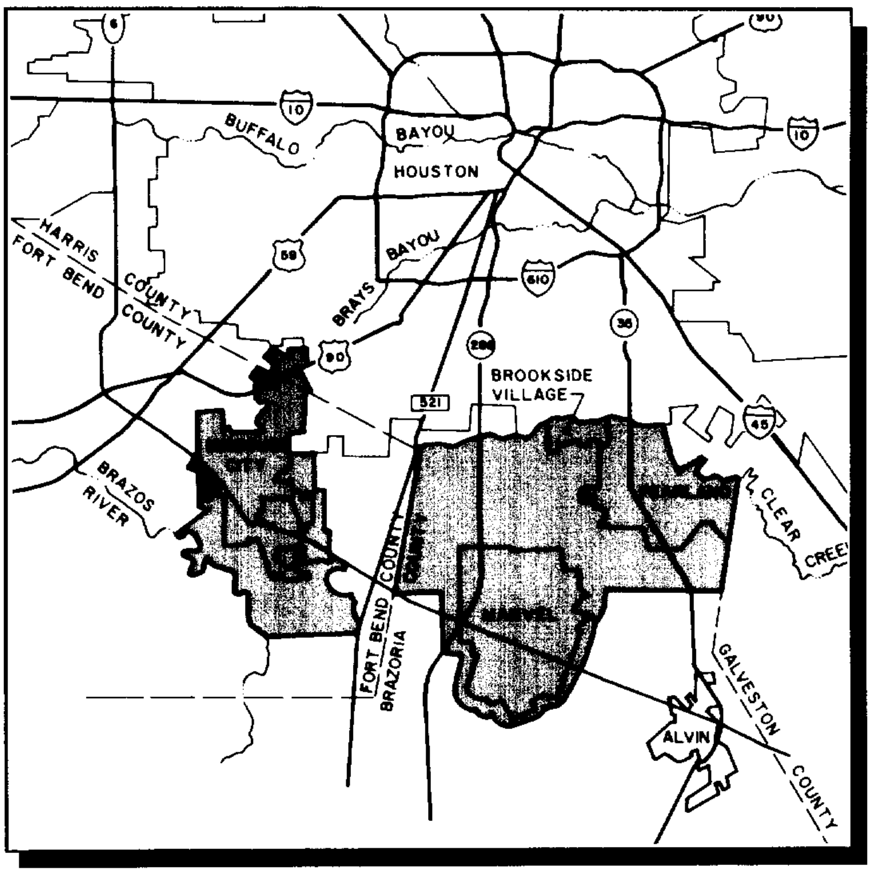
Comprehensive Plan

Regional Water Supply and Wastewater Treatment

BRAZOS BEND
WATER AUTHORITY



Lockwood, Andrews & Newnam, Inc.
Walsh Engineering, Inc.
A Joint Venture

January 31, 1990

ACKNOWLEDGEMENTS

We would like to express our thanks to the numerous individuals representing local and state governmental bodies and agencies for their cooperation and assistance in providing assistance during the course of the planning study. We especially appreciate the support provided by the Board of Directors of the Brazos Bend Water Authority and the help provided by the staffs of Galveston County Water Authority, the City of Missouri City, the City of Pearland, the Texas Department of Health, and the Texas Water Development Board.

AUTHORIZATION

On May 19, 1988, the Texas Water Development Board approved a matching funds grant for the development of a Comprehensive Plan for Regional Water Supply Facilities and Regional Wastewater Collection and Treatment Facilities within the boundaries of the Brazos Bend Water Authority. The joint venture of Lockwood, Andrews & Newnam, Inc. and Walsh Engineering, Inc. was authorized by the Board of Directors of the Brazos Bend Water Authority to proceed with the planning study, effective September 8, 1988.

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EXECUTIVE SUMMARY

BACKGROUND

The Brazos Bend Water Authority (Authority or BBWA) was organized by the cities of Brookside Village, Manvel, Missouri City and Pearland and was created by an act of the 69th Texas Legislature, effective June 14, 1985. The Authority's boundaries include the corporate and extraterritorial limits of the member cities, an area encompassing approximately 150 square miles immediately south and southwest of the City of Houston's municipal limits.

This planning study was authorized by the Authority in anticipation of a rapid growth in area population, from 53,100 reported during the 1980 census to an over 185,000 forecast for the region by the year 2040. The study provides a planning basis for regional water supply and wastewater treatment facilities to accommodate forecasted growth. The planning effort is consistent with the goals of the member cities to secure a long term source of water supply, to protect and enhance water quality in regional streams and lakes and to investigate the feasibility of regional facilities as a means of avoiding a proliferation of small, inefficient facilities.

WATER SUPPLY

Findings

Currently, domestic water supplies are provided by 16 public agencies at 26 water production sites within the region. Groundwater is the sole source of supply at these sites, with combined plant water production averaging 8.17 MGD from August, 1987 through July, 1988.

Although groundwater supplies are probably adequate to meet future regional domestic supply requirements, increased demand and continued sole use of groundwater resources is forecast to accelerate aquifer water level declines and ground surface subsidence within the region.

Surface water resources are potentially available from several sources within and adjacent to the region, including the Galveston County Water Authority, the Brazos Bend Water Authority, and the City of Houston. Upon consideration of accessibility, adequacy of supplies and estimates of cost, surface water supplies currently available from the Galveston County Water Authority are considered the most likely source for BBWA supply.

It is anticipated that sufficient impetus will exist such that conversion to surface water resources for regional domestic water supply will begin by the year 2000. Ideally, existing public water supply agencies opting to contract for BBWA surface water supplies would continue to operate existing storage and distribution facilities and utilize existing well facilities to augment supplies during periods of peak demand. Overall, it is anticipated that Authority surface water resources will ultimately provide 80 to 90 percent of regional domestic water requirements.

Accounting for water conservation measures to be implemented as mandated in the Authority charter, BBWA surface water requirements are forecast to average 25.65 MGD by the year 2040.

Regional Plan

The recommended regional plan provides for the construction of two surface water treatment plants, one plant each to serve the eastern and western portions of the region. It is anticipated that both plants and their respective distribution systems would be built incrementally over a 40 year period as required to match demands for Authority service.

It is proposed that Authority surface water treatment plant utilize a treatment process similar to the Galveston County Water Authority Treatment Plant at Texas City. This plant can be characterized as a conventional line softening plant utilizing catonic polymers for the coagulation of solids, with sand filtration and disinfection treatment processes. Both plants will be required to provide 30 MGD in terms of maximum day output.

The regional plan provides for the construction of over 75 miles of transmission mains varying in diameter from 8 to 36 inches. It is proposed that transmission mains follow existing roadway systems wherever feasible.

The estimated construction cost for all regional water plant and distribution facilities proposed by the plan is approximately 120 million dollars in terms of 1989 dollars. Based on an incremental construction of facilities, the unit cost of Authority water at the point of customer delivery is estimated to vary from an initial cost of $2.41/1000 gallons to $1.13/1000 gallons upon completion of all plan facilities.

WASTEWATER TREATMENT

Findings

Domestic wastewater treatment is currently provided by 14 public agencies at 15 sites within the region. Additionally, six privately owned plants provide service to mobile home developments within the eastern area of the region. Four of the publically owned plants have treatment capacities greater or equal to 1 MGD. The average daily volume of wastewater treated at all public and private facilities within the region was 6.25 MGD from August 1987 through July 1988.

Typically, all existing treatment plants within the region use a variation of the activated sludge treatment process. Recent records indicate that all existing plants are generally operating within state effluent standards.

Based on existing estimated per capita flow rates, forecasted population growth and accounting for reductions in wastewater flows associated with water conservation measures, public domestic wastewater flow for the region is forecast to average 18.42 MGD by the year 2040.

Regional Plan

The recommended regional plan identifies 14 proposed regional wastewater service areas, seven service areas each to service the eastern and western portions of the Authority region. Of the 14 identified service areas, seven of the service areas could be served by utilizing and expanding existing treatment facilities and collection systems within service area boundaries. The remaining seven service areas will require the construction of new plant and collection systems and are located primarily in developing or rural portions of the region.

New plant treatment processes would be dependent upon receiving water treatment standards but would be similar to existing plant facilities. Typically, new plant treatment units would consist of pretreatment units, liquid treatment units such as aeration basins and clarifers, and solids treatment units such as digestors, thickeners and sludge dewatering with landfill disposal.

The plan provides for the incremental construction of plant and collection facilities as required to accommodate customer demand. Plan collection facilities consist of gravity pipeline systems varying in diameter from 12 to 48 inches, with in-line lift stations as required to limit system depth.

The estimated construction cost for expanding existing plant systems and for constructing new service area facilities is approximately 115 million dollars in terms of 1989 dollars. The unit treatment costs for new service area facilities only were estimated to vary from an initial cost of $3.27/1000 gallons to $1.02/1000 gallons upon completion of all plan facilities.

RECOMMENDATIONS

Implementation of the regional plans for water supply and wastewater treatment presented in this report will require the support of local governments having jurisdiction within Authority boundaries. It is recommended that Authority representatives meet with local city and agency officials upon final plan approval, to inform these officials of plan provisions and to solicit backing and policies required for plan implementation.

I. GENERAL

1. INTRODUCTION

The Brazos Bend Water Authority (BBWA or Authority) was organized in the mid 1980's by the cities of Brookside Village, Manvel, Missouri City, and Pearland in order to provide planning for an anticipated rapid growth in area population and subsequent increased demand for municipal utility services. Specific goals of the member cities were to secure a long term source for area water supply, to protect and enhance water quality in regional streams and lakes, and to investigate the feasibility of regional facilities as a means of avoiding a proliferation of small scale, inefficient water supply and wastewater treatment plants.

The Authority was created by an act of the 69th Texas Legislature, regular session effective date June 14, 1985. The Authority is governed by five elected members, two from Missouri City, and one each from the cities of Brookside Village, Manvel and Pearland. The Authority may provide a variety of services including planning and research; developing plans for water supply, wastewater disposal, and solid waste facilities; and owning and operating said facilities. The Authority has no taxing powers and must secure all funds from gifts, grants and revenue from services.

A copy of the enabling legislation is reproduced in its entirety in Appendix D.

Planning Study

In March, 1988, the Brazos Bend Water Authority entered into contract with the Joint Venture of Lockwood, Andrews & Newnam, Inc./Walsh Engineering Inc. for the preparation of a comprehensive plan for regional water supply facilities and regional wastewater collection and treatment facilities. A total of 14 items of work were identified under the contract of services, as listed below:

Water Supply

- o Evaluate groundwater supplies, including aquifer characteristics and existing water wells, treatment units, pumping plants and storage facilities. Predict the remaining life of groundwater supplies and evaluate the impact of continued operations on area subsidence.

- o Prepare demographic studies and project demand requirements. Projections of demand will incorporate water savings identified in the water conservation plan.

- o Evaluate surface water supply alternatives.

- o Develop regional demand areas.

- o Design a treatment process for each surface water source and a system of transmission mains giving consideration of right-of-way corridors and routing.

- o Develop a conversion plan from solely groundwater to a combined supply of surface and groundwater.

- o Prepare a master plan report section on water supply facilities, incorporating a capital improvements program, including cost estimates, financing plan and debt service schedules.

- o Develop a conservation plan for the service area to emphasize more efficient use of water resources. Submit a draft of the water conservation plan to the Authority for review. Amend the draft report to incorporate Authority comments and submit the final plan report to the Authority for approval. Water savings identified in the water conservation plan will be incorporated in demand and loading projections.

Wastewater Collection and Treatment

- o Evaluate existing plant facilities, permits and associated treatment processes. Project the life expectancy of facilities, expansion possibilities, and operation and maintenance costs.

- Prepare demographic studies and project wastewater loadings which incorporate water savings identified in the water conservation plan.

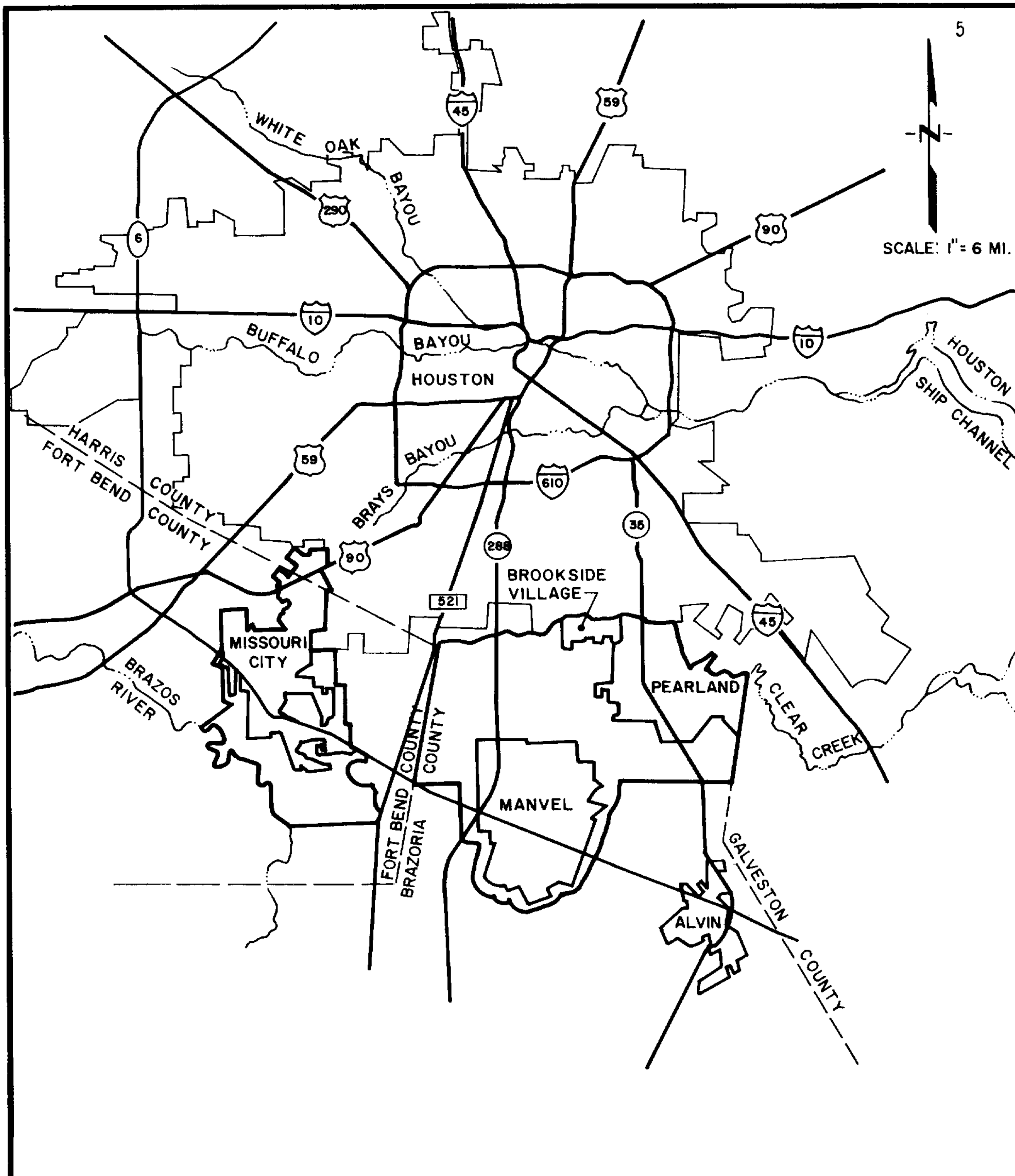
- Select suitable locations for treatment facilities.

- Develop a plan of right-of-way corridors and routing of outfall facilities.

- Develop state-of-the-art processes for each set of effluent standards.

- Prepare a master plan report section on wastewater facilities, incorporating a capital improvements program, including cost estimates, financing plan and debt service schedules.

The study area encompasses all land within the limits of the Authority which includes the municipal limits of member cities and all land within their respective extraterritorial jurisdiction limits (ETJ). As shown in Figure 1 on the following page, the study area consists of two separate areas, a westerly area including Missouri City and vicinity, and an easterly area encompassing Brookside Village, Manvel, Pearland and their respective ETJ's. Although not within the Authority's boundary, the area between the two study area segments was considered during the planning process. The study area encompasses approximately 150 square miles, is located in Brazoria, Harris and Fort Bend Counties, and had a total 1980 population of 53,100.



BRAZOS BEND WATER AUTHORITY

STUDY AREA

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A JOINT VENTURE

FIGURE No. 1

Report Organization

General information regarding the Authority, report organization, and a summary of population finding is presented in this chapter. Separate chapters are provided to report water supply and wastewater disposal study findings. Chapter II covers water supply and Chapter III wastewater disposal. Where appropriate, separate discussions are provided for eastern and western study area segments. Conclusions and recommendations for water supply and wastewater disposal studies are consolidated under Chapter IV.

Appendices following the body of the report contain detailed tabular data supporting information summarized within the report text, a water conservation report, a groundwater evaluation report, and legal information.

2. POPULATION STUDIES

The need for and scale of water supply and wastewater disposal facilities is by and large a function of population. For this reason, study area population potential was evaluated for the 1980 to 2040 planning period. Study area population studies were based on the 1980 U.S. census of population and housing; forecasts of county and municipal population developed by the Texas Water Development Board (TWDB); and a variety of other available information including city zoning maps, development status data, and regional growth trends. Population estimates, coupled with estimates of water use and wastewater disposal flow rates, form the basis for demand forecasts developed in following sections of this report.

1980 Census

The 1980 population of the BBWA study area was estimated to be 53,100. The study area includes all or part of 17 census tracts as shown in Figure 2, page 9. In cases of census tracts extending beyond BBWA boundaries, study area population was estimated from mapping showing 1980 building locations. Populations for 1980 for study area municipalities and other selected political subdivisions are listed in Table 1, on the following page. A summary of 1980 BBWA population by census tract and municipalities is shown in Table A-1, Appendix A.

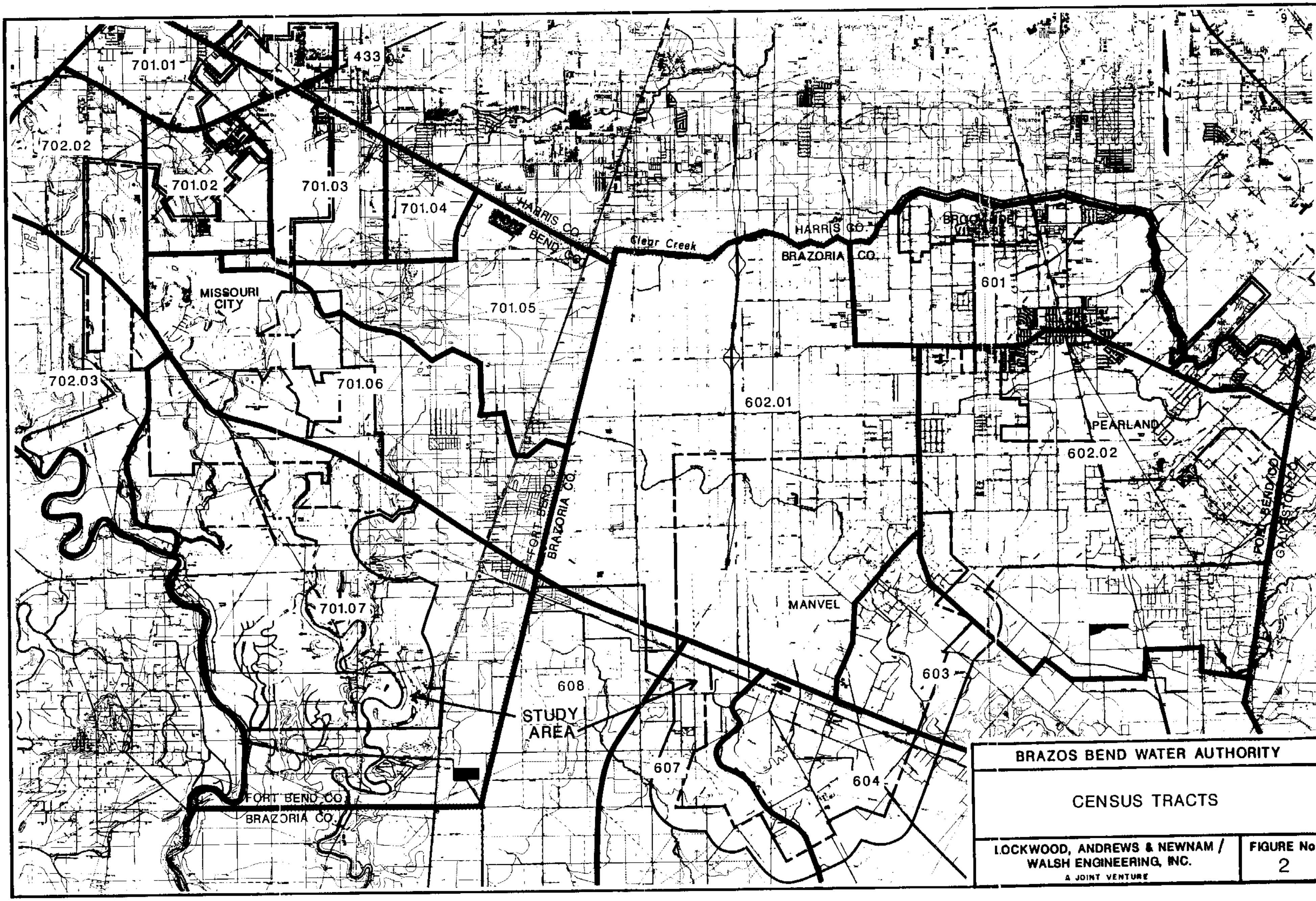
TABLE 1

SELECT POPULATIONS
1980 U.S. CENSUS OF POPULATION AND HOUSING

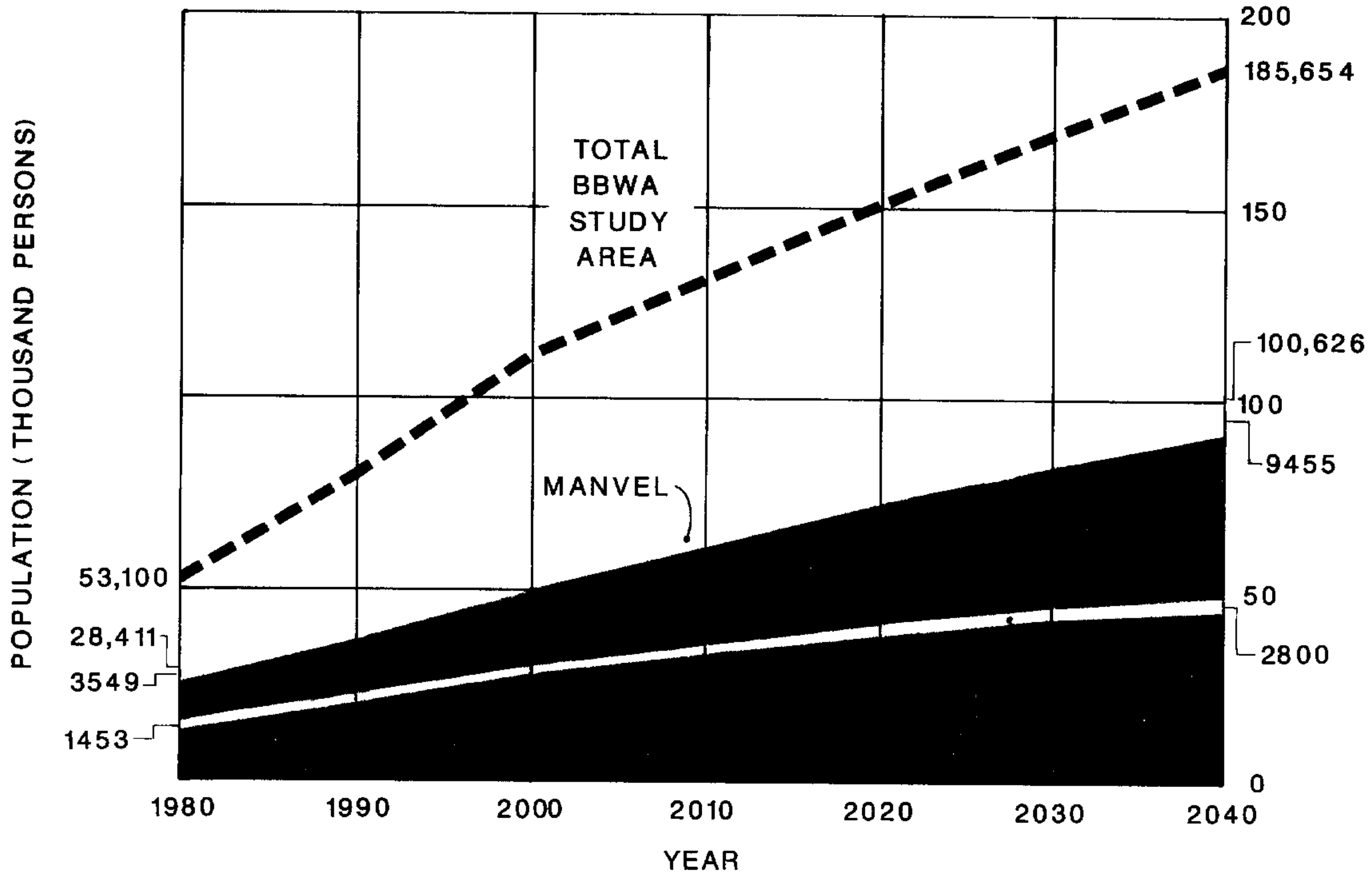
Cities, BBWA	Population
Brookside Village	1,453
Manvel	3,549
Missouri City	24,533
Pearland	13,248
Other	
Brazoria County	169,587
Fort Bend County	130,846
Harris County	2,409,544
City of Houston	1,594,086

TWDB Forecasts

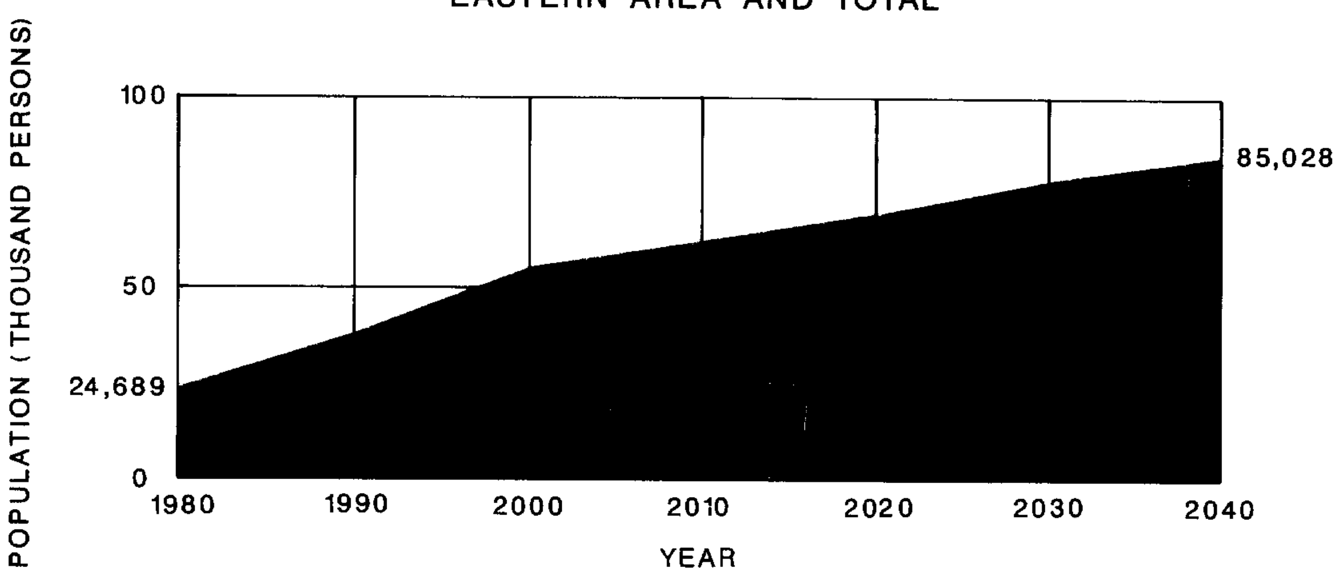
Texas Water Development Board Population Forecasts for Texas Counties and Municipalities, dated September, 1988 were selected as the basis for BBWA growth projections. These forecasts consisted of a high and low growth scenario, with the high growth series being used for this report. On this basis, study area population is forecasted to increase from 53,100 in the year 1980 to 185,654 by the year 2040. Study area population projections are graphically depicted in Figure 3, on the following page. A tabular presentation of forecasted BBWA population is shown in Table A-2, Appendix A.



BRAZOS BEND WATER AUTHORITY	
CENSUS TRACTS	
LOCKWOOD, ANDREWS & NEWNAM / WALSH ENGINEERING, INC. A JOINT VENTURE	FIGURE No. 2



EASTERN AREA AND TOTAL



WESTERN AREA

BRAZOS BEND WATER AUTHORITY

FORECASTED POPULATION
BBWA STUDY AREA

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FIGURE No.
3

Growth Distribution

As previously mentioned, planning for regional water supply and waste-water disposal facilities is dependent upon population. Equally important in this planning process is the locale of existing population centers and the probable location of future population growth.

Existing population centers were identified from census data and aerial photo studies. As a first step in identifying areas likely for future growth, areas with no growth or little growth potential were identified. Examples include non-residentially zoned parcels, floodways and swampy areas. Next, the remaining development potential of existing population generators such as utility districts was estimated from city planning data and land use documents. Finally, growth trends were identified upon consideration of recent growth patterns, transportation corridors, and proximity to employment centers.

Geographic locations within the study area identified as likely areas for rapid population growth include the southern portion of Missouri City, the City of Pearland, and land along the Route 288 corridor in Brazoria County. Estimates of the distribution of forecasted population by study area census tracts are shown in Table A-3, Appendix A.

II. WATER SUPPLY

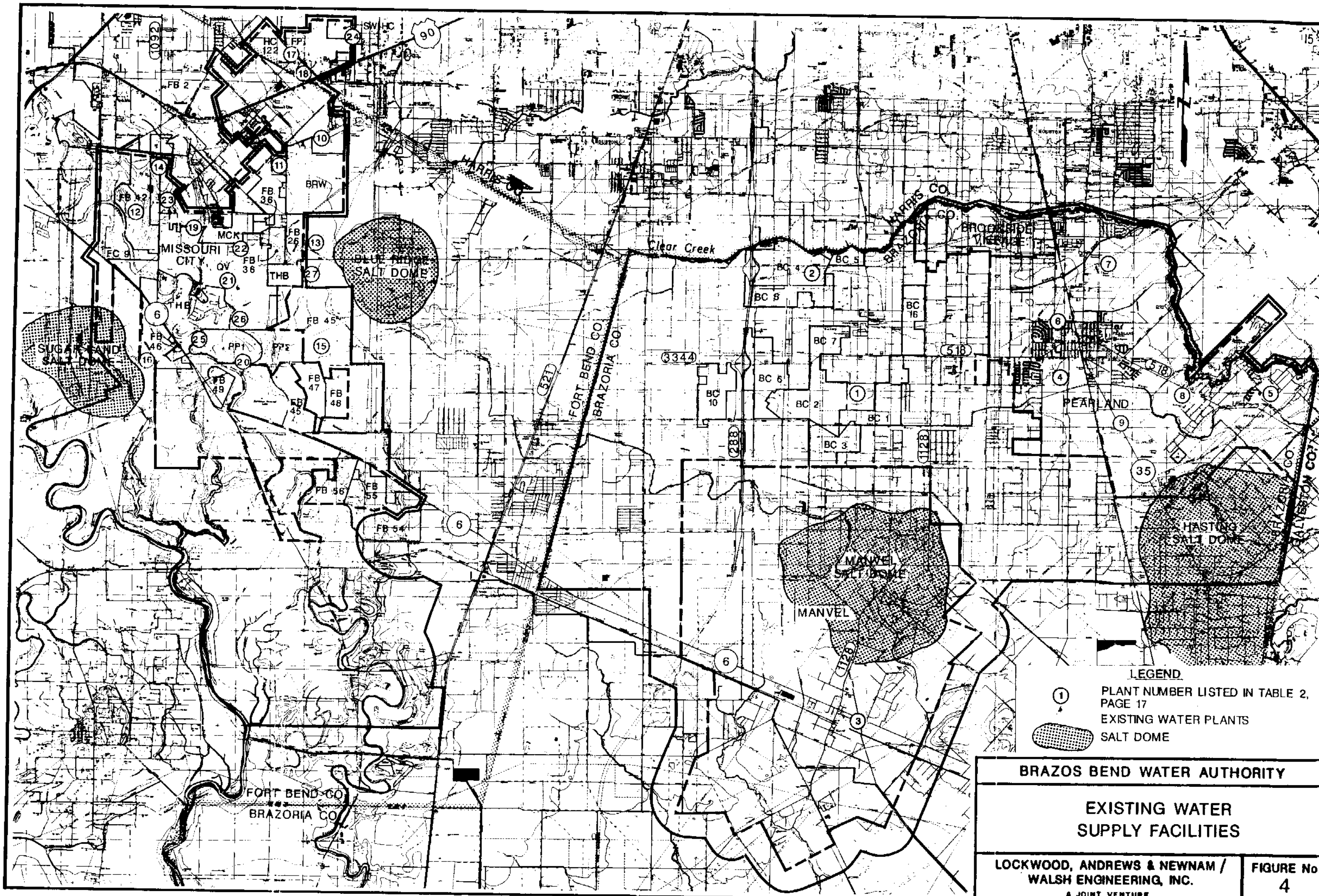
In light of recent large population increases in the southwestern United States, the State of Texas, and especially the metropolitan Houston area, management of dwindling water resources has become a major consideration and source of concern for area public water suppliers. This Chapter provides background information regarding existing sources of supply and existing public water facilities, sources and adequacy of future water supply resources, and presents a plan for regionalized water supply facilities to meet forecasted water demands for the BBWA Region through the year 2040.

1. CURRENT CONDITIONS

Currently, study area domestic water supplies are provided by 16 public agencies at 27 water production plant sites. With the exception of the City of Pearland, all public water supply systems are owned and operated by area utility districts. There are also a number of small, privately owned water supply systems providing water for mobile home parks, schools, strip centers, etc. Finally, a large area of the study is rural or largely undeveloped and relies on individually owned wells for water supply. The location of major public water supply plants within the study area is shown in Figure 4, on the following page. The plant location numbering system shown in Figure 4 is cross referenced to facility numbering shown in Table 2, page 17.

All public water suppliers within the study area utilize groundwater as the sole source of supply. Usually, area groundwater resources require only disinfection, typically chlorination, prior to domestic distribution. Typically, existing public water facilities consist of a well which penetrates one of two existing water supply aquifers beneath the study area, ground tanks for water storage, pumping equipment or elevated storage tanks for boosting and maintaining distribution system pressure, and a pipeline system bringing treated water to customers. Distribution pressures at plant sites usually range from 45 to 65 psi.

Information regarding existing public water supply facilities within the study area was obtained from the Texas Department of Health and water plant operators. Additionally, plant sites were visually inspected in the field. A total rated capacity of existing public well facilities within the study area is approximately 29,810 gallons per minute, with 14.19 million gallons of water storage capacity available. A summary of the capacities of major study area water supply facilities is shown in Table 2, on the following page. Detailed information regarding facility components are contained in Table A-4, Appendix A.



LEGEND

(1) PLANT NUMBER LISTED IN TABLE 2, PAGE 17

EXISTING WATER PLANTS

SALT DOME

BRAZOS BEND WATER AUTHORITY

EXISTING WATER SUPPLY FACILITIES

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FIGURE No. 4

TABLE 2

CAPACITIES
EXISTING PUBLIC WATER SUPPLY FACILITIES

SYSTEM OWNER	WELL (GPM)	STORAGE GROUND (MG)	STORAGE ELEVATED (MG)	PRESSURE MAINTENANCE BOOSTER PUMP (GPM)	PRESSURE MAINTENANCE TANK (GAL)
EASTERN AREA					
1. BC MUD 2[1]	1,100	0.50	---	1,360	15,000
2. BC MUD 5[2]	1,400[3]	0.50	---	1,800	30,000
3. Manvel Utilities	300	----	---	-----	2,500
4. Pearland, City	730	0.21	0.5	1,000	------
5. Pearland, City	710	0.50	---	1,000	20,000
6. Pearland, City	580	0.21	---	500	------
7. Pearland, City	1,130	0.42	0.5	2,100	------
8. Pearland, City	1,270	0.56	0.5	1,500	------
9. Pearland, City	950	0.56	---	1,500	------
WESTERN AREA					
10. Blue Ridge W MUD	1,200	0.35	---	3,000	30,000
11. Blue Ridge W MUD	1,200	0.10	0.5	1,500	20,000
12. First Colony 9	2,000	0.45	---	3,500	40,000
13. FBC MUD 26	1,350	0.50	---	2,000	25,000
14. FBC MUD 42	1,500	0.34	---	1,000	35,000
15. FBC MUD 47[4]	700	0.23	---	1,200	25,000
16. FBC MUD 46	700	0.23	---	1,200	25,000
17. HC WCID Fondren Road	1,690	0.53	---	1,850	25,000
18. HC WCID Fondren Road	750	0.20	---	1,000	10,000
19. Meadowcreek MUD	800	0.30	---	3,000	20,000
20. Palmer Plantation MUD[5]	1,300	0.42	---	1,500	20,000
21. Quail Valley UD	2,000	0.95	---	4,000	------
22. Quail Valley UD	1,500	0.75	---	3,000	------
23. Quail Valley UD	1,700	1.02	0.5	4,000	------
24. SW HC MUD 1	500	0.42	---	1,000	7,500
25. Thunderbird UD	1,200	0.64	---	2,600	24,000
26. Thunderbird UD	850	0.30	---	2,000	20,000
27. Thunderbird UD	700	0.50	---	1,950	20,000

[1] Also provides water to BC MUD 1
[2] Also provides water to BC MUD 4
[3] Includes 600 GPM capacity available from BC MUD 4
[4] Also provides water to FBC MUD 48
[5] Also provides water to FBC MUD 49

2. FORECASTED WATER DEMAND

Historical information regarding water utilization and forecasts of future study area water supply requirements are presented in this section.

Existing Use

Data regarding total water pumpage for existing study area water supply systems, for the months of August, 1987 through July, 1988, is presented in Table 3 on the following page. Water pumpage during this period totaled 2,980 million gallons, or approximately 8.17 million gallons per day. On January 1, 1988, the estimated population served by study area water supply systems was 53,325. Therefore, per capita water consumption was calculated to average 153 gallons per day.

Information regarding maximum day water usage and the ratio of maximum day use to average day use (peaking factor ratio) is also presented in Table 3. Peaking factor ratios are used in the sizing of certain water supply system components such as pressure maintenance equipment.

TABLE 3

WATER PRODUCTION
EXISTING PUBLIC WATER SUPPLY FACILITIES
AUGUST, 1987 THROUGH JULY, 1988[1]

SYSTEM OWNER	AMOUNT PRODUCED (MG)	AVERAGE DAY (MG)	MAXIMUM DAY (MG)	RATIO MAX/AV. DAY
EASTERN AREA				
BC MUD 2	85.8	0.24	0.80	3.41
BC MUD 5	126.3	0.34	0.64	1.90
Manvel Utilities		NOT AVAILABLE		
City of Pearland	963.0	2.64	4.51	1.73
Subtotal, Eastern Area	1,175.1	3.22		
WESTERN AREA				
Blue Ridge W MUD	292.4	0.80	2.22	2.77
First Colony MUD 9	69.3	0.19	0.66	3.45
FBC MUD 26	79.9	0.22	0.55	2.52
FBC MUD 42	29.9	0.08	0.38	4.60
FBC MUD 46		NOT IN SERVICE		
FBC MUD 47	38.6	0.11	0.58	5.42
HC WCID Fondren Road	113.2	0.31	0.61	1.96
Meadowcreek MUD	106.4	0.29	0.88	3.00
Palmer Plantation MUD	36.5	0.10	0.49	4.90
Quail Valley UD	619.3	1.70	3.87	2.28
SW HC MUD 1	42.8	0.12	0.35	2.92
Thunderbird UD	376.5	1.03	2.69	2.77
Subtotal, Western Area	1,804.8	4.95		
Grand Total, both Areas	2,979.9	8.17		

1 Source: Texas Department of Health, Monthly Operating Records.

Forecasted Water Demand

Forecasts of study area public water supply requirements from 1990 to 2040 are numerically presented in Table 4 below. Forecasts of water demand for existing and anticipated future water supply systems were separately developed.

For each existing public water supply system listed in Table 3, page 19, water demand forecasts were based on rates of water consumption reported during the August, 1987 through July, 1988 record period and forecasted population growth within these system service areas. Water demand forecasted for anticipated future water supply systems, such as may be installed by municipalities and utility districts currently lacking facilities, were based on the composited averaged water consumption rate of 153 gallons per day per capita and forecasts of population to be served. Detailed information regarding forecasted public system water demands for the study area is shown in Table A-5, Appendix "A". Forecasts of public water supply requirements summarized in Table 4, are prior to the implementation of water conservation measures.

TABLE 4

FORECASTED WATER DEMAND
PUBLIC WATER SUPPLY SYSTEMS
1990 - 2040

Average Day
(In Million Gallons)

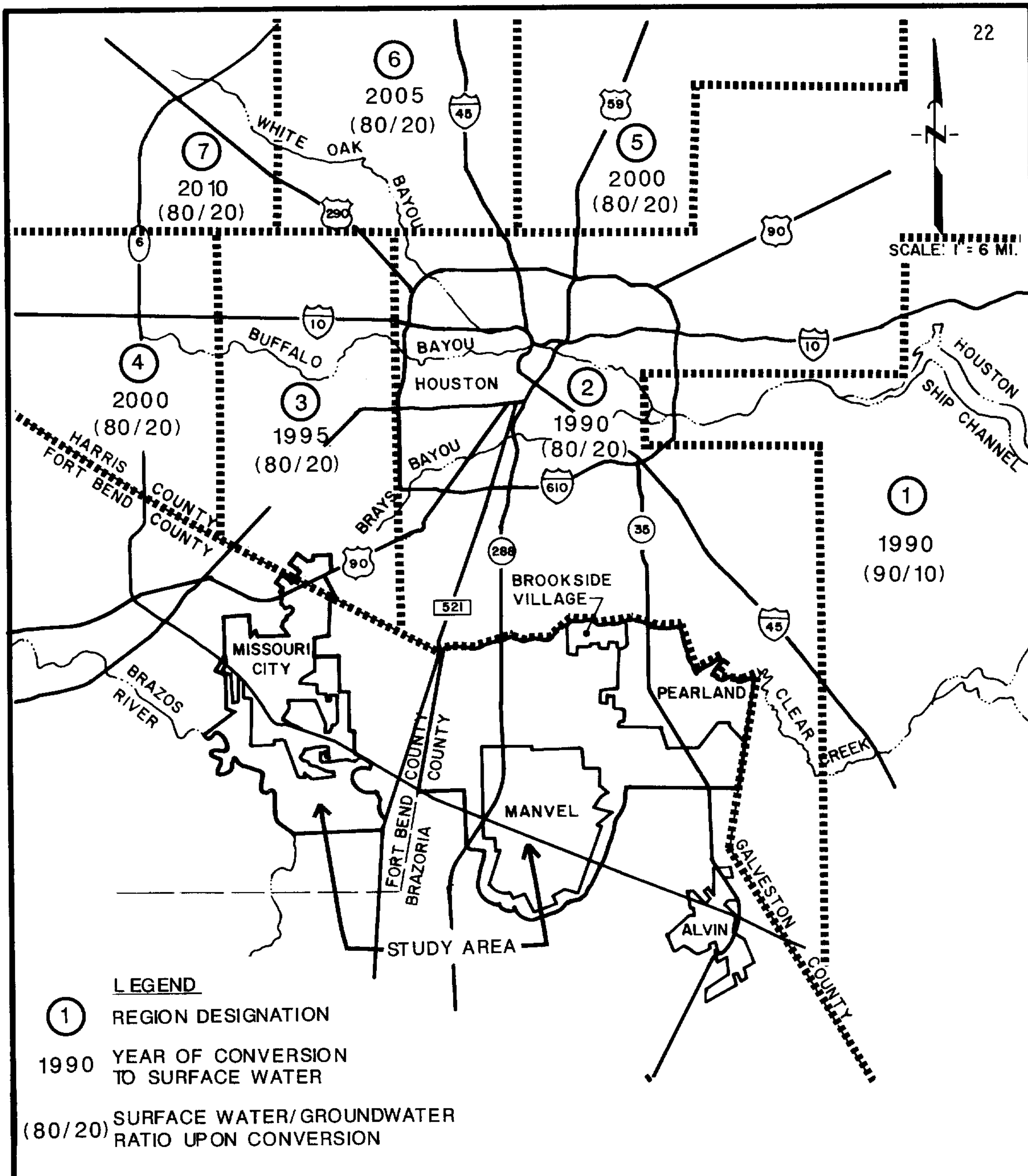
	1987/88	1990	2000	2010	2020	2030	2040
Eastern S.A.	3.22	3.67	7.00	8.89	10.74	12.41	13.74
Western S.A.	4.95	5.49	8.68	9.71	10.82	12.19	13.06
TOTAL	8.17	9.16	15.68	18.60	21.56	24.60	26.80

3. GROUNDWATER RESOURCES

Historically, groundwater resources have been used to satisfy demands along the Texas Gulf Coast. In the last several decades however, the rapid growth of the Houston Metroplex has taxed regional groundwater resources and has resulted in accelerated groundwater declines and surface subsidence rates.

The effects of this problem were first felt in regional coastal areas as evidenced by an increased frequency and magnitude of tidal flooding associated with land subsidence. The Harris-Galveston Coastal Subsidence District (HGCSD) was created by the 64th Texas Legislature in recognition of this problem. An HGCSD mandated conversion from groundwater to surface water use has successfully controlled subsidence in coastal areas. Recently, mitigation of subsidence and groundwater declines within the two county HGCSD area has shifted to inland areas. A conversion time schedule for inland areas of the subsidence district is shown in Figure 5 on the following page. Although the BBWA study area is not within the jurisdiction of HGCSD, the impact of the ongoing conversion in areas adjacent to the BBWA study area will benefit BBWA groundwater resources.

Recently, the 71st Texas Legislature approved the creation of a subsidence district in Fort Bend County. While no objectives are available at this time, it is likely that the proposed subsidence authority will provide further impetus for the use of surface water in Fort Bend County.



SOURCE:
DISTRICT PLAN, HARRIS-GALVESTON COSTAL SUBSIDENCE DISTRICT, NOV. 1985

BRAZOS BEND WATER AUTHORITY

HGCSD SURFACE WATER CONVERSION PLAN

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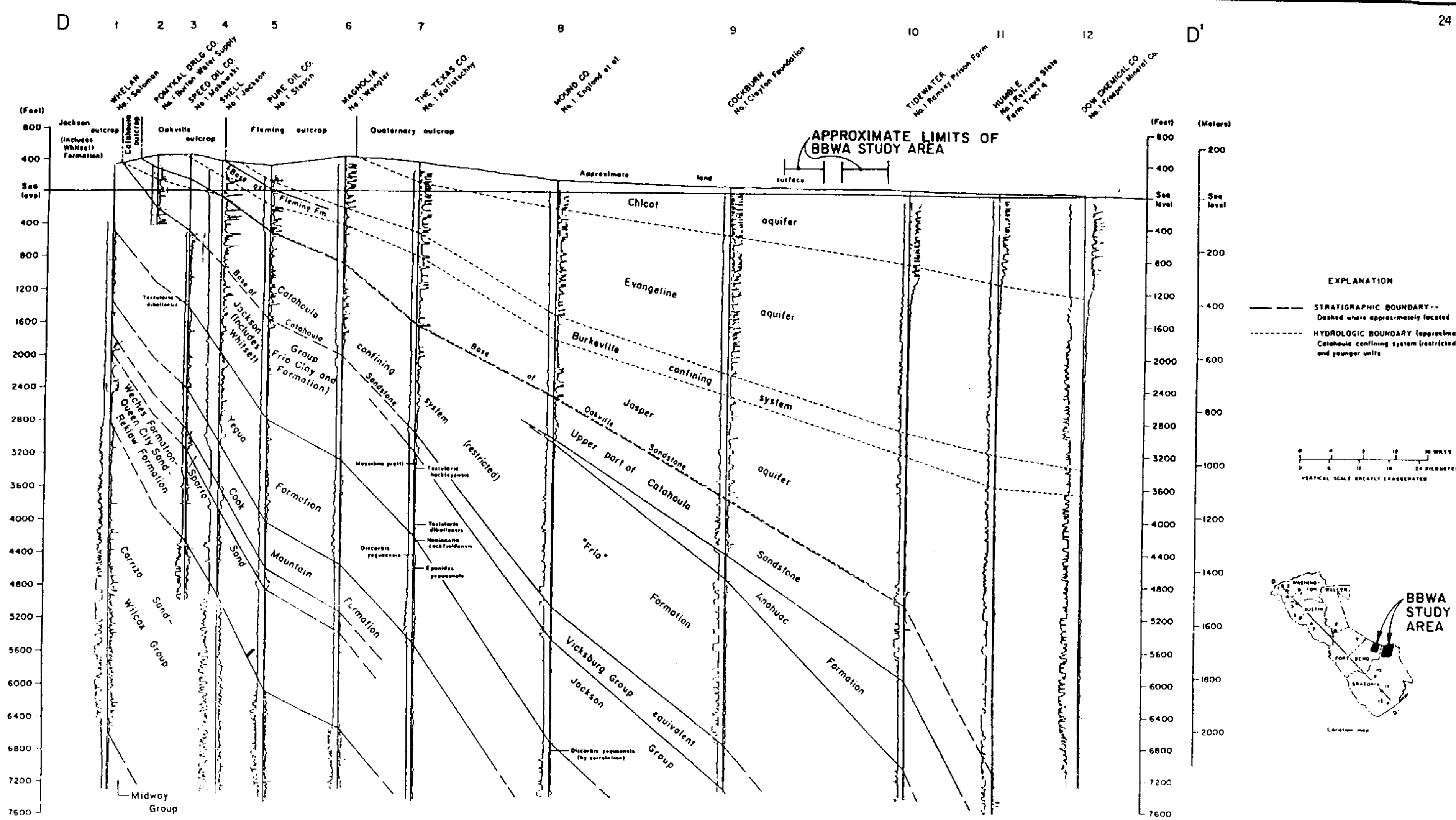
FIGURE No. 5

Hydrogeology

The study area is underlain by three water bearing zones, commonly referred to as aquifers. As shown in Figure 6 on the following page, and in decending elevation from the ground surface, study area aquifers are known as the Chicot, Evangeline, and Jasper Aquifers.

The two aquifers closest to the land surface, the Chicot and Evangeline Aquifers, are the primary source of study area groundwater supply. The Chicot Aquifer varies in thickness from 700 feet to 850 feet and generally produces smaller yields than the underlying Evangeline Aquifer. The Evangeline Aquifer varies from 1800 to 2050 feet in thickness within the study area and is the principal source of municipal water supply. Water quality within this aquifer is excellent requiring only disinfection prior to distribution for human consumption. The Jasper Aquifer generally is of poor quality due to the presence of inorganic salts and is not used as a water quality source within the study area.

Four salt domes are located within or in close proximity to the study area (see Figure 4, page 15). Water produced from wells over or near these geologic formations typically have a high saline content. As aquifer water pressures decline, water of high salt content will tend to migrate outward from salt dome locations.



Stratigraphic and Hydrogeologic Section D-D'

Source Texas Department of Water Resources Report 236 July, 1979

BRAZOS BEND WATER AUTHORITY

HYDROGEOLOGIC CROSS SECTION

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FIGURE No. 6

Impact of Future Groundwater Use

An investigation of groundwater resources for the BBWA study area was performed by the firm of McBride-Ratcliff and Associates, Inc., Houston, Texas. (See Appendix C). The report of this investigation presents information regarding area geology and hydrogeology and summarizes computer modeling results which forecast the effects of continued groundwater pumpage on area groundwater levels and surface subsidence.

Computer modeling was performed for two area groundwater use scenarios. Both scenarios considered the influence of groundwater useage in areas immediately adjacent to the BBWA study area (regional groundwater use), and recognized the impact of the HGCSD mandated conversion to surface water use within regional areas. With this in mind, modeled groundwater use scenarios were as follows:

Groundwater Use Scenario

Groundwater will be used to meet all BBWA public water demand through the year 2040.

Surface Water Use Scenario

Area conversion to surface water will begin by the year 2000. By 2020, surface water sources will provide approximately 90 percent of public water supplies.

Computer models used to predict groundwater level declines and subsidence were calibrated using existing well log data and historical subsidence data.

Forecasted study area groundwater declines and total subsidence from 1990 through 2040 are summarized in Table 5 below. Generally, model results indicate that the utilization of groundwater in regional areas north of the BBWA study area control study area groundwater and subsidence rates. On the average, conversion to surface water use within the study area could reduce groundwater declines by thirty feet (30') and subsidence by one half foot (0.5') during the planning period.

TABLE 5

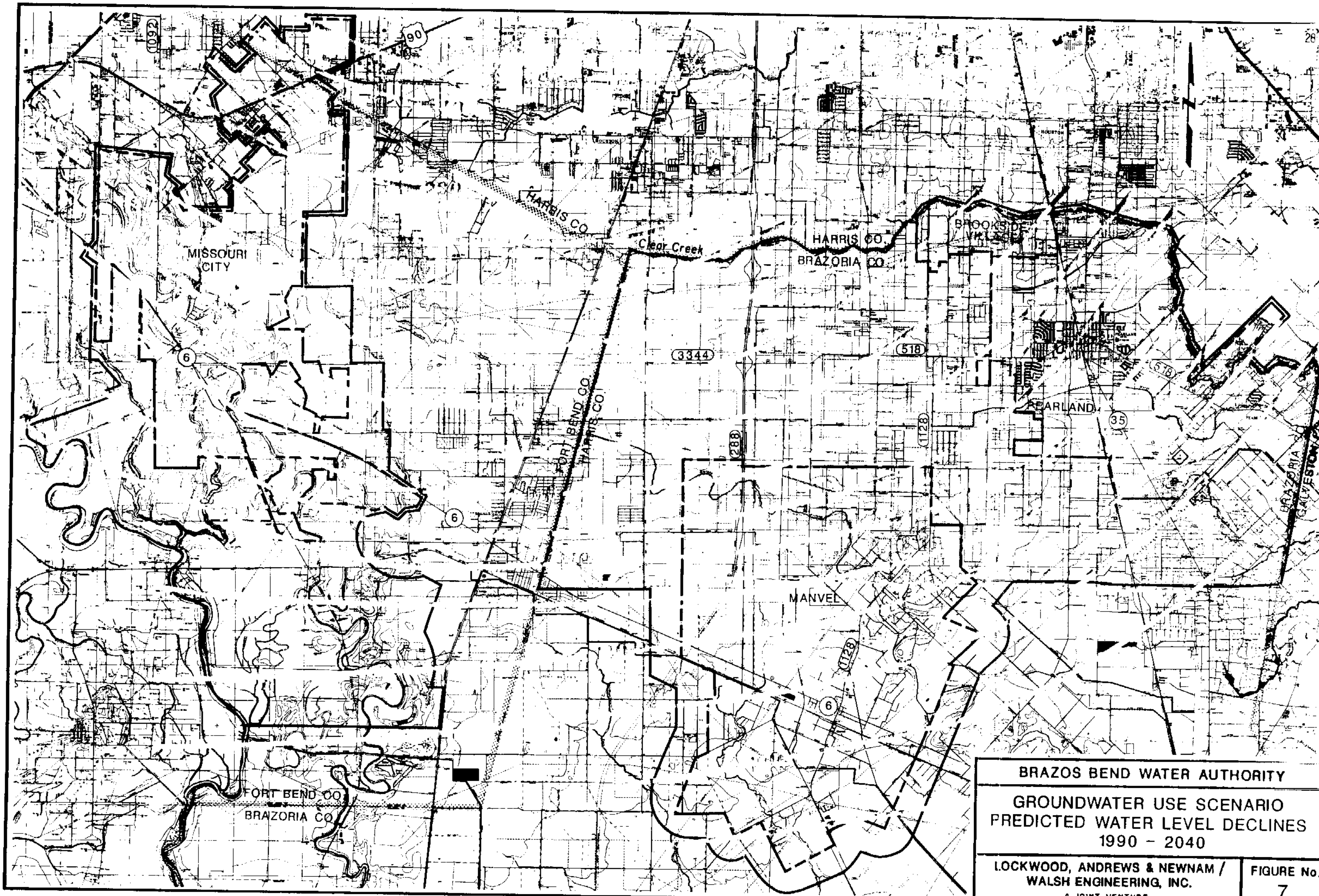
FORECASTED
GROUNDWATER DECLINE/SUBSIDENCE

	EASTERN AREA	WESTERN AREA
	(RANGE IN FEET)	
GROUNDWATER DECLINE[1]		
Groundwater Scenario	82 - 208	110 - 252
Surface Water Scenario	78 - 180	106 - 250
SUBSIDENCE		
Groundwater Scenario	1.4 - 4.4	3.6 - 4.7
Surface Water Scenario	1.2 - 4.0	3.0 - 4.2

[1]Evangaline Aquifer

Forecasted groundwater decline contours, by water use scenario, are shown in Figure 7 and 8, pages 28 and 29. Forecasted subsidence contours, by water use scenario, are shown in Figure 9 and 10, pages 30 and 31.

The McBride-Ratcliff study concludes that although groundwater declines are significant during the study period, groundwater resources would be adequate to meet BBWA public water demands.



BRAZOS BEND WATER AUTHORITY

GROUNDWATER USE SCENARIO
PREDICTED WATER LEVEL DECLINES
1990 - 2040

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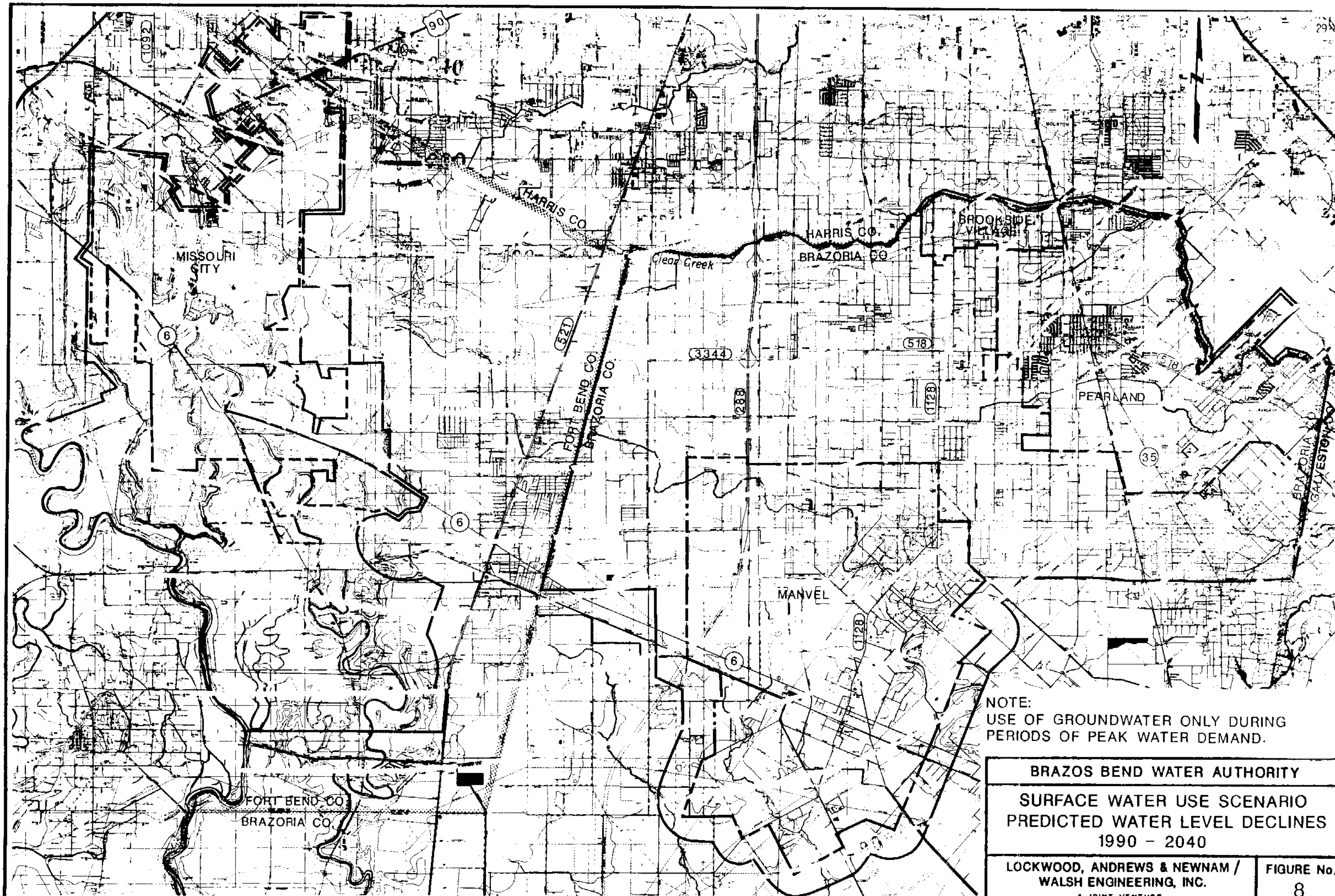
A JOINT VENTURE

FIGURE No. 7



NOTE:
USE OF GROUNDWATER ONLY DURING PERIODS OF PEAK WATER DEMAND.

BRAZOS BEND WATER AUTHORITY

SURFACE WATER USE SCENARIO
PREDICTED WATER LEVEL DECLINES
1990 - 2040

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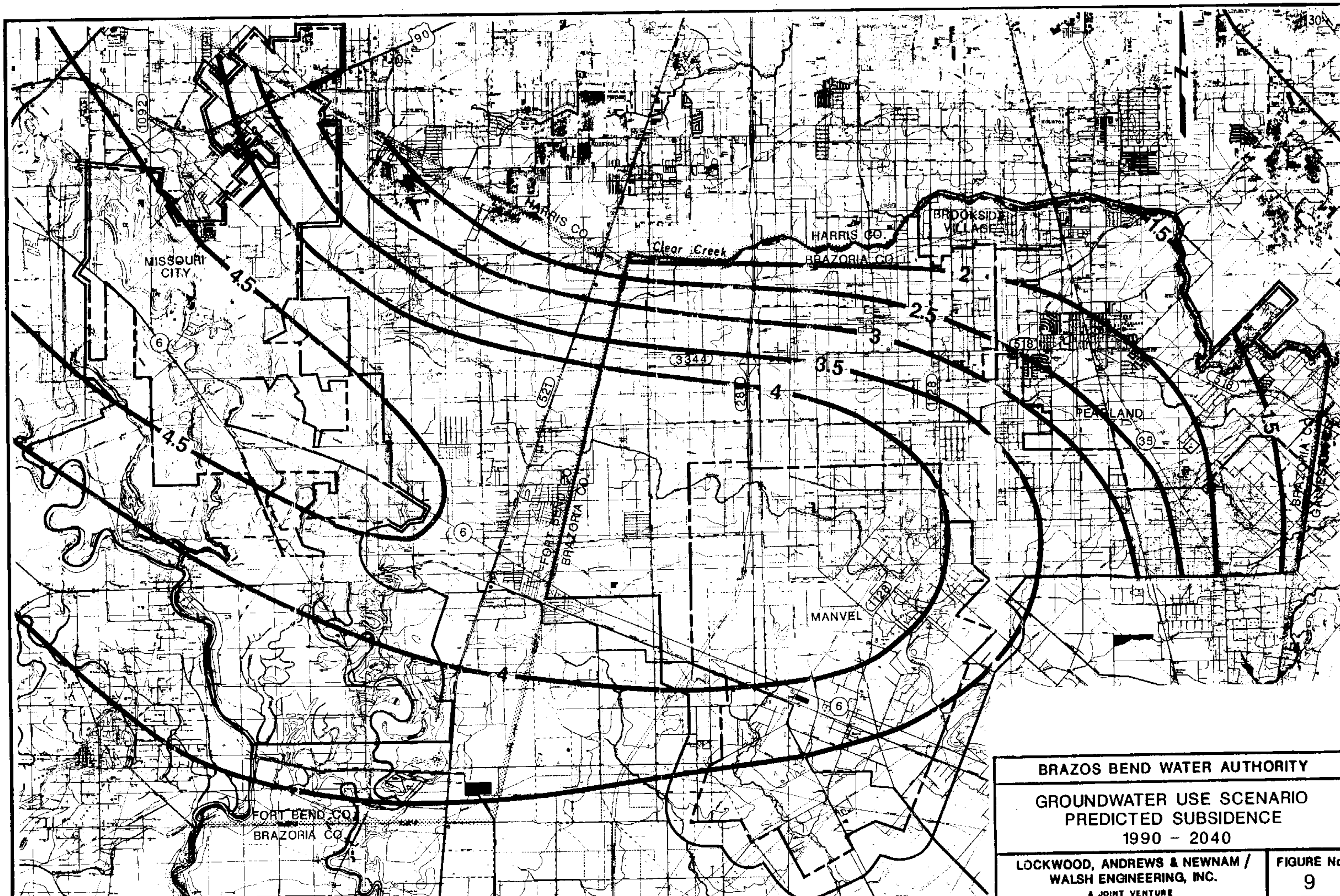
FIGURE No. 8



BRAZOS BEND WATER AUTHORITY

GROUNDWATER USE SCENARIO
PREDICTED SUBSIDENCE
1990 - 2040

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FIGURE No. 9

4. SURFACE WATER RESOURCES

Surface water available from the Galveston County Water Authority (GCWA), the Brazos River Authority (BRA) and the City of Houston (Houston) are identified as potential sources for BBWA supply. Water from the GCWA and BRA sources would require treatment prior to BBWA distribution, whereas treated water only is currently available from the City of Houston.

A description of the location of each potential source of supply in relation to the study area, and estimates of amounts of supplies available and cost of purchase are provided below. The locations of potential surface water supply sources are illustrated in Figure 11, page 34.

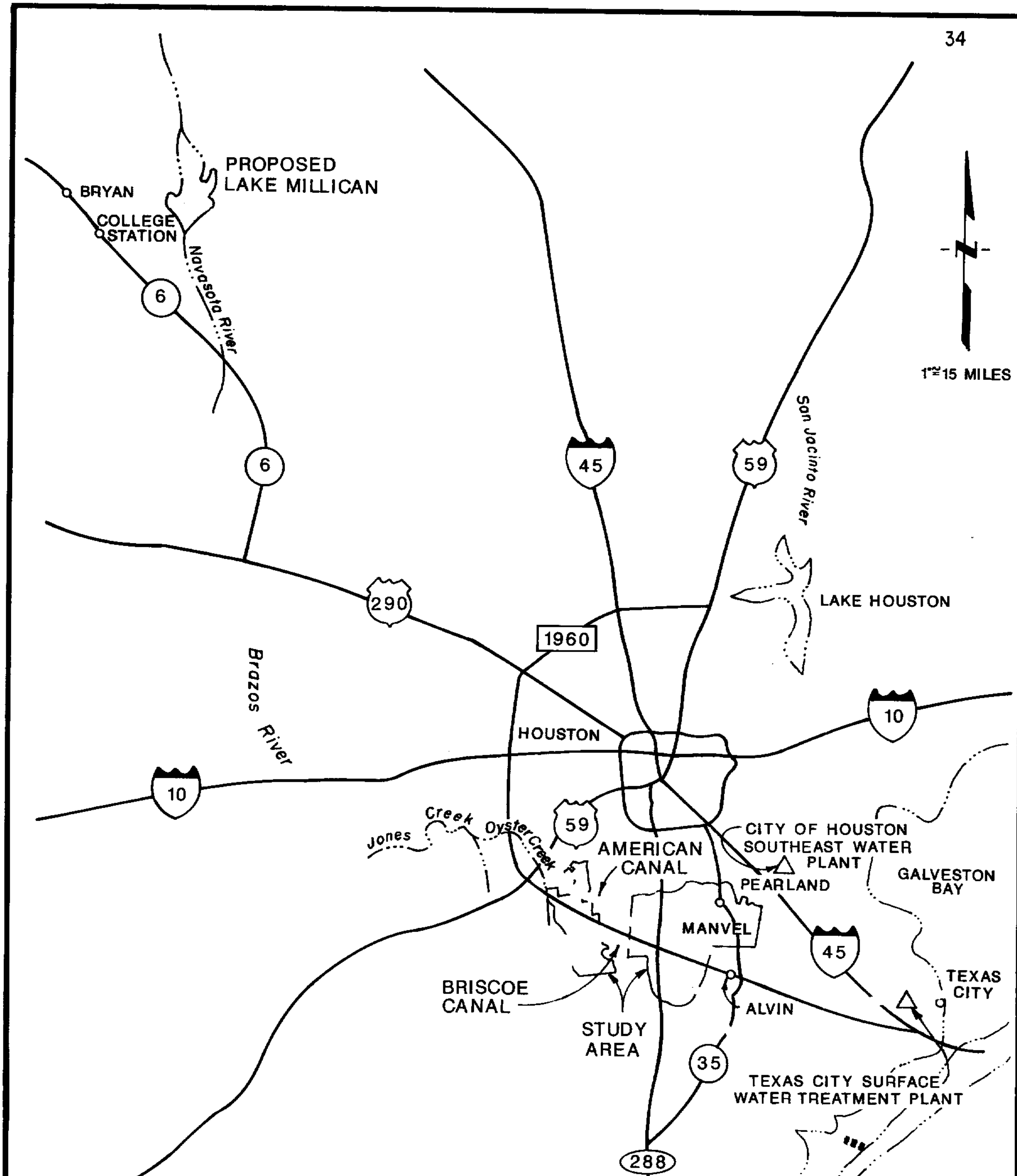
Current Sources

Surface water resources owned by the Galveston County Water Authority are currently available in two canal systems which traverse the study area from a source on the Brazos River to the west to an eastern terminus near Galveston Bay. These canals, known as the American and Briscoe Canals or "A" and "B" canals, were previously owned and operated by the Brazos River Authority and were used primarily to supply agricultural irrigation water. As shown in Figure 11, both canals are ready accessible within the BBWA study area. Currently, GWCA has approximately 60 mgd of raw surface water rights available at an estimated cost of $88.00 per million gallons.

Currently, the Brazos River Authority does not have sufficient unallocated water rights to meet the forecasted water requirements of the BBWA study area. Consequently, in order to provide adequate supplies to BBWA, it would be necessary for BRA to construct a new reservoir within the

Brazos River System, such as proposed Lake Millican near Bryan, Texas. Preliminary estimates indicate 203 mgd could be provided by Lake Millican; however, there are currently no plans to proceed with development of this project. It is estimated that the cost of BRA supplied raw water will exceed $194.00 per million gallons.

Treated surface water from the San Jacinto River system is available at the City of Houston's Southeast Treatment Plant located north of the City of Pearland. Limited amounts of water are available at this plant (3 mgd by 1995) and expansion of the SE plant or construction of a new plant in southwest Houston would be required to meet forecasted BBWA requirements. The current cost of treated city water supplies to resale customers is $2.20 per thousand gallons.



BRAZOS BEND WATER AUTHORITY

SURFACE WATER SOURCES

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A JOINT VENTURE

FIGURE No. 11

Source Selection

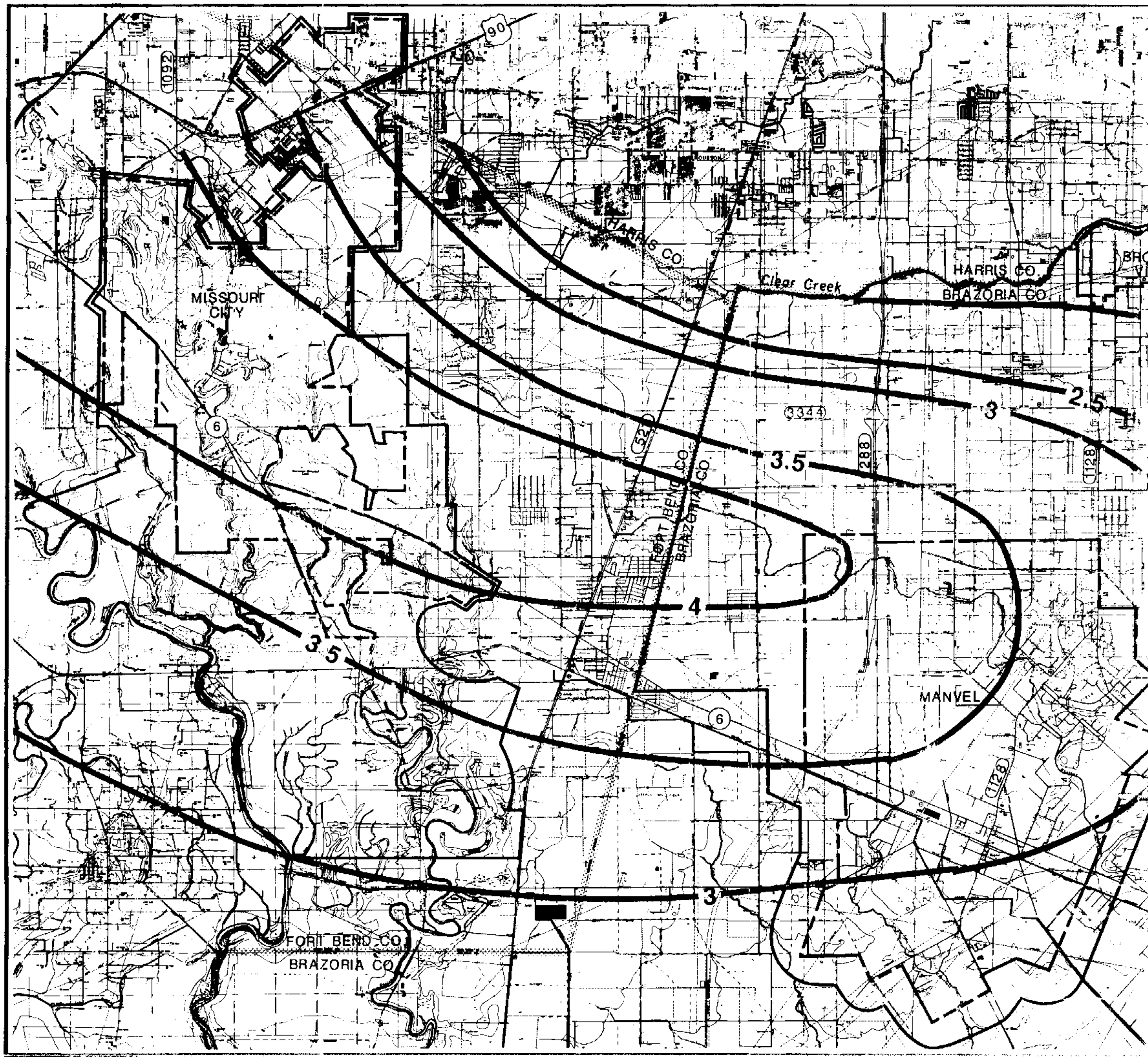
Upon consideration of the accessibility, adequacy of current supplies, and current estimates of cost, surface water supplies owned by the Galveston County Water Authority are considered the most likely source for BBWA use. GCWA currently treats water from the canal sources proposed for BBWA supplies at a plant site near Texas City, Texas. Canal water quality is similar to constituents of the Brazos River source and is treated at the GCWA Texas City Plant by conventional means to a level suitable for drinking water use. Additionally the Texas City plant uses a lime softening treatment process with sand filtration. Typical values for raw and finished water at the GCWA Texas City Plant are shown in Table 6 below:

TABLE 6

TYPICAL RAW AND FINISHED WATER CHARACTERISTICS AT THE GCWA TEXAS CITY WTP(1)

PARAMETER	RAW	FINISHED
pH (pH units)	8.6	9.2
Tubidity (NTU)	46	0.13
Hardness	192	112
Alkalinity	148	57
Calcium	67.3	38.5
Magnesium	5.9	3.9
Iron	1.66	0.04
Dissolved Solids	100	283
Total Solids	443	283
DO	7.3	8.3
Fluoride	0.42	0.68

(1) All values are in mg/l unless otherwise noted.



NOTE:
GROUNDWATER USE ONLY DURING PERIODS OF PEAK WATER DEMAND.

BRAZOS BEND WATER AUTHORITY

SURFACE WATER USE SCENARIO
PREDICTED SUBSIDENCE
1990 – 2040

LOCKWOOD, ANDREWS & NEWNAM / WALSH ENGINEERING, INC.
A JOINT VENTURE

FIGURE N
10

A facility plan for BBWA regional water supply facilities and associated estimates of cost, as described in following sections of this chapter, are based on the use of GCWA water as a source of BBWA supply.

5. CONVERSION PLAN

The continued use of groundwater as the primary water supply in future years will accelerate the undesirable results already experienced by BBWA's neighbors to the north and east. It is prudent therefore, that a plan be developed to convert from a primary source of groundwater to a primary source of surface water. A plan for conversion is presented in this section.

Basis

A variety of factors could influence public water agencies to convert to a surface water source of supply. Certainly the need to secure a reliable, long-term source of water supply in light of declining water tables and subsidence problems would be a primary consideration. Declining water tables will require the lowering of well pumps which could be costly, especially for owners of older well systems. Also, surface subsidence and groundwater declines could cause a deterioration of groundwater quality due to surface contamination and brackish water encroachment.

Further regulatory constraints on well drilling are most certainly forthcoming. This is evidenced by the passage of the safe drinking water act, 1986 amendments, which among other things, established additional regulatory requirements for drinking water wells and protection of sole source aquifers.

Ultimately, most decisions regarding conversion to surface water will probably be decided by financial considerations. These factors include the cost of maintaining existing well facilities, the relative cost of surface water supplies compared to the cost of groundwater production, and commitment of monetary resources and tax considerations for undeveloped properties proposed for development.

Schedule

It is not currently feasible to determine a scheduled demand for BBWA services. It is anticipated, however, that sufficient impetus will exist such that study area surface water conversion will begin by the year 2000. Additionally, it is anticipated that Authority plant and pipeline facilities will be incrementally constructed and that facility requirements will generally keep pace with the study area population base.

Proportion

The amount of surface water purchased and the proportion of surface to groundwater utilized by public water supply entities will be dependent on many of the operational and financial considerations previously discussed. Ideally, existing public water suppliers opting to purchase BBWA surface water would continue to operate existing distribution and storage facilities and would utilize existing well facilities to augment surface water supplies during periods of peak water demand. Proposed water supply systems could find it economically feasible to utilize BBWA surface water as a sole source of supply. Overall, it is anticipated surface water will ultimately supply 80 to 90 percent of study area water demand.

Surface Water Requirements

Authority surface water requirements, as required to service all potential public supply customers, beginning in the year 2000, are summarized in Table 7 below. This forecast is based on water demand requirements of existing and anticipated future water supply systems within the study area, as detailed in Table A-5, Appendix A and summarized in Table 4, page 20, less a nominal 4.3 percent water savings forecasted through implementation of Authority water conservation programs. (See Water Conservation Plan, Appendix B).

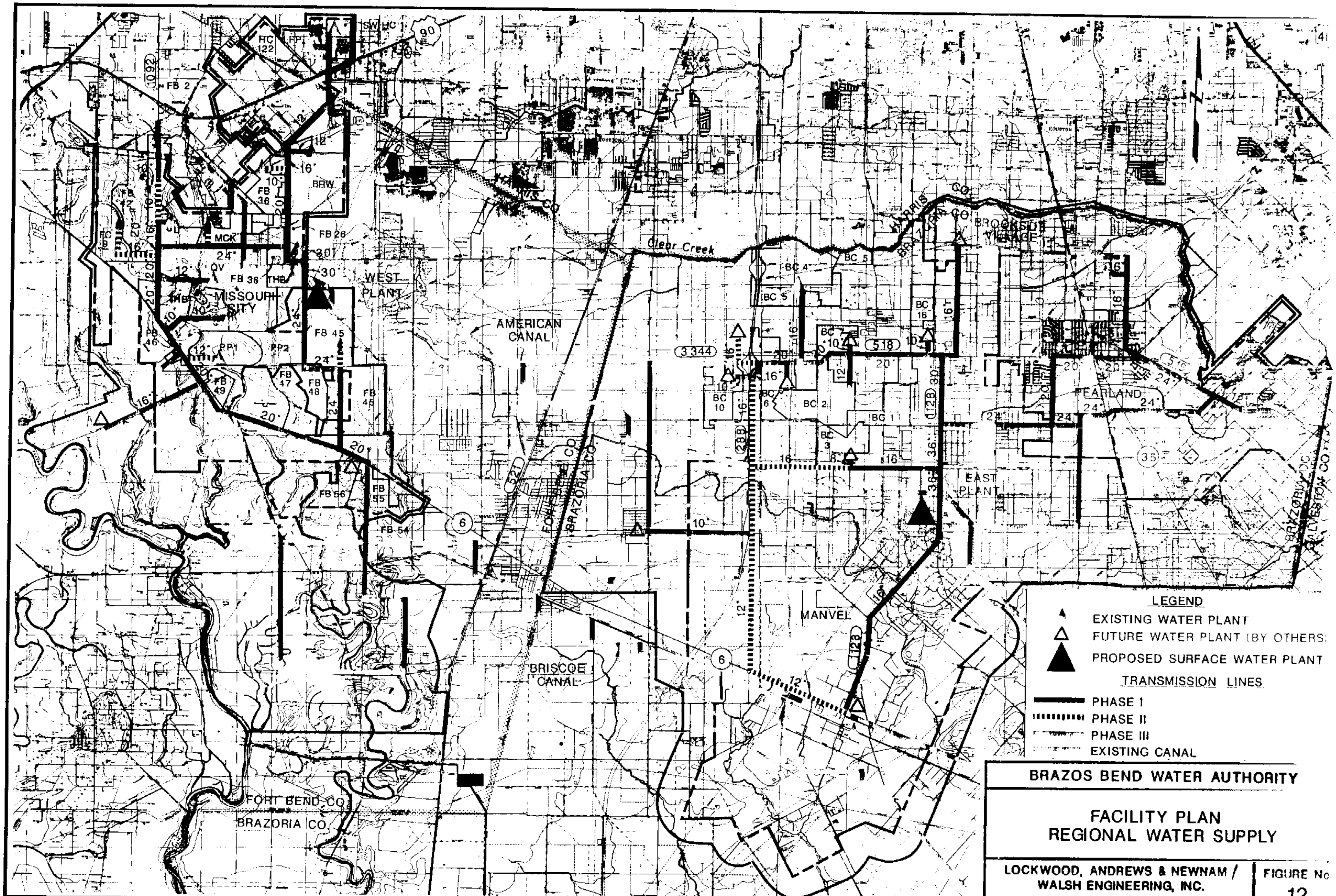
TABLE 7

BBWA SURFACE WATER REQUIREMENTS
2000 - 2040

Average Day (In Million Gallons)	2000	2010	2020	2030	2040
Eastern Area	6.70	8.51	10.28	11.88	13.15
Western Area	8.31	9.29	10.35	11.66	12.50
TOTAL	15.01	17.80	20.63	23.54	25.65

6. FACILITY PLAN

A phased facility plan for providing surface water supply to all potential BBWA customers within the study area is presented in this section. This plan anticipates that initial requests for service will be from owners of existing public water supply facilities servicing existing population centers. Future expansion of plant and pipeline facilities would be required to keep pace with predicted population growth and would primarily service potential customers in BBWA areas anticipated for development. A three phase plan for regional BBWA water facilities is shown in Figure 12 on the following page.



BRAZOS BEND WATER AUTHORITY

FACILITY PLAN
REGIONAL WATER SUPPLY

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FIGURE No
12

Plant Facilities

As shown in Figure 12, two surface water treatment plants will be required to service potential BBWA customers. Due to the considerable distance between eastern and western regions of the study area, it was not considered economically feasible to service the entire BBWA area from a single plant location. Both eastern and western plants are centrally located within their respective areas, are adjacent to the most likely source of surface water supplies, the Galveston County Water Authority Canal System, and could serve population centers adjacent to current Authority boundaries such as the cities of Alvin and Sugar Land. Both site locales were inspected and were found to be easily accessible, had power nearby, and seemed to have adequate land available for plant facilities.

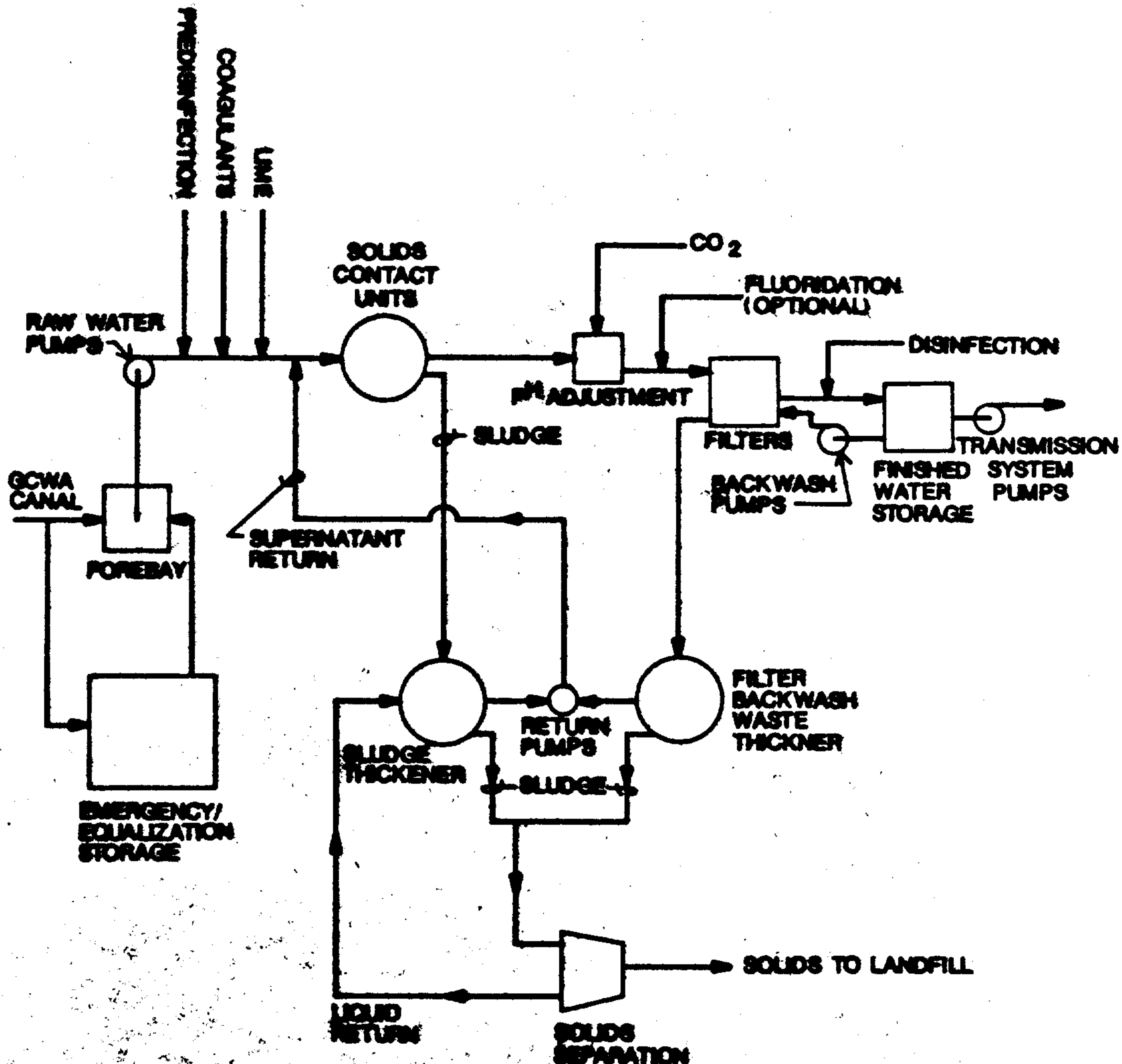
In order to supply forecasted average day water supplies to all potential BBWA customers, both BBWA treatment plants will ultimately be required to produce 30 mgd in terms of maximum day output. In order to manage capital outlay, it is proposed that each plant be designed to provide for construction of multiple treatment trains.

Each treatment plant should also include raw water storage facilities in the event of interruption of surface water supplies. It is proposed that seven days of storage be provided in earthen reservoirs adjacent to plant sites. Reservoirs could be constructed in two equal stages and should be lined to minimize water loss from seepage.

Land requirements for plant and storage reservoirs are estimated to be 98 acres for each plant site.

Plant Processes

A proposed BBWA treatment plant process is schematically shown in Figure 13, on the following page. The selected process is similar to the process used at the Galveston County Water Authority Plant at Texas City. The GCWA WTP is a conventional lime softening plant with sand filtration. Coagulation of solids is promoted by the use of cationic polymers. Chlorine dioxide is used for pre-disinfection and chlorine gas is used for post disinfection. Solids resulting from the treatment process are wet hauled for land disposal. The Texas City plant uses water from the same source proposed for BBWA supply and is providing excellent water treatment. Ultimately, the treatment process selected for BBWA facilities will be dependent upon prevailing regulatory requirements, available technologies, and customer requirements.



BRAZOS BEND WATER AUTHORITY

PROPOSED TREATMENT PROCESS
GCWA WATER

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FIGURE No. 13

Transmission Facilities

A system of water transmission pipelines will be required to deliver water from BBWA plant sites to potential BBWA customers. The proposed facility plan provides for a phased construction of transmission facilities as would be required to service all potential BBWA customers. Pipeline size selection is based on forecasted maximum day flow requirements and pressure requirements for delivery to customer ground storage facilities. As set forth in Section 5, distribution to individual water users and supplemental supplies required during periods of peak use are considered the responsibility of BBWA customers.

The Facility Plan provides for the construction of approximately 75 miles of transmission pipelines varying in size from 8 to 36 inches in diameter. Transmission pipeline routing follows existing roadway systems wherever feasible. Lines shown in currently undeveloped area of the study area are schematic in nature and are shown only to account for potential future pipeline costs.

Where distribution pipeline construction cannot be accommodated within existing roadway right-of-way, pipeline easements will need to be secured. Easements for pipeline construction should be 25 feet in width with a 15 foot width retained for permanent use.

Implementation

Due to uncertainties regarding requests for BBWA service, it is not practical at this time to present a schedule for construction of BBWA facilities. Even if requests for service are secured, BBWA will need to consider the locale and magnitude of supplies requested prior to committing to a program of construction.

There are, however, several topics that could be presently considered by the Authority. The first would be the reservation of surface water rights. In general, regional surface water rights are presently available on a first come - first served, take and pay basis. Reservation of water rights would require a commitment by local governments to cover purchase expenses until such time that costs could be passed on to BBWA customers. Another current consideration could be seeking policies in order to secure corridors or easements for future transmission pipelines. Again, local governments would most likely be required to act as agents for the Authority in this regard.

Finally, if sufficient demand for service is secured or likely to be secured, sufficient time should be allowed for construction of plant and pipeline systems. It is estimated that 5 years will be required to plan, design and construct initial BBWA facilities.

7. FINANCIAL

Initially, decisions regarding the feasibility of installing the phased regional surface water supply systems described in the preceding section will probably be based on financial considerations. In order to provide a basis for financial assessment, estimates of costs to design, construct and operate BBWA water supply facilities are developed in this section.

Cost Estimates

Table 8 below summarizes estimates of capital expenditures associated with a phased program of facility construction for both the eastern and western plant systems and in total. Since BBWA facility construction will be dependent upon voluntary requests for service, it is unlikely that construction will proceed along the scale and schedule presented in Section 6. Therefore, the following estimates of cost are provided only to establish a measure of magnitude of cost.

TABLE 8

ESTIMATED COST
BBWA WATER TREATMENT AND
DISTRIBUTION FACILITIES

(In Millions of Dollars)

	PHASE			
	I	II	III	TOTAL
East System	33.95	15.58	10.39	59.92
West System	33.78	14.31	12.95	61.04
Total, Both Systems	67.73	29.89	23.34	120.96

Cost estimates are based on a survey of construction costs associated with construction of similar plant and pipeline systems in the Houston area, land cost information supplied by area realtors, and bond cost data from BBWA fiscal consultants. Estimates of capital expenditures are based on 1989 dollars and include the following components:

- o Land Acquisition, Plant and Reservoir

- o Plant Treatment Facilities, complete including:
  - x Headworks
  - x Treatment Components
  - x Administrative/Control Building
  - x Distribution Pumping Equipment

- o Site Improvements, Plant

- o R/W Acquisition, Pipeline System

- o Pipeline Facilities, Complete

- o Design Costs at 12 percent, including:
  - x Surveying
  - x Geotechnical
  - x Engineering Design
  - x Construction Inspection

- o Construction Contingencies at 10 Percent

- o Bond Sale Expense at 8 Percent of Total Bond Cost

Total cost of BBWA regional water supply facilities, all phases, is estimated to be $120,960,000 in 1989 dollars. Detailed information regarding estimated construction costs is shown in Table A-6 in Appendix A.

A summary of annual cost and unit costs per 1000 gallons of treated water is shown in Table 9 below.

TABLE 9

ESTIMATED ANNUAL COST/UNIT COST
BBWA WATER SUPPLIES

PHASE (ALL IMPROVEMENTS)	ANNUAL EXPENSE ($1,000,000) BOND	O&M	TOTAL	ESTIMATED DAILY PRODUCTION, PHASE (MG)	UNIT COST ($/1000 GAL)
I	7.16	3.84	11.00	12.50	2.41
II	3.16	6.42	9.58	20.84	1.26
III	2.47	7.87	10.34	25.00	1.13

Annual costs include bond retirement expense and operational and maintenance expense as detailed below:

- o Bond Authorization, Expense, 20 Year Term at 8.5 Percent Interest Rate

- o Raw Water Purchase with Factor to Account for Storage Evaporation Losses

- o Plant Operational Costs Including:
  - x Labor, Operational and Maintenance
  - x Chemical Cost
  - x Power Expense
  - x Sludge Disposal Cost
- o Plant and Pipeline Maintenance Expense

Unit cost per 1000 gallons of BBWA treated water is estimated to range from \$2.43 upon completion of Phase I improvements to \$1.11 upon completion of all facilities. For comparison purposes, the estimated cost of treated water from the City of Houston delivered to BBWA boundaries is \$2.20 per 1000 gallons. Detailed information regarding estimated annual cost of BBWA water supply facilities are shown in Table A-7, in Appendix A.

Funding

Funding for the BBWA facilities is expected to be in the form of revenue bonds. Bonds could either be sold on the open market or to the Texas Water Development Board through the Water Loan Assistance Program. Water Loan Assistance Funds have been available at 5-1/4 percent annual interest rate. Although the BBWA projects are eligible for Water Loan Assistance monies according to existing guidelines, there are no guarantees that monies will be available at the time they are required. Therefore, the current bond market interest rate of 8-1/2 percent is used in all of the economic analyses.

III. WASTEWATER COLLECTION AND DISPOSAL

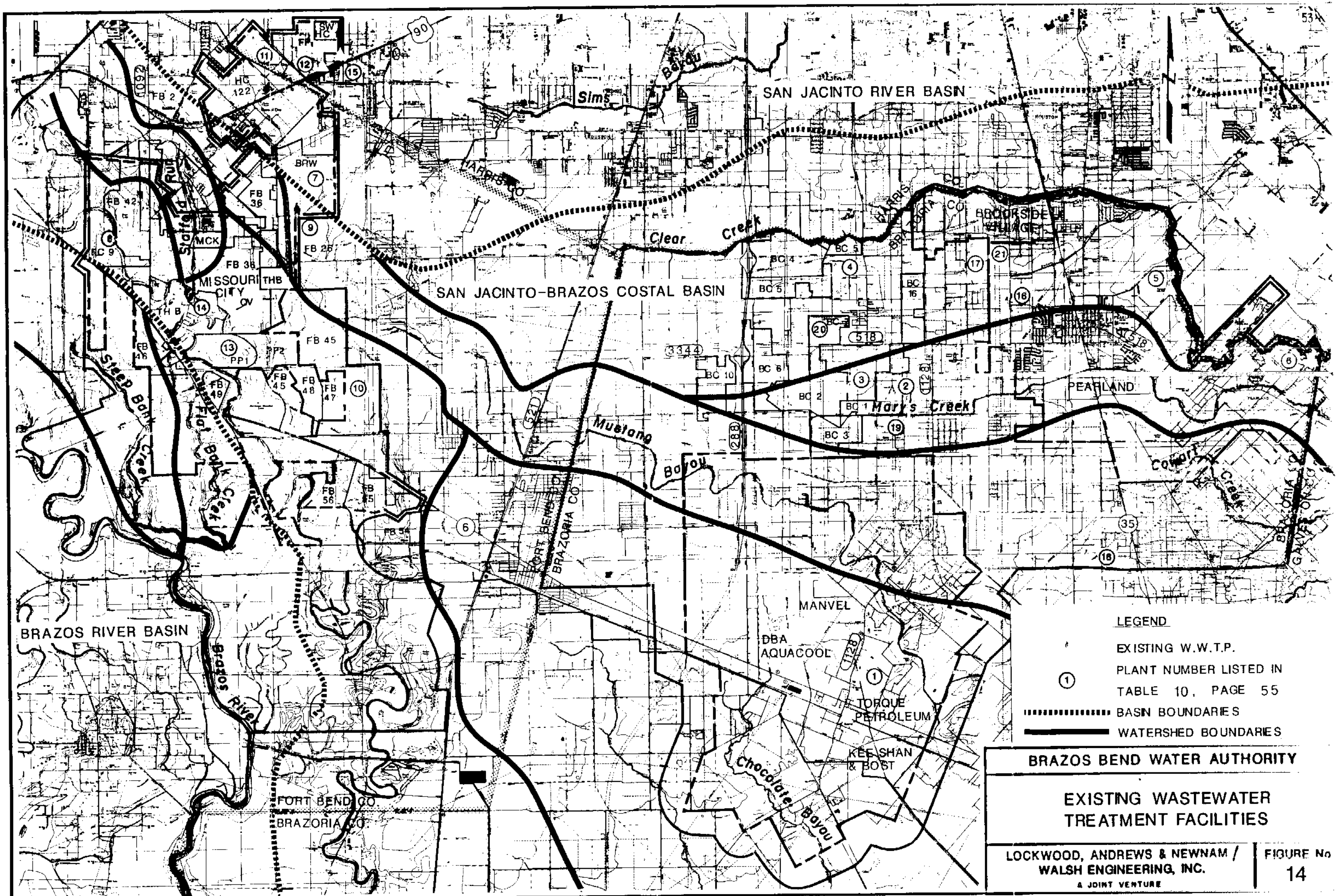
For 30 years, growth in the Houston metropolitan area has occurred by means of the municipal utility district. Abundant groundwater supplies made it easy to develop subdivisions on land remote from city utility systems. However, this development method resulted in a proliferation of small wastewater treatment plants. These plants were often inefficient and not designed to meet more stringent treatment requirements of recent years.

As briefly discussed in Chapter I, the consolidation of numerous small wastewater treatment facilities, that is, the regionalization of public treatment and collection facilities, presents an opportunity for local governments to better manage public wastewater disposal and protect water quality in area streams and lakes. Additionally, due to the shared nature of regional systems, regional facilities can usually be constructed at less cost than a comparable system of smaller facilities.

This chapter provides information regarding existing treatment facilities, regional treatment standards, existing and forecasted wastewater flows and presents a plan for regional wastewater collection and treatment facilities as required to service the BBWA study area through the year 2040.

1. CURRENT CONDITIONS

Domestic wastes are currently treated at 21 plants located within the study area. Fifteen plants are operated by public agencies, of which two are owned by the City of Pearland, 12 by the Utility Districts, and one by the Alvin Independent School District. The remaining six plants are privately owned and provide treatment for wastes from mobile home developments. Wastes in rural and unsewered portions of the study area are usually disposed of in individual septic tank and drain field systems. The locations of public and private wastewater treatment plants within the study area are shown in Figure 14 on the following page. The plant location numbering system shown in Figure 14 is cross referenced to facility numbering shown in Table 10, pages 55 and 56. Also shown in Figure 14 are the locations of three plants classified as industrial plants in the eastern region of the study area.



BRAZOS BEND WATER AUTHORITY

EXISTING WASTEWATER TREATMENT FACILITIES

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FIGURE No 14

Most existing study area treatment plants were constructed during the past 20 years. Typically, plant treatment design is a variation of the activated sludge process. The 4.0 MGD plant at Quail Valley Utility District uses oxygen as an aeration agent. Plants use aerobic digestors, and with the exception of the Quail Valley, Blue Ridge West, and City of Pearland Plants, sludge is directly wasted from digestors for wet haul disposal. Many of the smaller plants within the study area could be considered portable; that is, plant components with suitable refurbishment could be moved and returned to service at a new site.

Treatment standards for all public and private wastewater plants are established and monitored by the State of Texas. The Authority study area falls within the San Jacinto - Brazos Coastal Basin, the San Jacinto River Basin and the Brazos River Basin as defined by segment identification maps published by the Texas Water Commission. Area drainage basin boundaries within the above referenced regional basins are also shown in Figure 14.

Information regarding existing wastewater systems within the study area was gathered from a number of sources including the Texas Water Commission, local governments, plant operators and by site visitation. A summary inventory of plant operating standards, plant facilities, and capacities is shown in Table 10 on the following page. Based on visual inspection, all existing plants were found to be in working condition. Recent records indicate that all plants are generally operating within permitted effluent limitations.

TABLE 10

INVENTORY
EXISTING WASTEWATER TREATMENT PLANTS

OWNER (PLANT NAME)	CURRENT CAPACITY (MGD)	PROCESS TYPE[1]	PERMIT LIMITS CAPACITY AVERAGE DAY (MGD)	PERMIT LIMITS CAPACITY MAXIMUM DAY (MGD)	PERMIT LIMITS TREATMENT BOD (MG/L)	PERMIT LIMITS TREATMENT TSS (MG/L)	PERMIT LIMITS TREATMENT NH_3-N (MG/L)
PUBLIC PLANTS							
EASTERN AREA							
1. Alvin ISD	0.03	EA	0.03	0.06	20	20	-
2. BC MUD 1	0.15	CS	0.15	0.30	5	12	2
3. BC MUD 2[2]	0.10	CS	0.10	0.20	5	12	2
4. BC MUD 5[3]	0.38	RBC	0.38	1.33	5	12	2
5. Pearland, City (Barry Rose)	2.25	C	2.25	5.63	5	12	2
6. Pearland, City (Longwood)	1.75	EA	1.75	4.38	5	12	2
WESTERN AREA							
7. Blue Ridge W MUD	1.00	CM	1.00	2.50	10	15	-
8. First Colony MUD 9[4]	0.30	CS	0.30	0.60	10	15	-
9. FBC MUD 26	0.50	CS	0.50	1.50	10	15	-
10. FBC MUD 47/48	0.40	CS	0.40	0.60	10	15	-
11. HC MUD 122	0.25	CS	0.25	0.60	10	15	-
12. HC WCID Fondren Rd.	0.60	CS	0.60	1.80	10	15	-
13. Palmer Plant MUD 1[5]	0.20	CS	0.20	0.50	10	15	-
14. Quail Valley UD[6]	4.00	PO	4.00	----	10	15	2
15. SW HC MUD 1	0.40	CS	0.40	1.20	10	15	-

[1]Process Type Abbreviations:

C - Carousel
CS - Contact Stabilization
CM - Complete Mix
EA - Extended Aeration
PO - Pure Oxygen
RBC - Rotating Biological Contactors

[2]Also Serves BC MUD 3
[3]Also Serves BC MUD 4
[4]Also Serves FBC MUD 42
[5]Also Serves Palmer Plantation MUD 2 and FBC MUD 49
[6]Also Serves Meadowcreek MUD and Thunderbird UD

TABLE 10
(Continued)

INVENTORY
EXISTING WASTEWATER TREATMENT PLANTS

OWNER (PLANT NAME)	CURRENT CAPACITY (MGD)	PROCESS TYPE[1]	PERMIT LIMITS CAPACITY AVERAGE DAY (MGD)	MAXIMUM DAY (MGD)	TREATMENT BOD (MG/L)	TSS (MG/L)	NH_3-N (MG/L)
PRIVATE PLANTS							
EASTERN AREA							
16. Allied Pasadena N. Bank (Country Meadows MHP)	0.025	EA	0.025	0.045	5	12	2
17. Commodore (Raintree MHP)	0.055	EA	0.055	0.110	5	12	2
18. Gartner, Thomas (Country Village MHP)	0.052	EA	0.052	0.104	5	12	2
19. Korenek, Albert (Country Oaks Arbor MHP)	0.012	EA	0.012	0.024	5	12	2
20. Texas Municipal Utilities (Sommersetshire MHP)	0.02	EA	0.02	0.04	5	12	2
21. Trethewey, Robert (Pearland Heights MHP)	0.0225	EA	0.0225	0.045	5	12	2

[1]Process Type Abbreviation:

EA - Extended Aeration

2. PROJECTED WASTELOADS

As a prerequisite to the design of wastewater collection and treatment facilities, it is necessary to estimate the future wasteloads. Wasteloads include hydraulic flows and the chemical, biological and physical characteristics of the waste stream.

Existing Wastewater Flows

Data regarding wastewater flow rates at existing public and private plants treating domestic wastes within the study area for the months of August, 1987 through July, 1988 is presented in Table 11 on the following page. Average daily wastewater flow during this period totaled 6.247 MGD of which 6.071 MGD was treated by the publicly owned facilities. The 1988 estimated population served by the publicly owned facilities in the study area was 52,406. Therefore, the flow rate at public plants during this period was calculated to average 116 gallons per capita per day (gpcd). Pearland's per capita flow rate averaged 130 gpcd. The flow rate for the Quail Valley plant which serves Quail Valley Utility District, Meadow Creek MUD and Thunderbird MUD averaged 110 gpcd. The average flow rate for remaining public facilities was 99 gpcd.

Information regarding the biological and chemical composition of study area plant influents was not gathered; however, study area plant influents consist primarily of waste from domestic sources. Typical characteristics of domestic wastes are 250 mg/l CBOD, 250 mg/l TSS and 25 mg/l ammonia (as nitrogen).

TABLE-11

WASTEWATER FLOWS
EXISTING WASTEWATER TREATMENT PLANTS
AUGUST, 1987 THROUGH JULY, 1988[1]

OWNER (PLANT NAME)	AVERAGE DAY (MG)	MAXIMUM DAY (MG)	MAXIMUM DAY AVERAGE DAY (RATIO)
PUBLIC PLANTS			
EASTERN AREA			
1. Alvin ISD	0.017	0.017	1.00
2. BC MUD 1	0.093	0.144	1.55
3. BC MUD 2	0.020	0.050	2.50
4. BC MUD 5	0.155	0.276	1.78
5. Pearland, City (Barry Rose)	1.530	3.100	2.03
6. Pearland, City (Longwood)	0.818	2.040	2.49
SUBTOTAL EASTERN AREA	2.633		
WESTERN AREA			
7. Blue Ridge W. MUD	0.656	1.014	1.55
8. First Colony MUD 9	0.138	0.236	1.71
9. FBC MUD 26	0.200	0.300	1.50
10. FBC MUD 47/48	0.040	0.060	1.50
11. HC MUD 122	0.006	0.016	2.67
12. HC WCID Fondren Road	0.287	0.580	2.02
13. Palmer Plant MUD 1	0.051	0.133	2.61
14. Quail Valley UD	1.900	2.310	1.22
15. SW HC MUD 1	0.160	0.237	1.48
SUBTOTAL WESTERN AREA	3.438		
TOTAL, PUBLIC PLANTS	6.071		

[1]Source: Monthly Reporting Forms, Texas Water Commission.
[2]Flow Data Available for August, 1988 through October, 1988 only.

TABLE-11
(Continued)

WASTEWATER FLOWS
EXISTING WASTEWATER TREATMENT PLANTS
AUGUST, 1987 THROUGH JULY, 1988[1]

OWNER (PLANT NAME)	AVERAGE DAY (MG)	MAXIMUM DAY (MG)	MAXIMUM DAY AVERAGE DAY (RATIO)
PRIVATE PLANTS			
EASTERN AREA			
16. Allied Pasadena N. Bank (Country Meadows MHP)	0.008	0.097	12.13
17. Commodore (Raintree MHP)	0.037	0.040	1.08
18. Gartner, Thomas (Country Village MHP)	0.016	0.098	6.13
19. Korenek, Albert (Country Oaks Arbor MHP)	0.006	0.020	3.33
20. Texas Municipal Utilities (Sommersetshire MHP)	0.003	0.010	3.33
21. Trethewey, Robert (Pearland Heights MHP)	0.018	0.010	2.11
TOTAL, PRIVATE PLANTS	0.088		
GRAND TOTAL, ALL PLANTS	6.247		

[1]Source: Monthly Reporting Forms, Texas Water Commission.

Forecasted Wastewater Flows

Forecasts of study area wastewater flows were developed for two system categories, being, existing treatment systems and anticipated future treatment systems.

For existing wastewater treatment systems, estimated per capita flow rates reported during the August, 1987 through July, 1988 record period were used as a projection basis. These flow rates varied from 100 to 130 gallon per capital per day (GPCD). Approximately 20 GPCD of the City of Pearland system rate of 130 GPCD was considered attributable to above normal inflow and infiltration sources. Therefore City of Pearland wastewater forecasts were based on two rates; 130 GPCD for the existing system population and 110 GPCD for future population.

For anticipated future wastewater treatment systems a composited average rate of 100 GPCD was used.

Detailed information regarding forecasted wastewater flows for the study area is shown in Table A-8, Appendix A. Information from this table is summarized in Table 12 below. Forecasted flow quantities shown in Table 12 are prior to reductions in flow that could be expected from Authority water conservation measures.

TABLE 12

FORECASTED WASTEWATER FLOW
PUBLIC WASTEWATER TREATMENT SYSTEMS
2000 - 2040

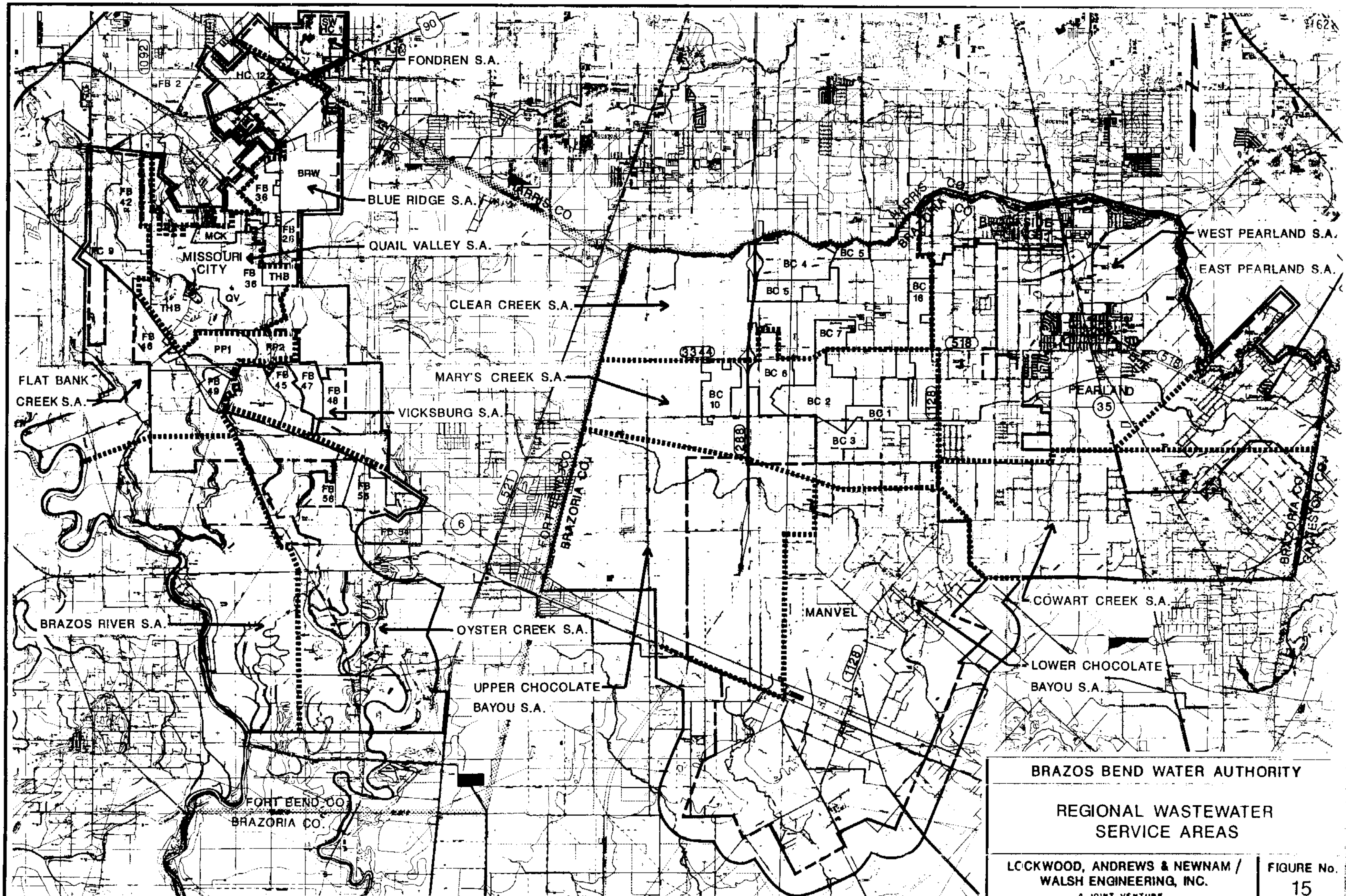
Average Day (In Million Gallons)	1989/88	1990	2000	2010	2020	2030	2040
Eastern Area	2.63	2.94	6.20	7.51	8.78	9.95	10.89
Western Area	3.44	3.89	5.51	6.16	6.89	7.72	8.36
Total		8.73	11.71	13.67	15.67	17.67	19.25

3. FACILITY PLAN

A facility plan was developed for the entire Brazos Bend Water Authority (BBWA) and certain appropriate adjacent areas. The Authority's eastern and western areas are separated by a portion of the City of Houston's extraterritorial jurisdiction which lies on the Mustang Bayou watershed and the City of Arcola and Iowa Colony which lie on the Upper Chocolate Bayou watershed.

The study area was first divided by watersheds, along their ridges and water courses. Study area watersheds are shown in Figure 14, Page 53. Political boundaries, the location and extent of existing collection and treatment systems, and the location of existing and forecasted population centers were considered in determining regional service area boundaries.

As a result, the BBWA study area was divided into 14 regional service areas as shown in Figure 15 on the following page. The land adjacent to BBWA was identified to contain regional service areas. One of these, Fort Bend WCID #2, serves a portion of northern Missouri City. Once identified, the service areas outside BBWA boundaries were not considered further. Each of the service areas within the BBWA boundaries was studied in detail to determine the most cost effective plant site and collection system route.



BRAZOS BEND WATER AUTHORITY

REGIONAL WASTEWATER SERVICE AREAS

LOCKWOOD, ANDREWS & NEWNAM / WALSH ENGINEERING, INC.
A JOINT VENTURE

FIGURE No. 15

Eastern Area

The eastern study area, with seven service areas, contains watersheds which drain to Clear Creek, Mary's Creek, Cowart Creek and Chocolate Bayou. The East and West Pearland service areas are mostly occupied by the City of Pearland and the City of Brookside Village. It is proposed that wastewater from Brookside Village be collected at a lift station west of Highway 35 and then pumped easterly to the nearest regional treatment facility located on Clear Creek.

The Clear Creek service area contains Brazoria County MUD's 4, 5, 7 and 16. The Mary's Creek service area includes Brazoria County MUD's 1, 2, 3, 6 and 10. Both the Clear Creek and Mary's Creek service areas extend across the Highway 288 corridor.

The upper Chocolate Bayou service area also extends across the Highway 288 corridor area. The Lower Chocolate Bayou service area totally contains the City of Manvel and its ETJ; it represents the largest service area in the BBWA planning area. The Cowart Creek service area contains most of the Hastings Oil Field complex.

Western Area

The western study area, with seven (7) service areas, contains watersheds which drain to Bray's Bayou, Oyster Creek and the Brazos River. The Fondren Park service area includes the Harris Municipal Utility District (MUD) 1 and the Harris County MUD 122 and it is the smallest service area in the BBWA planning area. The Fort Bend County Water Conservation and

Improvement District 2 service area is mostly outside of the BBWA planning area and for that reason is not considered a BBWA service area.

The Blue Ridge service area includes the Blue Ridge West MUD, the Fort Bend County MUD 26 and the Fort Bend County MUD 36. The Quail Valley service area contains the Quail Valley MUD, the Meadow Creek MUD and the Thunderbird Utility District. The Vicksburg service area includes Master MUD 45, of which Fort Bend County MUD's 47 and 48 are part, and the large Hermann Hospital Lake.

The Flat Bank Creek service area includes Fort Bend County MUD's 41, 46, and 49, Palmer Plantation MUD's 1 and 2 and First County MUD's 54, 55, and 56 and the Sienna Plantation Levee Improvement District. The Brazos River service area is bounded on the southwest by the Brazos River.

<u>Outside Study Area</u>

Areas outside of BBWA boundaries were studied since they impact the results of the study and in certain cases, represent potential future participants in the BBWA. The area between the eastern and western portions of the planning area include , but are not limited to, Fort Bend County MUD's 23, 24, and 71, Post Oak Road MUD, Briar Ridge MUD, the City of Arcola, Fresno and Iowa Colony, and a portion of Fort Bend County MUD 54. This area is large enough to be served by one or two regional plants, one on Mustang Bayou and the other on Chocolate Bayou south of Highway 6. The area north of Highway 6 is part of a City of Houston regionalization study which is underway at this time. Currently that area is planned to contain four relatively small service areas. BBWA's study conclusions and recommendation will be coordinated with the City of Houston's Study. The area east of Manvel, south of Pearland is also large enough to be served by a separate regional plant.

Service area acreages, forecasted wastewater flows based on service to all potential Authority customers, beginning in the year 2000, and ultimate treatment plant capacity requirements for each of the 14 regional service areas are shown in Table 13 on the following page. Forecasted wastewater flows shown in this table have been adjusted to account for a nominal 4.3 percent flow reduction forecast through implementation of Authority water conservation programs. (See Table A-8, Appendix A). A three phase plan showing facilities required to service all forecasted study area population centers is shown in Figure 16, page 67.

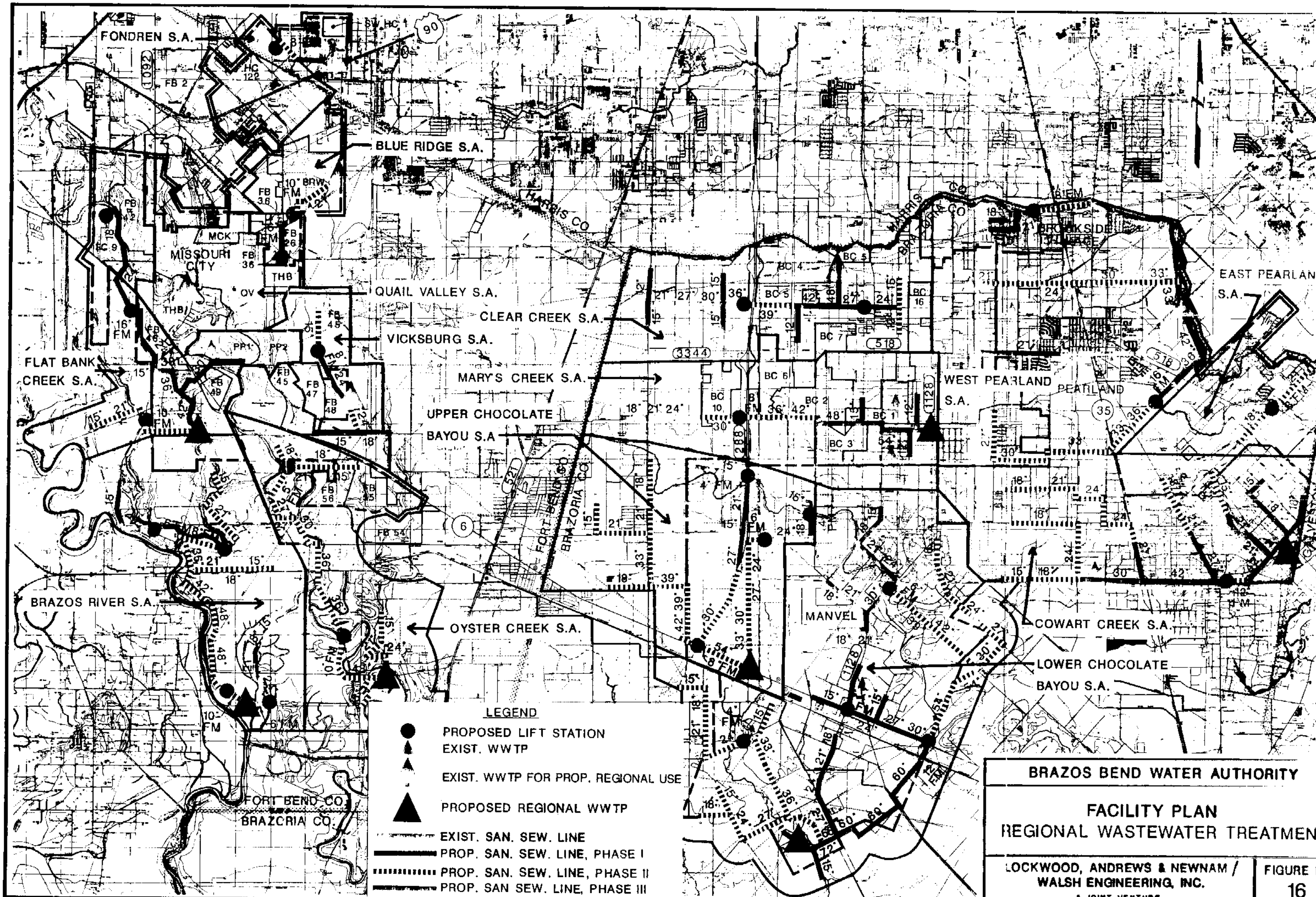

FONDREN S.A.
BLUE RIDGE S.A.
MISSOURI CITY
QUAIL VALLEY S.A.
CLEAR CREEK S.A.
VICKSBURG S.A.
FLAT BANK CREEK S.A.
MARY'S CREEK S.A.
UPPER CHOCOLATE BAYOU S.A.
BRAZOS RIVER S.A.
OYSTER CREEK S.A.
HARRIS CO
BRAZORIA CO
FORT BEND CO
FORT BEND CO.
BRAZORIA CO.
BROOKSIDE VILLAGE
EAST PEARLAND S.A.
WEST PEARLAND S.A.
PEARLAND
MANVEL
COWART CREEK S.A.
LOWER CHOCOLATE BAYOU S.A.
GALVESTON CO
LEGEND
PROPOSED LIFT STATION
EXIST. WWTP
EXIST. WWTP FOR PROP. REGIONAL USE
PROPOSED REGIONAL WWTP
EXIST. SAN. SEW. LINE
PROP. SAN. SEW. LINE, PHASE I
PROP. SAN. SEW. LINE, PHASE II
PROP. SAN SEW. LINE, PHASE III
BRAZOS BEND WATER AUTHORITY
FACILITY PLAN
REGIONAL WASTEWATER TREATMEN
LOCKWOOD, ANDREWS & NEWNAM / WALSH ENGINEERING, INC.
A JOINT VENTURE
FIGURE N
16

TABLE 13

FORECASTED WASTEWATER FLOWS
REGIONAL SERVICE AREA

SERVICE AREA	ACREAGE	1990	2000	2010	2020	2030	2040	PLAN PLANT CAPACITY 2040
		FORECASTED FLOW (MGD)						
EASTERN AREA								
Clear Creek	6,900	0.23	0.58	0.80	1.01	1.24	1.44	1.50
Cowart Creek	8,237	-0-	0.64	0.69	0.73	0.76	0.78	1.00
East Pearland	3,740	0.90	1.14	1.35	1.54	1.70	1.79	2.00
Lower Chocolate Bayou	17,890	-0-	0.51	0.60	0.69	0.77	0.82	1.00
Mary's Creek	7,525	0.13	0.40	0.64	0.87	1.12	1.39	1.50
Upper Chocolate Bayou	9,176	-0-	0.23	0.29	0.36	0.45	0.54	0.75
West Pearland	12,000	1.68	2.41	2.82	3.20	3.49	3.66	4.5
TOTAL	65,468	2.94	5.91	7.19	8.40	9.53	10.42	12.25
WESTERN AREA[1]								
Blue Ridge West	1,817	0.98	1.10	1.15	1.22	1.23	1.23	1.50
Brazos River	7,100	-0-	0.22	0.30	0.40	0.56	0.69	0.75
Flat Bank Creek	6,458	0.42	0.81	1.08	1.40	1.70	1.91	2.00
Fondren Park	826	0.44	0.67	0.67	0.67	0.67	0.67	0.90
Oyster Creek	6,414	-0-	0.23	0.34	0.47	0.65	0.83	0.80
Quail Valley	2,769	1.98	2.04	2.04	2.04	2.04	2.04	4.00
Vicksburg	8,445	0.07	0.23	0.31	0.40	0.53	0.63	0.80
TOTAL	33,829	3.89	5.30	5.89	6.60	7.38	8.00	10.75
GRAND TOTAL	99,297	6.83	11.21	13.08	15.00	16.91	18.42	23.0

[1]Does not include requirements of study area region currently served by Fort Bend County WCID No. 2

Regional Facilities

Regional wastewater facilities consist of a system of trunk sewers and a treatment plant. Lift stations are considered an integral part of the trunk collection system, while the influent pump station and outfall disposal lines are part of the treatment plant.

Prevailing design criteria was used to size trunk mains and treatment facilities for the growth anticipated to occur through the planning period. Factors used to test the effectiveness of service area alternatives included the following:

1. The availability of existing facilities.
2. The availability of rights-of-ways and plant sites.
3. The amount of slope provided by the topography.
4. The amount and characteristics of current and projected flows (population equivalents).
5. The type of soils, groundwater conditions and construction methods.
6. Interference of other major works (highways, railroads, pipelines).

Treatment Facilities

Treatment methods may include physical, chemical and biological processes. Physical and chemical are usually reserved for special disposal situations. Most domestic sewage treatment processes are a variation at the biologic reduction method. The type and characteristics of the wastewater expected to be generated in the study area can effectively be treated biologically by either aerobic or anaerobic decomposition or a combination of the two. Since aerobic decomposition produces the least amount of noxious odors, all the proposed facilities will employ a variation of the activated sludge process except where an existing plant is currently using the rotating-biological-contactor. In that case, it may be desirable to continue that process at that plant.

The required level of treatment is established by the Texas Water Commission. The receiving streams' condition and ability to assimilate discharges dictate plant effluent quality. A discussion of current and projected parameters is contained in Section 2 page 57.

The regional plant for each service area will be designed for its respective wastewater quantity and quality. The units which will make up the complete plant are listed below:

- Pretreatment
  - Influent Pump Station
  - Screens
    - Coarse (or)
    - Fine
  - Grit Removal
  - Flow Measurement
- Treatment (Liquid)
  - Aeration Basins
  - Clarifiers
  - Return Sludge Pumps
  - Waste Activated Sludge Pumps
  - Scum Pumps
  - Chlorine Contact Basins
  - Disinfectant Application Facility
  - Air (Oxygen) Supply System
- Treatment (Solids)
  - Digester
  - Thickener
  - Sludge Dewatering and/or Incineration

Auxiliary
- Power Supply
- Laboratory
- Administrative Office
- Maintenance Shop
- Dechlorination Facilities

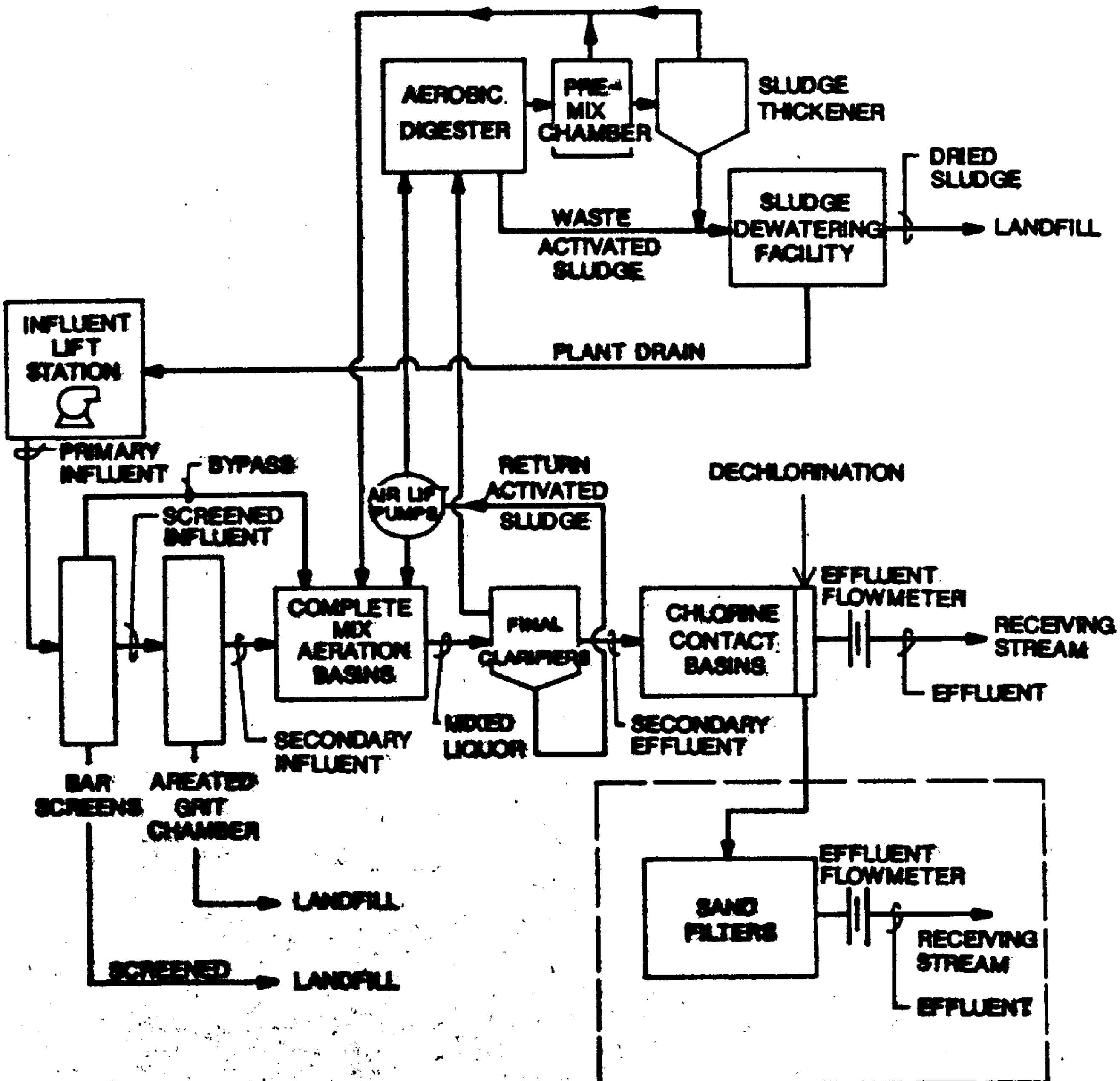
The plants that discharge into the Clear Creek Water shed will add sand filters as a final treatment to their effluents.

A schematic of the proposed plants is shown in Figure 17 on the following page.

<u>Plant Sites</u>

Selection of a plant site requires consideration of the availability of land, topography, proximity to receiving waters, cost, and orientation with the main trunk layout. Plants should be located as near as possible downstream from all points in the service area. By placing plants at lower elevations, the area's natural drainage allows the most economic trunk line installation, minimizing the number of lift stations without requiring deep trench construction.

Regional plants of the size described in this report can be constructed on relatively small tracts of land. The minimum size tract should be three acres. It is recommended that each new plant site be acquired with adequate space to accommodate the plant proposed in the year 2040.



BRAZOS BEND WATER AUTHORITY

PROPOSED WASTEWATER TREATMENT PROCESS

LOCKWOOD, ANDREWS & NEWNAM / WALSH ENGINEERING, INC.
A JOINT VENTURE

FIGURE No. 17

All plants must be protected from the flood expected to occur once in a 100 years. Also the plants must remain fully operational and accessible during the 20 year storm.

Trunk Collection System

Routing alternatives were studied for each service area. The selected alternative was the one which provided the greatest flexibility to phased implementation without jeopardizing cost effectiveness.

An initial depth of eight feet was choosen for the remote ends of the collection system to allow customer connections. An economic balance was achieved using lift stations along the trunk lines when the pipe depths approached 16 feet.

4. FINANCIAL

It is anticipated that wastewater treatment facilities in each of the 14 identified service areas will be constructed in stages as required to keep pace with regional wastewater treatment requirements. Although it is not currently feasible to present a time schedule for construction, a three-phase program of construction, as shown in Figure 16, has been developed for the purpose of estimating unit costs of treatment during the study planning period. In general, Phase I improvements would provide for forecasted study area wastewater flows through the year 2000, with Phase II and Phase III Improvements providing for forecasted study area requirements through 2020 and 2040, respectively.

Cost Estimates

Estimates of capital requirements for a three-phase program of construction are summarized in Table 14, on the following page. Seven of the 14 service areas can be served by existing plants and collection systems. For this reason, the cost of these seven service areas are shown separately and are based on estimates of plant replacement cost plus identified trunk line extension costs. Detailed estimates of treatment plant and collection system costs are shown in Table A-9, Appendix A.

TABLE A-5
FORECASTED WATER DEMAND
PUBLIC SUPPLY SYSTEMS
1990-2040

	1988 EST.POP. SERVED 1/1988	1988 AVER.DAY 8/87-7/88 (MGD)	1990 EST.POP SERVED 1/1990	1990 DAY USE DAY USE (MGD)	2000 EST.POP. SERVED 1/2000	2000 EST.AVER. DAY USE (MGD)	2010 EST.POP. SERVED 1/2010	2010 EST.AVER. DAY USE (MGD)	2020 EST.POP. SERVED 1/2020	2020 EST.AVER. DAY USE (MGD)	2030 EST.POP. SERVED 1/2030	2030 EST.AVER. DAY USE (MGD)	2040 EST.POP. SERVED 1/2040	2040 EST.AVER. DAY USE (MGD)
I EASTERN AREA														
A EXISTING SUPPLY SYSTEMS (1)														
1 BC MUD 2 (ALSO SERVES BC MUD 2)	1,100	0.24	1,350	0.29	2,250	0.49	3,200	0.70	3,800	0.83	4,400	0.96	4,800	1.05
2 BC MUD 5 (ALSO SERVES BC MUD 4)	2,050	0.34	2,250	0.37	3,200	0.53	4,050	0.67	4,800	0.80	5,600	0.93	6,100	1.01
3 PEARLAND,CITY	17,883	2.64	20,371	3.01	28,068	4.14	33,647	4.97	38,829	5.73	43,099	6.36	45,505	6.72
B FUTURE SUPPLY SYSTEMS (2)														
1 BC MUD 3	-	-	-	-	200	0.03	500	0.08	900	0.14	1,500	0.23	1,800	0.28
2 BC MUD 6	-	-	-	-	100	0.02	350	0.05	500	0.08	600	0.09	700	0.11
3 BC MUD 7	-	-	-	-	400	0.06	900	0.14	1,500	0.23	2,000	0.31	2,500	0.38
4 BC MUD 10	-	-	-	-	500	0.08	1,000	0.15	1,500	0.23	2,000	0.31	2,800	0.43
5 BC MUD 16	-	-	-	-	800	0.12	1,400	0.21	2,000	0.31	2,400	0.37	2,700	0.41
6 BROOKSIDE VILLAGE	-	-	-	-	1,727	0.26	2,073	0.32	2,392	0.37	2,655	0.41	2,800	0.43
7 MANVEL, CITY	-	-	-	-	5,835	0.89	7,000	1.07	8,077	1.24	8,965	1.37	9,455	1.45
8 OTHER, CITY ETJ'S	-	-	-	-	2,475	0.38	3,459	0.53	5,125	0.78	7,006	1.07	9,639	1.47
	21,033	3.22	23,971	3.67	45,555	7.00	57,578	8.87	69,423	10.74	80,225	12.41	88,799	13.74
II WESTERN AREA														
A EXISTING SUPPLY SYSTEMS (1)														
1 BLUE RIDGE W. MUD	6,651	0.80	7,050	0.85	7,464	0.90	7,464	0.90	7,464	0.90	7,464	0.90	7,464	0.90
2 FIRST COLONY MUD 9	966	0.19	1,368	0.27	4,611	0.91	5,214	1.03	5,739	1.13	5,191	1.16	5,919	1.16
3 FBC MUD 26	2,295	0.22	2,745	0.32	3,153	0.40	3,393	0.46	3,633	0.46	3,633	0.46	3,633	0.46
4 FBC MUD 42	429	0.08	480	0.09	900	0.17	1,260	0.23	1,881	0.35	2,481	0.46	3,033	0.57
5 FBC MUD 46	-	-	-	-	120	0.02	486	0.07	945	0.14	1,278	0.20	1,278	0.20
6 FBC MUD 47 (ALSO SERVES FBC MUD 48)	276	0.11	576	0.17	1,290	0.28	2,082	0.36	2,700	0.41	3,180	0.49	3,900	0.60
7 FBC WCID 2 (STUDY AREA ONLY)	-	N.A.	-	-	3,123	0.48	3,684	0.56	4,200	0.64	4,620	0.71	4,860	0.74
8 HC WCID FONDREN FD.	2,742	0.31	2,790	0.32	2,988	0.34	2,988	0.34	2,988	0.34	2,988	0.34	2,988	0.34
9 MEADOWCREEK MUD	1,938	0.29	2,091	0.31	2,694	0.40	2,694	0.40	2,694	0.40	2,694	0.40	2,694	0.40
10 P. PLANT MUDS (ALSO SERVES FBC MUD 49)	390	0.10	630	0.16	1,401	0.24	2,563	0.39	3,525	0.54	4,245	0.65	4,845	0.74
11 QUAIL VALLEY UD	10,059	1.70	10,452	1.77	11,190	1.89	11,190	1.89	11,190	1.89	11,190	1.89	11,190	1.89
12 SW HC MUD 1	1,335	0.12	1,440	0.17	1,557	0.24	1,557	0.24	1,557	0.24	1,557	0.24	1,557	0.24
13 THUNDERBIRD MUD	5,211	1.03	5,388	1.06	5,499	1.09	5,499	1.09	5,499	1.09	5,499	1.09	5,499	1.09
B FUTURE SUPPLY SYSTEMS (2)														
1 FBC MUD 36	-	-	-	-	861	0.13	1,140	0.17	1,536	0.24	1,719	0.26	1,719	0.26
2 FBC MUD 55	-	-	-	-	660	0.10	900	0.14	1,305	0.20	1,800	0.28	2,250	0.34
3 FBC MUD 56	-	-	-	-	664	0.10	900	0.14	1,296	0.20	1,800	0.28	2,250	0.34
4 HC MUD 122	-	-	-	-	1,827	0.28	1,827	0.28	1,927	0.28	1,827	0.28	1,827	0.28
5 OTHER, CITY ETJ	-	-	-	-	4,620	0.71	6,695	1.02	8,949	1.37	13,302	2.04	16,389	2.51
	32,292	4.95	35,010	5.49	54,622	8.68	61,536	9.71	68,928	10.82	77,196	12.19	83,295	13.06
TOTAL, BOTH AREAS	53,325	8.17	63,981	9.16	100,177	15.68	119,114	18.60	138,351	21.56	157,451	24.60	172,054	26.80
CONSERVATION SAVINGS @ 4.3%						-0.67		-0.80		-0.93		1.06		1.15
BBWA REQUIREMENTS						15.01		17.80		20.63		23.54		25.65

Notes:

TABLE A-8

FORECASTED WASTEWATER FLOWS PUBLIC TREATMENT SYSTEM

1990-2040

AREA	UNIT USE (GPD)	1990 POP SERVED	1990 FLOW (MPD)	2000 POP SERVED	2000 FLOW (MPD)	2010 POP SERVED	2010 FLOW (MPD)	2020 POP SERVED	2020 FLOW (MPD)	2030 POP SERVED	2030 FLOW (MPD)	2040 POP SERVED	2040 FLOW (MPD)
EASTERN AREA													
BROOKSIDE VILLAGE	100	0	0.000	1,727	0.173	2,073	0.208	2,392	0.240	2,655	0.266	2,800	0.280
MANVEL	100	0	0.000	5,835	0.584	7,000	0.700	8,077	0.808	8,965	0.897	9,455	0.946
PEARLAND	130/110	20,371	2.580	28,068	3.426	33,647	4.040	38,829	4.610	43,099	5.080	45,505	5.344
BC MUD #1	100	1,000	0.100	1,500	0.150	2,000	0.200	2,300	0.230	2,600	0.260	2,800	0.290
BC MUD #2	100	350	0.035	750	0.075	1,200	0.120	1,500	0.150	1,800	0.180	2,000	0.200
BC MUD #3	100	0	0.000	200	0.020	500	0.050	900	0.090	1,500	0.150	1,800	0.190
BC MUD #4	100	550	0.055	700	0.070	1,050	0.150	1,500	0.150	2,100	0.210	2,500	0.250
BC MUD #5	100	1,700	0.170	2,500	0.250	3,000	0.300	3,300	0.330	3,500	0.350	3,600	0.360
BC MUD #6	100	0	0.000	100	0.010	350	0.035	500	0.050	600	0.060	700	0.070
BC MUD #7	100	0	0.000	400	0.040	900	0.090	1,500	0.150	2,000	0.200	2,500	0.250
BC MUD #10	100	0	0.000	500	0.050	1,000	0.100	1,500	0.150	2,000	0.200	2,800	0.280
BC MUD #16	100	0	0.000	800	0.080	1,400	0.140	2,000	0.200	2,400	0.240	2,700	0.270
RURAL: 601	100	0	0.000	1,857	0.186	1,691	0.169	1,427	0.143	1,319	0.132	1,261	0.126
602.01	100	0	0.000	2,402	0.241	3,387	0.339	5,088	0.509	7,013	0.702	9,728	0.973
602.02	100	0	0.000	7,796	0.780	8,339	0.834	8,787	0.879	9,197	0.920	9,560	0.956
603	100	0	0.000	107	0.011	161	0.016	217	0.022	276	0.028	337	0.034
604	100	0	0.000	213	0.022	267	0.027	323	0.033	381	0.038	441	0.045
607	100	0	0.000	308	0.031	340	0.034	364	0.037	397	0.040	417	0.042
608	100	0	0.000	5	0.001	5	0.001	5	0.001	5	0.001	5	0.001
TOTAL, EASTERN AREA		23,971	2.940	55,768	6.200	68,310	7.508	80,509	8.782	91,807	9.954	100,909	10.887
WESTERN AREA													
BLUE RIDGE W. MUD	100	7,050	0.705	7,464	0.747	7,464	0.747	7,464	0.747	7,464	0.747	7,464	0.747
FIRST COLONY #9	100	1,368	0.137	4,611	0.462	5,214	0.522	5,739	0.574	5,919	0.592	5,919	0.592
FEC MUD #26	100	2,745	0.275	3,153	0.316	3,393	0.340	3,633	0.364	3,633	0.364	3,633	0.364
FBC MUD #36	100	0	0.000	861	0.087	1,140	0.114	1,536	0.154	1,719	0.172	1,719	0.172
FBC MUD #42	100	480	0.048	900	0.090	1,260	0.126	1,881	0.189	2,481	0.249	3,033	0.304
FBC MUD #46	100	0	0.000	120	0.012	486	0.049	945	0.095	1,278	0.128	1,278	0.128
FBC MUD #47	100	300	0.030	660	0.066	1,050	0.105	1,350	0.135	1,590	0.159	1,950	0.195
FBC MUD #48	100	276	0.028	630	0.063	1,032	0.104	1,350	0.135	1,590	0.159	1,950	0.195
FBC MUD #49	100	120	0.012	450	0.045	750	0.075	1,050	0.105	1,470	0.147	1,470	0.147
FBC MUD #55	100	0	0.000	540	0.054	900	0.090	1,305	0.131	1,800	0.180	2,250	0.225
FBC MUD #56	100	0	0.000	450	0.045	900	0.090	1,296	0.130	1,800	0.180	2,250	0.225
FBC WCID #2	100	1,884	0.189	3,123	0.313	3,684	0.369	4,200	0.420	4,620	0.462	4,860	0.486
HC WCID FONDREN PARK	100	2,790	0.279	2,999	0.299	2,988	0.299	2,988	0.299	2,988	0.299	2,988	0.299
HC MUD #122	100	180	0.018	1,827	0.183	1,827	0.183	1,827	0.183	1,827	0.183	1,827	0.183
MEADOWCREEK MUD	110	2,091	0.230	2,694	0.296	2,694	0.296	2,694	0.296	2,694	0.296	2,694	0.296
PALMER PLAN. MUD 1	100	510	0.051	951	0.096	1,413	0.142	1,875	0.188	1,875	0.188	1,875	0.188
PALMER PLAN. MUD 2	100	0	0.000	0	0.000	0	0.000	300	0.030	900	0.090	1,500	0.150
QUAIL VALLEY UD	110	10,452	1.150	11,190	1.231	11,190	1.231	11,190	1.231	11,190	1.231	11,190	1.231
SW HC MUD #1	100	1,440	0.144	1,557	0.156	1,557	0.156	1,557	0.156	1,557	0.156	1,557	0.156
THUNDERBIRD UD #1	110	5,358	0.593	5,499	0.605	5,499	0.605	5,499	0.605	5,499	0.605	5,499	0.605
OUTSIDE CITY													
701.06	100	0	0.000	0	0.000	0	0.000	0	0.000	600	0.060	1,200	0.120
701.07 E OF MP RR	100	0	0.000	400	0.040	536	0.051	754	0.076	1,500	0.150	2,000	0.200
701.07 W OF MP RR	100	0	0.000	1,700	0.170	2,500	0.250	3,600	0.360	5,200	0.520	6,000	0.600
702.03 N HAGERSON	100	0	0.000	1,100	0.110	1,750	0.175	2,250	0.225	3,000	0.300	3,800	0.780
702.03 S HAGERSON	100	0	0.000	250	0.025	450	0.045	600	0.060	1,007	0.101	1,714	0.172
TOTAL, WESTERN AREA		37,074	3.889	53,118	5.511	59,647	6.164	66,887	6.888	75,201	7.718	81,620	8.760
TOTAL, BOTH AREAS		61,045	6.829	108,886	11.711	127,957	[illegible]	[illegible]	15.670	167,008	17.672	182,529	19.247
CONSERVATION SAVINGS @ 4.3%					-0.504		[illegible]		-0.674		-0.76		[illegible]
TOTAL, ADJUSTED					11.207		[illegible]		[illegible]		16.912		[illegible]

TABLE 14

SUMMARY
ESTIMATED COST
WASTEWATER COLLECTION AND TREATMENT FACILITIES

(IN MILLIONS OF DOLLARS)
NEW PLANT SYSTEMS

SERVICE AREA	PHASE I	PHASE II	PHASE III	TOTAL
Brazos River	-	5.30	2.37	7.67
Cowart Creek	6.69	2.90	-	9.59
Flat Bank Creek	5.40	3.00	-	8.40
Lower Chocolate Bayou	7.03	7.85	1.84	16.72
Mary's Creek	2.93	2.53	1.82	7.28
Oyster Creek	-	4.63	0.96	5.59
Upper Chocolate Bayou	-	7.65	1.58	9.23
Total	22.05	33.86	8.57	64.48

EXISTING PLANT SYSTEMS

SERVICE AREA	TOTAL
Blue Ridge	4.18
Clear Creek	7.73
East Pearland	6.01
Fondren Park	2.27
Quail Valley	9.32
Vicksburg	3.42
West Pearland	18.37
Total	51.30

Cost estimates are based on a survey of construction costs of similar plant and pipeline systems in the Houston area, land cost information supplied by area realtors, and bond cost data from BBWA fiscal consultants. Estimates of capital expenditures are based on 1989 dollars and include the following components:

- o Land Acquisition, Plant

- o Plant Treatment Facilities, complete including:
  - x Pretreatment Component
  - x Treatment Components, Liquid
  - x Treatment Components, Solid
  - x Buildings: Office, Laboratory, Maintenance Space
  - x Site Improvements

- o Trunk Collection System, complete including:
  - x Easement Acquisition, Pipelines/Lift Stations
  - x Pipelines
  - x Lift Station/Force Mains

- o Construction Contingencies at 10 percent Estimated Construction Cost

- o Engineering Services @ 12 percent Estimated Construction Cost, including:
  - x Boundary/Topographic Surveys
  - x Geotechnical/Investigations

x Engineering Design

x Construction/Inspection

o Bond Sale Expense @ 8.5 Percent of Total Bond Cost

Detailed information regarding estimated for new plant service area systems are shown in Table A-10, Appendix A.

Existing wastewater treatment plants identified as regional plants may either be purchased by the authority or continued to be owned and operated by the present owners. Therefore, estimates of the unit cost of treatment shown in Table 15 below is limited to those service areas proposed to be served by new facilities.

TABLE 15

ESTIMATED ANNUAL COST
UNIT COST OF SERVICE
WASTEWATER TREATMENT FACILITIES
NEW SERVICE AREAS

PHASE	ANNUAL EXPENSE BOND ($1,000,000)	O&M	TOTAL	ESTIMATED AVERAGE DAILY FLOW PHASE PERIOD (MGD)	ESTIMATED AVERAGE UNIT COST ($/1000 GAL)
I	2.83	0.62	3.45	2.47	$3.82
II	3.58	1.24	4.82	5.00	$2.64
III	0.90	1.74	2.64	7.08	$1.02

Annual Costs include Bond Retirement Expense and Plant and Pipeline System Operation and Maintenance Expense as detailed below:

- o Bond amortization expense, 20 year bond term at 8.5 percent annual interest

- o Plant operation cost including:
  - x Labor Expense: operation and Maintenance
  - x Chemical Cost
  - x Power Expense
  - x Sludge Disposal Cost

- o Pipeline Operation Cost, including:
  - x Labor Expense: Operation and Maintenance
  - x Power Expense

- o Repair Cost, Plant and Pipeline System

The unit treatment costs shown in Table 15 are calculated only for the purpose of determining a probable range of cost for authority services. For comparison purposes, the City of Houston charges domestic customers $2.25 per 1,000 gallons of water useage for wastewater treatment services. Detailed information regarding estimated annual cost and unit cost for wastewater treatment in new regional service areas is shown in Table A-10 Appendix A.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. Study area population is forecasted to increase by 350% by the year 2040.

2. Likely areas of future population growth are the southern portion of Missouri City, The City of Pearland and land along Highway Route 288 corridor in Brazoria County.

3. Study area water demand is currently 8.17 MGD. Demand is forecasted to increase to 26.80 MGD by the year 2040.

4. Existing public water supply facilities are not adequate to meet forecasted regional water supply demand through the year 2040.

5. Water table declines and land subsidence are regional problems. Control of these problems will require regional reduction of groundwater use.

6. Continued use of groundwater supplies within the study area is forecasted to increase groundwater declines by thirty feet (30') and subsidence by one-half foot (0.5') on the average during the planning period.

7. Water currently owned by the Galveston County Water Authority (GCWA) is considered the most likely source of BBWA surface water supply. GCWA water supplies are readily accessible in canal systems traversing the BBWA study area.

8. The study area can be most economically served by two regional surface water supply plants, separately serving eastern and western regions of the study area.

9. Proposed regional water supply plants and transmission systems could be expanded to supply population centers adjacent to current authority boundaries.

10. The estimated cost of regional surface water treatment and transmission facilities with the study area is $120,960,000. The cost for treatment and delivery of surface water supplies to potential customers is estimated to range from $1.13 to $2.41 per 1000 gallons.

11. Short term water conservation measures could reduce study area water requirements by 4.3 percent or more.

12. Study area wastewater flows are currently 6.25 MGD. Wastewater flows are forecasted to increase 19.25 MGD by the year 2040.

13. Existing public wastewater treatment facilities are not adequate to meet forecasted wastewater treatment requirements through the year 2040.

14. The study area can be most economically served by 14 regional treatment plants and trunk collection systems.

15. Seven existing wastewater treatment plants within the study area could serve as regional facilities.

16. The estimated cost of regional wastewater treatment facilities in currently unserved areas is $64,480,000. The cost of treatment in these areas is estimated to range from $1.02 to 3.82 per 1000 gallons.

RECOMMENDATIONS

1. Seek policies from local governmental bodies which support regional plan implementation.

2. Select commitments from public water supply and wastewater treatment agencies for authority services.

3. Seek backing of local governments as a means for securing currently available surface water supplies.

4. Explore the possibility of jointly constructing regional facilities with other participants, such as the City of Alvin and the City of Sugar Land.

5. Seek policies from city governments to secure corridors for water transmission and wastewater collection pipelines.

6. Seek adoption of water construction measures as a means for optimizing water supply resources.

7. Begin conversion to surface water sources of supply by the year 2000.

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Appendix A

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APPENDIX A

TABLE A-1

1980 POPULATION AND HOUSING DATA[1]
BBWA STUDY AREA

POPULATION

EASTERN AREA

COUNTY	CENSUS TRACT	TOTAL POPULATION	POPULATION WITHIN STUDY AREA: BROOKSIDE VILLAGE	MANVEL	PEARLAND	SUBURBAN/ RURAL	TOTAL
HARRIS	371.01	24,209	-	-	787	-	787
BRAZORIA	601	10,160	1,453	-	7,028	1,679	10,160
BRAZORIA	602.01	13,348	-	1,766	-	1,577	3,343
BRAZORIA	602.02	12,250	-	7	5,433	6,675	12,115
BRAZORIA	603	5,314	-	641	-	10	651
BRAZORIA	604	13,785	-	1,004	-	115	1,119
BRAZORIA	607	1,707	-	131	-	100	231
BRAZORIA	608	6,689	-	-	-	5	5
	TOTAL, EASTERN AREA		1,453	3,549	13,248	10,161	28,411

WESTERN AREA

COUNTY	CENSUS TRACT	TOTAL POPULATION	POPULATION WITHIN STUDY AREA: MISSOURI CITY	SUBURBAN/ RURAL	TOTAL
HARRIS	433	14,931	3,936	-	3,936
FORT BEND	701.01	1,561	27	-	27
FORT BEND	701.02	7,547	3,508	-	3,508
FORT BEND	701.03	9,094	3,970	-	3,970
FORT BEND	701.05	9,202	558	-	558
FORT BEND	701.06	14,194	12,073	21	12,094
FORT BEND	701.07	1,130	124	55	179
FORT BEND	702.02	5,890	315	-	315
FORT BEND	702.03	2,335	22	80	102
	TOTAL, WESTERN AREA		24,533	156	24,689
		GRAND TOTAL, BBWA			53,100

HOUSING

BBWA CITIES	POPULATION 1980	DWELLING UNITS (TOTAL)	PERSON/ DWELLING UNIT
BROOKSIDE VILLAGE	1,453	453	3.21
MANVEL	3,549	1,187	2.99
MISSOURI CITY	24,533	8,180	3.00
PEARLAND	13,248	4,643	2.85
TOTAL, BBWA CITIES	42,783	14,463	2.96

OTHER	POPULATION 1980	DWELLING UNITS (TOTAL)	PERSON/ DWELLING UNIT
HOUSTON, CITY	1,594,086	677,697	2.35
BRAZORIA CO.	169,587	60,458	2.81
FORT BEND CO.	130,846	43,162	3.03
HARRIS CO.	2,409,544	984,577	2.45

1 SOURCE: 1980 UNITED STATES CENSUS OF POPULATION AND HOUSING

TABLE A-2

POPULATION PROJECTIONS, 1980-2040 [1]
BBWA STUDY AREA

HIGH SERIES PROJECTIONS

EASTERN AREA

	1980	1990	2000	2010	2020	2030	2040
BROOKSIDE VILLAGE	1,453	1,581	1,727	2,073	2,392	2,655	2,800
MANVEL	3,549	4,752	5,835	7,000	8,077	8,965	9,455
PEARLAND	13,248	20,371	28,068	33,647	38,829	43,099	45,505
(IN HARRIS CO.)	787	863	953	1,120	1,292	1,434	1,561
(IN BRAZORIA CO.)	12,461	19,508	27,115	32,527	37,537	41,665	43,944
SUBURBAN/RURAL [2]	10,161	14,690	19,940	25,366	30,969	36,819	42,866
TOTAL, EASTERN AREA	28,411	41,394	55,570	68,086	80,267	91,538	100,626

WESTERN AREA

	1980	1990	2000	2010	2020	2030	2040
MISSOURI CITY	24,533	38,593	55,349	62,014	69,595	78,217	84,628
(IN HARRIS CO.) [3]	3,936	4,410	6,849	6,849	6,849	6,849	6,849
(IN FORT BEND CO.)	20,597	34,483	48,500	55,165	62,746	71,368	77,779
SUBURBAN/RURAL [4]	156	300	350	400	400	400	400
TOTAL, WESTERN AREA	24,689	38,893	55,699	62,414	69,995	78,617	85,028
GRAND TOTAL, BBWA	53,100	80,287	111,269	130,500	150,262	170,155	185,654

1 Source: Texas Water Development Board, Water Data Collection, Studies and Planning Division, September 1988

2 Based on TWDB "other" category for Brazoria County. Assumes 75% of "other" category growth will occur within the BBWA study area.

3 Modified TWDB projections based on city zoning maps and utility district land use maps.

4 Estimated

TABLE A-3

ESTIMATED DISTRIBUTION
POPULATION PROJECTIONS, 1980-2040
BBWA STUDY AREA

BY CENSUS TRACT

EASTERN AREA

COUNTY	CENSUS TRACT	1980	1990	2000	2010	2020	2030	2040
HARRIS	371.01	787	863	953	1,120	1,292	1,434	1,561
BRAZORIA	601	10,160	15,223	20,382	24,355	27,966	30,956	32,688
BRAZORIA	602.01	3,343	7,391	12,040	17,062	22,450	28,133	33,817
BRAZORIA	602.02	12,115	15,240	18,954	21,738	24,258	26,370	27,672
BRAZORIA	603	651	910	1,140	1,379	1,590	1,711	1,850
BRAZORIA	604	1,119	1,491	1,788	2,087	2,342	2,532	2,616
BRAZORIA	607	231	271	308	340	364	397	417
BRAZORIA	608	5	5	5	5	5	5	5
TOTAL, EASTERN AREA		28,411	41,394	55,570	68,086	80,267	91,538	100,626

WESTERN AREA

COUNTY	CENSUS TRACT	1980	1990	2000	2010	2020	2030	2040
HARRIS	433	3,936	4,410	6,849	6,849	6,849	6,849	6,849
FORT BEND	701.01	27	42	177	177	177	177	177
FORT BEND	701.02	3,508	6,390	8,805	9,513	10,389	10,950	11,142
FORT BEND	701.03	3,970	8,355	9,489	9,789	9,999	10,239	10,479
FORT BEND	701.05	558	1,080	1,491	1,623	1,779	1,779	1,779
FORT BEND	701.06	12,094	14,473	16,955	18,829	20,659	22,865	24,585
FORT BEND	701.07	179	1,090	4,049	5,637	7,990	11,335	13,535
FORT BEND	702.02	315	2,004	4,431	4,929	5,550	6,150	6,702
FORT BEND	702.03	102	1,049	3,453	5,068	6,603	8,273	9,780
TOTAL, WESTERN AREA		24,689	38,893	55,699	62,414	69,995	78,617	85,028
GRAND TOTAL, BBWA		53,100	80,287	111,269	130,500	150,262	170,155	185,654

TABLE A-4

INVENTORY OF EXISTING WATER SUPPLY FACILITIES WITHIN THE BBWA STUDY AREA

SYSTEM NAME	FACILITY NUMBER	GROUND STORAGE (MG)	ELEVATED STORAGE (MG)	PRESSURE TANK CAP. (MG)	BOOSTER PUMP CAP. (GPM)	WELL CAP. (GPM)
EASTERN AREA						
B.C. MUD # 1	N/A	0	0	0	0	0
B.C. MUD # 2	1	1@0.500	0	1@0.015	1@500	1VT@1100
					1@100	
					1@760	
B.C. MUD # 4	N/A	0	0	0	0	2SUB@300
B.C. MUD # 5	1	1@0.500	0	2@0.015	3@600	1VT@800
MANVEL UTILITIES	1	0	0	1@0.0025	0	1SUB@300
PEARLAND	2	1@0.210	1@0.500	0	2@500	1VT@730
	3	1@0.500	0	1@0.020	2@500	1VT@710
	4	1@0.210	0	0	1@500	1VT@580
	5	1@0.420	1@0.500	0	3@700	1VT@1130
	6	1@0.560	1@0.500	0	2@750	1VT@1270
	7	1@0.560	0	0	2@750	1VT@950
WESTERN AREA						
BLUE RIDGE W. MUD	1	1@0.350	0	2@0.015	3@1000	1VT@1200
	2	1@0.100	1@0.500	1@0.020	2@750	1VT@1200
FIRST COLONY # 9	1	1@0.450	0	2@0.020	2@750	1VT@2000
					1@2000	
FBC MUD # 26	1	1@0.500	0	1@0.020	1@250	1VT@1200
				1@0.025	1@750	1VT@150
					1@1000	
FBC MUD # 42	1	1@0.340	0	1@0.035	2@500	1VT@1500
FBC MUD # 46	1	1@0.420	0	1@0.020		1VT@1000
FBC MUD # 47	1	1@0.229	0	1@0.025	2@600	1VT@700
FBC MUD # 48	N/A	0	0	0	0	0
FBC MUD # 49	N/A	0	0	0	0	0
WCID FONDREN ROAD	1	1@0.126	0	1@0.025	1@600	1VT@690
		1@0.400			1@500	1VT@1000
	2	1@0.200	0	2@0.005	2@500	1VT@750
MEADOWCREEK MUD	1	1@0.300	0	1@0.020	4@750	1VT@800
PALMER PLAN. MUD	1	1@0.420	0	1@0.020	2@750	1VT@1300
QUAIL VALLEY MUD	1	2@0.225		0	4@1000	1VT@1500
		1@0.500				1VT@500
	2	1@0.750	0	0	3@1000	1VT@1500
	3	1@1.020	1@0.500	0	4@1000	1VT@1700
SW HC MUD 1	1	2@0.210	0	1@0.008	2@200	1VT@500
					1@600	
THUNDERBIRD UD # 1	1	1@0.430	0	1@0.024	4@650	1VT@12090
		1@0.210				
	2	1@0.300	0	1@0.020	4@500	1VT@850
THUNDERBIRD UD # 2	1	1@0.500	0	1@0.020	3@650	1VT@700

TABLE A-6
ESTIMATED COST
REGIONAL WATER SUPPLY IMPROVEMENTS

EAST SYSTEM		ESTIMATED COST
PHASE I		
PLANT		
LAND ACQUISITION (98 ACRES)		$980,000
PLANT IMPROVEMENTS (15 MGD)		$11,285,000
RESERVOIR IMPROVEMENTS		$1,090,000
TRANSMISSION SYSTEM		
PUMP STATION		$1,036,000
PIPELINES		$10,111,000
EASEMENT ACQUISITION		$1,099,000
	SUBTOTAL	$25,601,000
CONTINGENCIES		$2,560,000
DESIGN SERVICES		$3,072,000
BOND COST		$2,715,000
	TOTAL, PHASE I	$33,948,000
PHASE II		
PLANT		
PLANT IMPROVEMENTS (TO 25 MGD)		$8,180,000
RESERVOIR EXPANSION		$1,090,000
TRANSMISSION SYSTEM		
PUMP STATION EXPANSION		$345,000
PIPELINES		$1,894,000
EASEMENT ACQUISITION		$236,000
	SUBTOTAL	$11,745,000
CONTINGENCIES		$1,175,000
DESIGN SERVICES		$1,410,000
BOND COST		$1,246,000
	TOTAL, PHASE II	$15,576,000
PHASE III		
PLANT		
PLANT IMPROVEMENTS (TO 30 MGD)		$5,150,000
TRANSMISSION SYSTEM		
PUMP STATION EXPANSION		$197,000
PIPELINES		$2,136,000
EASEMENT ACQUISITION		$353,000
	SUBTOTAL	$7,836,000
CONTINGENCIES		$784,000
DESIGN SERVICES		$940,000
BOND COST		$831,000
	TOTAL, PHASE III	$10,391,000
	GRAND TOTAL, ALL PHASES	$59,915,000

TABLE A-6
(CONTINUED)

WEST SYSTEM		ESTIMATED COST
PHASE I		
PLANT		
LAND ACQUISITION (98 ACRES)		$980,000
PLANT IMPROVEMENTS (15 MGD)		$11,285,000
RESERVOIR IMPROVEMENTS		$1,090,000
TRANSMISSION SYSTEM		
PUMP STATION		$1,036,000
PIPELINES		$9,526,000
EASEMENT ACQUISITION		$1,558,000
	SUBTOTAL	$25,475,000
CONTINGENCIES		$2,548,000
DESIGN SERVICES		$3,057,000
BOND COST		$2,703,000
	TOTAL, PHASE I	$33,783,000
PHASE II		
PLANT		
PLANT IMPROVEMENTS (TO 25 MGD)		$8,180,000
RESERVOIR EXPANSION		$1,090,000
TRANSMISSION SYSTEM		
PUMP STATION EXPANSION		$345,000
PIPELINES		$968,000
EASEMENT ACQUISITION		$207,000
	SUBTOTAL	$10,790,000
CONTINGENCIES		$1,079,000
DESIGN SERVICES		$1,295,000
BOND COST		$1,145,000
	TOTAL, PHASE II	$14,309,000
PHASE III		
PLANT		
PLANT IMPROVEMENTS (TO 30 MGD)		$5,150,000
TRANSMISSION SYSTEM		
PUMP STATION EXPANSION		$197,000
PIPELINES		$3,741,000
EASEMENT ACQUISITION		$676,000
	SUBTOTAL	$9,764,000
CONTINGENCIES		$976,000
DESIGN SERVICES		$1,172,000
BOND COST		$1,036,000
	TOTAL, PHASE III	$12,948,000
	GRAND TOTAL, ALL PHASES	$61,040,000

TABLE A-7
ESTIMATED ANNUAL COST
REGIONAL WATER SUPPLY IMPROVEMENTS

EAST SYSTEM		ESTIMATED COST
PHASE I		
WATER COST (6.25 MGD)		$205,300
OPERATION COST		
PLANT		$1,460,000
TRANSMISSION SYSTEM		$165,500
MAINTENANCE SYSTEM		
PLANT		$73,000
TRANSMISSION SYSTEM		$16,600
	SUBTOTAL	$1,920,400
BOND RETIREMENT		$3,587,300
	TOTAL ANNUAL COST	$5,507,700
	COST PER 1000 GALLONS	$2.41
PHASE II		
WATER COST (10.42 MGD)		$343,700
OPERATION COST		
PLANT		$2,441,100
TRANSMISSION SYSTEM		$276,600
MAINTENANCE SYSTEM		
PLANT		$122,000
TRANSMISSION SYSTEM		$27,600
	SUBTOTAL	$3,211,000
BOND RETIREMENT		$1,645,900
	TOTAL ANNUAL COST	$4,856,900
	COST PER 1000 GALLONS	$1.28
PHASE III		
WATER COST (12.50 MGD)		$491,500
OPERATION COST		
PLANT		$2,931,700
TRANSMISSION SYSTEM		$332,300
MAINTENANCE SYSTEM		
PLANT		$146,600
TRANSMISSION SYSTEM		$33,200
	SUBTOTAL	$3,935,300
BOND RETIREMENT		$1,098,000
	TOTAL ANNUAL COST	$5,033,300
	COST PER 1000 GALLONS	$1.10

TABLE A-7
(CONTINUED)

WEST SYSTEM		ESTIMATED COST
PHASE I		
WATER COST (6.25 MGD)		$205,300
OPERATION COST		
PLANT		$1,460,000
TRANSMISSION SYSTEM		$165,500
MAINTENANCE SYSTEM		
PLANT		$73,000
TRANSMISSION SYSTEM		$16,600
	SUBTOTAL	$1,920,400
BOND RETIREMENT		$3,569,900
	TOTAL ANNUAL COST	$5,490,300
	COST PER 1000 GALLONS	$2.41
PHASE II		
WATER COST (10.42 MGD)		$343,700
OPERATION COST		
PLANT		$2,441,100
TRANSMISSION SYSTEM		$276,600
MAINTENANCE SYSTEM		
PLANT		$122,000
TRANSMISSION SYSTEM		$27,600
	SUBTOTAL	$3,211,000
BOND RETIREMENT		$1,512,000
	TOTAL ANNUAL COST	$4,723,000
	COST PER 1000 GALLONS	$1.24
PHASE III		
WATER COST (12.50 MGD)		$491,500
OPERATION COST		
PLANT		$2,931,700
TRANSMISSION SYSTEM		$332,300
MAINTENANCE SYSTEM		
PLANT		$146,600
TRANSMISSION SYSTEM		$33,200
	SUBTOTAL	$3,935,300
BOND RETIREMENT		$1,368,200
	TOTAL ANNUAL COST	$5,303,500
	COST PER 1000 GALLONS	$1.16

TABLE A-9
ESTIMATED COST
REGIONAL WASTEWATER TREATMENT IMPROVEMENTS

A. SERVICE AREA, NO EXISTING PLANT

BRAZOS RIVER SERVICE AREA

		ESTIMATED COST
PHASE II		
PLANT		
LAND ACQUISITION (3 ACRES)		$30,000
PLANT IMPROVEMENTS (0.375 MGD)		$750,000
TRUNK COLLECTION SYSTEM		
LIFT STATIONS (2)		$185,000
FORCE MAINS		$95,000
GRAVITY SEWERS		$2,914,000
EASEMENT ACQUISITION		$20,000
	SUBTOTAL	$3,994,000
CONTINGENCIES		$399,000
ENGINEERING SERVICES		$479,000
BOND COST		$424,000
	TOTAL, PHASE II	$5,296,000
PHASE III		
PLANT		
PLANT EXPANSION (TO 0.75 MGD)		$750,000
TRUNK COLLECTION SYSTEM		
LIFT STATIONS (2)		$100,000
FORCE MAINS		$47,000
GRAVITY SEWERS		$839,000
EASEMENT ACQUISITION		$48,000
	SUBTOTAL	$1,784,000
CONTINGENCIES		$178,000
ENGINEERING SERVICES		$214,000
BOND COST		$189,000
	TOTAL, PHASE III	$2,365,000

TABLE A-9

A. SERVICE AREA, NO EXISTING PLANT (CONTINUED)

COWART CREEK SERVICE AREA

		ESTIMATED COST
PHASE I		
PLANT		
LAND ACQUISITION (3 ACRES)		$30,000
PLANT IMPROVEMENTS (1.0 MGD)		$1,900,000
TRUNK COLLECTION SYSTEM		
LIFT STATIONS		$135,000
FORCE MAINS		$68,000
GRAVITY SEWERS		$2,834,000
EASEMENT ACQUISITION		$75,000
	SUBTOTAL	$5,042,000
CONTINGENCIES		$504,000
ENGINEERING SERVICES		$605,000
BOND COST		$535,000
	TOTAL, PHASE I	$6,686,000
PHASE II		
TRUNK COLLECTION SYSTEM		
GRAVITY SEWERS		$2,039,000
EASEMENT ACQUISITION		$150,000
	SUBTOTAL	$2,189,000
CONTINGENCIES		$219,000
ENGINEERING SERVICES		$263,000
BOND COST		$232,000
	TOTAL, PHASE II	$2,903,000

TABLE A-9

A. SERVICE AREA, NO EXISTING PLANT (CONTINUED)

FLAT BANK CREEK SERVICE AREA

PHASE I		ESTIMATED COST
PLANT		
LAND ACQUISITION (5 ACRES)		$50,000
PLANT IMPROVEMENTS (1.0 MGD)		$1,750,000
TRUNK COLLECTION SYSTEM		
LIFT STATIONS		$130,000
FORCE MAINS		$30,000
GRAVITY SEWERS		$2,074,000
EASEMENT ACQUISITION		$35,000
	SUBTOTAL	$4,069,000
CONTINGENCIES		$407,000
ENGINEERING SERVICES		$488,000
BOND COST		$432,000
	TOTAL, PHASE I	$5,396,000

PHASE II		
PLANT		
PLANT EXPANSION (TO 2.0 MGD)		$1,750,000
TRUNK COLLECTION SYSTEM		
LIFT STATIONS		$105,000
FORCE MAINS		$64,000
GRAVITY SEWERS		$334,000
EASEMENT ACQUISITION		$10,000
	SUBTOTAL	$2,263,000
CONTINGENCIES		$226,000
ENGINEERING SERVICES		$272,000
BOND COST		$240,000
	TOTAL, PHASE II	$3,001,000

TABLE A-9

A. SERVICE AREA, NO EXISTING PLANT
(CONTINUED)

LOWER CHOCOLATE BAYOU SERVICE AREA

		ESTIMATED COST
PHASE I		
PLANT		
LAND ACQUISITION (3 ACRES)		$30,000
PLANT IMPROVEMENTS (1.0 MGD)		$1,750,000
TRUNK COLLECTION SYSTEM		
LIFT STATIONS (2)		$185,000
FORCE MAINS		$110,000
GRAVITY SEWERS		$3,072,000
EASEMENT ACQUISITION		$150,000
	SUBTOTAL	$5,297,000
CONTINGENCIES		$530,000
ENGINEERING SERVICES		$636,000
BOND COST		$562,000
	TOTAL, PHASE I	$7,025,000
PHASE II		
TRUNK COLLECTION SYSTEM		
LIFT STATIONS		$40,000
FORCE MAINS		$7,000
GRAVITY SEWERS		$5,616,000
EASEMENT ACQUISITION		$255,000
	SUBTOTAL	$5,918,000
CONTINGENCIES		$592,000
ENGINEERING SERVICES		$711,000
BOND COST		$628,000
	TOTAL, PHASE II	$7,849,000
PHASE III		
TRUNK COLLECTION SYSTEM		
LIFT STATIONS		$50,000
FORCE MAINS		$4,000
GRAVITY SEWERS		$1,195,000
EASEMENT ACQUISITION		$135,000
	SUBTOTAL	$1,384,000
CONTINGENCIES		$139,000
ENGINEERING SERVICES		$167,000
BOND COST		$147,000
	TOTAL, PHASE III	$1,837,000

TABLE A-9

A. SERVICE AREA, NO EXISTING PLANT
(CONTINUED)

MARY'S CREEK SERVICE AREA

		ESTIMATED COST
PHASE I		
PLANT		
LAND ACQUISITION (4 ACRES)		$40,000
PLANT IMPROVEMENTS (0.5 MGD)		$950,000
TRUNK COLLECTION SYSTEM		
GRAVITY SEWERS		$1,155,000
EASEMENT ACQUISITION		$60,000
	SUBTOTAL	$2,205,000
CONTINGENCIES		$220,000
ENGINEERING SERVICES		$265,000
BOND COST		$234,000
	TOTAL, PHASE I	$2,924,000
PHASE II		
PLANT		
PLANT EXPANSION (TO 1.0 MGD)		$950,000
TRUNK COLLECTION SYSTEM		
LIFT STATION		$95,000
FORCE MAINS		$24,000
GRAVITY SEWERS		$808,000
EASEMENT ACQUISITION		$30,000
	SUBTOTAL	$1,907,000
CONTINGENCIES		$191,000
ENGINEERING SERVICES		$229,000
BOND COST		$202,000
	TOTAL, PHASE II	$2,529,000
PHASE III		
PLANT		
PLANT EXPANSION (TO 1.5 MGD)		$950,000
TRUNK COLLECTION SYSTEM		
GRAVITY SEWERS		$389,000
EASEMENT ACQUISITION		$30,000
	SUBTOTAL	$1,369,000
CONTINGENCIES		$137,000
ENGINEERING SERVICES		$164,000
BOND COST		$145,000
	TOTAL, PHASE III	$1,815,000

TABLE A-9

A. SERVICE AREA, NO EXISTING PLANT
(CONTINUED)

OYSTER CREEK SERVICE AREA

PHASE II		ESTIMATED COST
LAND ACQUISITION (3 ACRES)		$30,000
PLANT IMPROVEMENTS (0.4 MGD)		$720,000
TRUNK COLLECTION SYSTEM		
LIFT STATIONS (4)		$320,000
FORCE MAINS		$88,000
GRAVITY SEWERS		$2,287,000
EASEMENT ACQUISITION		$45,000
	SUBTOTAL	$3,490,000
CONTINGENCIES		$349,000
ENGINEERING SERVICES		$419,000
BOND COST		$371,000
	TOTAL, PHASE II	$4,629,000

PHASE III		
PLANT		
PLANT EXPANSION (TO 0.8 MGD)		$720,000
	SUBTOTAL	$720,000
CONTINGENCIES		$72,000
ENGINEERING SERVICES		$87,000
BOND COST		$77,000
	TOTAL, PHASE III	$956,000

TABLE A-9

A. SERVICE AREA, NO EXISTING PLANT (CONTINUED)

UPPER CHOCOLATE BAYOU SERVICE AREA

		ESTIMATED COST
PHASE II		
PLANT		
LAND ACQUISITION (3 ACRES)		$30,000
PLANT IMPROVEMENTS (0.75 MGD)		$1,500,000
TRUNK COLLECTION SYSTEM		
LIFT STATION		$100,000
FORCE MAINS		$48,000
GRAVITY SEWERS		$4,042,000
EASEMENT ACQUISITION		$45,000
	SUBTOTAL	$5,765,000
CONTINGENCIES		$577,000
ENGINEERING SERVICES		$692,000
BOND COST		$612,000
	TOTAL, PHASE II	$7,646,000
PHASE III		
TRUNK COLLECTION SYSTEM		
LIFT STATIONS (3)		$120,000
FORCE MAINS		$28,000
GRAVITY SEWERS		$1,016,000
EASEMENT ACQUISITION		$23,000
	SUBTOTAL	$1,187,000
CONTINGENCIES		$119,000
ENGINEERING SERVICES		$143,000
BOND COST		$126,000
	TOTAL, PHASE III	$1,575,000

TABLE A-9
ESTIMATED COST
REGIONAL WASTEWATER TREATMENT COST

B. SERVICE AREA, WITH EXISTING PLANTS

BLUE RIDGE SERVICE AREA		ESTIMATED COST
PLANT		
REPLACE, EXPANSION (1.5 MGD)		$2,725,000
TRUNK COLLECTION SYSTEM		
LIFT STATIONS (2)		$215,000
FORCE MAINS		$33,000
GRAVITY SEWERS		$153,000
EASEMENT ACQUISITION		$25,000
	SUBTOTAL	$3,151,000
CONTINGENCIES		$315,000
ENGINEERING SERVICES		$378,000
BOND COST		$334,000
	TOTAL	$4,178,000

CLEAR CREEK SERVICE AREA		
PLANT		
REPLACE, EXPANSION (1.5 MGD)		$2,815,000
TRUNK COLLECTION SYSTEM		
LIFT STATIONS (2)		$210,000
FORCE MAINS		$20,000
GRAVITY SEWERS		$2,635,000
EASEMENT ACQUISITION		$150,000
	SUBTOTAL	$5,830,000
CONTINGENCIES		$583,000
ENGINEERING SERVICES		$700,000
BOND COST		$618,000
	TOTAL	$7,731,000

TABLE A-9

B. SERVICE AREA, WITH EXISTING PLANTS (CONTINUED)

EAST PEARLAND SERVICE AREA		ESTIMATED COST
PLANT		
REPLACE (2.0 MGD)		$3,825,000
TRUNK COLLECTION SYSTEM		
LIFT STATIONS		$90,000
FORCE MAINS		$18,000
GRAVITY SEWERS		$543,000
EASEMENT ACQUISITION		$56,000
	SUBTOTAL	$4,532,000
CONTINGENCIES		$453,000
ENGINEERING SERVICES		$544,000
BOND COST		$481,000
	TOTAL	$6,010,000

FONDREN PARK SERVICE AREA		
PLANT		
REPLACE, EXPANSION (.75 MGD)		$1,575,000
TRUNK COLLECTION SYSTEM		
LIFT STATIONS		$70,000
FORCE MAINS		$68,000
	SUBTOTAL	$1,713,000
CONTINGENCIES		$171,000
ENGINEERING SERVICES		$205,000
BOND COST		$182,000
	TOTAL	$2,271,000

TABLE A-9

B. SERVICE AREA, WITH EXISTING PLANTS
(CONTINUED)

QUAIL VALLEY SERVICE AREA		ESTIMATED COST
PLANT		
REPLACE (4.0 MGD)		$7,025,000
	SUBTOTAL	$7,025,000
CONTINGENCIES		$702,000
ENGINEERING SERVICES		$843,000
BOND COST		$745,000
	TOTAL	$9,315,000

VICKSBURG SERVICE AREA		
PLANT		
REPLACE, EXPANSION (0.75 MGD)		$1,575,000
TRUNK COLLECTION SYSTEM		
LIFT STATION		$85,000
FORCE MAINS		$15,000
GRAVITY SEWERS		$791,000
EASEMENT ACQUISITION		$112,000
	SUBTOTAL	$2,578,000
CONTINGENCIES		$258,000
ENGINEERING SERVICES		$309,000
BOND COST		$273,000
	TOTAL	$3,418,000

TABLE A-9

B. SERVICE AREA, WITH EXISTING PLANTS
(CONTINUED)

WEST PEARLAND SERVICE AREA		ESTIMATED COST
PLANT		
REPLACE, EXPANSION (4.50 MGD)		$8,350,000
TRUNK COLLECTION SYSTEM		
LIFT STATIONS (2)		$310,000
FORCE MAINS		$164,000
GRAVITY SEWERS		$4,636,000
EASEMENT ACQUISITION		$394,000
	SUBTOTAL	$13,854,000
CONTINGENCIES		$1,385,000
ENGINEERING SERVICES		$1,662,000
BOND COST		$1,470,000
	TOTAL	$18,371,000

TABLE A-10
ESTIMATED ANNUAL COST
REGIONAL WASTEWATER TREATMENT IMPROVEMENTS

BRAZOS RIVER SERVICE AREA

		ESTIMATED COST
PHASE II (ESTIMATED AVERAGE DAILY FLOW PHASE II = 0.35 MG)		
OPERATION AND MAINTENANCE		
PLANT		$85,600
TRUNK COLLECTION SYSTEM		$5,900
	SUBTOTAL	$91,500
BOND RETIREMENT EXPENSE		$559,600
	TOTAL, PHASE II	$651,100
	EST. COST PER 1000 GALLONS	$5.10
PHASE III (ESTIMATED AVERAGE DAILY FLOW PHASE III = 0.62 MG)		
OPERATION AND MAINTENANCE		
PLANT		$147,300
TRUNK COLLECTION SYSTEM		$8,800
	SUBTOTAL	$156,100
BOND RETIREMENT EXPENSE		$249,900
	TOTAL, PHASE III	$406,000
	EST. COST PER 1000 GALLONS	$1.79

TABLE A-10
(CONTINUED)

COWART CREEK SERVICE AREA

		ESTIMATED COST
PHASE I		
(ESTIMATED AVERAGE DAILY FLOW PHASE I = 0.67 MG)		
OPERATION AND MAINTENANCE		
PLANT		$159,200
TRUNK COLLECTION SYSTEM		$7,100
	SUBTOTAL	$166,300
BOND RETIREMENT EXPENSE		$706,500
	TOTAL, PHASE I	$872,800
	EST. COST PER 1000 GALLONS	$3.57
PHASE II		
(ESTIMATED AVERAGE DAILY FLOW PHASE II = 0.76 MG)		
OPERATION AND MAINTENANCE		
PLANT		$179,600
TRUNK COLLECTION SYSTEM		$13,200
	SUBTOTAL	$192,800
BOND RETIREMENT EXPENSE		$306,800
	TOTAL, PHASE II	$499,600
	EST. COST PER 1000 GALLONS	$1.80
PHASE III		
(ESTIMATED AVERAGE DAILY FLOW PHASE III = 0.82 MG)		
OPERATION AND MAINTENANCE		
PLANT		$195,300
TRUNK COLLECTION SYSTEM		$13,200
	SUBTOTAL	$208,500
BOND RETIREMENT EXPENSE		$0
	TOTAL, PHASE III	$208,500
	EST. COST PER 1000 GALLONS	$0.70

TABLE A-10
(CONTINUED)

FLAT BANK CREEK SERVICE AREA

		ESTIMATED COST
PHASE I		
(ESTIMATED AVERAGE DAILY FLOW PHASE I = 0.85 MG)		
OPERATION AND MAINTENANCE		
PLANT		$200,500
TRUNK COLLECTION SYSTEM		$4,800
	SUBTOTAL	$205,300
BOND RETIREMENT EXPENSE		$570,200
	TOTAL, PHASE I	$775,500
	EST. COST PER 1000 GALLONS	$2.52
PHASE II		
(ESTIMATED AVERAGE DAILY FLOW PHASE II = 1.46 MG)		
OPERATION AND MAINTENANCE		
PLANT		$317,200
TRUNK COLLECTION SYSTEM		$6,400
	SUBTOTAL	$323,600
BOND RETIREMENT EXPENSE		$317,200
	TOTAL, PHASE II	$640,800
	EST. COST PER 1000 GALLONS	$1.21
PHASE III		
(ESTIMATED AVERAGE DAILY FLOW PHASE III = 2.00 MG)		
OPERATION AND MAINTENANCE		
PLANT		$451,500
TRUNK COLLECTION SYSTEM		$6,400
	SUBTOTAL	$457,900
BOND RETIREMENT EXPENSE		$0
	TOTAL, PHASE III	$457,900
	EST. COST PER 1000 GALLONS	$0.63

TABLE A-10
(CONTINUED)

LOWER CHOCOLATE BAYOU SERVICE AREA

		ESTIMATED COST
PHASE I		
(ESTIMATED AVERAGE DAILY FLOW PHASE I = 0.53 MG)		
OPERATION AND MAINTENANCE		
PLANT		$131,300
TRUNK COLLECTION SYSTEM		$7,200
	SUBTOTAL	$138,500
BOND RETIREMENT EXPENSE		$742,300
	TOTAL, PHASE I	$880,800
	EST. COST PER 1000 GALLONS	$4.56
PHASE II		
(ESTIMATED AVERAGE DAILY FLOW PHASE II = 0.72 MG)		
OPERATION AND MAINTENANCE		
PLANT		$179,500
TRUNK COLLECTION SYSTEM		$20,100
	SUBTOTAL	$199,600
BOND RETIREMENT EXPENSE		$829,400
	TOTAL, PHASE II	$1,029,000
	EST. COST PER 1000 GALLONS	$3.90
PHASE III		
(ESTIMATED AVERAGE DAILY FLOW PHASE III = 0.86 MG)		
OPERATION AND MAINTENANCE		
PLANT		$212,200
TRUNK COLLECTION SYSTEM		$23,600
	SUBTOTAL	$235,800
BOND RETIREMENT EXPENSE		$194,100
	TOTAL, PHASE III	$429,900
	EST. COST PER 1000 GALLONS	$1.38

TABLE A-10
(CONTINUED)

MARY'S CREEK SERVICE AREA

		ESTIMATED COST
PHASE I (ESTIMATED AVERAGE DAILY FLOW PHASE I = 0.42 MG)		
OPERATION AND MAINTENANCE		
PLANT		$105,300
TRUNK COLLECTION SYSTEM		$2,500
	SUBTOTAL	$107,800
BOND RETIREMENT EXPENSE		$310,100
	TOTAL, PHASE I	$417,900
	EST. COST PER 1000 GALLONS	$2.70
PHASE II (ESTIMATED AVERAGE DAILY FLOW PHASE II = 0.91 MG)		
OPERATION AND MAINTENANCE		
PLANT		$215,900
TRUNK COLLECTION SYSTEM		$4,300
	SUBTOTAL	$220,200
BOND RETIREMENT EXPENSE		$267,300
	TOTAL, PHASE II	$487,500
	EST. COST PER 1000 GALLONS	$1.47
PHASE III (ESTIMATED AVERAGE DAILY FLOW PHASE III = 1.45 MG)		
OPERATION AND MAINTENANCE		
PLANT		$337,600
TRUNK COLLECTION SYSTEM		$5,500
	SUBTOTAL	$343,100
BOND RETIREMENT EXPENSE		$191,800
	TOTAL, PHASE III	$534,900
	EST. COST PER 1000 GALLONS	$1.02

TABLE A-10
(CONTINUED)

OYSTER CREEK SERVICE AREA

		ESTIMATED COST
PHASE II (ESTIMATED AVERAGE DAILY FLOW PHASE II = 0.42 MG)		
OPERATION AND MAINTENANCE		
PLANT		$103,000
TRUNK COLLECTION SYSTEM		$6,400
	SUBTOTAL	$109,400
BOND RETIREMENT EXPENSE		$489,100
	TOTAL, PHASE II	$598,500
	EST. COST PER 1000 GALLONS	$3.95
PHASE III (ESTIMATED AVERAGE DAILY FLOW PHASE III = 0.77 MG)		
OPERATION AND MAINTENANCE		
PLANT		$181,700
TRUNK COLLECTION SYSTEM		$6,400
	SUBTOTAL	$188,100
BOND RETIREMENT EXPENSE		$101,000
	TOTAL, PHASE III	$289,100
	EST. COST PER 1000 GALLONS	$1.03

TABLE A-10
(CONTINUED)

UPPER CHOCOLATE BAYOU SERVICE AREA

		ESTIMATED COST
PHASE II (ESTIMATED AVERAGE DAILY FLOW PHASE II = 0.38 MG)		
OPERATION AND MAINTENANCE		
PLANT		$94,800
TRUNK COLLECTION SYSTEM		$9,000
	SUBTOTAL	$103,800
BOND RETIREMENT EXPENSE		$808,000
	TOTAL, PHASE II	$911,800
	EST. COST PER 1000 GALLONS	$6.54
PHASE III (ESTIMATED AVERAGE DAILY FLOW PHASE III = 0.56 MG)		
OPERATION AND MAINTENANCE		
PLANT		$140,000
TRUNK COLLECTION SYSTEM		$12,600
	SUBTOTAL	$152,600
BOND RETIREMENT EXPENSE		$166,400
	TOTAL, PHASE III	$319,000
	EST. COST PER 1000 GALLONS	$1.55

Appendix B

BRAZOS BEND WATER AUTHORITY

WATER CONSERVATION PLAN

DROUGHT/EMERGENCY CONTINGENCY PLAN

TABLE OF CONTENTS

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EXECUTIVE SUMMARY

The act of 69th Texas Legislature authorizing creation of the Brazos Bend Water Authority (The Authority or BBWA) contains provisions requiring the Authority to adopt and implement a program of water conservation. The objective of State of Texas Water Conservation programs is to protect and extend the availability of State water resources through the promotion of efficient water use practices. Additionally, it is encumbant that water supply agencies have a plan in place to deal with temporary, short term, water shortages that result from drought and emergency situations.

As a first step in the development of water conservation and drought/emergency plans for The Authority, operating conditions and practices of existing public water and wastewater utilities in the study area were surveyed. Topics surveyed included service area boundaries, population projections through the year 2040, monthly water sales by user category, number and growth of utility connections, annualized water production and wastewater treatment flow rates, metering practices, water supply facility components, high-volume water customers, revenue sources, water and sewer rates, and prevailing governmental standards.

Based on this information, it was concluded that existing public water supply and wastewater treatment utilities in the study area were generally operating within prevailing standards but that implementation of short term water conservation measures could result in a 4.3 percent reduction in water consumption.

The Authority's recommended water conservation program consists of a short term and long term program. It is intended that The Authority act in concert with its customers in the implementation of these programs.

The Authority's short term program has a goal of reducing water consumption by 4.3 percent. The program consists primarily of activities to notify the public of Authority goals and standards and to identify measures effective in reducing individual water consumption.

The Authority's long term program goal is to reduce overall water consumption by 10 percent. This program continues public education activities but also includes provisions requiring adoption of water conserving plumbing codes and water rate structures, water conservation retrofit programs, assistance in the determination of sources of unaccounted water loss, and consideration of water recycling and reuse.

It is recommended that a member of The Authority board or staff be selected to work with Authority customer's to oversee these programs.

The Authority's recommended Drought/Emergency Contingency Plan provides a system for classifying the severity of temporary water supply shortages and identifies measures for dealing with the various shortage conditions. In addition to public notification activities, these measures include voluntary curtailment of non-essential water use during mild water supply shortage periods, mandatory curtailment and water rate surcharges during moderate water supply shortage periods, and water rationing during severe water supply shortage periods.

It is recommended that a member of The Authority board or staff be selected to work with authority customer's to assure equitable distribution of BBWA water resources during drought/emergency conditions.

I. INTRODUCTION

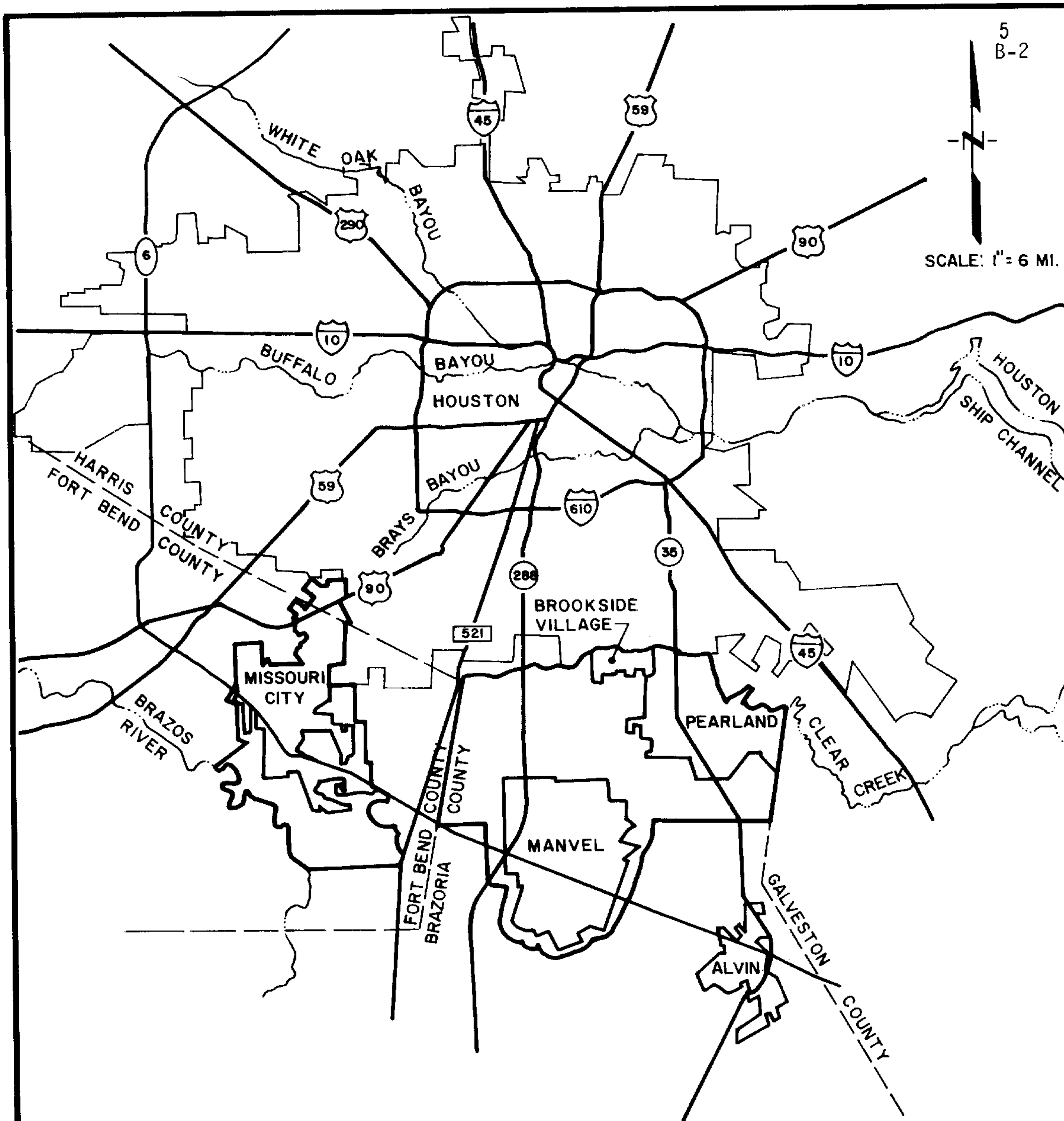
1. PURPOSE

To obtain financial assistance from the Texas Water Development Board or Water Loan Assistance fund by a political subdivision, a water conservation and drought contingency plan must be written and in place. These requirements were set by the 69th Texas Legislature in 1985 by House Bill (HB) 2 and Joint Resolution (HJR) 6. Texas voters approved the amendment to the Texas Constitution implementing HB 2 on November 5, 1985.

The purpose of this report is to satisfy the above requirements by presenting data and conservation alternatives for each district in the BBWA study area (See Figure 1). The study area includes the following cities and utility districts:

Eastern Study Area:	Brookside Village
	City of Manvel
	City of Pearland
	Brazoria County MUD 1
	Brazoria County MUD 2
	Brazoria County MUD 3
	Brazoria County MUD 4
	Brazoria County MUD 5
	Brazoria County MUD 6
	Brazoria County MUD 7
	Brazoria County MUD 10
	Brazoria County MUD 16
Western Study Area:	Blue Ridge West MUD
	First Colony MUD 9
	Fort Bend County MUD 26
	Fort Bend County MUD 36
	Fort Bend County MUD 42
	Fort Bend County MUD 46
	Fort Bend County MUD 47
	Fort Bend County MUD 48
	Fort Bend County MUD 49
	Fort Bend County MUD 55
	Fort Bend County MUD 56
	Fort Bend County WCID 2

5
B-2



BRAZOS BEND WATER AUTHORITY

STUDY AREA

LOCKWOOD, ANDREWS & NEWNAM /
WALSH ENGINEERING, INC.
A JOINT VENTURE

FIGURE No.
1

Western Study Area: (Continued)	Harris County MUD 122
	Harris County WCID Fondren Road
	Meadow Creek MUD
	Palmer Plantation MUD 1
	Palmer Plantation MUD 2
	Quail Valley Utility District
	Southwest Harris County MUD 1
	Thunderbird Utility District
	Missouri City

2. THE AUTHORITY

The Brazos Bend Water Authority was created by an act of Texas legislature in 1985. The legislature was initiated by the Cities of Brookside Village, Manvel, Missouri City and Pearland, resulting from concern that continued pumping of ground water could deplete the resources, causing considerable subsidence. Also, the organizers realized the need for regional planning to reduce the proliferation of small wastewater treatment facilities.

The Authority has five (5) board members, no taxing powers and can plan, develop, own, and operate utility facilities. Authority funding will be provided by grants, and revenues from contracted services. The objectives of the BBWA are to provide regional planning services, and to provide regional water supply and wastewater treatment services.

3. BACKGROUND

Water used in the residential and commercial sector involves the day-to-day activities of all citizens of the state and includes water used for drinking, bathing, cooking, toilet flushing, fire protection, lawn watering, swimming pools, laundry, dish washing, car washing, and sanitation. Since the early 1960s, per capita water use in the state has increased about four gallons per person per decade. More importantly per capita water use during droughts is usually about one-third greater than during periods of average precipitation.

The objective of a conservation program is to reduce the quantity required for each water using activity, to the extent as is practical, through the implementation of efficient water use practices. A drought contingency program provides procedures for voluntary and mandatory actions which are put into effect to temporarily reduce the demand placed upon a water supply system during a water shortage emergency. Both programs are tools that water suppliers should have available to operate effectively in all situations.

Water conservation programs are written for a long term reduction in water consumption. In the past such plans have resulted in as much as a 25 percent reduction in water use. Because water is becoming a scarce commodity, water conservation techniques are becoming increasingly important.

A drought contingency program includes those measures that a city or utility can use to cause a significant, but temporary, reduction in water use. These measures usually involve either voluntary use reductions, the restriction or elimination of certain types of water use, water rationing, or the temporary use of water from sources other than the established supplies. Communities that have used drought contingency programs have achieved short-term water use reductions in excess of 50 percent during drought emergency situations. Because the onset of emergency conditions is often rapid, it is important that a city or utility be prepared in advance.

Further, the citizen or customer must know that certain measures not used in an ongoing conservation program may be necessary if drought or other emergency conditions occur.

II. WATER CONSERVATION

1. INTRODUCTION

In order to identify water conservation measures and programs needed by BBWA to achieve future reductions in water consumption, current practices of existing water supply utilities within the study area were surveyed. Survey results, a discussion of potential supply and demand water conservation management methods, and an assessment of potential water and cost savings associated with identified management methods are presented in this section.

2. UTILITY SURVEY

Existing public utility agencies within the BBWA Study Area were surveyed regarding numbers of utility connections and service area boundaries; water production and sales quantities; wastewater flows; system rate structures, revenues and operating costs; and applicable regulatory standards. Additionally, forecasts of existing utility system populations through the year 2040 are listed.

Utility survey information is presented in tabular form on Pages B-9 through B-30.

Service areas of existing public water supply systems are presented in Table 1, Page B-9. Service area acreages were determined from information contained in utility district creation reports, planning data provided by municipalities and from municipal boundary maps.

Forecasted populations from 1988 through 2040, for municipalities (eastern area), existing utility districts and remaining undeveloped or rural regions are presented in Table 2, Page B-10. This information is based on demographic studies and forecasts developed for the accompanying regional water supply and wastewater planning study for the BBWA study area.

Table 3, Page B-11 through B-17 present estimated water sales for study area utility districts. Sales are categorized by user type and are based on information from monthly report forms and operator provided information. These tables illustrates that most water sold in the study area is for residential use.

Table 4, Page B-18, lists the number of current service connections and annual connection increase, by user category, for existing public water supply agencies.

Water production information is given in Table 5, Page B-19. This information was obtained from the monthly operating reports on file at the Texas Department of Health.

Tables 6 and 7, Pages B-20 and B-21, provide wastewater flow information. These tables show that currently, all wastewater treatment utilities are operating within permit flow standards and that most customers with water service also receive wastewater service.

Table 8, Page B-22, lists existing water system facility data and the percent of water supply connections metered. Currently all public water supply customers are metered.

Table 9, Page B-23, lists high volume water consumers in the area. It can be seen from this Table that there are a limited number of high volume consumers.

The revenues and cost for each public water system as well as the rate structures are presented in Tables 10, 11 and 12, Pages B-24 through B-29. The tables show that currently most public water supply and wastewater treatment agencies derive the majority of their revenue from service charges and the most rate structures are increasing block.

The last table in the utility survey, Table 13, Page B-30, presents applicable local, state and federal regulations. The Southern Standard Building Code is currently implemented in all the cities of the study area and the districts within these cities.

3. PUBLIC PARTICIPATION

The Brazos Bend Water Authority has held three public meetings, as follows: January 25, 1989 at Pearland City Hall, April 19, 1989 at Manvel Junior High School, and on July 19, 1989 at the Missouri City Civics Center Complex. The meetings were open to the public, and citizen comments were solicited.

TABLE 1
SERVICE AREA OF PUBLIC WATER SYSTEMS

AREA DESIGNATION	AREA (ACRES)
BLUE RIDGE RIDGE WEST MUD	850
BRAZORIA COUNTY MUD 1	450
BRAZORIA COUNTY MUD 2	350
BRAZORIA COUNTY MUD 4	600
BRAZORIA COUNTY MUD 5	500
FIRST COLONY MUD 9	950
FORT BEND COUNTY MUD 26	450
FORT BEND COUNTY MUD 42	550
FORT BEND COUNTY MUD 46	150
FORT BEND COUNTY MUD 47	250
FORT BEND COUNTY MUD 48	250
FORT BEND COUNTY MUD 49	150
FORT BEND COUNTY WCID 2	1,700
HARRIS COUNTY MUD 122	250
HARRIS COUNTY WCID FONDREN ROAD	350
MEADOWCREEK MUD	250
PALMER PLANTATION MUD 1	400
PEARLAND	11,900
QUAIL VALLEY UTILITY DISTRICT	1,570
SOUTHWEST HARRIS COUNTY MUD 1	150
THUNDERBIRD UTILITY DISTRICT	950

SOURCE: USGS MAP AND CREATION REPORTS FOR EACH UTILITY DISTRICT.

TABLE 2
POPULATION PROJECTIONS/ BBWA SERVICE AREA

AREA DESIGNATION	1988	1990	2000	2010	2020	2030	2040
<u>WESTERN STUDY AREA</u>							
BLUE RIDGE WEST MUD	6,651	7,050	7,464	7,464	7,464	7,464	7,464
FIRST COLONY MUD 9	966	1,368	4,611	5,214	5,739	5,919	5,919
FORT BEND COUNTY MUD 26	2,295	2,745	3,153	3,393	3,633	3,633	3,633
FORT BEND COUNTY MUD 36	0	0	861	1,140	1,536	1,719	1,719
FORT BEND COUNTY MUD 42	429	480	900	1,260	1,881	2,481	3,033
FORT BEND COUNTY MUD 46	0	0	120	486	945	1,278	1,278
FORT BEND COUNTY MUD 47	150	300	660	1,050	1,350	1,590	1,950
FORT BEND COUNTY MUD 48	126	276	630	1,032	1,350	1,590	1,950
FORT BEND COUNTY MUD 49	30	120	450	750	1,050	1,470	1,470
FORT BEND COUNTY MUD 55	0	0	660	900	1,305	1,800	2,250
FORT BEND COUNTY MUD 56	0	0	664	900	1,296	1,800	2,250
FORT BEND COUNTY WCID 2	1,749	1,884	3,123	3,684	4,200	4,620	4,860
HARRIS COUNTY MUD 122	102	180	1,827	1,827	1,827	1,827	1,827
HARRIS COUNTY WCID FN RD	2,742	2,790	2,988	2,988	2,988	2,988	2,988
MEADOWCREEK MUD	1,938	2,091	2,694	2,694	2,694	2,694	2,694
PALMER PLANTATION MUD 1	350	510	951	1,413	1,875	1,875	1,875
PALMER PLANTATION MUD 2	0	0	200	400	600	900	1,500
QUAIL VALLEY UD	10,059	10,452	11,190	11,190	11,190	11,190	11,190
SW HARRIS COUNTY MUD 1	1,335	1,440	1,557	1,557	1,557	1,557	1,557
THUNDERBIRD UD	5,211	5,388	5,499	5,499	5,499	5,499	5,499
OTHER, WESTERN AREA	599	1,819	5,497	7,573	10,016	14,723	18,122
<u>EASTERN STUDY AREA</u>							
BRAZORIA COUNTY MUD 1	850	1000	1,500	2,000	2,300	2,600	2,800
BRAZORIA COUNTY MUD 2	250	350	750	1,200	1,500	1,800	2,000
BRAZORIA COUNTY MUD 3	0	0	200	500	900	1,500	1,800
BRAZORIA COUNTY MUD 4	450	550	700	1,050	1,500	2,100	2,500
BRAZORIA COUNTY MUD 5	1,600	1,700	2,500	3,000	3,300	3,500	3,600
BRAZORIA COUNTY MUD 6	0	0	100	350	500	600	700
BRAZORIA COUNTY MUD 7	0	0	400	900	1,500	2,000	2,500
BRAZORIA COUNTY MUD 10	0	0	500	1,000	1,500	2,000	2,800
BRAZORIA COUNTY MUD 16	0	0	800	1,400	2,000	2,400	2,700
BROOKSIDE VILLAGE	1,581	1,625	1,727	2,073	2,392	2,655	2,800
MANVEL	4,535	4,752	5,835	7,000	8,077	8,965	9,455
PEARLAND	17,883	20,371	28,068	33,647	38,829	43,099	45,505
OTHER, EASTERN AREA	10,890	11,046	12,490	13,966	15,969	18,319	21,466
TOTAL STUDY AREA	72,721	80,287	111,269	130,500	150,262	170,155	185,654

SOURCE: <u>COMPREHENSIVE PLAN, REGIONAL WATER SUPPLY AND WASTEWATER TREATMENT FACILITIES- BRAZOS BEND WATER AUTHORITY</u>, NOVEMBER 3, 1989.

TABLE 3
ESTIMATED WATER SALES FOR INDIVIDUAL DISTRICTS BY USER CATEGORY(1000 gal.) Use months Aug 87 - July 88

DISTRICT: BLUE RIDGE WEST MUD

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	OTHER (1)	TOTAL
JUL 88	24,354	1,883	285	26,522
JUN 88	22,007	1,730	207	23,944
MAY 88	17,357	1,987	186	19,530
APR 88	14,918	1,409	131	16,458
MAR 88	13,578	1,649	209	15,436
FEB 88	14,895	1,770	111	16,776
JAN 88	14,345	1,630	124	16,099
DEC 87	15,013	1,842	262	17,117
NOV 87	17,744	2,313	473	20,530
OCT 87	16,430	2,059	735	19,224
SEP 87	32,342	2,531	1154	36,027
AUG 87	22,494	1,791	1090	25,375

DISTRICT: BRAZORIA COUNTY MUD 1

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	INDUSTRIAL	TOTAL
JUL 88	5,575	0	0	5,575
JUN 88	5,519	0	0	5,519
MAY 88	3,913	0	0	3,913
APR 88	2,685	0	0	2,685
MAR 88	2,140	0	0	2,140
FEB 88	1,777	0	0	1,777
JAN 88	2,980	0	0	2,980
DEC 87	2,559	0	0	2,559
NOV 87	4,502	0	0	4,502
OCT 87	3,657	0	0	3,657
SEP 87	11,953	0	0	11,953
AUG 87	6,467	0	0	6,467

DISTRICT: BRAZORIA COUNTY MUD 2

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	INDUSTRIAL	TOTAL
JUL 88	3,457	0	0	3,457
JUN 88	3,437	0	0	3,437
MAY 88	2,618	0	0	2,618
APR 88	1,276	0	0	1,276
MAR 88	1,051	0	0	1,051
FEB 88	720	0	0	720
JAN 88	1,742	0	0	1,742
DEC 87	1,308	0	0	1,308
NOV 87	2,176	0	0	2,176
OCT 87	2,788	0	0	2,788
SEP 87	6,533	0	0	6,533
AUG 87	5,262	0	0	5,262

TABLE 3 CONTINUED
ESTIMATED WATER SALES FOR INDIVIDUAL DISTRICTS BY USER CATEGORY(1000 gal.) Use months Aug 87 - July 88

DISTRICT: BRAZORIA COUNTY MUD 4

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	INDUSTRIAL	TOTAL
JUL 88	3,745	6	0	3,751
JUN 88	3,823	5	0	3,829
MAY 88	3,203	4	0	3,207
APR 88	2,450	12	0	2,462
MAR 88	1,886	3	0	1,889
FEB 88	1,428	3	0	1,431
JAN 88	1,482	2	0	1,484
DEC 87	1,539	15	0	1,554
NOV 87	2,752	20	0	2,773
OCT 87	2,877	4	0	2,882
SEP 87	4,064	3	0	4,067
AUG 87	4,441	3	0	4,444

DISTRICT: BRAZORIA COUNTY MUD 5

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	INDUSTRIAL	TOTAL
JUL 88	5,230	36	0	5,266
JUN 88	4,882	44	0	4,926
MAY 88	4,411	32	0	4,443
APR 88	3,920	24	0	3,944
MAR 88	3,337	26	0	3,363
FEB 88	3,525	24	0	3,550
JAN 88	3,377	24	0	3,401
DEC 87	3,122	29	0	3,151
NOV 87	3,993	40	0	4,033
OCT 87	3,817	31	0	3,848
SEP 87	5,461	38	0	5,500
AUG 87	5,904	25	0	5,930

DISTRICT: FIRST COLONY MUD 9

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	INDUSTRIAL	TOTAL
JUL 88	8,490	463	0	8,953
JUN 88	6,720	468	0	7,187
MAY 88	5,111	376	0	5,486
APR 88	4,134	393	0	4,526
MAR 88	2,287	270	0	2,557
FEB 88	2,083	244	0	2,327
JAN 88	1,765	303	0	2,068
DEC 87	2,059	237	0	2,296
NOV 87	2,117	238	0	2,355
OCT 87	2,926	330	0	3,256
SEP 87	3,190	483	0	3,673
AUG 87	4,930	526	0	5,456

TABLE 3 CONTINUED
ESTIMATED WATER SALES FOR INDIVIDUAL DISTRICTS BY USER CATEGORY(1000 gal.) Use months Aug 87 - July 88

DISTRICT: FORT BEND COUNTY MUD 26

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	INDUSTRIAL	TOTAL
JUL 88	6,645	1,034	0	7,680
JUN 88	6,357	742	0	7,100
MAY 88	5,463	722	0	6,187
APR 88	4,076	824	0	4,900
MAR 88	4,197	483	0	4,680
FEB 88	4,324	669	0	4,995
JAN 88	4,041	1,068	0	5,109
DEC 87	4,061	834	0	4,896
NOV 87	4,323	585	0	4,909
OCT 87	4,731	948	0	5,680
SEP 87	8,196	1,111	0	9,307
AUG 87	7,085	950	0	8,036

DISTRICT: FORT BEND COUNTY MUD 42

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	INDUSTRIAL	TOTAL
JUL 88	2,029	1,337	0	3,366
JUN 88	2,261	832	0	3,093
MAY 88	1,641	611	0	2,252
APR 88	1,235	543	0	1,779
MAR 88	1,127	496	0	1,623
FEB 88	1,002	448	0	1,450
JAN 88	820	517	0	1,337
DEC 87	847	640	0	1,487
NOV 87	1,306	1,127	0	2,434
OCT 87	1,270	1,252	0	2,522
SEP 87	1,656	1,415	0	3,072
AUG 87	1,563	1,328	0	2,892

DISTRICT: FORT BEND COUNTY MUD 47

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	INDUSTRIAL	TOTAL
JUL 88	1,819	0	0	1,819
JUN 88	3,527	0	0	3,527
MAY 88	2,827	0	0	2,827
APR 88	1,868	0	0	1,868
MAR 88	1,304	0	0	1,304
FEB 88	1,667	0	0	1,667
JAN 88	1,272	0	0	1,272
DEC 87	1,622	0	0	1,622
NOV 87	2,428	0	0	2,428
OCT 87	1,695	0	0	1,695
SEP 87	3,612	0	0	3,612
AUG 87	2,656	0	0	2,656

TABLE 3 CONTINUED
ESTIMATED WATER SALES FOR INDIVIDUAL DISTRICTS BY USER CATEGORY(1000 gal.) Use months Aug 87 - July 88

DISTRICT: FORT BEND COUNTY MUD 48

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	INDUSTRIAL	TOTAL
JUL 88	684	0	0	684
JUN 88	635	0	0	635
MAY 88	374	0	0	374
APR 88	351	0	0	351
MAR 88	453	0	0	453
FEB 88	172	0	0	172
JAN 88	374	0	0	374
DEC 87	185	0	0	185
NOV 87	717	0	0	717
OCT 87	545	0	0	545
SEP 87	1,242	0	0	1,242
AUG 87	719	0	0	719

DISTRICT: FORT BEND COUNTY MUD 49

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	INDUSTRIAL	TOTAL
JUL 88	159	0	0	159
JUN 88	243	0	0	243
MAY 88	89	0	0	89
APR 88	88	0	0	88
MAR 88	77	0	0	77
FEB 88	77	0	0	77
JAN 88	44	0	0	44
DEC 87	85	0	0	85
NOV 87	96	0	0	96
OCT 87	79	0	0	79
SEP 87	109	0	0	109
AUG 87	116	0	0	116

DISTRICT: FORT BEND COUNTY WCID 2

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	INDUSTRIAL	TOTAL
JUL 88	51,450	8,820	13,323	7,835,100
JUN 88	53,970	9,252	13,878	8,218,860
MAY 88	47,320	8,112	12,168	7,206,160
APR 88	38,993	6,523	10,061	5,917,080
MAR 88	39,299	6,672	10,077	5,976,230
FEB 88	39,200	6,720	10,009	5,969,600
JAN 88	34,650	5,940	8,910	5,276,700
DEC 87	39,210	6,732	10,009	5,972,460
NOV 87	47,241	7,990	12,100	7,180,030
OCT 87	47,950	8,220	12,330	7,302,100
SEP 87	27,050	9,780	14,690	4,787,900
AUG 87	73,556	12,432	18,648	11,178,440

TABLE 3 CONTINUED
ESTIMATED WATER SALES FOR INDIVIDUAL DISTRICTS BY USER CATEGORY(1000 gal.) Use months Aug 87 - July 88

DISTRICT: HARRIS COUNTY MUD 122

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	INDUSTRIAL	TOTAL
JUL 88	792	0	0	792
JUN 88	717	0	0	717
MAY 88	558	0	0	558
APR 88	240	0	0	240
MAR 88	186	0	0	186
FEB 88	199	0	0	199
JAN 88	257	0	0	257
DEC 87	618	0	0	618
NOV 87	658	0	0	658
OCT 87	482	0	0	482
SEP 87	1,543	0	0	1,543
AUG 87	7,123	0	0	7,123

DISTRICT: HARRIS COUNTY WCID FONDREN ROAD

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	INDUSTRIAL	OTHER(1)	TOTAL
JUL 88	11,289	338	0	180	11,807
JUN 88	10,804	324	0	180	11,308
MAY 88	8,842	265	0	180	9,287
APR 88	8,372	251	0	180	8,803
MAR 88	7,226	216	0	180	7,622
FEB 88	7,516	225	0	180	7,921
JAN 88	7,716	231	0	180	8,127
DEC 87	6,858	205	0	180	7,243
NOV 87	7,481	224	0	180	7,885
OCT 87	8,510	255	0	180	8,945
SEP 87	9,542	286	0	180	10,008
AUG 87	14,972	449	0	180	15,601

DISTRICT: MEADOW CREEK MUD

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	INDUSTRIAL	TOTAL
JUL 88	10,316	328	0	10,644
JUN 88	10,266	266	0	10,533
MAY 88	7,014	198	0	7,213
APR 88	6,753	291	0	7,045
MAR 88	4,752	245	0	4,998
FEB 88	5,789	189	0	5,978
JAN 88	5,538	244	0	5,782
DEC 87	4,890	207	0	5,098
NOV 87	6,446	190	0	6,637
OCT 87	6,910	185	0	7,096
SEP 87	12,943	316	0	13,260
AUG 87	10,854	264	0	11,119

TABLE 3 CONTINUED
ESTIMATED WATER SALES FOR INDIVIDUAL DISTRICTS BY USER CATEGORY(1000 gal.) Use months Aug 87 - July 88

DISTRICT: PALMER PLANTATION MUD 1

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	INDUSTRIAL	TOTAL
JUL 88	2,796	199	0	2,996
JUN 88	2,243	319	0	2,562
MAY 88	1,316	278	0	1,594
APR 88	1,258	188	0	1,446
MAR 88	1,025	183	0	1,208
FEB 88	803	243	0	1,046
JAN 88	918	226	0	1,144
DEC 87	993	179	0	1,172
NOV 87	1,249	296	0	1,546
OCT 87	1,321	496	0	1,818
SEP 87	2,320	574	0	2,894
AUG 87	1,990	352	0	2,342

DISTRICT: CITY OF PEARLAND

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	INDUSTRIAL	TOTAL
JUL 88	55,437	15,568	0	71,006
JUN 88	58,766	18,743	0	77,510
MAY 88	40,516	13,357	0	53,873
APR 88	37,360	14,558	0	51,919
MAR 88	37,937	15,280	0	53,217
FEB 88	33,241	14,067	0	47,309
JAN 88	37,705	15,382	0	53,087
DEC 87	32,595	13,645	0	46,241
NOV 87	37,350	15,940	0	53,291
OCT 87	35,681	18,741	0	54,422
SEP 87	58,443	19,002	0	77,446
AUG 87	58,359	18,314	0	76,674

DISTRICT: QUAIL VALLEY MUD

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	INDUSTRIAL	TOTAL
JUL 88	53,938	4,476	0	58,414
JUN 88	48,955	4,044	0	53,000
MAY 88	34,590	3,159	0	37,750
APR 88	30,524	2,273	0	32,798
MAR 88	29,675	1,948	0	31,623
FEB 88	26,447	1,890	0	28,338
JAN 88	29,084	2,363	0	31,448
DEC 87	26,732	2,463	0	29,196
NOV 87	36,467	3,412	0	39,880
OCT 87	37,709	4,166	0	41,876
SEP 87	65,754	4,911	0	70,666
AUG 87	51,737	4,441	0	56,178

TABLE 3 CONTINUED
ESTIMATED WATER SALES FOR INDIVIDUAL DISTRICTS BY USER CATEGORY(1000 gal.) Use months Aug 87 - July 88

DISTRICT: SOUTHWEST HARRIS COUNTY MUD 1

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	INDUSTRIAL	TOTAL
JUL 88	4,033	0	0	4,033
JUN 88	4,610	0	0	4,610
MAY 88	4,080	0	0	4,080
APR 88	2,361	0	0	2,361
MAR 88	3,251	0	0	3,251
FEB 88	2,456	0	0	2,456
JAN 88	2,927	0	0	2,927
DEC 87	2,734	0	0	2,734
NOV 87	6,494	0	0	6,494
OCT 87	2,819	0	0	2,819
SEP 87	4,252	0	0	4,252
AUG 87	5,696	0	0	5,696

DISTRICT: THUNDERBIRD UTILITY DISTRICT

MO/YR	RESIDENT	COMMERCIAL INSTITUTIONAL	INDUSTRIAL	TOTAL
JUL 88	30,902	3,463	0	34,366
JUN 88	32,830	3,300	0	36,131
MAY 88	21,868	2,765	0	24,633
APR 88	18,458	2,896	0	21,355
MAR 88	17,175	2,805	0	19,981
FEB 88	16,125	3,348	0	19,473
JAN 88	15,838	2,660	0	18,498
DEC 87	20,265	2,672	0	22,938
NOV 87	20,571	3,454	0	24,026
OCT 87	21,192	3,488	0	24,681
SEP 87	43,084	3,705	0	46,790
AUG 87	31,485	5,073	0	36,559

(1). OTHER REPRESENTS WATER USED FOR GOLF COURSES, ECT.

TABLE 4
NUMBER OF CONNECTIONS AND ADDITIONS PER YEAR

AREA DESIGNATION	CONNECTIONS (JULY 1988)			ADDITIONS (AUG. 87 - JULY 88)		
	RES.	COMM.	IND.	RES.	COMM.	IND.
BLUE RIDGE WEST MUD	2,520	28	0	0	0	0
BRAZORIA COUNTY MUD 1	393	9	0	0	0	0
BRAZORIA COUNTY MUD 2	88	10	0	0	0	0
BRAZORIA COUNTY MUD 4	311	1	0	44	0	0
BRAZORIA COUNTY MUD 5	633	2	0	0	0	0
FIRST COLONY MUD 9	367	1	0	55	1	0
FORTBEND COUNTY MUD 26	628	29	0	35	4	0
FORTBEND COUNTY MUD 42	177	7	0	93	-1	0
FORTBEND COUNTY MUD 47	59	5	0	0	0	0
FORTBEND COUNTY MUD 48	42	1	0	0	0	0
FORTBEND COUNTY MUD 49	9	2	0	1	1	0
FORTBEND COUNTY WCID 2	2,245	673	352	17	7	4
HARRIS COUNTY MUD 122	44	0	0	0	0	0
HARRIS COUNTY WCID FONDREN ROAD	914	3	3	0	0	0
MEADOW CREEKMUD	646	12	0	16	8	0
PALMER PLANTATION MUD 1	146	7	0	58	4	0
PEARLAND	5,169	585	0	167	8	0
QUAIL VALLEY UD	3,294	105	0	27	-26	0
SOUTHWEST HARRIS COUNTY MUD 1	452	2	0	0	0	0
THUNDERBIRD UD	1,699	44	0	18	-2	0

SOURCE: CONNECTIONS AND ADDITIONS PER YEAR WERE REPORTED BY INDIVIDUAL UTILITY DISTRICTS

TABLE 5

WATER PRODUCTION INFORMATION FOR ACTIVE PUBLIC WATER SYSTEMS

AREA DESIGNATION	WATER PRODUCTION FOR LAST YEAR 8/87-7/88 (MGAL/YR)	AVERAGE WATER PRODUCTION FOR LAST 2 YEARS (MGAL/YR)	AVERAGE MONTHLY WATER PRODUCTION FOR LAST 2 YEARS (MGAL/MO)	AVERAGE DAILY USE (MGPD) (3)	PEAK DAILY USE (MGPD) (3)	PEAK TO AVERAGE DAILY USE RATIO	UNACCOUNTED FOR WATER % PRODUCTION
BLUE RIDGE WEST MUD	291.809	280.741	23.395	0.754	1.415	1.87	10
BRAZORIA COUNTY MUD 1	*DISTRIBUTION ONLY	NA	NA	NA	NA	NA	NA
BRAZORIA COUNTY MUD 2	85.773	69.466	5.788	0.189	0.801	4.22	02
BRAZORIA COUNTY MUD 4	33.773	30.315	2.526	0.082	0.144	1.74	01
BRAZORIA COUNTY MUD 5	92.570	87.171	7.064	0.238	0.603	2.53	01
FIRST COLONY MUD 9	69.335	48.740	4.061	0.172	1.072	6.23	30
FORT BEND COUNTY MUD 26	79.940	76.828	.602	0.210	0.552	2.62	2
FORT BEND COUNTY MUD 42	29.907	NA	1.665 (2)	0.082	0.377	4.62	2
FORT BEND COUNTY MUD 47	38.839 (1)	NA	2.648 (2)	0.099	0.456	4.60	1
FORT BEND COUNTY MUD 48	*DISTRIBUTION ONLY	NA	NA	NA	NA	NA	1
FORT BEND COUNTY MUD 49	*DISTRIBUTION ONLY	NA	NA	NA	NA	NA	0
FORT BEND COUNTY WC&ID 2	74.289 (1)	929.234 (1)	77.272 (2)	2.539	4.305	1.69	15
HARRIS COUNTY MUD 122	NA	NA	.421 (2)	0.014	0.026	1.85	10
HARRIS COUNTY WCID FONDREN RD	NA	NA	NA	NA	NA	NA	NA
MEADOWCREEK MUD	106.418	NA	8.868 (2)	0.294	0.875	2.98	5-8
PALMER PLANTATION MUD 1	36.490	NA	3.040 (2)	0.100	0.158	1.58	4
PEARLAND	962.956	892.491	74.374	2.441	4.175	1.71	24
QUAIL VALLEY UD	619.314	629.103	52.425	1.679	3.544	2.11	08
SOUTHWEST HARRIS COUNTY MUD 1	*DISTRIBUTION ONLY	NA	NA	NA	NA	NA	6
THUNDERBIRD UD	281.933	NA	23.411 (2)	0.692	1.752	2.53	10

1. WATER PRODUCTION WAS ESTIMATED DUE TO 1 OR 2 MONTHS OF MISSING DATA.
2. DATA WAS BASED ON THE AVERAGE MONTHLY WATER PORDUCTION FOR THE LAST YEAR
3. AVERAGE DAILY USE AND PEAK DAILY USE BASED ON TWO YEARS OF DATA WHEN AVAILABLE

SOURCE: MONTHLY OPERATING REPORTS FROM THE TEXAS DEPARTMENT OF HEALTH.

TABLE 6
WASTEWATER FLOW INFORMATION
AUG 1987 - JULY 1988

AREA DESIGNATION	AVERAGE DAILY VOLUME OF WASTEWATER TREATED (MGD)	PEAK DAILY WASTEWATER VOLUMES (MGD)	PERMIT LIMIT FOR AVERAGE DAILY FLOW (MGD)	PERMIT LIMIT FOR PEAK DAILY WASTEWATER VOLUME (MGD)
BLUE RIDGE WEST MUD	0.656	1.014	1.00	2.50
BRAZORIA COUNTY MUD 1	0.093	0.144	0.15	
BRAZORIA COUNTY MUD 2 + 3	NA	0.100	0.20	
BRAZORIA COUNTY MUD 4 + 5	0.155	0.276	0.38	1.33
FIRST COLONY MUD 9 + FORT BEND COUNTY MUD 42	0.138	0.236	0.30	0.60
FORT BEND COUNTY MUD 26	0.200	0.300	0.50	2.50
FORT BEND COUNTY MUD 47 + FORT BEND COUNTY MUD 48	0.040	0.060	0.40	0.60
FORT BEND COUNTY WCID 2	2.300	4.230	4.50	11.25
FORT BEND COUNTY MUD 49 + PALMER PLANTATION	0.051	0.133	0.20	0.50
HARRIS COUNTY MUD 122	0.006	0.016	0.25	0.60
HARRIS COUNTY WCID FONDREN RD	0.287	0.580	0.60	1.80
MEADOWCREEK MUD + QUAIL VALLEY UTILITY + THUNDERBIRD UTILITY	1.900	2.310	4.00	
PEARLAND LONGWOOD	0.818	2.040	1.75	4.38
PEARLAND BARRYROSE	1.530	3.100	2.25	5.63
SOUTHWEST HARRIS COUNTY MUD 1	0.160	0.237	0.40	1.20

SOURCE: WALSE ENGINEERING

TABLE 7
WASTEWATER CUSTOMER INFORMATION

AREA DESIGNATION	PERCENTAGE OF WATER CUSTOMERS WHO ARE SEWERED BY THE DISTRICT WASTEWATER TREATMENT SYSTEM	PERCENTAGE OF WATER CUSTOMERS WHO HAVE PRIVATELY OWNED SEWAGE DISPOSAL SYSTEMS	PERCENTAGE OF WATER CUSTOMERS WHO ARE SEWERED BY THE ANOTHER WASTEWATER TREATMENT SYSTEM
BLUE RIDGE WEST MUD	100	0	0
BRAZORIA COUNTY MUD 1	100	0	0
BRAZORIA COUNTY MUD 2	100	0	0
BRAZORIA COUNTY MUD 4	100	0	0
BRAZORIA COUNTY MUD 5	100	0	0
FIRST COLONY MUD 9	100	0	0
FORT BEND COUNTY MUD 26	100	0	0
FORT BEND COUNTY MUD 42	100	0	0
FORT BEND COUNTY MUD 46	100	0	0
FORT BEND COUNTY MUD 47	100	0	0
FORT BEND COUNTY MUD 48	100	0	0
FORT BEND COUNTY MUD 49	100	0	0
FORT BEND COUNTY WC&ID 2	99	1	0
HARRIS COUNTY MUD 122	100	0	0
HARRIS COUNTY WC&IC FONDREN RD	97	3	0
MEADOWCREEK MUD	100	0	0
PALMER PLANTATION MUD 1	100	0	0
PEARLAND	99	1	0
QUAIL VALLEY UD	99	1	0
SOUTHWEST HARRIS COUNTY MUD 1	99	1	0
THUNDERBIRD UD	100	0	0

SOURCE: INDIVIDUAL UTILTIY OPERATORS

TABLE 8
EXISTING WATER SUPPLY SYSTEMS
BBWA SERVICE AREA

AREA DESIGNATION	TOTAL PUMPING CAPACITY (GPM)	TOTAL WELL/RAW WATER PUMPING CAPACITY, (GPM)	PERCENT OF WATER SUPPLY CONNECTIONS METERED
BLUE RIDGE WEST MUD	4,500	2,400	100
BRAZORIA COUNTY MUD 1	DISTRIBUTION ONLY	NA	100
BRAZORIA COUNTY MUD 2	1,360	1,100	100
BRAZORIA COUNTY MUD 4	DISTRIBUTION ONLY	600	100
BRAZORIA COUNTY MUD 5	1,800	800	100
FIRST COLONY MUD 9	3,500	2,000	100
FORT BEND COUNTY MUD 26	2,000	1,350	100
FORT BEND COUNTY MUD 42	1,500	1,000	100
FORT BEND COUNTY MUD 46	ONLY TESTED	NA	100
FORT BEND COUNTY MUD 47	1,200	700	100
FORT BEND COUNTY MUD 48	DISTRIBUTION ONLY	NA	100
FORT BEND COUNTY MUD 49	DISTRIBUTION ONLY	NA	100
FORT BEND COUNTY WCID 2	9,000	5,025	100
HARRIS COUNTY MUD 122	DISTRIBUTION ONLY	NA	100
HARRIS COUNTY WCID FONDREN ROAD	2,850	2,440	100
MEADOWCREEK MUD	3,000	800	100
PALMER PLANTATION MUD 1	1,500	1,300	100
PEARLAND	7,600	5,370	100
QUAIL VALLEY UD	11,000	5,200	100
SOUTHWEST HARRIS COUNTY MUD 1	DISTRIBUTION ONLY	NA	100
THUNDERBIRD UD	6,550	2,750	100

SOURCE: TEXAS DEPARTMENT OF HEALTH, DIVISION OF WATER HYGIENE - WATER SYSTEM DATA.

TABLE 9
HIGH VOLUME WATER CUSTOMERS
BBWA SERVICE AREA

AREA DESIGNATION	MAJOR HIGH VOLUME CUSTOMERS: CUSTOMER	GAL/MONTH
FORT BEND COUNTY WCID 2	COPPER FLOW CONTROL	2,500,000
	TRI-GAS	1,125,000
FORT BEND COUNTY 26	QUICARN WEST	588,825
FORT BEND COUNTY 42	MOBILE OIL	62,500
MEADOWCREEK MUD	QU LIMITED	170,625
PALMER PLANTATION	FT. BEND COUNTY ISD.	126,006
THUNDERBIRD UD	FT. BEND HOSPITAL	86,981

NOTE: IF NOT LISTED THERE ARE NO HIGH VOLUME CUSTOMERS REPORTED BY THE PUBLIC WATER SYSTEM OPERATORS.

TABLE 10
PUBLIC WATER SYSTEM REVENUE SOURCES

AREA DESIGNATION	AVERAGE ANNUAL REVENUES FROM WATER RATES ($)	AVERAGE ANNUAL REVENUES FROM SEWER RATES ($)	AVERAGE ANNUAL REV. FROM OTHER SOURCES ($)[1]	AVG. ANNUAL REV. FROM NON-RATE DERIVED SOURCES ($)	SOURCE (SEE NOTE)
BLUE RIDGE WEST MUD	258,166	172,312	149,396		
BRAZORIA COUNTY MUD 1	58,007	27,169	49,764		
BRAZORIA COUNTY MUD 2	27,576	10,328	11,672	41,166	5
BRAZORIA COUNTY MUD 4	48,181	34,138	47,420		
BRAZORIA COUNTY MUD 5	97,639	83,723	10,458	21,500	3
FIRST COLONY MUD 9	68,506	63,281	64,994		
FORT BEND COUNTY MUD 26	94,121	112,421	31,347		
FORT BEND COUNTY MUD 42	38,693	26,399	53,576		
FORT BEND COUNTY MUD 46	NOT APPLICABLE				
FORT BEND COUNTY MUD 47	NOT AVAILABLE				
FORT BEND COUNTY MUD 48	9,223	3,976	2,312	52,900	3
FORT BEND COUNTY MUD 49	2,149	(6)	8,400	30,150	3
FORT BEND COUNTY WCID 2	697,267	617,543	149,396		
HARRIS COUNTY MUD 122	12,795	7,621	633		
HARRIS COUNTY WCID FN RD.[2]	18,000	140,000	9,600		
MEADOWCREEK MUD[2]	112,817	60,333	54,810		
PALMER PLANTATION 1	28,450	16,960		8,169	4
PEARLAND	1,171,825	1,038,076	99,385		
QUAIL VALLEY UD	539,844	429,313	522,257	566,940	5
SOUTHWEST HARRIS COUNTY MUD 1	106,705	(6)	67,898		
THUNDERBIRD UD	309,909	232,693	46,045		

1. INCLUDES PROPERTY TAXES, PENALTY AND INTEREST, TAP CONNECTION AND SEWER INSPECTION FEES, INTERESTS ON DEPOSITS, OPERATING FEES, WATER CAPACITY LEASE
2. REVENUES AND EXPENDITURES REPORTED BY MANAGER OR OPERATOR OF UTILITY DISTRICT
3. DEVELOPER CONTRIBUTIONS
4. INTERFUND TRANSFER AND DEVELOPER ADVANCES
5. SPECIAL REVENUES AND PARTICIPANT CONTRIBUTIONS
6. WHEN THERE IS NO NUMBER ENTERED IN THE WASTEWATER COLUMN ONLY COMBINED WATER AND WASTEWATER REVENUES WERE AVAILABLE.

SOURCE: REVENUES AND EXPENDITURES WERE OBTAINED FROM THE YEARLY FINANCIAL REPORTS FOR EACH DISTRICT UNLESS OTHERWISE NOTED.

TABLE 11
PUBLIC WATER SYSTEMS OPERATING COSTS

AREA DESIGNATION	AVERAGE ANNUAL FIXED COSTS OF OPERATIONS ($)[1]	AVERAGE ANNUAL VARIABLE COSTS OF OPERATIONS ($)	AVERAGE ANNUAL WATER OR WASTEWATER REVENUES FOR OTHER PURPOSES ($)
BLUE RIDGE	125,227	384,727	
BRAZORIA COUNTY MUD 1	55,296	123,566	
BRAZORIA COUNTY MUD 2	13,036	95,332	
BRAZORIA COUNTY MUD 4	16,192	93,760	
BRAZORIA COUNTY MUD 5	21,912	158,581	
FIRST COLONY MUD 9	16,077	159,321	
FORT BEND COUNTY MUD 26	30,626	188,145	
FORT BEND COUNTY MUD 42	10,177	129,199	
FORT BEND COUNTY MUD 46	NOT APPLICABLE		
FORT BEND COUNTY MUD 47	NOT AVAILABLE		
FORT BEND COUNTY MUD 48	5,556	42,745	
FORT BEND COUNTY MUD 49	5,724	34,975	
FORT BEND COUNTY WCID 2	8,939	140,000	
HARRIS COUNTY MUD 122	8,802	89,309	
HARRIS COUNTY WCID FN RD[2]	160,000	140,000	
MEADOWCREEK MUD[2]		207,563	
PALMER PLANTATION 1	8,237	77,595	
PEARLAND	508,450	1,448,539	82349
QUAIL VALLEY UD	90,903	190,185	
SOUTHWEST HARRIS COUNTY MUD 1	82,522	84,230	
THUNDERBIRD UD	96,522	608,643	

1. INCLUDES ITERIM LEASE OR CONTRACTURAL SERVICES

2. EXPENDITURES REPORTED BY UTILITY DISTRICT OPERATOR OR MANAGER

NOTE: REVENUES AND EXPENDITURES OBTAINED FROM ANNUAL FINANCIAL REPORTS UNLESS OTHERWISE NOTED.

TABLE 12
WATER AND WASTEWATER RATE STRUCTURES

DISTRICT	TYPE OF CONNECTION	WATER: WATER USAGE (GAL)	WATER: AMOUNT OF PAYMENT (DOLLARS)	SEWER: WATER USAGE (GAL)	SEWER: AMOUNT OF PAYMENT (DOLLARS)
BLUE RIDGE WEST MUD	RESIDENTIAL	FIRST 8000 8000-15000 OVER 15000	\$ 7.00 MINIMUM \$ 1.00/1000 GAL \$ 1.25/1000 GAL	FLAT RATE	\$ 8.00 MINIMUM
	COMMERCIAL AND GOVERNMENTAL	FIRST 8000 8000-15000 OVER 15000		FIRST 8000 8000-15000 OVER 15000	\$ 1.00/1000 GAL \$ 1.25/1000 GAL \$15.00/1000 GAL
	NONPROFIT	FLAT RATE	\$15.00/1000 GAL	ANY QUANTITY	\$12.00
BRAZORIA COUNTY MUD 1	RESIDENTIAL, SF	FIRST 10000 10000-20000 OVER 20000	\$14.50 MINIMUM \$ 1.00/1000 GAL \$ 1.25/1000 GAL	FLAT RATE	\$ 5.50
	RESIDENTIAL, MF	WHICHEVER IS MORE	SINGLE RATE OR \$11.50 TIMES THE NUMBER OF RESIDENTS	FLAT RATE	\$ 5.50/UNIT
	COMMERCIAL	FIRST 10000 OVER 10000	\$23.00 MINIMUM \$ 1.00/1000 GAL	WHICHEVER IS GREATER	\$23.00 MINIMUM \$ 1.00/1000 GAL
	NONPROFIT	CONSTANT RATE	\$ 0.55/1000 GAL		
BRAZORIA COUNTY MUD 2	RESIDENTIAL, SF	FIRST 5000 5000-10000 10000-20000 OVER 20000	\$ 8.00 MINIMUM \$ 1.00/1000 GAL \$ 1.25/1000 GAL \$ 1.50/1000 GAL	FIRST 5000 OVER 5000	\$10.00 \$ 0.50/1000 GAL
	RESIDENTIAL, MF	WHICHEVER IS MORE	SINGLE RATE OR \$11.50 TIMES THE NUMBER OF RESIDENTS	FLAT RATE	\$ 5.50/UNIT
	COMMERCIAL	FIRST 10000 OVER 10000	\$23.00 MINIMUM \$ 1.00/1000 GAL	WHICHEVER IS MORE	\$23.00 MINIMUM OR \$ 1.00/1000 GAL
	NONPROFIT	CONSTANT RATE	\$ 0.55/1000 GAL		
BRAZORIA COUNTY MUD 4	RESIDENTIAL, SF	3000-5000 OVER 5000	\$ 1.00/1000 GAL \$ 0.85/1000 GAL	FLAT RATE	\$ 9.50/MONTH
	RESIDENTIAL, MF AND COMMERCIAL	FIRST 3000 OVER 3000	\$ 7.50 FLAT \$ 0.85/1000 GAL	FIRST \$9000 OVER \$9000	\$ 9.50/MONTH \$ 1.00/1000 GAL

TABLE 12 (Continued)

DISTRICT	TYPE OF CONNECTION	WATER: WATER USAGE (GAL)	WATER: AMOUNT OF PAYMENT (DOLLARS)	SEWER: WATER USAGE (GAL)	SEWER: AMOUNT OF PAYMENT (DOLLARS)
BRAZORIA COUNTY MUD 5	RESIDENTIAL AND COMMERCIAL	FIRST 5000 OVER 5000	$10.00 MINIMUM $ 1.25/1000 GAL GAL/UNIT	FIRST 2000	$ 7.50 MINIMUM 70% OF CHARGE FOR WATER OVER MINIMUM MONTHLY
FIRST COLONY MUD 9	RESIDENTIAL AND COMMERCIAL	SERVICE CHARGE	$10.00 MINIMUM + $ 0.88/1000 GAL	NO MINIMUM	$ 1.12/1000 GAL
	BUILDER CONNECTIONS	FLAT RATE	$10.00	FLAT RATE	$10.00
FORT BEND COUNTY MUD 26	RESIDENTIAL	FIRST 1000 1001-20000 OVER 20000	$ 4.50 MINIMUM $ 0.70/1000 GAL $ 1.41/1000 GAL	FIRST 1000 1001-20000 OVER 20000	$ 5.50 MINIMUM $ 0.90/1000 GAL $ 1.80/1000 GAL
	COMMERCIAL	FIRST 1000 1001-20000 OVER 20000	$ 6.75 MINIMUM $ 1.15/1000 GAL $ 1.40/1000 GAL	FIRST 1000 1001-20000 OVER 20000	$ 8.25 MINIMUM $ 1.45/1000 GAL $ 2.90/1000 GAL
FORT BEND COUNTY MUD 42	RESIDENTIAL, SF	FIRST 8000 OVER 8000	$14.00 MINIMUM $ 0.75/1000 GAL	FLAT RATE	$15.00
	RESIDENTIAL, MF	FIRST 8000 OVER 8000	$14.00 MINIMUM $ 0.85/1000 GAL	FLAT RATE	$10.00
	COMMERCIAL	FIRST 8000 OVER 8000	$20.00 MINIMUM $ 1.00/1000 GAL	FIRST 8000 OVER 8000	$20.00 MINIMUM $ 1.00/1000 GAL
FORT BEND COUNTY MUD 46	RESIDENTIAL	FIRST 10000 OVER 10000	$ 7.50 MINIMUM/UNIT $ 1.50/1000 GAL/UNIT	FLAT RATE	$ 7.50/UNIT
	COMMERCIAL	FIRST 10000 OVER 10000	$15.00 MINIMUM $ 1.50/1000 GAL	WHICHEVER IS MORE	$15.00 MINIMUM OR $ 1.50/1000 GAL
	TAX EXEMPT	FIRST 10000 OVER 10000	$30.00 MINIMUM $ 3.00/1000 GAL	WHICHEVER IS MORE	$30.00 OR $ 3.00/1000 GAL
FORT BEND COUNTY MUD 48	RESIDENTIAL	FIRST 10000 OVER 10000	$10.00 MINIMUM $ 1.50/1000 GAL	FLAT RATE	$10.00/MONTH
	COMMERCIAL	FIRST 10000 OVER 10000	$15.00 MINIMUM $ 2.00/1000 GAL	FIRST 10000 OVER 10000	$15.00 MINIMUM $ 2.00/1000 GAL
	NONPROFIT	FLAT RATE PAYABLE JANUARY 1	$ 1.00 PER YEAR	ANY QUANTITY	$ 1.00 PER YEAR PAYABLE JANUARY 1

TABLE 12 (Continued)

DISTRICT	TYPE OF CONNECTION	WATER: WATER USAGE (GAL)	WATER: AMOUNT OF PAYMENT (DOLLARS)	SEWER: WATER USAGE (GAL)	SEWER: AMOUNT OF PAYMENT (DOLLARS)
FORT BEND COUNTY MUD 49	RESIDENTIAL	FIRST 8000 OVER 8000	\$10.00 MINIMUM \$ 1.00/1000 GAL	FLAT RATE	\$10.00 MINIMUM
	COMMERCIAL	FIRST 8000 OVER 8000	\$10.00 \$ 1.00/1000 GAL	FIRST 8000 OVER 8000	\$15.00 MINIMUM \$ 1.00/1000 GAL
FORT BEND COUNTY WCID 2	RESIDENTIAL	FIRST 3000 OVER 3000	\$ 3.00 MINIMUM \$ 1.12/1000 GAL	FLAT RATE	\$ 7.00 MINIMUM
	DURING CONSTRUCTION AND TO AVAILABILITY FOR OCCUPANCY OF ANY UNIT	FIRST 3000 OVER 3000	\$ 3.00 MINIMUM \$ 0.56/1000 GAL	FIRST 3000 OVER 3000	\$ 7.00 MINIMUM \$ 0.65/1000 GAL
HARRIS COUNTY MUD 122	RESIDENTIAL	FIRST 6000 OVER 6000	\$21.00 MINIMUM \$ 1.75/1000 GAL	FIRST 20000 OVER 20000	\$25.00 MINIMUM \$ 1.75/1000 GAL
HARRIS COUNTY WCID - FONDREN ROAD	RESIDENTIAL OR COMMERCIAL	FIRST 8000 8000-15000 15000-25000 OVER 25000	\$11.50 MINIMUM \$ 0.50/1000 GAL \$ 0.75/1000 GAL \$ 1.00/1000 GAL	FIRST 8000 OVER 8000	\$11.50 MINIMUM \$ 0.50/1000 GAL
	NON-DISTRICT RESIDENTIAL OR COMMERCIAL	FIRST 8000 8000-15000 15000-25000 OVER 25000	\$ 0.32 MINIMUM \$ 0.50/1000 GAL \$ 0.75/1000 GAL \$ 1.00/1000 GAL	FIRST 8000 OVER 8000	\$32.00 MINIMUM \$ 0.50/1000 GAL
MEADOWCREEK MUD	RESIDENTIAL, SF	FIRST 5000 OVER 5000	\$11.00 MINIMUM \$ 0.50/1000 GAL	FLAT RATE	\$ 8.50/UNIT
	RESIDENTIAL, MF	WHICHEVER IS GREATER	\$11.00/UNIT \$ 0.75/1000 GAL	FLAT RATE	\$ 8.50/UNIT
	COMMERCIAL	FIRST 5000 OVER 5000	\$15.00 MINIMUM \$ 0.75/1000 GAL	FIRST 10000 OVER 10000	\$21.50 MINIMUM \$ 0.75/1000 GAL
PALMER PLANTATION MUD 1	RESIDENTIAL, SF	FIRST 7000 7000-10000 10000-20000 OVER 20000	\$12.00 MINIMUM \$ 1.00/1000 GAL \$ 1.25/1000 GAL \$ 1.50/1000 GAL	FLAT RATE	\$12.00/UNIT
	COMMERCIAL	FIRST 10000 10000-20000 OVER 20000	\$15.00 MINIMUM \$ 1.25/1000 GAL \$ 1.50/1000 GAL	FIRST 10000 OVER 10000	\$23.00 MINIMUM \$ 1.00/1000 GAL

TABLE 12 (Continued)

DISTRICT	TYPE OF CONNECTION	WATER		SEWER	
		WATER USAGE (GAL)	AMOUNT OF PAYMENT (DOLLARS)	WATER USAGE (GAL)	AMOUNT OF PAYMENT (DOLLARS)
PEARLAND	RESIDENTIAL	FIRST 2000 OVER 2000	$ 7.50 MINIMUM $ 1.38/1000 GAL	FIRST 2000 OVER 2000	$ 7.50 MINIMUM $ .966/1000 GAL
QUAIL VALLEY UTILITY DISTRICT	RESIDENTIAL, SF	FIRST 10000 OVER 10000	$11.50 MINIMUM $ 1.25/1000 GAL	FLAT RATE	$12.00
	RESIDENTIAL, MF	WHICHEVER IS GREATER	$ 8.50/UNIT OR $ 1.25/1000 GAL	FLAT RATE	$12.00
	COMMERCIAL	FIRST 10000 OVER 10000	$15.00 MINIMUM $ 1.25/1000 GAL	FIRST 10000 OVER 10000	$15.00 MINIMUM $ 1.25/1000 GAL
SOUTHWEST HARRIS COUNTY MUD 1	ALL	FIRST 5000 OVER 5000	$10.70 MINIMUM $ 0.70/1000 GAL	FIRST 12000 OVER 12000	$ 8.00 MINIMUM $ 0.75/1000 GAL
THUNDERBIRD UTILITY DISTRICT	RESIDENTIAL, SF	FIRST 10000 OVER 10000	$11.00 MINIMUM $ 1.25/1000 GAL	FLAT RATE	$12.00/UNIT
	RESIDENTIAL, MF	WHICHEVER IS GREATER	$ 8.50/UNIT OR $ 1.25/1000 GAL	FLAT RATE	$12.00/UNIT
	COMMERCIAL	FIRST 10000 OVER 10000	$16.00 MINIMUM $ 1.25/1000 GAL	FIRST 10000 OVER 10000	$17.00 MINIMUM $ 1.25/1000 GAL

TABLE 13
APPLICABLE LOCAL, STATE AND FEDERAL REGULATIONS

Brookside Village

Ordinance No. 111 adopting the Southern Standard Mechanical Code.
Ordinance No. 112-1 adopting the Southern Standard Plumbing Code.

Missouri City

Southern Standard Building Code.

City of Manvel

Southern Standard Building Code.

Pearland

Southern Standard Building Code, 1985.

Note: As a public supplier of water, the utility districts must also follow the regulations of the following agencies.

1. Texas Water Commission

2. Texas Department of Health

3. Environmental Protection Agency

Source: Attorneys for individual utility districts.

4. ADEQUACY OF EXISTING WATER SUPPLY SYSTEMS

All study area public water supply agencies currently derive water from groundwater sources. Treatment consists of chlorine disinfection with selected suppliers adding polyphosphates for corrosion control and iron and manganese precipitation. Water is tested according to EPA guidelines.

A comparison of facilities provided to minimum regulatory water supply requirements for study area water supply agencies is shown in Table 14 on the following page.

TABLE 14
EXISTING PUBLIC WATER SYSTEMS EVAULATION

AREA DESTINATION	EXISTING CONDITIONS NO. CONN. (1)	PUMPING CAP. (GPM)	WELL CAP. (GPM)	TOTAL STOR. (MG)	REGULATORY REQUIREMENT PUMPING CAP. (GPM)	WELL CAP. (GPM)	TOTAL STOR. (MG)
BLUE RIDGE WEST MUD	2018	4500	2400	0.95	4036	1211	0.404
BRAZORIA COUNTY MUD 1 AND 2	425	1360	1100	0.515	850	255	0.085
BRAZORIA COUNTY MUD 4 AND 5	637	1800	1400	0.53	1274	382	0.127
FIRST COLONY MUD 9	380	3500	2000	0.49	760	228	0.076
FORTBEND COUNTY 26	644	2000	1350	0.545	1288	386	0.129
FORTBEND COUNTY 42	114	1500	1000	0.375	228	68	0.228
FORTBEND COUNTY 47 AND 48	101	1200	700	0.255	202	61	0.02
PALMER PLANTATION MUD							
FORTBEND COUNTY 49 +	114	1500	1300	0.44	228	68	0.288
HARRIS COUNTY WCID FN RD.	911	2850	2440	0.761	1822	547	0.182
MEADOW CREEK MUD	611	3000	800	0.32	1222	367	0.122
CITY OF PEARLAND	5186	7600	5370	3.98	10382	3112	1.037
QUAIL VALLEY	2779	11000	5200	3.22	5558	1667	0.556
SOUTHWEST HARRIS COUNTY 1	452				904	271	0.09
THUNDERBIRD UD	1750	6550	2750	1.504	3500	1050	0.35

(1) TDH REQUIREMENTS: PUMPING CAPACITY = 2.0 GPM
(2) NUMBER OF ACTIVE SERVICES AS OF JULY 1988
(3) DISTRIBUTION ONLY

SOURCE: MONTHLY OPERATING REPORTS, TEXAS DEPARTMENT OF HEALTH

The Texas Department of Health reported the following problems at existing study area water plants between August 1987 through July 1988.

- o TNTC and or confluent growths found at least once in bacteriological analysis for the following districts: Meadowcreek MUD, Palmer Plantation MUD 1, Fort Bend County MUD 26.

- o Coliforms found in bacteriological analysis for Fort Bend County WCID District 2.

- o Failure to meet the minimum total capacity of .6 gpm per connection with 2 or more wells or provide a secondary source for Brazoria County MUD 2.

- o Failure to maintain a residual of 0.2 to 0.5 mg/l in the far reaches of the system by Harris County WCID Fondren Road.

All of the listed problems were corrected.

5. AVERAGE, SEASONAL AND PEAK USE PATTERNS

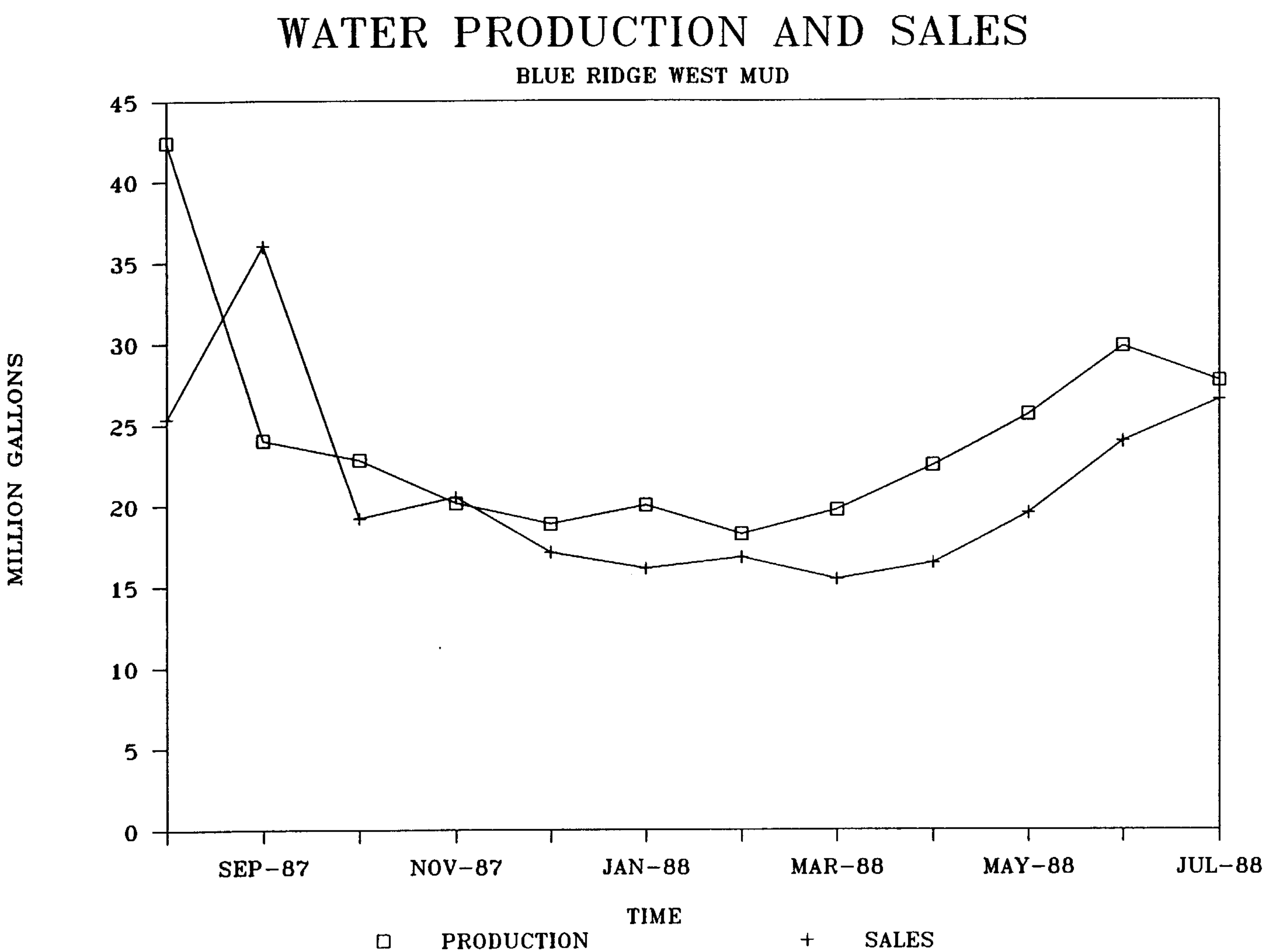
Seasonal water use rates for study area water supply agencies are graphically presented in Figures 2 through 16 of the following pages. Water use in these facilities follow typical patterns of higher use during summer months. The composited peak summer month to average annual month ratio is 3.1:1. This ratio is slightly higher than normal, which is considered to be 2.4:1.

6. UNACCOUNTED WATER, LIKELY CAUSES

Monthly water production and water sales information between August, 1987 and July, 1988, for study area water supply agencies is graphically presented in Figures 2 through 16 on the following pages.

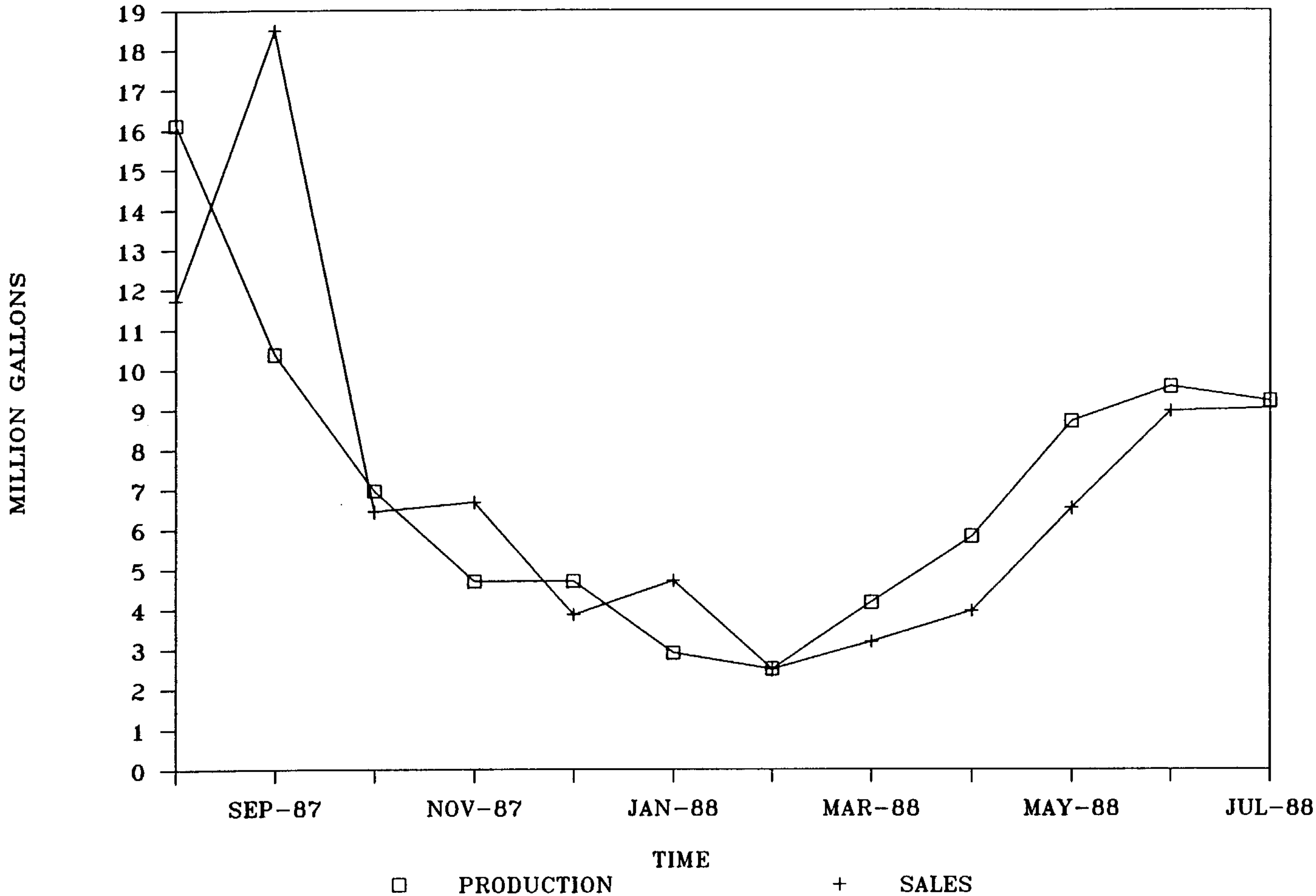
The difference between water production and metered water sales is termed "Unaccounted Water". As shown in Table 5, Page B-19, unaccounted water for existing study area water systems range from 0.1 percent to 24 percent of water produced. Unaccounted water loss can be attributable to a variety of causes, as follows:

- Flushing of water mains;
- Unmetered fire flows;
- Inaccurate meters;
- System leaks;
- Unauthorized water use
- Unmetered water sales (not anticipated to be a major concern in study area).


WATER PRODUCTION AND SALES
BLUE RIDGE WEST MUD
MILLION GALLONS
45
40
35
30
25
20
15
10
5
0
SEP-87
NOV-87
JAN-88
MAR-88
MAY-88
JUL-88
TIME
PRODUCTION
SALES

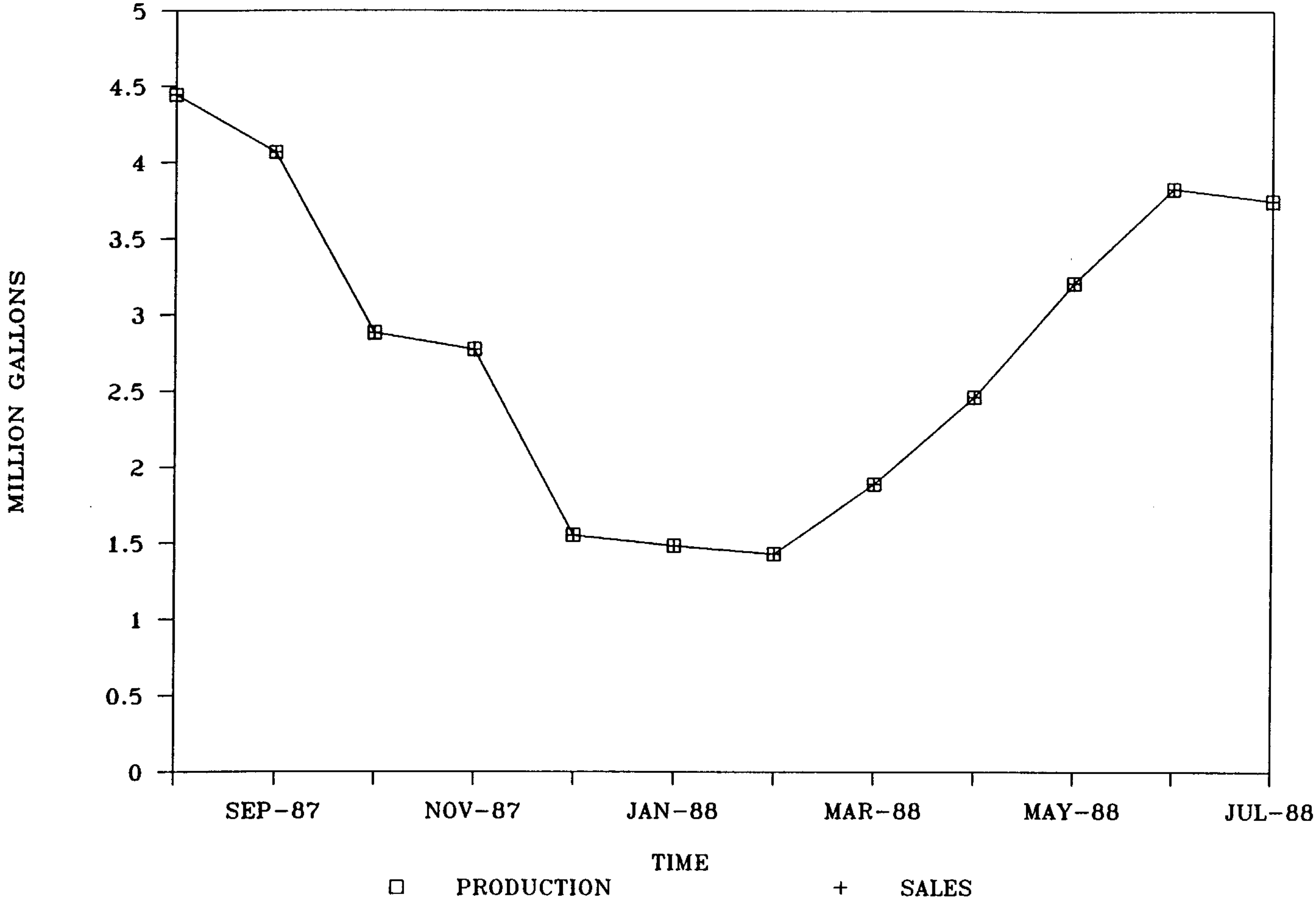
WATER PRODUCTION AND SALES

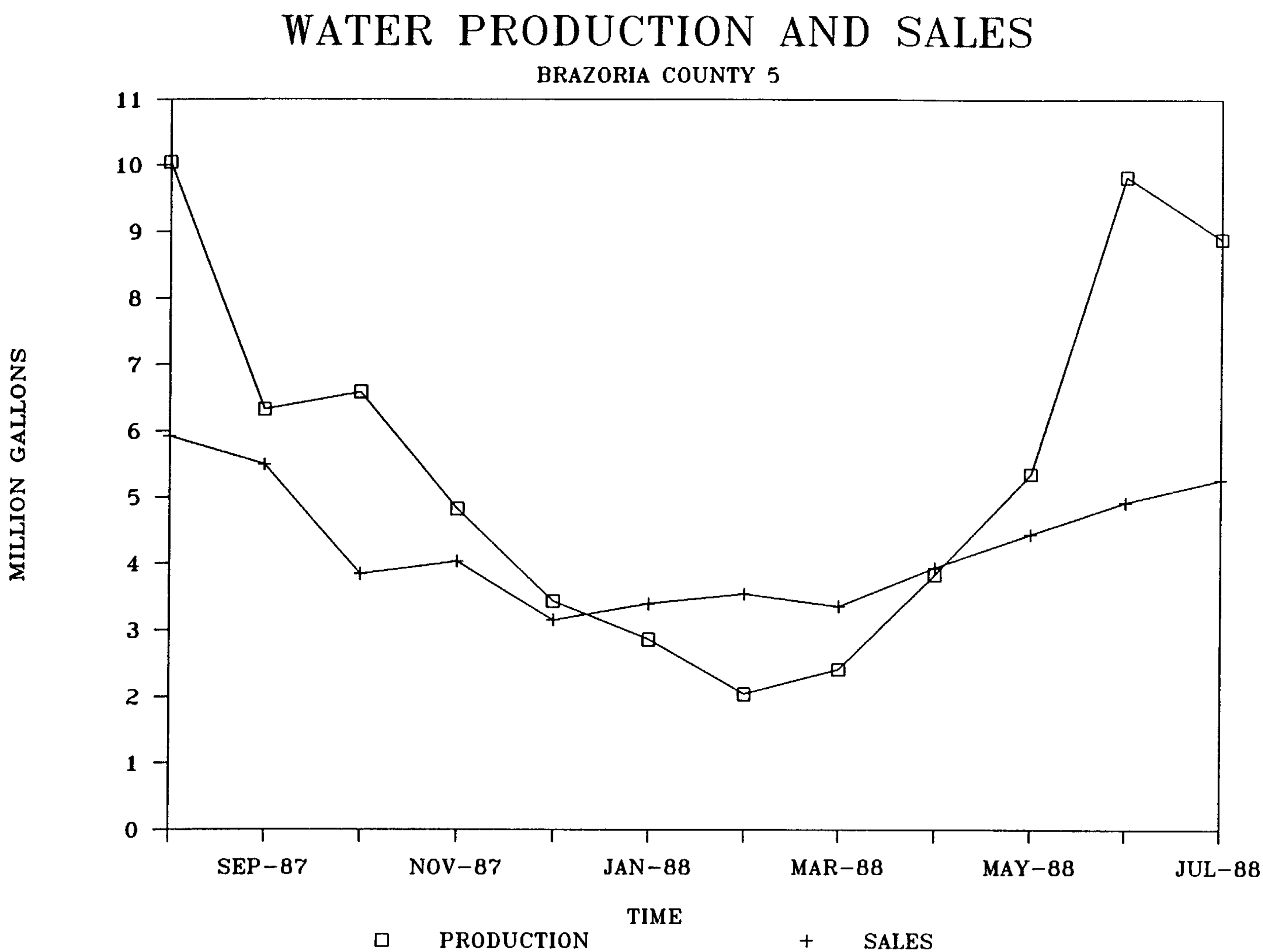
BRAZORIA COUNTY 1 AND 2



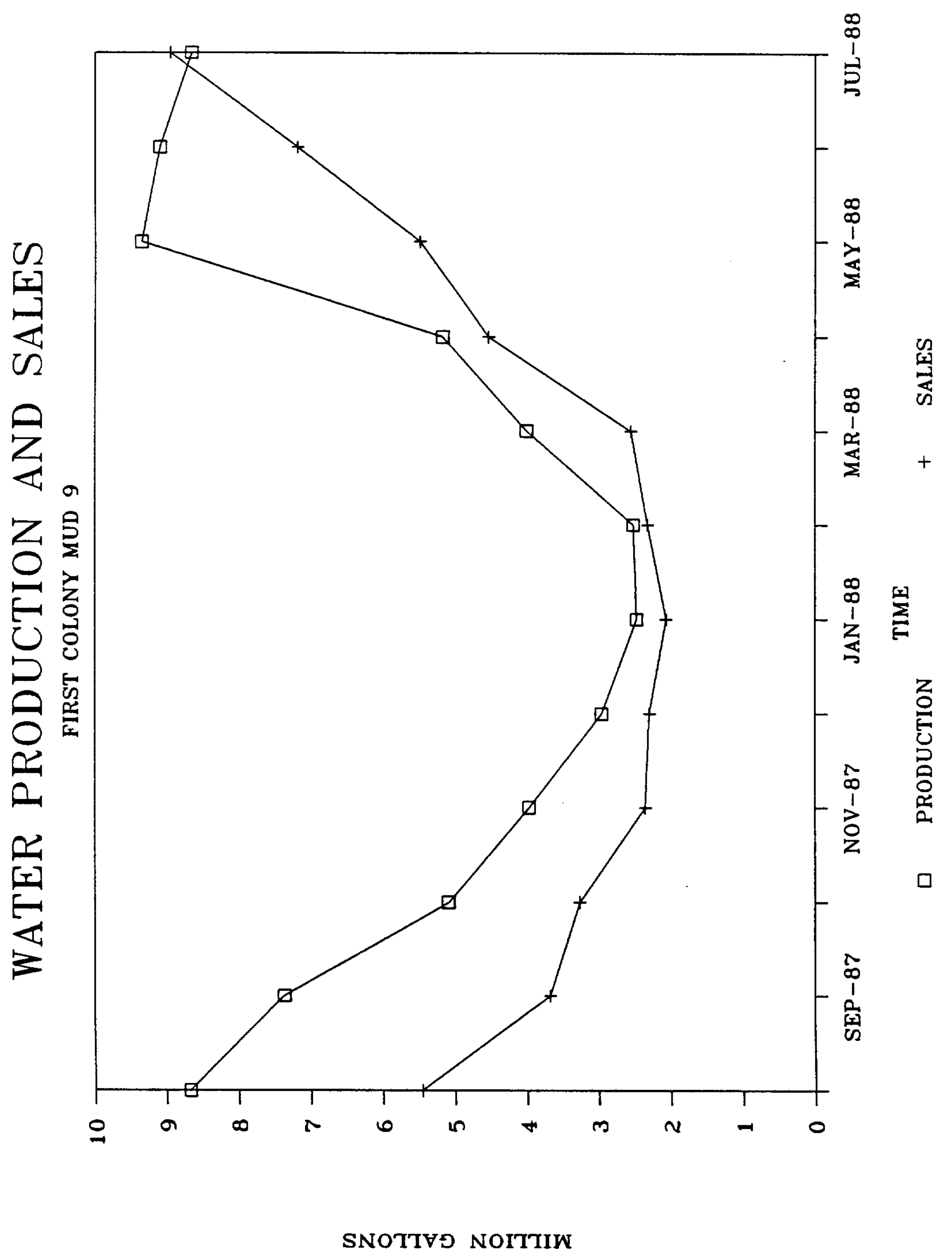
WATER PRODUCTION AND SALES

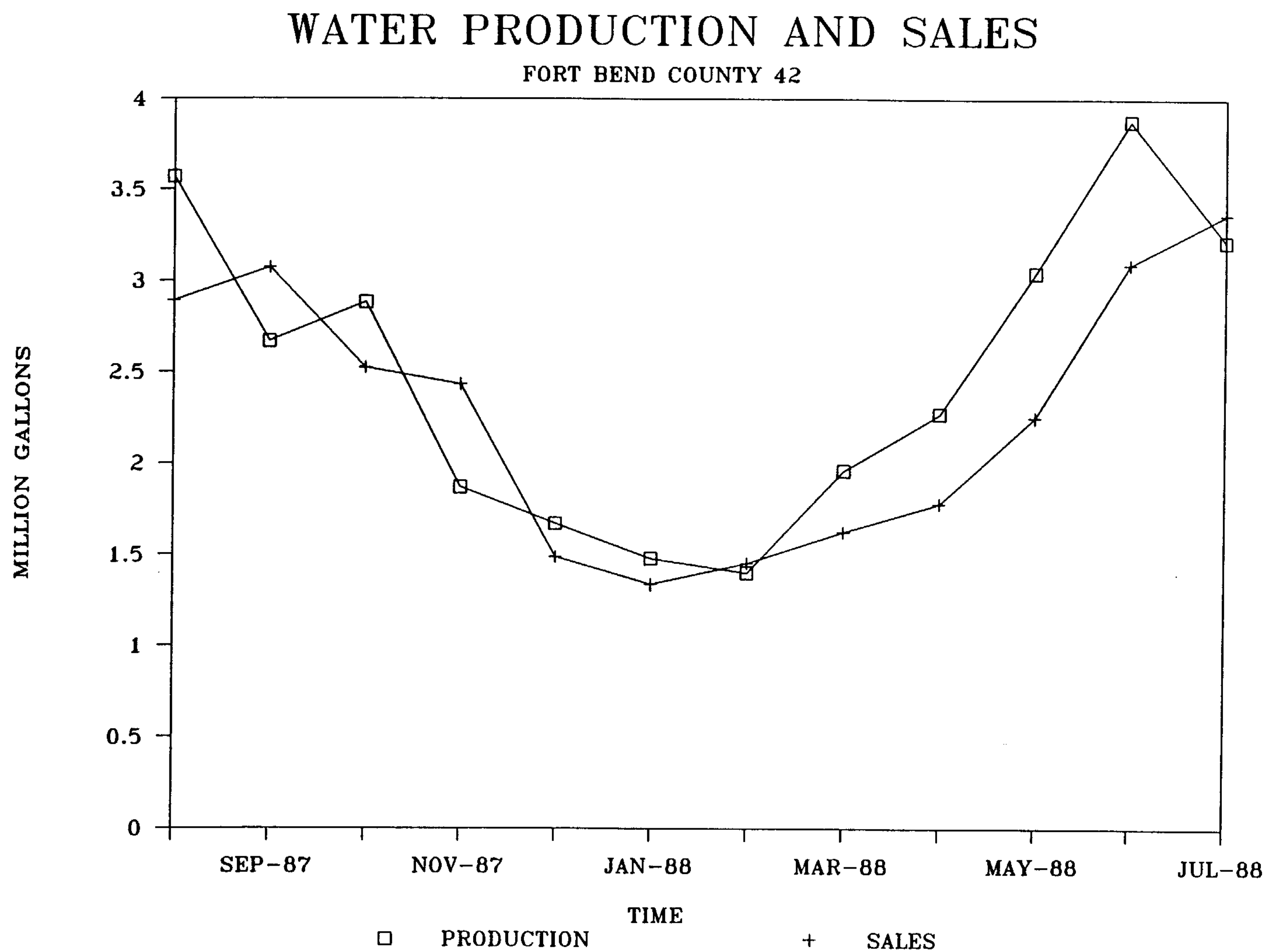
BRAZORIA COUNTY 4





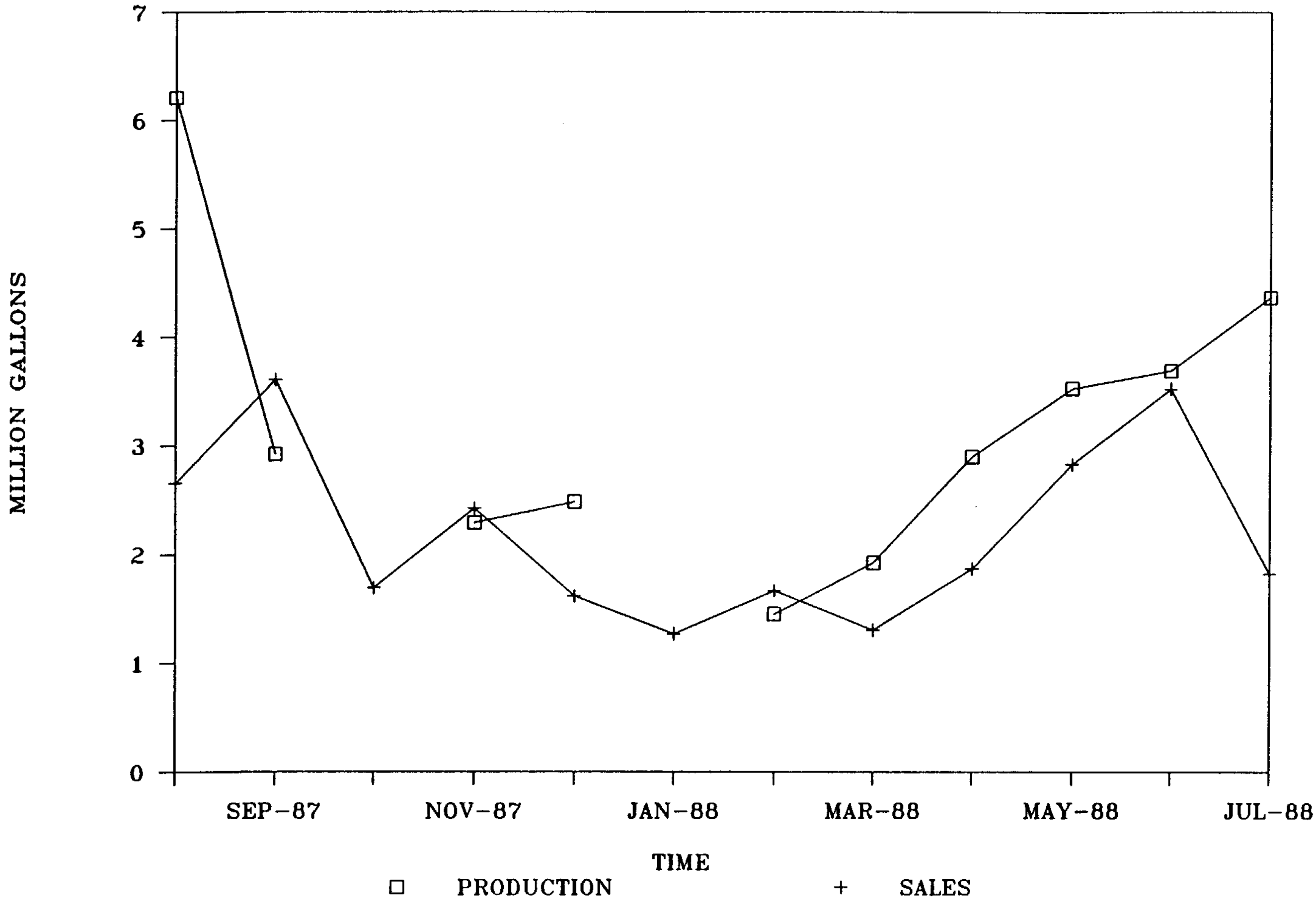
WATER PRODUCTION AND SALES
BRAZORIA COUNTY 5
MILLION GALLONS
0
1
2
3
4
5
6
7
8
9
10
11
SEP-87
NOV-87
JAN-88
MAR-88
MAY-88
JUL-88
TIME
PRODUCTION
SALES

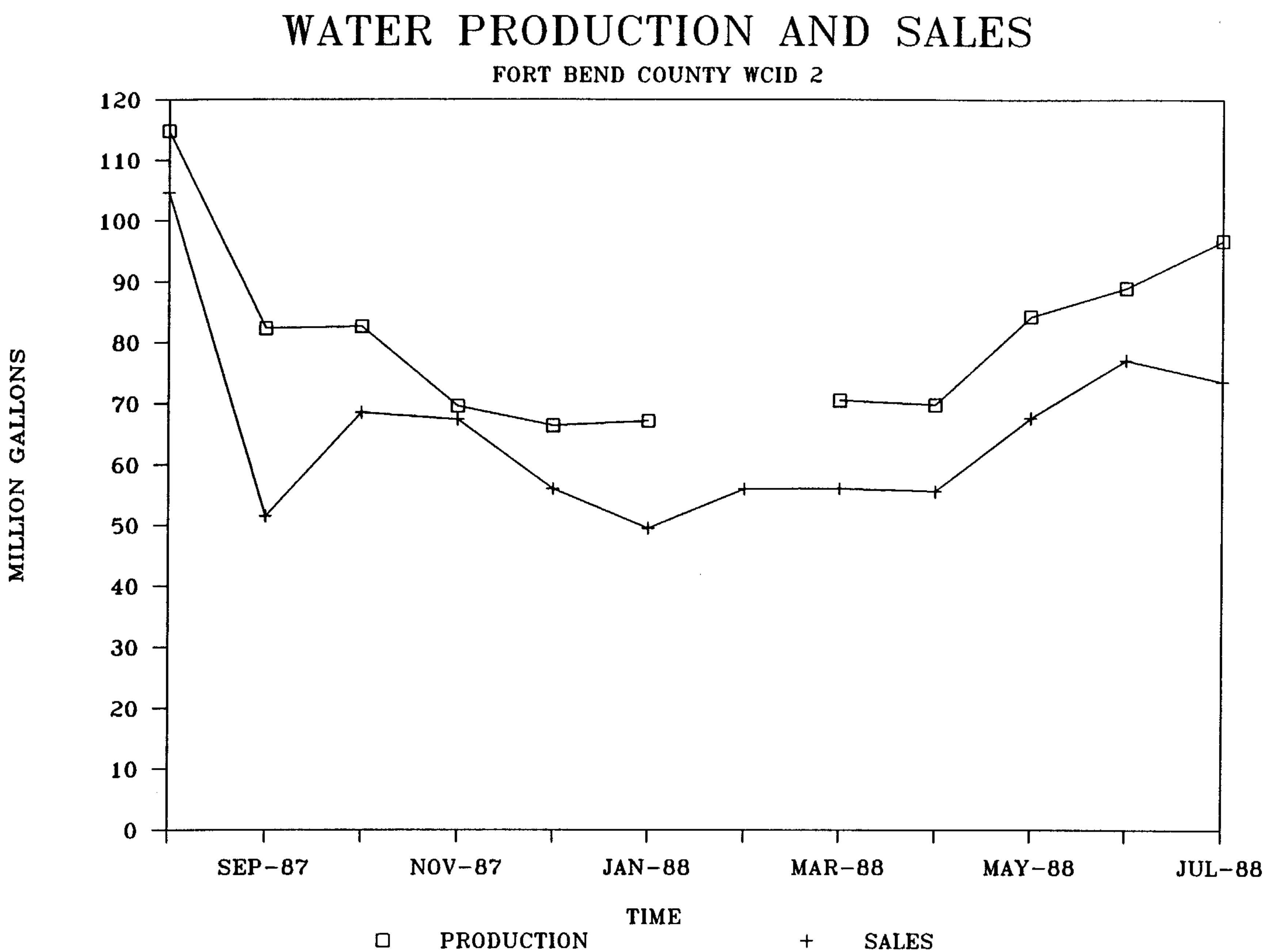

WATER PRODUCTION AND SALES
FIRST COLONY MUD 9
MILLION GALLONS
0
1
2
3
4
5
6
7
8
9
10
SEP-87
NOV-87
JAN-88
MAR-88
MAY-88
JUL-88
TIME
PRODUCTION
SALES


WATER PRODUCTION AND SALES
FORT BEND COUNTY 42
MILLION GALLONS
4
3.5
3
2.5
2
1.5
1
0.5
0
SEP-87
NOV-87
JAN-88
MAR-88
MAY-88
JUL-88
TIME
PRODUCTION
SALES

WATER PRODUCTION AND SALES

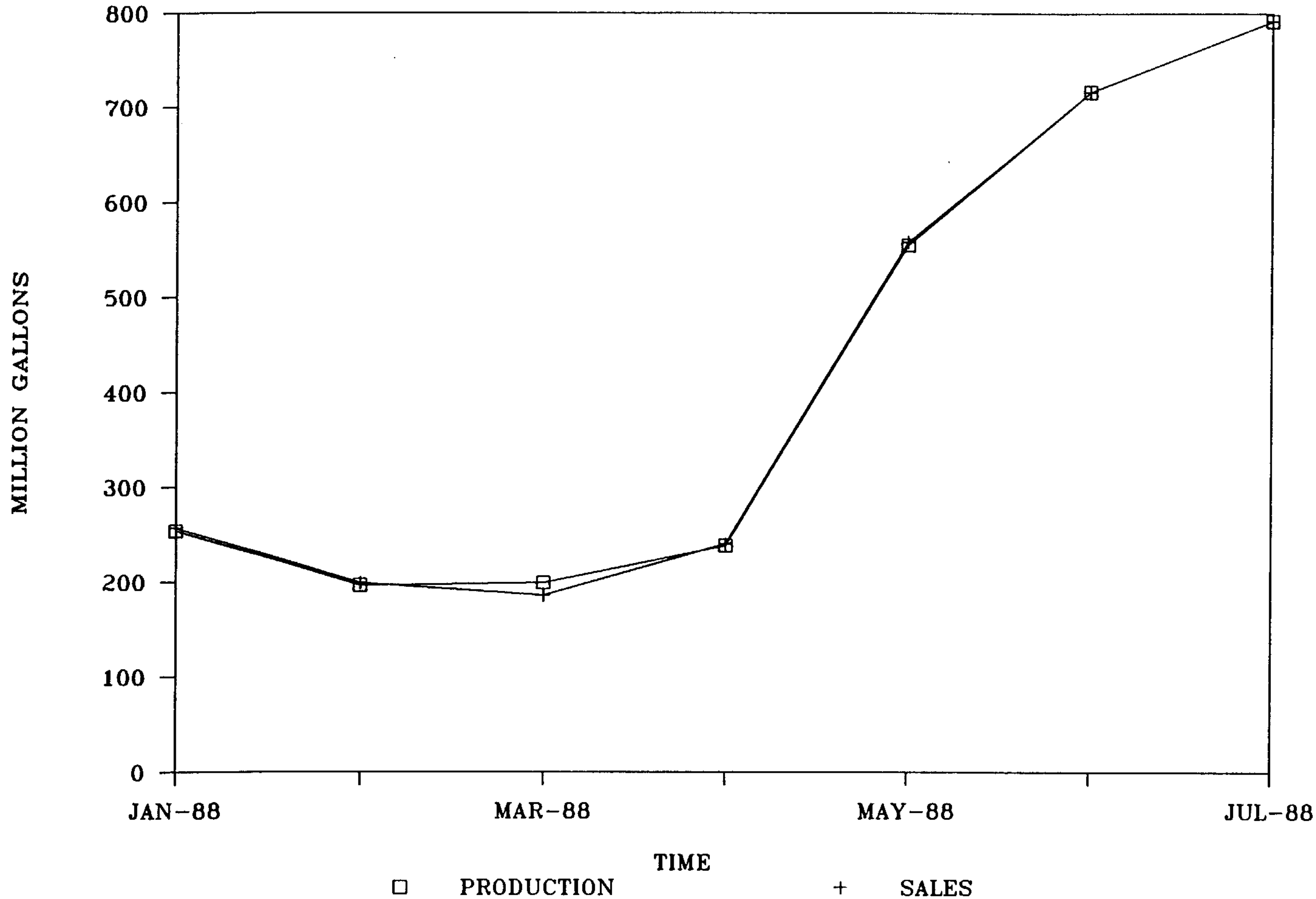
FORT BEND COUNTY 47

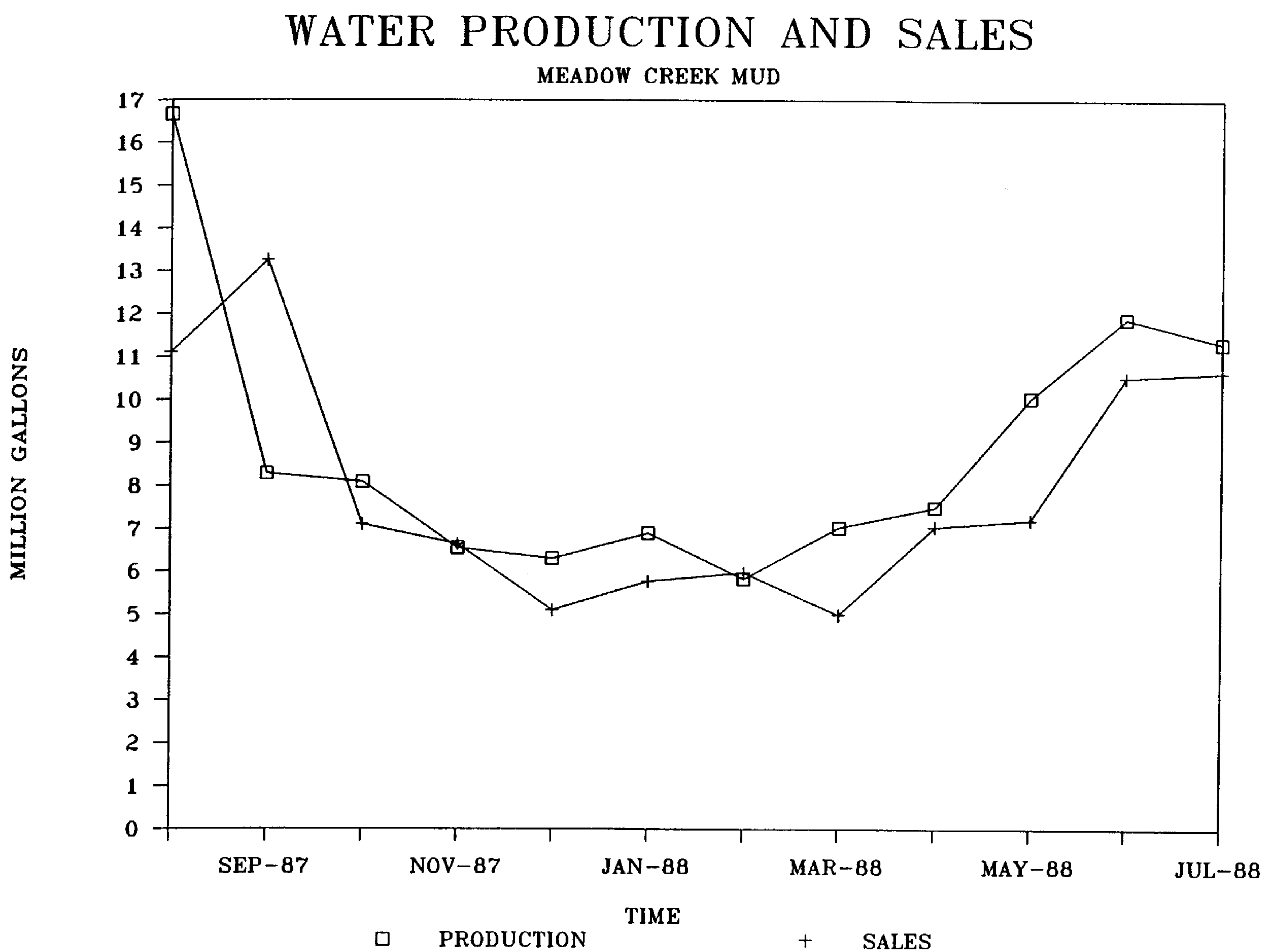


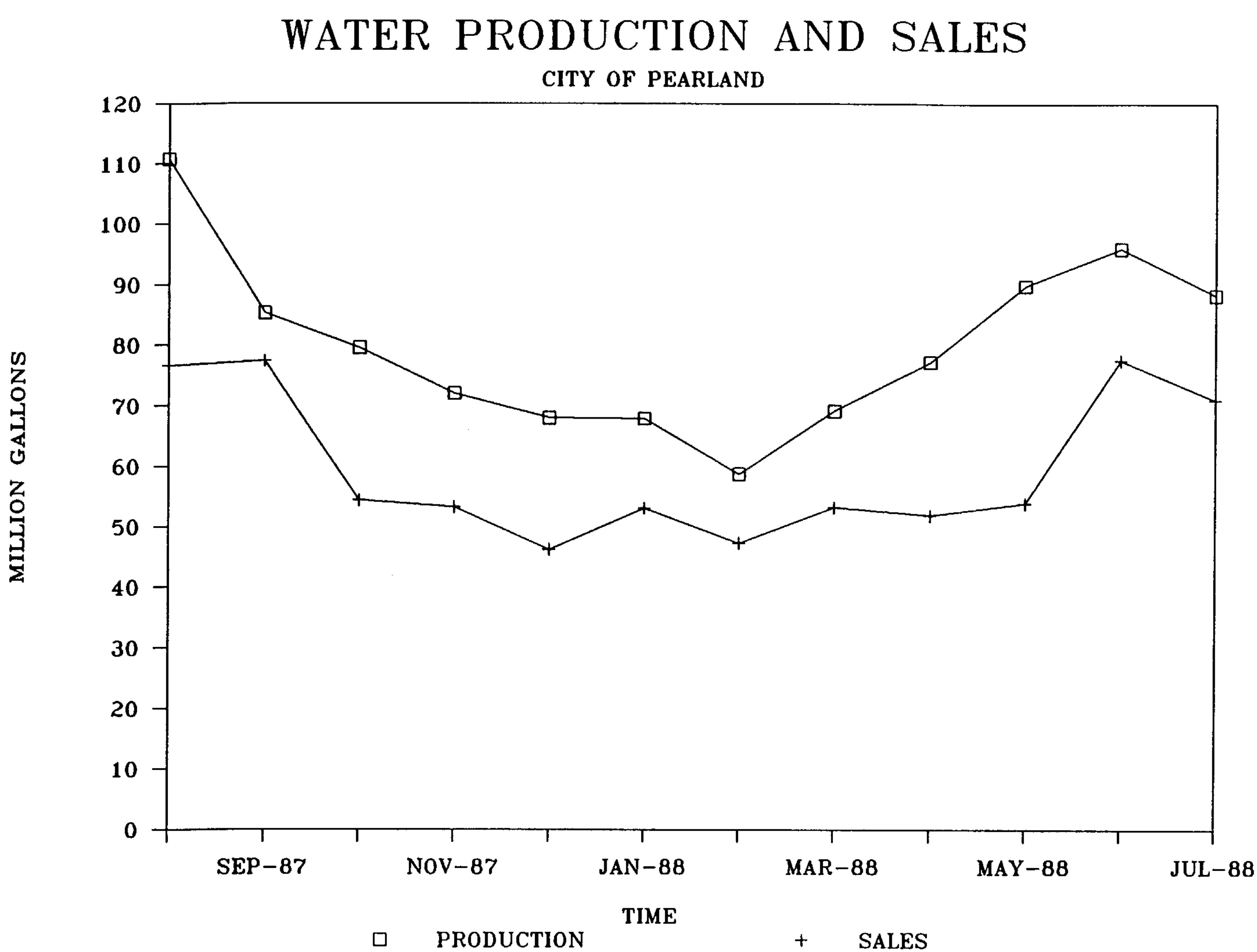

WATER PRODUCTION AND SALES
FORT BEND COUNTY WCID 2
MILLION GALLONS
120
110
100
90
80
70
60
50
40
30
20
10
0
SEP-87
NOV-87
JAN-88
MAR-88
MAY-88
JUL-88
TIME
PRODUCTION
SALES

WATER PRODUCTION AND SALES

HARRIS COUNTY MUD 122

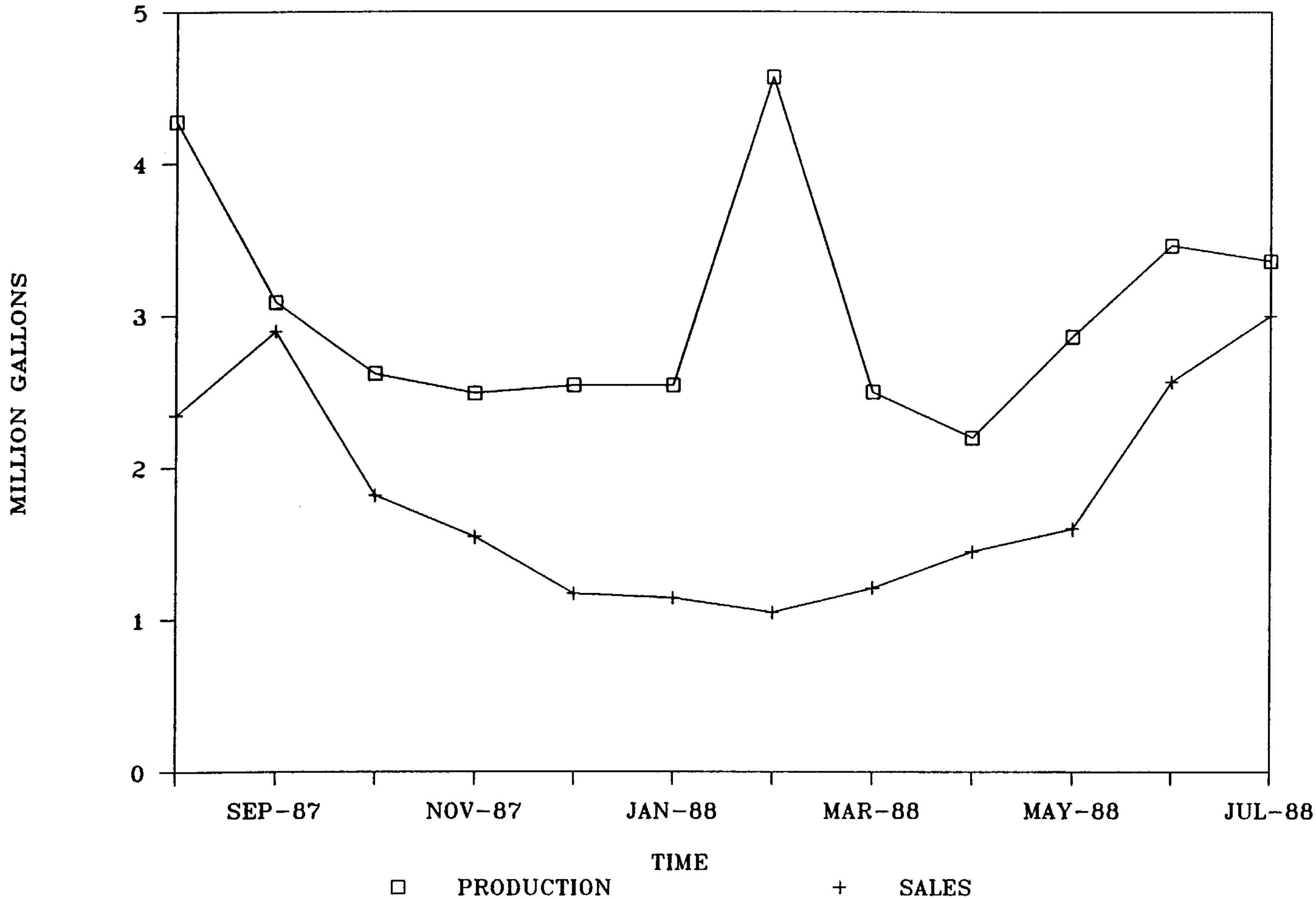


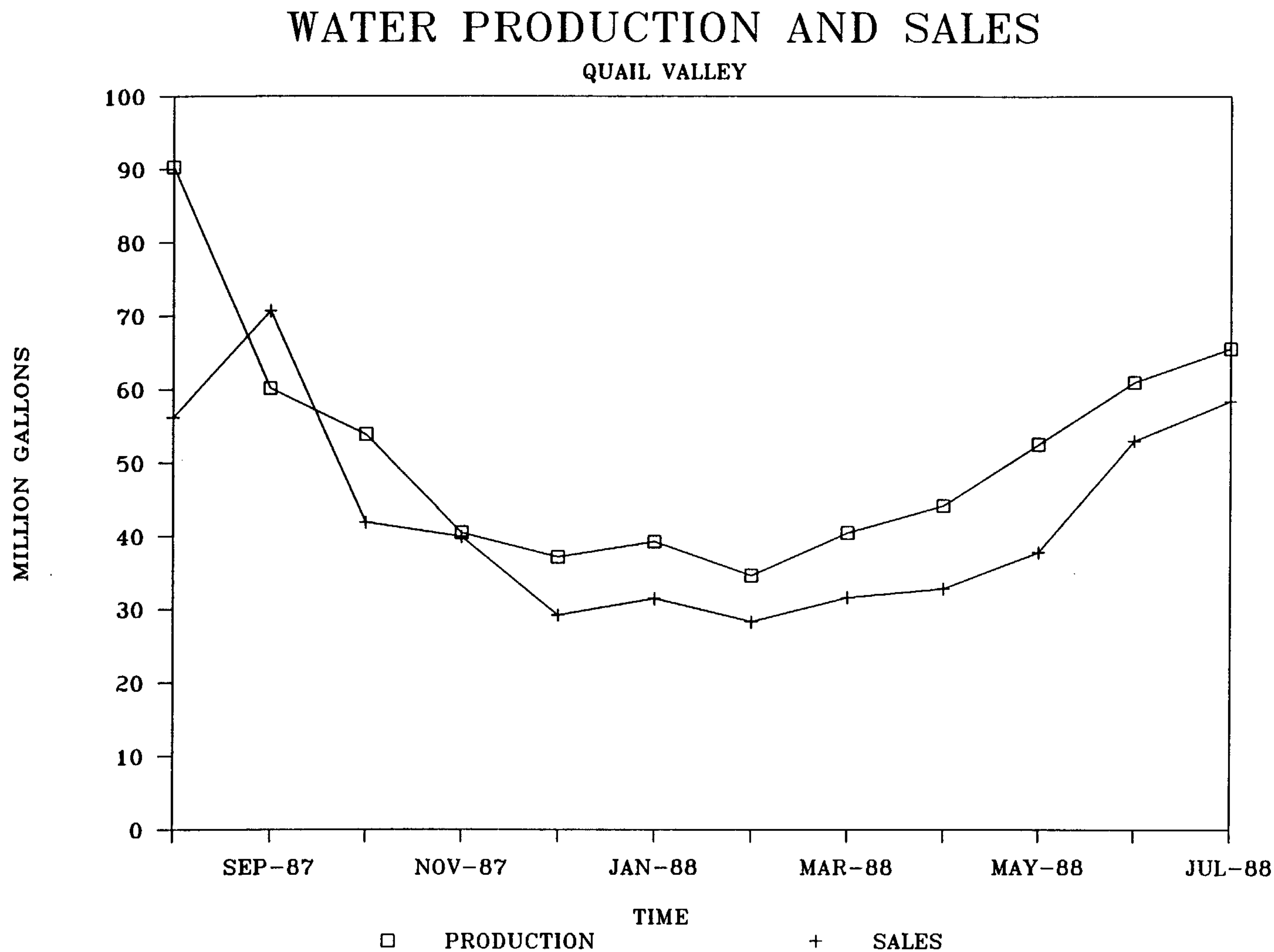

WATER PRODUCTION AND SALES
MEADOW CREEK MUD
MILLION GALLONS
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
SEP-87
NOV-87
JAN-88
MAR-88
MAY-88
JUL-88
TIME
PRODUCTION
SALES

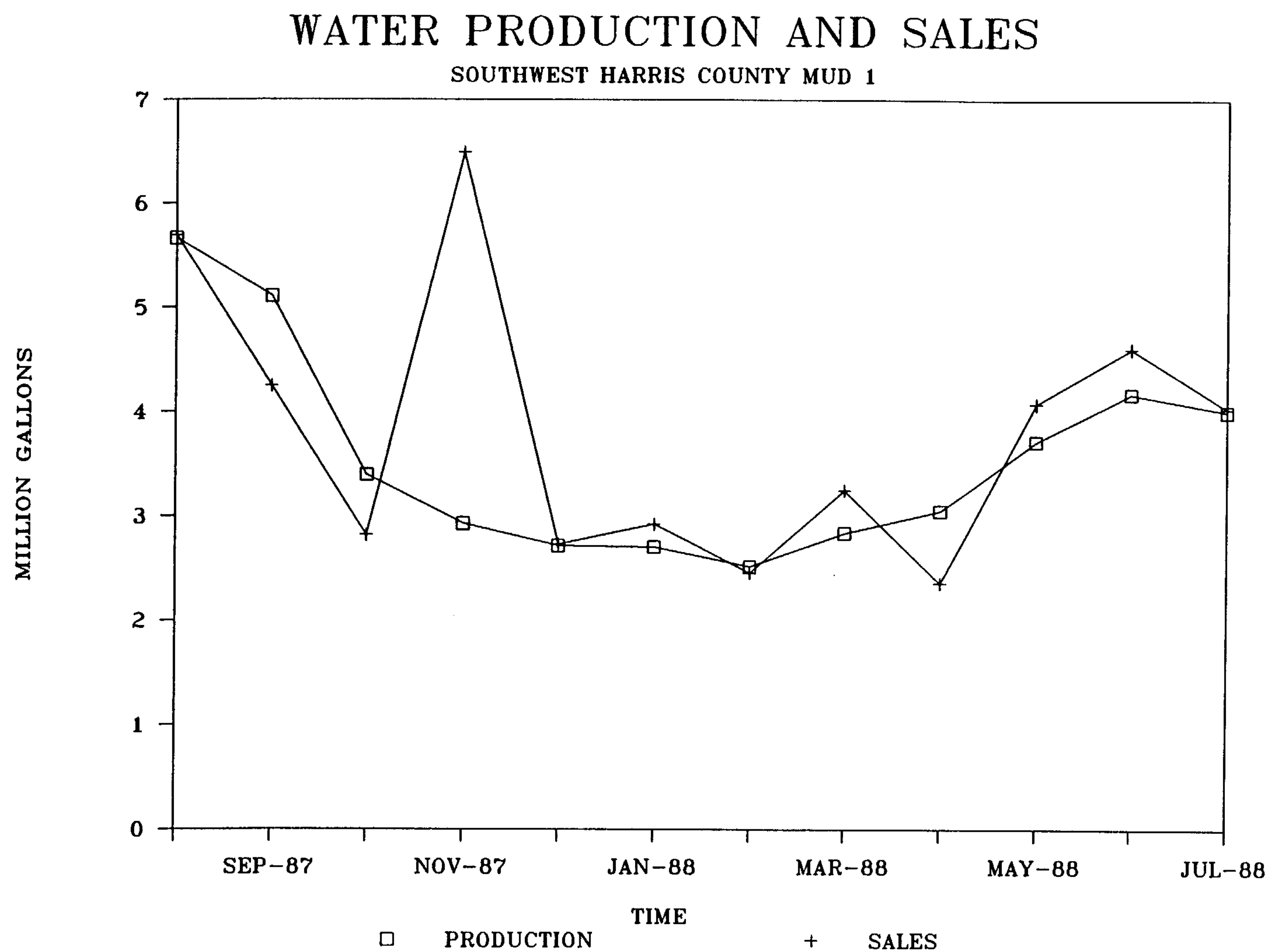

WATER PRODUCTION AND SALES
CITY OF PEARLAND
MILLION GALLONS
120
110
100
90
80
70
60
50
40
30
20
10
0
SEP-87
NOV-87
JAN-88
MAR-88
MAY-88
JUL-88
TIME
PRODUCTION
SALES

WATER PRODUCTION AND SALES

PALMER PLANTATION 1



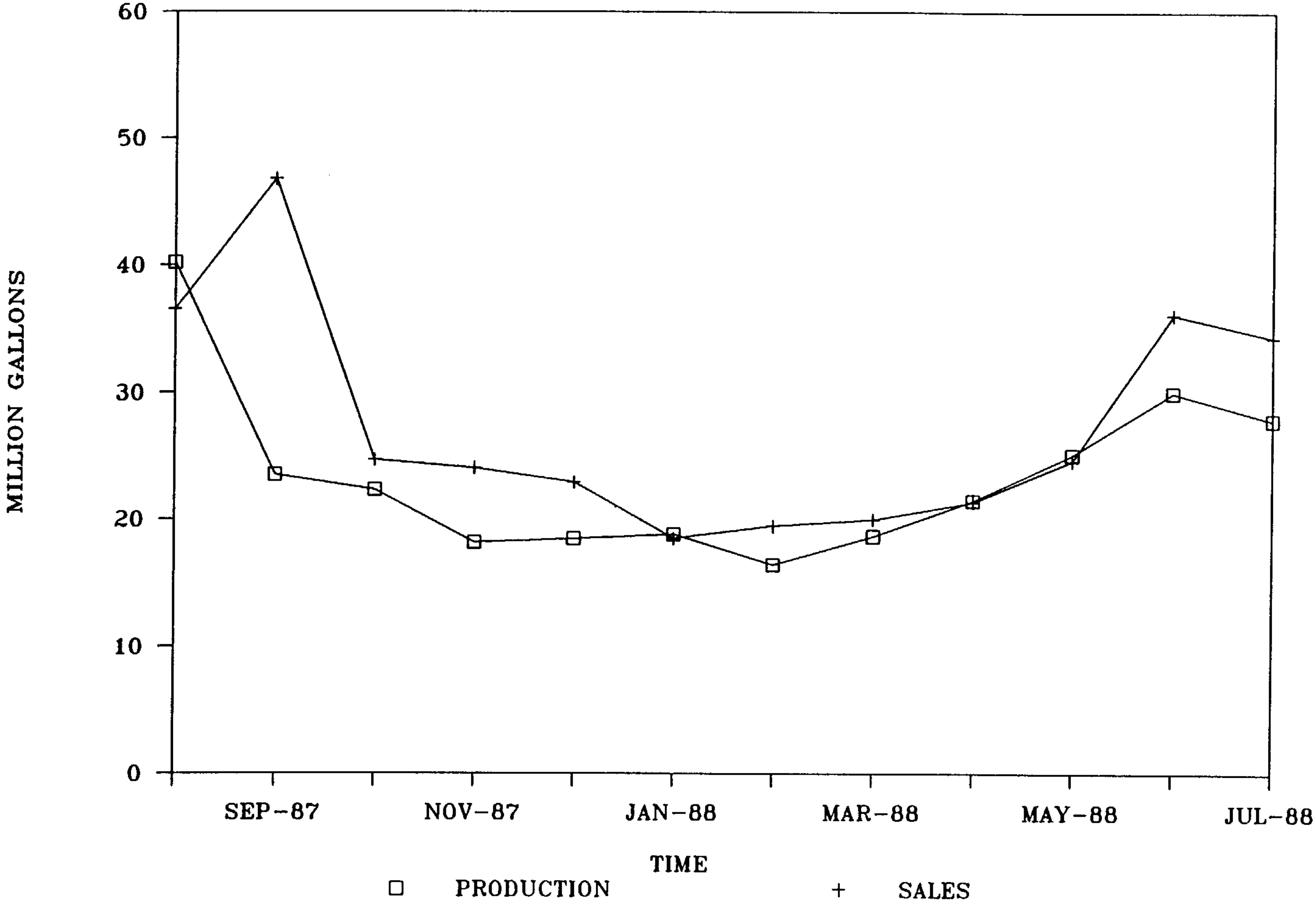

WATER PRODUCTION AND SALES
QUAIL VALLEY
MILLION GALLONS
100
90
80
70
60
50
40
30
20
10
0
SEP-87
NOV-87
JAN-88
MAR-88
MAY-88
JUL-88
TIME
PRODUCTION
SALES



WATER PRODUCTION AND SALES
SOUTHWEST HARRIS COUNTY MUD 1
MILLION GALLONS
0
1
2
3
4
5
6
7
SEP-87
NOV-87
JAN-88
MAR-88
MAY-88
JUL-88
TIME
PRODUCTION
SALES

WATER PRODUCTION AND SALES

THUNDERBIRD



7. LIMITS OF EXISTING SUPPLY/POTENTIAL NEW SOURCES

Currently, study area groundwater supplies are obtained from the Chicot and Evangeline aquifers. The safe annual yield obtained from the Texas Water Development Board for these aquifers is 50,400 acre-feet for Brazoria County and 79,033 acre-feet for Fort Bend County. The yield for the Fort Bend County aquifer includes the Brazos River Alluvium. A report prepared by McBride-Ratcliff and Associates, Inc. for Lockwood, Andrews & Newnam, Inc. estimated that the potentiometric surface of the groundwater will fall between 80 and 200 feet over the 50 year study period at withdrawal rates equal to the predicted future demands. Also, subsidence is estimated to be between 3 to 6 feet over the next 50 years. Salt water intrusion could also become a problem in the near future as a result of hydraulic and concentration gradients from salt domes and sea water toward the study area.

8. WASTEWATER COLLECTION AND TREATMENT SYSTEM

Currently, the majority wastewater from study area water systems is treated at City of Pearland and utility district wastewater treatment plants (see Table 7, Page B-21). These systems have sewer collection systems with a centralized treatment plant. Brookside Village, Manvel and rural developments within the study area use septic systems for sewage treatment and disposal.

9. SUPPLY AND DEMAND MANAGEMENT POTENTIALS

Water conservation methods can be divided into two (2) categories, supply and demand management. Supply management is management from the distribution side of the customer meter. Supply management encourages metering and meter repair, leak detection, pressure regulation and reuse. Demand management is obtained through pricing, regulation, and education of water use, to each individual customer. These provide incentives for the customer to conserve water.

Supply Management Methods

Metering and Meter Repair

Currently, all public water supply agencies within the study area meter customer water consumption. As a wholesaler or water supply, the Brazos Bend Water Authority will need to meter customer water use as a basis for collecting revenue. Meters become inaccurate or inoperable with the passage of time and should be tested periodically to insure their accuracy. A typical meter testing program could be as follows:

1. Production (master) meters - test once a year.
2. Meters larger than 1 inch - test once a year.
3. Meters 1 inch or smaller - test every 10 years.

Meter testing combined with meter repair and replacement can save significant quantities of water. In addition, utilities may be able to identify previously unbilled customers and generate additional revenues.

Leak Detection and Repair

A continuous leak detection, location, and repair program can be an important part of a water conservation plan. Currently most existing water supply agencies within the study area only use visual inspection for leak detection. When leaks show up at the surface, citizens or city employees report the leaks and they are subsequently repaired. However, regular water accounting can indicate that less obvious leaks are occurring. Leak detection as well as water accounting should become an integral part of a utility districts water conservation program if one is not currently being employed. The following leak detection program could be utilized.

1. Monthly water use accounting by the billing department;
2. Visual inspection of meter facilities by utility employees when reading meters;
3. Adequate staff to repair leaks if detected; and
4. Periodic use of leak detection devices such as electronic sonic devices.

Leak detection program expense should be quickly recovered in areas where unaccounted for water is high. As funds become available, the Authority could purchase leak detection and meter testing equipment and hire personnel to assist utility customers with leak detection and meter testing programs.

Recycling/Reuse

The Authority and its customers should evaluate the potential for recycling and reuse. Typical candidates for reuse are treated effluents used for irrigation or the recycling of cooling water. Because the study area is composed mainly of residential customers, recycling of cooling water is not a significant option. However, treated wastewater effluent for irrigation of golf courses or other public facilities should be carefully considered.

Demand Management Methods

Education and Information

As previously noted, the majority of water produced by study area water supply utilities is consumed by residential users. Education programs to inform the public of water saving techniques could be a very effective water conservation tool in the study area and could be implemented at a relatively low cost.

Information regarding individual water saving measures is readily available at both the State and local level. The Authority could act as a clearing house for this material for distribution to its utility customers. Individual water saving can be achieved through plumbing modifications, water conserving landscape design, efficient irrigation practices, and by changes in individual use habits. Attachment "1" at the back of this report lists water savings methods that can be practiced by the individual water user.

Water Conserving Plumbing Code

All municipalities within the study area have currently adopted the Southern Building Code International which includes a water conserving plumbing code. For new public water systems, the following standards should be considered for new construction and replacement of existing plumbing fixtures since they are readily available products and they do not involve additional cost when compared to standard fixtures:

Tank-type toilets	- No more than 3.5 gallons per flush
Flush valve toilets	- No more than 3.0 gallons per flush
Tank-type urinals	- No more than 3.0 gallons per flush
Flush valve urinals	- No more than 1.0 gallons per flush
Shower heads	- No more than 3.0 gallons per minute
Lavatory and kitchen faucets	- No more than 2.75 gallons per minute
All hot water lines	- Insulated
Swimming pools	- New pools must have recirculating filtration equipment

Retrofit Programs

The Authority and its utility customers could make information available through education programs to encourage individual users and plumbers to purchase water saving fixtures. The Authority could provide kits with retrofit devices (such as toilet dams, low flow shower heads and faucet aerators) free or at a reduced price to customers as funds become available.

Water Rate Structures

Many public water supply agencies within the study area are currently employing a conservation-oriented water rate structure (see Table 12, pages B-26 through B-29). In this type of rate structure, the price per unit of water increases in steps or blocks as customer use levels increase. The lower block limit should be set at a value that corresponds to minimum residential water requirements. The next block should cover all normal or average water users and the last block should increase the rate enough to discourage excessive water users. It is expected that all public water supply agencies will eventually convert to an increasing rate structure as the transportation and purchasing cost for water increase.

10. WATER REDUCTION AND COST ANALYSIS

Table 15, Page B-57, presents an estimate of short term water reduction and cost savings associated with authority water conservation measures. The reduction factors were derived from Grisham, Alice and Fleming, M., "Long-term options for Municipal Water Conservation", AWWA, March 1989. The reduction factors assume 100 percent participation, which is unreasonable. The expected BBWA participation was estimated to obtain a new reduction factor. The percentage of water reduction as a result of each method, the resulting loss or gain in revenues, and the cost of hardware are also illustrated in Table 15.

The water conservation methods outlined in Table 15 are estimated to result in a 4.3 percent reduction in water use and a $47,226.93 net gain in revenue. The assumption of a 4 percent increase in revenues due to meter repair, testing, and maintenance accounts for most of the revenue gain. If only a 2 percent increase in revenue is assumed, the water conservation methods are estimated to result in a small loss.

TABLE 15

BBWA STUDY AREA
WATER REDUCTION AND COST ANALYSIS

CONSERVATION METHOD	% REDUCTION	EXPECTED BBWA PARTICIPATION	NEW % REDUCTION	(LOST) OR GAINED REVENUES	COST OF HARDWARE OR IMPLEMENTATION	NET CHANGE IN REVENUE
Education and Information	5	Assume 20 percent of the population participates in water saving activities around the home.	1.0	0	$ 18,000(2)	$(18,000.00)
Rate Structure	10	Assume 10 percent of the districts employ new rate structures.	2.0	0	0	0
Meter Repair and Testing	10	Assume 4 percent increase in revenues.	---	$270,969.24	$ 80,000	$190,969.20
Leak Repair and Accounting System	8	Assume 3 percent more leaks are detected than at present and repaired.	.3	0	$ 40,000	$(40,000.00)
Plumbing Codes	5	Assume all new construction use low flow devices. Will have little effect because the Southern Building Code is currently employed.	.5	$(33,871.16)	0	$(33,871.10)
Retrofit Program and Water Saving Devices	5	Assume 10 percent of the population participates.	.50	$(33,871.16)	$ 8,000	$(51,871.10)
Recycling and Reuse	10	Assume 0 percent. Not applicable in this area.	0	0	0	0
TOTAL			4.3%	$203,226.92	$156,000	$ 47,226.93

Note: 1. Source of reduction factors, Grisham, Alice and Fleming, M., "Long-Term Options for Municipal Water Conservation", AWWA, March 1989.
2. Assuming distribution cost are 15¢/article.

III. DROUGHT/EMERGENCY CONTINGENCIES

1. INTRODUCTION

Drought conditions have a two-fold impact on the normal availability of public water supplies, being:

- o Reduction of water supply resources
- o Increased customer demand as compensation for less than normal rainfall

Additionally, other events can impact a public water utility's ability to meet customer water demand, such as contamination of water supplies and failures of treatment and distribution facilities. Therefore, it is prudent that public water supply agencies formulate plans to deal with temporary supply problems to assure that available supplies are equitably distributed to meet essential public requirements. Measures needed to deal with temporary water supply problems, whether caused by drought or other events, are briefly discussed in this section.

2. TRIGGER CONDITIONS

Periods of dry weather and other emergency conditions vary in length and severity. Typically, drought and emergency conditions are classified as mild, moderate, or severe. These conditions could be classified according to the following criteria.

Mild Conditions:

Demand or plant treatment capacity at 80 percent of plant production capacity.

Moderate Conditions:

Demand or plant treatment capacity at 90 percent of plant production capacity.

Severe Conditions:

Demand or plant treatment capacity at 100 percent of plant production capacity.

3. MANAGEMENT MEASURES

Depending on the severity of drought and/or emergency conditions, some to all of the following measures could be considered to manage temporary water supply problems:

Public/Customer Notification

Inform the public of impending and actual water supply problems and measures individual users can take to reduce water consumption. Keep the public appraised of the severity of temporary emergency conditions.

Use Restrictions

Limit non-essential water use on a voluntary to mandatory basis. Non-essential water use could include lawn and landscape irrigation, car washing, street washing, water hydrant flushing, swimming pool use, and all outdoor water use in general. Under moderate and severe emergency conditions, develop mandatory hourly and daily schedules for non-essential water use.

Water Use Surcharges

By meter size classification or special user classification, develop standards specifying normal water consumption. Under moderate to severe emergency conditions, bill customers on a surcharge basis for higher than normal water use.

Civil Penalties

Enforce mandatory water use restrictions through fines or other appropriate civil penalties.

Water Rationing

Ration water supplies equitably among water utility customers. Establish exceptions or variance procedures for granting relief from water use restrictions or rationing.

IV. CONCLUSIONS

1. Current estimated study area population is forecast to increase by 254 percent by the year 2040, from 73,075 to 185,654.

2. Water produced by public water supply agencies within the study area is predominately sold to residential customers.

3. Unaccounted water loss reported by public water supply agencies within the study area range from 0.2 percent to 24 percent of water produced.

4. All public wastewater treatment agencies within the study area are currently operating within permit standards for average daily and peak daily flow.

5. Almost all public water supply customers are also serviced by public wastewater collection and treatment facilities.

6. All public water supply agencies within the study area use groundwater as a source of supply.

7. Public water supply agencies within the study area meter customer connections.

8. Water and sanitary sewer charges are the primary source of revenues for public utilities within the study area.

9. Rate schedules of public utilities within the study area are either flat rate or ascending block rate.

10. All municipalities within the study area have adopted the Southern Standard Building Code.

11. Monthly water use reported by public water utilities within the study area follow typical patterns. Summer use rates are somewhat higher than typical.

V. RECOMMENDATIONS

WATER CONSERVATION PLAN

It is recommended that the Brazos Bend Water Authority (BBWA or Authority) adopt a Water Conservation Plan prior to entering into initial contracts for water service with the goal of achieving a 4.3% short term reduction in water consumption and an ultimate goal of a 10% reduction in customer water consumption. A program for short and long term water conservation is detailed below:

SHORT TERM PROGRAM

Prior to entering into contracts for service, BBWA shall:

1. Provide potential customers with a copy of the Authority's adopted Water Conservation Program specifying Authority goals and detailing potential water conservation measures.

Within one year of initiating service, BBWA shall:

1. Provide wholesale customer with an Authority newsletter and an initial fact sheet outlining the BBWA conservation program, suitable for distribution to retail customers.

2. Provide wholesale customers with water conservation material for distribution to retail customers on a minimum of two occasions, in a form suitable for bill stuffers, door hangers, door-to-door distribution or as otherwise requested by wholesale customer.

3. Prepare newspaper articles, radio or television announcements regarding water conservation for publication and broadcast on two occasions within wholesale customer's service area.

4. Prepare a water conservation educational program suitable for use within public and private schools in wholesale customer's service area.

5. On a quarterly basis, provide wholesale customers with water conservation tips for distribution with retail customer billings.

6. In association with wholesale customer, identify other measures and activities to inform public regarding water conservation.

LONG TERM PROGRAM

Following the first year program described above, BBWA shall provide at least two public education programs annuallly, and shall provide standards and assistance to wholesale customers in order to effect the Authority's long term goal of a 10% reduction in water consumption. It is recommended that the Authority's long term Water Conservation Plan consist of the following:

1. Public Education

   At least two of the public education programs initiated by the Authority and its wholesale customers during the short term program shall be continued in subsequent years.

2. Water Conserving Plumbing Codes

In order to assure that water conservation standards are included in plumbing codes in customer political subdivisions, the Authority shall adopt Water Conserving Plumbing Code Standards. Contracts for water service shall contain provisions requiring implementation of water conservation plumbing and fixture standards. Recommended fixture standards are listed below:

Recommended Plumbing Fixture Standards

Tank-type toilets	No more than 3.5 gallons per flush
Flush valve toilets	No more than 3.0 gallons per flush
Tank-type urinals	No more than 3.0 gallons per flush
Flush valve urinals	No more than 1.0 gallons per flush
Shower heads	No more than 3.0 gallons per minute
Lavatory and kitchen faucets	No more than 2.75 gallons per minute
All hot water lines	Insulated
Swimming pools	New pools must have recirculating filtration equipment

Note: All municipalities within the Brazos Bend Water Authority's jurisdiction have adopted the Southern Standard Plumbing Code. Water conservation provisions of the Southern Standard Plumbing Code are reproduced in Attachment 2.

3. Water Conservation Retrofit

The Authority, in conjunction with customer utilities, shall encourage local hardware stores and plumbing supply stores to stock retrofit fixtures and devices and promote their use. A program to supply retrofit fixtures to retail customers at reduced cost shall be investigated by the Authority and its wholesale customers.

4. Conservation-Oriented Rate Structure

The Authority, in order to assure that existing and future rate structures implemented by participating political subdivision remain non-wasteful, small contractually prohibit declining block rate structures.

5. Metering and Metering Repair

Metering requirements, meter testing schedules and meter replacement criteria shall be included in water supply contracts with participating subdivisions. It is recommended that individual meters be tested according to the following schedule:

- o Production (master) meters - test once a year
- o Meters larger than 1 inch - test once a year
- o Meters 1 inch or smaller - test every 10 years

The Authority shall assist wholesale customers with meter testing equipment and/or personnel if requested.

6. Water Conserving Landscaping

   o The BBWA shall provide wholesale customers with information pertaining to water conserving landscaping measures using one of the methods outlined in the short term educational program.

   o Contact local nurseries and landscaping professionals to encourage the use of water conserving plants and landscaping techniques.

7. Water Audits and Leak Detection

   The Authority shall require that participating utilities provide information on an annual basis regarding delivered versus total individual metered water consumption. The Authority shall provide leak detection and water audit assistance to customers experiencing high unaccounted water loss.

8. Recycling and Reuse

   The Brazos Bend Water Authority shall consider non-potable water reuse alternatives in conjunction with the Authority wastewater facilities projects.

IMPLEMENTATION

It is recommended that a member of the BBWA Board or staff be selected to administrator of the Authority's Water Conservation Program. The administrator shall work with each utility in a cooperative effort to ensure program implementation.

The Authority Administrator, as well as a designated person at each utility customer, shall submit an annual report to the Texas Water Development Board which, as a minimum, will include the following information:

- o Progress of the implementation of the program;
- o Response to the program by the public; and
- o Quantitative effectiveness of the plan.

The program shall be enforced by contractual agreement between the Brazos Bend Water Authority and its customers.

DROUGHT/EMERGENCY CONTINGENCY PLAN

It is recommended that the Authority adopt a Drought and Emergency Contingency Plan prior to entering into initial contracts for water service. The recommended plan is detailed below.

TRIGGER CONDITIONS

The Authority shall define the severity of Drought/Emergency conditions based on the following classification system.

Mild Conditions

- o Surface water demand approaching 80 percent of available treatment capacity at each water purification plant or

- o Production at each water purification plant reduced to such a point that the surface water demand is 80 percent of the reduced treatment capacity.

Moderate Conditions

- o Surface water demand approaching 90 percent of available treatment capacity at each water purification plant or

- o Production at each water purification plant reduced to such a point that the surface water demand is 90 percent of the reduced treatment capacity.

Severe Conditions

- o Surface water demand approaching 100 percent of available treatment capacity at each water purification plant or

- o Production at each water purification plant reduced to such a point that the surface water demand is 100 percent of the reduced treatment capacity or

- o Imminent or actual failure of a major component of the system which could cause immediate health problems or

- o Water demand is exceeding the system's capacity on a regular basis, thus presenting the real danger of a major system failure.

EMERGENCY MANAGEMENT PROGRAM

When it is evident that a water supply emergency is approaching, the Authority shall:

1. Notify Authority customers regarding an impending water supply emergency.

2. Prepare to notify individual water users, in conjunction with Authority wholesale customers, of the approaching emergency condition utilizing, as appropriate:

- o News releases for local publication
- o Radio and television public service announcements
- o letters, bill stuffers, and brochures for individual water users

Upon reaching various Drought/Emergency Trigger Conditions, the Authority, in conjunction with its utility customers, shall implement the following emergency management programs:

Mild Condition Measures

1. Activate programs to notify the public that mild drought/emergency conditions exist, including news releases, radio and television annoucements and direct mailings as appropriate.

2. Keep the public appraised of the status of drought/emergency conditions on a daily basis.

3. Request that the public curtail non-essential water use. Publish voluntary daily and hourly lawn and landscape irrigation schedules.

Moderate Condition Measures

1. Inform the public that Drought/Emergency conditions have been updated to moderate status.

2. Prohibit the following water use activities:

a. Street washing

b. Water hydrant flushing

c. Filling pools

d. Athletic field watering

3. Prohibit the "waste of water" defined as follows:

   a. Permitting water from landscape irrigation to escape into gutters, ditches, streets, sidewalks, and other surface drains.

   b. Failure to promptly repair a controllable leak due to defective plumbing after it is discovered.

   c. Recreational use of faucets, hoses, and hydrants.

   d. Other obviously wasteful uses.

4. Publish mandatory schedules for public non-essential water use, such as lawn and lawnscape irrigation and car washing, subject to civil penalties. Enforce mandatory compliance.

5. If conditions continue to worsen and prior to onset of severe conditions, implement a user surcharge for excessive water use, as follows:

   a. 5/8-inch meter - over 20,000 gallons, surcharge of \$.50/1000 gallons.

b. One 1-1/2-inch meter - over 25,000 gal/month surcharge of $.50/1000 gallons

c. 2-inch and larger - over 30,000 gal/month, surcharge of $.50/1000 gallons.

d. 2-inch and larger - over 35,000 gal/month, surcharge of $1.00/1000 gallons.

Severe Conditions

1. Inform the public that Drought/Emergency conditions have been updated to severe conditions.

2. Prohibit all outdoor water use subject to civil penalties.

3. Ration or terminate water service to selected portions of the system according to the following order:

   a. Industrial/institutional water,
   b. Commercial users,
   c. Residential users, and
   d. Public safety facilities.

   Notify the public of variance procedures for granting relief from rationing or restricted use. Possible exceptions to water rationing and restricted use are as follows:

a. Health and Safety uses of water.

b. Commercial business that use water to maintain (but not expand) their primary business practices (e.g., commercial car and trusk washes, nurseries, turf growers, water haulers, etc.).

c. Public gardens and arboretums of national, state, or regional significance where necessary to preserve specimens.

d. Watering at a minimum rate necessary to establish or maintain revegetation or landscape plantings required pursuant to law or regulation.

4. Implement a user surcharge for excessive water use, as follows:

a. 5/8-inch meter - over 5,000 gal/month, 200 percent surcharge.

b. One 1-1/2-inch meter - over 10,000 gal/month, 200 percent surcharge.

c. 2-inch and larger - over 15,000 gal/month, 200 percent surcharge.

d. 2-inch and larger - over 20,000 gal/month, 300 percent surcharge.

IMPLEMENTATION

It is recommended that a member of the BBWA Board or staff be selected to administrator of the Authority's Drought/Emergency Management Program. The administrator will work with each utility customer in a cooperative effort to ensure program implementation.

The program will be enforced by contractual agreement between the Brazos Bend Water Authority and its customers.

ATTACHMENT 1

WATER SAVING METHODS THAT CAN BE PRACTICED BY THE INDIVIDUAL WATER USER

In-home water use accounts for an average of 65 percent of total residential use, while the remaining 35 percent is used for exterior residential purposes such as lawn watering and car washing. Average residential in-home water use data indicate that about 40 percent is used for toilet flushing, 35 percent for bathing, 11 percent for kitchen uses, and 14 percent for clothes washing. Water saving methods that can be practiced by the individual water user are listed below.

In the bathroom, customers should be encouraged to:

1. Take a shower instead of filling the tub and taking a bath. Showers usually use less water than tub baths.

2. Install a low-flow shower head which restricts the quantity o9f flow at 60 psi to no more than 3.0 gallons per minute.

3. Take short showers and install a cutoff valve or turn the water off while soaping and back on again only to rinse.

4. Not use hot water when cold will do. Water and energy can be saved by washing hands with soap and cold water; hot water should only be added when hands are especially dirty.

5. Reduce the level of the water being used in a bath tub by one or two inches if a shower is not available.

6. Turn water off when brushing teeth until it is time to rinse.

7. Not let the water run when washing hands. Instead, hands should be wet, and water should be turned off while soaping and scrubbing and turned on again to rinse. A cutoff valve may also be installed on the faucet.

8. Shampoo hair in the shower. Shampooing in the shower takes only a little more water than is used to shampoo hair during a bath and much less than shampooing and bathing separately.

9. Hold hot water in the basin when shaving instead of letting the faucet continue to run.

10. Test toilets for leaks. To test for a leak, a few drips of food coloring can be added to the water in the tank. The toilet should not be flushed. The customer can then watch to see if the coloring appears in the bowl within a few minutes. If it does, the fixture needs adjustment or repair.

11. Use a toilet tank displacement device. A one-gallon plastic milk bottle can be filled with stones or with water, recapped, and placed in the toilet tank. This will reduce the amount of water in the tank but still provide enough for flushing. (Bricks which

some people use for this purpose are not recommended since they crumble eventually and could damage the working mechanism, necessitating a call to the plumber). Displacement devices should never be used with new low-volume flush toilets.

12. Install faucet aerators to reduce water consumption.

13. Never use the toilet to dispose of cleansing tissues, cigarette butts, or other trash. This can waste a great deal of water and also places an unnecessary load on the sewage treatment plant or septic tank.

14. Install a new low-volume flush toilet that uses 3.5 gallons or less per flush when building a new home or remodeling a bathroom.

In the kitchen, customers should be encouraged to:

1. Use a pan of water (Or place a stopper in the sink) for rinsing pots and pans and cooling implements when cooking rather than turning on the water faucet each time a rinse is needed.

2. Never run the dishwasher without a full load. In addition to saving water, expensive detergent will last longer and a significant energy saving will appear on the utility bill.

3. Use the sink disposal sparingly, and never use it for just a few scraps.

4. Keep a container of drinking water in the refrigerator. Running water from the tap until it is cool is wasteful. Better still, both water and energy can be saved by keeping cold water in a picnic jug on a kitchen counter to avoid opening the refrigerator door frequently.

5. Use a small pan of cold water when cleaning vegetables rather than letting the faucet run.

6. Use only a little water in the pot and put a lid on it for cooling most food. Not only does this method save water, but food is more nutritious since vitamins and minerals are not pured down the drain with the extra cooking water.

7. Use a pan of water for rinsing when hand washing dishes rather than a running faucet.

8. Always keep water conservation in mind, and think of other ways to save in the kitchen. Small kitchen savings from not making too much coffee or letting ice cubes melt in a sink can add up in a year's time.

In the laundry, customers should be encouraged to:

1. Wash only a full load when using an automatic washing machine (32 to 59 gallons are required per load).

2. Use the lowest water level setting on the washing machine for light loads whenever possible.

3. Use cold water as often as possible to save energy and to conserve the hot water for uses which cold water cannot serve. (This is also better for clothing made of today's synthetic fabrics.)

For appliances and plumbing, the customer should be encouraged to:

1. Check water requirements of various models and brands when considering purchasing any new appliance that uses water. Some use less water than others.

2. Check all water line connections and faucets for leaks. If the cost of water is $1.00 per 1,000 gallons, one could be paying a large bill for water that simply goes down the drain because of leakage. A slow drip can waste as much as 170 gallons of water EACH DAY, or 5,000 gallons per month, and can add as mush as $10.00 per month to the water bill.

3. Learn to replace faucet washers so that drips can be corrected promptly. It is easy to do, costs very little, and can represent a substantial amount saved in plumbing and water bills.

4. Check for water leakage that the customer may be entirely unaware of, such as a leak between the water meter and the house. To check, all indoor and outdoor faucets should be turned off, and

the water meter should be checked. If it continues to run or turn, a leak probably exists and needs to be located.

5. Insulate all hot water pipes to avoid the delays (and wasted water) experienced while waiting for the water to "run hot."

6. Be sure the hot water heater thermostat is not set too high. Extremely hot settings waste water and energy because the water often has to be cooled with cold water before it can be used.

7. Use a moisture meter to determine when house plants need water. More plants die from over-watering than from being too dry.

For out-of-door use, customers should be encouraged to:

1. Water lawns early in the morning during the hotter summer months. Much of the water used on the lawn can simply evaporate between the sprinkler and the grass.

2. Use a sprinkler that produces large drops of water, rather than a fine mist, to avoid evaporation.

3. Turn soaker hoses so the holes are on the bottom to avoid evaporation.

4. Water slowly for better absorption, and never water on windy days.

5. Forget about watering the street or walks or driveways. They will never grow a thing.

6. Condition the soil with compost before planting grass or flower beds so that water will soak in rather than run off.

7. Fertilize lawns at least twice a year for root stimulation. Grass with a good root system makes better use of less water.

8. Learn to know when grass needs watering. If it has turned a dull grey-green or if footprints remain visible, it is time to water.

9. Do not water too frequently. Too much water can overload the soil so that air cannot get to the roots and can encourage plant diseases.

10. Do not over-water. Soil can absorb only so much moisture and the reset simply runs off. A timer will help, and either a kitchen timer or an alarm clock will do. An inch and one-half of water applied once a week will keep most Texas grasses alive and healthy.

11. Operate automatic sprinkler systems only when the demand on the town's water supply is lowest. Set the system to operate between four and six a.m.

12. Do not scalp lawns when mowing during hot weather. Taller grass holds moisture better. Rather, grass should be cut fairly often, so that only 1/2 to 3/4 inch is trimmed off. A better looking lawn will result.

13. Use a watering can or hand water with the hose in small areas of the lawn that need more frequent watering (those near walks or driveways or in especially hot, sunny spots.)

14. Learn what types of grass, shrubbery, and plants do best in the area and in which parts of the lawn, and then plant accordingly. If one has a heavily shaded yard, no amount of water will make roses bloom. In especially dry sections of the state, attractive arrangements of plants that are adapted to arid or semi-arid climates should be chosen.

15. Consider decorating areas of the lawn with rocks, gravel, wood chips, or other materials now available that require no water at all.

16. Do not "sweep" walks and driveways with the hose. Use a broom or rake instead.

17. Use a bucket of soapy water and use the hose only for rinsing when washing the car.

ATTACHMENT 2

APPENDIX J
WATER CONSERVATION

J101 GENERAL

Automatic flushing devices of the siphonic design shall not be used to operate urinals.

J102 WATER CLOSETS

Water closets, either flush tank or flushometer operated, shall be designed, manufactured and installed to be operable and adequate flushed with no more than 4.0 gal per flushing cycle when tested in accordance with applicable standards.

J103 URINALS

Urinals shall be designed, manufactured, and installed to be operable and adequate flushed with no more than 1.5 gal of water per flush.

J104 LAVATORY FACILITIES

J104.1 Public Facilities

Faucets for public lavatories shall be equipped with outlet devices which limit the flow of water to a maximum of 0.5 gpm or be equipped with self-closing valves that limit the delivery to a maximum of 0.25 gallons of hot water for recirculating systems and to a maximum of 0.5 gallons for non-recirculating systems.

EXCEPTION: Separate lavatories for physically handicapped persons shall not be equipped with self-closing valves.

J104.2 Private Facilities

Faucets for private lavatories shall be designed, manufactured and installed to deliver water at a flow rate not to exceed 3.0 gpm when tested in accordance with applicable standards.

J105 SHOWER HEADS

Showerheads shall be designed, manufactured, and installed to deliver water at a rate not to exceed 3.0 gpm when tested in accordance with applicable standards.

J106 SINK FAUCETS

Sink faucets shall be designed, manufactured, and installed to deliver water at a rate not to exceed 3.0 gpm when tested in accordance with applicable standards.

ORDINANCE NO. 112 -1

BEING AN ORDINANCE ADOPTING THE SOUTHERN STANDARD PLUMBING CODE; PROVIDING FOR AN EFFECTIVE DATE HEREOF; AND PROVIDING FOR AN APPLICATION FORM AND FIXING FEES.

BE IT ORDAINED BY THE City Council of the City of Brookside Village, Texas:

SECTION 1: The Southern Standard Plumbing Code, and all amendments thereto, of 1985, is hereby adopted as the plumbing code of the City of Brookside Village, and shall hence forth be used by the building inspector and for granting of permits, inspections and construction within the corporate limits of the City of Brookside Village.

SECTION 2: Exhibit A and Exhibit B shall be used by all applicants for plumbing and gas permits and shall be properly completed before a permit will be issued and the fees affixed to these exhibits shall apply with the following exception. When a reinspection is required on this permit at the same time a reinspection is required on any other permit issued only one reinspection fee shall be charged. Fees may be changed by Council from time to time.

SECTION 3: This Ordinance shall be effective from and after the date of its passage.

SECTION 4: All Ordinances in conflict herewith are repealed to the extent of such conflict only.

PASSED, ADOPTED AND APPROVED this the 20th day of November, 1986.

Phillip W. Rutter

Phillip W. Rutter
Mayor

ATTEST:

Gayle Gaddis

Gayle Gaddis
City Secretary

APPROVED AS TO FORM:

Benjamin H. Best II

Benjamin H. Best, II
City Attorney

CITY OF MANVEL
P. O. BOX 187
MANVEL, TEXAS 77578

DEED

VOL 1604 PAGE 255

ORDINANCE NO. 81-16

AN ORDINANCE AMENDING ORDINANCE NO. 81-11 REGULATING PLUMBING WORK IN THE CITY OF MANVEL, TEXAS; DEFINING CERTAIN TERMS; PROVIDING FOR CERTAIN EXEMPTIONS; PROVIDING FOR THE ENFORCEMENT OF THIS ORDINANCE AND THE ISSUANCE OF PERMITS AND ESTABLISHING CERTAIN FEES; PROVIDING FOR A MINIMUM FIFTEEN DOLLAR PERMIT FEE; PROVIDING FOR SPECIFICATIONS, MATERIALS AND METHODS OF PLUMBING INSTALLATIONS; PROVIDING PENALTIES FOR VIOLATION OF THIS ORDINANCE; ANY PERSON, EITHER BY HIMSELF OR AGENT, AND ANY FIRM, CORPORATION OR OTHER ENTITY WHO VIOLATES ANY OF THE PROVISIONS OF THIS CODE SHALL BE DEEMED GUILTY OF A MISDEMEANOR AND, UPON CONVICTION, OF ANY SUCH VIOLATION, SHALL BE FINED IN ANY SUM NOT TO EXCEED TWO HUNDRED DOLLARS ($200.00); AND EACH DAY DURING WHICH SUCH VIOLATION CONTINUES SHALL CONSTITUTE A SEPARATE AND DISTINCT OFFENSE; PROVIDING A SEVERABILITY CLAUSE.

Be it ordained by the City Council of the City of Manvel:

1. This ordinance shall be known as the Plumbing Ordinance of the City of Manvel, and may be cited as such. The Standard Plumbing Code, current edition, is hereby adopted by reference as the plumbing code for the City of Manvel in its entirety.

2. Nothing in this code shall prevent a homeowner from installing or maintaining plumbing within his own property boundaries, provided such plumbing work is done by himself and is used exclusively by him or his family. Such privilege does not convey the right to violate any of the provisions of this code, nor is it to be construed as exempting any such property owner from obtaining a permit and paying the required fees therefor.

3. The fee for obtaining a plumbing permit is as set out in the Application for Plumbing Permit, Exhibit "A" and attached to this ordinance and made a part hereof for all purposes.

4. Each Master Plumber and each Journeyman Plumber shall have a license from the State of Texas and maintain said license in his or her possession at all times.

5. PENALTIES - Any person, either by himself or agent, and any firm, corporation or other entity who violates any of the provisions of this Code shall be deemed guilty of a misdemeanor and, upon conviction of any such violation, shall be fined in any sum not to exceed TWO HUNDRED DOLLARS ($200.00); and each day during which such violation continues shall constitute a separate and distinct offense. In any case of a violation of any of the terms or provisions of this ordinance by any corporation, the officers and agents actively in charge of the business of such corporation shall be subject to the penalty herein provided. Any offense defined herein which has been defined by laws of the State of Texas as an offense and for which penalty has been prescribed shall be punished as provided in said State Law, and nothing herein shall be held as fixing any penalty contrary to a penalty provided by the laws of the State of Texas.

6. SEVERABILITY CLAUSE - If any provision of this Code, or the application thereof to any person or circumstances, is held invalid, the remainder of the Code, and the application of such provision to other persons or circumstances, shall not be affected thereby.

7. REPEALING CLAUSE - All ordinances or parts of ordinances in conflict herewith are hereby repealed.

PASSED THIS 15th DAY OF October, 1981.

Mayor

ATTEST:

City Secretary

Chapter 20

PLUMBING CODE

State law reference—For state law as to plumbing generally, see Rev. Civil Stats., art. 6243-101.
Cross references—Building code, Ch. 5; electricity, Ch. 8; fire prevention, Ch. 10; heating, air conditioning and mechanical refrigeration code, Ch. 11; mobile homes and mobile home parks, Ch. 14; sewage and water, Ch. 21; swimming pools, Ch. 24; utilities, Ch. 24.

Article I. Plumbing Code

Article II. Gas Code

ARTICLE I. PLUMBING CODE

Editor's note—Ord. No. 0-86-33, § 1, adopted July 7, 1986, amended Ch. 20 to read as herein set out in Article I, with minor, nonsubstantive additions or deletions made for purposes of clarity. Formerly, Ch. 20, §§ 20-1—20-18, 20-20, 20-22, concerning plumbing code administration and enforcement, permits and fees, specifications for plumbing installations and specifications for gas piping and other gas installations, derived from Ord. No. 84, §§ 1—17, 19—24; Ord. No. 168, §§ 1—16; Ord. No. 192, § 1; Ord. No. 0-80-22, § 1, adopted Oct. 6, 1980; and Ord. No. 0-84-49, § 6, adopted July 2, 1984.

Sec. 20-1. Adoption.

The 1985 Edition of the Standard Plumbing Code, as published by the Southern Building Code Congress International, Inc., a copy of which is attached to Ordinance No. 0-86-33 and made a part hereof for all purposes, an authentic copy of which has been filed with the city secretary, is hereby adopted and made a part of this chapter, save and except those appendices deleted in section 20-2 of this chapter. (Ord. No. 0-86-33, § 1, 7-7-86)

Sec. 20-2. Deletions.

The Standard Plumbing Code adopted by section 20-1 is amended by deleting Appendices A and H thereof. (Ord. No. 0-86-33, § 1, 7-7-86)

Secs. 20-3—20-22. Reserved.

ARTICLE II. GAS CODE

Editor's note—Ord. No. 0-86-39, adding §§ 29-1, 29-2 to the Code has been included as §§ 20-23, 20-24, for classification purposes and in order to keep related material together, at the editor's discretion.
Cross references—Building code, § 5-1 et seq.; fire prevention, Ch. 10; mechanical code, § 11-1 et seq.; natural gas installations in mobile homes, § 14-20; portable service stations, § 15-4 et seq.; oil and gas wells, Ch. 18; inspection of gas pipe lines, § 25-9.

Sec. 20-23. Adoption.

The 1985 Edition of the Standard Gas Code, as published by the Southern Building Code Congress International, Inc., a copy of which is attached to Ordinance No. 0-86-39 and made a part hereof for all purposes, an authentic copy of which has been filed with the city secretary, is hereby adopted and made a part of this chapter, save and except those appendices deleted in section 29-2 of this chapter. (Ord. No. 0-86-39, § 1, 8-4-86)

Sec. 20-24. Deletions.

The Standard Gas Code adopted by section 29-1 is amended by deleting Appendices A, C, and D thereof. (Ord. No. 0-86-39, § 1, 8-4-86)

[The next page is 271]

Chapter 7

BUILDING*

ARTICLE I. IN GENERAL

Sec. 7-1. Fire district.

The fire district of this city shall include that territory or area situated within the following land use development districts, as delineated upon the official land use district map of the City of Pearland, Texas, to wit:

(1) Office and profession districts.

(2) Neighborhood service districts.

(3) General business districts.

(4) Commercial districts. (Ord. No. 44, § 1, 10-5-61; Ord. No. 44-1, § 1, 4-24-78)

Secs. 7-2—7-12. Reserved.

ARTICLE II. BUILDING CODE

Sec. 7-13. Adopted.

For the purpose of establishing rules and regulations for the construction, alteration, removal, demolition, equipment, use and occupancy, location and maintenance of buildings and structures, including penalties, there is hereby adopted and incorporated herein by reference as the building code of the city that certain

*Cross references—Electricity, Ch. 9; fire prevention and protection, Ch. 10; mobile homes, Ch. 17; plumbing and gas, Ch. 23; subdivisions, Ch. 27; utilities, Ch. 30.

building code known as the Standard Building Code, 1985 edition, with revisions, recommended and published by the Southern Building Code Congress International, Inc., which code is published in book form and which is referred to, incorporated herein and made a part hereof for all purposes, a true and correct copy of which code is filed of record in the office of the city secretary. (Ord. No. 224, § 2, 11-8-71; Ord. No. 224-1A, § 1, 8-9-76; Ord. No. 224-4, § 1, 6-23-80; Ord. No. 224-6, § 1, 9-26-83; Ord. No. 224-7, § 1, 6-23-86)

Sec. 7-13.1. Amendments, modifications, additions, deletions.

The building code adopted in section 7-13 is modified in the following respects:

403.1.4. Chapter IV, Section 403, Subsection 403.1.4 of the Standard Building Code, 1985 Edition, with revisions, shall be and the same is hereby expressly amended to read as follows:

> *403.1.4.* Unless otherwise specifically prescribed in 403.1, the separation of mixed occupancies shall provide not less than two-hour fire resistance (existing separations need not be modified to meet this requirement), except that portions of buildings used as accessory offices or for customary nonhazardous uses necessary for transacting the principal business in Group S and Group F occupancies may be separated by partitions of noncombustible construction without fire resistance or by partitions constructed of materials as permitted in the type of construction used.

403.2. Chapter IV, Section 403, Subsection 403.2 of the Standard Building Code, 1985 edition, with revisions, shall be and the same is hereby expressly amended to read as follows:

> *403.2—Tenant separation.* In a building, or portion of a building, of a single occupancy classification, when enclosed spaces are provided for separate tenants, such spaces shall be separated by not less than two-hour fire resistance.

702.3.3. Chapter VII, Section 702, Subsection 702.3.3 of the Standard Building Code, 1985 edition, with revisions, shall be and the same is hereby expressly amended to read as follows:

702.3.3. Group R-Residential. In all newly constructed buildings, except in one- and two-family dwellings, all partitions along exit access corridors or partitions that separate apartments, dormitory rooms or hotel rooms from other occupancies, shall be of not less than two-hour fire resistant construction (in buildings constructed prior to the enactment of this section not less than one-hour fire resistant construction shall be sufficient). Partitions not fire rated may be permitted within individual dwelling units. The tenant separation in a two-family or multifamily dwelling shall comply with 403.2 hereof.

1707.1. Chapter XVII, Section 1707, Subsection 1707.1 of the Standard Building Code, 1985 edition, with revisions, shall be and the same is hereby expressly amended by amending the table therein set forth, in pertinent part, as follows:

1707.1—Exterior wall framing. Studs shall be spaced not more than the following:

Stud size	2 × 4
Supporting roof and ceiling only	16 inches
Supporting 1 floor, roof and ceiling	16 inches
Supporting 2 floors, roof and ceiling	--

(Remainder of table unaffected.)

1707.5.2. Chapter XVII, Section 1707, Subsection 1707.5.2 of the Standard Building Code, 1985 edition, with revisions, shall be and the same is hereby expressly amended by amending the table therein set forth, in pertinent part, as follows:

1707.5.2. Studs shall be spaced not more than the following:

Stud	2 × 4
Supporting roof and ceiling only	16 inches
Supporting 1 floor, roof and ceiling	16 inches
Supporting 2 floors, roof and ceiling	--

(Remainder of table unaffected.)

Appendix K. Appendix K, Recommended schedule of permit fees, of the Standard Building Code, 1985 edition, with revisions, is hereby deleted in its entirety, and the city council shall, from time to time, establish fees and a fee schedule shall be kept on file in the office of the city secretary. (Ord. No. 224-2, §§ 1—3, 3-13-78; Ord. No. 224-3, § 1, 5-8-78; Ord. No. 224-4, § 2, 6-23-80; Ord. No. 224-5, § 1, 5-24-82; Ord. No. 224-6, § 2, 9-26-83; Ord. No. 224-7, § 2, 6-23-86)

Sec. 7-14. Conflicts.

In the event of any conflict between the provisions of the code adopted by this article and the provisions of this Code of Ordinances, state law or city ordinances, rules or regulations, the provisions of this Code of Ordinances, state law or city ordinances, rules or regulations shall prevail and be controlling. (Ord. No. 224, § 2, 11-8-71)

Sec. 7-15. Definitions.

Whenever the word "municipality" or the word "City" is used in the code adopted by this article it shall be construed to mean the City of Pearland, Texas.

Whenever the term "corporate counsel" or "city attorney" is used in the code adopted by this article it shall be construed to mean the city attorney of this city.

Whenever the term "building official" is used in the code adopted by this article it shall be construed to mean the city building inspector or his duly authorized deputy or assistant. (Ord. No. 224, § 2, 11-8-71)

Sec. 7-16. Penalty for violation.

Any person who shall violate any provision of the code adopted by the provisions of this article shall be deemed guilty of a misdemeanor, and shall be punished as provided by section 1-11 of this Code. Each day such violation continues shall be deemed a separate offense.

Sec. 7-17. Permit required.

(a) It shall be unlawful for any person within the city limits or extraterritorial jurisdiction of the city to commence construction or excavation for construction of any building or structure, including accessory buildings, or to commence the erection, recon-

Appendix C

BRAZOS BEND WATER AUTHORITY STUDY
FORT BEND/
BRAZORIA COUNTY, TEXAS

Prepared For

LOCKWOOD, ANDREWS, AND NEWNAM
HOUSTON, TEXAS

Prepared By

McBRIDE-RATCLIFF AND ASSOCIATES, INC.
HOUSTON, TEXAS

McBride-Ratcliff and Associates, Inc.
Geosciences and Materials Engineering Services

January 1, 1980
MRA Project No: 88-558

Lockwood, Andrews, and Newnam
1500 CityWest Blvd.
Houston, Texas 77042

ATTENTION: Mr. Herb Weisend

BRAZOS BEND WATER AUTHORITY STUDY
FORT BEND/BRAZORIA COUNTY, TEXAS

Presented herein for your review and review by the Harris Galveston Coastal Subsidence District is our draft report of the Brazos Bend Water Authority study for sites in Fort Bend and Brazoria Counties. This study was authorized November 4, 1988. We performed the work in general accordance with our proposal letter, MRA Proposal No. 88-P306, dated October 6, 1988.

This report presents our findings of the Brazos Bend water study for a site located in east Fort Bend County and a site located in North Brazoria County. The time span covered in the report ranges from the year 1990 to the year 2040. The groundwater and subsidence conditions were evaluated assuming two pumping scenarios. This Case 1 scenario involved continuation of the current water supply methods and trends. The Case 2 scenario combines groundwater and surface water to meet demands of the study area.

As the result of our groundwater study we have determined that the water supply is sufficient to meet future demands with about 2.5 ft to greater than 4.5 ft of settlement by the year 2040. Phasing of surface water supplies will reduce this settlement.

We appreciate the opportunity to work with you on this water study. If we may be of further assistance to you, please call us.

Sincerely,
McBRIDE-RATCLIFF AND ASSOCIATES, INC.

Jack Steele, C.P.G.
Project Manager

J. L. Ireland, C.P.G.
Vice-President

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EXECUTIVE SUMMARY

A groundwater study was performed for the northeast corner of Fort Bend County and the northwest corner of Brazoria County in an effort to evaluate what factors would affect the withdrawal of groundwater by the year 2040. Factors considered for the study included the availability of groundwater to meet population demand, ground surface subsidence, and possible contamination of wells from a natural occurring salt water plume from the Blue Ridge Salt Dome, in Fort Bend County, and the Hastings Salt Dome and Manual Salt Dome in Brazoria County.

The study area draws groundwater from the Chicot and Evangeline aquifer which lie in formations of the Quaternary and Tertiary periods. Three salt domes are nearby the study area but only one, the Blue Ridge Salt Dome, is a piercement structure that penetrates the aquifers and can cause salt water contamination of the aquifers.

Groundwater elevation changes were modelled using MODFLOW, the USGS three dimensional finite-difference groundwater flow model, and calibrated using historical information. The potentiometric surface head change of the Chicot aquifer is predicted to range from 70 ft in 1990 to 210 ft by 2040 for Case 1. The Evangeline Aquifer change is predicted to vary from 95 ft in 1990 to 230 ft by 2040. Under Case 2 the potentiometric head change within the Chicot Aquifer is predicted to exhibit about 70 ft in 1990 to 190 ft by 2040. The Evangeline Aquifer is predicted to exhibit about 95 ft of change in 1990 to 240 ft by 2040.

Two pumpage scenarios were performed using MODFLOW; the first called for all public water demands to be met solely by groundwater. The second scenario requires that a program using groundwater pumpage and surface water in the model area be initiated to meet public water demands. Phasing of surface water to begin by the year 2000 increasing to the year 2020 when 90% of the total population within the study area will be using surface water.

The model calculated water level data indicating that at no time did the Evangeline lose its artisan condition and go to a gravity condition.

The resulting water level data was also used to model subsidence using the PRESS model. Subsidence ranged from about 3.1 feet to over 4.5 feet by the year 2040 for Scenario 1 and 2.5 ft to about 4.0 ft in Scenario 2. Although the total estimated subsidence reveals a difference of 0.50 ft between the two scenarios it should be noted that the total amount of this subsidence is significant at the highend of either case.

The two models used in this evaluation considers a number of parameters and data input values. The interpretations presented within this report are based on our concept of groundwater conditions with respect to stratigraphic and depositional environments encountered in the study area. The interpreted contour liner generated from the models and presented on the figure represents the highend of a range of possible values. Factors counting for vertical leakage between groundwater aquifers are included. Vertical leakage between the ground surface and the Upper Chicot Aquifer is considered negligible.

According to published literature a portion of the study area will be impacted by salt water contamination from the Blue Ridge Salt Dome for water obtained from the Chicot Aquifer. The study area is situated north of the saline water line for the Evangeline Aquifer.

INTRODUCTION

This geological and hydrological assessment was undertaken for the Brazos Bend Water Authority. McBride-Ratcliff and Associates was contracted to perform the work by Lockwood, Andrews and Newnam, Inc. (LAN) / Walsh Engineering, Inc. (WEI). The elements of this study were discussed with Mr. Pete Styner and Mr. Herbert Weisend of LAN. This work was conducted in accordance with our proposal of October 6, 1988, Proposal No. 88-P306 and authorized on November 4, 1988 by Mr. Pete Styner.

Project Description

The study area includes two tracts, one in Ft Bend County and the other in Brazoria County (Figure 1). The purpose of this study is to provide preliminary groundwater and subsidence data for infrastructure planning purposes. The project involves an evaluation of the quantity of groundwater that is available to the study area for water supply, its distribution, and expected drawdown and subsidence associated with the groundwater withdrawal. The general time frame to be addressed by the study is from the present to the year 2040.

Scope of Work

The scope of work included the following tasks:

a) Assemble available data on existing wells and plans for new wells;

b) Assemble key oil and gas well logs for the area;

c) Review previous studies on groundwater withdrawal and subsidence for various municipalities, municipal utility districts, and special districts and agencies within the study area;

d) Develop a geologic model for the major aquifers, and delineate recharge zones and discharge zones;

e) Reorganize the studies and data bases from a regional geologic perspective;

f) Compartmentalize the study area on the basis of common geology, hydrogeology and groundwater usage;

g) Model two ground water extraction scenarios involving groundwater withdrawal at unique prescribed rates and with given well distributions;

h) Use the computed drawdown and subsidence patterns from those studies to draw conclusions concerning the future water supply from well fields in the study area; and

i) Prepare a report documenting activities and findings.

GEOLOGY

This section presents the regional and site specific geologic setting of the model area (Figure 2). The stratigraphic units associated with the geologic setting and the assessment of the impact of geologic faulting on the hydrogeologic regime are discussed within the section. The geologic parameters presented are based upon an evaluation of existing United States Geological Survey (U.S.G.S.), Texas Water Commission reports and our experience dealing with the geology and hydrogeology of the study area.

Geography

The model area is situated within the Gulf Coastal Plain of Texas. The Gulf Coastal Plain includes the area located between the Balcones Fault Zone, near Austin and San Antonio, Texas, and the offshore Gulf of Mexico basin (Hunt, 1967). The surface area varies from rolling hills north of the greater Houston area to the rather flat featureless surface found adjacent to the coast line. Regional uplift, subsidence, and surface erosion formed the present day surfaces.

Surface drainage for the Gulf Coastal Plain is accomplished by numerous rivers and their tributaries. The Brazos River and the San Jacinto River are the largest river systems in the general vicinity of the model area.

Regional Geology

The geologic interpretations presented herein have been developed by performing the following tasks:

- review of geologic literature concentrating on Gulf Coast Quaternary and Tertiary geology;

- analysis of regional topographic and geologic maps of the greater Houston and Gulf Coast area; and

- using our geologic experience with depositional environments within the Gulf Coastal Plain of Texas.

The regional setting includes geologic formations of the Quaternary and upper Tertiary Gulf Coastal Plain of Texas. The geologic formations addressed in this section comprise the primary hydrogeologic units in the Fort Bend County - Brazoria County vicinity. Table 1 exhibits the geologic formation and their hydrogeologic unit (Aquifer) counterparts.

TABLE 1
GEOLOGIC SCALE

PERIOD	EPOCH	FORMATION	AQUIFER
Quaternary	Holocene		
	Pleistocene	Beaumont	
		Lissie	Chicot
		Willis	Evangeline
Tertiary	Pliocene	Goliad	Evangeline
	Miocene	Fleming	Jasper

Upper Tertiary Formation. Upper Tertiary, Fleming and Goliad Formation sediments were deposited by fluvial and deltaic processes approximately 2 to 5 million years ago. The Fleming crops out approximately 45-50 miles north of the study area (Fisher, 1974). The estimated thickness of the Fleming Formation is on the order of 1100 ft. The surface outcrop of the Goliad Formation is not found east of the Colorado River due to erosion and subsequent burial of the Goliad by Willis sediments.

Quaternary. The model area (Figure 2) lies within surficial sediments of the Quaternary Period. Quaternary sediments consist of series of coalescing alluvial, deltaic and coastal interdeltaic plains deposited principally by the major river systems and coastal processes. The youngest Quaternary plain, the Holocene, is a recent (post-glacial) depositional surface of about 10,000 years of age. The recent sediments are primarily located along the coast and present alluvial valley systems. Older Quaternary plains were deposited during the Pleistocene Epoch. These plains include the following formations:

- Beaumont (25,000 to 65,000 years old),
- Lissie (100,000 to 675,000 years old), and
- Willis Formations (750,000 to 1,250,000 years old).

Site Geology

Geology for the model area was developed from a review of geologic literature and geophysical logs of water and petroleum wells in the Fort Bend County - Brazoria County vicinity.

Surficial Geologic Units. Holocene alluvium and sediments of the Beaumont formation comprise the geologic surface units of the investigated area. The Holocene alluvial sediments are clay, silt and sand deposited predominantly in the Brazos River alluvial valley. The thickness of the Brazos River Holocene alluvial sediments is on the order of 60 ft thick. The Beaumont formation has been deposited by a series of laterally coalescing fluvial and deltaic systems. These systems are represented by the following types of depositional environments.

Type System	Depositional Environment
Fluvial	Meanderbelt
	- Flood Basin
	- Channel Fill
	- Point Bar
	- Natural Levee
	- Crevase Splays
Deltaic	Deltas
	- Distributary Channels
	- Interdistributary Flood Basins
	- Crevase Splays
	- Delta Fringe
	- Mouthbar
	- Pro Delta

Each of the environments exhibit distinctive soil profiles primarily comprised of clays, sands, silts, and their intermixtures. The thickness of the Beaumont Formation is about 120 ft.

The Beaumont Formation is underlain by Lissie formation sediments. These sediments have been deposited in distributary channel fill and interdistributary flood basin depositional environments. The sources of these sediments were abandoned channel systems of the paleo-Brazos River. The Lissie consists of a series of alternating sand and clay sequences with an average thickness of approximately 250 ft throughout the model area.

The Willis Formation underlies the Lissie and consists primarily of fluvial sands, gravels, and interbedded clays. The average thickness of the Willis is on the order of 670 ft in the model area.

The Willis Formation is underlain by the Tertiary Goliad Formation sediments. Sediments of the Goliad Formation consist predominantly of sands & gravels which resemble those of the overlying Willis. The thickness of the Goliad is on the order of 120 ft in the model area.

Sediments of the Fleming Formation underlie the Goliad. The Fleming Formation consists predominantly of a clay section with interlayered distributary channel sands. The sand units vary in thickness and exhibit lateral transitions from sand to clay.

Geologic Faulting

This section presents our evaluation of the geologic fault conditions in the vicinity of the project area.

The entire Gulf Coast of Texas is underlain by a thick wedge of sediment. Exploration, principally by the petroleum industry, has identified these sediments to be extensively distributed by "growth" or contemporaneous faults and faults associated with shallow piercement and deep-seated salt domes.

Fault Characteristics. Growth faults are essentially slip surfaces formed by "landslides" contemporaneously with sediment deposition such that stratal displacement increases with depth. Faults associated with salt domes (radial faults) are similar to growth faults in that the faulting takes place in the sediments, but the mode of deformation is generated by mobile salt migration.

The primary direction of movement of faults along the gulf coast area is a few degrees from vertical. The width of the fault zones has not been researched extensively. Our observations of distress in structures over active faults in other parts of Houston suggest that the vertical displacement may occur on more than one plane, and in a zone several feet in width. Secondary motions consisting of buckling or folding of beds adjacent to the fault are noted paralleling the fault trace.

Fault Activity. Evidence of continuing activity of faults is demonstrated by minor topographic scarps and aligned ponds on virgin land, and disruption of pavements and structures, in developed areas. The relationship of mapped subsurface faults and ground surface displacement related to these faults has been demonstrated by various researchers.

Most investigators relate current rates of ground surface displacement in the Houston-Galveston area by faulting to the removal of groundwater, and to a lesser extent, oil and gas in the relatively shallow subsurface. Extensive groundwater development began in the late thirties and has increased to the present. These investigators believe the near surface movement of faults in the area is due to differential consolidation of sediments bounding the faults. Sediments are depressured by heavy pumping, thus inducing consolidation. It is postulated that this differential consolidation is manifested in movement along the preexisting fault planes, which in turn is propagated to the surface.

Site Fault Assessment. The boundaries of the Brazos Bend Water Authority District are traversed by several fault systems. These fault systems are associated with the Blue Ridge Salt Dome, the Manvel Salt Dome, the Hasting Salt Dome and the Pearland Fault Systems. Faults associated with these features have been identified on the surface. It is speculated that the faults penetrate stratigraphic units comprising the aquifers being analyzed by this study.

Research in the Houston area has revealed two schools of thought regarding faults and their interaction with groundwater systems. One theory reflects that faults act as hydrologic barrier to the flow of groundwater. The second school of thought theorizes that the fault plane does not totally restrict groundwater flow.

It is our belief that near surface faults do not act as hydrologic barriers to groundwater flow. This is because the displacements that occur are not great enough to break the aquifer into a discontinuous layer. The locations of documented surface faults in the general vicinity of the ground water evaluation area are illustrated on Figure 3.

HYDROGEOLOGY

This section presents the regional and site hydrogeologic characteristics of the aquifer systems used by the Brazos Bend Water Authority.

Regional Hydrogeology

The Texas Coastal Plain is characterized by several hydrogeologic units spanning Tertiary and Quaternary time periods (Table 1). Hydrogeologic units are distinguished by characteristic hydrologic and stratigraphic properties. Variations in lithology both laterally and vertically results in unit boundaries which are time-stratigraphic.

Hydrogeologic unit boundaries are identified by evaluation of formation outcrops, geophysical log interpretation, and analysis of well production data including static water levels, water level fluctuation, and aquifer properties. Delineation and correlation of hydrogeologic units are focused on post-Oligocene strata which are predominate in supplying groundwater to the Texas Coastal Plain. As outlined by Baker (1979), post-Oligocene hydrogeologic units include the Catahoula confining system, Jasper aquifer, Burkeville confining system, Evangeline aquifer and Chicot aquifer.

The Jasper, Evangeline, and Chicot Aquifers were deposited in shallow waters by rivers and riverene deltas along the coast. What is seen in profile is not a single, thick water bearing layer confined by impermeable clay layers, but dozens of sand and clay layers that form a thickening wedge towards the coast. The Chicot, Evangeline, and Jasper aquifers fit the definition of an aquifer system of Lofgren and Klausing (1969) as a heterogeneous body of intercalated permeable and poorly permeable material that functions regionally as a water yielding hydraulic unit.

The Catahoula Confining System. The Catahoula confining system is composed predominantly of clay and tuff and acts as a hydrologic barrier between the overlying Jasper aquifer and underlying aquifers. The base of the Catahoula confining system is a time-stratigraphic unit corresponding to the base of the Catahoula formation. The top of the Catahoula confining system, however, is delineated lithologically on the basis of hydrologic properties and does not coincide with the top of the Catahoula formation which in many areas contains abundant amounts of sand.

Jasper Aquifer. The Jasper aquifer is recognized as a rock-stratigraphic unit delineated on the basis of lithology. As a result, the aquifer is geometrically irregular with boundaries which are independent of formation contacts. The lower boundary of the Jasper aquifer ranges from the base of the Fleming Formation to lying within the Catahoula. The top of the aquifer ranges from the Fleming Formation to the Oakville Sandstone. The Jasper aquifer exhibits several distinct sand layers containing zones of fresh to highly saline water varying with aquifer thickness and proximity to the coastline. The Jasper is brackish in the study area.

Burkeville Confining System. The Burkeville confining system acts as a hydrologic barrier inhibiting groundwater flow between the underlying Jasper and overlying Evangeline aquifers. The unit is composed predominately of clay and silt yet contains individual sand layers permeated with fresh to slightly saline water. The Burkeville confining system is delineated lithologically with boundaries which fall within the Fleming Formation and at the Fleming/Oakville Sandstone contact where the Oakville is present.

Evangeline Aquifer. The Evangeline aquifer is delineated as a rock-stratigraphic unit composed typically of the Goliad Sand and the upper Fleming Formation which contains interbedded sand and clay layers. In some areas the Evangeline includes lower Pleistocene sands which are lithologically similar to the underlying Goliad. Characteristic thick sands within the Evangeline yield abundant supplies of good quality groundwater throughout most of the Texas Coastal Plain. The Evangeline aquifer outcrops in a zone about 20 miles wide roughly paralleling the coast about 80 to 100 miles inland.

Chicot Aquifer. The Chicot aquifer is the youngest aquifer in the Texas Coastal Plain and is characterized by high percentages of sand which diminish southwest of Goliad County. The base of the Chicot is typically delineated at the base of the Pleistocene which includes the Willis, Lissie, and Beaumont Formations. At many locations, however, the base of the Pleistocene is difficult to distinguish from strata of the Goliad and Fleming Formations. In these instances, prominent marker beds located on well logs are used to delineate the base of the Chicot. The Chicot aquifer outcrops in a zone about 15 miles wide roughly paralleling the coast about 70 to 90 miles inland.

Site Hydrogeology

Site hydrogeology was evaluated with analysis of ground water publications United States Geological Survey (U.S.G.S.) well records and publications, and interpretation of electric geophysical logs of key water and petroleum wells in the site area. The extent of hydrologic unit delineation is limited to the upper 2500 feet of sediments which have historically produced ground water of good quality and supply.

Site Aquifer Systems. Hydrogeologic evaluation of the study area has revealed a system of two aquifers: the Chicot and Evangeline. The aquifers are characterized by distinct transmissivities resulting from variation in sand and clay composition.

Burkeville Confining System. The Burkeville confining system constitutes basal strata of the Fleming formation and, as shown by wells penetrating the Burkeville, consists predominately of clay with sand interbeds typically 5 to 10 feet thick. Transmissibility values are considerably lower than those of the overlying Evangeline aquifer, thus the Burkeville acts as a barrier retarding the flow of ground water from the Evangeline to units below.

Evangeline Aquifer. The lower surface of the Evangeline aquifer correlates with the top of the Fleming Formation. Sediments are characterized dominantly as clays with sand interbeds ranging from 10 to 50 feet thick in the lower 500 feet while the upper 800 to 1000 ft is dominantly characterized as sands with clay interbeds of 5 to 50 feet. The Evangeline aquifer ranges from about 1700 to 1900 ft in thickness, but the basal 300 ft, which is dominantly clays, is brackish.

<u>Chicot Aquifer</u>. The top of the Chicot aquifer is interpreted to lie at the Lissie-Willis formation contact. Indicated by electric well log data, the Chicot is characterized by a predominance of sand with clay interbeds from 10 to 50 feet thick. The Chicot aquifer ranges from about 400 ft to 450 ft in thickness in the area, and contains fresh water throughout.

Jorgensen (1975), subdivides the Chicot aquifer into upper and lower units. This differentiation is based on a predominance of clay in the upper portions of the Chicot and a massive heavily pumped sand zone in the lower portions of the Chicot aquifer. It has also been found that the upper portions of the Chicot aquifer (approximately 100 to 200 feet below ground surface) is only partially saturated and typically more highly mineralized groundwater than that in deeper zones (Gabrysch, 1980). Because of the limited availability of quality ground water in the upper Chicot aquifer, description of aquifer characteristics and ground water modeling pertains only to the lower Chicot aquifer.

<u>Aquifer Recharge</u>

Recharge is the intake of water into an aquifer to replenish or add to the zone of saturation. This may occur several different ways:

- water may enter laterally through surface outcrops of the formation,
- water may enter vertically from above or below from other formation due to differences in head,
- water may enter from a river or lake whose bed intersects with the aquifer,
- water may seep down from the surface.

In the study area, it is our interpretation that recharge to the Chicot aquifer occurs laterally from the outcrop area. Recharge to the Evangeline aquifer is received laterally from the outcrop and vertically from the Chicot aquifer. Lateral recharge for both aquifers is slow and hindered by pumpage to the north. As a result we interpret recharge from the out crops to be a negligible factor in the modeling area but is considered in our modelling effort.

<u>Chicot Aquifer</u>. Water levels in wells penetrating the Chicot at various depths indicate a decrease in aquifer head with depth. This suggests that the Chicot is a recharge aquifer system characterized by downward flow of groundwater in response to a hydraulic gradient.

The alluvial valley of the Brazos River has been mapped as a recharge zone for the Chicot aquifer (Gabrysch, 1977). Based upon analyses of stratigraphy, water quality, and water levels there is no evidence to support this conclusion relative to the Chicot aquifer zone in the study areas. As stated above, it is our interpretation that recharge to the Chicot is chiefly based on lateral flow through the aquifer.

Evangeline Aquifer. Like the Chicot, water wells penetrating the Evangeline aquifer indicate a zone of ground water recharge. The Evangeline does not outcrop in the study area. Recharge to the Evangeline occurs as the result of groundwater leakage from the overlying Chicot aquifer.

Groundwater Discharge

Groundwater discharge of the Chicot aquifer in the study area is due to groundwater withdrawal from wells and leakage to the underlying Evangeline aquifer. Historic pumpage will be discussed in a later section. Groundwater discharge of the Evangeline aquifer is due to groundwater withdrawal from wells.

HISTORIC PUMPAGE, GROUNDWATER DECLINE, AND SUBSIDENCE

Prior to 1940 the chief utilization for groundwater throughout the greater portion of the study area and surrounding environs was for agricultural purposes. The Fort Bend County and Brazoria Area was a major center for sugarcane as well as rice cultivation. Both crops were irrigated within the area. The agricultural use of the groundwater supplies remained relatively consistent until the later 1960's and early 1970's. The growth of greater Houston area brought urban development into the area such that major pumpage began in southwestern sectors of Houston as well as the Cities of Sugar Land, Stafford, and Missouri City. Several utility districts were created in the late 1970's up and through the 1980's which draw upon groundwater as a chief water supply. Alvin and Pearland were also centers for rice cultivation.

The current pumpage in the model area is about 20 million gallons per day. The pumpage immediately to the east in the greater Houston area is about 250-300 mgpd. Groundwater levels have been declining in both the Chicot and Evangeline Aquifers in response to this pumpage. Water levels have declined between 100-150 ft within the Chicot Aquifer within the greater study area and 175-200 ft within the Evangeline Aquifer since 1940.

Historic Subsidence has been about 3 ft in the model area during the period from 1906 to 1978.

HISTORIC HYDROLOGIC AND SUBSIDENCE MODELLING

Since about the middle sixties, considerable emphasis has been placed upon the construction of ground water models. Some, such as the Gulf Coast Model Study (Carr, Meyer, Sandeen & McLane, 1974), covered the area from Lake Charles, Louisiana to Falfurrias, Texas. Due to the unavailability of data in Mexico, it was not possible to carry that model as far south as had been originally intended. The Houston Area was included in all of the models listed (Table 2).

TABLE 2 - COMPARISON OF REPRESENTATIVE MODEL STUDIES WHICH INCLUDE THE HOUSTON AREA

Authors	Year Published	Type	Size of Area Modeled (Sq. Miles)	Time Period Calibrated	No. of Layers	Comments
Wood & Gabrysch	1965	Analog	5000	1890-1965	2 4	Drawdown, Distribution
Jorgensen	1975	Elect. Analog	9100	1890-1970	4	Drawdown, Dis. & Subsidence
Meyer & Carr	1979	Digital	27000	1890-1975	5	Subsidence Distribution
Muller & Price	1979	Digital	61500	1960-1969	2	Added sub-areas Drawdown: 2020
Espey Huston Associates	1982	Digital	8400	1960-1980	5	Added 2 scen-arios: 2020
Carr, Meyer Sandeen, & McLane	1984	Digital	100000	1890-1975 1900-1975	5	Covered area: Lake Charles to Falfurrias
Law Engineering	1986-7	Modular 3/D-Fin.	22000	1900-1983	7a	Covered 22 counties.
McBride-Ratcliff & Associates	1987-8	Modular 3/D-Fin. Dif.	16000	1890-1988	3	2 Scenarios to 2030

Note:
a: Includes the Jasper aquifer.

Such studies developed a means for predicting water level declines in the Chicot and Evangeline aquifers. They also simulated declines of the potentiometric surfaces and subsidence of the land-surface.

Some scenarios projected water level declines far into the future (year 2020). Now that eastern Harris County has turned to the use of surface water some of these projections are merely academic.

Nearly all of these studies were cooperative projects that were funded in part by one or more of the following agencies: U.S. Geological Survey, Harris Galveston Subsidence District, Texas Water Development Board and the City of Houston.

DESCRIPTION OF THE HYDROLOGIC MODEL AND SUBSIDENCE MODEL FOR THIS INVESTIGATION

Both hydrologic projections and subsidence predictions were modelled on computer. The models used in this evaluation considers a number of parameters. Interpretation of values used herein are based on our concept of groundwater conditions with respect to stratigraphic and depositional environments encountered in the study area. These models are both digital models designed or modified for use on personal computers. The subsidence model works in conjunction with the groundwater model using the potentiometric head data generated to predict subsidence.

Hydrologic Model

The groundwater model, MODFLOW, selected for the program was authored by McDonald and Harbough (1985) of the U.S. Geological Survey.

MODFLOW is a finite-difference model simulating ground water flow in three dimensions. Groundwater flow within the aquifer is simulated using a block-centered finite-difference approach. Layers can be simulated as confined, unconfined, or a combination of confined and unconfined. Flow from external stresses, such as flow to wells, areal recharge, evapotranspiration, flow to drains, and flow through riverbeds, can also be simulated.

The computer program is written in a modular form. It consists of a main program and a series of highly independent subroutines called "modules". The modules are grouped into "packages". Each package deals with a specific feature of the hydrologic system which is to be simulated.

The model grid utilized was a 33 x 33 x 2 grid, Figure 4. The Chicot and Evangeline aquifers were modeled as individual layers with a leaky clay aquitard between. A 15 x 15 cell area in the center of the grid was utilized in the model area with the size of the cell in this area being 6000 ft on a side. The cells increase in size away from the central area by a factor of 1.4 until the boundary which is about 80 miles away from the study area. The boundary was placed this far away to minimize the influence of fixed heads at the model boundaries on the site area.

Subsidence Model

The model utilized for subsidence analyses was the PRESS Model. The PRESS Model utilized by McBride-Ratcliff is essentially the same as that utilized by Espey Huston and Associates for their study for the Harris Galveston County Subsidence District (HGCSD) in 1982. The program has been modified such that program execution can be accomplished on a personal computer.

The program was initially developed by Dr. Donald C. Helm for one-dimensional simulation of aquifer system compaction using constant parameters (Helm, 1975). The input requirements have been modified to increase the flexibility of the program for handling multiple aquifers and to simplify input preparation. Output options have been added to accept empirical correlations of computed values with observed results.

The program computes the ground surface subsidence resulting from a given change in potentiometric head within a system of aquifers. Both virgin and rebound compressibilities of the clay layers existing within aquifers are taken into account. The aggregate ground surface subsidence as a function of time is computed by summing the individual contributions of the clay layers. The program uses one-dimensional Terzaghi consolidation theory with some simplification of parameter descriptions to relate a time history of potentiometric head change to a time history of subsidence. Calibration of the model to historically measured subsidence and potentiometric head changes in a given area allows predictions of future subsidence to be made for various input conditions of projected head changes.

The subsidence resulting from groundwater withdrawal is assumed to be attributable only to the consolidation of clay layers within the aquifers experiencing changes in potentiometric head. The consolidation of sand strata is assumed to be insignificant compared to that of the fine-grained materials.

The consolidation (or compaction) of the clay layers is assumed to be one-dimensional and related to the changes in effective vertical stress in the clay. This concept is generally referred to as "Terzaghi one-dimensional consolidation theory" soils loaded by structures (Terzaghi and Peck, 1967; Terzaghi, 1925). This approach has been shown to be well-suited to determination of subsidence of the ground surface as a result of loading the clays by drawing down the potentiometric surface of the water within an aquifer.

MODEL PARAMETERS

The two models used for this study require the input of several parameters. For the groundwater model these parameters include:

- aquifer geometry,
- aquifer characteristics,
    - transmissivity values
    - storage coefficients
    - leakage values
- historic pumpage demands, and
- future pumpage demands.

The settlement model requires the following geotechnical and hydrological parameters:

- hydraulic conductivity,
- elastic specific storage,
- virgin specific storage,
- preconsolidation stress,
- clay layer thickness and location, and
- drawdown data.

Hydrologic Model

The input parameters for the hydrologic model are presented in this section.

Aquifer Geometry. The geometry of the Chicot and Evangeline aquifer was obtained from a variety of sources. Electric logs of wells in the site area were analyzed and checked against maps published by Wesselman, 1972, and Sandeen and Wessleman 1973. The geometry of the aquifers beyond the study areas was obtained from TDWR field data, Meyer-Carr 1979, and Meyer & Carr/et al 1985.

Aquifer Characteristics. Transmissivity values, storage coefficients, and selected leakage values were taken from file data of the Meyer & Carr 1979 report. This data was regrided for our model grid area. Transmissivities and storage coefficients were checked with pumping tests in the area. It is our interpretation that verticle leakage from surface recharge is to the Chicot Aquifer negligible. Therefore for this modelling effort, recharge parameters with respect to vertical leakage from the surface are modelled at 0. Vertical leakage from the Chicot Aquifer to the Evangeline Aquifer was checked by model calibration.

Historic Pumpage Demands. Pumpage demands from 1890 to 1975 are from Meyer & Carr 1979 file data. More specific information in the site area was obtained from TDWR Surveys of Ground and Surface Water Use, Surveys of Irrigation in Texas, 1986, the Houston Water Master Plan, 1986, and the City of Houston Water Pumpage Statistics Report, 1985.

Future Pumpage Demands. Two future demands scenarios were modeled, Case 1 and Case 2. Both these cases met groundwater demands with wells pumping a maximum of 800 gpm. These wells were placed at known well locations in each census tract. When demand exceeded production capacity a new well would be added at a predetermined location for that census tract. The new well would produce to match demand until its 800 gpm capacity was reached. If demand was reduced production would drop, but still be distributed to all wells that had been emplaced. No wells were removed.

The Case 1 scenario involves meeting all groundwater demands within the study area from groundwater. Case 2 uses a combination of groundwater and surface water to meet the public water demands of the study area. Phasing of surface water is to begin by the year 2000. Ultimately, approximately 90 percent of the total population within the study area is expected to be using surface water by the year 2020. The Case 1 and Case 2 demands are given in the LAN/WEI Report Regional Water Supply and Waste Water Treatment Study.

In both cases the Harris Galveston Coastal Subsidence District's (HGCSD) existing Plan was imposed. The area to the west of Fort Bend consisting of Sugar Land and Stafford was modeled to convert to 80% surface water in the year 2000 to meet demands given in MRA Report 87-338. The area to the west of the Fort Bend sites, consisting of Sugar Land and Stafford, followed demands given in a previous study (MRA File 87-338) with an 80% conversion to surface water in the year 2000.

Case 1 future pumpage demands in the site areas were met with groundwater. The projected demands were supplied by LAN.

Case 2 future pumpage demands were met with groundwater until the year 2000. At this time certain areas in both sites were partially converted to surface water. These locations, conversion times, and amounts were supplied by LAN.

Subsidence Model

The geotechnical model parameters were developed using the HGCSD's PRESS data values for the USGS Addicks compaction monitor site. Regression analyses were performed on the values of hydraulic conductivity, elastic specific storage, and virgin specific storage with respect to depth. The resulting fitted values are judged to be reasonable first approximations with respect to magnitude and variation with depth and were used directly in this study. Preconsolidation stresses in the HGCSD data ranged from 0 (normally consolidated) to 100 feet of water. An average value of 50 feet of water was used as the preconsolidation stress, since it was judged that this value was more representative.

Geophysical logs were obtained from eleven well locations (Figure 6). The well sites which were selected were based on the availability of relatively deep geophysical well logs together with historic subsidence data near the wells. The geophysical logs were interpreted to obtain clay layer thicknesses, depth, and estimated values for hydraulic conductivity, elastic specific storage, and virgin specific storage (Figure 7). Drawdown data for each well was taken from the groundwater model results and input to the settlement model.

Calibration of Models

Calibration is an essential part of modeling. For future projections to be accurate, historical data should be mimicked as closely as possible. This assures that the various input parameters are accurate and that future predictions are credible. It should be noted that the longer range the prediction, the greater the variability of results.

Calibration of the Press Model and the Modflow models was accomplished by comparing the output data to published historical data. In the event the comparison indicated the simulation was not accurate, various parameters were adjusted and the model rerun. A minimum of four calibration runs were performed for each model. For the PRESS Model calibrations were performed for each of the well sites used to develop the PRESS Model parameters.

The groundwater model was compared to USGS data showing water level altitudes in both aquifers in the Houston area (Gabrysch 1980). The settlement model was compared to historic benchmark data from the National Geodetic Survey when possible or from USGS map showing historic settlements in the Houston area (Gabrysch 1980).

HYDROLOGIC MODELLING RESULTS

The cases that were modelled have resulted in predicted changes in the potentiometric surface of the Chicot and Evangeline Aquifers. The resultant altitude of the potentiometric surface has been calculated per grid node in each aquifer for each case. Contour maps have been constructed to illustrate the altitude of common potentiometric surface predicted. It must be stated that the modeling results and the contouring are approximations of future conditions and become less accurate when projected further into the future.

The model results are representative of the center of each node, thus in the study area, the results are cast into the center of the 6000 ft of 6000 ft grid cell. The modeling effort has not predicted potentiometric heads at specific wells pumping in a particular grid but represents an average potentiometric head for the grid cell.

Potentiometric Contours. Figures 8 through 27 represent contours of head (or elevation of potentiometric surface) for the Chicot and Evangeline aquifers as predicted from the cases modelled for the years 1990, 2000, 2010, 2020, 2030 and 2040. Case 1 represents the most severe case relative to groundwater withdrawal and consequently greatest change in the potentiometric surface. Case 2 represents the least severe case with the smallest change in potentiometric surface.

The altitude of the potentiometric surfaces are the same for both cases for the years 1990 and 2000 since the demands are the same. The 1990 potentiometric surface of the Chicot aquifer ranges from about -100 ft to -170 ft. The potentiometric surface of the Evangeline aquifer ranges from about -105 ft to -200 ft. In the year 2000 the Chicot heads range from about -120 ft to -210 ft with the Evangeline heads ranging from about -125 ft to -250 ft. As the years progress the demands begin to change resulting in a change of potentiometric surface between the two cases which increases as time goes on.

POTENTIOMETRIC SURFACE FT, MSL

	CASE 1		CASE 2	
Year	Chicot	Evangeline	Chicot	Evangeline
1990	-100 to -170	-105 to -200	-100 to -170	-105 to -200
2000	-120 to -210	-125 to -250	-120 to -210	-125 to -250
2010	-145 to -230	-140 to -280	-132 to -225	-135 to -225
2020	-150 to -280	-165 to -340	-185 to -275	-150 to -320
2030	-170 to -350	-175 to -400	-165 to -340	-170 to -375
2040	-190 to -400	-220 to -450	-185 to -375	-190 to -430

Hydrologic Modelling Conclusions. The maximum areas of concentrated pumpage remain to the northeast of the west study area for all cases modeled, which mimics the current pumpage trends. Groundwater flow, through the study area is from the south and east, to the north or northwest. In all cases modelled, the withdrawals do not result in the Evangeline aquifer changing from an artisan condition to a gravity condition.

SUBSIDENCE MODELLING RESULTS

The PRESS model is one dimensional. This means that only the settlements in one discrete location is modeled. To show settlement contours eleven locations in and around the study areas were used. This information was then contoured across the site.

Subsidence has been modelled based upon the changes in potentiometric head with time for Cases 1, and 2.

Settlement Contours. Figures 28 through 36 represent contours of equal settlement in feet (ft) for the cases modelled. The predicted subsidence for both cases in early years is about the same. Beyond the year 2000, less subsidence is predicted from Case 2 than Case 1. The greatest change in elevation of the land surface is realized in Case 1 followed by Case 2. The predicted subsidence for Case 1 for the period 1990 to 2040 ranges from about 3.1 in the south to slightly greater than 4.5 ft in the north while the range of Case 2 in this same period is 2.5 to greater than 4.0 ft, south to north.

SALT WATER MIGRATION

The Texas Water Development Board Report No. 155, Groundwater Resources of Fort Bend County, Texas and Report No. 163, Groundwater Resources of Brazoria County Texas, were reviewed to evaluate the potential of salt water contamination to impact the groundwaters of the study area. Figures 37 and 38 illustrate maps of the base fresh water for both Brazoria and Fort Bend counties. As shown the study area is situated north of the interpreted fresh water/saline water contact for the Evangeline Aquifer. Also illustrated on this figure is a salt water plume which is associated with the Blue Ridge Salt Dome. This plume is only present in the upper and intermediate sands of the Chicot aquifer. Water supply is drawn from lower sands of the Chicot, and the Evangeline aquifer which are not apparently impacted by the plume.

Salt water within the Chicot Aquifer has been reported to be associated with brine disposal in oil and gas fields in northern Brazoria County, specifically the Manvel and Hastings fields. The occurrence of saline waters at shallow depths in the Chicot and Evangeline aquifers has not been studied extensively. Care should be exercised in evaluating the location of future water supply wells to minimize the potential for salt water encroachment.

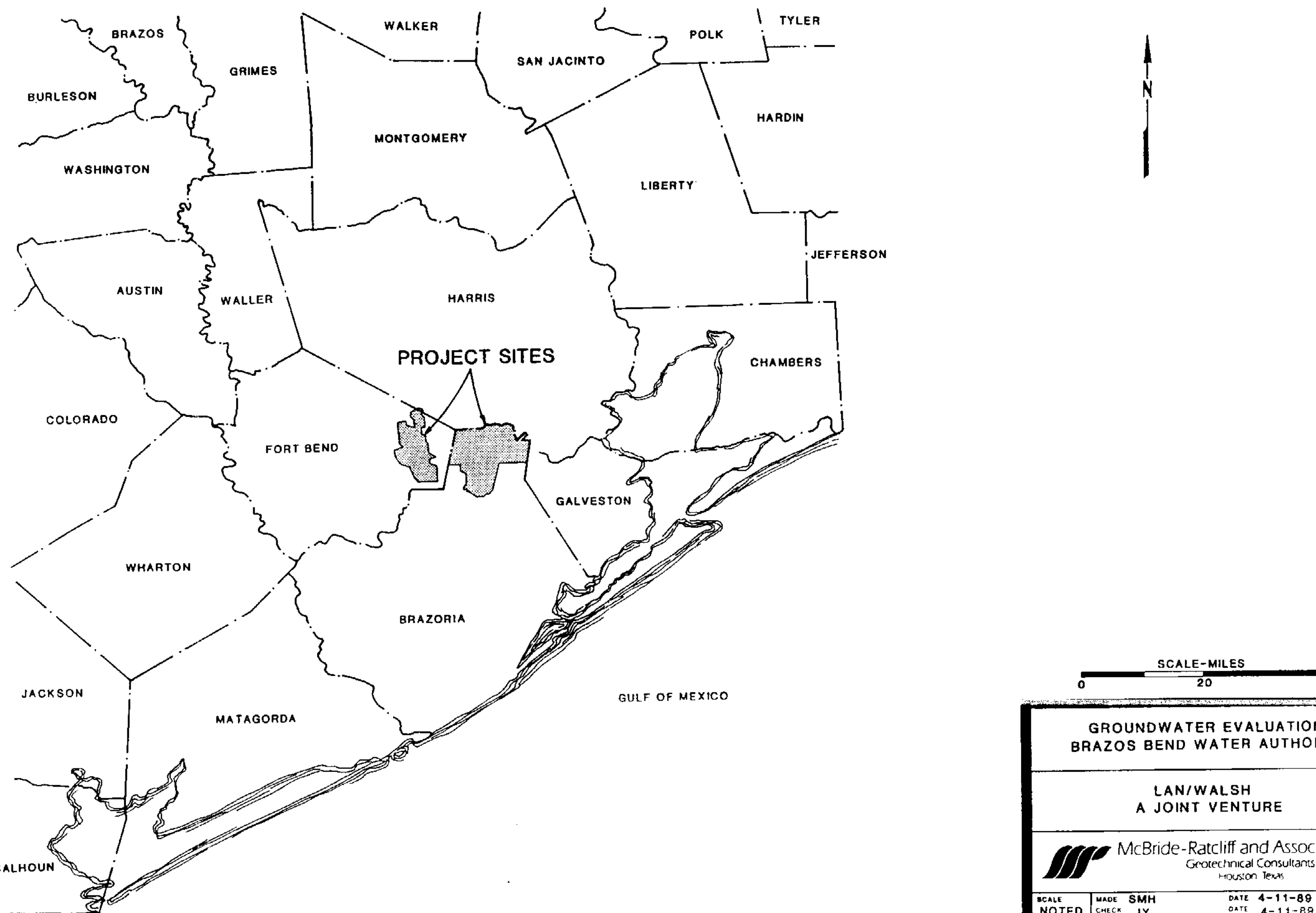
GENERAL

It is our opinion, based on the results of our modelling effort, that the Evangeline Aquifer will not experience a change from artisan to gravity conditions. Thus the potentiometer head should stay above the saturated zone of the top of the aquifer allowing the yield of the Evangeline to remain fairly constant.

The upper portion of the Chicot Aquifer is an unconfined system. The yield of the Chicot will diminish as withdrawn from the aquifer system container.

STUDY LIMITATIONS

The purpose of this study is to provide preliminary groundwater utilization and subsidence information for regional infrastructure planning. This assessment was based primarily upon published and open file information. Computer modelling has been utilized to forecast changes in water levels and consequent subsidence for two groundwater extraction scenarios. Inherent in the modelling programs are assumptions which yield averaged output. The magnitude and trends of data presented are representative. The program output does not implicitly model site specific drawdown at wells or well clusters, but does render an average approximation within a specific vicinity.



GROUNDWATER EVALUATION
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LAN/WALSH
A JOINT VENTURE

McBride-Ratcliff and Associates, Inc.
Geotechnical Consultants
Houston, Texas

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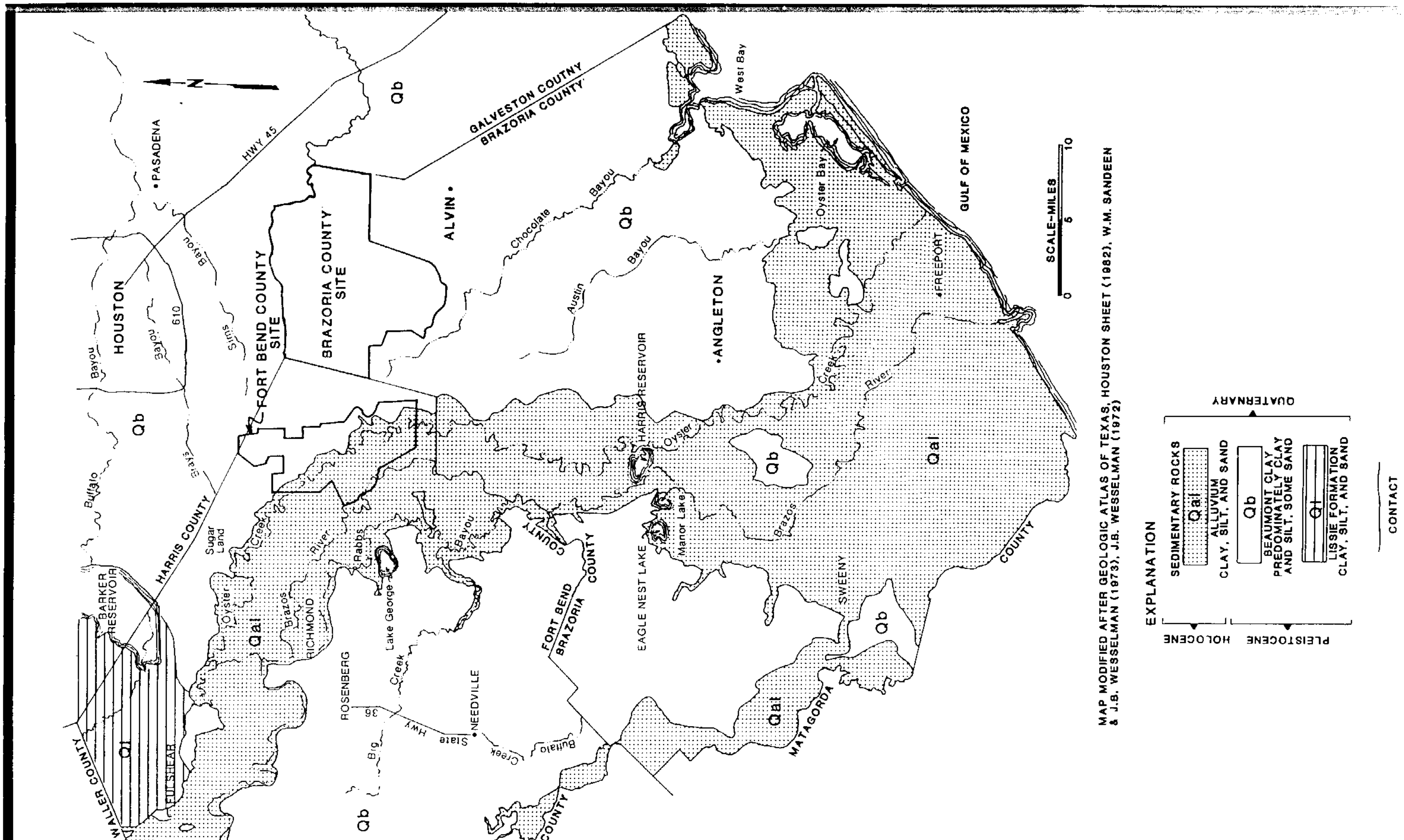
LOCATION MAP

FIGURE 1



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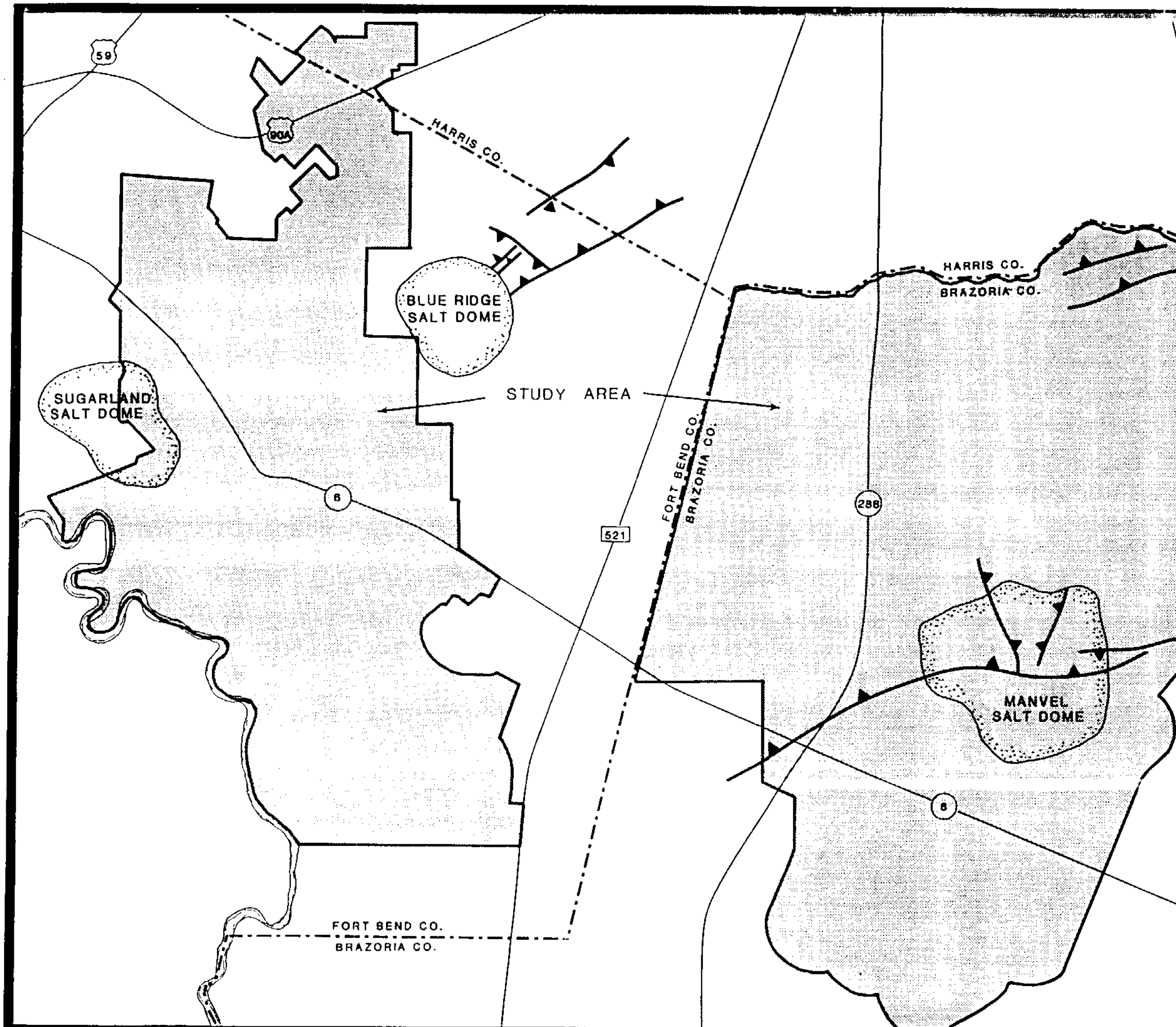
GEOLOGIC MAP

FIGURE 2



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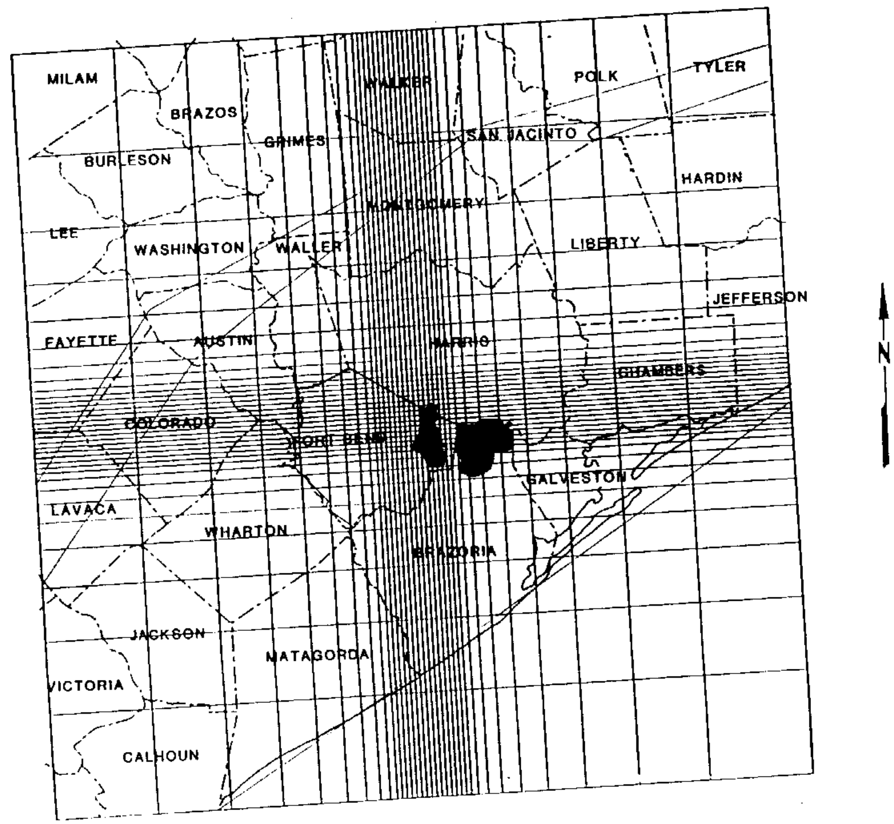
FAULT MAP



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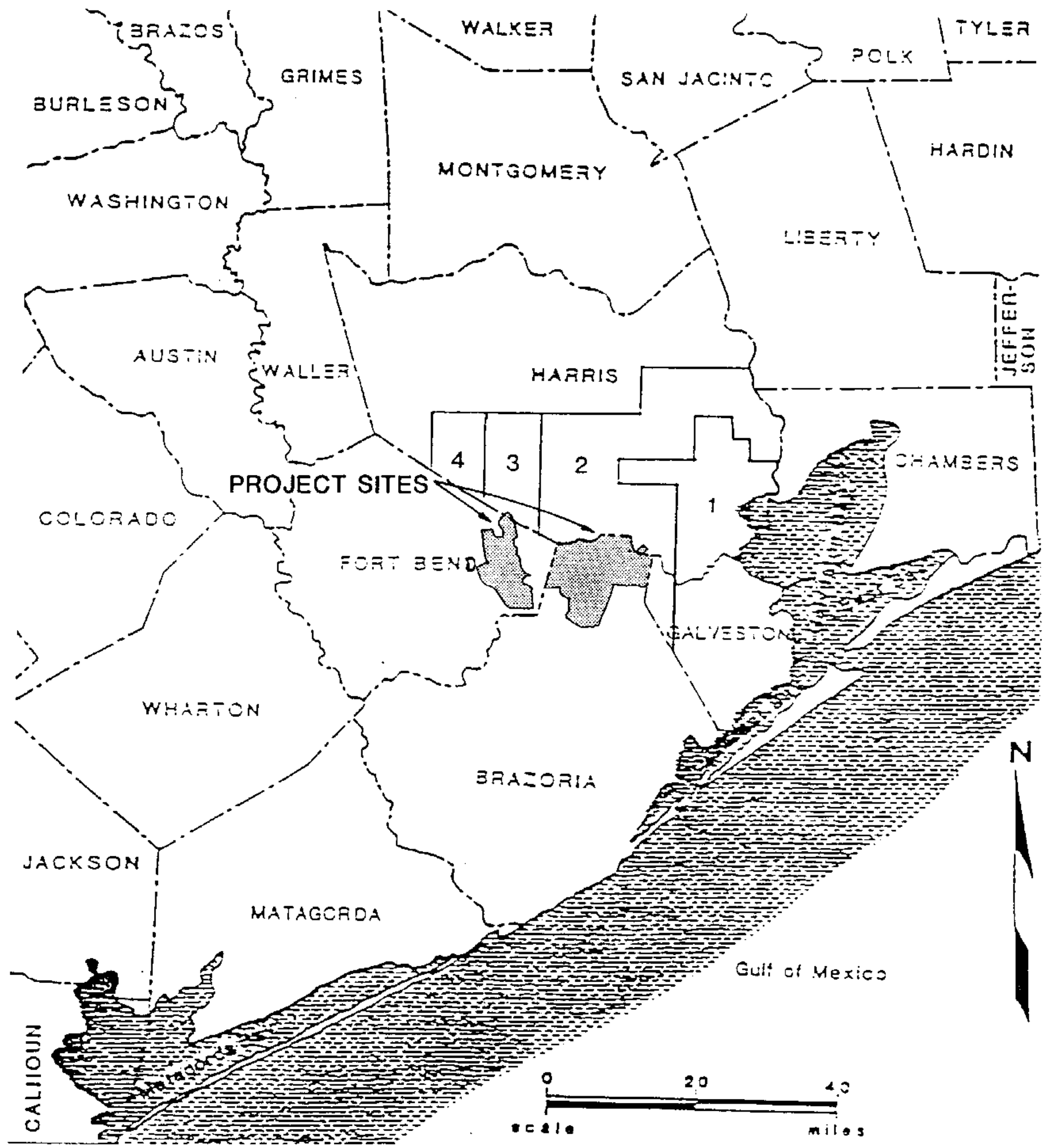
MODEL GRID			FIGURE 4



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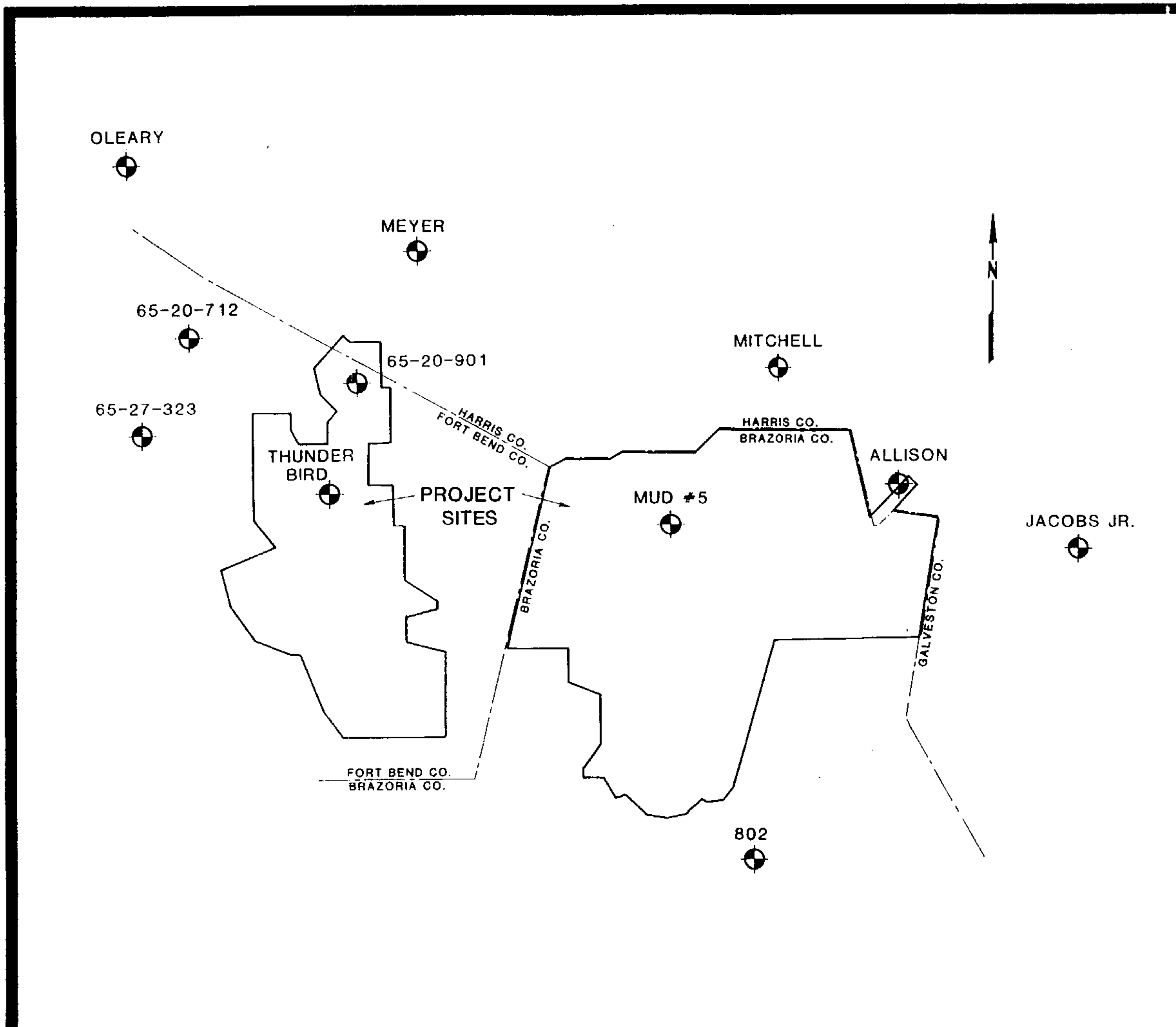
STUDY AREA & SUBSIDENCE DISTRICT AREAS 1,2,3, & 4

FIGURE 5



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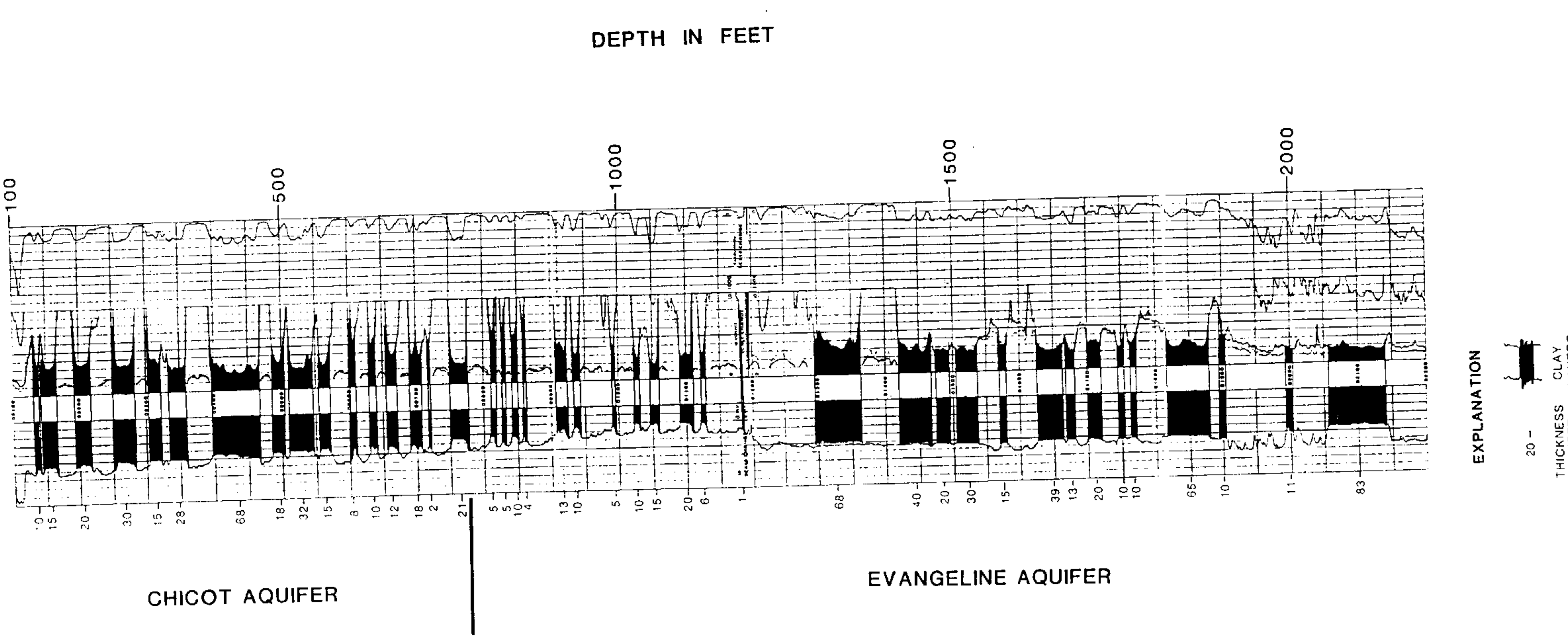
GEOPHYSICAL LOG LOCATIONS — FIGURE 6



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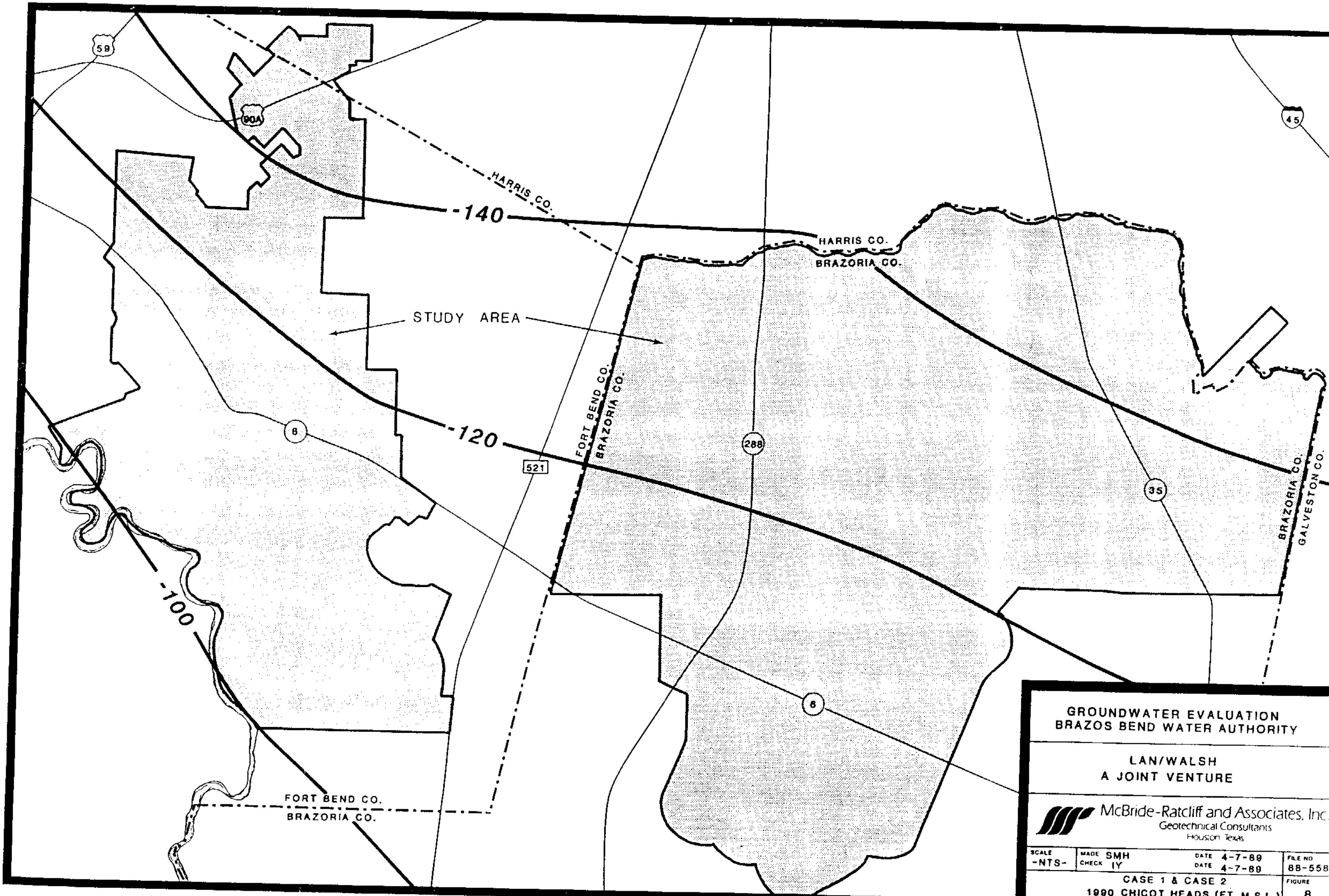
TYPICAL GEOPHYSICAL LOG
SHOWING CLAY LAYERS

FIGURE 7



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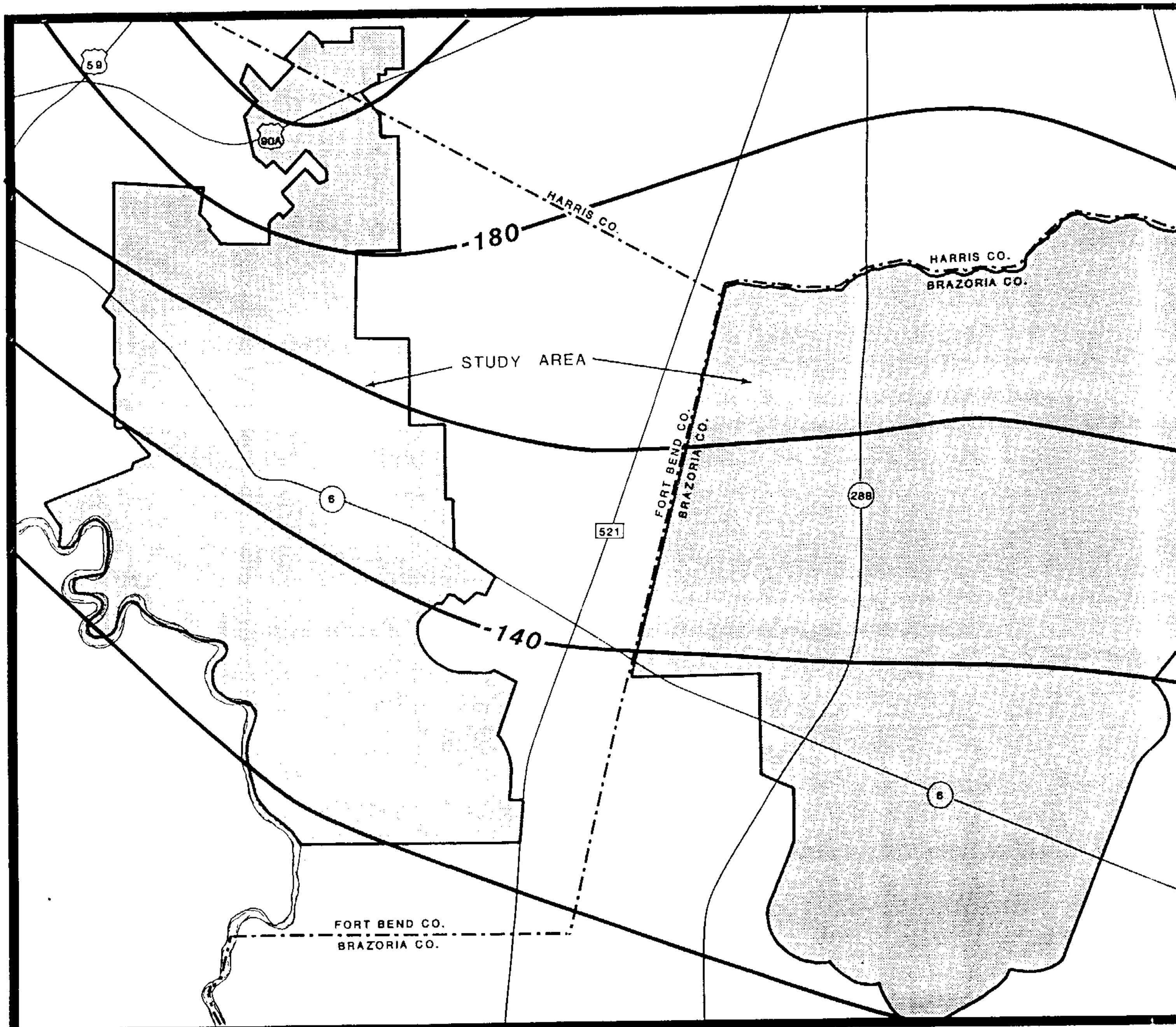
CASE 1 & CASE 2			FIGURE
1990 CHICOT HEADS (FT. M.S.L.)			8



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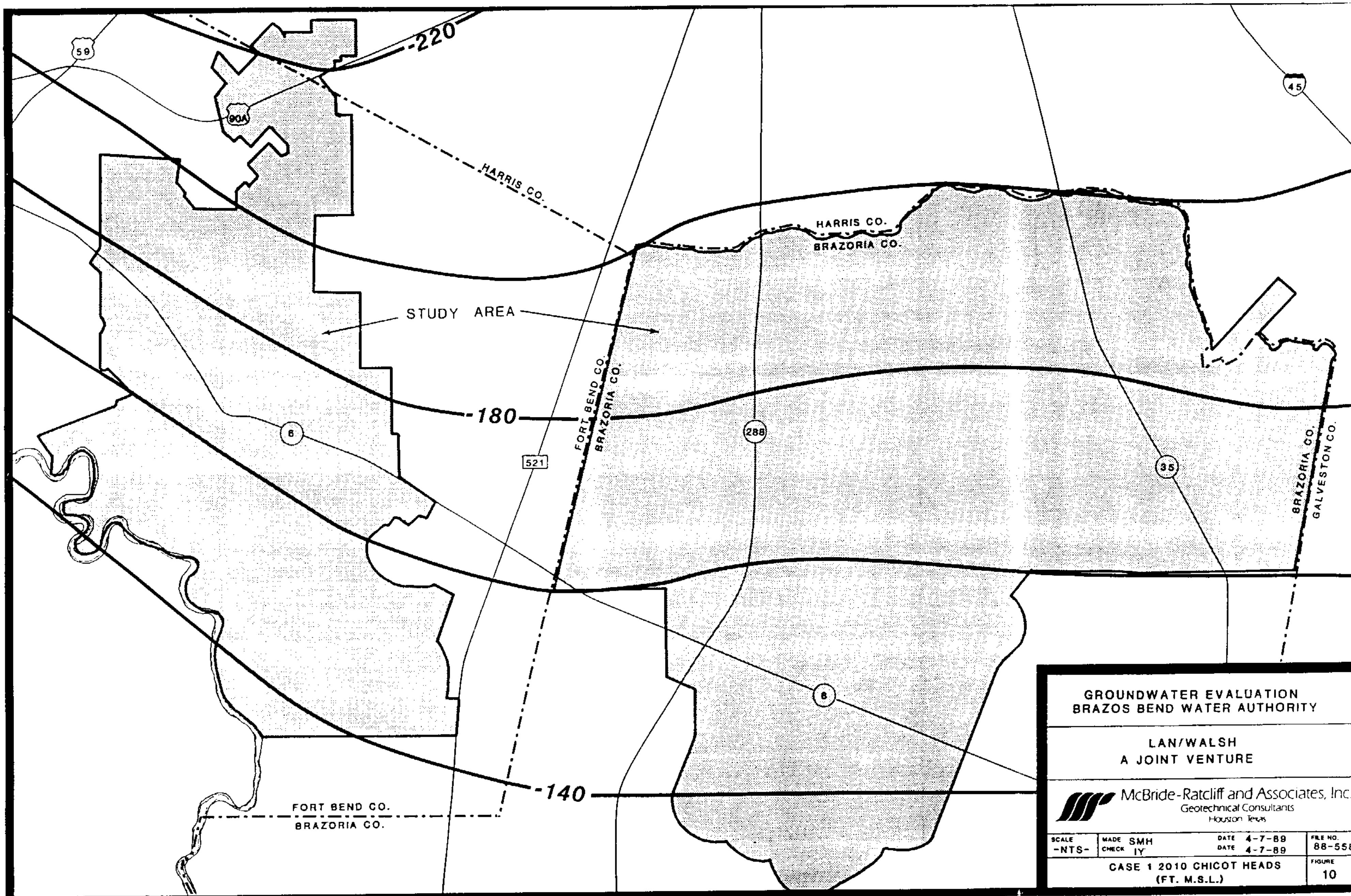
CASE 1 & CASE 2			FIGURE
2000 CHICOT HEADS (FT. M.S.L.)			9



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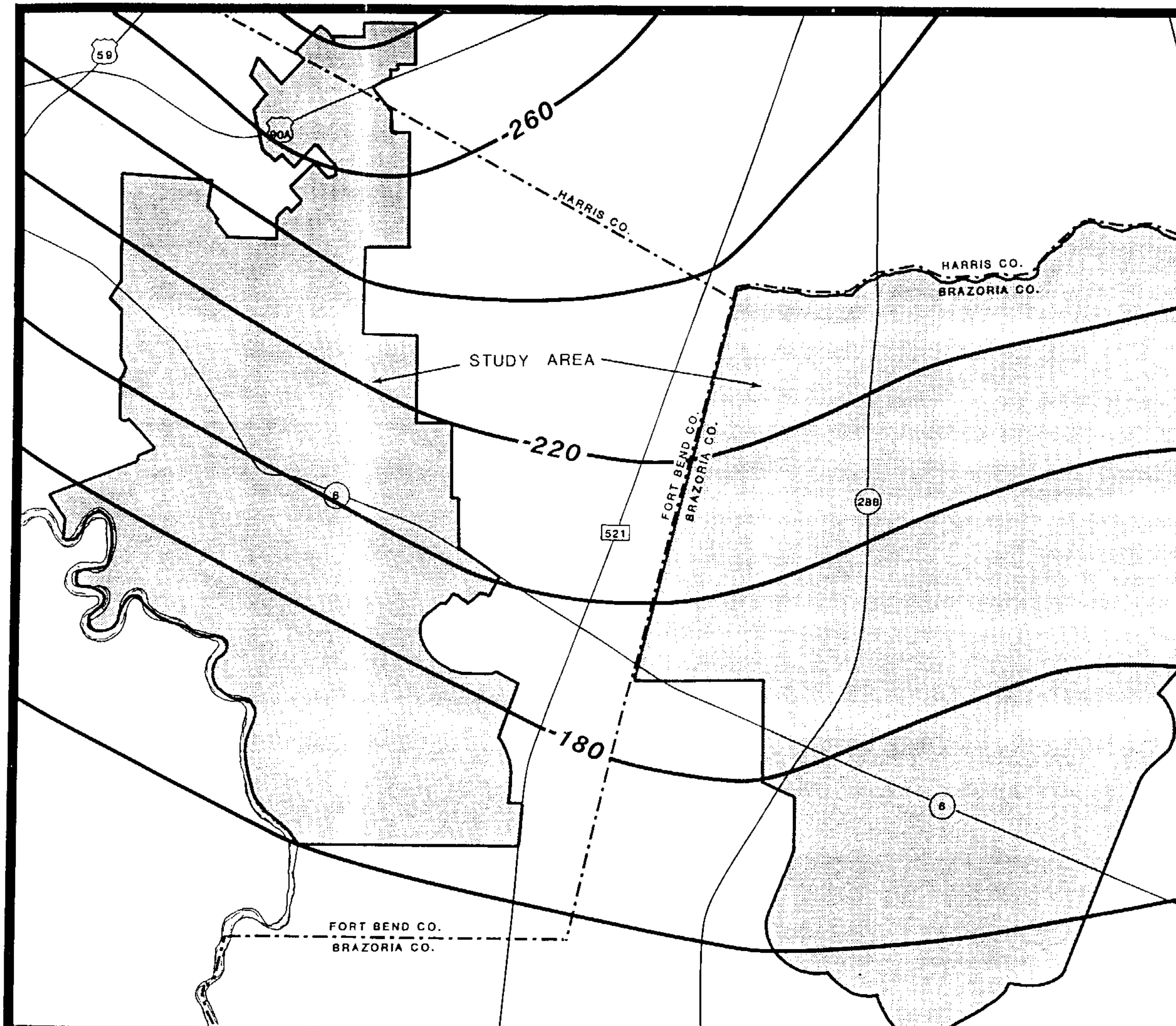
CASE 1 2010 CHICOT HEADS
(FT. M.S.L.)

FIGURE 10



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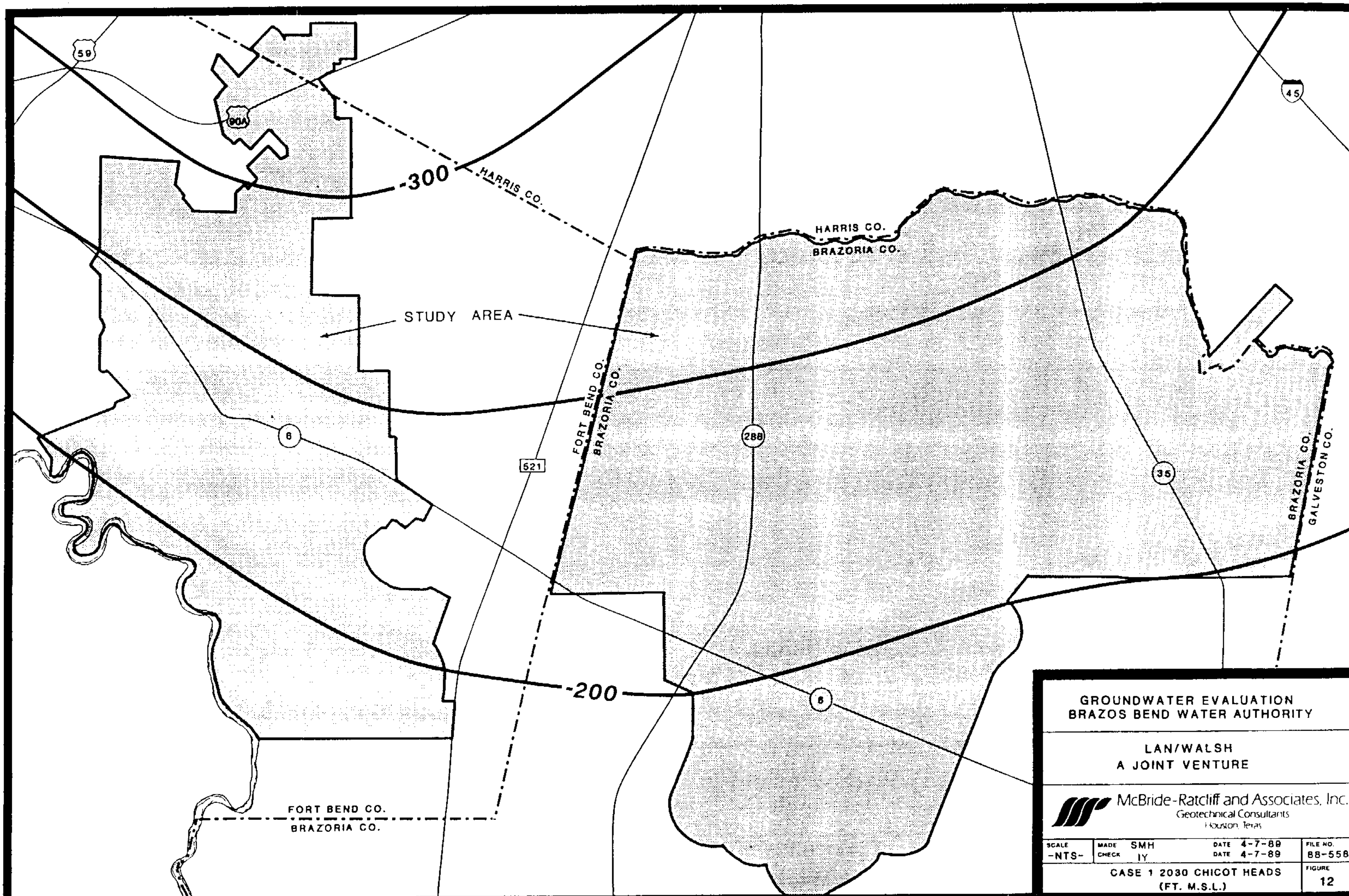
CASE 1 2020 CHICOT HEADS (FT.M.S.L.)			FIGURE 11



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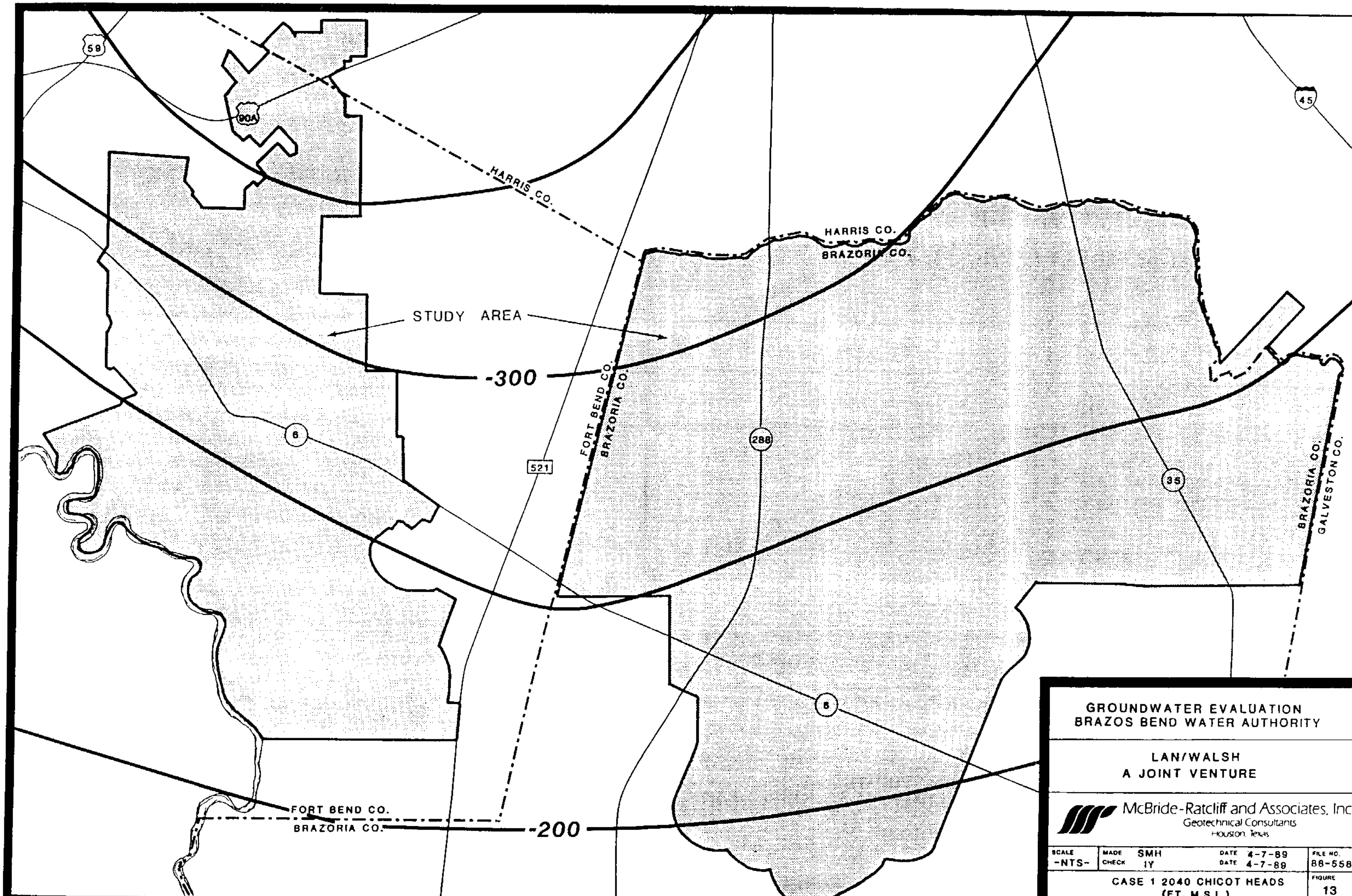
CASE 1 2030 CHICOT HEADS (FT. M.S.L.)

FIGURE 12



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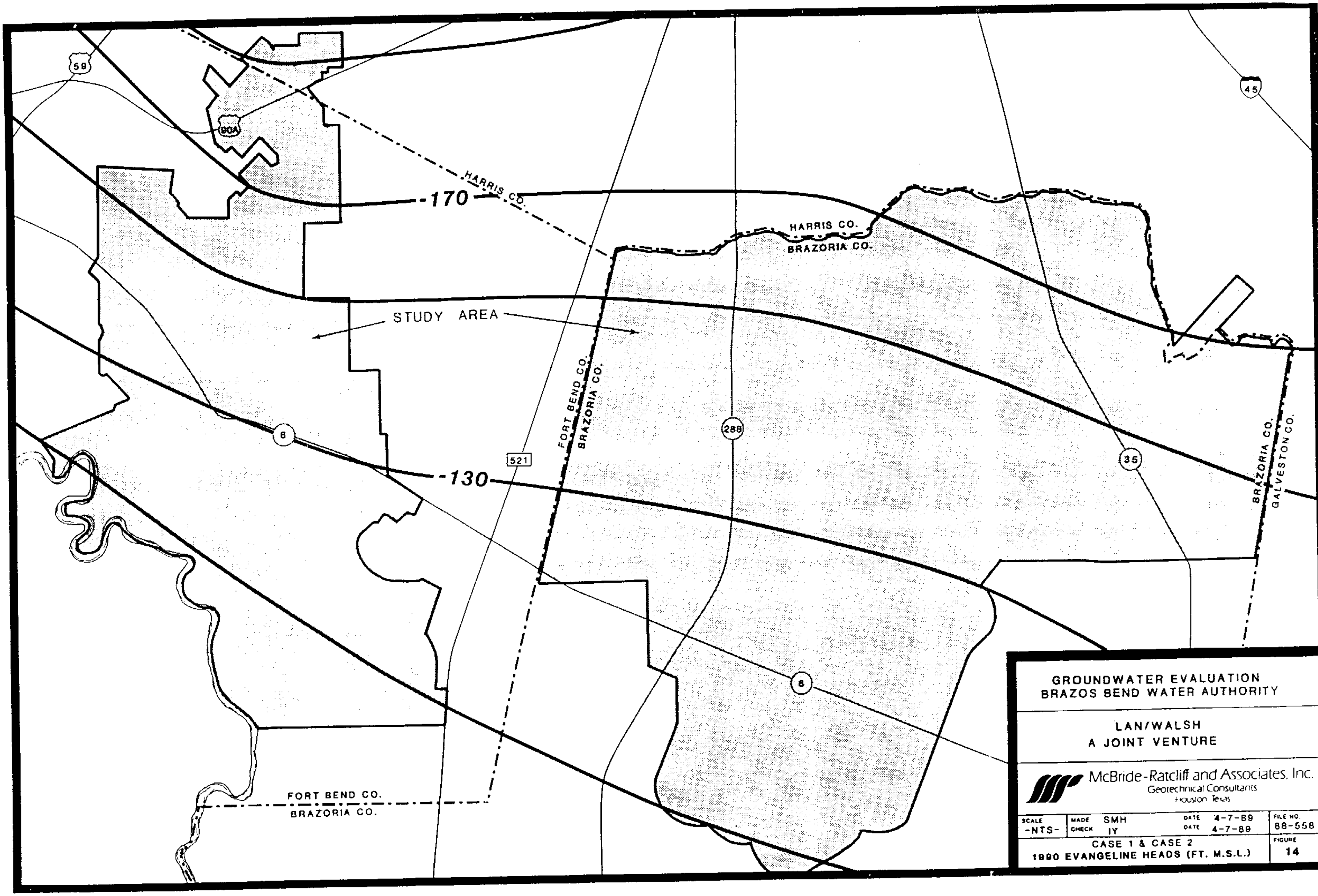
SCALE -NTS-	MADE SMH CHECK IY	DATE 4-7-89 DATE 4-7-89	FILE NO. 88-558
CASE 1 2040 CHICOT HEADS (FT. M.S.L.)			FIGURE 13



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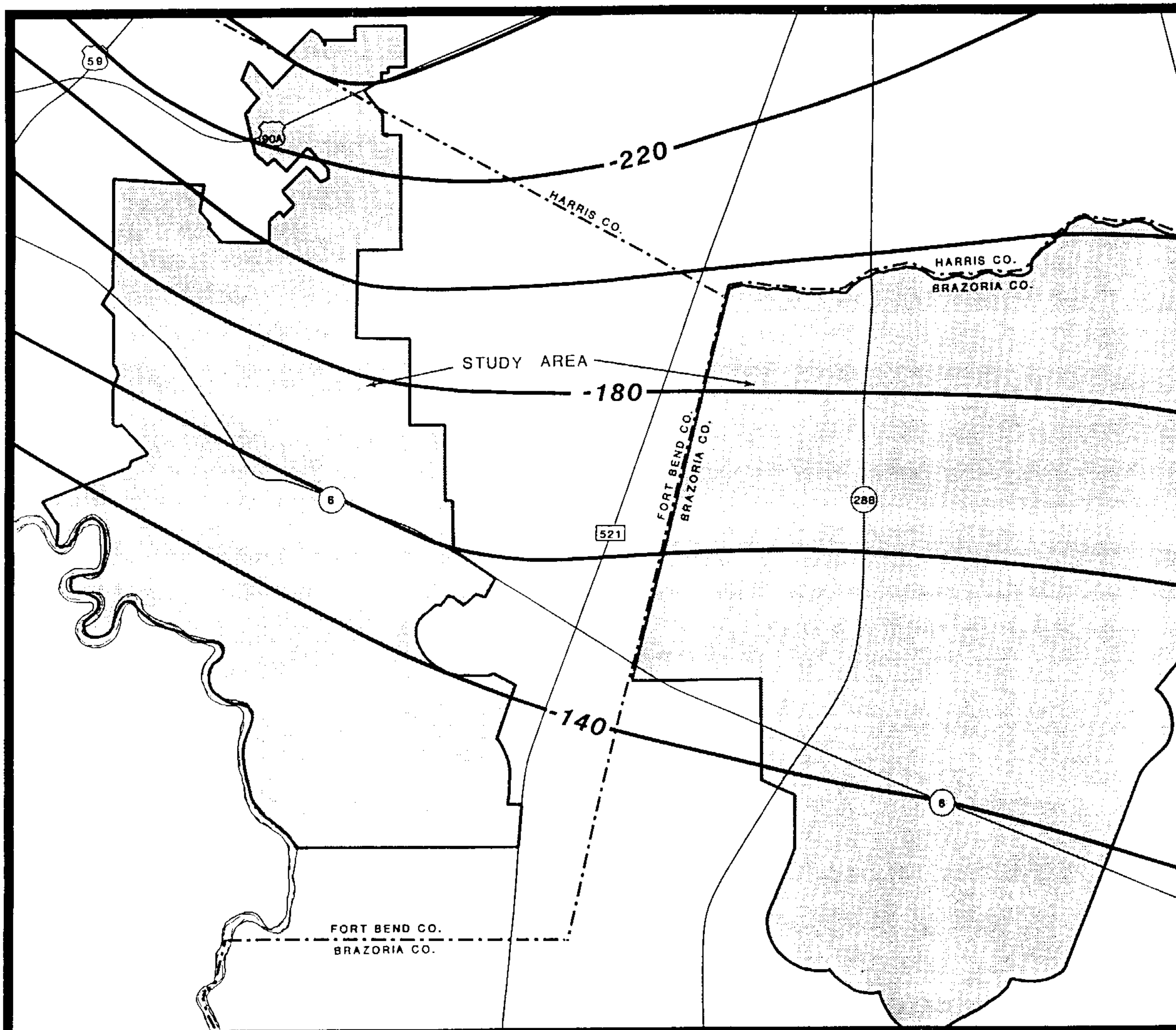
-NTS-	CHECK	IY	DATE	4-7-89	
CASE 1 & CASE 2					FIGURE
1990 EVANGELINE HEADS (FT. M.S.L.)					14



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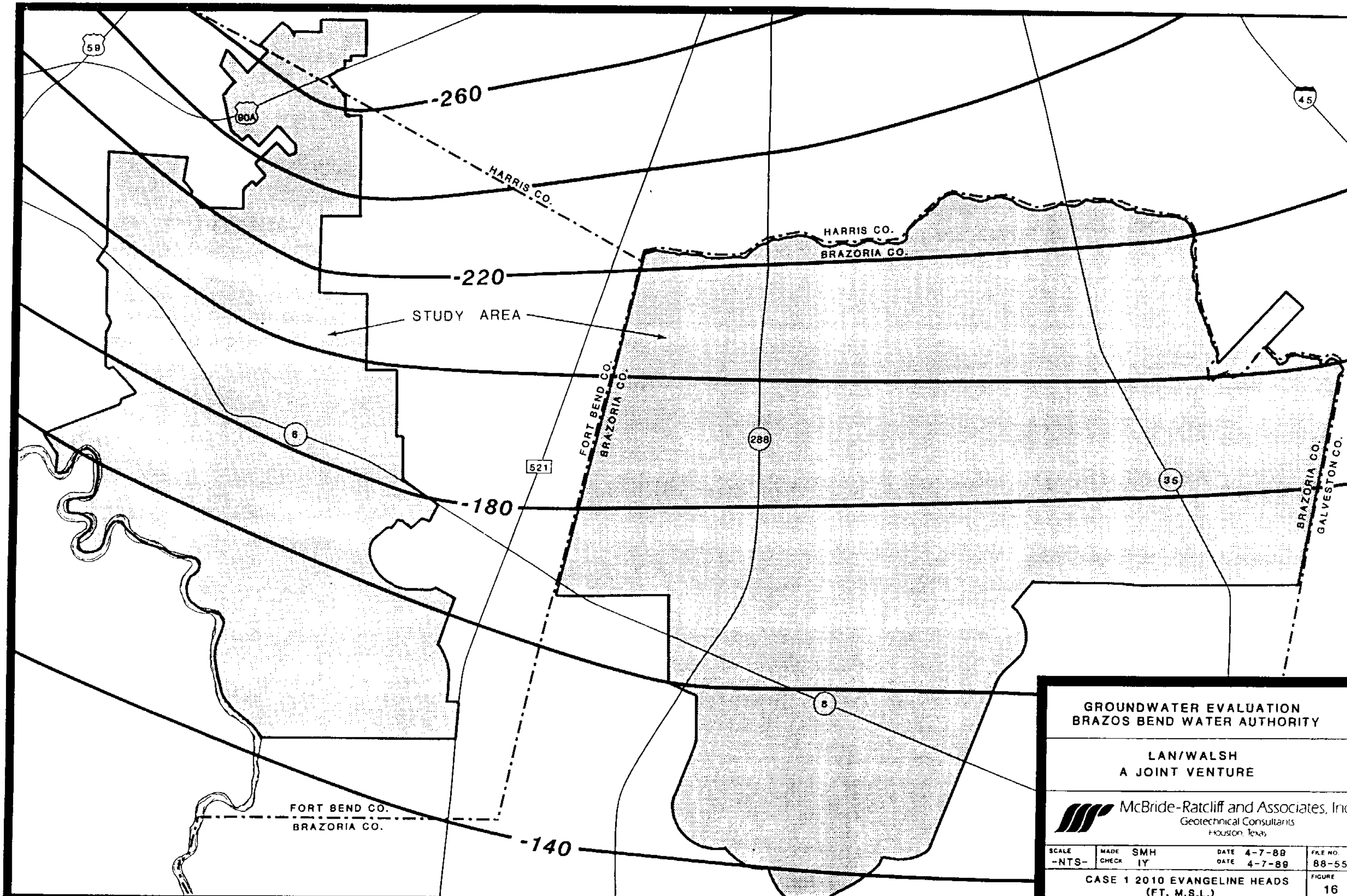
CASE 1 & CASE 2 2000 EVANGELINE HEADS (FT. M.S.L.)			FIGURE 15



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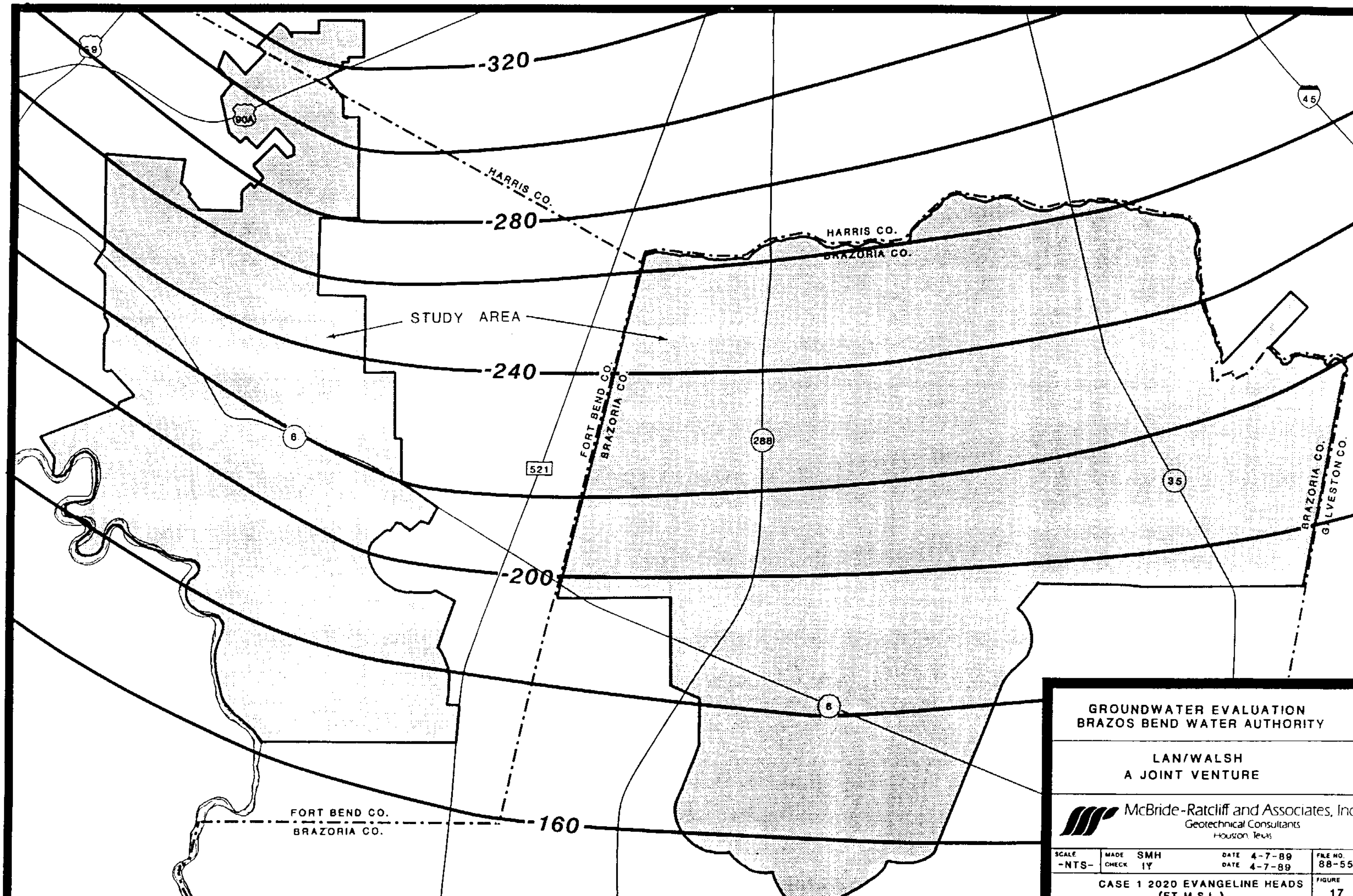
CASE 1 2010 EVANGELINE HEADS
(FT. M.S.L.)

FIGURE 16



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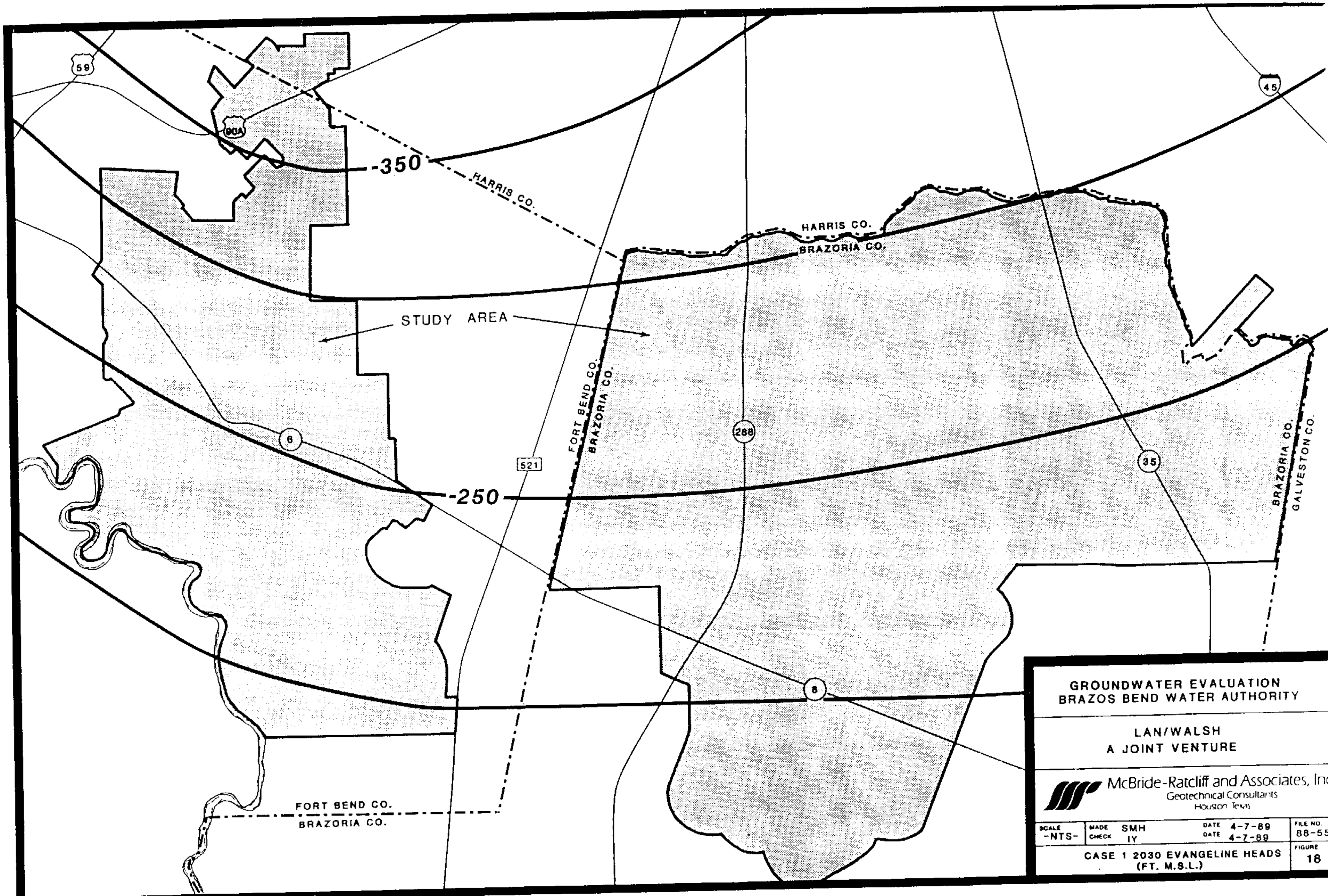
CASE 1 2020 EVANGELINE HEADS (FT M.S.L.) — FIGURE 17



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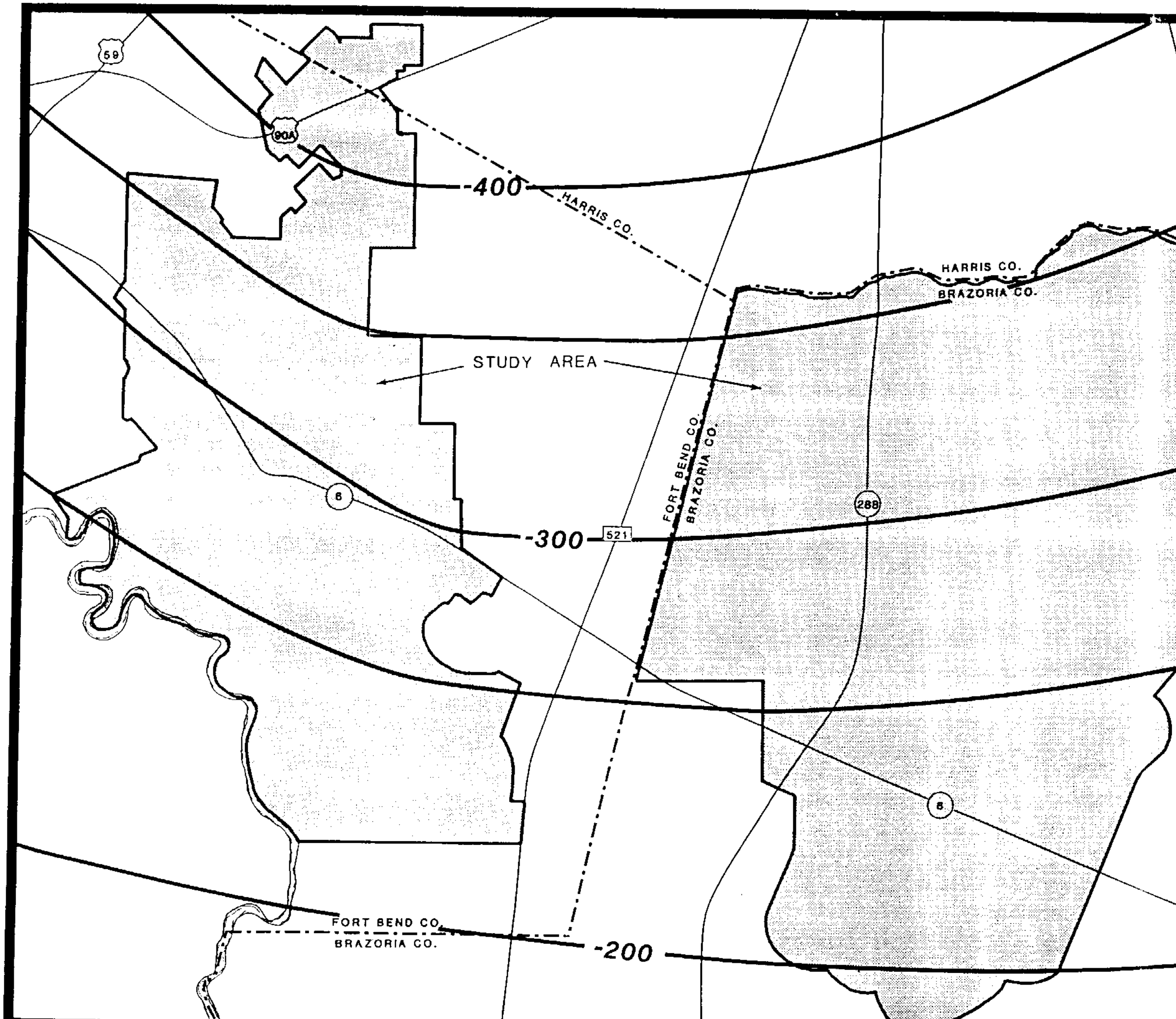
	CHECK	IY	DATE 4-7-89	

CASE 1 2030 EVANGELINE HEADS
(FT. M.S.L.)

FIGURE 18



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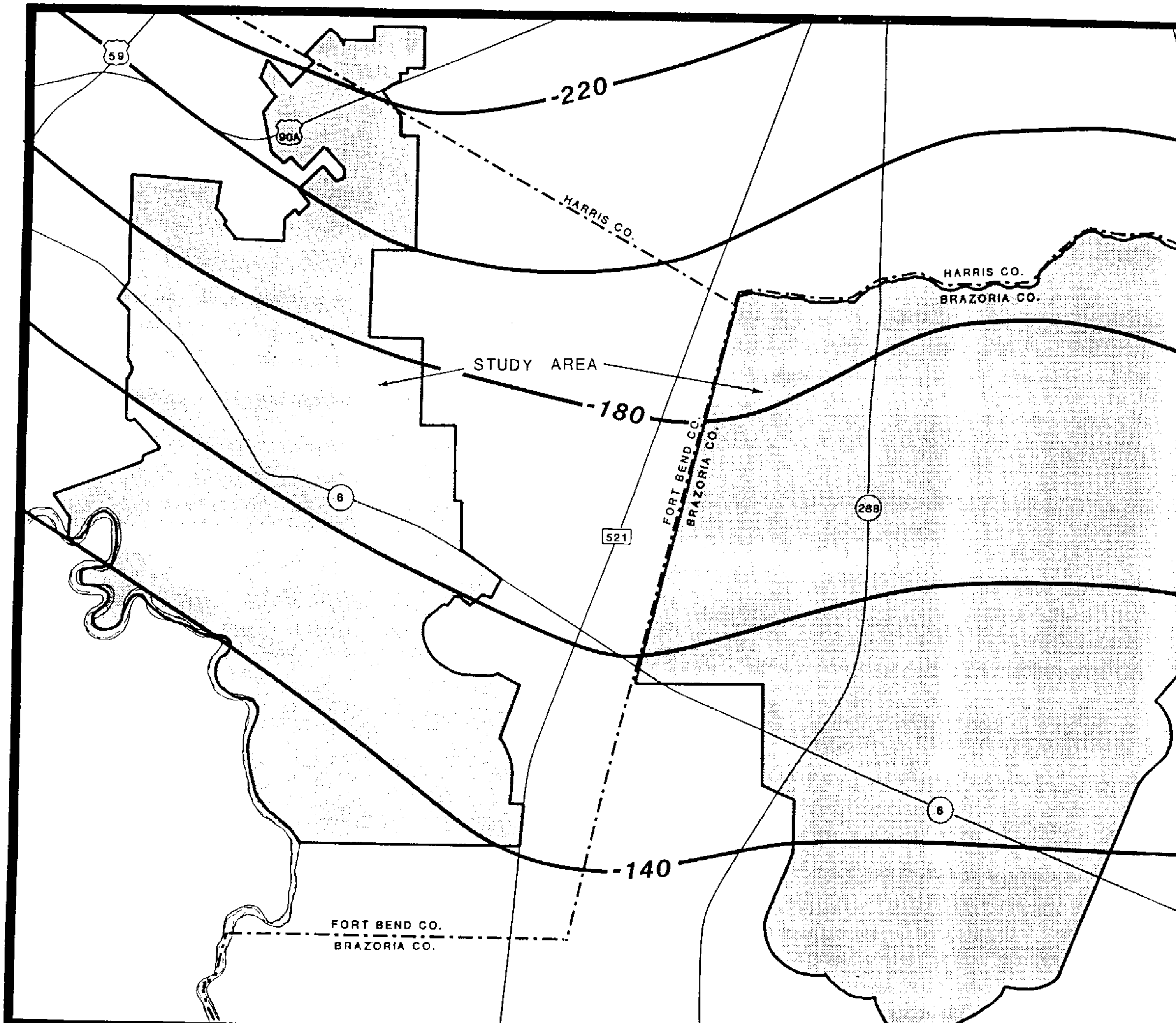
-NTS-	CHECK IY	DATE 4-7-89	88-55?

CASE 1 2040 EVANGELINE HEADS
(FT. M.S.L.)

FIGURE 19



GROUNDWATER EVALUATION BRAZOS BEND WATER AUTHORITY					
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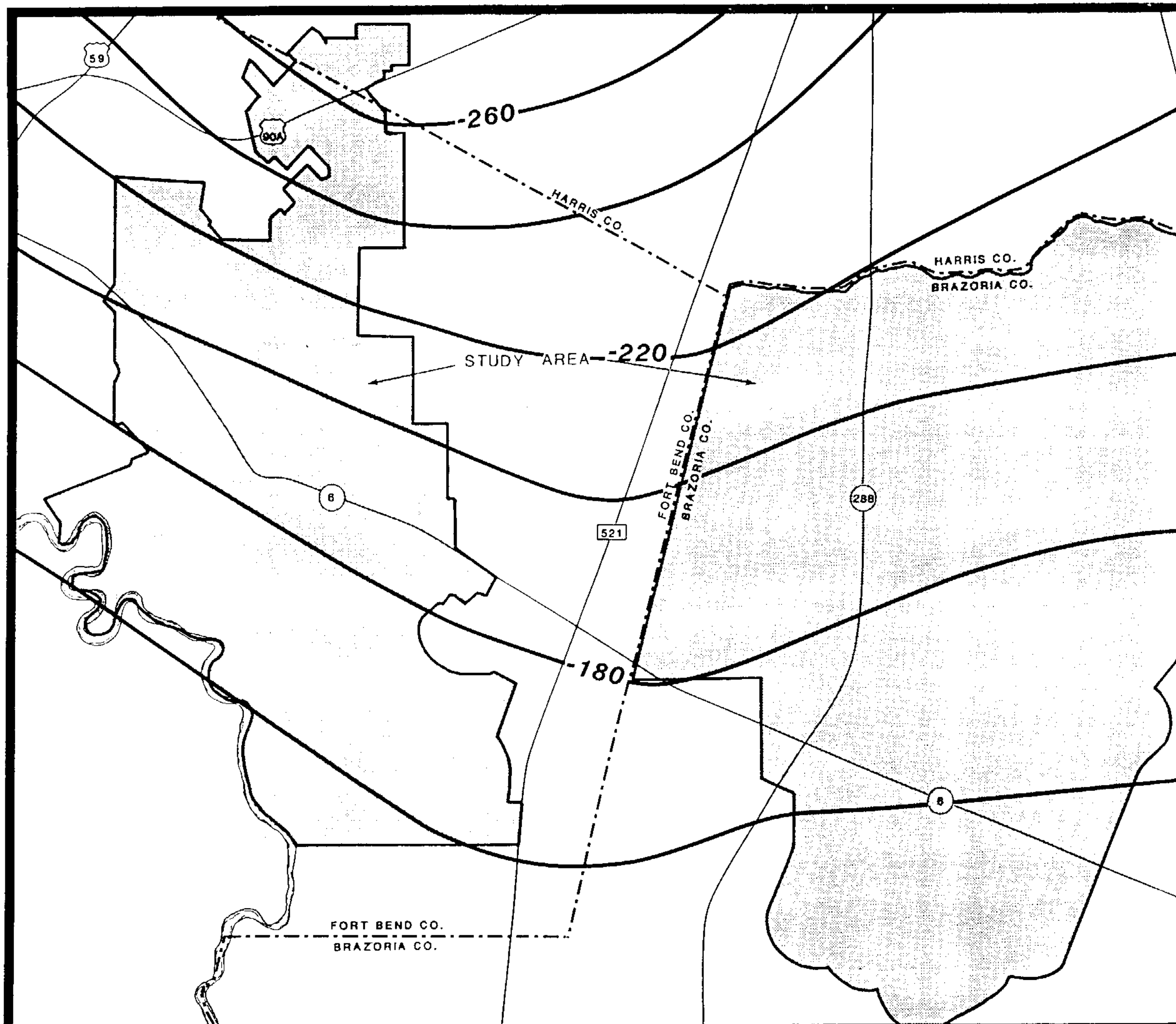
McBride-Ratcliff and Associates, Inc. Geotechnical Consultants Houston, Texas					
SCALE -NTS-	MADE SMH	DATE 4-7-89		FILE NO 88-558	
	CHECK IY	DATE 4-7-89			
CASE 2 2010 CHICOT HEADS (FT. M.S.L.)				FIGURE 20	



GROUNDWATER EVALUATION
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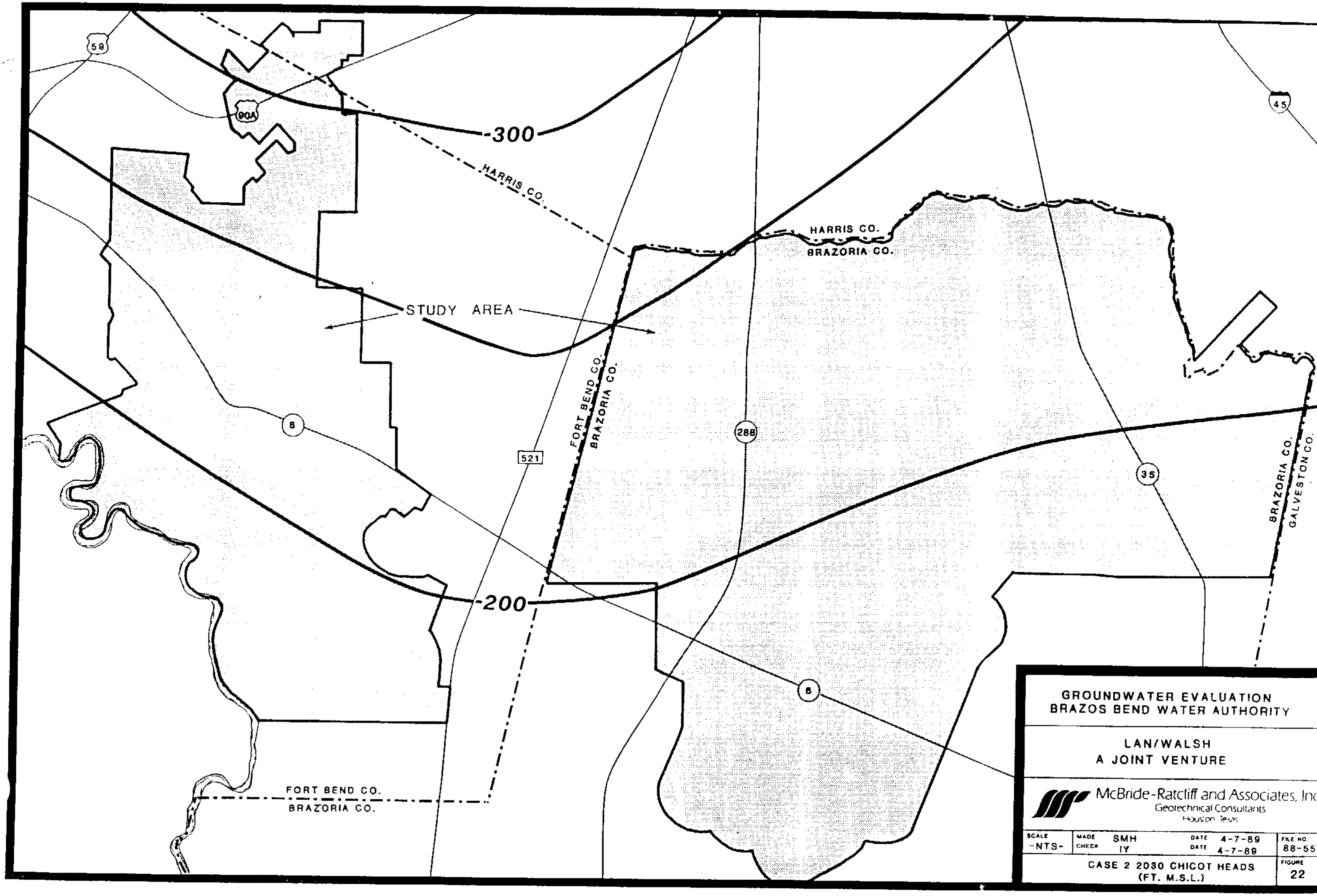
SCALE	MADE / CHECK	DATE	FILE NO
-NTS-	SMH / IY	4-7-89 / 4-7-89	88-558

CASE 2 2020 CHICOT HEADS
(FT. M.S.L.)

FIGURE 21



GROUNDWATER EVALUATION
BRAZOS BEND WATER AUTHORITY

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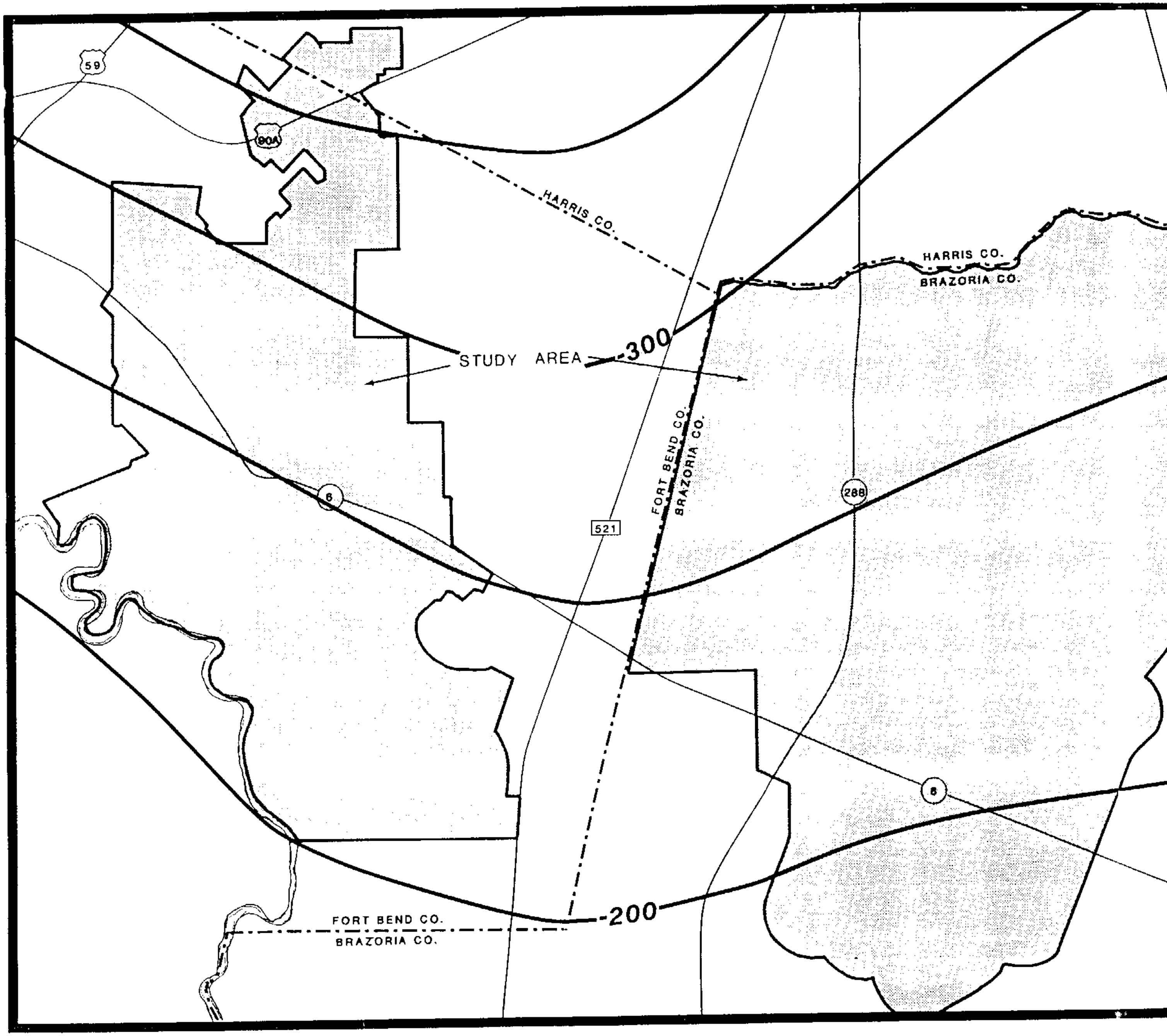
-NTS-	CHECK	IY	DATE	4-7-89	88-558

CASE 2 2030 CHICOT HEADS
(FT. M.S.L.)

FIGURE 22



GROUNDWATER EVALUATION
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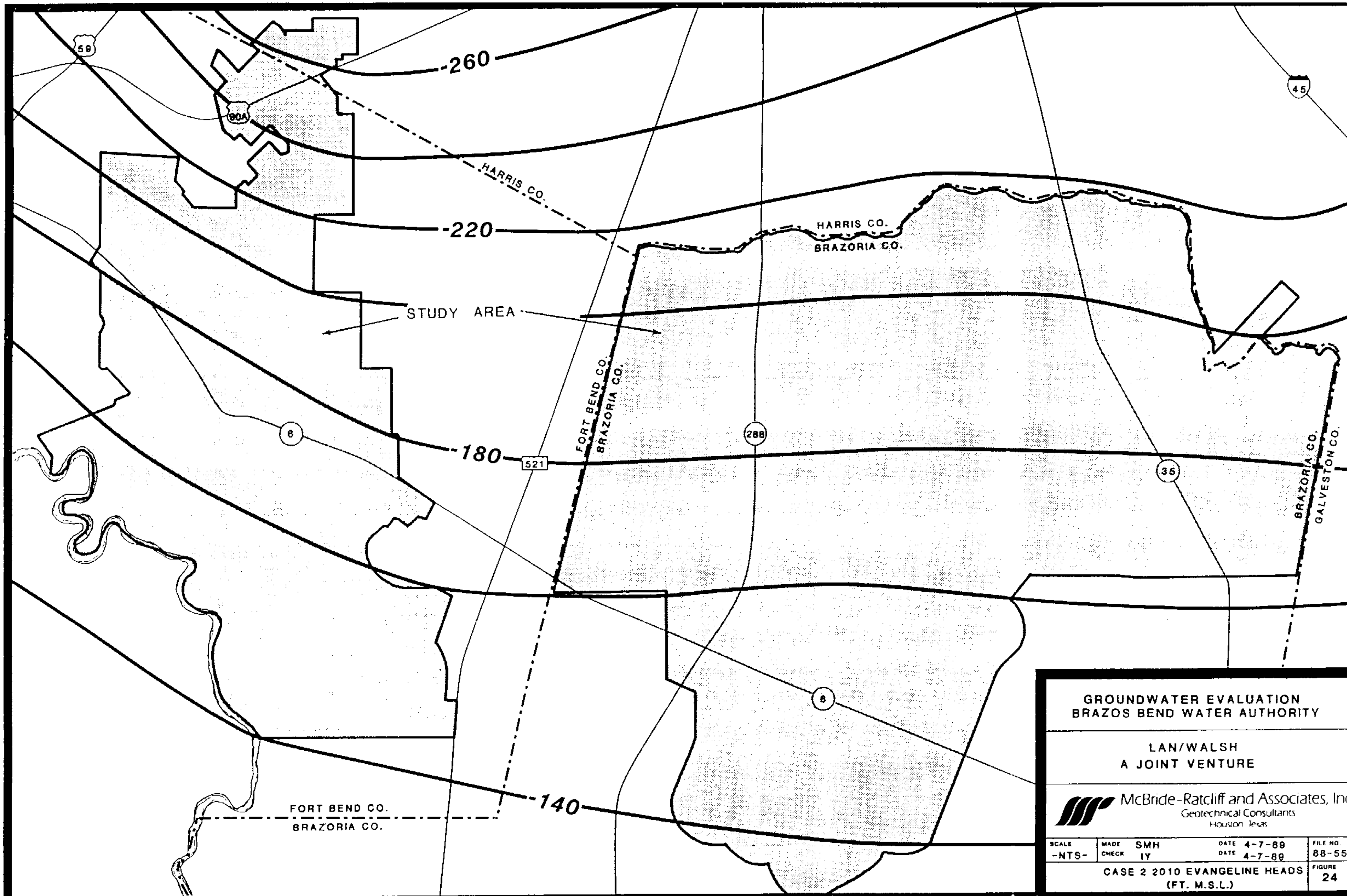
SCALE	MADE SMH	DATE 4-7-89	FILE N. 88-
-NTS-	CHECK IY	DATE 4-7-89	
	CASE 2 2040 CHICOT HEADS (FT. M.S.L.)		FIGURE 23



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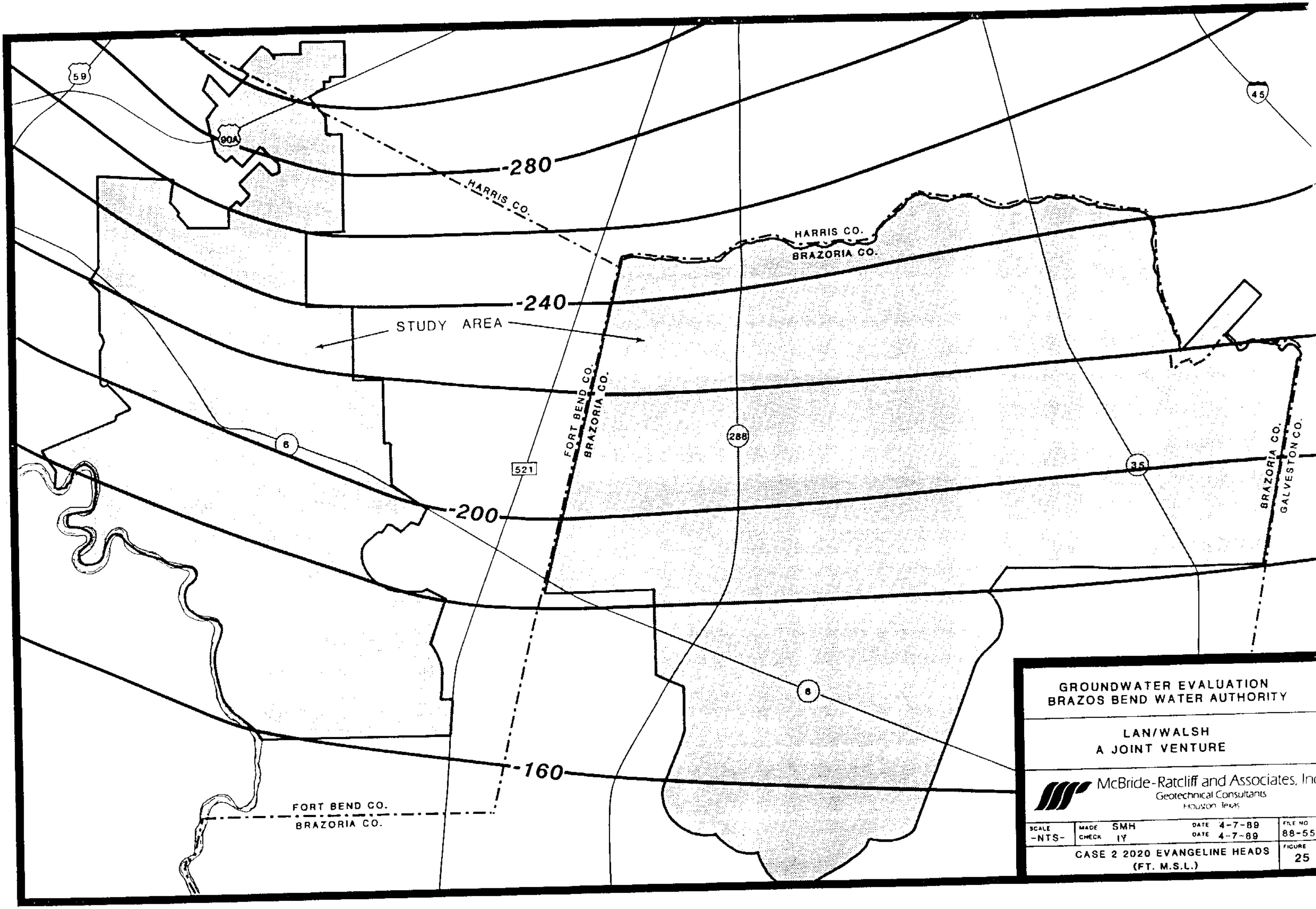
SCALE -NTS-	MADE SMH CHECK IY	DATE 4-7-89 DATE 4-7-89	FILE NO. 88-558
CASE 2 2010 EVANGELINE HEADS (FT. M.S.L.)			FIGURE 24



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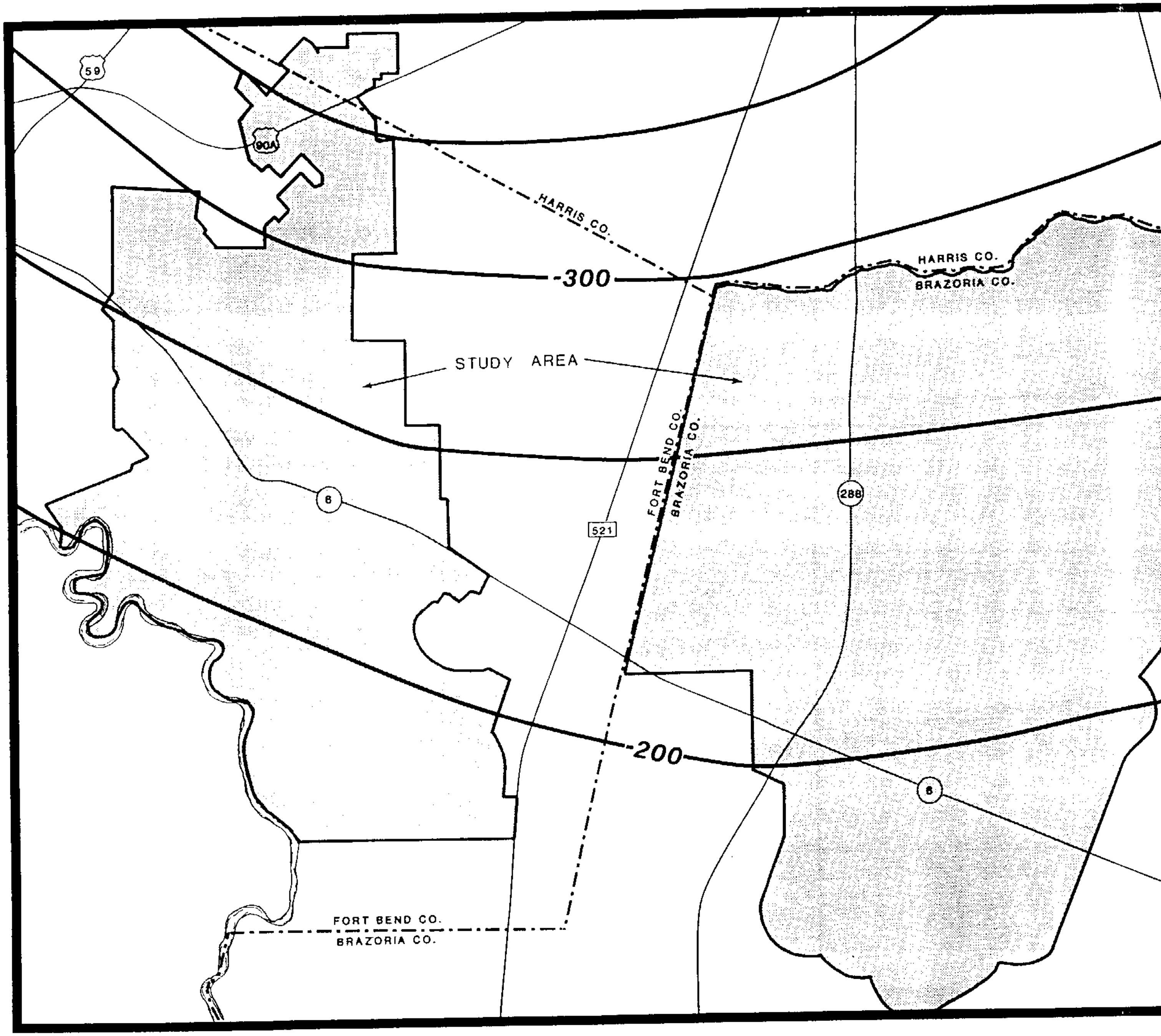
CASE 2 2020 EVANGELINE HEADS
(FT. M.S.L.)

FIGURE 25



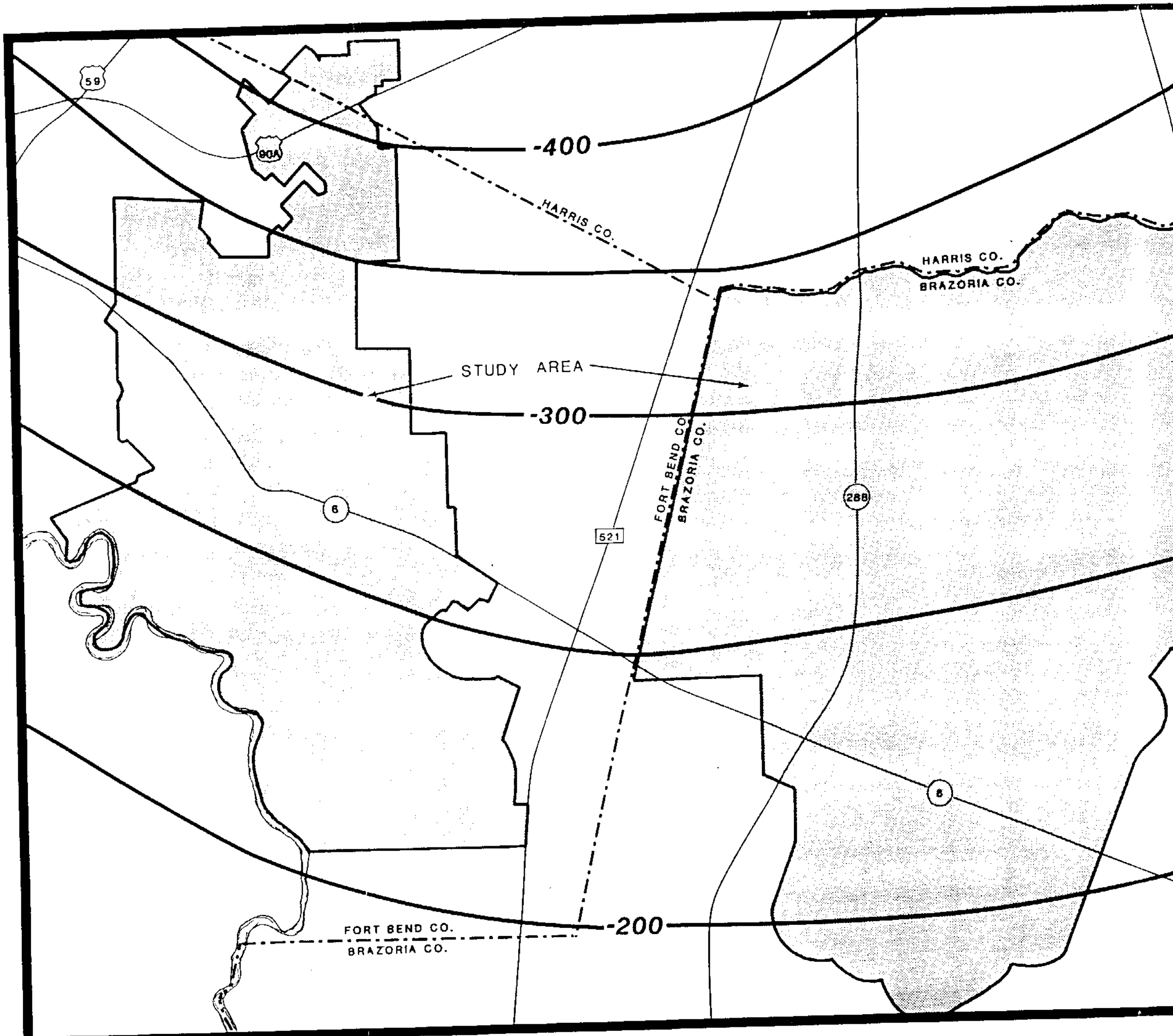
GROUNDWATER EVALUATION
BRAZOS BEND WATER AUTHORITY

LAN/WALSH
A JOINT VENTURE

McBride-Ratcliff and Associates, Inc.
Geotechnical Consultants
Houston Texas

SCALE	MADE / CHECK	DATE	FILE NO.
-NTS-	SMH / IY	4-7-89 / 4-7-89	88-5

CASE 2 2030 EVANGELINE HEADS (FT. M.S.L.) — FIGURE 26



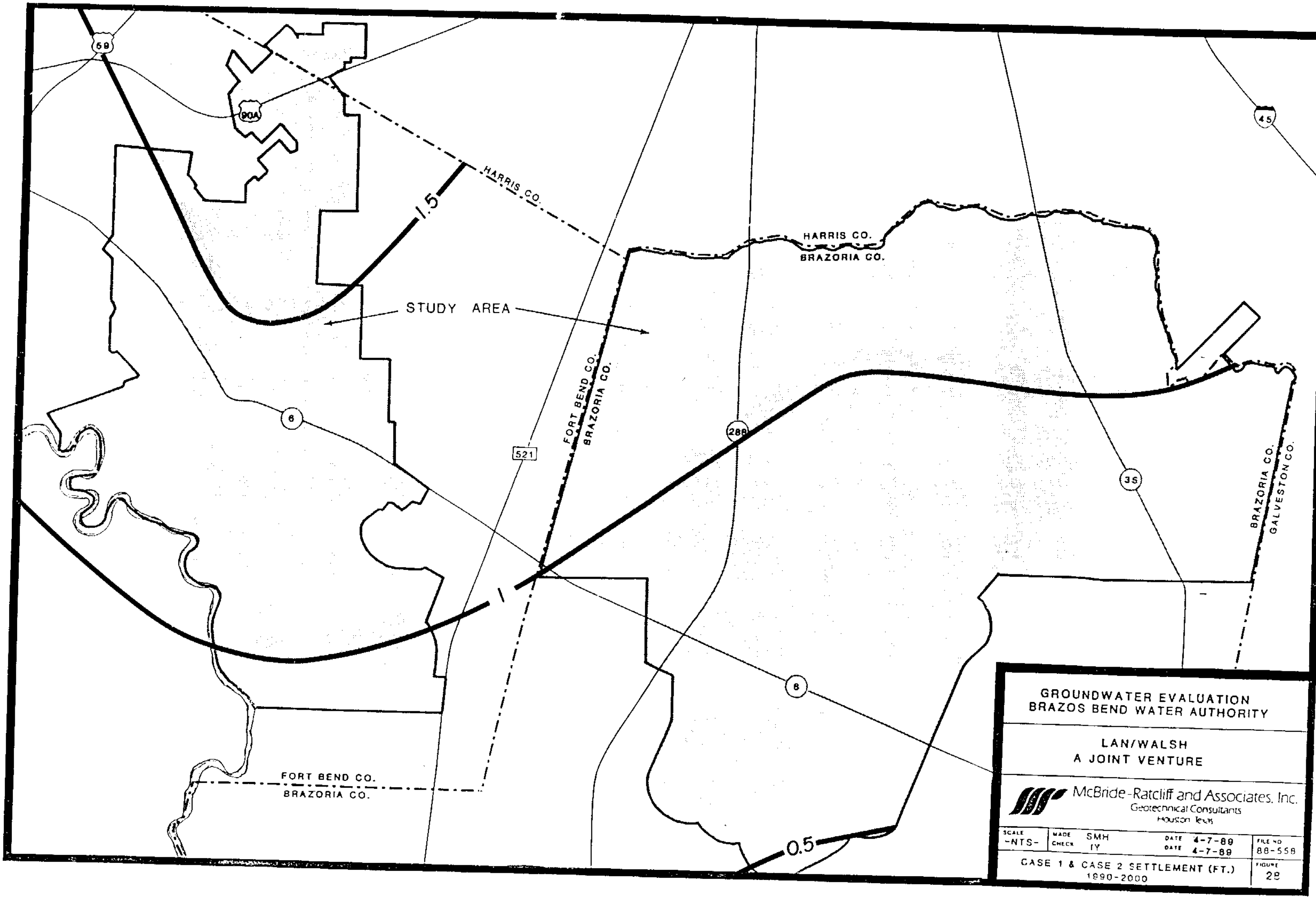
GROUNDWATER EVALUATION
BRAZOS BEND WATER AUTHORITY

LAN/WALSH
A JOINT VENTURE

McBride-Ratcliff and Associates, Inc
Geotechnical Consultants
Houston Texas

SCALE	MADE	DATE	FILE NO
-NTS-	SMH	4-7-89	88-558
	CHECK IY	DATE 4-7-89	FIGURE 27

CASE 2 2040 EVANGELINE HEADS
(FT. M.S.L.)



GROUNDWATER EVALUATION
BRAZOS BEND WATER AUTHORITY

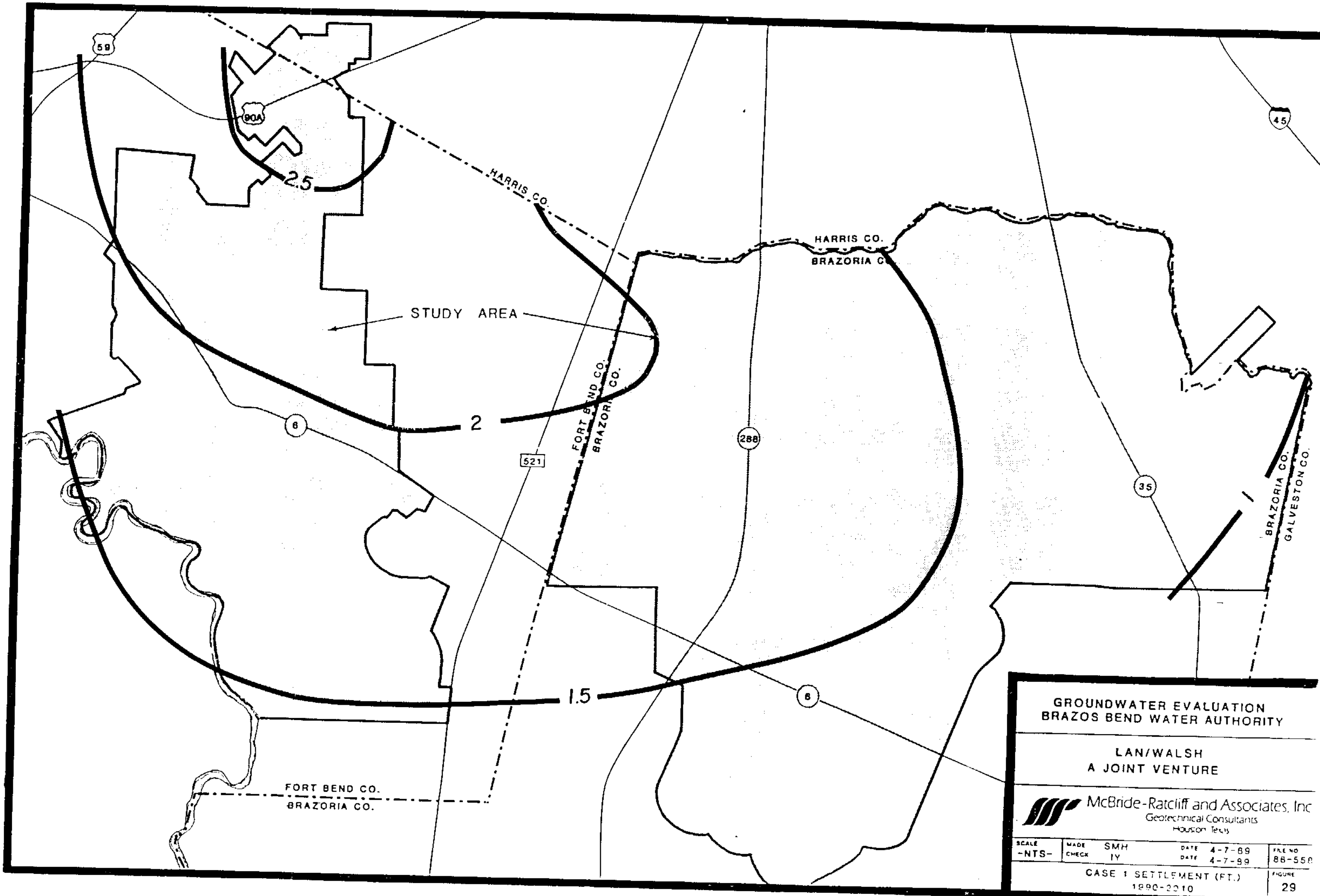
LAN/WALSH
A JOINT VENTURE

McBride-Ratcliff and Associates, Inc.
Geotechnical Consultants
Houston Texas

SCALE	MADE / CHECK	DATE	FILE NO
-NTS-	MADE SMH CHECK IY	DATE 4-7-89 DATE 4-7-89	88-558

CASE 1 & CASE 2 SETTLEMENT (FT.)
1990-2000

FIGURE 2B



GROUNDWATER EVALUATION
BRAZOS BEND WATER AUTHORITY

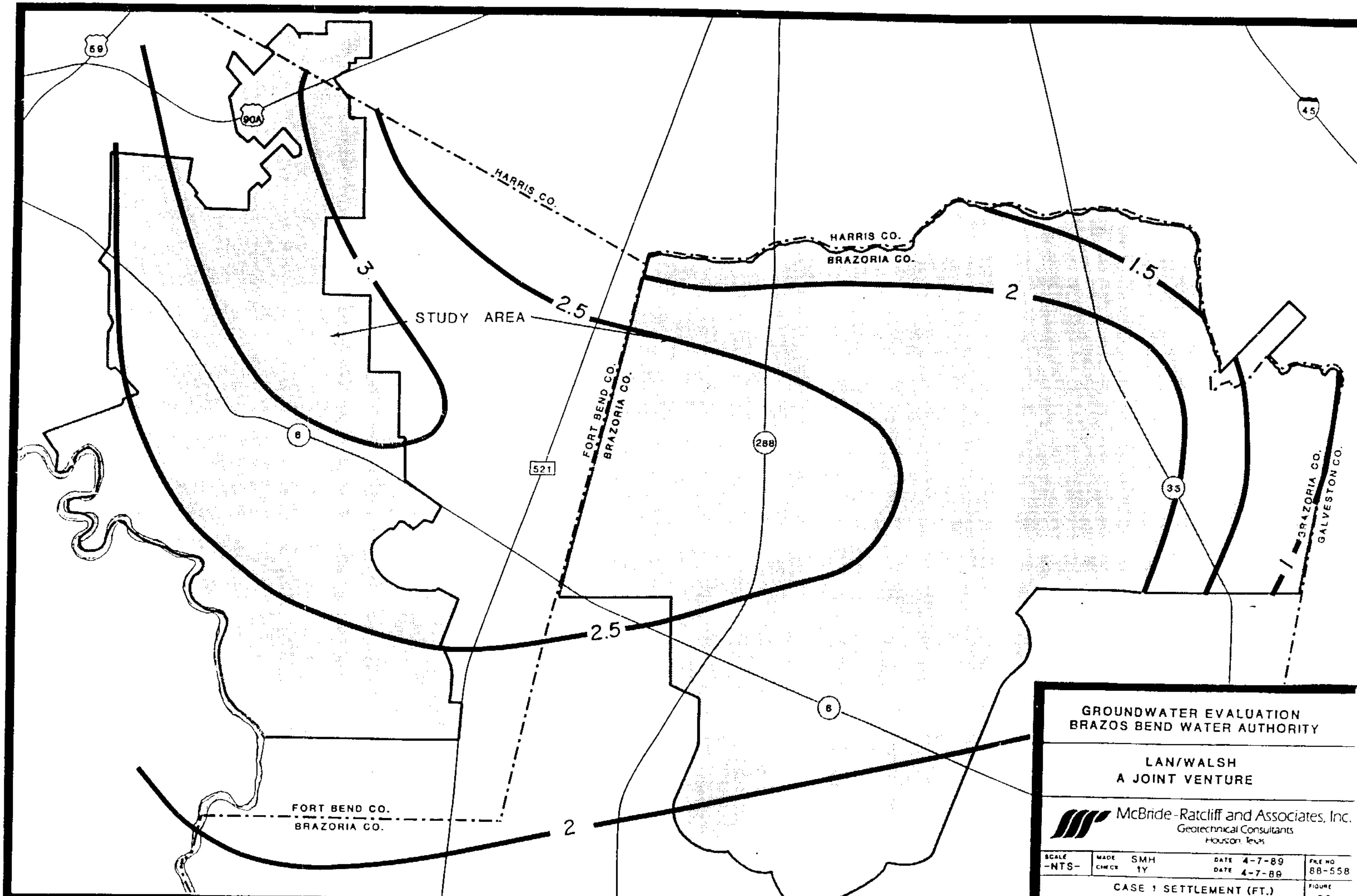
LAN/WALSH
A JOINT VENTURE

McBride-Ratcliff and Associates, Inc
Geotechnical Consultants
Houston Texas

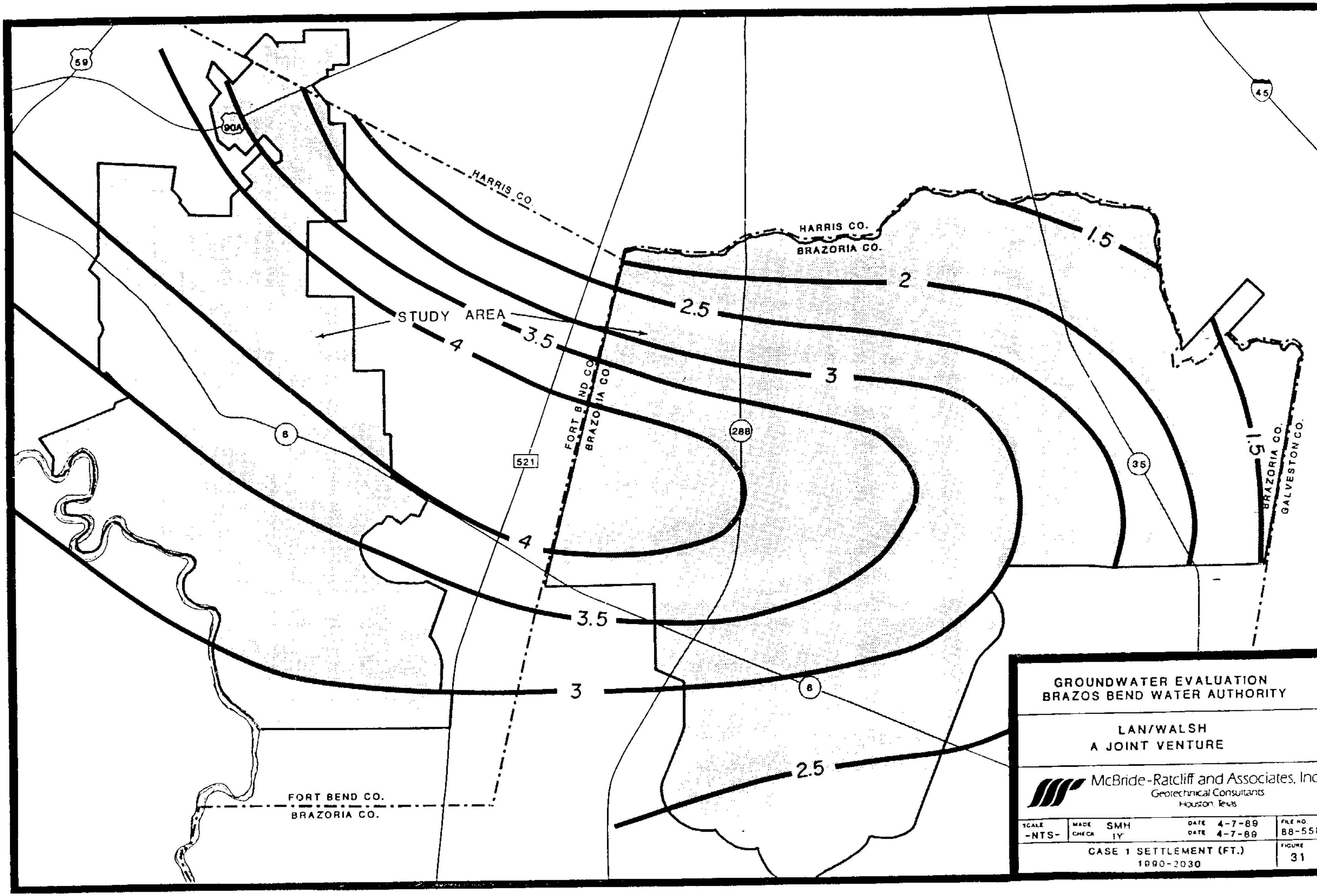
SCALE	MADE / CHECK		DATE		FILE NO
-NTS-	MADE	SMH	DATE	4-7-89	86-558
	CHECK	IY	DATE	4-7-89	

CASE 1 SETTLEMENT (FT.)
1990-2010

FIGURE 29



GROUNDWATER EVALUATION BRAZOS BEND WATER AUTHORITY			
LAN/WALSH A JOINT VENTURE			
McBride-Ratcliff and Associates, Inc. Geotechnical Consultants Houston, Texas			
SCALE -NTS-	MADE SMH CHECK 1Y	DATE 4-7-89 DATE 4-7-89	FILE NO 88-558
CASE 1 SETTLEMENT (FT.) 1990-2020			FIGURE 30



GROUNDWATER EVALUATION
BRAZOS BEND WATER AUTHORITY

LAN/WALSH
A JOINT VENTURE

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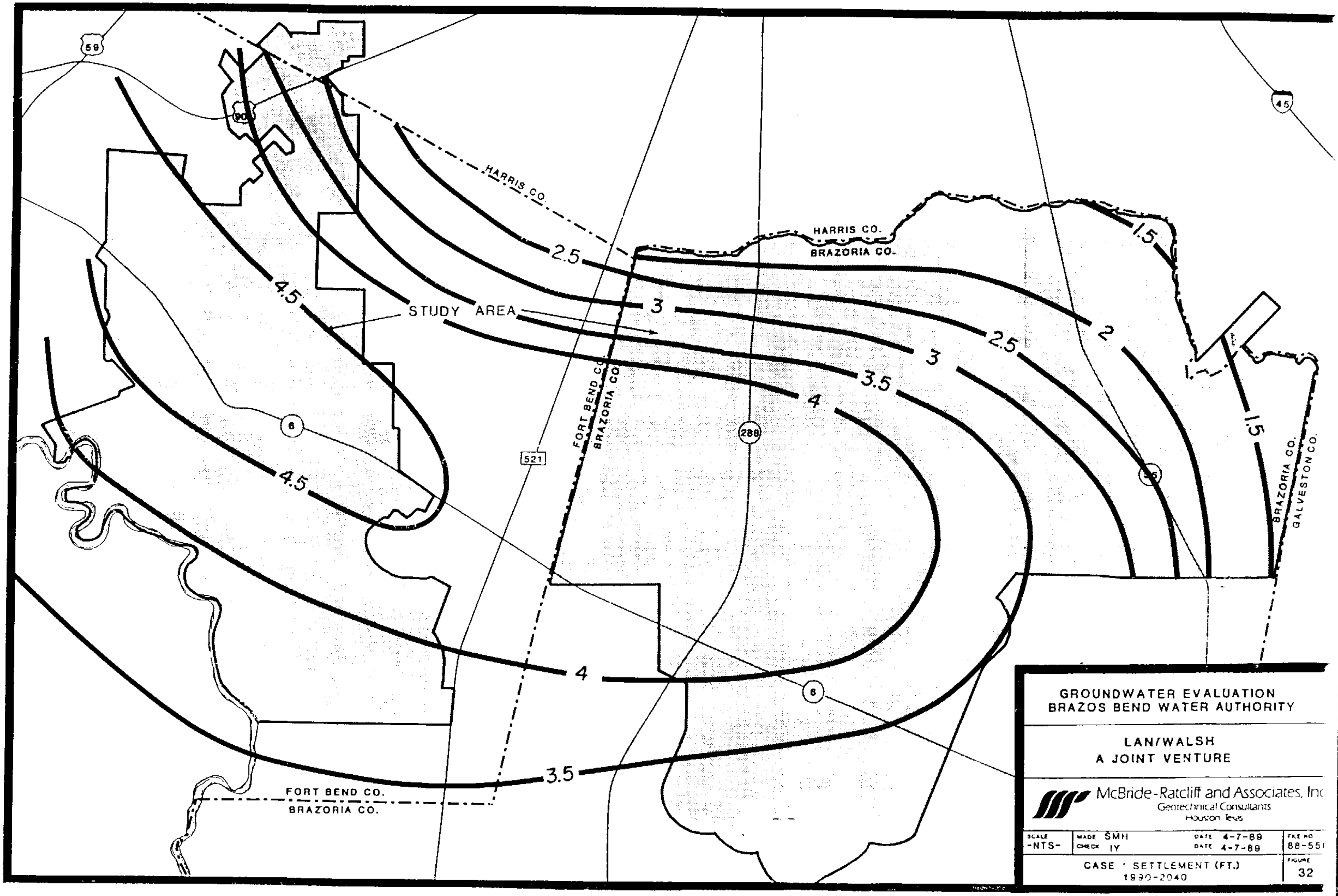
Geotechnical Consultants
Houston, Texas

SCALE	MADE	SMH	DATE	4-7-89	FILE NO.
-NTS-	CHECK	IY	DATE	4-7-89	88-558

CASE 1 SETTLEMENT (FT.)
1990-2030

FIGURE 31



GROUNDWATER EVALUATION
BRAZOS BEND WATER AUTHORITY

LAN/WALSH
A JOINT VENTURE

McBride-Ratcliff and Associates, Inc
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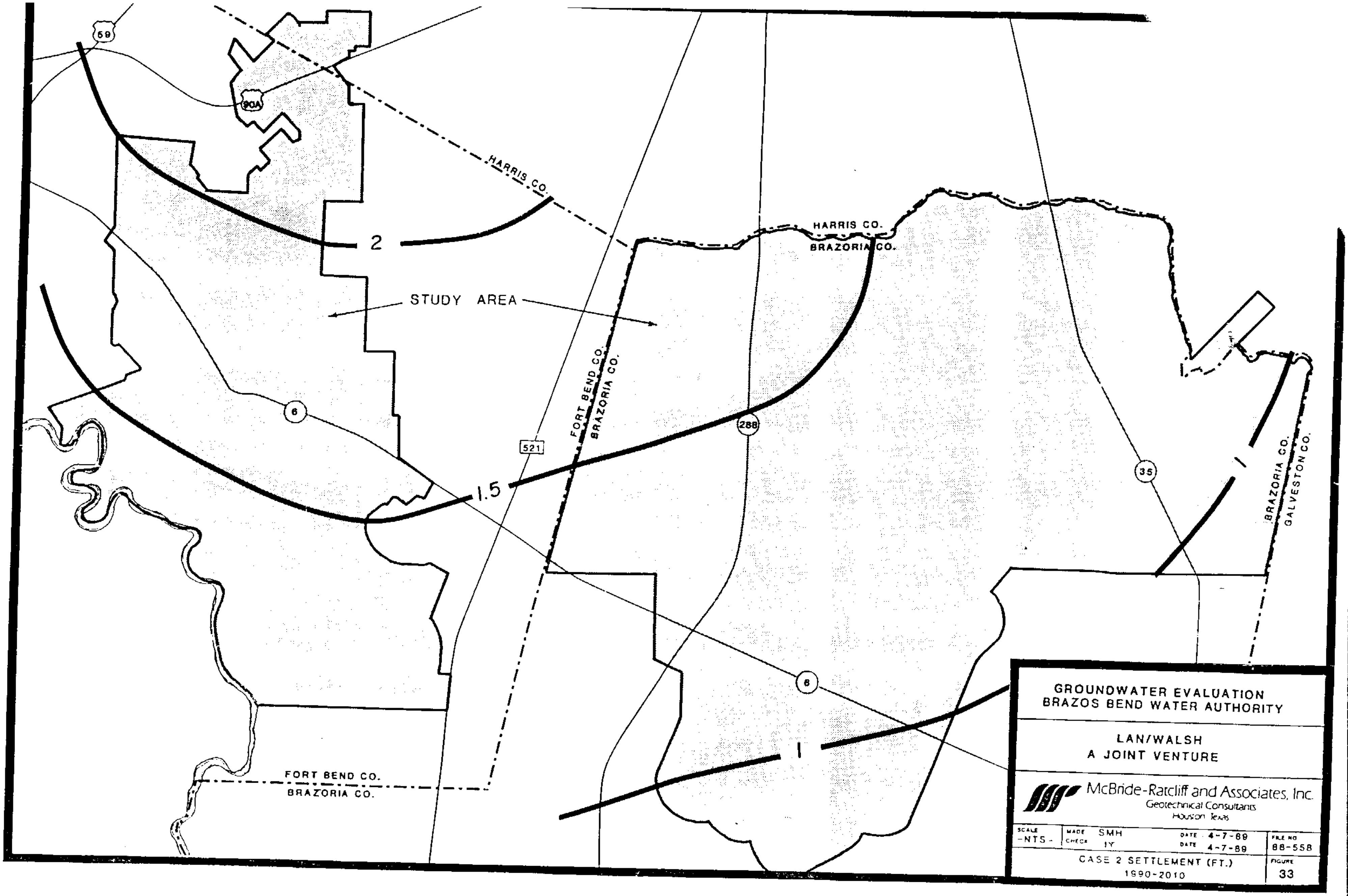
Houston Texas

SCALE -NTS-	MADE SMH CHECK IY	DATE 4-7-89 DATE 4-7-89	FILE NO 88-551

CASE [illegible] SETTLEMENT (FT.)
1990-2040

FIGURE 32



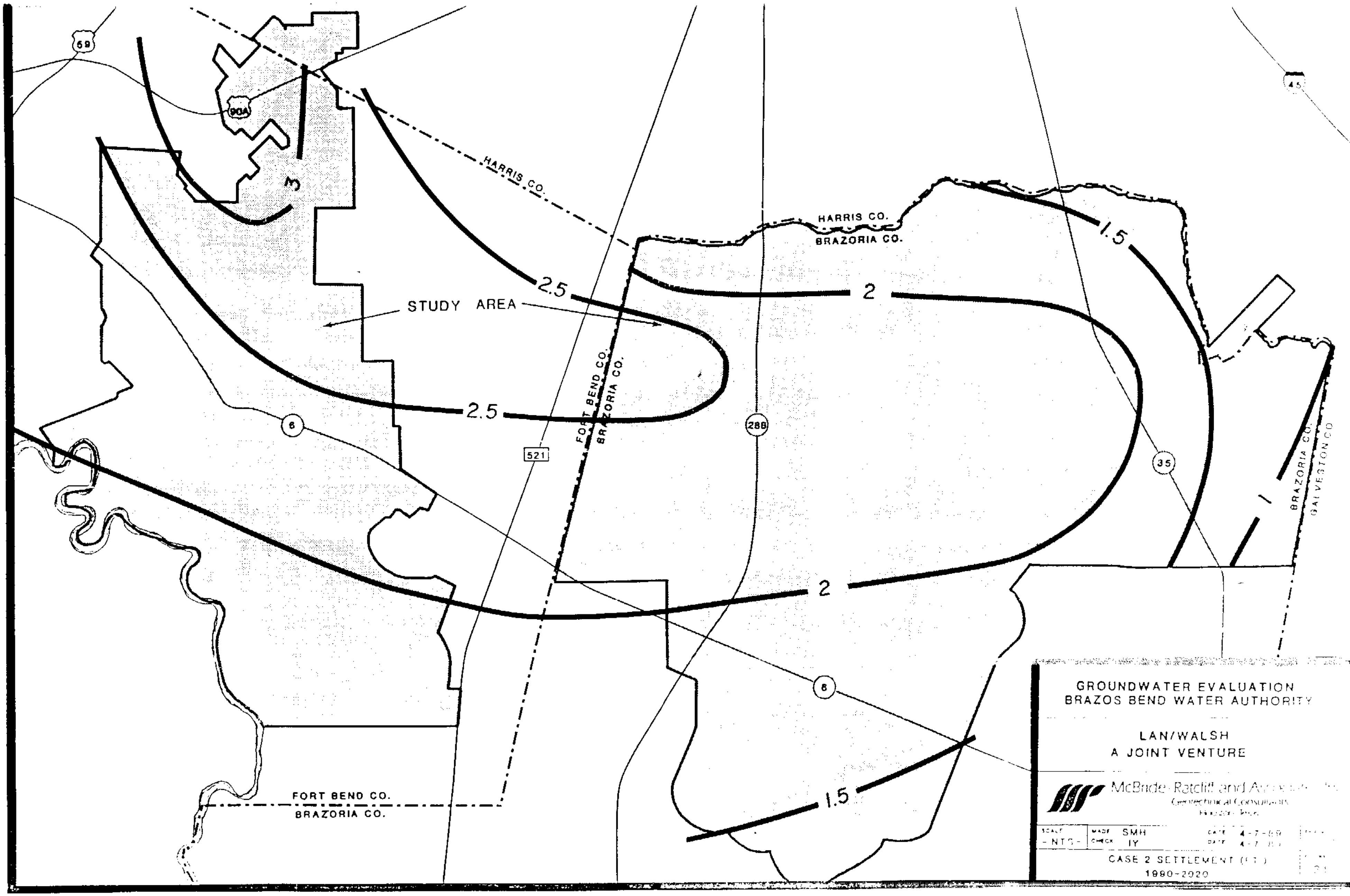
GROUNDWATER EVALUATION
BRAZOS BEND WATER AUTHORITY

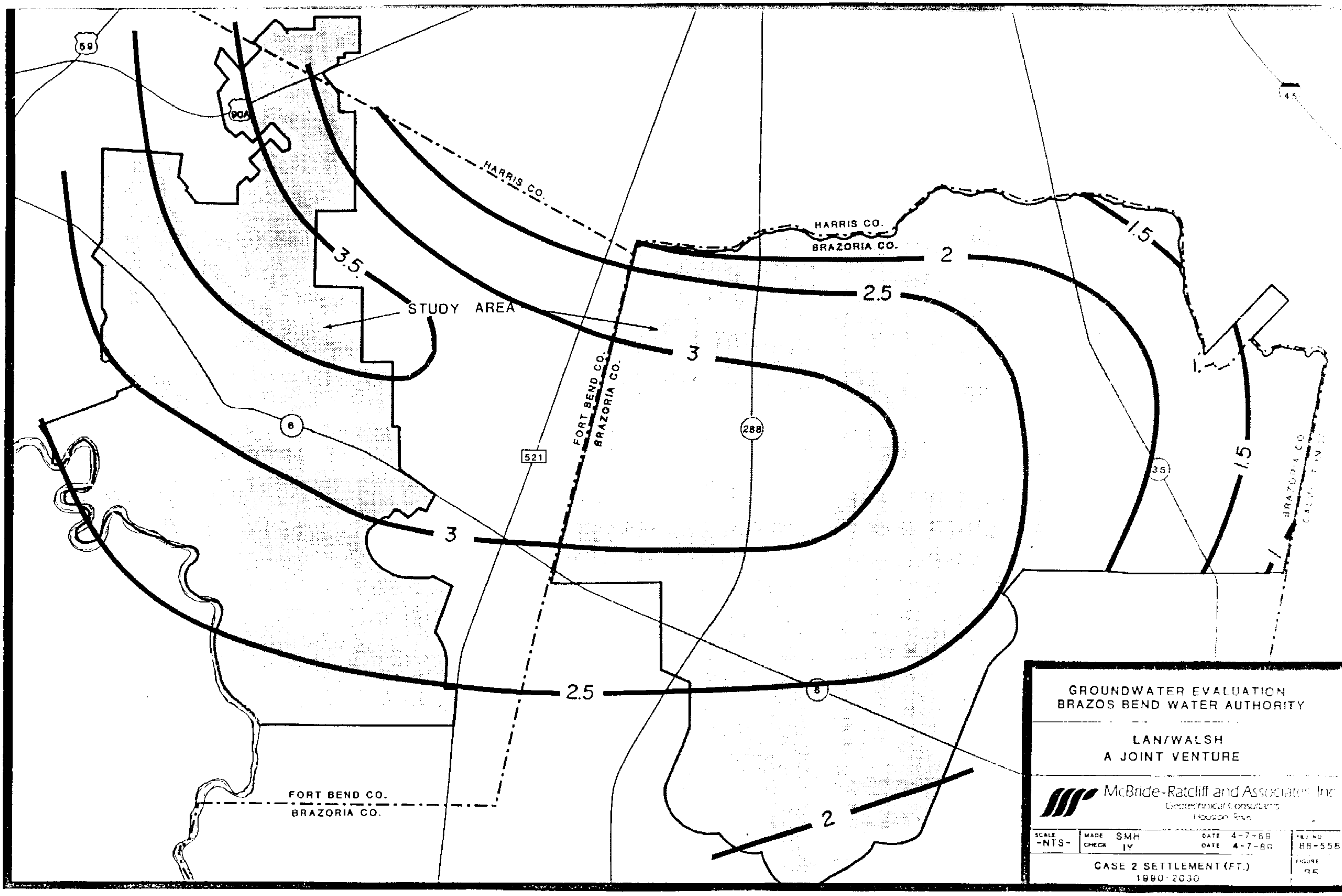
LAN/WALSH
A JOINT VENTURE

McBride-Ratcliff and Associates, Inc.
Geotechnical Consultants
Houston Texas

SCALE	MADE SMH	DATE 4-7-89	FILE NO
-NTS-	CHECK IY	DATE 4-7-89	88-558

CASE 2 SETTLEMENT (FT.) 1990-2010	FIGURE 33


59
90A
3
HARRIS CO.
2.5
STUDY AREA
2.5
FORT BEND CO.
BRAZORIA CO.
521
6
288
HARRIS CO.
BRAZORIA CO.
2
1.5
35
2
BRAZORIA CO.
GALVESTON CO.
1
45
6
1.5
FORT BEND CO.
BRAZORIA CO.
GROUNDWATER EVALUATION
BRAZOS BEND WATER AUTHORITY
LAN/WALSH
A JOINT VENTURE
McBride-Ratcliff and Associates
Geotechnical Consultants
SCALE - NTS -
MADE SMH
CHECK IY
DATE 4-7-89
CASE 2 SETTLEMENT (FT.)
1990-2020



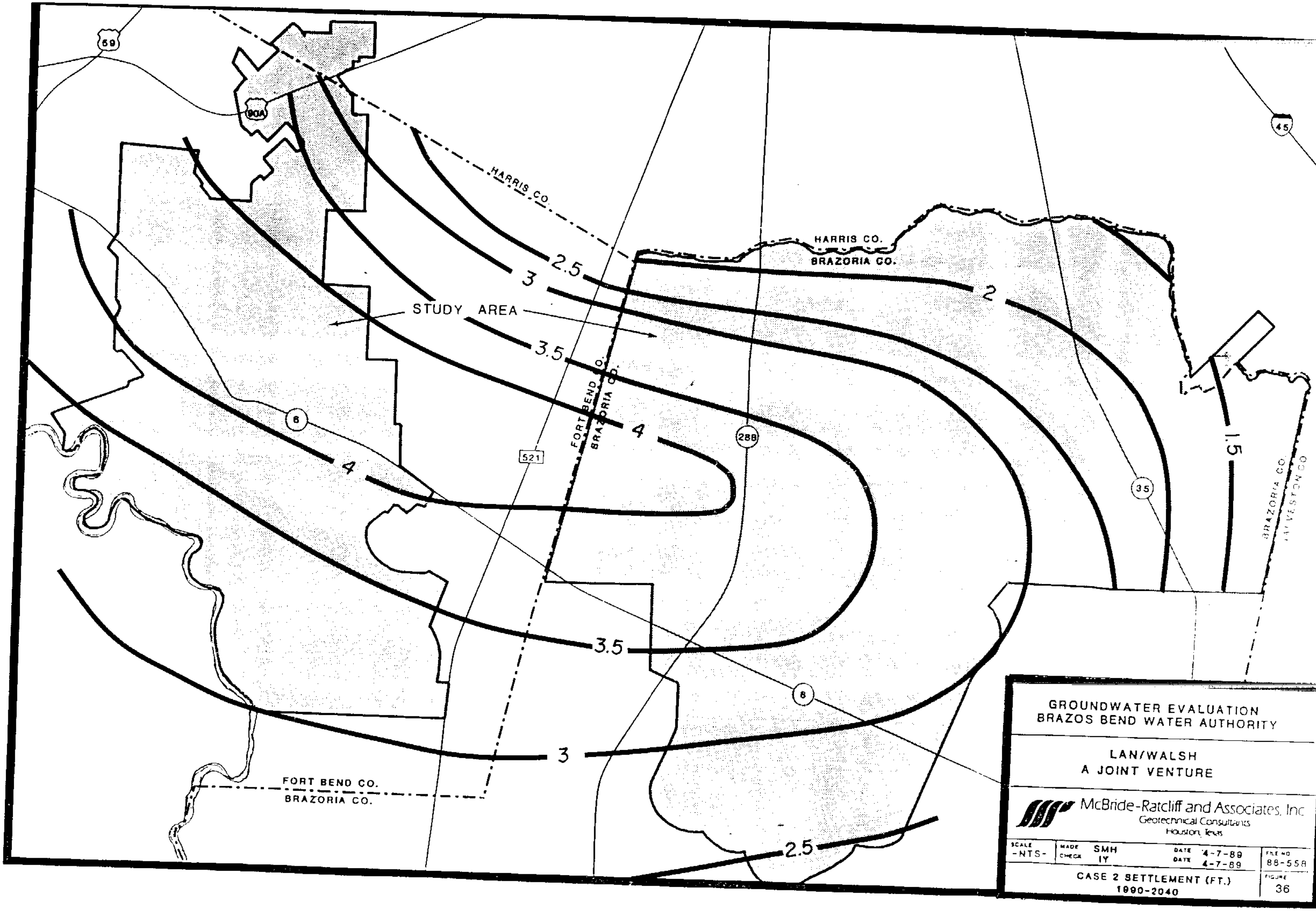
GROUNDWATER EVALUATION
BRAZOS BEND WATER AUTHORITY

LAN/WALSH
A JOINT VENTURE

McBride-Ratcliff and Associates Inc
Geotechnical Consultants
Houston, Texas

SCALE	MADE	SMH	DATE	4-7-69	JOB NO
-NTS-	CHECK	IY	DATE	4-7-69	88-558

CASE 2 SETTLEMENT (FT.)
1990-2030



GROUNDWATER EVALUATION
BRAZOS BEND WATER AUTHORITY

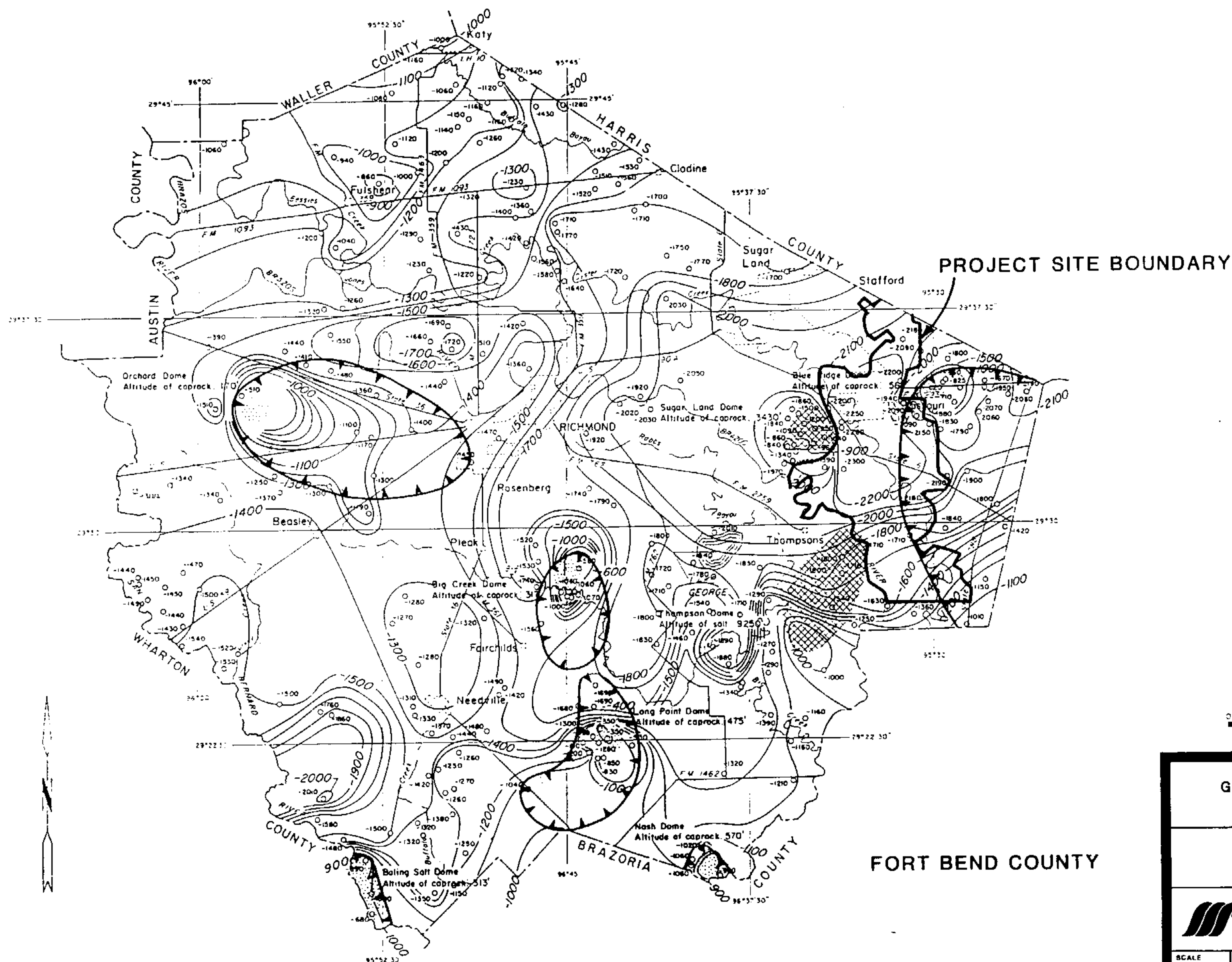
LAN/WALSH
A JOINT VENTURE

McBride-Ratcliff and Associates, Inc
Geotechnical Consultants
Houston, Texas

SCALE -NTS-	MADE SMH CHECK IY	DATE 4-7-89 DATE 4-7-89	FILE NO 88-558

CASE 2 SETTLEMENT (FT.)
1990-2040

FIGURE 36



Base from U.S. Geological Survey topographic quadrangles

EXPLANATION

Well used for control
Number indicates altitude of base of fresh water

-2000

Water-interface contour
Shows approximate altitude of base of fresh water
Contour interval 100 feet
Datum is mean sea level

(Piercement type) (Deep-seated)
Salt domes

Areas where intermediate sands in the Chicot aquifer contain water with more than 1000 milligrams per liter of dissolved solids

0 2 4 6 8 10 Miles

GROUNDWATER EVALUATION
BRAZOS BEND AUTHORITY

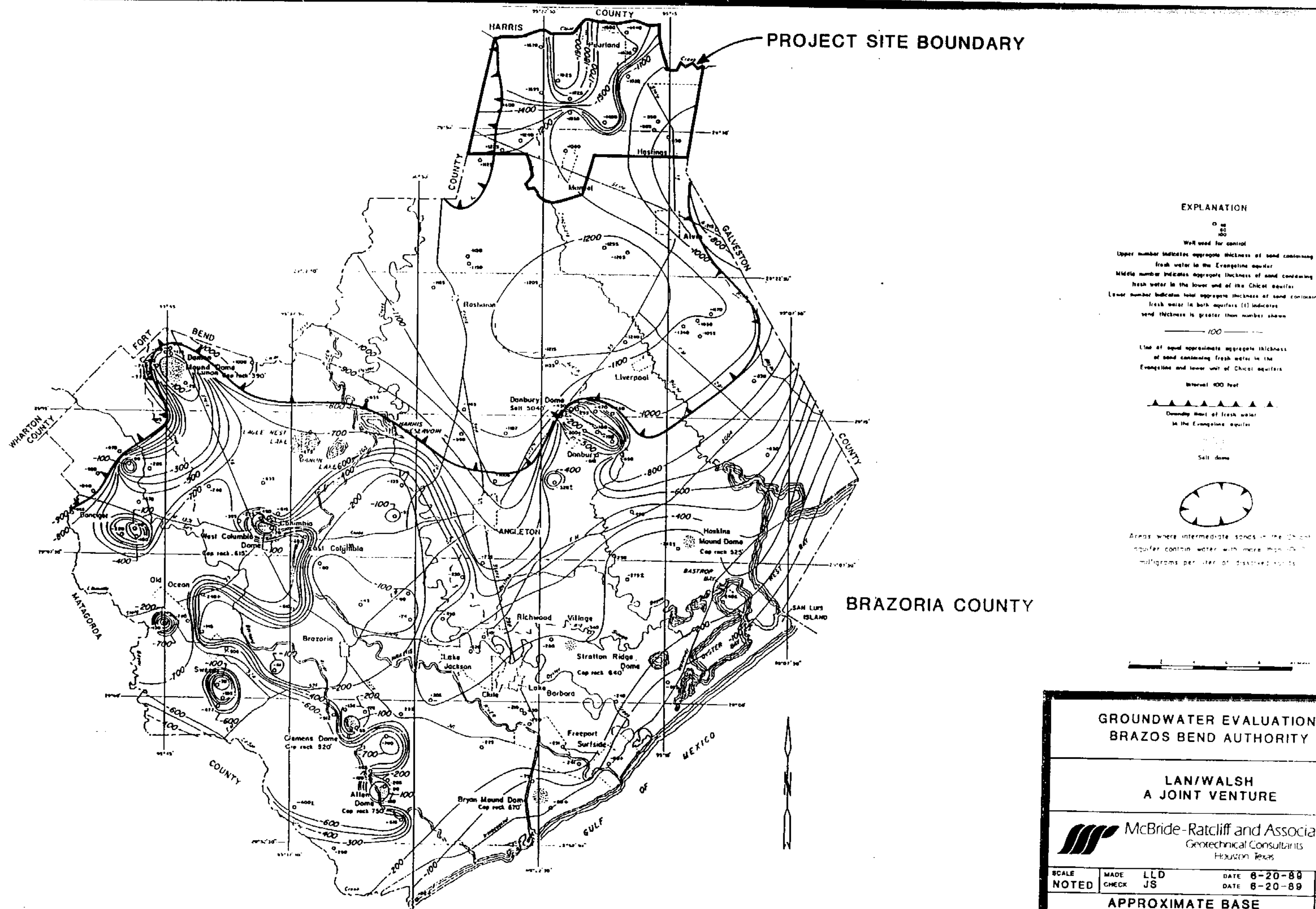
LAN/WALSH
A JOINT VENTURE

McBride-Ratcliff and Associates, Inc.
Geotechnical Consultants
Houston, Texas

SCALE	MADE	LLD	DATE	6-20-89	FILE NO.
NOTED	CHECK	JS	DATE	6-20-89	88-558

APPROXIMATE BASE OF FRESH WATER

FIGURE 37



GROUNDWATER EVALUATION
BRAZOS BEND AUTHORITY

LAN/WALSH
A JOINT VENTURE

McBride-Ratcliff and Associates, Inc.
Geotechnical Consultants
Houston, Texas

SCALE	MADE	LLD	DATE	6-20-89	FILE NO.
NOTED	CHECK	JS	DATE	6-20-89	88-558

APPROXIMATE BASE OF FRESH WATER

FIGURE 38

Appendix D

4--250

AN ACT

relating to the creation, administration, powers, duties, operations, functions, and financing of the Brazos Bend Water Authority.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF TEXAS:

SECTION 1. CREATION OF AUTHORITY; LIMITATION. Pursuant to Article XVI, Section 59, of the Texas Constitution and on approval at the confirmation election required by Section 6 of this Act, a conservation and reclamation district is created in Brazoria, Fort Bend, and Harris counties, to be known as the Brazos Bend Water Authority. The authority is a governmental agency and a body politic and corporate.

SECTION 2. DEFINITIONS. In this Act:

(1) "Authority" means the Brazos Bend Water Authority.

(2) "Board" means the board of directors of the authority.

(3) "Person" means an individual, corporation, organization, government or governmental subdivision or agency, business trust, estate, trust, partnership, joint venture, association, or any other legal entity.

SECTION 3. BOUNDARIES. The authority may be created to include the portion of the cities of Brookside Village, Manvel, Missouri City, and Pearland and the extraterritorial jurisdiction of each of those cities that is not located within the boundaries of the Brazoria County Conservation and Reclamation District No. 3.

SECTION 4. GENERAL POWERS AND DUTIES. (a) The authority may exercise all of the rights, powers, privileges, authority, and functions provided by Subchapter D, Chapter 51, Water Code, excluding Sections 51.121, 51.133, 51.143, 51.158, 51.161-51.165, 51.170-51.172, 51.184, 51.190, and 51.195. If any provisions of the laws cited in this subsection are in conflict or inconsistent with any provision of this Act, this Act prevails.

(b) The authority may acquire surface and underground water supplies from sources both inside and outside the boundaries of the authority and may conserve, store, transport, treat, purify, distribute, sell, and deliver water to persons, corporations, municipal corporations, political subdivisions of the state, and others, inside and outside the boundaries of the authority.

(c) The authority may build, construct, acquire by purchase, gift, or other manner, lease as lessor or lessee, improve, enlarge, extend, repair, maintain, or replace any improvements, facilities, works, contract rights, property, or interests in property that the board considers necessary to control, store, convey, treat, dispose, recycle, or reclaim any waste, including sewage, solid waste, industrial waste, municipal waste, recreational waste, agricultural waste, and other waste as those terms are defined by Chapter 26, Water Code, and to accomplish these purposes, the authority may issue bonds, notes, or other obligations in the manner provided by this Act.

(d) The authority may make, purchase, construct, lease, or otherwise acquire property, works, facilities, and improvements including existing as well as new works, facilities, and improvements inside or outside the boundaries of the authority, necessary to carry out the rights, powers, and authority granted by this Act and general law.

(e) The authority may enter into contracts with persons, including the cities within the boundaries of the authority and political subdivisions of the state, on terms and conditions the board considers desirable, fair, and advantageous for the performance of its rights, powers, and authority under this Act. The contracts may provide that they will continue in effect until bonds issued by the authority to finance the cost of facilities authorized by this Act, and refunding bonds issued in lieu of those bonds, are paid. Chapter 224, Acts of the 56th Legislature, Regular Session, 1959 (Article 1109j, Vernon's Texas Civil Statutes), applies to any contract between the authority and any city.

(f) The authority may enter into contracts with others for transporting their water and may act jointly with others in the performance of all functions and purposes of the authority.

(g) An election is not required by the authority for approval of contracts to carry out the general powers and duties of the authority.

(h) This Act does not preclude the authority from acquiring water rights under any law or permit.

SECTION 5. CONSERVATION PROGRAM. The authority shall adopt and implement a program of water conservation consistent with rules and criteria duly adopted and enforceable by the Department of Water Resources for similarly situated districts in the region. A program of water conservation means the practices, techniques, and technologies that will reduce the consumption of water, reduce the loss of waste of water, improve efficiency in the use of water, or increase the recycling and reuse of water so that a water supply is made available for future uses.

SECTION 6. CONFIRMATION ELECTION. (a) Before the authority is created, the creation of the authority must be approved at a confirmation election as provided by this section.

(b) Except as specifically provided by this section, Sections 54.026-54.029, Water Code, govern the calling and holding of the confirmation election.

(c) The ballots for the confirmation election shall be printed to provide for voting for or against: "The creation of the Brazos Bend Water Authority, which does not have the power to levy or collect any tax."

(d) A general law requiring elections to be held on uniform or specified election dates does not apply to an election ordered under this section.

(e) The temporary board shall canvass the returns and declare the results separately for each city voting in the confirmation election.

(f) If a majority of the qualified voters in each of at least three cities listed in Section 3 of this Act approve the creation of the authority at the confirmation election, the authority is created.

(g) For a city to be included as part of the newly created authority, a majority of the qualified voters of that city voting at the confirmation election must approve the creation of the authority.

(h) If a city is included in the authority under this section, the area within the corporate limits and the extraterritorial jurisdiction of the city on the date of the confirmation election is included in the district.

SECTION 7. EXCLUSIONS OF LAND. (a) Before land is excluded from the authority, the board shall call and hold a hearing on exclusion of the land from the authority.

(b) The board has sole authority to initiate the consideration of and make the decision to exclude land or other property from the authority.

SECTION 8. ANNEXATION. (a) A city may be annexed to the authority as provided by this section.

(b) Before the authority may institute annexation proceedings, the board shall provide an opportunity for all interested persons to be heard at two public hearings to be held not more than 40 days or less than 20 days before institution of the annexation proceedings.

(c) At least one public hearing must be held within the city proposed to be annexed if, within 10 days after the publication of the notice required by this section, more than 20 persons who are 18 years of age or older and who reside in the city proposed to be annexed protest in writing to the general manager the institution of annexation proceedings. Each written protest shall include the name, address, and age of each protestor signing.

(d) Notice of the hearings shall be published in a newspaper having general circulation in the area of the authority and in the city proposed to be annexed. The notice for each hearing shall be published at least one time not more than 20 days or less than 10 days before that hearing.

(e) Additional notice shall be given by certified mail to railroad companies then serving the authority if the railroad right-of-way is included in the city to be annexed.

(f) Not later than the 10th day after the date of the last required hearing held under this section, the board shall issue an order stating whether the city should be annexed to the authority. If the board issues an order that the city should be annexed, the board shall call and hold a confirmation election within the boundaries of the city proposed to be annexed to determine whether the city will become a part of the authority.

(g) At an election called under Subsection (f) of this section, the ballots shall be printed to provide for voting for or against the proposition: "The annexation of (Name of city to be annexed) to the Brazos Bend Water Authority, which does not have the power to levy or collect any tax." If a majority of the qualified voters of the city proposed to be annexed voting at the election vote for annexation of the city to the authority, the area within the corporate limits of the city on the date of the confirmation election is annexed to the authority. If a majority of the qualified voters of the city proposed to be annexed voting at the election vote against the annexation of the city to the authority, the city is not annexed to the authority. Except as specifically provided by this section, the confirmation election shall be called and held in the manner provided by Section 6 of this Act for the confirmation election creating the authority.

(h) A city may be annexed to the authority either before or after revenue bonds of the authority are issued, and the boundary change does not affect the validity of any bonds of the authority.

SECTION 9. TAXES; OTHER DISTRICTS. (a) The authority may not impose, levy, assess, or collect taxes on any property, and the authority may not issue bonds or create indebtedness that would be payable directly from ad valorem taxes levied by the authority.

(b) The enactment of this law does not prevent the organization of conservation and reclamation districts, as authorized by Article XVI, Section 59, and Article III, Section 52, of the Texas Constitution, within the boundaries of the authority and does not prevent boundary changes of those districts.

(c) To prevent wasteful duplication, all conservation and reclamation districts created after the effective date of this Act within the boundaries of the authority may contract with the authority for the provision of facilities and services that the authority is authorized to provide under this Act whenever the authority has or in its determination can provide those facilities and services.

SECTION 10. TEMPORARY BOARD. (a) On the effective date of this Act, the following persons constitute the temporary board:

Position 1: Phil Rutter;

Position 2: Ron Kichens;

Position 3: Jerry Wyatt;

Position 4: Tom Reid.

(b) A vacancy in the office of temporary director shall be filled by appointment made by the governing body of the city that the director represented.

(c) The temporary board shall call and hold a confirmation election on the same date in each of the cities listed in Section 3 of this Act and perform other duties necessary to assure the orderly creation of the authority.

SECTION 11. BOARD OF DIRECTORS. (a) The regular board of directors is composed of five directors. Except for Missouri City, one director shall be appointed from each city in the authority by the governing body of that city. Two directors shall be appointed from Missouri City by the governing body of that city. To be eligible to serve on the board a person must be a resident of the city from which he is appointed.

(b) On creation of the authority, the board of directors shall manage and control the authority.

(c) On approval of the creation of the authority at the confirmation election called and held under Section 6 of this Act, the governing body of each city shall appoint the appropriate number of persons to become directors of the authority.

(d) The board members shall meet and organize as soon as practicable after the creation of the district takes effect and shall file their official bonds and subscribe to the constitutional oath of office.

(e) Vacancies on the board shall be filled by appointment of the governing body of the city represented by the vacant position.

(f) For each new city annexed to the authority, the authority shall add a member to the board to represent that city and to be appointed by the governing body of that city.

(g) Each temporary director shall serve until the first regular directors are appointed and have qualified.

(h) Except for the temporary members of the board and new members added to the board on annexation of a city, members of the board shall serve for two years. The board shall assign position numbers to each position of the first regular directors and to each member added to the board in continuing sequence. Persons serving in even-numbered positions shall serve until September 1 of even-numbered years and persons serving in odd-numbered positions shall serve until September 1 of odd-numbered years.

(i) A director is not entitled to compensation for his service on the board.

(j) Each year after the appointment of directors, the board shall elect a president, vice-president, secretary, and any other officers the board considers necessary. The president shall preside over meetings of the board, and in his absence, the vice-president shall preside. The president, vice-president, secretary, and other officers shall perform the duties and may exercise the powers specifically given them by this Act and orders of the board.

(k) At the direction of the board, the general manager of the authority may execute all contracts entered into by the board on behalf of the authority.

(l) At the first organizational meeting of the board, the board shall adopt bylaws, which may be amended as necessary.

consistent with this Act for the management and operation of the authority.

(m) A majority of the directors constitutes a quorum for transaction of business, and a concurrence of a majority of those directors present and voting is sufficient in all matters relating to the business of the authority, including the authorization of contracts for construction work, purchase of existing facilities, and matters relating to construction work.

SECTION 12. GENERAL MANAGER. (a) The general manager shall be appointed by the president of the board and confirmed by a majority of the members of the board and may be removed by a majority vote of the members of the board.

(b) The general manager is the chief executive officer of the authority. Under policies established by the board, the general manager is responsible to the board for the following duties:

(1) administrating the orders of the board;

(2) keeping the authority's records, including minutes of the board's meetings;

(3) coordinating with state, federal, and local agencies;

(4) developing plans and programs for the board's approval;

(5) formulating a budget for the authority's fiscal year subject to the approval of the board;

(6) hiring, supervising, training, and discharging the authority's employees;

(7) contracting for or retaining technical, scientific, legal, fiscal, and other professional services; and

(8) performing any other duties assigned to him by the board.

(c) The general manager and each employee of the authority charged with the collection, custody, or payment of money of the authority shall execute a bond approved by the board as to form, amount, and surety. The authority shall pay the premiums on the general manager's and the employees' bonds under this section.

(d) The board may contract with one of the cities within the boundaries of the authority or with other outside sources for the services of a general manager or other employees of the authority.

SECTION 13. GENERAL FINANCIAL AUTHORITY. (a) The authority shall reimburse the cities within its boundaries for all reasonable expenses incurred in connection with the creation and establishment of the authority, including publication costs, legal fees, engineering fees, charges for the services of other consultants, and other incidental costs.

(b) The authority may borrow money from time to time to carry out any of the powers granted to the authority under this Act by:

(1) issuing and selling negotiable or nonnegotiable notes and providing the terms and conditions of those notes and rights of the holders of those notes payable from and secured by the sources described in this Act;

(2) issuing and selling revenue bonds without the necessity of an election and providing the terms and conditions of those bonds and the rights of the holders of those bonds payable from and secured by the sources described in this Act; and

(3) delivering those notes and bonds to the United States or any agency or instrumentality of the United States or to the State of Texas or any agency or instrumentality of the State of Texas when it is determined by the board to be in the best interest of the authority.

(c) The authority may invest any money held in any sinking fund, reserve fund, or other fund or any money not required for immediate use or disbursement in securities as provided by this Act.

(d) The authority may apply for, accept, and administer grants, loans, and other assistance from the United States and any agency or instrumentality of this state or any other state to carry out the purpose of this Act and may enter into any agreement in relation to those grants, loans, or other assistance that is not in conflict with the constitution of this state.

(e) The authority may:

(1) fix, charge, alter, and collect reasonable rentals, rates, fees, and other charges for the use of any facilities or for any services rendered by the authority;

(2) provide for the imposition of reasonable penalties for any rentals, rates, fees, and charges that are delinquent; and

(3) comply with any duty to fix, charge, alter, and collect the rentals, rates, fees, and charges sufficient to fulfill any agreement with the holders of bonds or notes issued under this Act.

SECTION 14. BONDS AND NOTES. (a) Bonds and notes of the authority shall be authorized by resolution of the board, and at least a majority of the board members must concur in a bond resolution.

(b) The bonds and notes shall:

(1) be in the form, have the characteristics, and bear the designation and date or dates provided in the resolution;

(2) mature at the time or times whether serially, term, or otherwise not more than 40 years from their date of issuance;

(3) bear interest at the rate or rates, be payable annually, semiannually, quarterly, or otherwise, and be in the denominations provided by the resolution;

(4) be registrable as to principal only or as to both principal and interest;

(5) provide for the successive exchange of bonds or notes of one denomination for bonds or notes of other denominations; and

(6) be executed in the manner, payable at the place or places inside or outside the state, and sold for the price or prices provided by the resolution.

(c) Bonds or notes may be issued from time to time in one or more installments.

(d) The proceeds from the sale of bonds or notes shall be deposited in the authority's depository and shall be paid out pursuant to the terms and conditions agreed on by the authority and the purchasers.

(e) Bonds or notes and any coupons appurtenant to the bonds or notes issued under this Act shall be signed by the president or vice-president of the board, be attested by the board's secretary, and bear the seal of the authority.

(f) The resolution authorizing the issuance of any installment or any series of bonds or notes may provide the extent to which the authority, in executing the bonds or notes and appurtenant coupons, may use facsimile signatures and facsimile seals instead of manual signatures and manually impressed seals. If any officer whose manual or facsimile signature appears on a bond or note or any coupon ceases to be an officer before the bond or note is delivered, the signature is valid and sufficient for all purposes as if he had remained in office until the delivery had been made.

(g) Neither the officers or members of the authority nor anyone executing the bonds, notes, or coupons for and on behalf of the authority are liable personally for the bonds, notes, or coupons of the authority by reason of their participation in the issuance of the bonds, notes, or coupons.

(h) The bonds or notes of the authority may be secured by and payable from pledges of all or any part of the revenues, receipts, or assets of the authority or the revenues of any one or more leases or other contracts of the authority, and all such security shall be specified by the resolution or in the trust indenture or other instrument securing the bonds or notes. The pledge may reserve the right, under conditions specified in it, to issue additional bonds or notes that will be on a parity with or subordinate to the bonds or notes being issued.

(i) A pledge or security instrument made by the authority is valid and binding from the time when it is made. The revenues, receipts, or assets pledged and entrusted and received by the authority shall immediately be subject to the lien of the pledge or security instrument without any physical delivery or further act. The lien of the pledge or security instrument is valid and binding against all parties having claims of any kind in tort, contract, or otherwise against the authority, irrespective of whether the parties have notice of the lien. It is not necessary for the resolution or any security instrument or other instrument by which a pledge or security interest is created to be recorded or filed, and compliance with any provision of any other law is not required in order to perfect the pledge of other security interest.

(j) A resolution authorizing bonds or notes or a trust indenture securing bonds or notes which are part of the agreement with the holders may contain provisions:

(1) pledging all or any designated part of the revenues and receipts of the authority received or to be received from the planning, financing, ownership, or operation of, leasing, or other actions in connection with any specified facilities or assets to secure the payment of the bonds or notes;

(2) pledging all or any part of assets of the authority, including any obligation acquired by the authority, to secure the payment of the bonds or notes;

(3) relating to the use and disposition of rentals, rates, fees, and other charges made or received by the authority;

(4) pledging to fix, charge, alter, and collect rents, rates, fees, and other charges with respect to any designated facilities or assets that will be sufficient to produce revenues adequate to pay all expenses necessary to the operation and maintenance of the designated facilities or assets of the

authority, to pay the principal of and interest on all bonds or notes issued and payable out of the revenues and receipts when and as they become due and payable, to pay all sinking fund and reserve or other fund payments agreed to be made with respect to any of those bonds or notes payable out of the revenues and receipts when and as they become due and payable, and to fulfill the terms of any agreement made with the holders of the bonds or notes and with any person in their behalf;

(5) relating to setting aside reserves or sinking funds and regulation and disposition of those reserves and sinking funds;

(6) providing limitations on the purpose to which the proceeds from the sale of the bonds or notes may be applied and pledging the proceeds to secure the payment of the bonds or notes;

(7) providing limitations on the issuance of additional bonds and on the refunding of outstanding bonds or notes or other bonds or notes;

(8) relating to the acquisition, construction, improvement, operation, extension, enlargement, maintenance, and repair of any facilities or assets and stating the duties of the authority with reference to facilities and assets;

(9) providing the procedure, if any, by which the terms of any agreement with bondholders or noteholders may be amended or abrogated, the amount of bonds or notes the holders of the bonds or notes are required to give consent to, and the manner in which the consent may be given;

(10) providing limitations on the amount of money to be spent by the authority for administrative or other expenses;

(11) vesting in a trustee or other fiduciary the property, rights, powers, and duties in trust as the authority determines, which may include any of the rights, powers, and duties of the trustee appointed by the bondholders or noteholders under this Act, and abrogating the right of the bondholders or noteholders to appoint a trustee under this Act or limiting the rights, powers, and duties of the trustee;

(12) designating the management, operation, and control of specified facilities or assets of the authority or trust indenture and specifying the terms of office of the board of trustees, their powers and duties, the manner of exercising their powers and duties, the appointment of successors, and all matters pertaining to their organization and duties; and

(13) relating to any other matters that in any way affect the security or protection of the bonds or notes or the bondholders or noteholders.

(k) The resolution authorizing the issuance of the bonds or notes or the trust indenture or other instrument securing them may provide that in the event of a default or, under the conditions stated in those instruments, a threatened default in the payment of principal of or interest on bonds or notes, any court of competent jurisdiction may, on petition of the holders of outstanding bonds or notes, appoint a receiver with authority to collect and receive pledged revenues and receipts, and the instruments may limit or qualify the rights of less than all of the holders of the outstanding bonds or notes payable from the same source to institute or prosecute any litigation affecting the authority's properties or revenues.

(l) Bonds or notes, including refunding bonds, authorized t this Act may be additionally secured by a trust indenture unde which the trustee may be a bank having trust powers located eithe inside or outside the state. The bonds or notes, within th discretion of the authority, may be additionally secured by mortgage or deed of trust lien or security interest on facilitie or assets of the authority and all real property, franchises easements, leases, or assets of the authority and all rea property, franchises, easements, leases, and contracts and al rights appurtenant to the properties, vesting in the trustee powe to sell the facilities or assets for the payment of th indebtedness, power to operate the facilities or assets, and al other authority for the further security of the bonds or notes The trust indenture, regardless of the mortgage of the deed o trust lien or security interest in the facilities or assets, ma contain any provisions prescribed by the authority for the securit of the bonds or notes and the preservation of the trust estate, ma make provision for amendment or modification of them, may conditio the right to spend the authority's money or sell the authority' facilities or assets on approval of a registered professiona engineer selected as provided in the trust indenture, and may mak any other provisions for protecting and enforcing the rights an remedies of the bondholders or noteholders as may be reasonable an proper and not in violation of the law. The resolution or trus indenture may also contain provisions governing the issuance o bonds and notes to replace lost, stolen, or mutilated bonds o notes.

(m) The authority may direct the investment of money in the funds created by the resolutions, trust indentures, or other instruments securing the bonds or notes. From the proceeds from the sale of bonds or notes, the authority may set aside amounts for payments into the interest and sinking fund until completion of construction and until adequate revenues and receipts are available from operations to pay principal and interest and amounts for payments into reserve funds. Provision for this may be made in the resolution authorizing the bonds, notes, or the trust indenture or other instrument securing the bonds or notes. Proceeds from the sale of the bonds or notes may be used for the payment of all expenses of issuing and selling the bonds or notes.

(n) The proceeds from the sale of the bonds and notes and money in any funds created in connection with the bonds or notes may be invested in:

(1) direct or indirect obligations of or obligations unconditionally guaranteed by the United States maturing in the manner that may be specified by the resolution authorizing the bonds or notes or the trust indenture or other instrument securing the bonds or notes; or

(2) certificates of deposit of any bank or trust company whose deposits are secured by the obligations described in Subdivision (1) of this subsection.

(o) The authority may provide by resolution for the issuance of refunding bonds or notes to refund outstanding bonds or notes issued under this Act and their accrued interest. The authority may sell the refunding bonds or notes and use the proceeds to retire the outstanding bonds or notes issued under this Act, or the authority may exchange the refunding bonds or notes for the outstanding bonds or notes. The issuance of the refunding bonds or notes, their maturity, the rights of the bondholders, and the duties of the authority with respect to refunding bonds or notes are governed by the provisions of this Act relating to original bonds or notes to the extent that they may be made applicable. The authority may also refund any bonds under any general law of the state.

(p) After bonds and notes, including refunding bonds and notes, are authorized by the authority, the bonds and notes and the record relating to their issuance shall be submitted to the attorney general for his examination as to their validity. If the bonds and notes recite that they are secured by a pledge of the revenues and receipts of a lease or leases or other contract or contracts previously made between the authority and any person, the leases and contracts may also be submitted to the attorney general. If the bonds or notes have been validly authorized and if the leases or contracts have been made in accordance with the constitution and laws of this state, the attorney general shall approve the bonds or notes and the leases or contracts, and the bonds or notes shall be registered by the comptroller of public accounts.

(q) After the bonds or notes, and the leases or other contracts, if any, have been submitted, have been approved by the attorney general, and have been registered by the comptroller of public accounts and delivered to the purchasers, the bonds and notes and the leases and contracts are incontestable for any cause.

(r) Payment of bonds and notes according to the term and tenor, performance of agreements with the holders of bonds or notes or any person in their behalf, and performance of official duties prescribed by this Act in connection with any bonds or notes may be enforced in any court of competent jurisdiction by mandamus or other appropriate proceeding.

(s) Bonds issued under this Act and coupons, if any, representing interest on those bonds, when delivered, are considered to be a "security" within the meaning of Chapter 8 of the Business & Commerce Code.

(t) Bonds and notes issued under this Act, the interest on the bonds and notes, and the profit from the sale of the bonds and notes are exempt from taxation by the state or by any municipal corporation, county, or other political subdivision or taxing district of the state.

(u) Bonds and notes issued under this Act, together with the interest on them, shall be secured by and payable only from the sources provided by this Act.

(v) This Act shall not be construed to authorize the giving or lending of the credit of the state or to be a pledge of the credit of the state for payment of any bonds or notes issued under this Act, and the purchasers and holders of any bonds or notes shall never have the right to demand payment from any revenues, receipts, or assets of the authority except those pledged to the payment of bonds or notes. This state, however, pledges and agrees with the holders of any bonds issued under this Act that it will not limit or alter the rights vested in the authority to fulfill the terms of any agreements with the holders of the bonds or notes, together with interest on them, with interest on any unpaid installments of interest, and all costs and expenses for which the authority is liable in connection with any action or proceedings by or on behalf of the holders. The authority may include this pledge and agreement of the state in any agreements it makes with the holders of the bonds or notes.

SECTION 15. FACILITIES; EMINENT DOMAIN. (a) The authority may construct, lay, maintain, and operate canals, laterals, ditches, levees, pipelines, bridges, and all other facilities for the transportation, treatment, purification, and distribution of water together with service roads and all other facilities incidental to and designated for use in connection with the transportation, treatment, purification, and distribution of water and facilities and works necessary to control, store, convey, treat, dispose of, recycle, or reclaim any waste as defined by Section 4(c) of this Act under, along, and across any railroad, railroad right-of-way, canal, stream, pipeline, utility line, streets or alleys in cities, subject to reasonable regulation by the cities, and public roads and highways, but the crossing shall not impair the uses of the facilities crossed, and the facilities shall be promptly restored to their former condition of usefulness.

(b) The authority may exercise the power of eminent domain to acquire by condemnation a fee simple or other interest in property located inside or outside the authority if the property interest is necessary for the exercise of the powers conferred by this Act. The authority must exercise the power of eminent domain in the manner provided by Chapter 21, Property Code, but the authority is not required to deposit with the trial court money or a bond as provided by Section 21.021(a), Property Code.

(c) If the authority, in the exercise of the power of eminent domain or power of relocation or any other power granted under this Act, makes necessary the relocation, raising, lowering, rerouting, or changing the grade of or altering the construction of any highway, railroad, electric transmission or distribution line, telegraph or telephone properties and facilities, or pipeline, the authority shall accomplish this necessary relocation, raising, lowering, rerouting, changing of grade, or alteration of construction at the sole expense of the authority. The term "sole expense" means the actual cost of relocation, raising, lowering, rerouting, change in grade, or alteration of construction in providing comparable replacement facilities, after deducting from the actual cost the net salvage value derived from the old facility.

(d) The authority is not required to give bond for appeal or bond for costs in any condemnation suit or any other suit to which it may be a party.

SECTION 16. DEPOSITORY. The board shall select any bank or banks in the state to act as depository or depositories for the funds of the authority. So long as Chapter 179, Acts of the 60th Legislature, Regular Session, 1967 (Article 2529c, Vernon's Texas Civil Statutes), and Chapter 640, Acts of the 68th Legislature, Regular Session, 1983 (Article 988b, Vernon's Texas Civil Statutes), are observed, any director of the authority may be a shareholder in a depository bank or banks.

SECTION 17. AUDIT. (a) A complete system of accounts shall be kept by the authority and an audit of its affairs for each fiscal year shall be prepared by a certified public accountant or a firm of certified public accountants of recognized integrity and ability.

(b) The fiscal year of the authority shall be from October 1 to September 30 of the following year, unless changed by the board.

(c) A written report of the audit shall be delivered to each member of the board not later than 90 days after the close of each fiscal year. A copy of the audit report shall be delivered on request to the holder or holders of at least 25 percent of the then outstanding bonds of the authority. At least one copy of the audit shall be delivered to the chief administrator of each city, and at least 10 additional copies of the audit shall be delivered to the office of the authority.

(d) One copy of the audit shall be kept on file in the authority office and shall constitute a public record open to inspection by any interested person or persons during normal office hours.

(e) The cost of the audit shall be paid by the authority.

SECTION 18. AUTHORITY OFFICE. The board shall designate and establish an authority office and meeting place within the authority. The meeting place shall be a public place and open to the public to attend any meeting of the board.

SECTION 19. NOTES AND BONDS AS INVESTMENTS AND SECURITY. All bonds of the authority are legal and authorized investments for banks, savings banks, trust companies, savings and loan associations, insurance companies, fiduciaries, trustees, guardians, and sinking funds of cities, counties, school districts, and political subdivisions of the state and public agencies of the state. The bonds are eligible to secure the deposit of funds of the state or of a city, county, school district, or any other agency or political subdivision of the state. The bonds are lawful and sufficient security for those deposits to the extent of their face value.

SECTION 20. EMERGENCY. The importance of this legislation and the crowded condition of the calendars in both houses create an emergency and an imperative public necessity that the constitutional rule requiring bills to be read on three several days in each house be suspended, and this rule is hereby suspended, and that this Act take effect and be in force from and after its passage, and it is so enacted.

H.B. No. 2207

President of the Senate

Speaker of the House

I certify that H.B. No. 2207 was passed by the House on May 17, 1985, by the following vote: Yeas 134, Nays 0, 1 present, not voting; and, pursuant to the provisions of Article XVI, Section 59(d) of the Constitution of Texas, a copy of H.B. No. 2207 was transmitted to the Governor on March 8, 1985, and the recommendation of the Texas Water Commission was filed with the Speaker of the House on May 24, 1985.

Chief Clerk of the House

I certify that H.B. No. 2207 was passed by the Senate on May 24, 1985, by the following vote: Yeas 29, Nays 0.

Secretary of the Senate

APPROVED: ____________________

Date

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Governor