to yield 2,100 gpm.

3. Well spacing is at 2,000-foot intervals.

4. Water from all proposed wells will require cooling from 120°F to 88°F with cooling towers.

The ground-water supply system was also developed using the following additional assumptions:

1. Design intervals were assumed at 10-year increments beginning in year 2000 and meeting the demands with and without the conservation factors noted in Table 7-1.

2. Because this is a regional water supply study, individual municipal facilities necessary to receive and further distribute the treated water at the delivery points were not included in the scope.

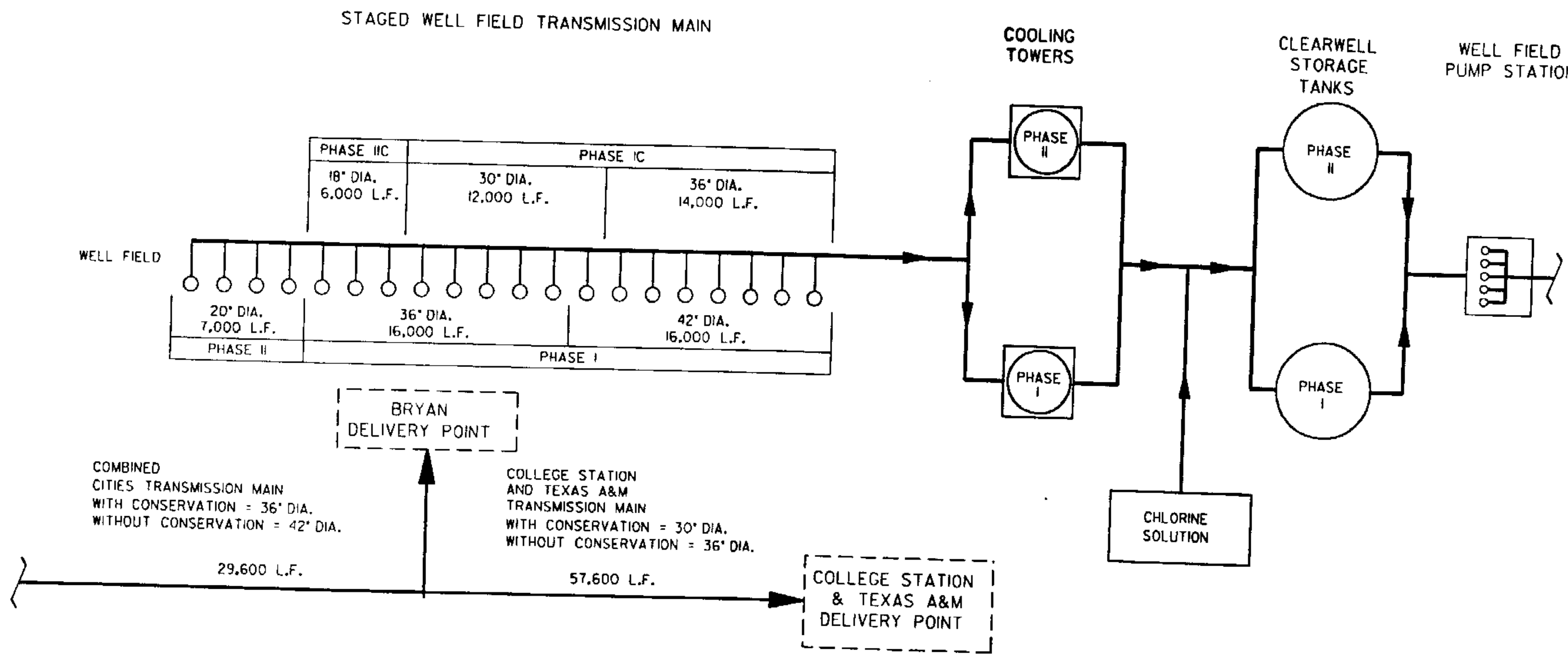
In general, the ground-water alternative will consist of a well field north of Bryan as described in Section 5.0 and as shown on Figure 5-7. The well field will be staged to meet demands of each construction phase. A well field transmission main will convey ground-water to cooling towers. The water will then be chlorinated, stored in clearwells and pumped from the booster pump station to two delivery points. A schematic showing the well field design can be found on Figure 7-1 and a map showing the location of well field facilities can be found on Figure 7-2.

7.2.1.2 Supply Facilities

Ground-water shall be obtained to meet maximum day demands from a series of wells north of Bryan, Texas and located in proximity to Highway 6 as shown on Figure 7-2. The wells will be constructed to meet the phasing demand as shown in Figure 7-1. Each well will be located on a separate lot and consist of a standard deep well, pump, motor with an electrical motor starter, and radio telemetry. Wells will have increased pumping head due to drawdown levels shown on Table 5-7. Increased power costs and possible pump replacement will be expected due to increased drawdown levels. The well field will tie into a well field transmission main which will be sized for each construction phase to provide maximum flow at a velocity of less than or equal to 10 feet per second. The size and length of each phased pipeline is shown on Figure 7-1.

7.2.1.3 Treatment Facilities

As described in Section 5.2.3, the temperature of the water from the Simsboro wells will require cooling towers. The cooling towers will reduce the temperature from approximately 120° to 88°F. Cooling towers will also be sized and staged in accordance with the construction phases. The quality of the Simsboro Aquifer is considered acceptable with minimal treatment. Post-chlorination will be added following the cooling process and air stripping will also be accomplished by the cooling towers.



CONSTRUCTION PHASE

PHASE	CONSTRUCTION YEAR	COOLING TOWERS	CLEARWELL GALLONS
WITHOUT CONSERVATION PLAN			
I	2000	11	2,300,000
II	2010	3	800,000
WITH CONSERVATION PLAN			
IC	2000	9	1,500,000
IIC	2010	3	600,000

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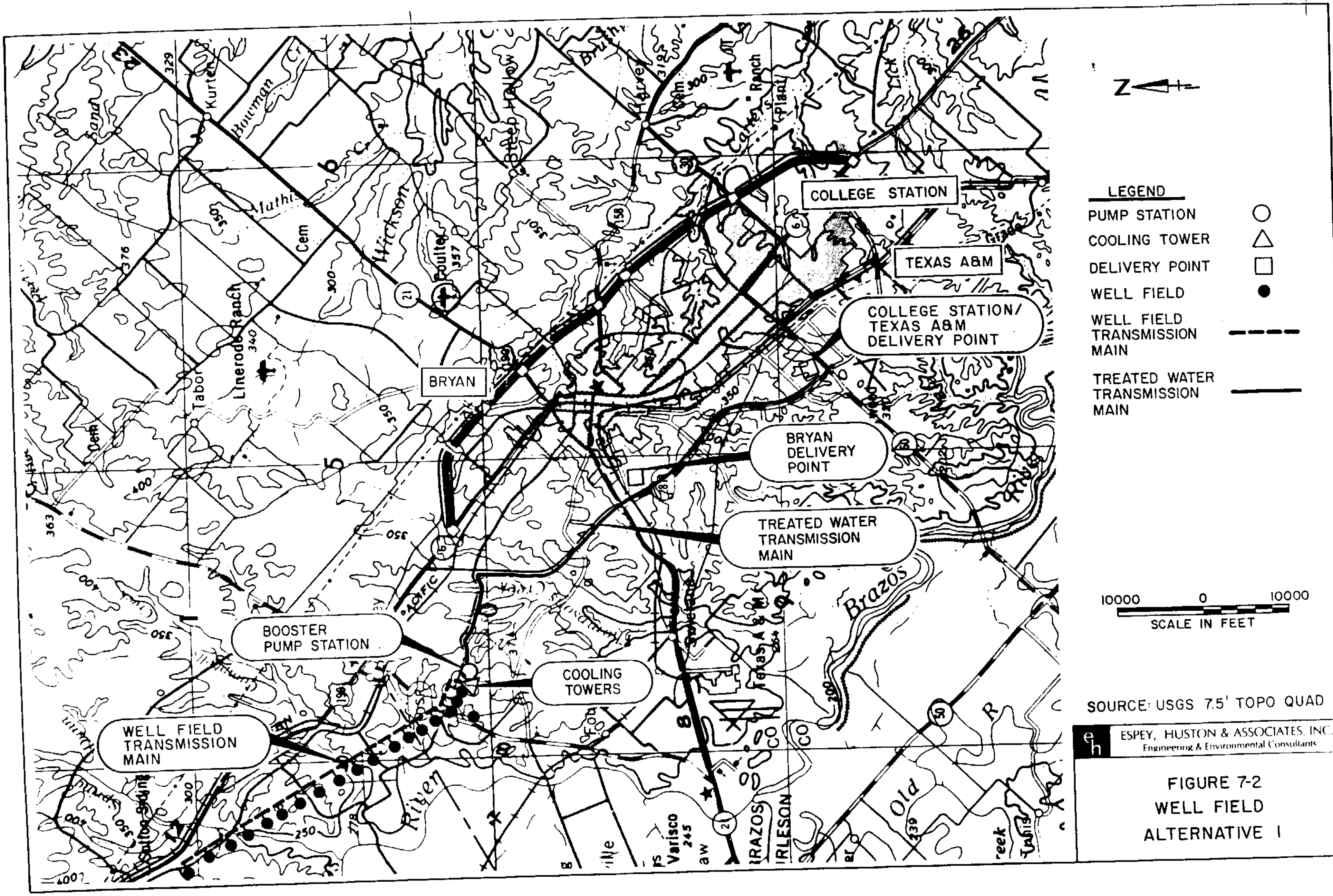
FIGURE 7-1
GROUND WATER SYSTEM



SOURCE: USGS 7.5' TOPO QUAD

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FIGURE 7-2
WELL FIELD
ALTERNATIVE I

PROJECT NO.

7.2.1.4 Pumping and Transmission

The pump station will use clearwell storage of treated water to reduce the cycle time of the pumps. The preliminary design of the clearwells was developed to store treated water prior to pumping to the delivery points. For the purpose of this study the clearwells are sized assuming a 6-hour storage of average day flow between pump starts. The clearwells will be welded steel and above ground. The size of the clearwells at the different construction phases and the schematic location can be found on Figure 7-1.

A booster pump station will be constructed to deliver the maximum day demands of a regional system. The structure will be initially sized to meet year 2020 demands, with only the required pumps being installed to meet each construction phase demands. The pumps will be multi-stage vertical turbine pumps. The reinforced-concrete station will be below ground, with a control building with heat, ventilation, air conditioning, and lighting. Auxiliary power may be from an internal combustion engine, gas turbine or secondary electrical source. The station will be complete with valves, piping, and radio telemetry.

The proposed treated water transmission main was aligned along existing road right-of-ways so as to minimize the impact to property and to minimize the right-of-way acquisition effort. The transmission main was sized to ultimate capacity to provide a single line for all phases. Low velocities will occur during the first phase with increased velocities to a maximum of 10 feet per second at Phase II maximum day demands. Two delivery point locations were selected. The proposed transmission line will carry the flow for the entire primary study area, approximately 5.6 miles along FM 2818 to the intersection of State Highway 21 where treated water will be delivered to the City of Bryan. This transmission main will be a 42-inch diameter without the conservation plan and transporting 58.94 mgd, and will be 36-inch diameter with the conservation plan and transporting 45.56 mgd. The transmission main will continue along FM 2818, approximately 10.9 miles, to the intersection of FM 60, delivering the remaining treated water to the second delivery point for College Station and Texas A&M. This transmission main will be 36-inch diameter without the conservation plan, delivering a maximum flow of 41.26 mgd, and will be 30-inch diameter with the conservation plan, delivering a maximum day flow of

31.89 mgd. The delivery points were located as shown on Figure 7-2 such that the cities' own facilities can easily be tied into the regional transmission main.

7.3 SURFACE WATER ALTERNATIVES

7.3.1 General

Three surface water sources were selected to compare construction costs and operation and maintenance costs with the ground water alternative. Many surface water sources were considered; however, Lake Somerville, the Brazos River and Millican Lake were used for this study. Section 6.0 describes the screening process used to select the alternatives.

This section will describe the improvements used to develop the surface water systems to deliver water for the primary study area for each alternative. Section 7.3.1 will describe those features and assumptions that are common for the three surface water alternatives. Features and assumptions which are unique to each alternative will be described in the paragraphs which follow each alternative.

In general, the alternatives will consist of a raw water intake channel and pump station located near the reservoir dam or river's edge. Raw water will be pumped through a raw water transmission main to a treatment plant. Treated water will be stored in clearwells and a booster pump station will deliver water to two delivery points through two treated water transmission mains. The typical surface water system can be found on Figure 7-3.

The surface water supply system was based on accepted engineering practices and the following conceptual design criteria:

1. The quality of water supplied must meet current criteria of the Texas Department of Health and U.S. Environmental Protection Agency (USEPA). The following are the U.S. EPA National Interim Primary Drinking Water Regulations and National Secondary Drinking Water Regulations:

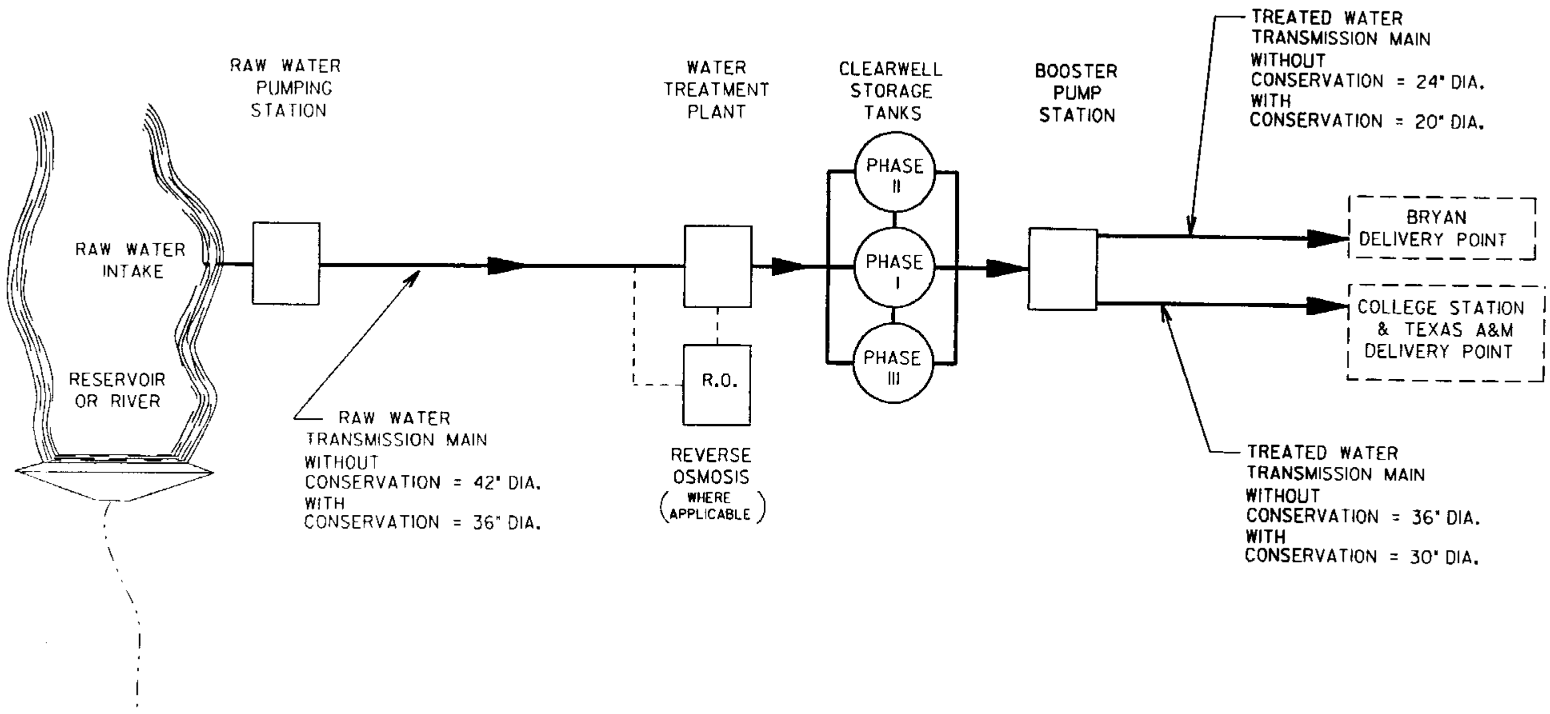

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FIGURE 7-3
TYPICAL SURFACE WATER FACILITIES

NATIONAL INTERIM PRIMARY DRINKING WATER REGULATIONS

Contaminant	MCL (enforceable)*
Organics	
2,4-D	0.1 mg/L
Endrin	0.0002 mg/L
Lindane	0.0004 mg/L
Methoxychlor	0.1 mg/L
Toxaphene	0.005 mg/L
2,4,5-TP (Silvex)	0.01 mg/L
Trihalomethanes (sum of chloroform, bromoform, chloromethane, dibromochloromethane)	0.10 mg/L
Inorganics	
Arsenic	0.05 mg/L
Barium	1.0 mg/L
Cadmium	0.010 mg/L
Chromium	0.05 mg/L
Fluoride	1.4-2.4 mg/L+ (ambient temperature)
Lead	0.05 mg/L
Mercury	0.002 mg/L
Nitrate (as N)	10 mg/L
Selenium	0.01 mg/L
Silver	0.05 mg/L
Sodium and corrosion	No MCL; monitoring and reporting only
Radionuclides	
Beta particle and photon radioactivity	4 mrem (annual dose equivalent)
Gross alpha particle activity	15 pCi/L
Radium-226 plus radium-228	5 pCi/L
Microbials	
Coliforms	<1/100 mL
Turbidity	1 ntu (up to 5 ntu)

*Monitoring and reporting for each contaminant are also required.
+Revised MCL and MCLG for fluoride is 4 mg/L.

NATIONAL SECONDARY DRINKING WATER REGULATIONS

Contaminant	Current SMCLs	SMCLs Proposed Under Phase II*	SMCL Being Considered Under Phase V*
Chloride	250 mg/L		
Color	15 cu		
Copper	1 mg/L		
Corrosivity	Noncorrosive		
Fluoride	2 mg/L+		
Foaming agents	0.5 mg/L		
Iron	0.3 mg/L		
Manganese	0.05 mg/L		
Odor	3 Threshold odor number		
pH	6.5-8.5		
Sulfate	250 mg/L		
Total dissolved solids	500 mg/L		
Zinc	5 mg/L		
Aluminum		0.05 mg/L	
o-Dichlorobenzene		0.01 mg/L	
p-Dichlorobenzene		0.005 mg/L	
Ethylbenzene		0.03 mg/L	
Monochlorobenzene		0.1 mg/L	
Pentachlorophenol		0.03 mg/L	
Silver		0.09 mg/L	
Toluene		0.04 mg/L	
Xylene		0.02 mg/L	
Hexachlorocyclopentadiene			0.008 mg/L

*Phases are identified and defined in the text.
+The SMCL for fluoride was revised in 1986.

2. Each surface water alternative has sufficient water to meet the average day demands for the year 2020.

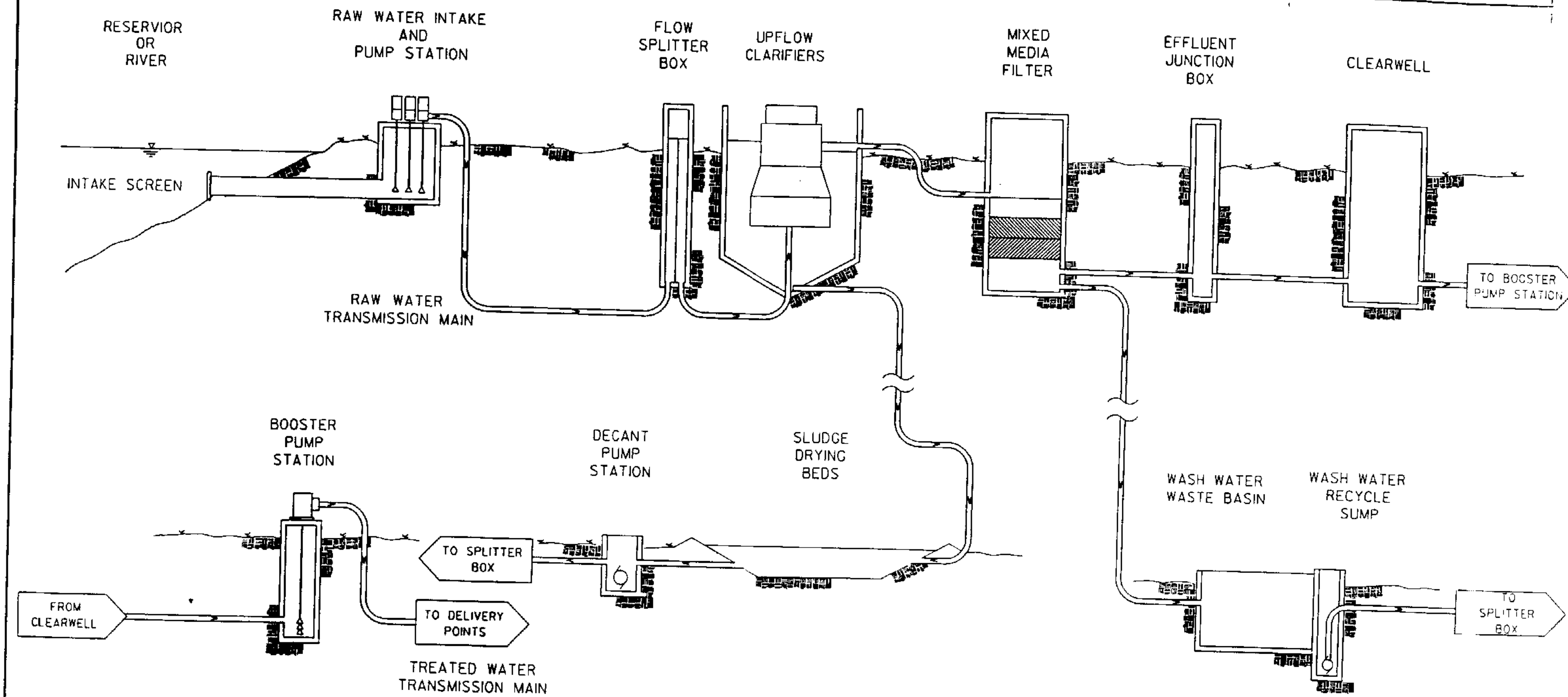
3. Demands for all surface water alternatives assume 10 existing Simsboro wells will yield 2,100 gpm each throughout the study period.

4. For the purpose of this study the first construction phase will be in the year 2000 and is designed to meet the demands of the year 2010. The second construction phase will be in the year 2010 meeting the demands of the year 2020. Cost scenarios were determined with and without the implementation of conservation measures. Design flows meet the demands of Table 3-13 and 3-14 and are summarized on Table 7-1.

5. Because this is a regional water supply study, individual city facilities necessary to receive and further distribute the treated water at the delivery points were not included in the scope.

7.3.1.1 Raw Water Intake and Pump Station

The location of each alternative's raw water intake and pump station was optimized based on reducing the length of raw water transmission pipeline, minimizing the amount of earthwork required for the construction of the structures and providing good access for maintenance. The intakes were assumed to be channels extending from the reservoir or river to the pump station. The intake will be equipped with bar screens to protect the pumps from debris. The pump station will be a reinforced-concrete structure sized to meet the year 2020 demands and containing vertical turbine pumps added at each construction phase to match the demands at each design phase. In general, three pumps will be installed in the first construction phase: two pumps combined to meet maximum day demand and one pump to serve as a back-up pump. The three pumps will be alternated to provide equal usage time. The second construction phase will add one pump meeting Phase II demands. An electrical control building with heating, ventilation, air conditioning, lighting and auxiliary power is also included. Stations will be complete with valves, pipes, fittings and controls.



CONSTRUCTION PHASE

PHASE	CONSTRUCTION YEAR	WATER TREATMENT PLANT MGD	CLEARWELL GALLONS
WITHOUT CONSERVATION			
I	2000	50	2,300,000
II	2010	10	800,000
WITH CONSERVATION			
IC	2000	38	1,500,000
IIC	2010	8	600,000

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FIGURE 7-4
TYPICAL TREATMENT PROCESS

7.3.1.4 Booster Pump Station and Transmission Main

Booster pump stations will use clearwell storage to reduce pump cycle times. Clearwell sizing assumed storing average day demands and a 6-hour storage between pump starts. The clearwells will be above ground and welded steel construction. The size of the clearwells at different construction phases can be found on Figure 7-4.

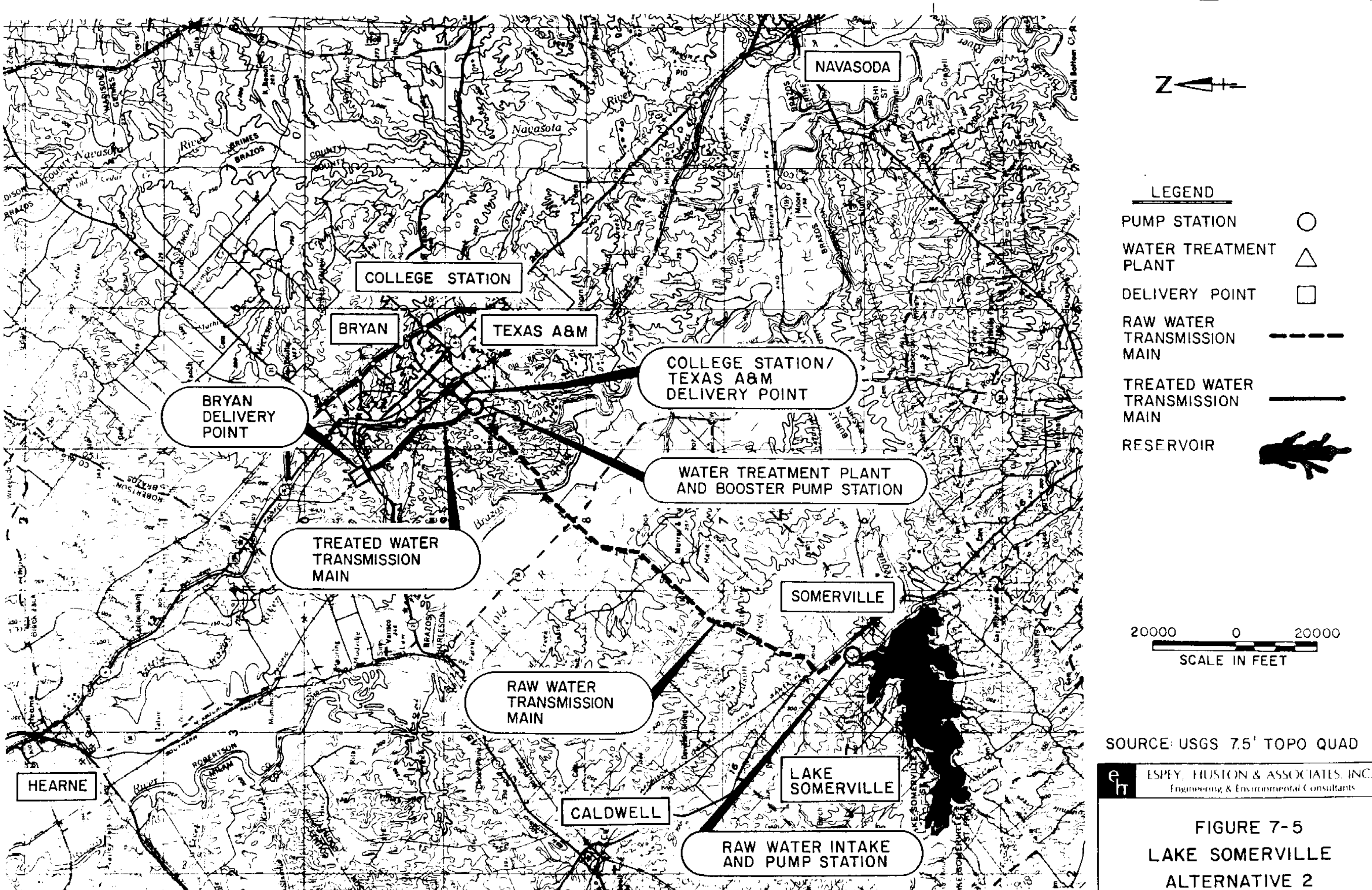
To deliver maximum day demands a booster pump station will be constructed. The structure will be sized to meet year 2020 demands, with pumps being added to meet construction phase demands. The pumps will be multi-stage vertical turbine pumps. The reinforced-concrete station will be below ground, equipped with heat, ventilation, air conditioning, lighting, auxiliary power and control instrumentation.

The treated water transmission mains were aligned along existing road right-of-way so as to reduce impact upon property. To minimize cost, a single transmission main was designed to meet year 2020 demands for each alternative. In general, delivery points for each alternative were located to provide each city with a minimum distance to tie to their own system.

7.3.2 <u>Alternative No. 2 - Lake Somerville</u>

7.3.2.1 Raw Water Intake and Pump Station

The raw water intake and pump station from Lake Somerville will be located on the northeast end of the lake near the dam (see Figure 7-5). The intake channel will be approximately 1,000 feet long. The pump station will be located at the end of the channel. The raw water pumps will pump against approximately 120 feet of elevation.



SOURCE: USGS 7.5' TOPO QUAD

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FIGURE 7-5
LAKE SOMERVILLE
ALTERNATIVE 2

PROJECT NO.

7.3.2.2 Raw Water Transmission Main

The transmission pipeline alignment was selected to follow FM 60 approximately 22 miles from the pump station to the treatment plant site located in proximity to the intersection with FM 2818. The alignment along FM 60 is relatively clear of existing utilities. A 42-inch pipeline from the pump station will provide 58.94 mgd without the conservation plan, and a 36-inch pipeline will provide 45.56 mgd with the conservation plan.

7.3.2.3 Water Treatment Plant

The preliminary design of the treatment process for water from Lake Somerville evaluated the existing water treatment process used by the City of Brenham, Texas whose supply is also from Lake Somerville. In general, the treatment process will be as that described in Paragraph 7.3.1.3 and as shown in Figure 7-4. The water quality from Lake Somerville is favorable for drinking water. The proposed treatment plant will be located at the intersection of FM 60 and FM 2818.

7.3.2.4 Booster Pump Station and Transmission Main

The facilities for the booster pump station including clearwells and pump station will all be located with the water treatment plant at the intersection of FM 60 and FM 2818. Clearwells and pump stations were sized as described in Paragraph 7.3.1.4. The size of the clearwells can be found on Figure 7-4. The vertical turbine pumps will pump against approximately 25 feet of elevation. The transmission facilities will consist of two pipelines from the booster pump station, one line to a delivery point for the City of College Station and Texas A&M, and one line to a delivery point for the City of Bryan.

The pipeline for the College Station and Texas A&M delivery point was assumed to be 500 feet along FM 60. The transmission main was designed to provide 41.26 mgd and will be 36-inch diameter without a conservation plan and was designed to provide 31.89 mgd and will be 30-inch diameter with the conservation plan.

The pipeline for the Bryan delivery point will follow FM 2818 north 5.4 miles to the intersection of State Highway 21. The transmission main was designed to provide 17.68 mgd and will be 24-inch diameter without a conservation plan, and was designed to provide 13.67 mgd and will be 20-inch diameter with a conservation plan. There are some existing utilities along FM 2818 which would need to be considered in order to locate the transmission main.

7.3.3 Alternative No. 3 - Brazos River

7.3.3.1 Raw Water Intake and Pump Station

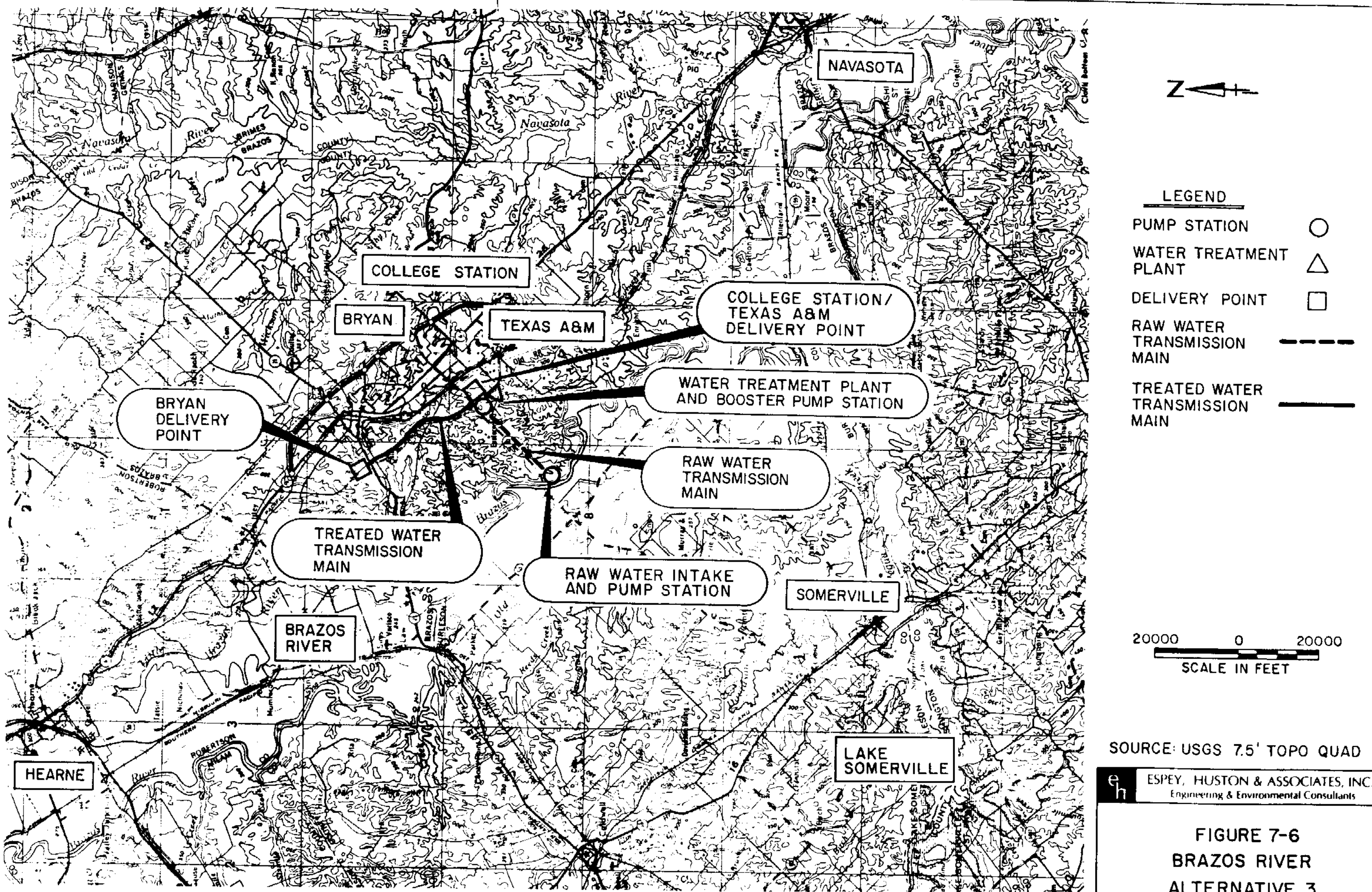
The proposed raw water intake for this study was located on the Brazos River at FM 60. The intake will be a channel approximately 200 linear feet. Location of Alternative No. 3 can be seen on Figure 7-6. The pump station located adjacent to FM 60 will pump raw water from the river to the water treatment plant. The raw water pumps will pump against approximately 150 feet of elevation.

7.3.3.2 Raw Water Transmission Main

The transmission pipeline alignment will follow FM 60 approximately 4.5 miles to the treatment plant site located at the intersection of FM 60 and FM 2818 which is the same site as that used in Alternative No. 2. The pipeline was designed to provide 58.94 mgd and will be 42-inch diameter without a conservation plan, and was designed to provide 45.56 mgd and will be 36-inch diameter with the conservation plan.

7.3.3.3 Water Treatment Plant

Water from the Brazos River exceeds the U.S. Environmental Protection Agency's maximum level of total dissolved solids of 500 mg/l as described in Paragraph 7.3.1. Texas A&M performed a statistical evaluation of the salt concentrations in the Brazos River. The statistical analysis is provided in a letter from the Brazos River Authority, dated March 8, 1990 and



SOURCE: USGS 7.5' TOPO QUAD

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FIGURE 7-6
BRAZOS RIVER
ALTERNATIVE 3

provided in Appendix D. The analysis indicated that at the College Station Gage the total dissolved solids exceeds 500 mg/l about 50 percent of the time. Therefore, an alternative means of reducing the concentration of total dissolved solids must be provided.

Two alternative methods of reducing the total dissolved solids were considered, Termination Storage and Reverse Osmosis treatment.

A. Termination Storage

To achieve the maximum levels of total dissolved solids with termination storage, a pond was designed to store water during periods of lower told dissolved solids concentration. If water is stored at an assumed concentration of 400 mg/l or less, which, according to the Texas A&M analysis occurs 30 percent of the time, then it can be mixed with water at 600 mg/l or less, which according to the analysis occurs 70 percent of the time, to achieve the required 500 mg/l. The volume of the termination pond was determined based on filling with 400 mg/l water and providing 6 months storage at 30 percent of the maximum demand. Without the conservation plan, the volume is 3,177 acre-feet, and with the conservation plan will be 1,940 acre-feet. Pond costs were assumed at $5,000 per acre-foot. Therefore, costs were estimated at $15.9 million without a conservation plan, and $9.7 million with a conservation plan. Termination storage will also require the addition of low head, mix-flow pumps and a pump station located at the intake structure.

B. Reverse Osmosis

Reverse osmosis is a treatment process whereby water diffuses through a semipermeable membrane. The membrane acts as a barrier to dissolved solids. Reverse osmosis can be utilized during low river flow and high dissolved solids concentrations to provide concentrations within the EPA standards. To achieve an acceptable level of dissolved solids, raw water will be mixed with water treated by reverse osmosis. Reverse osmosis will reduce the concentration to near zero. Reverse osmosis capacities were determined assuming maximum day demand, a raw water concentration of 600 mg/l, and mixing with water from reverse osmosis at 1 mg/l. The following capacities were determined in order to achieve 500 mg/l:

Year	Capacity (mgd)
2000	7.75
2000 with conservation	6.15
2010	9.85
2010 with conservation	7.61

The cost for construction was determined using $1.00 per gpd.

In comparing the cost of providing reverse osmosis versus constructing an off-channel reservoir, the construction cost for the reverse osmosis for year 2020 is about half the cost of the termination pond without considering the additional pump station made necessary by the pond. Therefore, for the purpose of this study reverse osmosis was selected as the method of providing water with an acceptable level of dissolved solids from the Brazos River.

The treatment process described in Paragraph 7.3.1.3 and as shown on Figure 7-4, will be operated in parallel when there is a need for the reverse osmosis system. If the river concentration is below the EPA regulated total dissolved solids concentration of 500 mg/l, the reverse osmosis system is not needed and the treatment plant will operate without it. The treatment plant will be located in the same location as that used for Alternative No. 2 at the intersection of FM 60 and FM 2818.

7.3.3.4 Booster Pump Station and Transmission Main

The facilities for the booster pump station and the treated water transmission main are identical in location and size to those facilities presented for Alternative No. 2 - Lake Somerville, specifically Paragraph 7.3.2.4. Therefore, the location and size of facilities and the alignment, size and lengths of the booster pump station and transmission facilities can be found in Alternative No. 2 description.

7.3.4 Alternative No. 4 - Millican Lake

7.3.4.1 Raw Water Intake and Pump Station

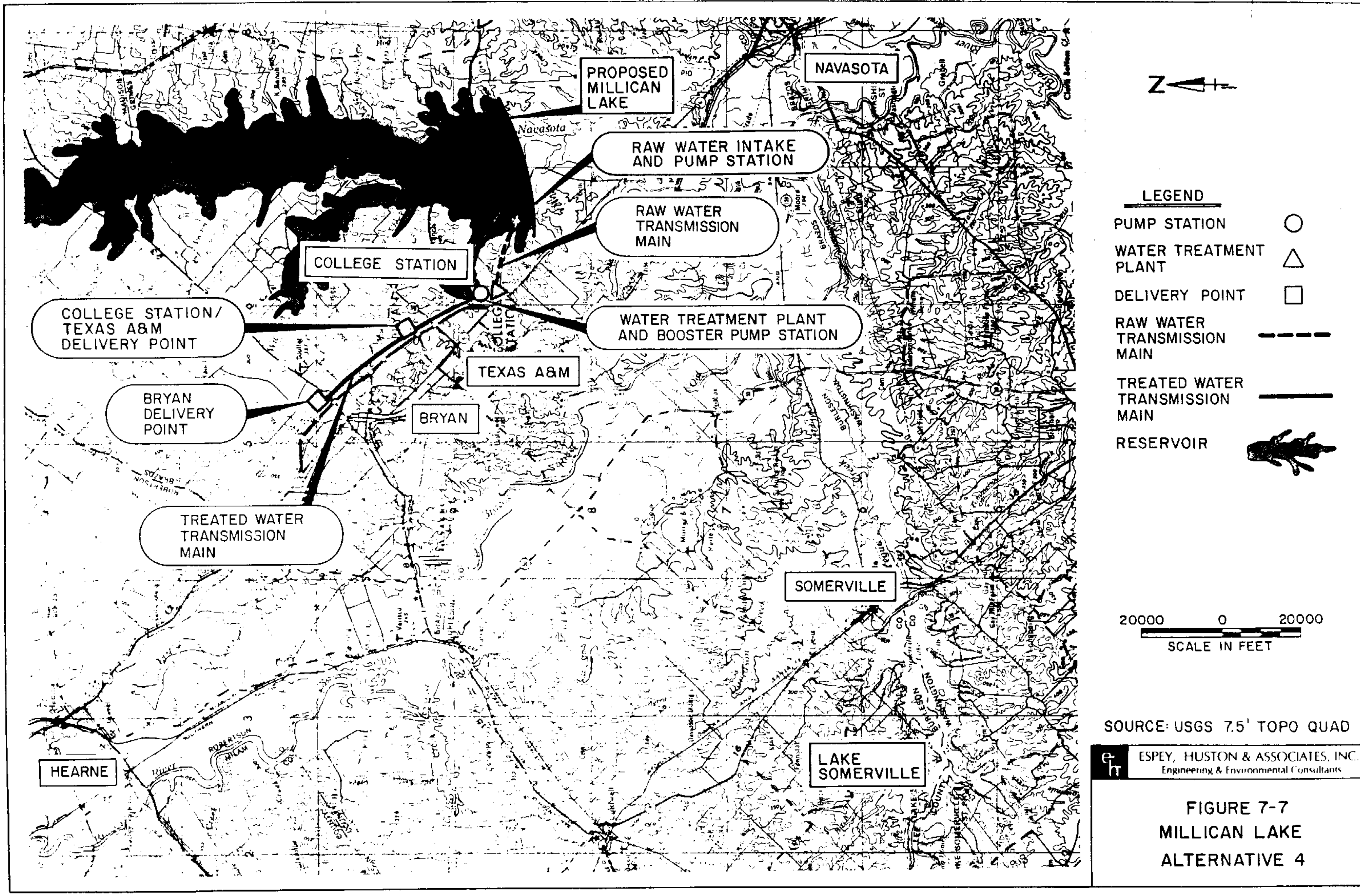
The location of the dam for this alternative is located at mile 36 on the Navasota River. The raw water intake and pump station will be located near the intersection of FM 159 and the dam for the reservoir (see Figure 7-7). The design of the facilities are described in Paragraph 7.3.1. The intake channel will be approximately 1,000 linear feet. The raw water pumps will pump against approximately 80 feet of elevation.

7.3.4.2 Raw Water Transmission Main

The transmission pipeline designed to provide 58.94 mgd will be a 42-inch diameter for non-conservation flows, and to provide 45.56 mgd will be 36-inch diameter for conservation flows. The pipeline will follow FM 159 northwest 4.6 miles until it intersects State Highway 6 where the treatment plant will be located. The alignment along FM 159 is considered relatively clear of other utilities.

7.3.4.3 Water Treatment Plant

The water quality of the Navasota River is considered good, and raw water from Millican Lake will require the treatment facilities described in Paragraph 7.3.1.3 and as shown on



SOURCE: USGS 7.5' TOPO QUAD

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FIGURE 7-7
MILLICAN LAKE
ALTERNATIVE 4

Less than 6,000 acre-feet of ground-water pumpage occurred for municipal use from the Sparta, Queen City, Carrizo, Calvert Bluff, Hooper, and other aquifers in the five-county area in 1987. About 1,700 acre-feet was from the Sparta, most of which was from Texas A&M University's Sparta well field. The remainder was produced by over 40 small municipal users scattered over the five-county area. Most of the users produced less than 200 acre-feet in 1987. Moderate users include the City of Centerville in Leon County, the City of Madisonville in Madison County, Texas Department of Corrections in Grimes County, the City of Buffalo in Leon County, and the City of Navasota in Grimes County.

In the general vicinity of the Cities of Bryan and College Station, and their respective well fields, the only aquifers capable of furnishing potable water are the Sparta Sand and Simsboro Sand. Water in the Sparta within Bryan-College Station proper is mineralized with total dissolved solid concentrations in excess of 2,000 mg/l. However, to the west mineralization is lower, and both Bryan and Texas A&M have developed well supplies from the Sparta having total dissolved solids content of about 300 mg/l. The City of College Station has never developed any Sparta supplies.

The City of Bryan has an older well field in the Sparta which is not currently used, except on occasion to meet peak summer demands. Texas A&M University is the only major user of the Sparta in the Bryan-College Station area. In 1987 about three percent of their total pumpage was from the Sparta. The remaining pumpage was from the Simsboro. The Texas A&M University Sparta well field coupled with the earlier Bryan pumpage from the Sparta, virtually resulted in full development of the Sparta (Guyton, 1971), so any significant future ground-water development could only be from the Simsboro.

The City of College Station used one Queen City production well located within the City. The water was of moderately high mineralization, (about 1,700 mg/l total dissolved solids content) and was mixed with Simsboro water. In 1987 the City of College Station produced only about 0.5 percent of their total pumpage from the Queen City. In recent years this Queen City well has been little used.

5.3.4 Availability of Water to Meet Demands of the Year 2020

The northern half of the five-county planning area is endowed with significant ground-water resources which could be utilized to meet water demand through 2020. Six aquifers are present including the Sparta, Queen City, Carrizo, Calvert Bluff, Simsboro, and Hooper. Each can furnish significant additional supplies to present users from expanded or properly-located well fields. In many areas the extent of the aquifers overlaps, and potential users of small supplies will have some options with respect to which zones can be utilized. Local water quality and available well yield likely will dictate choices.

To generally evaluate the potential availability of water from the six aquifers, some typical hydraulic and common characteristics of the aquifers and larger-capacity wells are presented in Table 5-9. Included are typical values which can be used to compare transmissivity, well screen length, and well yield for the different aquifers. The source of the information is primarily published reports which has been supplemented by information from owners and experience in evaluating or developing water supplies from each of the aquifers.

The transmissivity values shown in Table 5-9 represent the typical maximums which can be expected where wells screen the full sand thicknesses commonly present in those areas which have been developed by wells or in those areas considered more favorable for development. Other factors being equal the availability of water from the aquifers is proportional to their transmissivity. It can be seen that the Simsboro is overwhelmingly the most important, however other units have significant availability of water, especially in relation to the widely-scattered and small projected 2020 demand for those small to moderate users in the planning area.

Table 5-9 also shows typical well screen lengths for high-capacity wells completed in the aquifers as well as typical well yields for high-capacity wells. The last column in Table 5-9 ranks the estimated availability of ground water from the aquifers. The numbers are comparative only and reflect the relative quantitative potential of the aquifers. For example, the Queen City, Hooper, and Calvert are considered to have the least water available and to be about equal, with the Sparta considered to have about twice the availability that the Calvert Bluff, Hooper or Queen

TABLE 5-9

TYPICAL AQUIFER VALUES

Aquifer	Transmissivity (gpd/ft)	Well Screen Length (ft)	Well Yield (gpm)	Estimated Relative Water Availability
Sparta	12,000	<100	500	2X
Queen City	<10,000	<100	250	1X
Carrizo	25,000	100	1,000	4X
Calvert Bluff	<10,000	<100	250	1X
Simsboro	100,000	300+	2,400	16X
Hooper	<10,000	<100	250	1X

City has. The Carrizo is considered to have about twice the availability that the Sparta has. The Simsboro is considered to have about four times the availability that the Carrizo has in as much as the Simsboros transmissivity is about four times larger.

Within Robertson, Leon, and Madison counties, future municipal demands are not significantly larger than existing ground-water pumpage. Also, users are widely scattered and have little interference effects on one another. It is judged from Table 5-9 and the amounts of the projected 2020 demand that all small and moderate users will likely be able to obtain future amounts from the same sources which they are currently using or from nearby well fields in available aquifers. The same is likely true for projected industrial demands which are all small (except for Robertson County). The projected industrial use for Robertson County will be from the Simsboro, and the amount is considered available from local well fields.

In southern Brazos County and in Grimes County some other aquifers exist. These include sands of the Yegua Formation, Jackson Group, Catahoula Formation, and Fleming Formation. Evaluations of these aquifers are outside the scope of this study. However, some estimates of availability for Grimes County are given in Baker, et al (1974). They are:

Aquifer	Amount
Yegua	3.5 mgd
Jackson	2.2 mgd
Catahoula	4.5 mgd
Fleming	36 mgd

The values are relatively small excepting for the Fleming. The Fleming is present only in southernmost Grimes County. Both the current and projected demand in the southern part of the planning area are also small. This suggests the aquifers probably are capable of supplying most of those needs, especially if some well fields were located in the Fleming.

5.4 GROUND-WATER RECHARGE ENHANCEMENT AS A SOURCE OF WATER

A variety of methods have been used to artificially recharge aquifers in order to maintain or augment the natural supply. However, artificial recharge methods are generally not applicable to supplementing the type of storage/transmission system present in either the Simsboro or the other aquifers considered herein.

Artificial recharge is defined as augmenting the natural movement of water into underground formations by some method of construction, by spreading of water, or by artificially changing natural conditions. (Todd, 1959) A variety of methods have been used including water spreading via basins, stream channels, ditches, flooding and irrigation. Other techniques employ pits or recharge wells. In addition, sometimes wells are located specifically near surface water bodies and pumped to induce recharge. The particular methods used are governed by local geohydrologic conditions, the quantity of water available to be recharged and the use of the recharged water. In many situations, recharge projects also assist to overcome local problems such as progressive lowering of ground-water levels or brackish water intrusion. Of course, adequate amounts of water must be available in order to place water underground for future use. Common sources include storm runoff collected for subsequent recharge, treated wastewater, or importation of distant surface water sources.

Water spreading techniques or artificially changing natural conditions in outcrops of the water-bearing formations are generally not applicable to the Simsboro or other regional aquifers. At present, the recharge areas of all of the aquifers are full to overflowing. Water levels in outcrop areas adjacent to major stream valleys are a few to several tens of feet higher than the adjacent stream valleys. Thus, any amounts recharged would not benefit downdip areas where wells are located but would only serve to increase natural discharge in outcrop areas. With current water levels, recharging in outcrop areas would do little to increase storage and would not affect transmission to wells in downdip areas.

Recharging in downdip artesian areas could only be accomplished by wells. Recharging via wells is normally done to combat adverse conditions such as brackish water intrusion or progressively declining water levels in addition to maintaining or augmenting the supply. No progressive declines of water levels, excepting those caused by pumpage increases, are occurring in the study area. Also, no troublesome brackish water intrusion is occurring, and there is no lack of overall supply. Recharging via wells in the artesian portion of the aquifers, especially in the Simsboro, would only serve to raise water levels (artesian pressures) and lessen pumping levels in adjacent well fields with the amount being related to the locations and amounts recharged. The net benefit would only be small reductions in lifting costs. At present, lifting costs are essentially an unimportant part of ground-water development costs, and the large capital and operating expenses associated with recharge wells certainly would be an uneconomical way to raise water levels. Furthermore, there would have to be a source for the water used to recharge with that source being large in quantity and of good quality. No such source which could not more economically be utilized directly is available.

6.0 SURFACE WATER RESOURCES

6.1 GENERAL DESCRIPTION

Municipal and manufacturing water demands within the primary study area are currently met exclusively from ground-water sources. However, in the future it is to be expected that the demand for water in the primary study area will exceed the capacity of existing well facilities. The development of surface water supplies represents an alternative course of action to the expansion of existing ground-water supplies. The following sections describe the existing and proposed surface water resources that may be available to supplement the future municipal water demands of Brazos County that would not be met by ground-water sources. Refer to Table 6-1 for a summary of existing and proposed reservoirs.

6.2 EXISTING RESOURCES

6.2.1 Brazos River

The Brazos River is the primary source of a basin-wide water supply system managed by the Brazos River Authority (BRA). In addition to the management of the Brazos River, the BRA manages 11 water supply reservoirs throughout the basin. The BRA reports that a long-term water supply capable of providing over 45 mgd is currently available from the Brazos River near College Station (see Appendix D for BRA's letter of recommendation). This quantity is well in excess of the projected deficiencies that would occur if no new ground-water supplies were developed to meet future water demands. The river is located approximately 5 miles to the southwest of the Bryan-College Station area.

While water quality within the Brazos River is generally satisfactory for water supply, the BRA reports some problems with elevated salt concentrations, particularly during periods of low flow. Because of the available water rights and the close proximity to the Bryan-College Station area, the Brazos River has been carried forward as a potential source of water supply for the primary study area.

TABLE 6-1

EXISTING AND PROPOSED SURFACE WATER RESOURCES

Name	County Location	Status	Basin	Approximate Distance to B-CS	Yield	
					ac-ft/yr	mgd
Brazos River	Brazos	Existing	Brazos	5 mi	ND	ND
Lake Somerville	Burleson, Lee, Washington	Existing	Brazos	23 mi	31,136	27.8
Lake Limestone	Limestone, Robertson, leon	Existing	Brazos	45 mi	65,500	58.5
Twin Oak Reservoir	Robertson	Existing	Brazos	35 mi	ND	ND
Gibbons Creek Reservoir	Grimes	Existing	Brazos	12 mi	ND	ND
Lake Livingston	Polk, San Jacinto	Existing	Trinity	65 mi	1,288,000	1,149.8
Lake Conroe	Montgomery	Existing	San Jacinto	45 mi	100,600	89.8
Camp Creek Lake	Robertson	Existing	Brazos	26 mi	2,600	2.3
Millican Lake	Grimes, Brazos	Proposed	Brazos	3-5 mi	252,000	225.0
Bedias Reservoir	Madison, Grimes, Walker	Proposed	Trinity	25 mi	109,758	98.0
Lake Navasota	Robertson	Proposed	Brazos	22 mi	231,600	206.7
Caldwell Reservoir	Burleson, Milam	Proposed	Brazos	16 mi	97,438	87.0
Brazos Coal Lake	Brazos	Proposed	Brazos 10 mi	ND	1.8	

SOURCES: Brazos River Authority, Personal Correspondence, 1990. See Appendix D
Trinity River Authority, Personal Correspondence, 1990. See Appendix D
Metcalf & Eddy, Houston Water Master Plan, 1985.

ND - No Data

11753/890674

6.2.2 Lake Somerville

Lake Somerville is a multi-purpose reservoir located in Burleson County, approximately 23 miles to the southwest of College Station. With a surface area of approximately 11,460 acres, Lake Somerville has a total capacity of 160,110 ac-ft and a 2020 estimated yield of 37,900 ac-ft. The BRA notes a current available yield of 31,136 ac-ft/yr, or approximately 27.8 mgd, from Lake Somerville. See Appendix D for BRA's letter of recommendation. This yield exceeds the projected deficiencies that have been identified if no new ground-water development occurs.

Water quality from Lake Somerville is excellent for water supply. This source has been carried forward as a potential source of water supply for the primary study area of Brazos County.

6.2.3 Lake Limestone

Lake Limestone is located on the Navasota River approximately 45 miles north of the City of Bryan. This reservoir was constructed and is operated by the BRA. Lake Limestone currently supplies make-up water for off-channel cooling lakes that serve the lignite-fueled steam electric power plants located in the area. The lake has a total estimated capacity of 225,400 ac-ft and an estimated yield of approximately 65,500 ac-ft/yr, or approximately 58.5 mgd. Although Lake Limestone has some available water rights, this source has been eliminated for consideration due to the high costs that would be associated with transmission from the reservoir to the Bryan-College Station area.

6.2.4 Twin Oak Reservoir

The Twin Oak Reservoir is located in Robertson County, approximately 35 miles to the north of the Bryan-College Station area. This 2,330 surface acre reservoir is operated by the Texas Utilities Generating Company (TUGCO) and provides cooling water for the lignite-fueled steam electric power plant located in the area. Based on this single purpose use and distance from Bryan-College Station, this reservoir has been eliminated as a potential source of water supply for the primary study area.

6.2.5 Gibbons Creek Reservoir

Gibbons Creek Reservoir is owned and operated by the Texas Municipal Power Agency for the sole purpose of providing cooling water for a lignite-fueled steam electric power plant. This reservoir was eliminated for consideration as a potential source of water for the primary study area for this reason.

6.2.6 Lake Livingston

Lake Livingston is a multi-purpose reservoir located in the Trinity River Basin approximately 65 miles to the east of the Bryan-College Station area. This reservoir is operated by the Trinity River Authority. See Appendix D for TRA's letter of recommendation. Although the TRA has indicated that sufficient water rights exist to meet the future water demands of the primary study area, it has been assumed that this source would not be economically feasible in light of the high costs associated with conveyance.

6.2.7 Lake Conroe

Lake Conroe is located in the San Jacinto River Basin approximately 45 miles to the southeast of the Bryan-College Station area. Although this reservoir may have some available yield for allocation, it has been eliminated for consideration as a viable source of water supply due to the high costs of transmission from the lake to the twin cities area.

6.2.8 Camp Creek Lake

Camp Creek Lake is located in Robertson County approximately 26 miles to the north of the cities of Bryan and College Station. This lake has a total capacity of approximately

8,550 ac-ft and is used primarily for recreation. Because of its small size and its distance from the Bryan-College Station area, this surface water option has been eliminated from consideration as a potential source of water supply.

6.3 PROPOSED RESOURCES

6.3.1 Millican Lake

Millican Lake is a planned multi-purpose reservoir that has been proposed for construction on the Navasota River in portions of Brazos, Grimes, Leon, Madison and Robertson counties. At its closest point, the site would be located several miles to the east of the cities of Bryan and College Station. This proposed reservoir would be constructed and operated by the BRA, and would have an estimated total storage capacity of approximately 1,973,000 ac-ft, and an available reservoir yield of approximately 248,600 ac-ft/yr, the equivalent of 222 mgd. Although still in the planning stages, this reservoir was suggested by BRA and has been carried forward as a potentially viable water supply option for Brazos County. See Appendix D for BRA's letter of recommendation.

6.3.2 Bedias Reservoir

The proposed Bedias Reservoir has been studied by the Trinity River Authority (TRA) and the Bureau of Reclamation as a potential municipal supply for the Houston area and local areas. See Appendix D for TRA's letter of recommendation. As proposed, the 17,000 surface acre Bedias Reservoir would be located in portions of Madison, Grimes, and Walker counties and have a projected yield of approximately 76 mgd. In the absence of firm commitments from users, however, the TRA halted all planning for this potential project in early 1988. If constructed, the proposed reservoir would be located in the Trinity River basin approximately 25 miles from the Bryan-College Station area. Because of the high costs associated with transmission of water from the Trinity River basin to the Brazos River basin, this proposed reservoir has been eliminated for consideration as a viable source of water supply.

6.3.3 Lake Navasota

Lake Navasota is a proposed water supply project on the Navasota River that has been under joint study by the US Army Corps of Engineers and the BRA. The proposed location in Robertson and Leon Counties would be approximately 22 miles from Bryan-College Station. As currently planned, Lake Navasota would have a total capacity of approximately 1,384,900 ac-ft and a yield of approximately 231,600 ac-ft/yr. In light of the distance from the Bryan-College Station area, this alternative has been eliminated from consideration as a viable surface water source for Brazos County.

6.3.4 Caldwell Reservoir

The proposed Caldwell Reservoir has been reviewed for feasibility by a number of entities including the Corps of Engineers and is currently under study by the BRA as a potential source of water supply. The proposed reservoir would be located in Burleson and Milam counties. The damsite is proposed on Cedar Creek west of FM 1362, near Goodwill, approximately 8 miles northeast of Caldwell. Projected yields of this reservoir are approximately 97,438 ac-ft/yr, or approximately 87 mgd. The reservoir would be developed from stormflow down Cedar Creek, and because of the small size of the reservoir it would need to be supplemented by unregulated high flows directly from the Brazos River. Because of its location to the primary study area, Caldwell Reservoir is a potentially viable surface water source and was suggested by BRA. See Appendix D. However, because supplementary flows from the Brazos River were necessary with an additional cost for conveyance, direct pumpage from the Brazos River as discussed in Section 6.2.1 was considered in lieu of pumpage from Caldwell Reservoir.

6.3.5 Brazos Coal Lake

The Brazos Coal Lake is a proposed reservoir that is in the early stages of planning by a private developer. Proposed for location in Brazos County on Peach Creek, a tributary of the Navasota River, approximately 10 miles south of College Station, this lake would have an estimated surface area of approximately 1,500 to 2,500 acres. As planned, a primary purpose of this lake would be to serve as an amenity feature for surrounding land development. The yield of this proposed lake has been estimated at approximately 1.8 mgd. In light of the size and available yield, this project was eliminated for consideration as a surface water alternative for Brazos County.

6.3.6 Upper Keechi Creek Reservoir

The Upper Keechi Creek reservoir is a potential project located in the Trinity River basin. As planned, this potential project would be located in Leon County and would have an estimated firm yield of 25 mgd. This surface water alternative has been eliminated from consideration due to distance-related conveyance costs.

6.4 SURFACE WATER RESOURCES SCREENING PROCESS

Based on the wide range of existing and proposed surface water resources potentially available to serve Brazos County, EH&A conducted a screening of these resources in order to select alternatives for master planning of a regional system. This screening process consisted of an evaluation of each of the previously described surface water alternatives according to several general criteria:

- Sufficient and Available Yield;
- Distance-related Conveyance Costs;
- Designated Use; and,
- Recommendation or suggested consideration by BRA and TRA.

Where possible, EH&A gave consideration to the use of existing resources over proposed. However, in several cases the economic costs of conveyance, for example, would be expected to be prohibitively high, resulting in the consideration of proposed projects situated in closer proximity to the Bryan-College Station area. In the screening of proposed reservoirs, EH&A did not attempt to evaluate the technical, economic, or political feasibility of these projects. Instead, all proposed projects were generally assumed to have an equal probability of construction.

Based on a screening of the surface water alternatives noted in Table 6-1, EH&A identified three potential sources of surface water for the Bryan-College Station area. Table 6-2 provides a screening matrix of the existing and proposed surface water resources considered for the master planning of a regional water supply system.

6.5 RECOMMENDED SURFACE WATER ALTERNATIVES

Based on a screening of all surface water resources with potential to supplement the existing ground-water supplies in the primary study area, EH&A selected three alternatives. These alternatives are: 1) the Brazos River, 2) Lake Somerville, and 3) Lake Millican. Although Lake Millican is a proposed project, this alternative was selected because of its high yield and close proximity to the Bryan-College Station area. The Lake Millican alternative was also suggested by the BRA.

TABLE 6-2

PRELIMINARY SCREENING MATRIX

Resource	Screening Criteria: Sufficient Yield	Screening Criteria: Conveyance Costs	Screening Criteria: Designated Use	Screening Criteria: Recommendations	Status: Eliminated	Status: Retained
EXISTING:						
Brazos River	●	●	●	●		■
Lake Somerville	●	●	●	●		■
Lake Limestone	●	○	●	-	■	
Twin Oak Reservoir	○	○	○	-	■	
Gibbons Creek Res.	○	●	○	-	■	
Lake Livingston	●	○	●	-	■	
Lake Conroe	●	○	●	-	■	
Camp Creek Lake	○	○	●	-	■	
PROPOSED						
Millican Lake	●	●	●	●		■
Bedias Reservoir	●	○	●	●	■	
Lake Navasota	●	○	●		■	
Caldwell Reservoir	●	○	●	●	■	
Brazos Coal Lake	○	○	○	-	■	
Upper Keechi Creek Reservoir	●	○	●	●	■	

● Favorable.
○ Unfavorable.

7.0 RECOMMENDED ALTERNATIVE SOURCES

7.1 GENERAL

The purpose of this section is to describe the selected water resources and the methodology used to evaluate the alternatives for a regional water supply for the primary study area. The water demands for the study period have been identified and can be found in Section 3.0, Population and Water Demand Projections. This section will identify four alternative sources selected to meet the expected water demands, describe the necessary improvements and the associated cost of those improvements for each alternative, and develop a reasonable determination of the unit cost of raw water.

In general, three surface water resources and the Simsboro Aquifer wells have been selected. This section provides an economic comparison of each resource. The surface water improvements will consist of intake facilities, pump station, raw water transmission mains, treatment facilities, booster pump stations and treated water transmission mains. The ground water improvements will consist of a well field, well field transmission main, cooling towers, booster pump station and treated water transmission mains. The design of each alternative has been developed using the following criteria:

- Because surface water alternatives are being compared to ground water alternatives, all reservoir alternatives assume the reservoir is in place. Estimated reservoir construction costs were not considered, and the technical, economic, and political feasibility and probability of proposed reservoirs were not evaluated in detail. The cost to purchase water from reservoirs was obtained from the Brazos River Authority at $85.00 per acre-foot. See Appendix D.

- Alternatives were developed for a regional water supply system. Additional facilities to distribute and store water for individual participants in the regional supply system were not considered. Therefore, the cost for regional facilities terminates prior to the individual delivery facility. The cost to convey water from the regional system to smaller municipalities and water supply corporations is discussed in Section 8.0, Comparison of Alternatives.

- Alternative water sources and the necessary facilities were developed only for the primary study area.

- The alternatives assume that throughout the planning period a total of 10 existing Simsboro wells will remain in use. As described in Section 3.7 and Section 5.0, these wells each are assumed to have a capacity of 2,100 gpm, for a total of 30.24 mgd of demand to be supplied by the existing wells throughout the study period. Two construction phases have been considered. The first phase is in the year 2000, with construction meeting the demands for the year 2010. The second phase will be in the year 2010 and will meet the demands for the year 2020. Demands prior to the year 2000 will be met by the existing wells. Ten year construction intervals provide sufficient time to study, plan, permit, design and construct each phase. Conservation factors were applied to each construction phase to develop parallel construction costs. Table 7-1 describes each of the construction phases and the year of construction, the conservation factor being applied to the demands, and the demands used for design.

TABLE 7-1

CONSTRUCTION PHASES

Construction Year	Demand Year	Project[1] Phase	Conservation Factor Applied	Total Demands[2] Q Max-Day mgd	Q Average-Day mgd
2000	2010	I	N/A	46.39	12.66
2000	2010	Ic	12.5%	36.81	7.30
2010	2020	II	N/A	58.94	18.91
2010	2020	IIc	15.0%	45.56	11.54

[1]Phase with subscript "c" have Conservation Factors applied.
[2]Brazos County demands assume 10 existing wells at flow of 2,100 gpm per well, or 30.24 mgd maintained throughout life of study period. See Section 3.0 for demand descriptions.

7.2 GROUND-WATER ALTERNATIVE

7.2.1 Simsboro Aquifer Wells

7.2.1.1 General

The proposed water supply source for Alternative No. 1 is from a well field located in the Simsboro Aquifer north of Bryan. Section 5.0 of this report discusses the feasibility of using well fields to meet the demands of the primary study area. Table 5-7 and Figure 5-7 describe the quantity and location of a well field. Section 5.0 also describes the effects of a well field upon the Simsboro Aquifer. Specifically, it was determined that a well field used to meet the year 2020 demands will provide good quality drinking water with a minimal potential for salt water intrusion and with acceptable projected declines in pumping levels.

This section will describe the design of the improvements used to develop a ground-water supply system and the conveyance facilities used to transfer raw and treated water to the regional delivery points. To develop the costs associated with Alternative No. 1, design assumptions described in Section 5.0 were utilized to determine the engineering requirements of the ground-water system. These assumptions are as follows:

1. Ten existing Simsboro wells were maintained throughout the study period. Although there are more wells existing currently, it is assumed that some of these wells will become ineffective.

2. All wells, both existing and proposed, are assumed to yield 2,100 gpm.

3. Well spacing is at 2,000-foot intervals.

4. Water from all proposed wells will require cooling from 120°F to 88°F with cooling towers.

The ground-water supply system was also developed using the following additional assumptions:

1. Design intervals were assumed at 10-year increments beginning in year 2000 and meeting the demands with and without the conservation factors noted in Table 7-1.

2. Because this is a regional water supply study, individual municipal facilities necessary to receive and further distribute the treated water at the delivery points were not included in the scope.

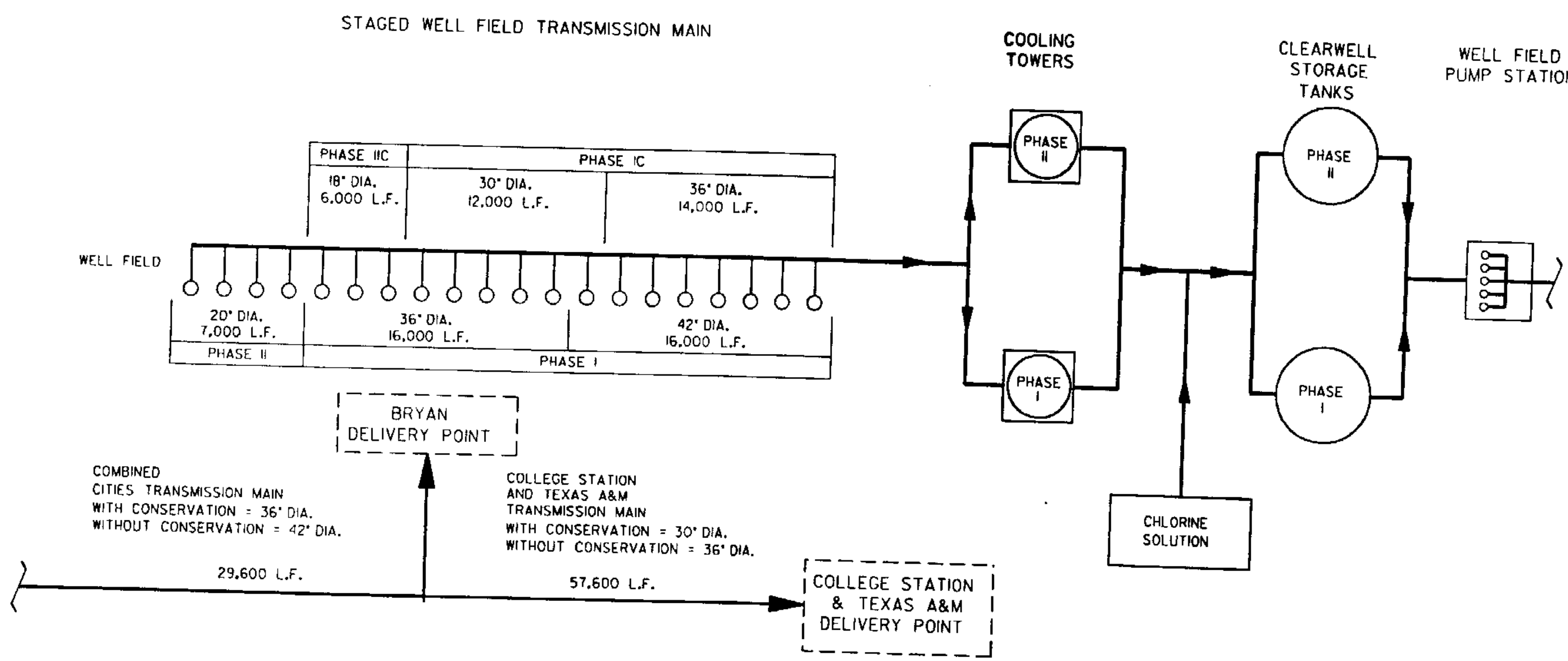
In general, the ground-water alternative will consist of a well field north of Bryan as described in Section 5.0 and as shown on Figure 5-7. The well field will be staged to meet demands of each construction phase. A well field transmission main will convey ground-water to cooling towers. The water will then be chlorinated, stored in clearwells and pumped from the booster pump station to two delivery points. A schematic showing the well field design can be found on Figure 7-1 and a map showing the location of well field facilities can be found on Figure 7-2.

7.2.1.2 Supply Facilities

Ground-water shall be obtained to meet maximum day demands from a series of wells north of Bryan, Texas and located in proximity to Highway 6 as shown on Figure 7-2. The wells will be constructed to meet the phasing demand as shown in Figure 7-1. Each well will be located on a separate lot and consist of a standard deep well, pump, motor with an electrical motor starter, and radio telemetry. Wells will have increased pumping head due to drawdown levels shown on Table 5-7. Increased power costs and possible pump replacement will be expected due to increased drawdown levels. The well field will tie into a well field transmission main which will be sized for each construction phase to provide maximum flow at a velocity of less than or equal to 10 feet per second. The size and length of each phased pipeline is shown on Figure 7-1.

7.2.1.3 Treatment Facilities

As described in Section 5.2.3, the temperature of the water from the Simsboro wells will require cooling towers. The cooling towers will reduce the temperature from approximately 120° to 88°F. Cooling towers will also be sized and staged in accordance with the construction phases. The quality of the Simsboro Aquifer is considered acceptable with minimal treatment. Post-chlorination will be added following the cooling process and air stripping will also be accomplished by the cooling towers.



CONSTRUCTION PHASE

PHASE	CONSTRUCTION YEAR	COOLING TOWERS	CLEARWELL GALLONS
WITHOUT CONSERVATION PLAN			
I	2000	11	2,300,000
II	2010	3	800,000
WITH CONSERVATION PLAN			
IC	2000	9	1,500,000
IIC	2010	3	600,000

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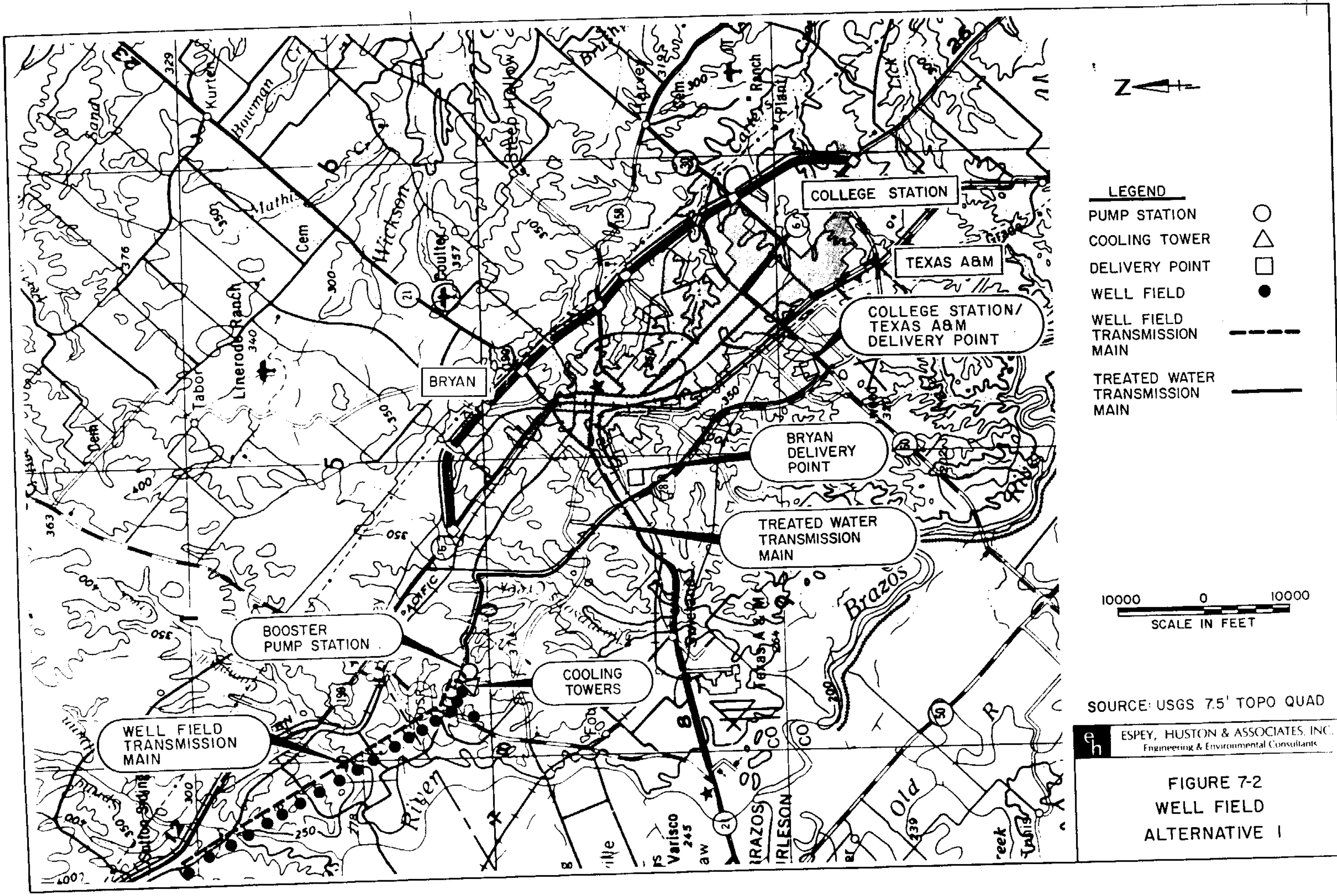
FIGURE 7-1
GROUND WATER SYSTEM



SOURCE: USGS 7.5' TOPO QUAD

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FIGURE 7-2
WELL FIELD
ALTERNATIVE I

PROJECT NO.

7.2.1.4 Pumping and Transmission

The pump station will use clearwell storage of treated water to reduce the cycle time of the pumps. The preliminary design of the clearwells was developed to store treated water prior to pumping to the delivery points. For the purpose of this study the clearwells are sized assuming a 6-hour storage of average day flow between pump starts. The clearwells will be welded steel and above ground. The size of the clearwells at the different construction phases and the schematic location can be found on Figure 7-1.

A booster pump station will be constructed to deliver the maximum day demands of a regional system. The structure will be initially sized to meet year 2020 demands, with only the required pumps being installed to meet each construction phase demands. The pumps will be multi-stage vertical turbine pumps. The reinforced-concrete station will be below ground, with a control building with heat, ventilation, air conditioning, and lighting. Auxiliary power may be from an internal combustion engine, gas turbine or secondary electrical source. The station will be complete with valves, piping, and radio telemetry.

The proposed treated water transmission main was aligned along existing road right-of-ways so as to minimize the impact to property and to minimize the right-of-way acquisition effort. The transmission main was sized to ultimate capacity to provide a single line for all phases. Low velocities will occur during the first phase with increased velocities to a maximum of 10 feet per second at Phase II maximum day demands. Two delivery point locations were selected. The proposed transmission line will carry the flow for the entire primary study area, approximately 5.6 miles along FM 2818 to the intersection of State Highway 21 where treated water will be delivered to the City of Bryan. This transmission main will be a 42-inch diameter without the conservation plan and transporting 58.94 mgd, and will be 36-inch diameter with the conservation plan and transporting 45.56 mgd. The transmission main will continue along FM 2818, approximately 10.9 miles, to the intersection of FM 60, delivering the remaining treated water to the second delivery point for College Station and Texas A&M. This transmission main will be 36-inch diameter without the conservation plan, delivering a maximum flow of 41.26 mgd, and will be 30-inch diameter with the conservation plan, delivering a maximum day flow of

31.89 mgd. The delivery points were located as shown on Figure 7-2 such that the cities' own facilities can easily be tied into the regional transmission main.

7.3 SURFACE WATER ALTERNATIVES

7.3.1 General

Three surface water sources were selected to compare construction costs and operation and maintenance costs with the ground water alternative. Many surface water sources were considered; however, Lake Somerville, the Brazos River and Millican Lake were used for this study. Section 6.0 describes the screening process used to select the alternatives.

This section will describe the improvements used to develop the surface water systems to deliver water for the primary study area for each alternative. Section 7.3.1 will describe those features and assumptions that are common for the three surface water alternatives. Features and assumptions which are unique to each alternative will be described in the paragraphs which follow each alternative.

In general, the alternatives will consist of a raw water intake channel and pump station located near the reservoir dam or river's edge. Raw water will be pumped through a raw water transmission main to a treatment plant. Treated water will be stored in clearwells and a booster pump station will deliver water to two delivery points through two treated water transmission mains. The typical surface water system can be found on Figure 7-3.

The surface water supply system was based on accepted engineering practices and the following conceptual design criteria:

1. The quality of water supplied must meet current criteria of the Texas Department of Health and U.S. Environmental Protection Agency (USEPA). The following are the U.S. EPA National Interim Primary Drinking Water Regulations and National Secondary Drinking Water Regulations:

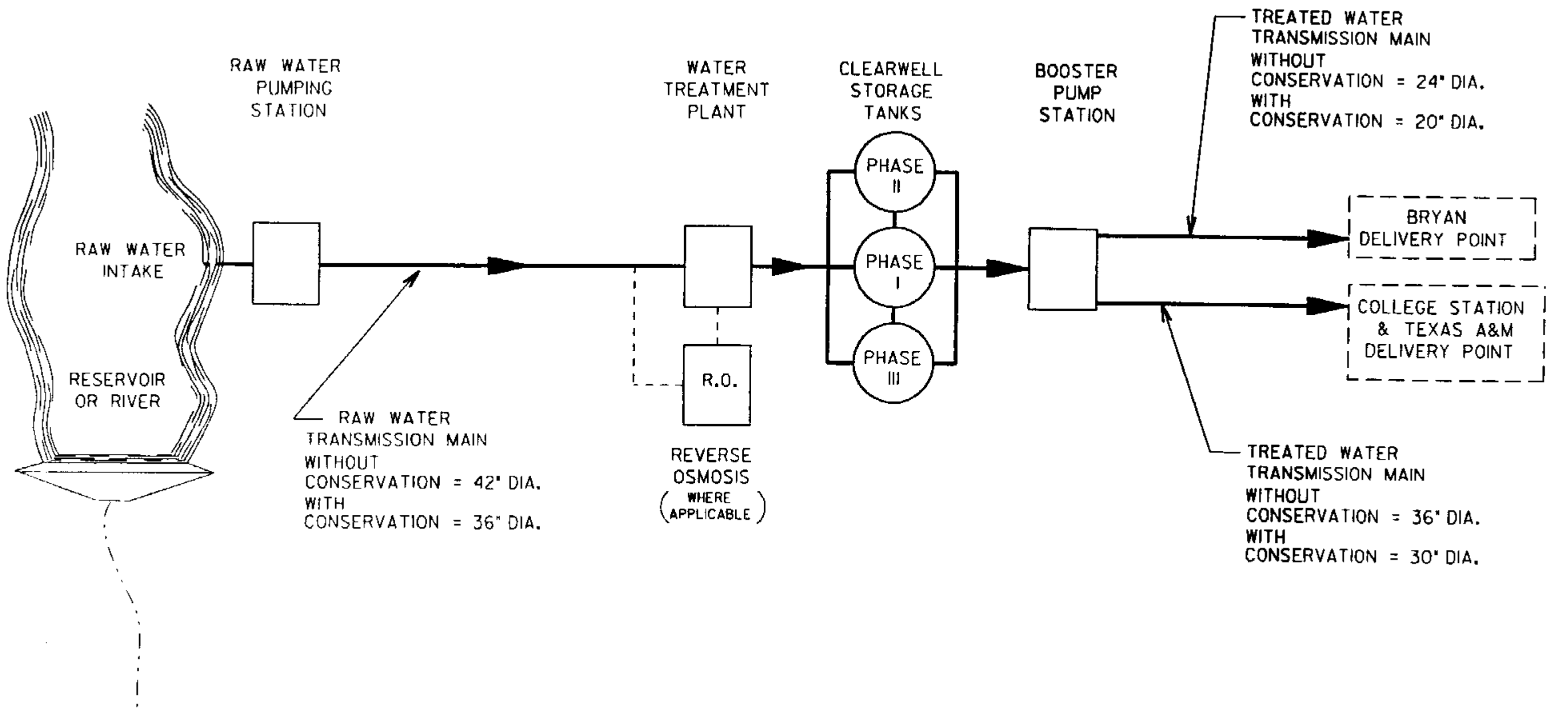

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FIGURE 7-3
TYPICAL SURFACE
WATER FACILITIES

NATIONAL INTERIM PRIMARY DRINKING WATER REGULATIONS

Contaminant	MCL (enforceable)*
Organics	
2,4-D	0.1 mg/L
Endrin	0.0002 mg/L
Lindane	0.0004 mg/L
Methoxychlor	0.1 mg/L
Toxaphene	0.005 mg/L
2,4,5-TP (Silvex)	0.01 mg/L
Trihalomethanes (sum of chloroform, bromoform, chloromethane, dibromochloromethane)	0.10 mg/L
Inorganics	
Arsenic	0.05 mg/L
Barium	1.0 mg/L
Cadmium	0.010 mg/L
Chromium	0.05 mg/L
Fluoride	1.4-2.4 mg/L+ (ambient temperature)
Lead	0.05 mg/L
Mercury	0.002 mg/L
Nitrate (as N)	10 mg/L
Selenium	0.01 mg/L
Silver	0.05 mg/L
Sodium and corrosion	No MCL; monitoring and reporting only
Radionuclides	
Beta particle and photon radioactivity	4 mrem (annual dose equivalent)
Gross alpha particle activity	15 pCi/L
Radium-226 plus radium-228	5 pCi/L
Microbials	
Coliforms	<1/100 mL
Turbidity	1 ntu (up to 5 ntu)

*Monitoring and reporting for each contaminant are also required.
+Revised MCL and MCLG for fluoride is 4 mg/L.

NATIONAL SECONDARY DRINKING WATER REGULATIONS

Contaminant	Current SMCLs	SMCLs Proposed Under Phase II*	SMCL Being Considered Under Phase V*
Chloride	250 mg/L		
Color	15 cu		
Copper	1 mg/L		
Corrosivity	Noncorrosive		
Fluoride	2 mg/L+		
Foaming agents	0.5 mg/L		
Iron	0.3 mg/L		
Manganese	0.05 mg/L		
Odor	3 Threshold odor number		
pH	6.5-8.5		
Sulfate	250 mg/L		
Total dissolved solids	500 mg/L		
Zinc	5 mg/L		
Aluminum		0.05 mg/L	
o-Dichlorobenzene		0.01 mg/L	
p-Dichlorobenzene		0.005 mg/L	
Ethylbenzene		0.03 mg/L	
Monochlorobenzene		0.1 mg/L	
Pentachlorophenol		0.03 mg/L	
Silver		0.09 mg/L	
Toluene		0.04 mg/L	
Xylene		0.02 mg/L	
Hexachlorocyclopentadiene			0.008 mg/L

*Phases are identified and defined in the text.
+The SMCL for fluoride was revised in 1986.

2. Each surface water alternative has sufficient water to meet the average day demands for the year 2020.

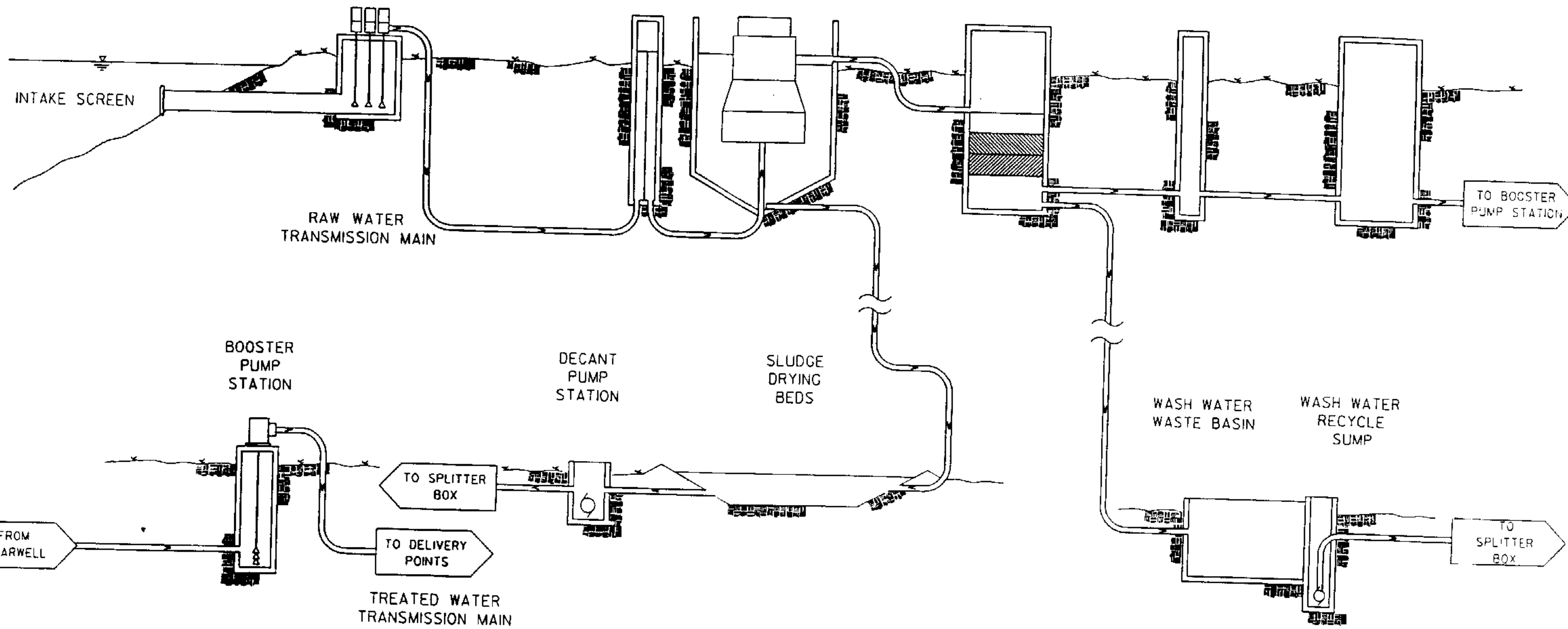
3. Demands for all surface water alternatives assume 10 existing Simsboro wells will yield 2,100 gpm each throughout the study period.

4. For the purpose of this study the first construction phase will be in the year 2000 and is designed to meet the demands of the year 2010. The second construction phase will be in the year 2010 meeting the demands of the year 2020. Cost scenarios were determined with and without the implementation of conservation measures. Design flows meet the demands of Table 3-13 and 3-14 and are summarized on Table 7-1.

5. Because this is a regional water supply study, individual city facilities necessary to receive and further distribute the treated water at the delivery points were not included in the scope.

7.3.1.1 Raw Water Intake and Pump Station

The location of each alternative's raw water intake and pump station was optimized based on reducing the length of raw water transmission pipeline, minimizing the amount of earthwork required for the construction of the structures and providing good access for maintenance. The intakes were assumed to be channels extending from the reservoir or river to the pump station. The intake will be equipped with bar screens to protect the pumps from debris. The pump station will be a reinforced-concrete structure sized to meet the year 2020 demands and containing vertical turbine pumps added at each construction phase to match the demands at each design phase. In general, three pumps will be installed in the first construction phase: two pumps combined to meet maximum day demand and one pump to serve as a back-up pump. The three pumps will be alternated to provide equal usage time. The second construction phase will add one pump meeting Phase II demands. An electrical control building with heating, ventilation, air conditioning, lighting and auxiliary power is also included. Stations will be complete with valves, pipes, fittings and controls.



CONSTRUCTION PHASE

PHASE	CONSTRUCTION YEAR	WATER TREATMENT PLANT MGD	CLEARWELL GALLONS
WITHOUT CONSERVATION			
I	2000	50	2,300,000
II	2010	10	800,000
WITH CONSERVATION			
IC	2000	38	1,500,000
IIC	2010	8	600,000

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FIGURE 7-4
TYPICAL TREATMENT PROCESS

7.3.1.4 Booster Pump Station and Transmission Main

Booster pump stations will use clearwell storage to reduce pump cycle times. Clearwell sizing assumed storing average day demands and a 6-hour storage between pump starts. The clearwells will be above ground and welded steel construction. The size of the clearwells at different construction phases can be found on Figure 7-4.

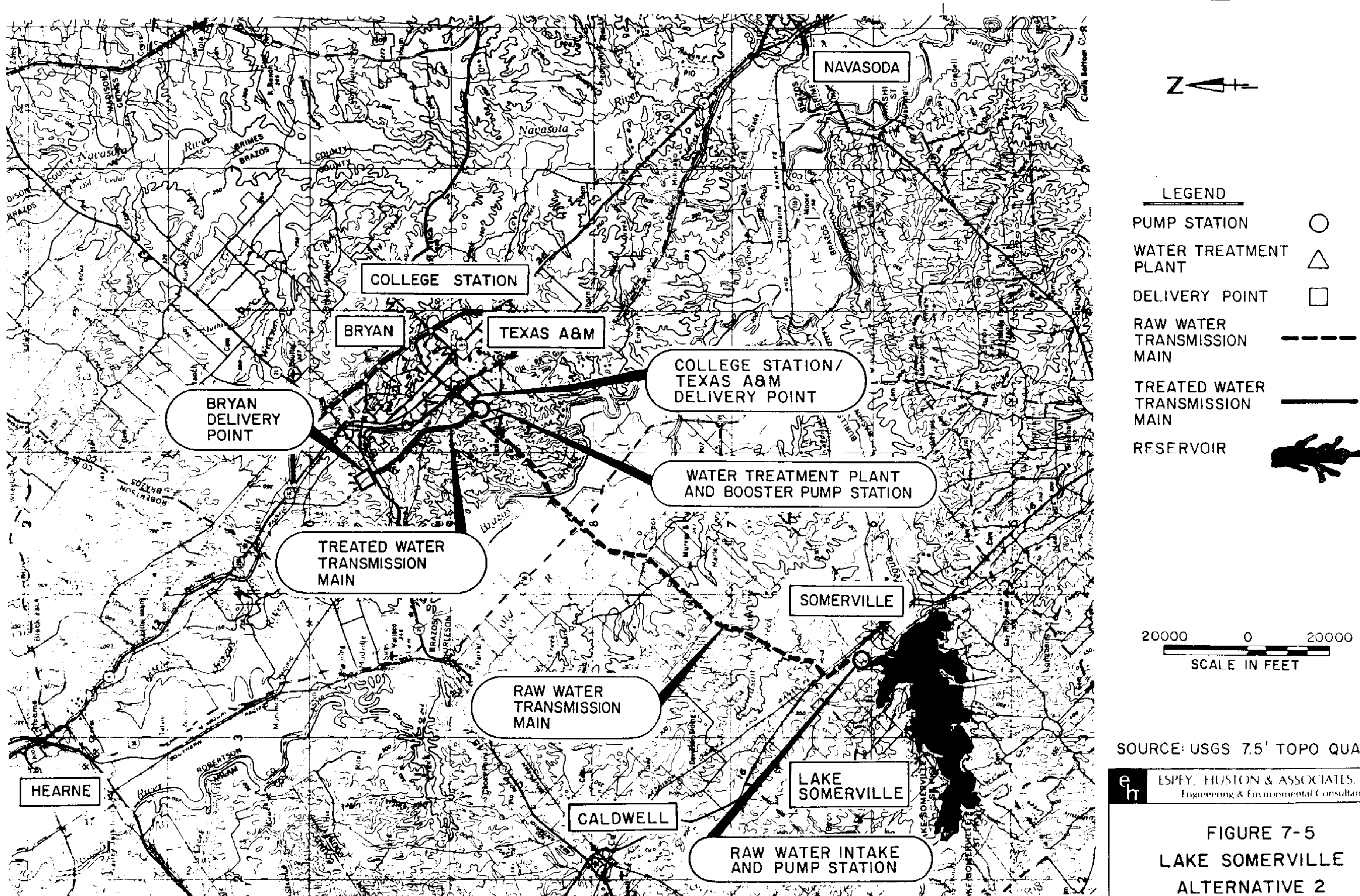
To deliver maximum day demands a booster pump station will be constructed. The structure will be sized to meet year 2020 demands, with pumps being added to meet construction phase demands. The pumps will be multi-stage vertical turbine pumps. The reinforced-concrete station will be below ground, equipped with heat, ventilation, air conditioning, lighting, auxiliary power and control instrumentation.

The treated water transmission mains were aligned along existing road right-of-way so as to reduce impact upon property. To minimize cost, a single transmission main was designed to meet year 2020 demands for each alternative. In general, delivery points for each alternative were located to provide each city with a minimum distance to tie to their own system.

7.3.2 <u>Alternative No. 2 - Lake Somerville</u>

7.3.2.1 Raw Water Intake and Pump Station

The raw water intake and pump station from Lake Somerville will be located on the northeast end of the lake near the dam (see Figure 7-5). The intake channel will be approximately 1,000 feet long. The pump station will be located at the end of the channel. The raw water pumps will pump against approximately 120 feet of elevation.



SOURCE: USGS 7.5' TOPO QUAD

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FIGURE 7-5
LAKE SOMERVILLE
ALTERNATIVE 2

PROJECT NO.

7.3.2.2 Raw Water Transmission Main

The transmission pipeline alignment was selected to follow FM 60 approximately 22 miles from the pump station to the treatment plant site located in proximity to the intersection with FM 2818. The alignment along FM 60 is relatively clear of existing utilities. A 42-inch pipeline from the pump station will provide 58.94 mgd without the conservation plan, and a 36-inch pipeline will provide 45.56 mgd with the conservation plan.

7.3.2.3 Water Treatment Plant

The preliminary design of the treatment process for water from Lake Somerville evaluated the existing water treatment process used by the City of Brenham, Texas whose supply is also from Lake Somerville. In general, the treatment process will be as that described in Paragraph 7.3.1.3 and as shown in Figure 7-4. The water quality from Lake Somerville is favorable for drinking water. The proposed treatment plant will be located at the intersection of FM 60 and FM 2818.

7.3.2.4 Booster Pump Station and Transmission Main

The facilities for the booster pump station including clearwells and pump station will all be located with the water treatment plant at the intersection of FM 60 and FM 2818. Clearwells and pump stations were sized as described in Paragraph 7.3.1.4. The size of the clearwells can be found on Figure 7-4. The vertical turbine pumps will pump against approximately 25 feet of elevation. The transmission facilities will consist of two pipelines from the booster pump station, one line to a delivery point for the City of College Station and Texas A&M, and one line to a delivery point for the City of Bryan.

The pipeline for the College Station and Texas A&M delivery point was assumed to be 500 feet along FM 60. The transmission main was designed to provide 41.26 mgd and will be 36-inch diameter without a conservation plan and was designed to provide 31.89 mgd and will be 30-inch diameter with the conservation plan.

The pipeline for the Bryan delivery point will follow FM 2818 north 5.4 miles to the intersection of State Highway 21. The transmission main was designed to provide 17.68 mgd and will be 24-inch diameter without a conservation plan, and was designed to provide 13.67 mgd and will be 20-inch diameter with a conservation plan. There are some existing utilities along FM 2818 which would need to be considered in order to locate the transmission main.

7.3.3 Alternative No. 3 - Brazos River

7.3.3.1 Raw Water Intake and Pump Station

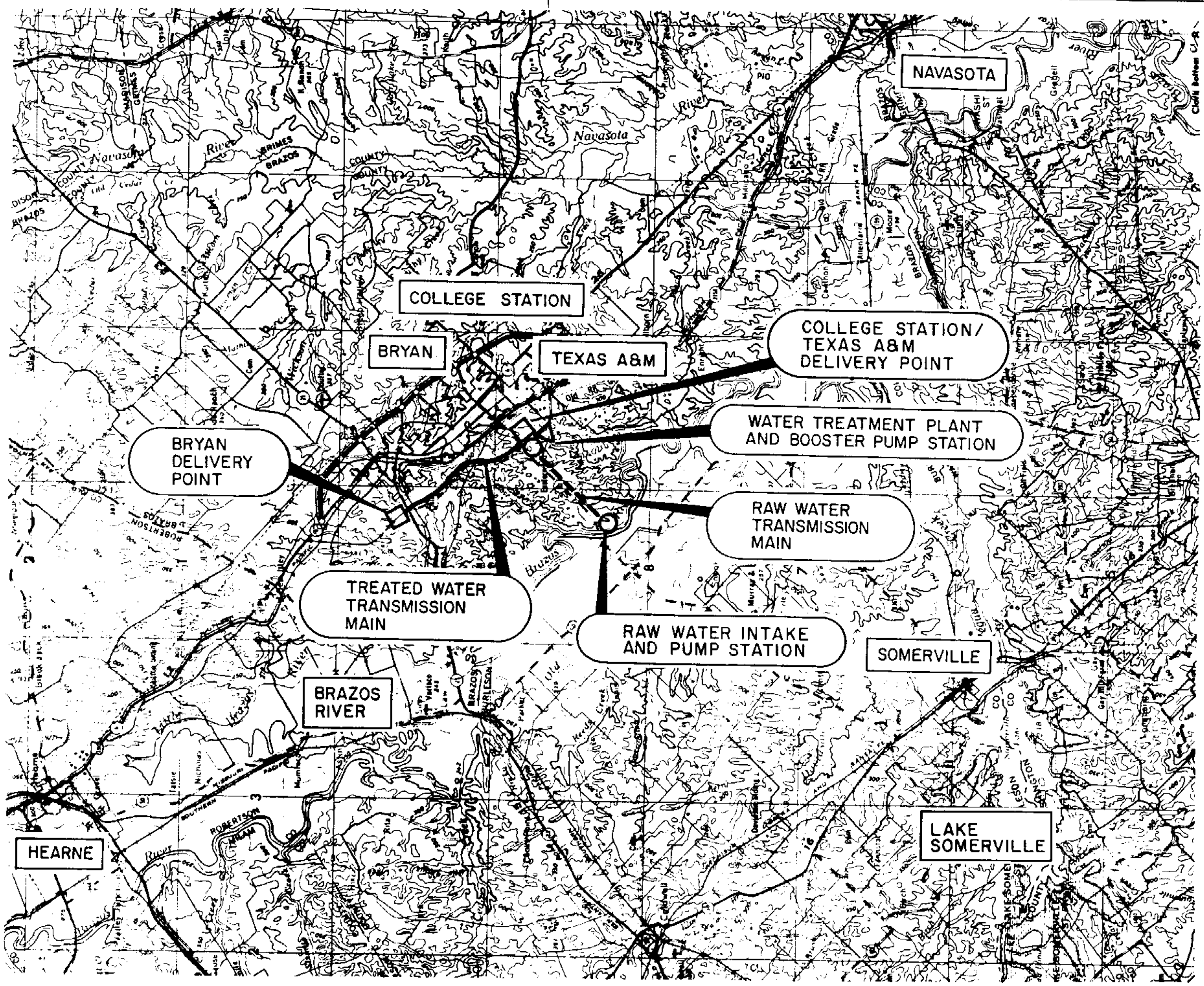
The proposed raw water intake for this study was located on the Brazos River at FM 60. The intake will be a channel approximately 200 linear feet. Location of Alternative No. 3 can be seen on Figure 7-6. The pump station located adjacent to FM 60 will pump raw water from the river to the water treatment plant. The raw water pumps will pump against approximately 150 feet of elevation.

7.3.3.2 Raw Water Transmission Main

The transmission pipeline alignment will follow FM 60 approximately 4.5 miles to the treatment plant site located at the intersection of FM 60 and FM 2818 which is the same site as that used in Alternative No. 2. The pipeline was designed to provide 58.94 mgd and will be 42-inch diameter without a conservation plan, and was designed to provide 45.56 mgd and will be 36-inch diameter with the conservation plan.

7.3.3.3 Water Treatment Plant

Water from the Brazos River exceeds the U.S. Environmental Protection Agency's maximum level of total dissolved solids of 500 mg/l as described in Paragraph 7.3.1. Texas A&M performed a statistical evaluation of the salt concentrations in the Brazos River. The statistical analysis is provided in a letter from the Brazos River Authority, dated March 8, 1990 and



N

LEGEND

PUMP STATION ○
WATER TREATMENT PLANT △
DELIVERY POINT □
RAW WATER TRANSMISSION MAIN - - - -
TREATED WATER TRANSMISSION MAIN ———

20000 0 20000
SCALE IN FEET

SOURCE: USGS 7.5' TOPO QUAD

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FIGURE 7-6
BRAZOS RIVER
ALTERNATIVE 3

PROJECT NO.

provided in Appendix D. The analysis indicated that at the College Station Gage the total dissolved solids exceeds 500 mg/l about 50 percent of the time. Therefore, an alternative means of reducing the concentration of total dissolved solids must be provided.

Two alternative methods of reducing the total dissolved solids were considered, Termination Storage and Reverse Osmosis treatment.

A. Termination Storage

To achieve the maximum levels of total dissolved solids with termination storage, a pond was designed to store water during periods of lower told dissolved solids concentration. If water is stored at an assumed concentration of 400 mg/l or less, which, according to the Texas A&M analysis occurs 30 percent of the time, then it can be mixed with water at 600 mg/l or less, which according to the analysis occurs 70 percent of the time, to achieve the required 500 mg/l. The volume of the termination pond was determined based on filling with 400 mg/l water and providing 6 months storage at 30 percent of the maximum demand. Without the conservation plan, the volume is 3,177 acre-feet, and with the conservation plan will be 1,940 acre-feet. Pond costs were assumed at $5,000 per acre-foot. Therefore, costs were estimated at $15.9 million without a conservation plan, and $9.7 million with a conservation plan. Termination storage will also require the addition of low head, mix-flow pumps and a pump station located at the intake structure.

B. Reverse Osmosis

Reverse osmosis is a treatment process whereby water diffuses through a semipermeable membrane. The membrane acts as a barrier to dissolved solids. Reverse osmosis can be utilized during low river flow and high dissolved solids concentrations to provide concentrations within the EPA standards. To achieve an acceptable level of dissolved solids, raw water will be mixed with water treated by reverse osmosis. Reverse osmosis will reduce the concentration to near zero. Reverse osmosis capacities were determined assuming maximum day demand, a raw water concentration of 600 mg/l, and mixing with water from reverse osmosis at 1 mg/l. The following capacities were determined in order to achieve 500 mg/l:

Year	Capacity (mgd)
2000	7.75
2000 with conservation	6.15
2010	9.85
2010 with conservation	7.61

The cost for construction was determined using $1.00 per gpd.

In comparing the cost of providing reverse osmosis versus constructing an off-channel reservoir, the construction cost for the reverse osmosis for year 2020 is about half the cost of the termination pond without considering the additional pump station made necessary by the pond. Therefore, for the purpose of this study reverse osmosis was selected as the method of providing water with an acceptable level of dissolved solids from the Brazos River.

The treatment process described in Paragraph 7.3.1.3 and as shown on Figure 7-4, will be operated in parallel when there is a need for the reverse osmosis system. If the river concentration is below the EPA regulated total dissolved solids concentration of 500 mg/l, the reverse osmosis system is not needed and the treatment plant will operate without it. The treatment plant will be located in the same location as that used for Alternative No. 2 at the intersection of FM 60 and FM 2818.

7.3.3.4 Booster Pump Station and Transmission Main

The facilities for the booster pump station and the treated water transmission main are identical in location and size to those facilities presented for Alternative No. 2 - Lake Somerville, specifically Paragraph 7.3.2.4. Therefore, the location and size of facilities and the alignment, size and lengths of the booster pump station and transmission facilities can be found in Alternative No. 2 description.

7.3.4 Alternative No. 4 - Millican Lake

7.3.4.1 Raw Water Intake and Pump Station

The location of the dam for this alternative is located at mile 36 on the Navasota River. The raw water intake and pump station will be located near the intersection of FM 159 and the dam for the reservoir (see Figure 7-7). The design of the facilities are described in Paragraph 7.3.1. The intake channel will be approximately 1,000 linear feet. The raw water pumps will pump against approximately 80 feet of elevation.

7.3.4.2 Raw Water Transmission Main

The transmission pipeline designed to provide 58.94 mgd will be a 42-inch diameter for non-conservation flows, and to provide 45.56 mgd will be 36-inch diameter for conservation flows. The pipeline will follow FM 159 northwest 4.6 miles until it intersects State Highway 6 where the treatment plant will be located. The alignment along FM 159 is considered relatively clear of other utilities.

7.3.4.3 Water Treatment Plant

The water quality of the Navasota River is considered good, and raw water from Millican Lake will require the treatment facilities described in Paragraph 7.3.1.3 and as shown on

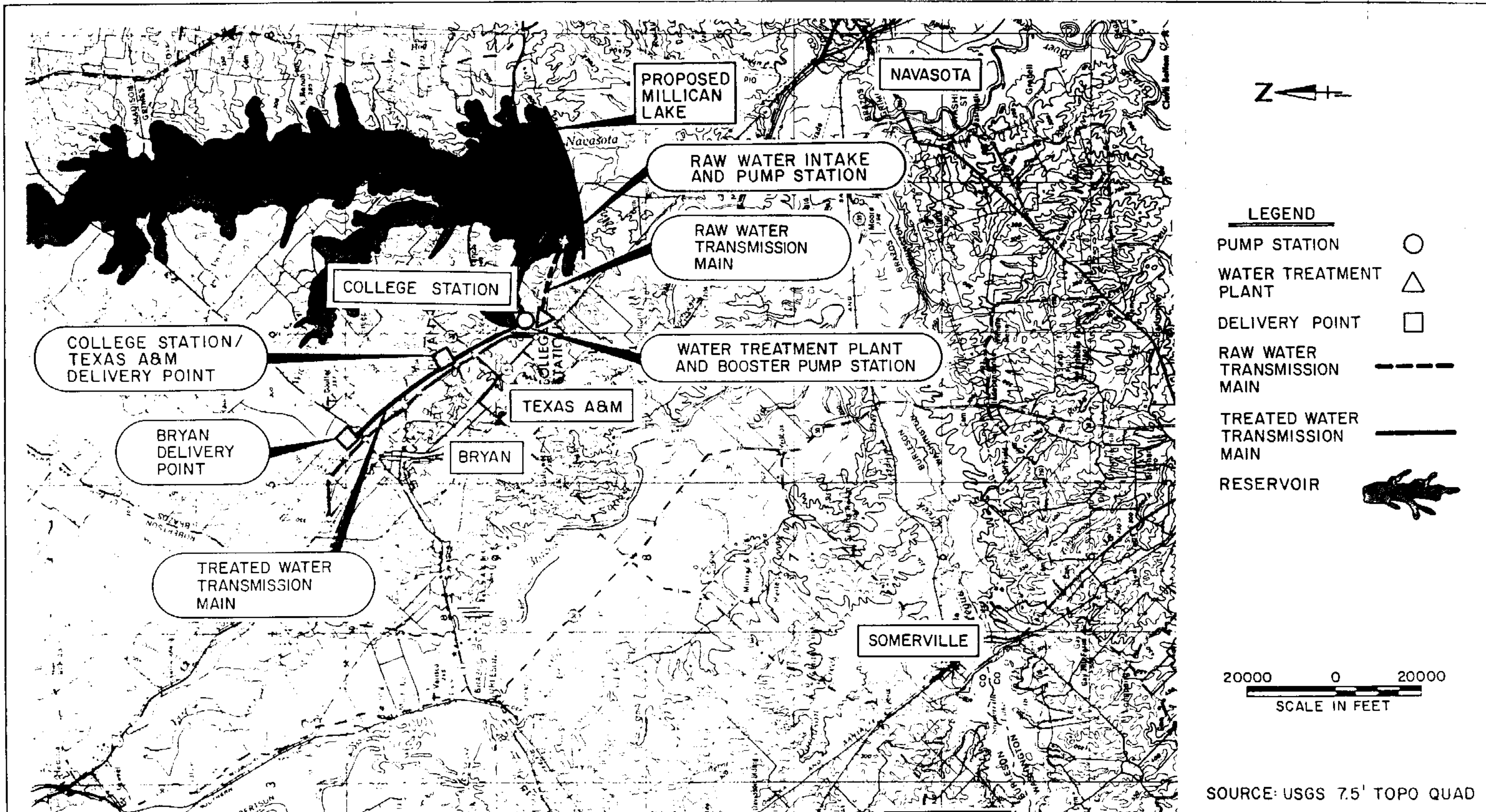

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FIGURE 7-7
MILLICAN LAKE
ALTERNATIVE 4

7.3.5 Cost Estimates

The cost estimates presented in this report are intended to provide an economic comparison of the selected alternatives for a regional water supply system.

7.3.5.1 Ground Water Costs

A. General

The probable cost associated with the improvements necessary to provide water under Alternative No. 1 are described in this section. The costs are presented according to the construction phases.

B. Construction Costs

In general, construction costs will include costs associated with the construction of wells, well field transmsision main, cooling towers, booster pump station, storage tanks, treated water transmission mains and the land and rights-of-way for the facilities. The costs for the construction of facilities have been developed using current estimated unit costs for construction and the following criteria:

- Well cost includes pump, motor, well, site work, electrical and instrumentation.
- Each well is expected to require approximately one-half acre of land.
- The land requirement for new water transmission main is assumed to be 50 feet of right-of-way, and land costs are assumed to be $10,000 per acre for sites 5 acres and smaller and $5,000 per acre for sites greater than 5 acres.
- Clearwell storage tank costs were based upon welded steel above ground construction, estimated at $0.56 per gallon.

- The costs for the transmission mains include pipe, fittings, road crossings and miscellaneous appurtenances, and were estimated according to the following schedule:

Pipe Diameter (in.)	Cost per Linear Foot
18	$ 40
20	45
30	60
36	70
42	80

- Costs do not include the storage facility located at each delivery point nor the pumping and transmission facility to each city system.
- Costs do not include relocation of existing facilities nor mitigation costs.
- Costs include engineering and contingency at 20 percent of construction costs.

The estimated capital cost to construct Alternative No. 1 can be found in Table 7-2.

C. Operation and Maintenance Costs

The operation and maintenance (O&M) requirements have been assessed to determine the annual O&M cost for the well field system. The assessment included requirements for staff, equipment, power, and facility maintenance. The estimated cost for O&M of the facilities was developed using historical unit costs and the following criteria:

- The annual O&M cost for wells is based upon $1,500 per well.
- The annual O&M cost for the transmission line is based upon $7.50 per inch-diameter per mile.

TABLE 7-2

CONSTRUCTION COST ESTIMATES
WELL FIELD - ALTERNATIVE NO. 1

Description	Phase:[1] I	Ic	II	IIc
Well Field - Pumps, Motor, Well	$7,200,000	$5,850,000	$1,800,000	$1,350,000
Electrical and Instrumentation	336,000	273,000	84,000	63,000
Lands and Rights-of-Way	80,000	65,000	20,000	15,000
Well Field Transmission Main	2,400,000	1,700,000	315,000	200,000
Lands and Rights-of-Way	185,000	150,000	40,000	35,000
Cooling Towers and Chlorination	993,000	813,000	284,000	224,000
Clearwell	1,288,000	840,000	448,000	336,000
Booster Pump Station	1,727,200	1,403,400	268,800	187,400
Lands and Rights-of-Way	50,000	50,000	--	--
Treated Water Transmission Main	6,400,000	5,528,000	--	--
Lands and Rights-of-Way	20,000	20,000	--	--
SUBTOTAL	$20,679,200	$16,692,400	$3,259,800	$2,410,400
Contingency and Engineering	4,135,800	3,338,500	652,000	482,100
TOTAL CONSTRUCTION COST	$24,815,000	$20,030,900	$3,911,800	$2,892,500

1 Construction Phases

Year	Without Conservation Plan	With Conservation Plan
2000	I	Ic
2010	II	IIc

- The annual O&M cost for the cooling towers is based upon 1.0 percent of construction costs.
- The annual O&M cost for the booster pump station is based upon $5.20 per horsepower.
- The electrical power cost is based upon $0.063 per kilowatt-hour.
- The electrical power costs include well draw down levels, static and friction heads.
- Administration fees were included based on 15 percent of total operation and maintenance costs excluding pump power costs.

The estimated annual operation and maintenance cost for Alternative No. 1 can be found in Table 7-3.

7.3.5.2 Surface Water Costs

A. General

The costs associated with the improvements necessary to provide water from the three surface water alternatives are described in this section. The costs are based on historical unit costs for construction and applying engineering judgment. In general, the costs are determined for those facilities necessary to take raw water from the source and to deliver potable water to the primary study area. The costs presented in this report will serve as a basis for comparison among the proposed alternatives. This section will provide those assumptions used to arrive at the construction costs and operation and maintenance costs.

B. Construction Costs

In general, construction costs will include those costs associated with the construction of the raw water intake and pump station, raw water transmission pipes, water treatment facilities, booster pump station, storage tanks, treated water transmission mains and the land and right-of-ways for the facilities.

TABLE 7-3

OPERATION AND MAINTENANCE COST ESTIMATES

WELL FIELD - ALTERNATIVE NO. 1

Description	Phase:[1] I	Ic	II	IIc
Salaries and Wages				
Employee Expenses and Benefits	$21,000	$21,000	$21,000	$21,000
Salaries and Wages	70,000	70,000	70,000	70,000
Operational Supplies and Service				
Equipment Supplies, Professional Fees, Miscellaneous Operating	50,000	50,000	50,000	50,000
Pump Station Power[2]				
Well Field	731,200	398,100	1,283,200	718,900
Booster Pump Station	58,500	20,800	142,000	82,800
Maintenance and Repair				
Pipelines - Well Field and Treated Water	6,500	5,200	6,700	5,400
Wells	24,000	19,500	6,000	4,500
Cooling Towers	9,800	8,000	2,800	2,200
Booster Pump Station	200	100	700	400
SUBTOTAL OPERATION AND MAINTENANCE	$971,200	$592,700	$1,582,400	$955,200
Administrative and General[3]	27,200	26,100	23,600	23,000
TOTAL ANNUAL OPERATION AND MAINTENANCE	$998,400	$618,800	$1,606,000	$978,200

1 Construction Phases

Year	Without Conservation Plan	With Conservation Plan
2000	I	Ic
2010	II	IIc

2 Power cost determined at $0.063 per KWH

3 Administrative cost determined at 15% subtotal O&M excluding Pump Station Power

The estimated costs for the construction of surface water facilities are based on the following criteria:

- This regional system is a stand-alone system not tied into the existing water supply facilities of the primary study area. The costs for facilities assumes the source of water is in place, begins with diversion facilities and ends with the transmission facility to the individual delivery points.

- The cost for surface water facilities assumes that 10 existing Simsboro wells will remain active throughout the study period. These wells will produce at 2,100 gpm each.

- The cost of land was assumed to be $10,000 per acre for sites less than or equal to 5 acres and $5,000 per acre for sites greater than 5 acres.

- Clearwell storage tank costs were based on welded steel, above ground construction, estimated at $0.56 per gallon.

- Water treatment plant costs were based upon $0.70 per gallon for the first construction phase and $0.50 per gallon for the second construction phase.

- Reverse osmosis cost was based upon $1.00 per gallon.

- Land costs for the clearwell and booster pump station are included in the water treatment plant land and right-of-way costs.

- Transmission mains follow roads and rights-of-way where possible. The cost for transmission mains includes pipe, valves, fittings, road crossings and miscellaneous appurtenances and were estimated based upon the following:

Pipe Diameter (in.)	Cost per Linear Foot
18	$ 40
20	45
24	50
30	60
36	70
42	80

- The costs include engineering and contingency costs at 20 percent of construction costs.

- Costs do not include relocation of existing utilities and facilities nor mitigation costs.

The estimated capital cost to construct Alternatives 2, 3 and 4 can be found in Tables 7-4, 7-5 and 7-6. Surface water construction costs are compared to ground-water costs in Section 8.0.

C. Operation and Maintenance Costs

The operation and maintenance (O&M) requirements for the surface water alternatives have been assessed to determine the annual O&M cost. The assessment includes requirements for staff, equipment, power, and facility maintenance for each surface water alternative. The estimated costs for the O&M of the facilities were developed using historical unit costs and the following criteria:

TABLE 7-4

CONSTRUCTION COST ESTIMATES

LAKE SOMERVILLE - ALTERNATIVE NO. 2

Description	Phase:[1] I	Ic	II	IIc
Raw Water Intake Approach Channel	$1,200,000	$1,200,000	--	--
Raw Water Intake Structure and Pump Station	1,656,100	1,314,500	$268,800	$187,400
Lands and Rights-of-Way	50,000	50,000	--	--
Raw Water Transmission Main	9,292,800	8,131,200	--	--
Lands and Rights-of-Way	50,000	50,000	--	--
Water Treatment Plant	35,000,000	26,600,000	5,000,000	4,000,000
Clearwell	1,288,000	840,000	448,000	336,000
Booster Pump Station	1,656,100	1,314,500	268,800	187,400
Lands and Rights-of-Way	150,000	100,000	--	--
Treated Water Transmission Main	1,460,600	1,313,000	--	--
Lands and Rights-of-Way	20,000	20,000	--	--
SUBTOTAL	$51,823,600	$40,933,200	$5,985,600	$4,710,800
Contingency and Engineering	10,364,700	8,186,600	1,197,100	942,200
TOTAL CONSTRUCTION COST	$62,188,300	$49,119,800	$7,182,700	$5,653,000

1 Construction Phases

Year	Without Conservation Plan	With Conservation Plan
2000	I	Ic
2010	II	IIc

TABLE 7-5

CONSTRUCTION COST ESTIMATES
BRAZOS RIVER - ALTERNATIVE NO. 3

Description	Phase:[1] I	Ic	II	IIc
Raw Water Intake Approach Channel	$240,000	$240,000	--	--
Raw Water Intake Structure and Pump Station	1,656,100	1,314,500	$268,800	$187,400
Lands and Rights-of-Way	50,000	50,000	--	--
Raw Water Transmission Main	1,900,800	1,663,100	--	--
Lands and Rights-of-Way	20,000	20,000	--	--
Water Treatment Plant	35,000,000	26,600,000	5,000,000	4,000,000
Clearwell	1,288,000	840,000	448,000	336,000
Booster Pump Station	1,656,100	1,314,500	268,800	187,400
Reverse Osmosis	7,750,000	6,150,000	2,100,000	1,460,000
Lands and Rights-of-Way	150,000	100,000	--	--
Treated Water Transmission Main	1,460,600	1,313,000	--	--
Lands and Rights-of-Way	20,000	20,000	--	--
SUBTOTAL	$51,191,600	$39,625,100	$8,085,600	$6,170,800
Contingency and Engineering	10,238,300	7,925,000	1,617,100	1,234,200
TOTAL CONSTRUCTION COST	$61,429,900	$47,550,100	$9,702,700	$7,405,000

1 Construction Phases

Year	Without Conservation Plan	With Conservation Plan
2000	I	Ic
2010	II	IIc

TABLE 7-6

CONSTRUCTION COST ESTIMATES
MILLICAN LAKE - ALTERNATIVE NO. 4

Description	Phase:[1] I	Ic	II	IIc
Raw Water Intake Approach Channel	$1,200,000	$1,200,000	–	–
Raw Water Intake Structure and Pump Station	1,656,100	1,314,500	$268,800	$187,400
Lands and Rights-of-Way	50,000	50,000	–	–
Raw Water Transmission Main	2,259,800	1,977,400	–	–
Lands and Rights-of-Way	30,000	30,000	–	–
Water Treatment Plant	35,000,000	26,600,000	5,000,000	4,000,000
Clearwell	1,288,000	840,000	448,000	336,000
Booster Pump Station	1,656,100	1,314,500	268,800	187,400
Lands and Rights-of-Way	150,000	100,000	–	–
Treated Water Transmission Main	3,347,600	2,742,800	–	–
Lands and Rights-of-Way	20,000	20,000	–	–
SUBTOTAL	$46,657,600	$36,189,200	$5,985,600	$4,710,800
Contingency and Engineering	9,331,500	7,237,800	1,197,100	942,200
TOTAL CONSTRUCTION COST	$55,989,100	$43,427,000	$7,182,700	$5,653,000

1 Construction Phases

Year	Without Conservation Plan	With Conservation Plan
2000	I	Ic
2010	II	IIc

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- The annual O&M cost for the transmission mains is based upon $7.50 per inch-diameter per mile.

- The annual O&M cost for the raw water intake is based upon $5.20 per horsepower.

- The annual O&M costs for the water treatment plant are based on 2 percent of the construction costs.

- The electrical power costs are based upon $0.063 per kilowatt-hour.

- The cost of raw water is based on average day demands at the unit cost of water as proposed by the Brazos River Authority's letter dated March 8, 1990 and provided in Appendix D. The cost is $85.00 per acre-foot.

- Administration costs were included based on 15 percent of total operation and maintenance costs excluding pump power costs and costs for raw water.

The estimated annual operation and maintenance cost associated with the three surface water alternatives can be found in Tables 7-7, 7-8 and 7-9. Surface water O&M costs are compared to ground water O&M costs in Section 8.0.

TABLE 7-7

OPERATION AND MAINTENANCE COST ESTIMATES
LAKE SOMERVILLE - ALTERNATIVE NO. 2

Description	Phase:[1] I	Ic	II	IIc
Salaries and Wages				
Employee Expenses and Benefits	$30,000	$30,000	$30,000	$30,000
Salaries and Wages	100,000	100,000	100,000	100,000
Operational Supplies and Service				
Equipment Supplies, Professional Fees, Miscellaneous Operating	60,000	60,000	60,000	60,000
Pump Station Power[2]				
Raw Water Intake	189,400	104,800	353,000	204,700
Booster Pump Station	34,300	23,700	63,600	42,500
Water Treatment Plant Chemicals	50,000	50,000	60,000	60,000
Maintenance and Repair				
Pipelines - Raw Water and Treated Water	7,900	6,800	7,900	6,800
Raw Water Pump Station	2,400	1,300	4,200	2,600
Water Treatment Plant	70,000	53,200	80,000	61,200
Booster Pump Station	500	500	800	800
SUBTOTAL OPERATION AND MAINTENANCE	$544,500	$430,300	$759,500	$568,600
Administrative and General[3]	48,100	45,300	51,400	48,200
Raw Water Supply[4]	1,205,600	695,200	1,800,800	1,099,000
TOTAL ANNUAL OPERATION AND MAINTENANCE	$1,798,200	$1,170,800	$2,611,700	$1,715,800

1 Construction Phases

Year	Without Conservation Plan	With Conservation Plan
2000	I	Ic
2010	II	IIc

2 Power cost determined at $0.063 per KWH
3 Administrative cost determined at 15% subtotal O&M excluding Pump Station Power and Raw Water Supply
4 Unit cost of raw water per Brazos River Authority at $85.00 per Ac.-Ft. (see Appendix D)

TABLE 7-8

OPERATION AND MAINTENANCE COST ESTIMATES

BRAZOS RIVER - ALTERNATIVE NO. 3

Description	Phase:[1] I	Ic	II	IIc
Salaries and Wages				
Employee Expenses and Benefits	$30,000	$30,000	$30,000	$30,000
Salaries and Wages	100,000	100,000	100,000	100,000
Operational Supplies and Service				
Equipment Supplies, Professional Fees, Miscellaneous Operating	60,000	60,000	60,000	60,000
Pump Station Power[2]				
Raw Water Intake	197,900	113,300	310,000	187,000
Booster Pump Station	34,300	23,700	66,600	42,500
Reverse Osmosis	509,200	403,900	138,000	96,400
Water Treatment Plant Chemicals	50,000	50,000	60,000	60,000
Maintenance and Repair				
Pipelines - Raw Water and Treated Water	2,400	2,000	2,400	2,400
Raw Water Pump Station	2,500	1,400	3,900	2,400
Water Treatment Plant	70,000	53,200	80,000	61,200
Booster Pump Station	500	500	800	800
SUBTOTAL OPERATION AND MAINTENANCE	$1,056,800	$838,000	$851,700	$642,700
Administrative and General[3]	47,300	44,600	50,600	47,500
Raw Water Supply[4]	1,205,600	695,200	1,800,800	1,099,000
TOTAL ANNUAL OPERATION AND MAINTENANCE	$2,309,700	$1,577,800	$2,703,100	$1,789,200

1 Construction Phases

Year	Without Conservation Plan	With Conservation Plan
2000	I	Ic
2010	II	IIc

2 Power cost determined at $0.063 per KWH

3 Administrative cost determined at 15% subtotal O&M excluding Pump Station Power and Raw Water Supply

4 Unit cost of raw water per Brazos River Authority at $85.00 Ac.-Ft. (see Appendix D)

TABLE 7-9

OPERATION AND MAINTENANCE COST ESTIMATES
MILLICAN LAKE - ALTERNATIVE NO. 4

Description	Phase:[1] I	Ic	II	IIc
Salaries and Wages				
Employee Expenses and Benefits	$30,000	$30,000	$30,000	$30,000
Salaries and Wages	100,000	100,000	100,000	100,000
Operational Supplies and Service				
Equipment Supplies, Professional Fees, Miscellaneous Operating	60,000	60,000	60,000	60,000
Pump Station Power[2]				
Raw Water Intake	110,500	62,600	182,200	108,500
Booster Pump Station	152,000	85,100	260,300	155,900
Water Treatment Plant Chemicals	50,000	50,000	60,000	60,000
Maintenance and Repair				
Pipelines - Raw Water and Treated Water	3,900	3,300	3,900	3,300
Raw Water Pump Station	1,400	900	2,300	1,400
Water Treatment Plant	70,000	53,200	80,000	61,200
Booster Pump Station	1,900	1,100	3,300	2,000
SUBTOTAL OPERATION AND MAINTENANCE	$579,700	$446,200	$782,000	$582,300
Administrative and General[3]	47,600	44,800	50,900	47,700
Raw Water Supply[4]	1,205,600	695,200	1,800,800	1,099,000
TOTAL ANNUAL OPERATION AND MAINTENANCE	$1,832,900	$1,186,200	$2,633,700	$1,729,000

1 Construction Phases

Year	Without Conservation Plan	With Conservation Plan
2000	I	Ic
2010	II	IIc

2 Power cost determined at $0.063 per KWH

3 Administrative cost determined at 15% subtotal O&M excluding Pump Station Power and Raw Water Supply

4 Unit cost of raw water per Brazos River Authority at $85.00 per Ac.-Ft. (see Appendix D)

8.0 COMPARISON OF ALTERNATIVES

8.1 GENERAL

The purpose of this section is to present the comparison of costs for the construction of facilities to provide water to the primary study area from the four alternatives: Alternative 1 - Ground water from proposed Simsboro Aquifer wells; Alternative 2 - Surface water from Lake Somerville; Alternative 3 - Surface water from the Brazos River; Alternative 4 - Surface water from Millican Lake.

It is important to recognize that this study presents the costs for improvements for a regional system to provide water to the primary study area and does not present additional costs for all improvements necessary to provide individual cities and other private water supply corporations with potable water.

Table 8-1 presents a summary of construction costs and operation and maintenance costs for each alternative for each construction phase with and without the conservation factors. These costs represent current values.

To provide water from the regional water system for the secondary study area would require, in many cases, extensive transmission and pumping facilities, thereby increasing the cost of construction. For example, to pump the maximum day demands of .038 mgd from the Bryan delivery point to the Madison County Water Supply Corporation would require 27 miles of 2-inch diameter pipe and an additional booster pump station. The transmission line cost is estimated at $1,400,000 versus the cost for a well which would be about $400,000. Therefore, from an economic viewpoint, supplying the secondary study area with water from a regional facility would not be recommended. Madison County W.S.C. was the only entity in the secondary study area which responded with a favorable interest in a regional water supply system.

TABLE 8-1

COST COMPARISON

GROUND WATER VS. SURFACE WATER

Construction Costs[1]		Total Construction Costs			
		I	Ic	II	IIc
Source:	Well Field	$24,815,000	$20,030,900	$3,911,800	$2,892,500
	Lake Somerville	62,188,300	49,119,800	7,182,700	5,653,000
	Brazos River	61,429,900	47,550,100	9,702,700	7,405,000
	Millican Lake	55,989,100	43,427,000	7,182,700	5,653,000

Operation and Maintenance Costs[2]		Total Annual Operation and Maintenance			
		I	Ic	II	IIc
Source:	Well Field	$998,400	$618,800	$1,606,000	$978,200
	Lake Somerville	1,798,200	1,170,800	2,611,700	1,715,800
	Brazos River	2,309,700	1,577,800	2,703,100	1,789,200
	Millican Lake	1,832,900	1,186,200	2,633,700	1,729,000

1 Construction Costs include contigency and engineering.

2 Operation and Maintenance Costs include Administrative.

8.2 RECOMMENDED ALTERNATIVE SOURCE

The purpose of this section is to provide a recommendation for a regional water supply for the future demands of the primary study area. This study reviewed three surface water sources and provided the cost for those facilities that would be required to provide potable water to the delivery points, and compared those costs to the ground water source.

One objective of the investigation of a water source for the future demands was to determine the feasibility of continuing to use ground water. Section 5.0 discusses the effects on the Simsboro Aquifer with the addition of wells to meet the future demands. The conclusion of Section 5.0 was that the addition of wells to meet the demands is feasible.

To compare surface water alternatives with the ground water alternative, the most feasible surface water sources were selected. The selections were based on location, availability of water supply, and designated uses as discussed in Section 6.0.

Table 8-1 summarizes the construction cost and the operation and maintenance cost for each alternative, and Tables 8-2 through 8-9 show a comparative unit cost of water. The ground-water alternative is shown to be approximately 50 percent of the construction cost and operation and maintenance cost of any of the surface water alternatives.

Because wells can be constructed to meet the demands of the primary study area without a significant impact to the Simsboro Aquifer and because the cost for construction and operation and maintenance is approximately 50 percent of any surface water source, we recommend that the ground-water alternative be used to meet the demands through the year 2020. In addition, as shown in Section 8.1, water supply from a regional facility for the secondary study area is not considered feasible and is not recommended.

8.3 UNIT COST OF TREATED WATER

A key aspect in the evaluation of regional water system alternatives is the comparison of the estimated unit costs of treated water. The final cost of treated water is dependent upon many factors, including, but not limited to, the construction costs, the annual operations and maintenance (O & M) expenditures, the terms of project financing, and the mechanisms by which revenues would be collected.

Each alternative has been evaluated under both a "with" and "without" water conservation scenario. The construction costs and estimated annual O & M costs have been previously described in Section 7.0 and further summarized in Table 8-1. For the purposes of this comparison, the capital construction costs have been assumed to be financed from revenue bonds, a conventional long-term financing method. All alternatives have assumed equal annual debt service payments according to a fixed interest rate (8.5%) and a 20-year bond life. The bond issues have been assumed to correspond with the two construction phases (2000 and 2010) and sized to account for fiscal, legal, and bond counsel expenses, as well as reserve fund requirements.

O & M costs have been estimated for the project, beginning in 2000 and continuing through the defined planning horizon at 2020. Both the annual debt service on capital expenditures and the annual O & M costs have been summed to comprise an estimated annual cost of service for a regional system. These annual costs have been divided by the projected annual water usage in the milestone years to determine the unit cost of water. A unit of 1000 gallons has been selected for the purposes of comparison. Upon completion of construction phases in 2000 and 2010, the corresponding water usages in those years would be the lowest for that phase's capacity and thus reflect a highest unit cost for that phase. In subsequent years as water usages increase, the unit costs would decrease.

Tables 8-2 through 8-9 present the financing and cost of service summaries for the four regional water supply alternatives under both "with" and "without" water conservation scenarios. It should be noted that all of the figures in these tables are presented in uninflated and undiscounted 1990 dollars, and do not include an evaluation or estimation of system

TABLE 8 - 2
ALTERNATIVE 1 - SIMSBORO GROUND-WATER
WITHOUT CONSERVATION

ITEM	1990	2000	2010	2020
CONSTRUCTION COSTS				
WELL FIELD	-	$7,536,000	$1,884,000	-
WELL FIELD TRANSMISSION MAIN	-	$2,400,000	$315,000	-
COOLING TOWERS & CHLORINATION	-	$993,000	$284,000	-
CLEARWELL	-	$1,288,000	$448,000	-
BOOSTER PUMP STATION	-	$1,727,200	$268,800	-
TREATED WATER TRANSMISSION	-	$6,400,000	-	-
LANDS AND RIGHT-OF-WAY	-	$335,000	$60,000	-
CONSTRUCTION COST SUBTOTAL	$0	$20,679,200	$3,259,800	$0
ENGINEERING AND CONTINGENCY	$0	$4,135,800	$652,000	$0
TOTAL CONSTRUCTION COST	$0	$24,815,000	$3,911,800	$0
FISCAL	$0	$287,700	$45,900	$0
LEGAL	$0	$575,400	$91,700	$0
RESERVE FUND	$0	$3,040,200	$484,500	$0
COST OF BOND ISSUANCE	$0	$51,700	$51,100	$0
BOND ISSUE REQUIREMENTS	$0	$28,770,000	$4,585,000	$0
ANNUAL DEBT SERVICE	$0	$3,040,200	$484,500	$0
CUMULATIVE DEBT SERVICE	$0	$3,040,200	$3,524,700	$484,500
OPERATIONS & MAINTENANCE				
SALARY & WAGES	-	$91,000	$91,000	$91,000
SUPPLIES & SERVICE	-	$839,700	$1,475,200	$1,475,200
MAINTENANCE & REPAIR	-	$40,500	$16,200	$16,200
ADMINISTRATION	-	$27,200	$23,600	$23,600
O & M SUBTOTAL	$0	$998,400	$1,606,000	$1,606,000
ANNUAL DEBT SERVICE	$0	$3,040,200	$3,524,700	$484,500
TIMES COVERAGE REQUIREMENT	$0	$760,100	$881,200	$121,100
ANNUAL O & M COSTS	$0	$998,400	$1,606,000	$1,606,000
TOTAL ANNUAL COSTS	$0	$4,798,700	$6,011,900	$2,211,600
AVERAGE DAY WATER DEMAND (mgd)	0.0	5.5	12.7	18.9
ANNUAL WATER DEMAND (mg)	0.0	2,007.5	4,635.5	6,898.5
PRICE PER 1000 GALS	NA	$2.39	$1.30	$0.32

NOTES:

Engineering and Contingency estimated at 20% of construction cost subtotal.
Fiscal estimated at 1% of bond issue; Legal estimated at 2% of bond issue.
Reserve fund consists of one year's debt service.
Debt service based on equal annual payments over 20 years at 8.5% interest.
Times coverage assumed at 25% of debt service.
All figures are in 1990 dollars.

TABLE 8 - 3
ALTERNATIVE 1 - SIMSBORO GROUND-WATER
WITH CONSERVATION

ITEM	1990	2000	2010	2020
CONSTRUCTION COSTS				
WELL FIELD	-	$6,123,000	$1,413,000	-
WELL FIELD TRANSMISSION MAIN	-	$1,700,000	$200,000	-
COOLING TOWERS & CHLORINATION	-	$813,000	$224,000	-
CLEARWELL	-	$840,000	$336,000	-
BOOSTER PUMP STATION	-	$1,403,400	$187,400	-
TREATED WATER TRANSMISSION	-	$5,528,000	-	-
LANDS AND RIGHT-OF-WAY	-	$285,000	$50,000	-
CONSTRUCTION COST SUBTOTAL	$0	$16,692,400	$2,410,400	$0
ENGINEERING AND CONTINGENCY	$0	$3,338,500	$482,100	$0
TOTAL CONSTRUCTION COST	$0	$20,030,900	$2,892,500	$0
FISCAL	$0	$232,400	$34,100	$0
LEGAL	$0	$464,700	$68,100	$0
RESERVE FUND	$0	$2,455,300	$359,800	$0
COST OF BOND ISSUANCE	$0	$51,700	$50,500	$0
BOND ISSUE REQUIREMENTS	$0	$23,235,000	$3,405,000	$0
ANNUAL DEBT SERVICE	$0	$2,455,300	$359,800	$0
CUMULATIVE DEBT SERVICE	$0	$2,455,300	$2,815,100	$359,800
OPERATIONS & MAINTENANCE				
SALARY & WAGES	-	$91,000	$91,000	$91,000
SUPPLIES & SERVICE	-	$468,900	$851,700	$851,700
MAINTENANCE & REPAIR	-	$32,700	$12,500	$12,500
ADMINISTRATION	-	$26,100	$23,000	$23,000
O & M SUBTOTAL	$0	$618,700	$978,200	$978,200
ANNUAL DEBT SERVICE	$0	$2,455,300	$2,815,100	$359,800
TIMES COVERAGE REQUIREMENT	$0	$613,800	$703,800	$90,000
ANNUAL O & M COSTS	$0	$618,700	$978,200	$978,200
TOTAL ANNUAL COSTS	$0	$3,687,800	$4,497,100	$1,428,000
AVERAGE DAY WATER DEMAND (mgd)	0.0	2.8	7.3	11.5
ANNUAL WATER DEMAND (mg)	0.0	1,033.0	2,664.5	4,212.1
PRICE PER 1000 GALS	NA	$3.57	$1.69	$0.34

NOTES:
Engineering and Contingency estimated at 20% of construction cost subtotal.
Fiscal estimated at 1% of bond issue; Legal estimated at 2% of bond issue.
Reserve fund consists of one year's debt service.
Debt service based on equal annual payments over 20 years at 8.5% interest.
Times coverage assumed at 25% of debt service.
All figures are in 1990 dollars.

TABLE 8 - 4
ALTERNATIVE 2 - LAKE SOMERVILLE
WITHOUT CONSERVATION

ITEM	1990	2000	2010	2020
CONSTRUCTION COSTS				
RAW WATER INTAKE	-	$2,856,100	$268,800	-
RAW WATER TRANSMISSION MAIN	-	$9,292,800	-	-
WATER TREATMENT PLANT	-	$35,000,000	$5,000,000	-
CLEARWELL	-	$1,288,000	$448,000	-
BOOSTER PUMP STATION	-	$1,656,100	$268,800	-
TREATED WATER TRANSMISSION	-	$1,460,600	-	-
LANDS AND RIGHT-OF-WAY	-	$270,000	-	-
CONSTRUCTION COST SUBTOTAL	$0	$51,823,600	$5,985,600	$0
ENGINEERING AND CONTINGENCY	$0	$10,364,700	$1,197,100	$0
TOTAL CONSTRUCTION COST	$0	$62,188,300	$7,182,700	$0
FISCAL	$0	$720,100	$83,700	$0
LEGAL	$0	$1,440,200	$167,400	$0
RESERVE FUND	$0	$7,609,400	$884,500	$0
COST OF BOND ISSUANCE	$0	$52,000	$51,700	$0
BOND ISSUE REQUIREMENTS	$0	$72,010,000	$8,370,000	$0
ANNUAL DEBT SERVICE	$0	$7,609,400	$884,500	$0
CUMULATIVE DEBT SERVICE	$0	$7,609,400	$8,493,900	$884,500
OPERATIONS & MAINTENANCE				
SALARY & WAGES	-	$130,000	$130,000	$130,000
SUPPLIES & SERVICE	-	$333,700	$536,600	$536,600
MAINTENANCE & REPAIR	-	$80,800	$92,900	$92,900
ADMINISTRATION	-	$48,100	$51,400	$51,400
RAW WATER PURCHASE	-	$1,205,600	$1,800,800	$1,800,800
O & M SUBTOTAL	$0	$1,798,200	$2,611,700	$2,611,700
ANNUAL DEBT SERVICE	$0	$7,609,400	$8,493,900	$884,500
TIMES COVERAGE REQUIREMENT	$0	$1,902,400	$2,123,500	$221,100
ANNUAL O & M COSTS	$0	$1,798,200	$2,611,700	$2,611,700
TOTAL ANNUAL COSTS	$0	$11,310,000	$13,229,100	$3,717,300
AVERAGE DAY WATER DEMAND (mgd)	0.0	5.5	12.7	18.9
ANNUAL WATER DEMAND (mg)	0.0	2,007.5	4,635.5	6,898.5
PRICE PER 1000 GALS	NA	$5.63	$2.85	$0.54

NOTES:
Engineering and Contingency estimated at 20% of construction cost subtotal.
Fiscal estimated at 1% of bond issue; Legal estimated at 2% of bond issue.
Reserve fund consists of one year's debt service.
Debt service based on equal annual payments over 20 years at 8.5% interest.
Times coverage assumed at 25% of debt service.
All figures are in 1990 dollars.

TABLE 8 - 6
ALTERNATIVE 3 - BRAZOS RIVER
WITHOUT CONSERVATION

ITEM	1990	2000	2010	2020
CONSTRUCTION COSTS				
RAW WATER INTAKE	-	$1,896,100	$268,800	-
RAW WATER TRANSMISSION MAIN	-	$1,900,800	-	-
WATER TREATMENT PLANT	-	$35,000,000	$5,000,000	-
CLEARWELL	-	$1,288,000	$448,000	-
BOOSTER PUMP STATION	-	$1,656,100	$268,800	-
REVERSE OSMOSIS TREATMENT	-	$7,750,000	$2,100,000	-
TREATED WATER TRANSMISSION	-	$1,460,600	-	-
LANDS AND RIGHT-OF-WAY	-	$240,000	-	-
CONSTRUCTION COST SUBTOTAL	$0	$51,191,600	$8,085,600	$0
ENGINEERING AND CONTINGENCY	$0	$10,238,300	$1,617,100	$0
TOTAL CONSTRUCTION COST	$0	$61,429,900	$9,702,700	$0
FISCAL	$0	$711,300	$112,900	$0
LEGAL	$0	$1,422,600	$225,700	$0
RESERVE FUND	$0	$7,516,400	$1,192,500	$0
COST OF BOND ISSUANCE	$0	$49,800	$51,200	$0
BOND ISSUE REQUIREMENTS	$0	$71,130,000	$11,285,000	$0
ANNUAL DEBT SERVICE	$0	$7,516,400	$1,192,500	$0
CUMULATIVE DEBT SERVICE	$0	$7,516,400	$8,708,900	$1,192,500
OPERATIONS & MAINTENANCE				
SALARY & WAGES	-	$130,000	$130,000	$130,000
SUPPLIES & SERVICE	-	$851,400	$634,600	$634,600
MAINTENANCE & REPAIR	-	$75,400	$87,100	$87,100
ADMINISTRATION	-	$47,300	$50,600	$50,600
RAW WATER PURCHASE	-	$1,205,600	$1,800,800	$1,800,800
O & M SUBTOTAL	$0	$2,309,700	$2,703,100	$2,703,100
ANNUAL DEBT SERVICE	$0	$7,516,400	$8,708,900	$1,192,500
TIMES COVERAGE REQUIREMENT	$0	$1,879,100	$2,177,200	$298,100
ANNUAL O & M COSTS	$0	$2,309,700	$2,703,100	$2,703,100
TOTAL ANNUAL COSTS	$0	$11,705,200	$13,589,200	$4,193,700
AVERAGE DAY WATER DEMAND (mgd)	0.0	5.5	12.7	18.9
ANNUAL WATER DEMAND (mg)	0.0	2,007.5	4,635.5	6,898.5
PRICE PER 1000 GALS	NA	$5.83	$2.93	$0.61

NOTES:

Engineering and Contingency estimated at 20% of construction cost subtotal.
Fiscal estimated at 1% of bond issue; Legal estimated at 2% of bond issue.
Reserve fund consists of one year's debt service.
Debt service based on equal annual payments over 20 years at 8.5% interest.
Times coverage assumed at 25% of debt service.
All figures are in 1990 dollars.

TABLE 8 - 7
ALTERNATIVE 3 - BRAZOS RIVER
WITH CONSERVATION

ITEM	1990	2000	2010	2020
CONSTRUCTION COSTS				
RAW WATER INTAKE	-	$1,554,500	$187,400	-
RAW WATER TRANSMISSION MAIN	-	$1,663,200	-	-
WATER TREATMENT PLANT	-	$26,600,000	$4,000,000	-
CLEARWELL	-	$840,000	$336,000	-
BOOSTER PUMP STATION	-	$1,314,500	$187,400	-
REVERSE OSMOSIS TREATMENT	-	$6,150,000	$1,460,000	-
TREATED WATER TRANSMISSION	-	$1,313,000	-	-
LANDS AND RIGHT-OF-WAY	-	$190,000	-	-
CONSTRUCTION COST SUBTOTAL	$0	$39,625,200	$6,170,800	$0
ENGINEERING AND CONTINGENCY	$0	$7,925,000	$1,234,200	$0
TOTAL CONSTRUCTION COST	$0	$47,550,200	$7,405,000	$0
FISCAL	$0	$550,800	$86,300	$0
LEGAL	$0	$1,101,500	$172,500	$0
RESERVE FUND	$0	$5,819,800	$911,400	$0
COST OF BOND ISSUANCE	$0	$52,700	$49,800	$0
BOND ISSUE REQUIREMENTS	$0	$55,075,000	$8,625,000	$0
ANNUAL DEBT SERVICE	$0	$5,819,800	$911,400	$0
CUMULATIVE DEBT SERVICE	$0	$5,819,800	$6,731,200	$911,400
OPERATIONS & MAINTENANCE				
SALARY & WAGES	-	$130,000	$130,000	$130,000
SUPPLIES & SERVICE	-	$650,900	$445,900	$445,900
MAINTENANCE & REPAIR	-	$57,100	$66,800	$66,800
ADMINISTRATION	-	$44,600	$47,500	$47,500
RAW WATER PURCHASE	-	$695,200	$1,099,000	$1,099,000
O & M SUBTOTAL	$0	$1,577,800	$1,789,200	$1,789,200
ANNUAL DEBT SERVICE	$0	$5,819,800	$6,731,200	$911,400
TIMES COVERAGE REQUIREMENT	$0	$1,455,000	$1,682,800	$227,900
ANNUAL O & M COSTS	$0	$1,577,800	$1,789,200	$1,789,200
TOTAL ANNUAL COSTS	$0	$8,852,600	$10,203,200	$2,928,500
AVERAGE DAY WATER DEMAND (mgd)	0.0	2.8	7.3	11.5
ANNUAL WATER DEMAND	0.0	1,033.0	2,664.5	4,212.1
PRICE PER 1000 GALS	NA	$8.57	$3.83	$0.70

NOTES:
Engineering and Contingency estimated at 20% of construction cost subtotal.
Fiscal estimated at 1% of bond issue; Legal estimated at 2% of bond issue.
Reserve fund consists of one year's debt service.
Debt service based on equal annual payments over 20 years at 8.5% interest.
Times coverage assumed at 25% of debt service.
All figures are in 1990 dollars.

TABLE 8 - 8
ALTERNATIVE 4 - MILLICAN LAKE
WITHOUT CONSERVATION

ITEM	1990	2000	2010	2020
CONSTRUCTION COSTS				
RAW WATER INTAKE	-	$2,856,100	$268,800	
RAW WATER TRANSMISSION MAIN	-	$2,259,800	-	
WATER TREATMENT PLANT	-	$35,000,000	$5,000,000	
CLEARWELL	-	$1,288,000	$448,000	
BOOSTER PUMP STATION	-	$1,656,100	$268,800	
POTABLE WATER TRANSMISSION	-	$3,347,600	-	
LANDS AND RIGHT-OF-WAY	-	$250,000	-	
CONSTRUCTION COST SUBTOTAL	$0	$46,657,600	$5,985,600	$0
ENGINEERING AND CONTINGENCY	$0	$9,331,500	$1,197,100	$0
TOTAL CONSTRUCTION COST	$0	$55,989,100	$7,182,700	$0
FISCAL	$0	$648,400	$83,700	$0
LEGAL	$0	$1,296,700	$167,400	$0
RESERVE FUND	$0	$6,851,200	$884,500	$0
COST OF BOND ISSUANCE	$0	$49,600	$51,700	$0
BOND ISSUE REQUIREMENTS	$0	$64,835,000	$8,370,000	$0
ANNUAL DEBT SERVICE	$0	$6,851,200	$884,500	$0
CUMULATIVE DEBT SERVICE	$0	$6,851,200	$7,735,700	$884,500
OPERATIONS & MAINTENANCE				
SALARY & WAGES	-	$130,000	$130,000	$130,000
SUPPLIES & SERVICE	-	$372,500	$562,500	$562,500
MAINTENANCE & REPAIR	-	$77,200	$89,500	$89,500
ADMINISTRATION	-	$47,600	$50,900	$50,900
RAW WATER PURCHASE	-	$1,205,600	$1,800,800	$1,800,800
O & M SUBTOTAL	$0	$1,832,900	$2,633,700	$2,633,700
ANNUAL DEBT SERVICE	$0	$6,851,200	$7,735,700	$884,500
TIMES COVERAGE REQUIREMENT	$0	$1,712,800	$1,933,900	$221,100
ANNUAL O & M COSTS	$0	$1,832,900	$2,633,700	$2,633,700
TOTAL ANNUAL COSTS	$0	$10,396,900	$12,303,300	$3,739,300
AVERAGE DAY WATER DEMAND (mgd)	0.0	5.5	12.7	18.9
ANNUAL WATER DEMAND (mg)	0.0	2,007.5	4,635.5	6,898.5
PRICE PER 1000 GALS	NA	$5.18	$2.65	$0.54

NOTES:
Engineering and Contingency estimated at 20% of construction cost subtotal.
Fiscal estimated at 1% of bond issue; Legal estimated at 2% of bond issue.
Reserve fund consists of one year's debt service.
Debt service based on equal annual payments over 20 years at 8.5% interest.
Times coverage assumed at 25% of debt service.
All figures are in 1990 dollars.

TABLE 8 - 9
ALTERNATIVE 4 - MILLICAN LAKE
WITH CONSERVATION

ITEM	1990	2000	2010	2020
CONSTRUCTION COSTS				
RAW WATER INTAKE	-	$2,514,500	$187,400	
RAW WATER TRANSMISSION MAIN	-	$1,977,400	-	
WATER TREATMENT PLANT	-	$26,600,000	$4,000,000	
CLEARWELL	-	$840,000	$336,000	
BOOSTER PUMP STATION	-	$1,314,500	$187,400	
TREATED WATER TRANSMISSION	-	$2,742,800	-	
LANDS AND RIGHT-OF-WAY	-	$200,000	-	
CONSTRUCTION COST SUBTOTAL	$0	$36,189,200	$4,710,800	$0
ENGINEERING AND CONTINGENCY	$0	$7,237,800	$942,200	$0
TOTAL CONSTRUCTION COST	$0	$43,427,000	$5,653,000	$0
FISCAL	$0	$503,100	$66,000	$0
LEGAL	$0	$1,006,100	$132,000	$0
RESERVE FUND	$0	$5,315,800	$697,400	$0
COST OF BOND ISSUANCE	$0	$53,000	$51,600	$0
BOND ISSUE REQUIREMENTS	$0	$50,305,000	$6,600,000	$0
ANNUAL DEBT SERVICE	$0	$5,315,800	$697,400	$0
CUMULATIVE DEBT SERVICE	$0	$5,315,800	$6,013,200	$697,400
OPERATIONS & MAINTENANCE				
SALARY & WAGES	-	$130,000	$130,000	$130,000
SUPPLIES & SERVICE	-	$257,700	$384,400	$384,400
MAINTENANCE & REPAIR	-	$58,500	$67,900	$67,900
ADMINISTRATION	-	$44,800	$47,700	$47,700
RAW WATER PURCHASE	-	$695,200	$1,099,000	$1,099,000
O & M SUBTOTAL	$0	$1,186,200	$1,729,000	$1,729,000
ANNUAL DEBT SERVICE	$0	$5,315,800	$6,013,200	$697,400
TIMES COVERAGE REQUIREMENT	$0	$1,329,000	$1,503,300	$174,400
ANNUAL O & M COSTS	$0	$1,186,200	$1,729,000	$1,729,000
TOTAL ANNUAL COSTS	$0	$7,831,000	$9,245,500	$2,600,800
AVERAGE DAY WATER DEMAND (mgd)	0.0	2.8	7.3	11.5
ANNUAL WATER DEMAND (mg)	0.0	1,033.0	2,664.5	4,212.1
PRICE PER 1000 GALS	NA	$7.58	$3.47	$0.62

NOTES:

Engineering and Contingency estimated at 20% of construction cost subtotal.
Fiscal estimated at 1% of bond issue; Legal estimated at 2% of bond issue.
Reserve fund consists of one year's debt service.
Debt service based on equal annual payments over 20 years at 8.5% interest.
Times coverage assumed at 25% of debt service.
All figures are in 1990 dollars.

improvements beyond 2020. Additionally, the unit prices presented in these tables are assumed to approximate the wholesale price to regional customers.

Table 8-2 summarizes Alternative 1, the use of ground-water from the Simsboro aquifer. As modelled, this alternative has the lowest unit cost ($2.39 per 1000 gals in 2000) of all the alternatives under consideration, including the conservation scenario presented in Table 8-3. In the later milestone years of 2010 and 2020 the unit costs are seen to decrease, providing some indication that the regional water demand is more closely reaching the design capacity of the system. In addition, decreasing unit costs can also be attributed to the up-front construction of certain facilities (e.g., treated water transmission) that would be sized to meet the ultimate system capacity. With inflation, the actual unit cost would likely increase over time.

Table 8-3 summarizes the ground-water alternative under a water conservation scenario. This evaluation indicates a higher unit cost ($3.57 per 100 gals in 2000), reflecting a diminution in the economy of scale under the without conservation scenario in Table 8-2. However, because of the reduction in water demands there is a corresponding reduction in the overall cost of construction, equating to a savings to the customers water bill.

For the surface water alternatives, Alternative 2, obtaining surface water from Lake Somerville, has a significantly higher unit cost than the ground-water alternatives previously discussed. The estimated unit cost to wholesale customers in 2000 ($5.63 per 1000 gals) would be over twice that estimated under the ground-water. Under the conservation scenario (see Table 8-5), the unit cost of delivering treated water to the customer cites from Lake Somerville via a regional system would be an estimated $8.41 per 1000 gallons in 2000. This cost would be over 135% higher than the comparable ground-water option presented in Table 8-3.

Similarly, the development of the Brazos River as a regional water supply source would be a potentially feasible alternative, but at a much higher unit cost than ground-water. Initially, in 2000, the unit cost would be an estimated $5.83 per 1000 gallons under a without conservation scenario (see Table 8-6). This unit cost represents a 144% higher cost than that projected for the comparable without conservation ground-water alternative. A similar magnitude is projected in the later milestone years of 2010 and 2020, in spite of decreasing unit costs.

Under a water conservation scenario, the Brazos River would have a much higher initial unit cost of $8.57 per 1000 gallons in 2000 (see Table 8-7) than that projected under the without conservation scenario. Unit costs are significantly higher than the comparable ground-water alternative discussed previously.

Finally, the proposed Millican Lake alternative also represents a potentially feasible surface water supply option, although at an initial unit cost in 2000 ($5.18 per 1,000 gals) that has been estimated to be 116% higher than of the comparable ground-water alternative. Table 8-8 provides a summary of the unit costs for this proposed surface water alternative. As with the other alternatives, the unit cost of treated water has been projected to drop as water demands approach the design capacity of the regional system.

Table 8-9 presents the proposed Millican Lake surface water alternative under a conservation scenario. As with the other alternatives, the unit cost of treated water is significantly higher ($7.58 per 1,000 gals in 2000) than the without conservation scenario under the same alternative, thus reflecting, in part, a diminished economy of scale.

9.0 INSTITUTIONAL ORGANIZATION AND FINANCING

9.1 OVERVIEW

In order to establish a regional water system that operates efficiently and economically, and provides quality service, it is necessary to select an institutional structure that can effectively represent the interests of the whole region. Each institutional structure brings certain authorities (and restrictions) that pertain to the administration, operation, and financing of a regional system, and, therefore, must be selected only after a thorough and careful evaluation.

The following sections of this report contain an evaluation of several institutional arrangements that could be potentially used in Brazos County. This evaluation provides a general overview of these institutional structures and is not intended to serve as an exhaustive analysis of the many legal, financial, administrative, and political elements that must be considered before selecting a final alternative.

The institutional structures that have been evaluated are:

- Regional System Operated by a Major City or Cities;
- Regional System Operated by the Brazos River Authority;
- Newly-created Water District;
- Newly-created Regional Water Authority.

The preceding list does not include all possible institutions potentially available in Texas, such as non-profit water supply corporations or private investor-owned utilities. However, given the limitations of such entities when viewed in a regional context, only those institutional structures considered politically, economically, and administratively feasible have been evaluated.

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9.2 REVIEW OF INSTITUTIONAL STRUCTURES

9.2.1 Regional System Operated by a Major City or Cities

The cities of Bryan and College Station offer some potential, either individually or collectively, to serve as a sponsor and operator of a regional water system for Brazos County. Generally, this would be accomplished through means currently available to the cities and would not require any significant legislative action. Under this scenario, one or both of the cities would construct and operate a regional water system that would supply wholesale service to other customers and entities in the regional area.

9.2.1.1 Administration

As with most publicly-owned municipal water systems, much of the final authority and responsibility for administration would lie with the Director of Public Works, and, by extension, the City Manager and elected council members of the sponsoring city.

In the case of a regional system jointly operated by the cities of Bryan and College Station, for example, the administration, financing, and operation of facilities would likely be accomplished through a framework built on inter-local agreements.

9.2.1.2 Powers

A city has the power to contract for water sale with neighboring entities, as in the way the cities of Bryan and College Station currently provide treated water on a wholesale basis to the small water supply corporations in outlying areas. With a regional system, the sponsoring city or cities would be required to employ similar contractual arrangements with its wholesale customers, although perhaps stipulating a greater degree of long-term assurance of participation n may now be the case.

The review and adoption of a water rate structure and related fees and charges would typically be the sole responsibility of the sponsoring city. It would be recommended that all such rates, fees, and/or charges be clearly based on the cost of service in order to minimize disputes over the calculation methodology. In the event of a rate challenge, the Texas Water Commission would generally have appellate jurisdiction. In addition, a city-sponsored regional system would retain powers to condemn land inside and outside the defined corporate limits for project-related facilities.

The powers to finance regional improvements would generally be limited to those currently afforded municipal governments, subject to certain restrictions. For example, a city-sponsored regional system would be able to meet bond-related debt service payments from rate collections and up-front cash contributions, but would not be able to pledge or collect ad valorem taxes outside of its corporate limits.

9.2.1.3 Accountability

The relationship between a city-sponsored regional system and its participants would effectively be no different than that which now exists between major cities and their wholesale customer cities or agencies. Negotiation of inter-local agreements among regional participants may provide additional assurance to the sponsoring city of minimal financial participation, as in the case of "take-or-pay" contracts. For the customer cities, these same inter-local agreements may provide opportunities for oversight and representation in the rate-setting process, as well as establishing minimal levels of service.

There would be no significant changes expected in the functional relationship between a city-sponsored regional system and the State and Federal governments.

9.2.2 Regional System Operated by the Brazos River Authority

The BRA offers some potential for operation of a regional water supply system to supplement the future water demands of Brazos County. Brazos County is located entirely within the Brazos River Basin and BRA would, therefore, be the logical choice among existing river authorities. The enabling legislation that led to the creation of the BRA permits the development of treatment and transmission facilities to serve municipalities.

As with all of the BRA's operating projects, any regional facilities would be owned and operated by the BRA, although their use would be pledged to benefit the contracting parties. Distribution systems for retail sales and localized needs would be maintained by the existing municipalities or owners of quasi-public or private water supply systems.

9.2.2.1 Administration

If the BRA were established as the regional water authority, an Advisory Committee would likely be established to provide for representation by the participating entities. An Advisory Committee would be expected to create and implement certain procedures and by-laws for operation of a regional system. The purpose of the Advisory Committee would be to:

- consult with and advise the BRA on all matters pertaining to operation, maintenance and administration of a regional system;
- review and recommend approval of annual budgets;
- review and recommend capital expenditures when system needs are identified;
- assist in providing a framework for the negotiation of contracts among participating entities and the BRA.

In conjunction with the Advisory Committee, BRA would plan, design, construct, operate, maintain and manage a regional system in accordance with the terms of a regional contract.

9.2.2.2 Powers

The BRA would contract with participating entities to provide wholesale water service. Rates would be established and collected according to a cost-of-service basis. The BRA would maintain current powers of eminant domain within its territorial boundaries, which include all of Brazos County. BRA has no powers of taxation, therefore, all revenue would be derived from rate collections and/or participant contributions as negotiated under contracts between the BRA and its wholesale customers.

9.2.2.3 Accountability

The functional relationship between the BRA and its participating entities would likely be through the Advisory Committee. The Advisory Committee would share responsibility to review and approve all matters pertaining to annual operating budgets, needed capital improvements, and system policies. The size and structure of an Advisory Committee would be a function of the level of participation by entities within Brazos County.

9.2.3 <u>Newly-created Water District</u>

The Texas Water Code allows for the creation of water districts to construct, operate, and manage systems for public water supply. The most common forms of water districts in Texas consist of Water Control and Improvement Districts (WCIDs) and Municipal Utility Districts (MUDs), created under Chapters 51 and 54, respectively, of the Texas Water Code.

WCIDs and MUDs are political subdivisions of the State of Texas, and, therefore, typically have certain powers of bonding and taxation that are set forth at the time of creation. Although water districts may be created by the Texas Water Commission and under certain conditions by a county commissioners court, most regional water districts are created by an act of the State Legislature. In virtually all cases, the creation of water districts is subject to confirmation elections by resident voters within the proposed boundaries of the district.

9.2.3.1 Administration

The administration of a water district is typically carried out by an elected board, usually consisting of five resident members. The District Board oversees the operations staff and makes policy decisions, although subject to certain limitations. For example, the issuance of district bonds is normally subject to approval by district residents.

Water districts may under certain conditions provide service outside of their defined service area. The out-of-district customers, however, are not typically eligible to participate in the administration of the district, although certain contract terms could possibly ensure some role.

9.2.3.2 Powers

Water districts, as political subdivisions of the state, typically have certain powers that ensure viability of the system. These powers include the ability to negotiate contracts with out-of-district parties, as well as to collect revenues for capital expenditures and O & M costs through rates, fees, and charges, and to levy ad valorem taxes. As with most rate-setting, the method should be based on actual cost of service in order to minimize the likelihood of rate challenges or litigation.

9.2.3.3 Accountability

Because water districts are generally governed by elected board members, the primary accountability for operation of the system is to resident voters. To the extent stipulated by the terms of contracts negotiated with out-of-district customers, the district would also be accountable to this constituency.

9.2.4 Newly-created Water Authority

A final institutional option that has been used for other regional systems around the state would involve the creation of a regional water authority. A regional water authority would have to be created by a special act of the Texas Legislature for the express purpose of supplementing the water supply of participating entities within Brazos County. The creation of such an authority would be defined by the participants, in accordance with state laws, including the Texas Water Code. Generally, an authority of this type would act in the capacity of a wholesaler of treated water to participating entities.

9.2.4.1 Administration

A newly-created water authority would likely be governed by a Board of Directors, with each participating entity appointing one local member. The Board would elect from among themselves a President, Vice-President, Secretary and Treasurer. The Board would also be responsible for the hiring of a General Manager of the Authority. Once constructed, the General Manager would generally assume responsibility and authority for the operation, maintenance and management of the regional system.

9.2.4.2 Powers

A newly-created authority would have the power to contract with either public or private entities. The power of eminent domain could also be provided by the enabling legislation.

The agency would typically be organized as a non-profit agency, thereby setting rates according to an actual cost-of-service basis. The authority would stipulate to the member entities the conditions of service for wholesale water supply. The agency would have the ability to issue long-term or short-term debt and be eligible for financial assistance from the State or Federal government. Water authorities are not typically granted ad valorem taxing powers, thereby limiting the generation of revenue to largely rate- and fee-based mechanisms.

9.2.4.3 Accountability

A water authority would be first accountable to its participating members, although still subject to the terms of contracts negotiated with outside parties. Participation in a regional water authority would not be limited to only municipal government, but would also be potentially open to quasi-public and private entities, such as Texas A & M University and water supply corporations. The extent of the authority's accountability to participating members would be defined within the enabling legislation.

9.3 ALTERNATIVE FINANCING METHODS

The construction of major capital improvements requires that a long-term financing strategy be developed by the project sponsor. In the case of a regional system for Brazos County, the financing mechanisms that would be available would depend upon the institutional organization that would construct, operate, maintain, and manage the system. The following sections evaluate the most prevalent long-term methods for financing major capital improvement projects.

9.3.1 Conventional Long-Term Financing Methods

The most prevalent method of providing long-term financing for major projects is through the issuance of bonds, many of which provide tax-exempt returns to the bond purchaser. Generally, the two most common bonds issued by political subdivisions are (1) general obligation bonds and (2) revenue bonds.

9.3.1.1 General Obligation Bonds

General obligation (GO) bonds are generally the strongest pledge of security available to an issuing institution at the lowest effective interest cost. GO bonds are backed by the full faith and credit of the issuing entity, typically relying on tax collections to retire the debt obligation. The administration of these bonds is relatively simple and, therefore, bonds are able to be issued at a lower cost when compared with other types of bonds.

A primary disadvantage of GO bonds is that voter approval prior to issuance is typically required. This process is likely to take a relatively long period of time, which could have adverse impacts on project scheduling and construction. Regional systems throughout the State of Texas do not generally rely upon GO bonds for water utility project financing.

9.3.1.2 Revenue Bonds

The issuance of revenue bonds constitutes a second long-term financing mechanism for a regional water utility system. Revenue bond debt is generally retired from revenues collected from operations of the financed capital improvements. A primary advantage of revenue bonds is that the general obligation bond debt limitations are not impacted by issuance of these bonds, thus leaving the GO bonds available for other uses.

A primary disadvantage of revenue bonds is that the costs of issuance are typically higher due to the complexities of the financing method. Another disadvantage of revenue bonds is that the interest rates are generally higher than GO bonds, since debt retirement cannot be secured from tax collections.

9.3.2 Water Development Board Funds

Another financing alternative would be to obtain financing from the TWDB through the Water Development Fund (WDF), which can finance certain water supply projects, and which offers extremely competitive interest rates. The WDF is funded by the sale of State of Texas general obligation bonds. The bond proceeds are then used to purchase bond issues from political subdivisions and non-profit water supply corporations for water projects. As the political subdivision bonds are repaid to the TWDB, the general obligation bonds used to fund the program are repaid by the State. The program is currently self-supporting.

10.0 PROJECT IMPLEMENTATION AND SCHEDULE

10.1 RECOMMENDED PLAN

Based on a comparative evaluation of the four sources of water supply for Brazos County, the recommended alternative would be to continue the use of existing ground-water resources, particularly the Simsboro aquifer. As discussed in detail in Section 5.0, this alternative has been estimated to sustain a yield sufficient to meet the future water needs of Brazos County. The following sections provide a recommended implementation plan for meeting the future water needs through a regional water supply system.

10.2 RECOMMENDED PLAN IMPLEMENTATION PHASES

The construction of a regional water supply system should typically occur in phases in order to optimize the relationship between capital expenditures and the participants' ability to pay. Failure to adequately relate the facility design capacity with the timing of future demands may result in an overbuilt and overcapitalized system, leading to high unit costs and long-term underutilization of facilities. Conversely, undersizing of regional facilities may provide lower initial costs, but diminish the quality and level of service available to system customers.

The use of existing facilities should be relied upon to the greatest possible extent in developing the implementation plan for a regional system. Reliance on existing facilities provides some flexibility in the scheduling and sizing of potential regional improvements. For example, the useful life of some existing ground-water wells that would normally be phased out over the next decade could potentially be extended to match the phased construction of a regional system.

For the purposes of this regional master plan, construction has been assumed to occur in two phases, beginning in 2000. The second phase has been scheduled for 2010. Table 10-1 presents a preliminary schedule and description of the facilities that would be constructed in the first and second phases of a regional water supply system. It should be noted that this schedule and inventory of facilities is based on full participation within Brazos County, and, therefore,

TABLE 10-1

PRELIMINARY SCHEDULE
FOR THE REQUIRED FACILITY EXPANSIONS
(ALTERNATE NO. 1)

Description	Unit	Regional Expansion Capacity I (2000)	Ic	II (2010)	IIc
Well Capacity	mgd	48.38	39.31	12.10	9.07
Well Field Transmission Main	mgd	60.48	48.38	--	--
Cooling Towers	mgd	46.39	36.82	12.55	8.75
Clearwell Storage Tanks	gals	2,300,000	1,500,000	800,000	600,000
Booster Pump Station	mgd	46.39	36.82	12.55	8.75
Treated Water Transmission Main	mgd	46.39	36.82	--	--

would be subject to change in the event of decreased levels of participation, shifts in water demand, and/or modifications to the capacity of existing facilities.

10.3 RECOMMENDED ACTION STEPS

It is recommended that the following steps be taken to begin implementation of a regional plan:

1. The final number of regional participants and their associated level of involvement should be determined. Provisions for future participation should be considered.

2. The regional participants should review, evaluate, and select the institutional entity that will be responsible for the implementation of the recommended regional plan. The necessary legal and organizational framework should be determined and created, as required under state and local laws.

3. Agreements between the designated entity and the regional participants (or local entities desiring to become customers of the regional system) should be negotiated.

4. The regional entity should further develop the regional system concept as required to prepare a project financing plan, including the completion of project funding applications and the selection of mechanisms for the generation of revenue. Other project-related aspects of project financing and permitting should be considered, including such items as defining the terms of cost-sharing and the assessment of project-related environmental consequences.

5. A construction and installation management plan should be developed and should include a prioritization of project facilities. This list of priorities would

be used to determine the sequence of construction and installation of project facilities.

6. The detailed design required for preparation of construction documents for various segments of the project should be developed. An updated opinion of design capacities and probable costs should be prepared.

7. Project operation and maintenance procedures should be formalized and adopted to assure that the project adequately meets the regional water supply requirements for all customers.

11.0 CONCLUSIONS

The following are the conclusions of the long-term regional water supply planning study:

- Population growth within the primary study area of Brazos County is expected to continue throughout 2020. Based on current estimates, the population of Brazos County is approximately 124,389, and is projected to increase to 197,522 by 2020.

- Municipal and manufacturing water demand in the primary study area is expected to increase significantly over the next 30 years. Current average day water demand is estimated at approximately 25.2 mgd and is expected to increase to 49.1 mgd in 2020. With the implementation of conservation measures, 2020 water demand would be projected at approximately 41.8 mgd.

- Projected water demand would be expected to exceed the capacity of existing facilities in the primary study area within the next decade if no significant system improvements or expansions are made.

- Following an evaluation of both ground-water and surface water sources to meet projected water demands, the use of ground-water was determined to be the most economically feasible source of long-range water supply. This selection is reinforced by the determination that the Simsboro Aquifer can be used with no significant impacts with respect to aquifer yield and/or related declines in water quality.

- A regional water supply for entities in the secondary study area is not considered feasible.

- If additional study and future monitoring of ground water in the Simsboro Aquifer indicate that continued and increased usage of the aquifer may result in significant adverse impacts, another detailed study of a surface water alternative, with consideration of direct and indirect costs associated with long-term environmental impacts, should be considered. Another study may also be relevant if BRA, TRA, or any other major user plans and proceeds with any of the reservoirs proposed in the area.

- A number of diverse institutional arrangements are potentially available to construct, operate, and manage a regional water system within Brazos County. It has been recommended that the study participants closely review these institutional arrangements.

- An equally broad range of financing mechanisms are available to fund the construction and operation of a regional system. The financing mechanisms are dependent in large part on the institutional framework of a regional system. As with the institutional arrangements, these should be thoroughly reviewed by potential participants in a regional system prior to selection of a final alternative.

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APPENDIX A

LIST OF ENTITIES NOTIFIED BY CERTIFIED MAIL

COUNTIES

Brazos County
County Courthouse
Bryan, Texas 77803

Grimes County
County Courthouse
Anderson, Texas 77830

Leon County
County Courthouse
Centerville, Texas 75833

Madison County
101 West Main
Madisonville, Texas 77864

Robertson County
County Courthouse
Franklin, Texas 77856

CITIES

City of Navasota
P.O. Box 910
Navasota, Texas 77868

City of Buffalo
P.O. Box 219
Buffalo, Texas 75831

City of Centerville
P.O. Box 279
Centerville, Texas 75833

City of Leona
P.O. Box 126
Leona, Texas 75850

City of Jewett
P.O. Box 189
Jewett, Texas 75846

City of Marquez
P.O. Box 128
Marquez, Texas 77865

City of Normangee
P.O. Box 37
Normangee, Texas 77817

City of Oakwood
P.O. Box 96
Oakwood, Texas 75855

City of Madisonville
P.O. Box 549
Madisonville, Texas 77864

City of Bremond
P.O. Box E
Bremond, Texas 76629

City of Calvert
P.O. Box 505
Calvert, Texas 77837

City of Franklin
P.O. Box 428
Franklin, Texas 77856

City of Hearne
210 Cedar Street
Hearne, Texas 77859

COUNCIL OF GOVERNMENTS

Brazos Valley Development Council
P.O. Drawer 4128
Bryan, Texas 77805-4128

SPECIAL DISTRICTS

Brazos County Water Control and Improvement District No. 1 - Big Creek
Route 4, Box 790
Navasota, Texas 77868

Brazos River Authority
P.O. Box 7555
Waco, Texas 76714-7555

Grimes County Municipal Utility District No. 1
c/o Andrew P. Johnson, III
2707 North Loop West, Suite 300
Houston, Texas 77002-5087

North Zulch Municipal Utility District
P.O. Box 118
North Zulch, Texas 77872

San Jacinto River Authority
P.O. Box 329
Conroe, Texas 77305

Trinity River Authority
P.O. Box 60
Arlington, Texas 76010

WATER SUPPLY CORPORATIONS

Brushy W.S.C.
P.O. Box 1134
College Station, Texas 77841

Fairview-Smetana W.S.C.
Route 5, Box 596F
Bryan, Texas 77803

Wellborn W.S.C.
P.O. Box 1040
Wellborn, Texas 77881

Wixon W.S.C.
P.O. Box 3297
Bryan, Texas 77802

Carlos W.S.C.
P.O. Box 310
Iola, Texas 77861

Dobbins-Plantersville W.S.C.
P.O. Box 127
Plantersville, Texas 77363

Concord Robbins W.S.C.
P.O. Box 35
Concord, Texas 77850

Flo W.S.C.
P.O. Box 1090
Buffalo, Texas 75831

Flynn W.S.C.
P.O. Box 125
Flynn, Texas 77855

St. Paul Shiloh-Timesville W.S.C.
Route 2, Box 106
Oakwood, Texas 75855

Madison County W.S.C.
P.O. Box 537
Madisonville, Texas 77864

Midway W.S.C.
P.O. Box 136
Midway, Texas 75852

Bethany-Hearne W.S.C.
Route 2, Box 98
Hearne, Texas 77859

North Hamilton Hill W.S.C.
P.O. Box 555
Franklin, Texas 77856

Robertson County W.S.C.
P.O. Box 875
Franklin, Texas 77856

Tri-County W.S.C.
P.O. Box 976
Marlin, Texas 76661

Twin Creek W.S.C.
P.O. Box 88
New Baden, Texas 77870

Wheelock W.S.C.
P.O. Box 49
Wheelock, Texas 77892

APPENDIX B

QUESTIONNAIRE FOR

REGIONAL WATER SUPPLY PLANNING STUDY

Agency________________________

Date__________________________

Please return this completed questionnaire to:

Espey, Huston & Associates, Inc.
P.O. Box 519
Austin, Texas 78767

ATTN: Ken Schroeder

Please contact Ken at 512/327-6840 if you have questions.

WATER SUPPLY

1. Please provide a map showing limits of your current service area. Also indicate any known or anticipated expansion of your service area and the timing of the expansion.

2. Do you purchase all or part of your water supply on a wholesale basis from another agency? ____________________. If so, please describe.

3. Provide map showing location of water supply facilities
   - Raw water intake, pump station and transmission line
   - Treatment facilities
   - Wells
   - Distribution system including pump station
   - Ground and elevated storage

4. Provide the following information on your current water supply source.

Source

a) Wells No. ________ Capacity ____________ MGD

________ ____________ MGD

________ ____________ MGD

________ ____________ MGD

b) Surface Water

1) Raw (Source) ______________________________

*Water Rights (MGD) ______________________________
(or Acre-Feet)

2) Treated (Source) ______________________________

Supplier ______________________________

Quantity (MGD) ______________________________

* If water rights are held by other agency, provide name of agency, contract quantity and length of contract.

Please list the cities you serve and indicate whether wholesale or retail.

Also indicate what entities other than cities that you serve. Retail or wholesale?

5. Type of Agency. Please describe your agency.

(a) Investor Owned______________________________

(b) Non-profit corporation______________________________

(c) Utility district______________________________

(d) Authority______________________________

(e) Other (describe)______________________________

6. Provide the following population data for your service area if available:

Historical		Projection	
1960	______	1990	______
1970	______	1995	______
1980	______	2000	______
1988	______	2010	______
		2015	______
		2020	______

7. Provide the following information concerning water consumption if available:

Historical	1960	1970	1980	1988
Average day demand	____	____	____	____
Maximum day demand	____	____	____	____
# of customer connections	____	____	____	____
Gallons per capita per day	____	____	____	____

Projected	1990	2000	2010	2015	2020
Average day demand	____	____	____	____	____
Maximum day demand	____	____	____	____	____
Gallons per capita per day	____	____	____	____	____
Source of projections	______				

Water demand may be in MGD (million gallons per day) or gpm (gallons per minute). Please indicate units used.

8. Provide the following information on existing and proposed expansion of your water supply facilities:

Raw Water Pumping Facilities

Current capacity __________ MGD

Ultimate capacity __________ MGD

Planned expansion __________ MGD

Scheduled in-service (year) __________

Estimated Construction Cost __________

Raw Water Pipeline

Capacity __________ MGD

Size __________

Length __________

Planned New Line

Capacity __________ MGD

Size __________

Length __________

Scheduled in-service (year) __________

Estimated Construction Cost __________

Treatment Facilities

Current capacity __________ MGD

Ultimate capacity __________

Planned expansion __________ MGD

Scheduled in-service (year) __________

Estimated Construction Cost __________

Ground Storage

No. of tanks	______	Planned additional storage capacity	______	GAL.
Storage capacity of each tank	______	Scheduled in-service (year)	______	
Current total storage capacity	______	Estimated Construction Cost	______	

Elevated Storage

No. of tanks	______	Planned additional storage capacity	______	GAL.
Storage capacity of each tank	______	Scheduled in-service (year)	______	
Current total storage capacity	______	Estimated Construction Cost	______	

New Wells

a) Capacity______________________

Scheduled in-service (year)______________________

Estimated construction cost______________________

b) Capacity______________________

Scheduled in-service (year)______________________

Estimated construction cost______________________

IMPORTANT

For any of the above facilities for which you indicate a "planned expansion," please list any of the planned facilities that are currently under contract, under construction, or for which you have a firm commitment to construct.

9. Please provide current rate schedule for water service.

10. Indicate any treatment that is provided and note any problems associated with meeting the requirements of the Safe Drinking Water Act and State Drinking Water Standards.

11. Describe significant customer complaints associated with taste, odor, color, pressure.

12. Please identify any Capital Improvement Programs, Engineering Reports or Planning Reports you have that may relate to or be useful in this regional planning effort for water supply.

We would appreciate receiving a copy of the above. Please indicate if we need to return the reports to you. ________________

13. Is your public water supply "Approved" by the State? _________

14. Do you consider your existing water supply adequate to meet your....

	YES	NO
. . . Present Needs	_________	_________
. . . Year 1990 Needs	_________	_________
. . . Year 2000 Needs	_________	_________
. . . Year 2010 Needs	_________	_________
. . . Year 2020 Needs	_________	_________

If you do not consider your existing water supply adequate to meet your short or long range needs, is your entity actively planning or negotiating to meet your present or future needs? _________. If yes, please describe.

15. Would your agency be interested in participating in a regional water supply delivery system? If so, please indicate the year in which your participation would be feasible.

16. Has your agency adopted any water conservation plan or drought management plan? __________ If yes, please provide a copy.

Please provide the name and telephone number of the person in your organization who can be contacted concerning questions or additional information on the above requested data and information:

Name________________________________

Telephone No.__________________________

APPENDIX C

TABLE C-1
PROJECTED MUNICIPAL POPULATION, PER CAPITA USAGE
AND PROJECTED AVERAGE DAY WATER DEMAND
City of Bryan

BRAZOS VALLEY REGIONAL WATER SUPPLY PLANNING STUDY

ITEM	1990	2000	2010	2020
POPULATION				
TWDB LOW	62,034	64,123	70,994	74,552
TWDB HIGH	62,327	76,238	85,043	90,870
SELF-REPORTED	56,000	66,345	76,845	81,478
PER CAPITA USAGE (gpd)				
1980-86 AVERAGE	158	158	158	158
TWDB AVERAGE	160	160	160	160
W/ CONSERVATION	156	148	140	136
TWDB HIGH	185	185	185	185
W/ CONSERVATION	180	171	162	157
SELF-REPORTED	164	164	164	164
WATER DEMAND (mgd)				
TWDB LOW POPULATION x				
1980-86 AVERAGE	9.801	10.131	11.217	11.779
TWDB AVERAGE	9.925	10.260	11.359	11.928
W/ CONSERVATION	9.677	9.490	9.939	10.139
TWDB HIGH	11.476	11.863	13.134	13.792
W/ CONSERVATION	11.166	10.965	11.501	11.705
SELF-REPORTED PC	10.174	10.516	11.643	12.227
TWDB HIGH POPULATION x				
1980-86 AVERAGE	9.848	12.046	13.437	14.357
TWDB AVERAGE	9.972	12.198	13.607	14.539
W/ CONSERVATION	9.723	11.283	11.906	12.358
TWDB HIGH	11.530	14.104	15.733	16.811
W/ CONSERVATION	11.219	13.037	13.777	14.267
SELF-REPORTED PC	10.222	12.503	13.947	14.903
SELF-REPORTED POPULATION x				
1980-86 AVERAGE	8.848	10.483	12.142	12.874
TWDB AVERAGE	8.960	10.615	12.295	13.036
W/ CONSERVATION	8.736	9.819	10.758	11.081
TWDB HIGH	10.360	12.274	14.216	15.073
W/ CONSERVATION	10.080	11.345	12.449	12.792
SELF-REPORTED PC	9.184	10.881	12.603	13.362
MINIMUM (mgd)	8.7	9.5	9.9	10.1
MAXIMUM (mgd)	11.5	14.1	15.7	16.8
MEDIAN (mgd)	10.1	11.8	12.8	13.5
DIFFERENCE (mgd)	2.8	4.6	5.8	6.7

SOURCE: TEXAS WATER DEVELOPMENT BOARD, 1989. Apr-90
EH&A SURVEY QUESTIONNAIRE, 1989.

TABLE C-2
PROJECTED MUNICIPAL POPULATION, PER CAPITA USAGE, AND PROJECTED AVERAGE DAY WATER DEMAND
City of College Station

BRAZOS VALLEY REGIONAL WATER SUPPLY PLANNING STUDY

ITEM	1990	2000	2010	2020
POPULATION				
TWDB LOW	47,134	57,326	63,467	66,648
TWDB HIGH	47,356	68,156	76,027	81,236
SELF-REPORTED	44,636	57,926	65,000	74,000
PER CAPITA USAGE (gpd)				
1980-86 AVERAGE	261	261	261	261
TWDB AVERAGE	266	266	266	266
W/ CONSERVATION	260	246	233	226
TWDB HIGH	335	335	335	335
W/ CONSERVATION	327	310	293	285
SELF-REPORTED	161	189	228	248
WATER DEMAND (mgd) [a]				
TWDB LOW POPULATION x				
1980-86 AVERAGE	12.302	14.962	16.565	17.395
TWDB AVERAGE	12.538	15.249	16.882	17.728
W/ CONSERVATION	12.255	14.105	14.772	15.069
TWDB HIGH	15.790	19.204	21.261	22.327
W/ CONSERVATION	15.395	17.764	18.604	18.978
SELF-REPORTED PC	7.603	10.846	14.445	16.533
W/ TAMU [b]	14.603	19.846	24.345	27.423
TWDB HIGH POPULATION x				
1980-86 AVERAGE	12.360	17.789	19.843	21.203
TWDB AVERAGE	12.597	18.129	20.223	21.609
W/ CONSERVATION	12.313	16.770	17.695	18.367
TWDB HIGH	15.864	22.832	25.469	27.214
W/ CONSERVATION	15.468	21.120	22.285	23.132
SELF-REPORTED PC	7.639	12.894	17.304	20.151
W/ TAMU [b]	14.639	21.894	27.204	31.041
SELF-REPORTED POPULATION x				
1980-86 AVERAGE	11.650	15.119	16.965	19.314
TWDB AVERAGE	11.873	15.408	17.290	19.684
W/ CONSERVATION	11.605	14.253	15.129	16.731
TWDB HIGH	14.953	19.405	21.775	24.790
W/ CONSERVATION	14.579	17.950	19.053	21.072
SELF-REPORTED PC	7.200	10.959	14.794	18.356
W/ TAMU [b]	14.200	19.959	24.694	29.246
MINIMUM (mgd)	7.2	10.8	14.4	15.1
MAXIMUM (mgd)	15.9	22.8	27.2	31.0
MEDIAN (mgd)	11.5	16.8	20.8	23.1
DIFFERENCE (mgd)	8.7	12.0	12.8	16.0

SOURCE: TEXAS WATER DEVELOPMENT BOARD, 1989. Apr-90
EH&A SURVEY QUESTIONNAIRE, 1989.

[a]. TWDB WATER DEMAND PROJECTIONS FOR COLLEGE STATION ALSO INCLUDE TAMU WATER DEMAND.

[b]. SELF-REPORTED W/TAMU PROJECTIONS INCLUDE AVERAGE DAY PROJECTIONS OF 7 AND 9 mgd FOR 1990 AND 2000.

TABLE C-3
PROJECTED MUNICIPAL POPULATION, PER CAPITA USAGE
AND PROJECTED WATER DEMAND
Other Municipal - Brazos County

BRAZOS VALLEY REGIONAL WATER SUPPLY PLANNING STUDY

ITEM	1990	2000	2010	2020
POPULATION				
TWDB LOW	11,020	27,096	30,309	34,494
TWDB HIGH	11,071	32,214	36,306	42,044
PER CAPITA USAGE (gpd)				
TWDB AVERAGE	110	110	110	110
W/ CONSERVATION	107	102	96	94
TWDB HIGH	139	139	139	139
W/ CONSERVATION	135	128	121	118
WATER DEMAND (mgd)				
TWDB LOW POPULATION x				
TWDB AVERAGE	1.212	2.981	3.334	3.794
W/ CONSERVATION	1.182	2.757	2.917	3.225
TWDB HIGH	1.527	3.756	4.201	4.781
W/ CONSERVATION	1.489	3.474	3.676	4.064
TWDB HIGH POPULATION x				
TWDB AVERAGE	1.218	3.544	3.994	4.625
W/ CONSERVATION	1.187	3.278	3.494	3.931
TWDB HIGH	1.535	4.465	5.032	5.828
W/ CONSERVATION	1.496	4.130	4.403	4.954
MINIMUM	1.2	2.8	2.9	3.2
MAXIMUM	1.5	4.5	5.0	5.8
MEDIAN	1.4	3.6	4.0	4.5
DIFFERENCE	0.4	1.7	2.1	2.6

SOURCE: TEXAS WATER DEVELOPMENT BOARD, 1989. Apr-90
EH&A SURVEY QUESTIONNAIRE, 1989.

APPENDIX D

BRAZOS RIVER AUTHORITY

4400 COBBS DRIVE • P. O. BOX 7555 • TELEPHONE AREA CODE 817 776-1441

WACO, TEXAS 76714-7555

March 8, 1990

U P S

Mr. Ken Schroeder, P.E.
Senior Staff Engineer
Espey, Huston & Associates, Inc.
P. O. Box 519
Austin, Texas 78767

Dear Mr. Schroeder:

This letter is in response to your letter dated February 2, 1990 concerning potential surface water supplies for Brazos County.

The Brazos River Authority operates a basin-wide water supply system consisting of eleven major reservoirs, from which water supply is committed to supply needs both in the immediate vicinity of the individual reservoirs and in areas downstream, areas all the way to the Gulf of Mexico. It is from this basin-wide system that the Authority could make available surface-water supplies to Brazos County on a long-term, dependable basis.

Your letter includes two potential scenarios for surface water supply based on maximum-day demands. Since the adequacy of surface water supplies is determined by their ability to meet average-day, rather than maximum-day demands, the maximum-day demands presented in your table were converted to average-day using a factor of 2.0. The following table of average-day demands table collates with the maximum-day demand table in your letter:

Surface-Water Required in MGD(Acre-Feet/Year)

SCENARIO NO.	1990	2000	2010	2020
No. 1 (10 wells)	7.75 (8680)	17.1 (19152)	23.2 (25984)	29.5 (33040)
No. 2 (no wells)	22.85 (25592)	32.2 (36063)	38.3 (42896)	44.6 (49952)

Sufficient supplies are currently available from the Authority's Basin-wide System to provide for the long-term (year 2020) demands under either scenario. Two supply sources are currently available to meet these demands. First, the demands can be supplied entirely from System supplies diverted from the Brazos River near College Station. The long-term, dependable supply that can be made available at the Brazos River near College Station is currently over 45.0 mgd. The second currently available source is Lake Somerville; however, sufficient supply is not currently available from Lake Somerville to meet the long-term (year 2020 under Scenario 1 and year 2000 under Scenario 2) demand under either scenario. The dependable long-term supply currently available from Lake Somerville is approximately 27.8 mgd (31,136 AF/Yr). If Lake Somerville were used, future supplemental supplies from the Brazos River or from a new supply source would be needed.

Lake Somerville offers excellent water quality (low dissolved constituents); however, it is located substantially further from the Bryan-College Station area than the Brazos River. Conversely, the Brazos River at College Station has periods of elevated salt concentrations. A statistical evaluation of the reoccurrence intervals for salt (chloride) concentrations in the Brazos River at the College Station gauge has recently been done by Texas A&M University. This analysis indicates that the 250 mg/l chloride concentration is exceeded 10 percent of the time; a 100 mg/l chloride concentration is maintained about 35 percent of the time (a copy of the duration curves for total dissolved solids, chlorides, and sulfates is attached). Termination storage is one method that has been used successfully to provide potable supplies during periods of elevated salt concentrations. The storage must be of sufficient volume to provide the maximum-day demand for the treatment plant during periods when the chloride concentrations are elevated. If Lake Somerville is used in combination with the Brazos River, termination storage would not be required. The supply system could be designed to overdraft Lake Somerville during periods of high salinity and to overdraft the Brazos River during periods of low salinity.

With regard to the price of long-term System water supply, the Authority has recently formulated a price proposal for future commitments of System water supply that would achieve a uniform, equitable price. This proposal was made to a large group of entities located throughout the Brazos Basin that needed additional water supply to meet present and future demands. This proposed pricing structure for available System supplies is being reviewed by the Texas Water Commission in a rate proceeding that began in August 1989. The final decision of the Commission will govern the System price that the Authority can offer. Since this proceeding has just gotten underway, it may be some time before the final price is determined.

Sufficient supplies are currently available from the Authority's Basin-wide System to provide for the long-term (year 2020) demands under either scenario. Two supply sources are currently available to meet these demands. First, the demands can be supplied entirely from System supplies diverted from the Brazos River near College Station. The long-term, dependable supply that can be made available at the Brazos River near College Station is currently over 45.0 mgd. The second currently available source is Lake Somerville; however, sufficient supply is not currently available from Lake Somerville to meet the long-term (year 2020 under Scenario 1 and year 2000 under Scenario 2) demand under either scenario. The dependable long-term supply currently available from Lake Somerville is approximately 27.8 mgd (31,136 AF/Yr). If Lake Somerville were used, future supplemental supplies from the Brazos River or from a new supply source would be needed.

Lake Somerville offers excellent water quality (low dissolved constituents); however, it is located substantially further from the Bryan-College Station area than the Brazos River. Conversely, the Brazos River at College Station has periods of elevated salt concentrations. A statistical evaluation of the reoccurrence intervals for salt (chloride) concentrations in the Brazos River at the College Station gauge has recently been done by Texas A&M University. This analysis indicates that the 250 mg/l chloride concentration is exceeded 10 percent of the time; a 100 mg/l chloride concentration is maintained about 35 percent of the time (a copy of the duration curves for total dissolved solids, chlorides, and sulfates is attached). Termination storage is one method that has been used successfully to provide potable supplies during periods of elevated salt concentrations. The storage must be of sufficient volume to provide the maximum-day demand for the treatment plant during periods when the chloride concentrations are elevated. If Lake Somerville is used in combination with the Brazos River, termination storage would not be required. The supply system could be designed to overdraft Lake Somerville during periods of high salinity and to overdraft the Brazos River during periods of low salinity.

With regard to the price of long-term System water supply, the Authority has recently formulated a price proposal for future commitments of System water supply that would achieve a uniform, equitable price. This proposal was made to a large group of entities located throughout the Brazos Basin that needed additional water supply to meet present and future demands. This proposed pricing structure for available System supplies is being reviewed by the Texas Water Commission in a rate proceeding that began in August 1989. The final decision of the Commission will govern the System price that the Authority can offer. Since this proceeding has just gotten underway, it may be some time before the final price is determined.

Our proposal specifies an initial term and an extended term. During the initial term, which is a period from January 1, 1991 through December 31, 2025, the water supply made available for diversion (Current Use Water) is priced as follows:

1991-92	$35.00 per acre-foot
1993-94	$65.00 per acre-foot
1995 and thereafter	$85.00 per acre-foot

This price, which will escalate in accordance with the Consumer Price Index, is based on the assumption that at least 86,000 acre-feet per year (76.8 mgd) of available System supply will be sold as Current Use Water before the end of 1990. During the initial term, the price of the Current Use Water will never exceed the 1995 price. The price would be adjusted downward as additional water is sold and existing pre-1990 water supply contracts expire and are rolled-over as long-term contracts.

Option Water can be reserved for use during the extended term beginning in the year 2026. Option Water is not available for diversion until additional water supply facilities are made available. The proposal includes a procedure for exercising the option to convert Option Water to Current Use Water during the extended term, which would begin in January 2026 or whenever additional water supply facilities become operational, whichever is later. The price of Option Water for the initial term is $10.00 per acre-foot.

As requested in a subsequent telephone conversation, I have enclosed information on Lake Caldwell, a potential reservoir site located in Burleson County, and on Lake Millican, the former COE project proposed for the Panther Creek dam site. I understand that this information is needed for a complete evaluation of all potential supply sources.

Please review the information provided in this letter. If you have any questions about the availability of price for surface water to meet the needs of Brazos County, please do not hesitate to contact me.

Sincerely,

J. TOM RAY, P.E.
Planning Division Manager

JTR:rp

Table 73

CONCENTRATION-DURATION CURVE
FOR TOTAL DISSOLVED SOLIDS

Percent Equalled or Exceeded	Seymour Gage (mg/l)	Possum Kingdom Gage (mg/l)	Whitney Gage (mg/l)	College Station Gage (mg/l)	Richmond Gage (mg/l)
0.01	15,400	2,810	2,050	1,360	978
0.05	15,400	2,810	2,050	1,360	978
0.1	15,400	2,810	2,050	1,360	978
0.2	15,400	2,810	2,050	1,360	978
0.5	15,000	2,800	1,580	1,260	910
1	14,500	2,710	1,560	1,040	902
2	13,700	2,540	1,520	1,010	845
5	12,700	2,420	1,400	870	701
10	11,900	2,290	1,250	763	635
15	11,000	2,190	1,210	704	601
20	10,500	2,090	1,170	659	566
30	8,530	1,890	1,070	596	498
40	7,320	1,780	1,000	557	426
50	6,220	1,620	945	505	382
60	5,270	1,510	864	448	346
70	4,320	1,420	750	412	317
80	3,320	1,350	723	370	264
85	2,800	1,300	699	339	250
90	2,420	1,130	666	313	235
95	1,870	948	639	270	218
98	1,400	739	567	238	198
99	1,290	583	552	231	169
99.5	1,190	508	487	228	164
99.8	817	500	476	225	161
99.9	774	495	472	223	160
99.95	742	492	469	221	159
99.99	692	486	464	218	157
100	618	475	456	212	153

Table 74

CONCENTRATION-DURATION CURVE
FOR CHLORIDE

Percent Equalled or Exceeded	Seymour Gage (mg/l)	Possum Kingdom Gage (mg/l)	Whitney Gage (mg/l)	College Station Gage (mg/l)	Richmond Gage (mg/l)
0.01	7,740	1,100	771	512	355
0.05	7,740	1,100	771	512	355
0.1	7,740	1,100	771	512	355
0.2	7,740	1,100	771	512	355
0.5	7,270	1,100	637	370	340
1	6,850	1,100	625	364	328
2	6,530	1,000	612	353	290
5	6,110	989	551	288	213
10	5,760	949	484	250	192
15	5,270	892	451	220	176
20	4,850	844	437	198	162
30	3,810	756	400	173	135
40	3,240	706	376	154	108
50	2,610	652	350	134	93
60	2,210	594	316	113	80
70	1,690	562	270	91	67
80	1,290	522	256	79	55
85	1,080	503	247	69	49
90	851	447	236	60	43
95	647	362	218	41	36
98	455	282	176	35	34
99	339	223	169	32	33
99.5	297	195	156	30	32
99.8	271	192	148	28	31
99.9	256	190	146	27	31
99.95	244	189	145	26	30
99.99	224	187	143	24	30
100	190	183	139	20	28

Table 75

CONCENTRATION-DURATION CURVE
FOR SULFATE

Percent Equalled or Exceeded	Seymour Gage (mg/l)	Possum Kingdom Gage (mg/l)	Whitney Gage (mg/l)	College Station Gage (mg/l)	Richmond Gage (mg/l)
0.01	2,220	582	481	262	185
0.05	2,220	582	481	262	185
0.1	2,220	582	481	262	185
0.2	2,220	582	481	262	185
0.5	2,090	582	325	239	172
1	2,040	574	317	213	166
2	2,010	547	313	191	157
5	1,910	501	291	170	124
10	1,800	481	267	143	113
15	1,720	459	237	133	105
20	1,640	436	228	121	98
30	1,400	396	214	109	86
40	1,300	364	195	100	73
50	1,160	328	181	90	64
60	986	309	160	80	58
70	854	289	141	72	51
80	686	273	132	62	45
85	604	258	127	57	40
90	539	219	122	51	37
95	367	180	116	41	33
98	281	147	103	39	29
99	224	118	93	38	27
99.5	145	99	83	38	25
99.8	137	98	80	37	25
99.9	132	97	79	37	25
99.95	128	97	79	37	25
99.99	122	96	79	36	24
100	112	94	78	35	24

Trinity River Authority of Texas

General Office

2011/4001

March 1, 1990

Mr. Ken Schroeder, P.E.
Senior Staff Engineer
Espey, Huston & Associates, Inc.
P. O. Box 519
Austin, Texas 78767

Dear Mr. Schroeder:

In response to your letter regarding surface water alternatives in the Trinity River Basin, I offer the following:

1. TRA at present has sufficient water rights in Lake Livingston to meet the needs as specified in Scenario Nos. 1 and 2.

   As for preferred conveyance locations, we would consider all reasonable alternatives based on further engineering analyses and the customers' needs and desires.

2. The Authority, in cooperation with the Bureau of Reclamation, completed a feasibility study of the Bedias Reservoir located in southwest Madison and northwest Walker Counties in 1988 which has a projected yield of about 76 mgd. The Bureau of Reclamation estimated construction of the reservoir to be approximately $150 Million, not including recreational facilities.

   Conveyance of water from Bedias Lake to the west is expected to require an intake on the south shore; the exact site to be based on further engineering considerations. We have previously provided a copy of the Bedias report.

Regarding your question concerning services the Authority can provide. TRA is willing and capable of providing three levels of service. Under contract with other municipalities in the Trinity Basin, TRA has financed, constructed and operated; financed and constructed; or financed only projects similar to those that would be necessary to supply surface water to Bryan or College Station from the Trinity. Enclosed is a general brochure that outlines projects in which the Authority is involved.

P.O. Box 60
Arlington, Texas 76004
Metro (817) 467-4343
TeleFax (817) 465-0970

I believe there are several options of service the Authority is capable of providing under the two scenarios presented above. Our overall approach is to design projects in conjunction with the water customer so as to provide the most efficient project. We would welcome the opportunity to visit you and representatives of the cities of Bryan and College Station about several of these options and how they could be evaluated.

Should further detailed information be needed, you should contact Mr. Grady Manis, TRA's Southern Region Manager, 1117 10th Street, Huntsville, Texas 77340 (409) 295-5485.

Yours very truly,

SAM SCOTT
Executive Services Manager

JSS/cc

Enclosure

cc: Mr. C. Grady Manis, TRA Southern Region Manager

ATTACHMENT NO. 1

Review Comments and Suggested Revision to the Draft Final Report for the Brazos Valley Long-Range Regional Water Supply Planning Study

TEXAS WATER DEVELOPMENT BOARD

1. The Final Report needs to be amended to fully satisfy the scope of work detailed in TWDB Contract No. 9-483-718.

2. A discrepancy occurs between the narrative on page 3-22, Section 3.5.1.2, paragraph two and Table 3-7 shown on page 3-23. The former indicates that all the projections in Table 3-7 on page 3-23 are based on TWDB high series projections. This is inaccurate inasmuch as the municipal category in the table is generated from self-reported per capita data, as noted in footnote (a) of the table. Footnote (b) which refers to manufacturing water use is the TWDB high demand series for manufacturing water use and has no connection with population or per capita projections. The narrative in Section 3.5.1.2 on page 3-23 should be corrected.

3. The third sentence in Section 3.5.2 on page 3-22 indicates that the factors developed by TWDB, which represent savings in per capita use, are applied to "both the municipal and manufacturing categories of water demand." Table 3-8 is the reference for a display of demands which utilize the water conservation scenario developed by TWDB. However, this is an incorrect statement. TWDB does not apply municipal factors depicting conservation savings to manufacturing water use. Rather, savings in manufacturing water use are the result of reductions in water intake volumes on the basis of a per unit manufactured product savings due to technological improvements rather than being based on a per capita figure. These savings are already factored into both the high and low TWDB manufacturing projections. Therefore, applying an additional water use reduction factor to manufacturing water use projected by the TWDB methodology would imply even greater water savings than is believed technically feasible at this time. These reduced manufacturing water volumes are also displayed and, in some cases, incorrectly footnoted or numbered in Tables 3-11, 3-13, and 3-14. These tables should be amended to reflect accurate footnotes, numberings, and corrected water volumes for both the high and low TWDB series.

4. In Table 5-2 on page 5-7 of the report, the 1987 pumpage of the City of Hearne in Robertson County is reported to be 0.01299 Million Gallons per Day (MGD) or 14.55 acre-feet. The amount actually reported by the City of Hearne to the Board was 1.20719 MGD or 1,352 acre-feet.

5. In Table 5-7 on page 5-28 and in the discussion of future yields of the proposed well fields, the Well Field Capacity is derived using all wells being pumped for 24 hours per day. In most projections of well or well-field capacity, the maximum expected pumpage is derived assuming some reduction of pumping time for the wells, and usually only 60 percent, 75 percent, or 80 percent of the total pumpage is used. If this practice is followed for the proposed well field, additional wells may be needed.

6. On Figure 5-9 on page 5-37, the maps or labels for the Queen City and the Carrizo Aquifers have been reversed, so that the map which is labeled Queen City shows the outcrop and fresh water area of the Carrizo and vice versa.

7. To improve the proposed water conservation plan, the following changes are recommended.

   (a) Education and Information - The initial program does not provide for a mailout of an initial announcement of the program and does not include the direct distribution of literature to existing customers. These activities should be included.

   (b) Plumbing Codes - The participants should consider inclusion of 1.6 gallon-per-flush toilets and the elimination of tank-type urinals in their codes.

   (c) Retrofit Program - Local retail stores should also be asked to carry low water-using fixtures if they carry plumbing supplies.

   (d) Water Rate Structure - Bryan and College Station have acceptable uniform rate structures. The plan should recommend that all utilities have acceptable rate structures as a condition of any future contract.

   (e) Implementation and Enforcement - Since the actual nature of the regional authority has not been established, final implementation procedures cannot be specified. However, at a minimum, the regional authority should require applicable water conservation practices by its customer utilities as a contract condition.

8. Drought Contingency Plan

   Since details concerning both the project design and how the regional authority will be established have not yet been determined, specific trigger conditions cannot be finalized. The ones included in the plan are acceptable as a starting point. However, the plan should include provisions to modify trigger conditions once plans are finalized. A recommendation to that effect should be included in the plan.

9. In estimating project costs for the with and without conservation cases, the analysis is incorrect due to the misleading way final costs are presented, and accordingly, the discussion in the Executive Summary is also incorrect.

Tables 8-2 through 8-9 (pages 8-5 through 8-12) of the draft final report provide cost summaries of the various alternatives. The annual debt service and O&M costs were, as best as can be determined, correctly derived. The tables end with an estimate of marginal costs for the area. The tables show that while total annual costs and total capital costs are significantly less (over 25 percent of annual costs and 20 percent for capital costs) with conservation, marginal unit costs are higher, especially in the first few years. However, the marginal unit costs could produce the misleading conclusion that total customer bills would be higher with conservation. This is not true. First, total year 2000 annual costs (groundwater case) with conservation are $1.11 million dollars less than the without conservation case. When distributed over the almost 150,000 people projected to live in the study area, this represents an annual savings of approximately $7.40 per person in total outlay. Secondly, although the unit cost of water in the conservation case is 1.49 times higher, incremental water use in the without conservation case is 1.96 times higher than the conservation case in the year 2000. The difference in unit cost of water narrows to $0.32 versus $0.34 per 1,000 gallons by 2020, but 1.64 times as much water is used without conservation. Thus, citizens will pay more, not less as is suggested in the analysis, under the without conservation case. In conclusion, total annual costs with conservation, regardless of water rates, are 23 to 35 percent lower depending on which year is examined.

In light of the above analysis, the discussion on pages XVI and XVII of the Executive Summary is in error since it addresses only marginal costs per unit and not the overall reduced cost to the citizen. The discussion on final costs in the Executive Summary should be re-written to accurately depict the impact of conservation on customer costs.

10. It should be noted that the report differs with the draft Texas Water Plan with regard to the source of additional water supplies. The draft Water Plan recommends that Bryan and College Station seek Brazos River Authority water from Somerville Reservoir, while the draft regional report recommends the continued use of groundwater. One reason for

the different approaches could be in the estimate of groundwater available for use. Based on the draft State Water Plan, the availability of groundwater was estimated to be approximately 30,000 acre-feet. According to this estimate, Bryan's and College Station's projected water needs would exceed this availability by the year 2010.

ESPEY,
HUSTON &
ASSOCIATES, INC.
Engineering & Environmental Consultants

RECEIVED SEP 7 1990

RECEIVED SEP 07 1990 WATER PLANNING

September 6, 1990

Mr. G.E. (Sonny) Kretzschmar
Executive Administrator
Texas Water Development Board
P.O. Box 13231
Capitol Station
Austin, Texas 78711-3231

EH&A Project No. 11753-95

Re: Brazos Valley Long-Range Regional Water Supply Planning Study, TWDB Contract No. 9-483-718

Dear Mr. Kretzschmar:

We have received a copy of the letter summarizing the review comments of the Draft Final Report for the referenced planning study. The Final Report has been completed and includes revisions recommended by the TWDB staff comments. Twelve copies of the Final Report have been delivered to John Miloy.

We did not make any revisions to the report in response to a couple of the comments. With respect to comment number three, we agree that the municipal use conservation factors should not have been applied directly to manufacturing water demands. However, the greatest difference in projected demand for manufacturing use would be about 100,000 gallons per day in the year 2020, which is less than 0.3% of the total projected demand. This is an insignificant difference and well within an acceptable margin for the total demand projections. It has no effect on the estimated facility costs or the conclusions of the study.

Secondly, comment number five suggests that the projected well field capacity should be reduced by some factor for an assumed reduction of pumping time. The number of wells was determined based on the peak day demand and an average well capacity of 2100 gallons per minute (gpm). Theoretically, this would require all wells to pump 24 hours a day to meet a peak day demand which would occur at the end of a construction phase. However, there are several factors which tend to offset this potential problem and preclude the need for additional wells. The construction phasing of additional wells can be optimized in the future based on actual peak demands and actual well capacities. The assumed capacity of 2100 gpm per well is considered conservative based on the actual capacities of recent wells in the area. Also, the water storage capacities of the individual water systems were not considered in the development of a regional supply system and could provide a factor of safety in meeting peak day demands. Therefore, we do not believe that there would be a significant number of, if any, additional wells required.

916 Capital of Texas Highway South • P.O. Box 519 • Austin, Texas 78767 • (512) 327-6840 • FAX (512) 327-2453

We hope that we have satisfactorily addressed the staff comments with the appropriate revisions and this response. We appreciate the cooperation of John Miloy and all the other staff members who provided assistance throughout the study.

Sincerely,

Ken Schroeder

Ken Schroeder, P.E.
Senior Staff

KS:pc

cc: John Miloy, TWDB
John Woody, City of College Station

TEXAS WATER DEVELOPMENT BOARD

INTEROFFICE MEMORANDUM

TO : Stephen Densmore

DATE: September 20, 1990

THRU : Gordon Thorn _GT 9/25/90_
Tommy Knowles _TK_ Tony Bagwell _TB_
T. James Fries _T. J. Fries_

FROM : John Miloy _John Miloy_

SUBJECT: Response to Board Review Comments on the Brazos Valley Long-Range Regional Water Supply Planning Study

With regard to the referenced topic, attached are copies of the Board's review comments and the consultant's September 6, 1990, letter which explains actions taken or not taken in response to the Board's review comments. The letter provides a discussion on comment number five in the Board's review comments and concludes that additional wells do not appear to be needed.

Your concurrence, disagreement, or general reaction to the explanation offered in the consultant's letter would be appreciated. If you have any questions, please contact me at 463-8422.

Attachments (3)

Do after TWP!

TK

draft-rpreston-10-01-90

FURTHER REVIEW OF FINAL REPORT
BRAZOS VALLEY LONG-RANGE REGIONAL
WATER SUPPLY PLANNING STUDY
August, 1990
and a comparison with the
Board's 1990 Draft Water Plan

The Brazos Valley report discusses 4 potential scenarios for providing Brazos County residents with their projected water needs through 2020. These scenarios involve the continued production of water from the Carrizo-Wilcox (Simsboro) aquifer and the possible use of surface water from three sources, Lake Somerville, the Brazos River, and Lake Millican. Based on research and computer modeling of the Carrizo-Wilcox, a total ground-water use scenario was selected and proposed. This scenario is based on systematic lowering of the potentiometric surface of the aquifer, and based on well-construction and water-use projections would result in pumping-level declines of about 350 feet by 2020. This would result in pumping levels averaging about 525 feet below the land surface. The model considered pumpage by existing users in adjacent counties, including projected pumpage for mining in Robertson County. This pumpage is estimated to have caused about 30 feet of the decline to 525 feet below the land surface in 2020.

Allocations for the 1990 TWDB Plan were based on new (post 1984) estimations of recharge for the Carrizo-Wilcox in the Central Texas area. These figures came from a computer model of the Carrizo-Wilcox aquifer between the Trinity and Brazos Rivers. The amount of recharge was calculated as a total for the area and assigned to the counties based on the proportion of the area of extent of the aquifer within each county to the total aquifer area. This equated to an estimated annual average recharge for Brazos County of 35,249 acre-feet. We did not consider water from storage (either artesian or water-table) in the allocations for Brazos County.

The Brazos Valley Plan was based on 30 years, 1990-2030. The Board plan was based (as required by law) on 50 years, 1990-2040.

The Board Plan used TWDB developed population and water demand projections. The Brazos Valley Plan used Board projections for rural domestic population and demands, but used figures reported by Bryan, College Station, and Texas A&M for population and demands for these entities. The 2020 municipal demand estimates (including Bryan, College Station, Texas A&M, and rural domestic projections) total 54,256 acre-feet per year in the Brazos Valley Plan and 55,856 acre-feet in the TWDB Plan. The projected demand for 2040 in the TWDB Plan is 61,557 acre-feet.

Both Plans indicate that the demand for Bryan, College Station, and Texas A&M would exceed the amount of recharge allocated to Brazos County by about 2000. The TWDB Plan suggests that the area should obtain surface water from Lake Somerville to supplement the 35,000 acre-feet per year ground water estimated to be available from recharge to the Carrizo-Wilcox aquifer.

In the aquifer model constructed for the Brazos Valley Plan, demands were estimated for 1995, 2000, ...2020, and the results were used in the model as pumpage for five-year periods, 1990-1995, 1996-2000, etc. These model simulations resulted in declines in the pumping levels in the wells. After the first 5-year pumping period, the declines ranged from 25 to 35' during the other periods, falling from 425 to 450 from 1995-2000, to 480 by 2000, and to 575 by 2020. If ground-water pumpage of the total estimated demand for the area is continued from 2020 to 2040, an additional 120-130' of decline should result, with pumping level falling to around 700' below the land surface.

Depths of Carrizo-Wilcox (Simsboro) wells in the Bryan-College Station-Texas A&M area range in depth from about 2,800-3,400', with screen tops often 2,400 or more feet below the land surface. Current pumping levels average about 225 feet. Thus in most of the wells there is at least 2,000 feet of artesian head available for drawdown. Therefore, if artesian storage within the aquifer is considered and pumping levels down to below 700 feet are allowed, there is adequate water available from the Carrizo-Wilcox aquifer to supply the projected demands of Bryan-College Station-Texas A&M for well beyond 2020 or even 2040. Such a pumpage scenario would of course draw water from an extensive area around the well fields and cause significant water-level declines at some distance. The actual amount of drawdown and extent of the cone of depression would have to be determined from running one of the aquifer models, but should not cause significant problems for current and potential users in adjacent counties.