WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION

IMPLEMENTATION PLAN

APPENDIX II

WATER DEMAND AND SUPPLY

October 1987

DEC

Dannenbaum Engineering Corporation
3100 West Alabama
Houston, Texas 77098
(713) 622-8011

WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION

IMPLEMENTATION PLAN

APPENDIX II

WATER DEMAND AND SUPPLY

Prepared by:
DANNENBAUM ENGINEERING CORPORATION
Houston, Texas

The purpose of this study, undertaken by the West Harris County Surface Water Supply Corporation (WHCSWSC), is to produce an implementation program that will provide a reliable, long-term surface water supply to West Harris County.

This appendix is prepared as part of the overall implementation program and deals with water supplies and demands for the WHCSWSC study area.

Further information on the content of this document or the overall implementation plan may be obtained from:

Dannenbaum Engineering Corporation
3100 West Alabama
Houston, Texas 77098
(713)622-8011
Mr. Louis H. Jones, Jr., P.E.

Comments regarding this draft must be received by December 1, 1987.

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ISSUED TO: Mr. John Miloy - Texas Water Development Board

EXECUTIVE SUMMARY

Purpose and Scope

The purpose of this study, undertaken by the West Harris County Surface Water Supply Corporation (WHCSWSC), is to produce an implementation program that will provide a reliable, long-term surface water supply to west Harris County. This implementation program is an extension of the Houston Water Master Plan (HWMP) which is a comprehensive look at water supplies and demands for the Houston region through the year 2030.

The scope of work for this phase of the implementation plan deals with water supplies and demands for the WHCSWSC study area. Current demand information for municipal and public utility districts, cities and private industries will be used to supplement the information provided in the HWMP to arrive at present and future water requirements for the area. Three potential surface water supply sources, the Northeast System, the North System and the Southwest System will be evaluated and service areas will be defined.

Study Area

The WHCSWSC study area encompasses the majority of western Harris County. Approximate boundaries are Spring Creek on the north, the Harris County line on the west and south, the City of Houston city limits on the east and F.M. 149 on the northeast.

Background

Area growth has resulted in a substantial increase in groundwater withdrawal which, in turn, has caused a decline in the area water table, partial or complete capacity loss of a number of wells, intrusion of contaminates and land subsidence.

Efforts to reduce subsidence have called for shifts from groundwater use to surface water. The Harris-Galveston Coastal Subsidence District was created in 1975 to regulate groundwater pumpage and has developed a plan to address the subsidence problem in eight regulatory areas. The HGCSD has the power to amend or revoke well permits and require conservation measures be taken.

Population growth and associated increases in water demand are expected to occur in the WHCSWSC study area between the present and 2030. Much of this study area falls within one of the HGCSD regulatory areas requiring conversion to surface water. Currently, there are no surface water supplies available to serve the demands of the area. An implementation program defining timing and costs to develop a surface water source, treatment facilities, and transmission networks is therefore needed.

Authorization

This implementation plan was authorized by contract between the Texas Water Development Board and the West Harris County Surface Water Supply Corporation dated July 29, 1987.

Water Demands

Data Sources and Collection

Data was collected from the HWMP and the HGCSD to determine historic and future water demands within the WHCSWSC study area. The study area was divided into six municipal demand areas (MDAs) comprised of a number of contiguous census tracts with similar land use characteristics. Historic and future water demands were determined for each MDA to establish a total demand required by the WHCSWSC study area. Data relative to the overall Houston area was derived from the HWMP while data on the individual users within the WHCSWSC was obtained from the HGCSD and the users themselves.

The existing water users within the WHCSWSC study area consist primarily of conservation and reclamation districts such as municipal utility districts, water control and improvement districts and fresh water supply districts, and a few small cities. These users presently rely on groundwater as their sole source of water supply.

Existing Water Use

The WHCSWSC study area is divided into six MDAs similar to those used in the HWMP. The WHCSWSC study area contains all of MDAs 31 and 32 and portions of MDAs 24, 25, 26 and 33. The four partial MDAs, which will be called MDAs 24W, 25W, 26W and 33W, consist of portions of the HWMP MDAs which fall inside the WHCSWSC planning boundaries.

Groundwater pumpage records were obtained for each municipal utility district, city and industry for a seven year period from 1980 to 1986. This data was compiled to determine water pumpage for each of the six WHCSWSC MDAs. Table ES-1 presents this historical data.

TABLE ES-1

AVERAGE DAILY WATER PUMPAGE IN WHCSWSC PLANNING AREA, 1980 - 1986

	AVERAGE DAILY PUMPAGE (MGD)						
	1980	1981	1982	1983	1984	1985	1986
MDA 24W	1.77	2.56	4.15	4.32	5.53	5.97	6.12
MDA 25W	1.70	2.02	2.91	3.18	3.87	4.57	4.29
MDA 26W	3.30	3.76	5.08	5.08	6.17	6.79	6.66
MDA 31	5.51	6.19	8.46	8.88	10.28	11.32	10.39
MDA 32	2.03	2.33	2.99	3.19	3.91	4.20	4.25
MDA 33W	1.83	1.84	2.61	2.82	3.30	3.49	4.09
TOTAL WHCSWSC	16.14	18.70	26.20	27.47	33.06	36.34	35.80

Projected Water Demands

Projected water demands were computed in the HWMP by determining gallons per capita (or per employee) per day use criteria, assigning these demand criteria to each MDA, and multiplying them by the projected population and employment figures for each MDA. An econometric model developed by Rice Center was selected in the HWMP to project future growth. Table ES-2 lists the historic and projected average daily water usage for each of the WHCSWSC MDAs.

TABLE ES-2

HISTORIC AND PROJECTED AVERAGE DAILY WATER USAGE BY MDA

	MDA 24W		MDA 25W		MDA 26W	
YEAR	HISTORIC USAGE (MGD)	PROJECTED USAGE (MGD)	HISTORIC USAGE (MGD)	PROJECTED USAGE (MGD)	HISTORIC USAGE (MGD)	PROJECTED USAGE (MGD)
1980	1.47		1.41		2.74	
1981	2.12		1.68		3.12	
1982	3.44		2.42		4.22	
1983	3.59		2.64		4.22	
1984	4.59		3.21		5.12	
1985	4.96		3.79		5.64	
1986	5.08		3.56		5.53	
1990		5.39		6.52		8.11
2000		8.34		9.49		12.11
2010		9.79		12.20		16.23
2020		9.86		14.53		18.28
2030		9.59		15.94		20.63

	MDA 31		MDA 32		MDA 33W	
YEAR	HISTORIC USAGE (MGD)	PROJECTED USAGE (MGD)	HISTORIC USAGE (MGD)	PROJECTED USAGE (MGD)	HISTORIC USAGE (MGD)	PROJECTED USAGE (MGD)
1980	4.57		1.68		1.52	
1981	5.14		1.93		1.53	
1982	7.02		2.48		2.17	
1983	7.37		2.65		2.34	
1984	8.53		3.25		2.74	
1985	9.40		3.49		2.90	
1986	8.62		3.53		3.39	
1990		11.32		5.64		3.61
2000		21.53		9.37		6.06
2010		32.98		14.30		8.76
2020		42.47		18.92		10.60
2030		53.86		24.47		11.84

NOTE: Historic water usages computed based on average 1986 losses. 1986 projected usages determined by straight-line interpolation.

When these water usage figures are shown graphically, the HWMP projections appear to be reasonable extensions of the historic use data for the area. The highest growth scenario as presented in Appendix D of the HWMP was used for all projections and per capita demand criteria assigned to each MDA by the HWMP were consistently higher than recorded historic per capita demand criteria. These factors result in a conservative but prudent approach to planning future water requirements.

Maximum day demands were used to determine required water supply systems and were computed by multiplying the average daily demands by a peak day factor which ranged from 1.6 to 2.0. Table ES-3 presents projected maximum daily demands within the WHCSWSC study area.

TABLE ES-3

PROJECTED MAXIMUM DAILY WATER USAGE BY MDA

MAXIMUM DAILY USAGE (MGD)

MDA	1985	1990	2000	2010	2020	2030
24W	7.52	9.28	14.36	16.83	16.97	16.50
25W	10.52	12.51	18.23	22.08	26.30	28.86
26W	12.48	14.56	21.80	27.81	31.30	35.32
31	16.05	20.50	37.04	56.71	73.20	86.20
32	8.34	10.80	18.02	25.89	34.28	42.08
33W	6.12	7.36	11.65	16.84	19.21	21.44
TOTAL WHCSWSC	61.03	75.01	121.10	166.16	201.26	230.40

Surface Water Supply

Area River Basins

A number of surface water sources are available for use by the WHCSWSC. The WHCSWSC planning area is located in the San Jacinto River Basin, however, major rivers and reservoirs within the adjacent Trinity and Brazos River Basins were also considered as potential sources.

The San Jacinto River Basin contains two existing reservoirs, Lake Conroe and Lake Houston with available yields of 90 MGD and 178 MGD respectively. One additional reservoir is proposed south of Lake Conroe, Lake Creek, with an estimated yield of 48 MGD.

The Trinity River Basin contains one existing reservoir, Lake Livingston. The estimated safe yield of Lake Livingston is 1374 MGD, however, 254 MGD is committed to downstream water rights obtained prior to the construction of the reservoir and 180 MGD is needed to control salt water intrusion. Two smaller reservoirs are proposed in the area-Bedias Reservoir with an estimated yield of 98 MGD and Wallisville Reservoir with an estimated yield of 80 MGD.

The Brazos River Basin currently has no existing reservoirs adjacent to the WHCSWSC study area. Lake Millican is a proposed reservoir on the Navasota River with an estimated safe yield of 225 MGD and Allens Creek is a proposed reservoir on the Brazos River with an estimated safe yield of 67 MGD.

Northeast Supply System

The Northeast Supply System consists of raw water from the San Jacinto River Basin supplemented by water from the Trinity and Sabine River Basins as outlined in the HWMP. The City of Houston has indicated that they propose to build a Northeast Water Purification Plant near Lake Houston. Preliminary sizing of this plant ranges from 425 MGD to 625 MGD ultimate maximum daily capacity (year 2030).

Southwest Supply System

The Southwest Supply System consists of raw water taken from the Brazos River Basin. The Brazos River and/or Canals A and B would supply a proposed Southwest Purification Plant located near Highway 6 and the Fort Bend-Harris County line. Preliminary sizing of this plant indicates approximately 100 MGD ultimate maximum daily capacity (year 2030). Allen's Creek Reservoir, originally proposed by Houston Lighting and Power Company to supply cooling water for a proposed power plant, is also a potential source of surface water. A permanent supply of water up to 143 MGD is available upon construction of this reservoir and recapturing water previously committed to HL&P by the Brazos River Authority. This 143 MGD supply excludes any additional water which may be available from the Brazos Canals A and B.

North Supply System

The North Supply System consists of surface water from the Trinity, Brazos and San Jacinto River Basins. Development of Lake Millican and Bedias Reservoir and raw water conveyance systems to Lake Conroe would be part of this supply system. The proposed location of a Northwest Water Purification Plant would be south of Lake Conroe with an ultimate maximum daily capacity of 350 MGD (year 2030).

Alternate Service Areas

Approach and Methods

Five alternate service areas were investigated to determine surface water supply versus demand relationships and also availability to meet the conversion dates outlined in the HGCSD Plan. The alternate service areas were divided as follows:

Alternate No. 1	-	Southwest System Service South of Highway 290 Northeast System Service North of Highway 290
Alternate No. 2	-	Southwest System Service South of F.M. 529 Northeast System Service North of F.M. 529
Alternate No. 3	-	Southwest System Service South of Clay Road Northeast System Service North of Clay Road
Alternate No. 4	-	Southwest System Service South of I.H. 10 Northeast System Service North of I.H. 10
Alternate No. 5	-	Southwest System Service South of Clay Road North System Service North of Clay Road

Table ES-4 presents a summary of surface water requirements for each alternate from 1985 to 2030. For purposes of computing surface water requirements in 2030, it was assumed that HGCSD regulatory area eight will be given a conversion requirement of 80% in that year. All surface water requirements are in terms of maximum day demands.

Alternate No. 1

In Alternate 1, the City of Houston will require 69 MGD from the Southwest System in 1995, while the WHCSWSC has no mandate in 1995. The Southwest System yield of 143 MGD would be adequate until 2010, when 97 MGD would be used by the City of Houston and the WHCSWSC would need 52 MGD. After 2010, the supply deficiency in the Southwest System would have to be made up from another source.

The Northeast Supply System will require 11 MGD at the first conversion date of 2005, increasing to 50 MGD in 2030.

Alternate No. 2

In Alternate 2, the City of Houston will require 69 MGD from the Southwest System in 1995, while the WHCSWSC has no mandate in 1995. The Southwest System yield of 143 MGD would be adequate until 2010, when 97 MGD would be used by the City of Houston, and the WHCSWSC would need 46 MGD. After 2010, the supply deficiency in the Southwest System would have to be made up from another source.

The Northeast Supply System will require 11 MGD at the first conversion date of 2005, increasing to 62 MGD in 2030.

Alternate No. 3

In Alternate 3, the City of Houston will require 69 MGD from the Southwest System in 1995, while the WHCSWSC has no mandate in 1995. The Southwest System yield of 143 MGD would be adequate until 2030, when 106 MGD would be used by the City of Houston and the WHCSWSC would need 44 MGD. After 2030, the supply deficiency in the Southwest System would have to be made up from another source.

The Northeast Supply System will require 0.5 MGD at the first conversion date of 2000, increasing to 104 MGD in 2030.

Alternate No. 4

In Alternate 4, the City of Houston will require 69 MGD from the Southwest System in 1995, while the WHCSWSC has no mandate in 1995. The Southwest System yield of 143 MGD would be more than adequate until 2030, when 106 MGD would be used by the City of Houston, and the WHCSWSC would need 23 MGD.

The Northeast Supply System will require 5 MGD at the first conversion date of 2000, increasing to 125 MGD in 2030.

Alternate No. 5

In Alternate 5, the City of Houston will require 69 MGD from the Southwest System in 1995, while the WHCSWSC has no mandate in 1995. The Southwest System yield of 143 MGD would be adequate until 2030, when 106 MGD would be used by the City of Houston, and the WHCSWSC would need 44 MGD. After 2030, the supply deficiency in the Southwest System would have to be made up from another source.

The North Supply System will require 0.5 MGD at the first conversion date of 2000, increasing to 104 MGD in 2030.

TABLE ES-4

SUMMARY OF SURFACE WATER REQUIREMENTS BY ALTERNATE
(MAXIMUM DAILY DEMANDS)

YEAR	CITY OF HOUSTON SOUTHWEST	WHCSWSC SOUTHWEST	TOTAL SOUTHWEST	TOTAL NORTHEAST*	TOTAL ALL AREAS
ALTERNATE 1 - BOUNDARY AT U.S. 290					
1985	0.00	0.00	0.00	0.00	0.00
1995	69.35	0.00	69.35	0.00	69.35
2000	97.02	19.83	116.85	0.00	116.85
2005	97.02	19.83	116.85	10.68	127.53
2010	97.02	52.45	149.47	41.24	190.71
2012	106.33	52.45	158.78	41.24	200.02
2020	106.33	52.45	158.78	41.24	200.02
2030**	106.33	98.52	204.85	49.92	254.77
ALTERNATE 2 - BOUNDARY AT F.M. 529					
1985	0.00	0.00	0.00	0.00	0.00
1995	69.35	0.00	69.35	0.00	69.35
2000	97.02	19.83	116.85	0.00	116.85
2005	97.02	19.83	116.85	10.68	127.53
2010	97.02	45.77	142.79	47.92	190.71
2012	106.33	45.77	152.10	47.92	200.02
2020	106.33	45.77	152.10	47.92	200.02
2030**	106.33	86.62	192.95	61.81	254.76
ALTERNATE 3 OR 5 - BOUNDARY AT CLAY ROAD					
1985	0.00	0.00	0.00	0.00	0.00
1995	69.35	0.00	69.35	0.00	69.35
2000	97.02	19.31	116.33	0.52	116.85
2005	97.02	19.31	116.33	11.20	127.53
2010	97.02	19.31	116.33	74.37	190.70
2012	106.33	19.31	125.64	74.37	200.01
2020	106.33	19.31	125.64	74.37	200.01
2030**	106.33	44.48	150.81	103.96	254.77
ALTERNATE 4 - BOUNDARY AT I.H. 10					
1985	0.00	0.00	0.00	0.00	0.00
1995	69.35	0.00	69.35	0.00	69.35
2000	97.02	15.32	112.34	4.51	116.85
2005	97.02	15.32	112.34	15.20	127.54
2010	97.02	15.32	112.34	78.36	190.70
2012	106.33	15.32	121.65	78.36	200.01
2020	106.33	15.32	121.65	78.36	200.01
2030**	106.33	22.94	129.27	125.48	254.75

*In Alternate 5, the Northeast System is replaced by the North System.

**Harris-Galveston Coastal Subsidence District plan for surface water use ends at 2020. Required surface water for 2030 was estimated assuming that Area 8 will be required to convert to 80% surface water in that year.

Comparison of Alternates

Considerations of supply adequacy were based on the minimum surface water required to meet the HGCSD conversion plan. The minimum requirements climb in a stair-step fashion rather than linearly, however, the minimum requirements for the City of Houston Southwest Supply System and the total for the WHCSWSC supply area do not vary between alternates.

The total supply available from the SWWPP is assumed to be 143 MGD. Alternate 1 and Alternate 2 require more than 143 MGD in the Southwest service area early in the planning period, and have large supply deficits by 2030. The Southwest Service area for Alternate 3 and Alternate 5 shows a smaller deficit after 2030. A surplus supply is developed in the Southwest area through 2030 for Alternate 4. In the cases where supply deficits are noted, an alternate supply source will be required to make up the difference after the deficit occurs.

Some consideration must be given to the timing of the availability of the surface water. In the Southwest service area, the first conversion requires 69 MGD in 1995. This is the same for all alternates. It may be estimated that the SWWPP will take around ten years to bring on-line from design to completion. Since the next conversion date for the area is 2000, it would be more efficient to design the plant based on the requirement for that year, which varies from 112 MGD to 117 MGD.

Timing issues are more complex in the North and Northeast service areas. Alternates 1 and 2 both require about 11 MGD at 2005. Alternates 3 and 5 call for 0.5 MGD in 2000, and Alternate 4 requires 5 MGD in 2000. The quantities of surface water needed in 2000 or 2005 for any alternate are small and it is likely that this area would be supplied from the Southwest Supply System until 2005 or 2010, when most of the northern area will then convert to surface water. The WHCSWSC has been asked to provide the City with an amount of surface water needed from the NEWPP so that it can be designed for the additional capacity. The amount of surface water required from the proposed plant would be approximately 50 MGD by 2010 if Alternate 1 or Alternate 2 is chosen, and 75 to 80 MGD if one of the other alternates is considered.

For Alternate 5, the North Supply System must be considered. The NWWPP is proposed to have a capacity of 350 MGD in 2030. However, the majority of the surface water for this plant is to originate in two proposed reservoirs, Lake Millican and Bedias Reservoir. Construction of these sources would probably take about thirty years, yielding a completion date of 2018. Using this alternate, it would be unlikely to meet the HGCSD conversion dates for regulatory areas six and seven. The areas could not be temporarily supplied from the Southwest System, since the total demand exceeds 143 MGD beginning in 2010.

Conclusions

By the year 2030, the boundary between the Northeast or North and the Southwest Supply Systems will fall just south of Clay Road, since that is the boundary which produced the closest demand to the 143 MGD supply available from the SWWPP. However, the ultimate boundary need not be the same as the boundary used for interim conditions. For instance, Alternates 1 and 2 showed large deficits in 2030, but smaller ones at earlier dates. Alternates 1 and 2 maximize the use of the Southwest Supply System capacity at an early date. This could be useful if the supply from the northern alternatives is reduced or delayed. Water from the North System in Alternate 5 may not be available in time to meet HGCSD target dates.

A cost analysis of the major sources and distribution systems will be necessary before any alternate can be eliminated and this will be accomplished later in Appendix IV.

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1.0 INTRODUCTION

1.0 INTRODUCTION

Purpose and Scope

The purpose of this study is to produce an implementation program that will provide a reliable, long-term surface water supply to West Harris County. This proposed implementation program is an extension of the Houston Water Master Plan (the "HWMP") which has been three years in the making. The Houston Water Master Plan is a comprehensive study of water demands and supplies for the region through the year 2030 and provides a realistic look at the limits of groundwater availability and a conceptual plan for conversion to surface water. In order to bring this plan to reality, careful consideration must be given to specific details of a workable implementation program. To this extent, the West Harris County Surface Water Supply Corporation (the "WHCSWSC") intends to refine the HWMP for its specified study area and provide the details necessary for implementation.

The project scope of work for this phase of the implementation program deals with water demands and supplies. Evaluation of water demands for West Harris County will entail identifying current demands for municipal and public utility districts, incorporated municipalities, and private industries. This demand information will be used to supplement the information provided in the HWMP, which will be the primary planning document for this effort. All demands and projections presented in the HWMP will be compared with historic data for the WHCSWSC study area for general agreement.

Evaluation of water supplies for West Harris County will involve investigation of three potential sources of surface water. The first is purchasing water from a future City of Houston Northeast Water Purification Plant (the "Northeast System"). The second is from the Brazos River out of a future Southwest Water Purification Plant (the "Southwest System"). The third is from a Trinity/Brazos/San Jacinto System as described in the western alternative of the HWMP (the "North System"). The evaluation of the North Water Supply System will be accomplished under Phase III of this study, which will allow the City of Houston time to decide if a western alternative is to be selected for the HWMP.

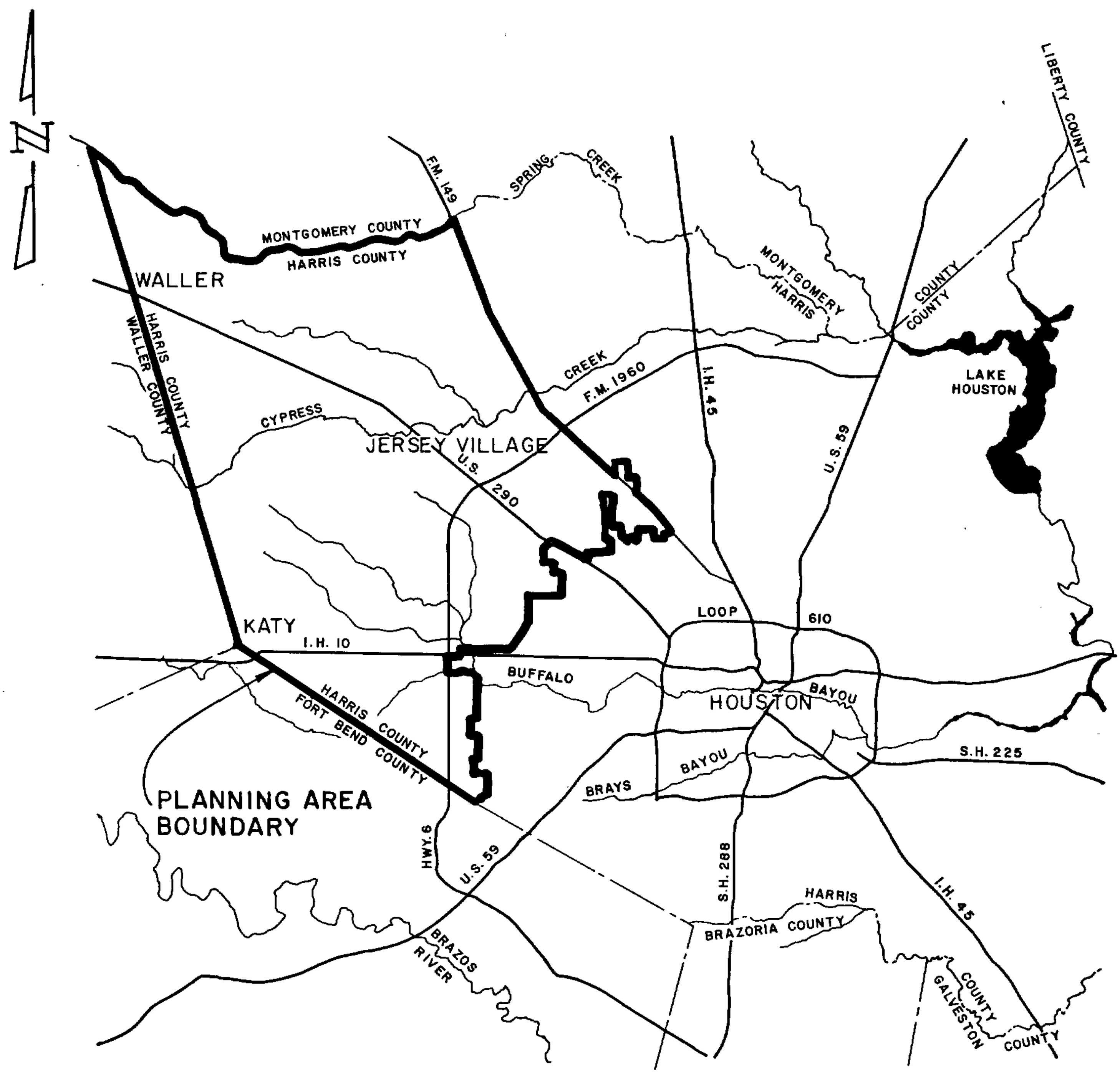
Several alternate service areas will be defined and evaluated based on water demands and timing for each of the supply systems. The service areas will be investigated with regard to the long-term conversion plans as designated by the Harris-Galveston Coastal Subsidence District (the "HGCSD").

Study Area

The geographical area for the WHCSWSC implementation program consists of a large portion of West Harris County. The approximate boundaries are Spring Creek on the north, Harris County boundary line on the west and south, the City of Houston current City limits on the east and F.M. 149 on the northeast, as shown on Figure 1. Approximately 443 square miles (283,500 acres) comprise the planning area with the majority located within the City of Houston's extraterritorial jurisdiction. Smaller portions of the planning area encompass either the City limits or a portion of the extraterritorial jurisdiction of Jersey Village, Waller and Katy. Approximately 200 conservation and reclamation districts fall within the planning area. These are listed on Table 1. The planning boundaries were selected to allow regional surface water planning to be accomplished on a large scale, which will help to reduce the cost to individual users.

The planning boundaries to the north and northeast were located to eliminate overlaps with studies presently being done by the North Harris County Water Supply Corporation and to minimize any overlap with the San Jacinto River Authority. The boundaries on the south and southeast were located to coincide with the City of Houston city limits, therefore eliminating any duplication of studies being done within the city limits of Houston.

FIGURE 1



WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION

PLANNING AREA

TABLE 1

PLANNING AREA CONSERVATION AND RECLAMATION DISTRICTS

No.	Name of District	No.	Name of District
1.	Addicks U.D.	42.	Harris County MUD 90
2.	Barker-Cypress MUD	43.	Harris County MUD 102
3.	Beechnut MUD	44.	Harris County MUD 105
4.	Bissonet MUD	45.	Harris County MUD 107
5.	Braes U.D.	46.	Harris County MUD 118
6.	Camfield MUD	47.	Harris County MUD 119
7.	Castlewood MUD	48.	Harris County MUD 120
8.	Chelford City MUD	49.	Harris County MUD 127
9.	Chelford One MUD	50.	Harris County MUD 130
10.	Chimney Hill MUD	51.	Harris County MUD 136
11.	Cimarron MUD	52.	Harris County MUD 137
12.	Cinco MUD 3	53.	Harris County MUD 144
13.	Cinco MUD 5	54.	Harris County MUD 147
14.	Cinco MUD 6	55.	Harris County MUD 149
15.	Cinco MUD 9	56.	Harris County MUD 155
16.	Clay Road MUD	57.	Harris County MUD 156
17.	Cornerstone MUD	58.	Harris County MUD 157
18.	Cypress Creek U.D.	59.	Harris County MUD 158
19.	Cypress Hill MUD 1	60.	Harris County MUD 162
20.	Cypress Hill MUD 2	61.	Harris County MUD 163
21.	Emerald Forest U.D.	62.	Harris County MUD 165
22.	Faulkey Gully MUD	63.	Harris County MUD 166
23.	Fry Road MUD	64.	Harris County MUD 167
24.	Grant Road PUD	65.	Harris County MUD 168
25.	Green Trails MUD	66.	Harris County MUD 170
26.	Harris County FWSD 61	67.	Harris County MUD 172
27.	Harris County MUD 6	68.	Harris County MUD 173
28.	Harris County MUD 18	69.	Harris County MUD 175
29.	Harris County MUD 23	70.	Harris County MUD 177
30.	Harris County MUD 25	71.	Harris County MUD 179
31.	Harris County MUD 29	72.	Harris County MUD 183
32.	Harris County MUD 52	73.	Harris County MUD 185
33.	Harris County MUD 61	74.	Harris County MUD 186
34.	Harris County MUD 62	75.	Harris County MUD 188
35.	Harris County MUD 63	76.	Harris County MUD 190
36.	Harris County MUD 64	77.	Harris County MUD 194
37.	Harris County MUD 65	78.	Harris County MUD 195
38.	Harris County MUD 69	79.	Harris County MUD 196
39.	Harris County MUD 70	80.	Harris County MUD 197
40.	Harris County MUD 71	81.	Harris County MUD 199
41.	Harris County MUD 81	82.	Harris County MUD 208

TABLE 1 (Cont'd)

PLANNING AREA CONSERVATION AND RECLAMATION DISTRICTS

No.	Name of District	No.	Name of District
83.	Harris County MUD 216	125.	Harris County U.D. 6
84.	Harris County MUD 222	126.	Harris County WCID 113
85.	Harris County MUD 223	127.	Harris County WCID 133
86.	Harris County MUD 225	128.	Harris-Ft. Bend MUD 1
87.	Harris County MUD 229	129.	Harris-Ft. Bend MUD 3
88.	Harris County MUD 230	130.	Harris-Ft. Bend MUD 4
89.	Harris County MUD 237	131.	Harris-Ft. Bend MUD 5
90.	Harris County MUD 238	132.	Horsepen Bayou MUD
91.	Harris County MUD 239	133.	Interstate MUD
92.	Harris County MUD 240	134.	Jackrabbit Road PUD
93.	Harris County MUD 243	135.	Kingsbridge MUD
94.	Harris County MUD 246	136.	Lake Forest U.D.
95.	Harris County MUD 247	137.	Langham Creek U.D.
96.	Harris County MUD 248	138.	Longhorn Town U.D.
97.	Harris County MUD 250	139.	Malcomson Road U.D.
98.	Harris County MUD 252	140.	Mason Creek U.D.
99.	Harris County MUD 255	141.	Mayde Creek MUD
100.	Harris County MUD 256	142.	Memorial MUD
101.	Harris County MUD 257	143.	Mills Road MUD
102.	Harris County MUD 259	144.	Mission Bend MUD 1
103.	Harris County MUD 261	145.	Mission Bend MUD 2
104.	Harris County MUD 263	146.	Morton Road MUD
105.	Harris County MUD 264	147.	Northwest Freeway MUD
106.	Harris County MUD 268	148.	NW Harris County MUD 5
107.	Harris County MUD 272	149.	NW Harris County MUD 9
108.	Harris County MUD 273	150.	NW Harris County MUD 10
109.	Harris County MUD 276	151.	NW Harris County MUD 12
110.	Harris County MUD 277	152.	NW Harris County MUD 15
111.	Harris County MUD 280	153.	NW Harris County MUD 16
112.	Harris County MUD 281	154.	NW Harris County MUD 25
113.	Harris County MUD 282	155.	NW Harris County MUD 27
114.	Harris County MUD 283	156.	NW Harris County MUD 29
115.	Harris County MUD 284	157.	Northwest Park MUD
116.	Harris County MUD 286	158.	Nottingham Country MUD
117.	Harris County MUD 287	159.	Park Ten MUD
118.	Harris County MUD 288	160.	Pecan Park MUD
119.	Harris County MUD 289	161.	Reid Road MUD 1
120.	Harris County MUD 306	162.	Reid Road MUD 2
121.	Harris County MUD 317	163.	Remington MUD 1
122.	Harris County MUD 318	164.	Remington MUD 2
123.	Harris County MUD 319	165.	Remington MUD 3
124.	Harris County MUD 325	166.	Renn Road MUD

TABLE 1 (Cont'd)

PLANNING AREA CONSERVATION AND RECLAMATION DISTRICTS

No.	Name of District
167.	Ricewood MUD
168.	Rolling Creek U.D.
169.	Rolling Fork PUD
170.	Spencer Road PUD
171.	Timberlake I.D.
172.	West Harris County MUD 1
173.	West Harris County MUD 2
174.	West Harris County MUD 4
175.	West Harris County MUD 5
176.	West Harris County MUD 6
177.	West Harris County MUD 7
178.	West Harris County MUD 8
179.	West Harris County MUD 9
180.	West Harris County MUD 10
181.	West Harris County MUD 11
182.	West Harris County MUD 14
183.	West Harris County MUD 15
184.	West Harris County MUD 16
185.	West Harris County MUD 17
186.	West Harris County MUD 20
187.	West Memorial MUD
188.	Westlake MUD 1
189.	Weston MUD
190.	Westpark MUD
191.	Westway U.D.
192.	White Oak Bend MUD
193.	White Oak/1960 MUD
194.	Willow Chase MUD
195.	Windfern Forest U.D.

Background

Development of surface water supply sources to supplement groundwater supplies has been an ongoing process by the City of Houston since 1966 when Phase I of a three-phase Water Master Plan was completed. Since that time, numerous revisions and updates to this plan have been initiated with the latest effort being the comprehensive Houston Water Master Plan (HWMP) by Metcalf and Eddy. The HWMP represents a detailed study of water demands and supplies for the entire eight county region surrounding the City of Houston. The HWMP also provides a realistic look at the limits of groundwater availability in the region and addresses a conceptual plan for conversion to surface water.

The existing users within the WHCSWSC planning area consist primarily of conservation and reclamation districts, such as municipal utility districts, water control and improvement districts and fresh water supply districts, and a few small incorporated cities. These users presently rely on ground water as their sole source of water supply. Water supply for municipal use has been facilitated in the past by the abundance and excellent quality of regional groundwater. Wells yielding quality water requiring only chlorination could be easily drilled virtually anywhere at fairly low cost. For this reason, the municipal water system has developed as a series of wells and distribution pump stations with each individual well and distribution system supplying a specific subdivision or area of a city.

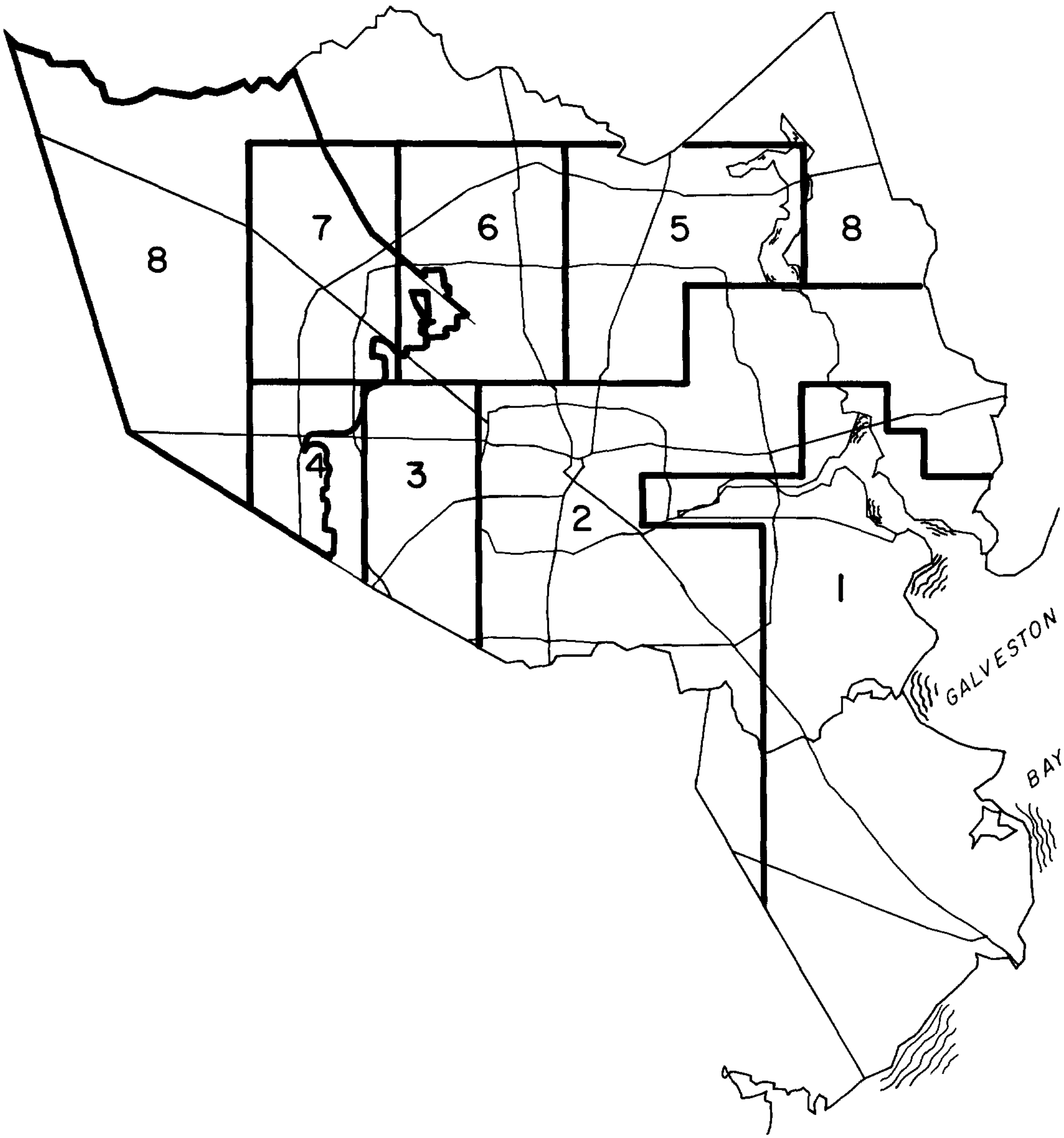
As a result of heavy groundwater withdrawal, the area water table has substantially declined over the last several years, causing partial or complete capacity loss in a number of wells. A portion of the wells in operation have experienced a serious intrusion of natural gas causing increased treatment costs. Contamination from radiation and other trace elements presently regulated by the State Department of Health has occurred in a smaller portion of the existing wells. Continued increased pumpage will likely lower the water table further and increase the chances of well contamination, eventually producing a shortage of potable water in the planning area.

Land subsidence, caused by the pumping of groundwater, has also been a problem in the Houston area. By 1975, land subsidence had reached a critical state with nearly nine feet of elevation lost in southeast Houston and over one foot lost in the majority of Harris and Galveston Counties. Efforts to reduce or eliminate subsidence have called for shifts by municipal and industrial users from groundwater to surface water. The dramatic decreases in subsidence realized in southeast Houston are the direct result of reducing groundwater withdrawal. Recently a shift in the location of greatest subsidence has occurred from the eastern coastal region to west and southwest Houston where between 1978 and 1983 over one foot of elevation was lost. Projections have indicated the possibility of up to 12 feet of elevation loss between now and 2020 if a surface water source is not developed in southwest Houston.

With the creation of the Harris-Galveston Coastal Subsidence District in 1975, the reality of conversion to surface water has come into focus. As a result of growth and increased groundwater withdrawal, the HGCSD has developed an eight regulatory area plan to address subsidence through 2020 (see Attachment 2). Figure 2 shows the boundary lines of the eight regulatory areas as determined by the HGCSD. Regulatory areas which overlap with the WHCSWSC study planning boundaries are Areas 3, 4, 6, 7 and 8. Table 2 lists a summary of the HGCSD plan requirements. Basically, Areas 3 thru 7 will be limited by the HGCSD to using not more than 20% groundwater at certain conversion years. The conversion dates fall between the years 1995 to 2010, and increases in groundwater use above 20% will be permitted thereafter only as long as surface water use does not decrease. In Area 8 increases in groundwater withdrawal may be permitted through 2020, however, supplying areas outside of the boundaries of Area 8 would be prohibited. For the purpose of this study, Area 8 was assumed to have a conversion date of 2030, when not more than 20% groundwater withdrawal will be permitted. The HGCSD has the power to amend or revoke permits as well as requiring conservation measures as a condition on certain well permits.

Population is expected to grow in all eight surrounding counties of the Houston region between the present and 2030. The highest growth is forecast for Harris County, with a net change of approximately 2,300,000 persons. Previous studies have indicated that within Harris County itself, the western portions of the county will experience the majority of the projected

FIGURE 2



HARRIS - GALVESTON COUNTY SUBSIDENCE DISTRICT
REGULATORY AREAS

TABLE 2

SUMMARY OF HGCSD PLAN REQUIREMENTS BY SUB-AREA

REQUIREMENTS AND YEAR IN WHICH THEY TAKE EFFECT

SUB-AREA	CURRENT-1990	1990-2000	2000-2010	2010-2020
One	No increases in groundwater withdrawal permitted	Not more than 10% of water use from groundwater	Same as prior period.	Same as prior period.
Two	Increases in groundwater permitted if surface water use not reduced	1999-Not more than 20% of water use from groundwater	2007-Same as prior period.	2015-Same as prior period.
Three	Increases in groundwater permitted if surface water use not reduced	1995-Not more than 20% of water use from groundwater	Increases in groundwater permitted if surface water use not reduced	2012-Not more than 20% of water use from groundwater
Four	Increases in groundwater permitted if surface water use not reduced	Same as prior period.	2000-Not more than 20% of water use from groundwater	Increases in groundwater permitted if surface water use not reduced
Five	Increases in groundwater permitted if surface water use not reduced	Same as prior period.	2000-Not more than 20% of water use from groundwater	Increases in groundwater permitted if surface water use not reduced
Six	Increases in groundwater permitted if surface water use not reduced	Same as prior period.	2005-Not more than 20% of water use from groundwater	Increases in groundwater permitted if surface water use not reduced
Seven	Increases in groundwater permitted if surface water use not reduced	Same as prior period.	Same as prior period.	2010-Not more than 20% of water use from groundwater

TABLE 2 (Cont'd)

SUMMARY OF HGCSD PLAN REQUIREMENTS BY SUB-AREA

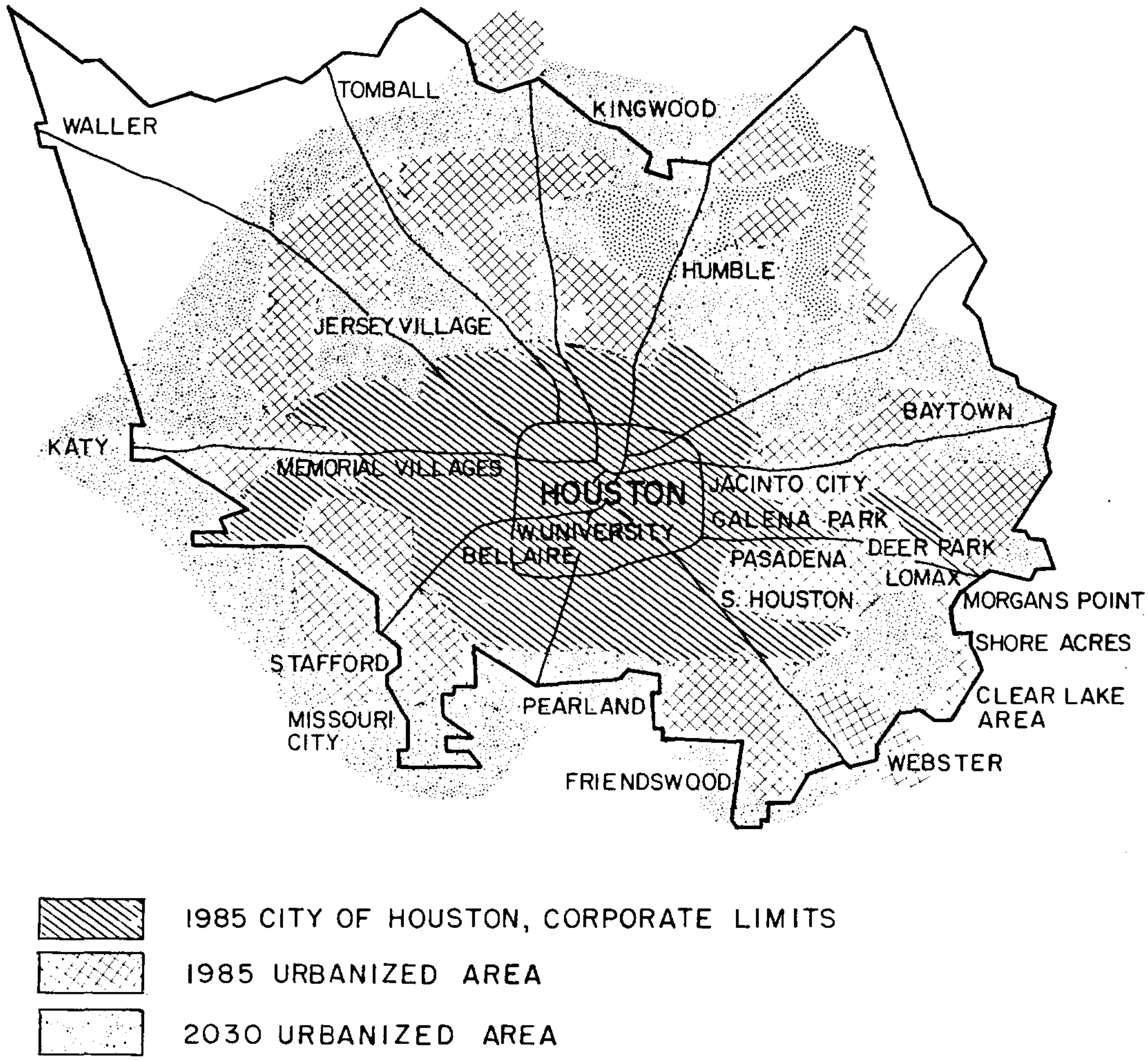
	REQUIREMENTS AND YEAR IN WHICH THEY TAKE EFFECT			
SUB-AREA	CURRENT-1990	1990-2000	2000-2010	2010-2020
Eight	Increases in groundwater permitted; Groundwater withdrawn in this area may not be supplied to areas outside boundaries.	Same as prior period.	Same as prior period.	Same as prior period.

municipal growth. Figures 3 and 4 are reproduced directly from Appendix D of the HWMP and graphically show the extent of future Houston urbanization and population change between 1985 and 2030.

Along with this expected future growth will come a steady increase in water demand. For the WHCSWSC planning area, the maximum daily water demand is projected to increase from a 1985 figure of 61 MGD to approximately 230 MGD by the year 2030. At present virtually 100% of the water demands of the area are supplied by groundwater.

As previously presented, much of the WHCSWSC planning area falls within one of the HGCSD regulatory areas requiring conversion to surface water. Subsidence monitors located in southwest Houston and Addicks indicate a continuing land subsidence of approximately one and a half inches per year. To reduce this loss of elevation will require reduction in groundwater pumpage and the delivery of surface water to the area. Currently, there are no existing surface water supplies available in West Harris County to serve the present or future demands of the area. The majority of alternative surface water supplies mentioned in prior studies for the City of Houston are located to the northeast of the City. This will result in a substantial long-term cost of transporting water across the City to areas in West Harris County where the greatest future municipal demand is expected. Clearly, a surface water source, treatment facilities, and transmission networks are needed to serve the West Harris County area and comply with the existing HGCSD regulations.

FIGURE 3

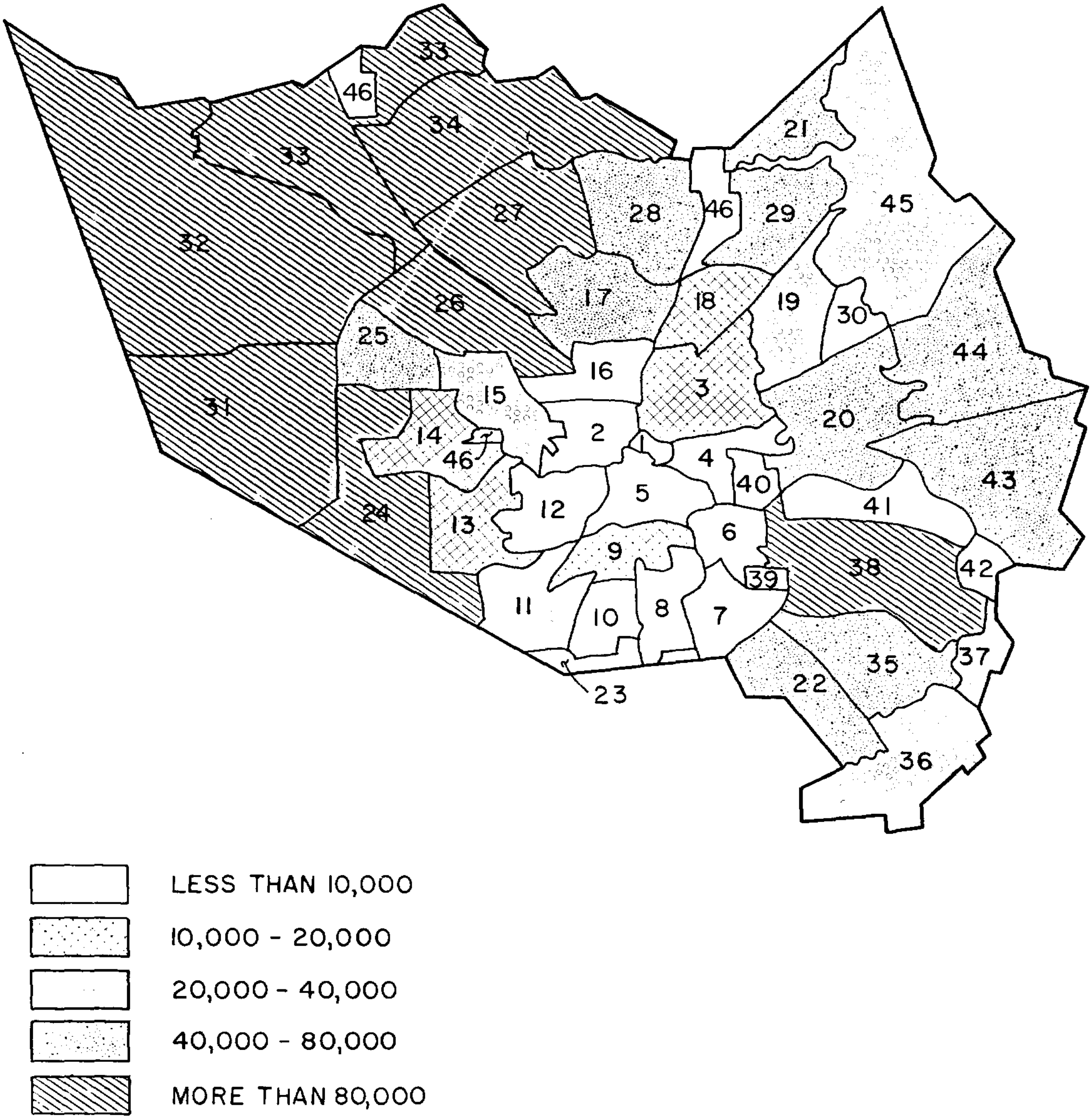


REPRODUCED FROM FIGURE I-4, HOUSTON WATER MASTER PLAN, APPENDIX D

WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION

EXTENT OF HOUSTON URBANIZED AREA

FIGURE 4



REPRODUCED FROM FIGURE 4-26, HOUSTON WATER MASTER PLAN, APPENDIX D - REVISED BY W.H.C.S.W.S.C.

WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION

POPULATION CHANGE, 1985 - 2000

Lead time and revenue are necessary to provide new surface water supplies and the associated treatment and transmission facilities. An implementation program accurately defining timing and costs of a new surface water supply is therefore a necessity.

Authorization:

This implementation plan was authorized by contract between the Texas Water Development Board and the West Harris County Surface Water Supply Corporation dated July 29, 1987.

Fifty percent of the costs associated with the implementation plan will be funded by Texas Water Development Board Planning and Research Grant funds with the remaining fifty percent being funded by the West Harris County Surface Water Supply Corporation.

2.0 WATER DEMANDS

2.0 WATER DEMANDS

Approach and Methods

It is the goal of the WHCSWSC to provide surface water for West Harris County in a timely and efficient manner. Existing and future water demands are the most important pieces of information needed to formulate a plan to accomplish this goal. While historic water use data is fairly easy to obtain, projections of future water use are affected by numerous factors which make estimating difficult. Economic growth is the driving force behind these factors. The City of Houston Water Master Plan examined three projections of economic growth for Houston and the surrounding areas, covering the years 1985 to 2030. Of the three, an econometeric model developed by Rice Center was selected to form projections of population, employment and water demands. The HWMP projections were used to compute future water demands for the service area of WHCSWSC. To better understand the potential customers of the WHCSWSC and to confirm the projections in the HWMP, detailed knowledge of the types of water use currently in the study area was gathered. This data was compiled into a Lotus 1-2-3 database for easy reference and handling.

Data Sources and Collection

Data was collected from a variety of sources to build a complete picture of historical and future water use in the proposed study area of the WHCSWSC. This data falls into two broad categories: information relative to large areas derived from the HWMP, and information obtained on the individual water users in the WHCSWSC study area. The following paragraphs explains the sources of data used to formulate water demand projections and the types of data obtained.

Data from the Houston Water Master Plan

The City of Houston Water Master Plan thoroughly addresses the question of projected water demand in three appendices. They are Appendix C, "Current Water Uses," Appendix D, "Population and Growth Projections," and Appendix H, "Water Demands."

Appendix C provides an inventory of current water uses during the period from 1980 to 1984. This is limited to the City of Houston and to the Coastal Water Authority. Water use is not broken down by location, but trends of water demand by user category are examined for the five years.

Population and growth projections from the Rice Center econometric model of Houston's economic growth are the topic of Appendix D of the HWMP. For a breakdown of the projected variables by location, census tracts were used. The tracts were grouped into 46 Municipal Demand Areas (MDAs) within Harris County and 19 in the seven surrounding counties. Each MDA is contiguous and has fairly similar land use characteristics. Projections for population, employment, housing and land use were prepared for each census tract in the HWMP study area, and the data was presented in the appendix for each MDA. The Rice Center econometric model yielded consistently higher forecasts than did other projection scenarios thereby producing a prudent basis for water demand projections.

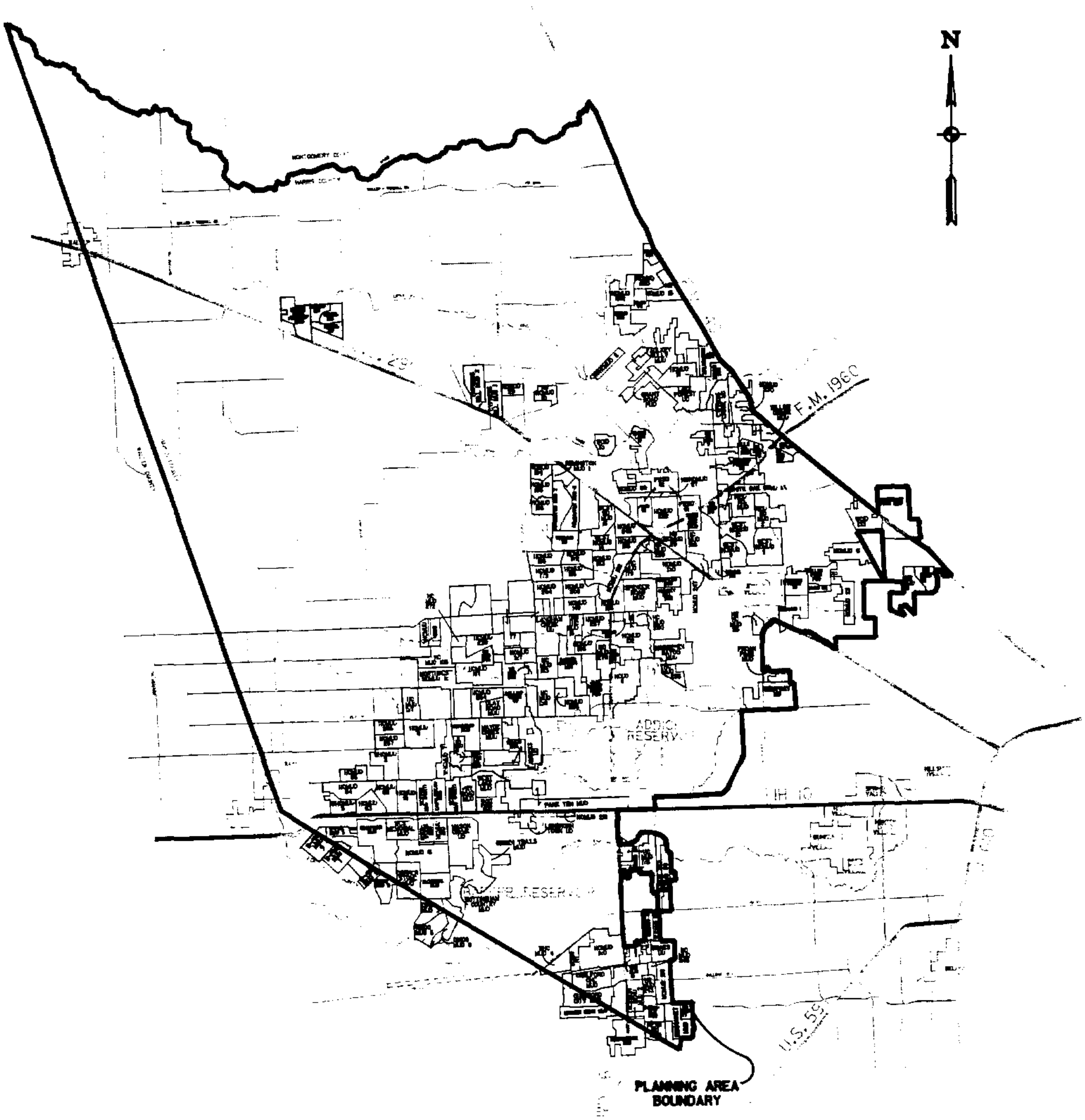
Appendix H of the HWMP combined the information amassed in Appendix D with a one year record of water billing in the City of Houston to calculate per capita and per employee water demands throughout the City. These numbers were used to project water demand during the time period of the study. As in Appendix D, computations were performed on a census tract level and reported by MDA. All water demand projections in the HWMP are for consumer use only and do not include unaccounted-for water in the system. Predictions of water needs in the WHCSWSC study area were taken from Appendix H. For greater accuracy when dealing with partial MDAs, a listing of water demands by census tract was obtained from Metcalf and Eddy, the engineers for the HWMP.

Data on Specific WHCSWSC Water Users

To aid in the deeper understanding of water needs, a list of the water users in the WHCSWSC study area was compiled. These users are principally municipal utility districts and the cities of Jersey Village, Katy and Waller, although there are some commercial and industrial users present. An alphabetical listing of the municipal districts within the study area was previously presented in Table 1. This list of utility districts has two sources. The names of districts in the study area were taken from a municipal utility district map published by the Houston City Planning Commission in 1984, updated to December 30, 1986. In addition, a complete listing of active utility districts within Harris County, as of January 1987, was obtained from the Texas Water Commission. This list was used to eliminate districts which had been dissolved, consolidated, annexed, or become inactive; and to add districts which had been created recently. Districts within the WHCSWSC planning area boundary are shown on Figure 5. All deleted districts have been removed from the figure and all but five new districts have been added. No boundary map could be obtained for the omitted districts; however, none of these had begun pumping water by 1986.

Industrial and commercial water users having their own wells with yearly consumptions greater than approximately three million gallons are listed in Table 3. This list was compiled using well permit data available from the HGCSD. The list of industrial users is not intended

FIGURE 5



WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION
MUNICIPAL UTILITY DISTRICTS

TABLE 3

INDUSTRIAL AND COMMERCIAL WATER USERS HAVING WELL PERMITS

NO.	NAME OF INDUSTRY
1.	Baker Service Tools
2.	Baker Tubular Services
3.	Bear Creek Golf World
4.	Britmore Utility Company
5.	Cameron Iron Works
6.	Enchanted Valley Water Supply
7.	Gifford-Hill & Company
8.	Hearthstone Country Club
9.	National Steel Products
10.	Northwest Water Systems, Inc.
11.	Peek Road Utilities
12.	Tall Pines Utility
13.	Texas Instruments
14.	Tower Oak Bend Water Supply
15.	Treeline Golf Club, Inc.
16.	Trumix Concrete Company
17.	Trunkline Gas Company

to be a complete list of all significant industries in the area, since many industries and businesses buy their water from cities and water districts. It was compiled to account for additional water use in the study area.

The most important information needed to evaluate projected water demands is the historic demand of all users. A time frame from 1980 to 1986 was chosen to overlap the time frame in Appendix C of the HWMP, 1980 to 1984. Since no surface water is currently used in western Harris County, groundwater pumpage reports form a nearly complete record of water use within the service area. The HGCSD proved to be the most convenient source of pumping data. Each owner of a well five inches or greater in diameter is required to submit to HGCSD a yearly report indicating groundwater pumpage by month. Copies of these reports were obtained for each utility district in the study area having a well permit. An annual summary of these reports was provided for each city and business of interest. Only the annual pumpage totals were included in the water user database. The pumpage includes water billed as well as unaccounted-for water.

In a few instances, water for a district is purchased from another district, the City of Houston, or imported from Fort Bend County, where the HGCSD has no authority. In these cases, the operators of the water plants for the districts in question were asked to provide pumpage records for the period of study. Where one district supplies water for another, the water use was divided among them when the split could be determined, especially if the water was consumed in different MDAs.

Additional data for many characteristics of the utility districts in the study area was sought from the district operators in the WHCSWSC study area. Each operator was asked to supply information on current number of connections, amounts of ground and elevated storage, primary and booster pumping capacities, water rates, billed versus pumped percentages, well permits and water analysis reports. Not all districts have operators, and not all of this information was readily available to each operator, but much of it was received and tabulated in database form. Of the 195 districts, some or all the information was available on approximately 132 districts. This data was useful not only in evaluating water demands but also in providing insights into the types of water users in the WHCSWSC study area.

To gather information on future development, the local office of the Texas Water Commission was visited in order to make copies of portions of bond issue and creation reports containing projected types of development and build-out schedules. These reports were available for 136 of the districts in the WHCSWSC study area. This general information was helpful in resolving questions of water sources for the districts as well as describing likely development trends.

Existing Water Use

Two sources of data on existing water usage were available for this study. The first, groundwater pumpage information collected from the HGCSD, provides the most useful evidence of water consumption trends in the study area. Water demand can be broken out by location to better understand growth patterns. The second source, Appendix C of the HWMP, is concerned only with City of Houston billed water use. This information is not directly applicable to the WHCSWSC study area; however, general trends found in the City will be compared to those in western Harris County. This section examines the data from both sources, compares them, and makes conclusions about current water uses.

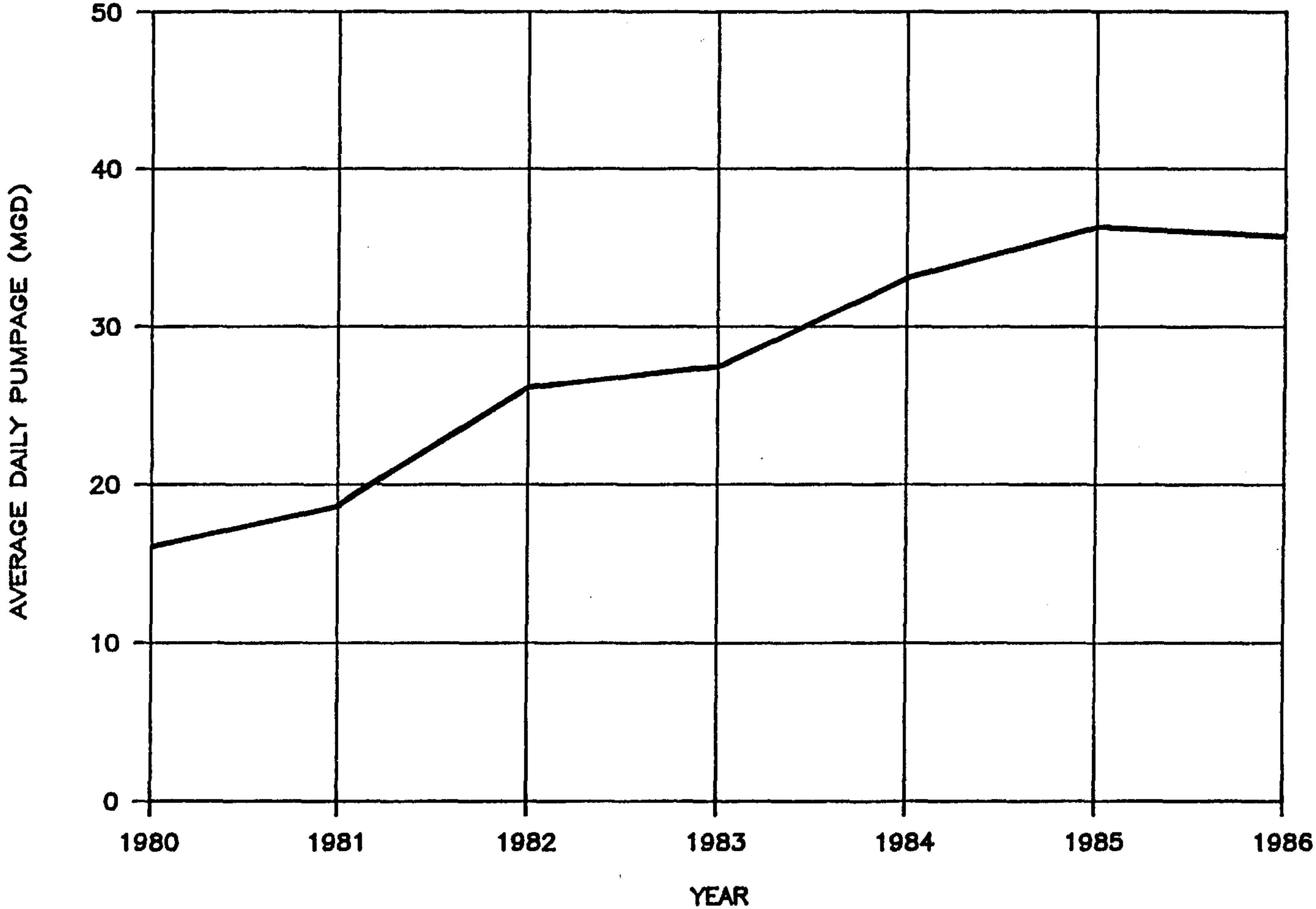
Groundwater Pumpage in the WHCSWSC Study Area

Groundwater pumpage records for each municipal utility district, city and industry were obtained for the period from 1980 to 1986. In order to determine the daily water supply needed, the annual pumpage of each water user was divided by 365 to yield an average daily demand. These demands were added to give the total average daily demand for each MDA. Since small wells are not required to have permits, the total computed is slightly smaller than the actual groundwater used. The total groundwater pumpage during the 1980 to 1986 period is plotted on Figure 6.

FIGURE 6

HISTORIC GROUNDWATER PUMPAGE

IN THE WHCSWSC SERVICE AREA

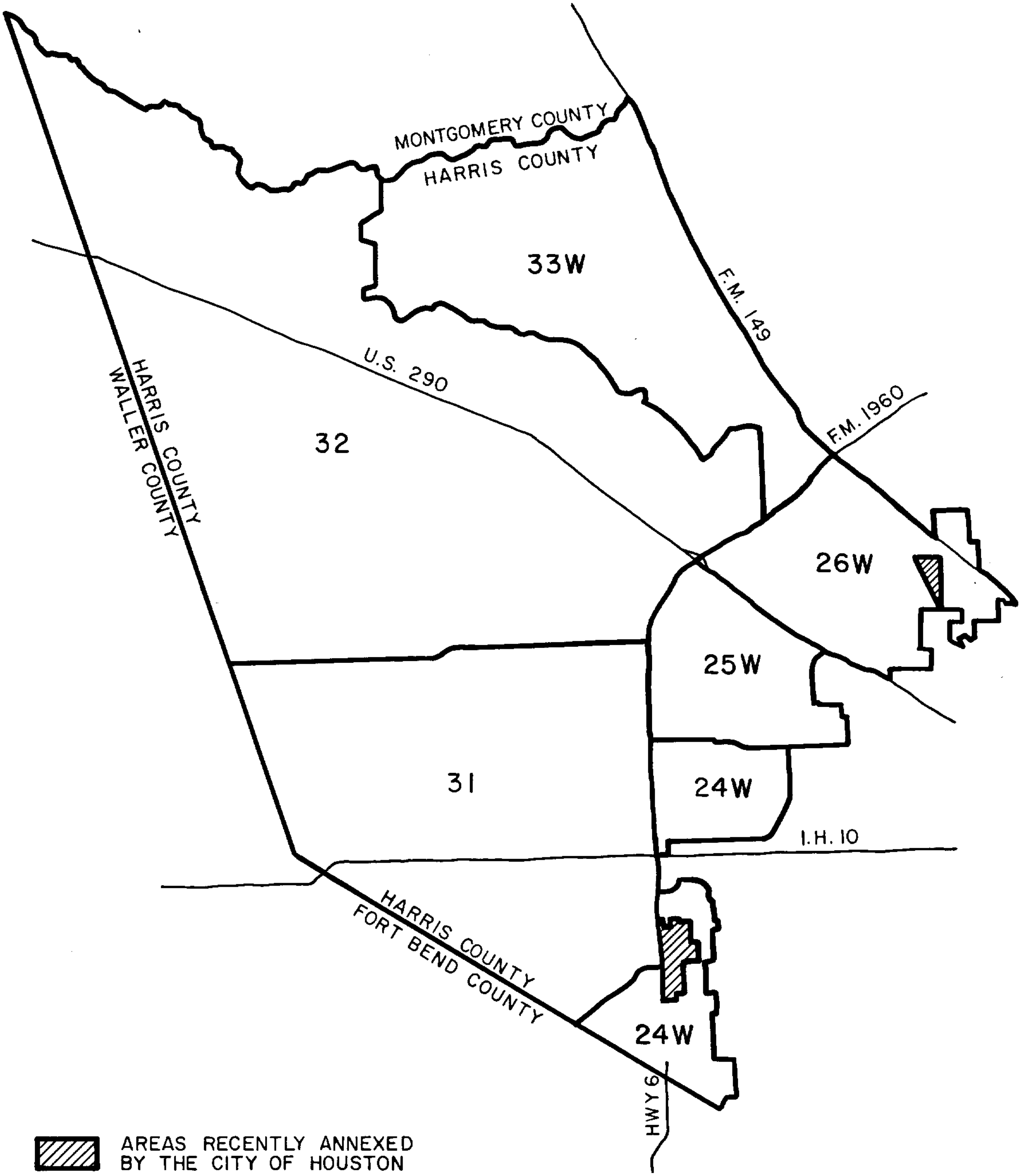


The WHCSWSC study area contains all of MDAs 31 and 32, and portions of MDAs 24, 25, 26 and 33. The four partial MDAs, hereinafter called MDAs 24W, 25W, 26W and 33W are not identical to those in the HWMP, but consist of the portions of the HWMP MDAs which fall inside the WHCSWSC planning area. Figure 7 shows the WHCSWSC MDAs. Table 4 lists the census tracts which make up the WHCSWSC MDAs. When the planning area boundary did not coincide with a census tract boundary, the percentage of land within the WHCSWSC study area was computed.

Historic water pumpages in the WHCSWSC study area have been calculated for each of the six WHCSWSC MDAs. Table 5 shows a breakdown per year of average daily pumpage and Figure 8 graphically presents these results. Examination of the data reveals pumpage trends for each MDA. Note that all six MDAs experienced rapid growth during the seven year period. Water pumpage in MDA 24W more than tripled while water pumpage in the other areas at least doubled. In general, groundwater pumpage grew steadily except during 1983, when it slowed somewhat in all MDAs, and in 1986, when MDAs 25W, 26W and 31W actually recorded drops in water usage.

Groundwater pumpage records were obtained in monthly and annual form. Therefore, no analysis of maximum daily or peak hourly demands could be performed. It was also impossible to break down the pumpage reported for a city or district into user categories such as commercial or single-family residential, since no billing records were obtained.

FIGURE 7



WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION

MUNICIPAL DEMAND AREAS

TABLE 4

COMPARISON OF 1980 CENSUS TRACTS TO MUNICIPAL DEMAND AREAS

MDA 24 W	
CENSUS TRACT	PERCENT INCLUDED
437.01	100%
437.02	66%
438.01	39%
438.06	31%
448.00	100%

MDA 25 W	
CENSUS TRACT	PERCENT INCLUDED
542.01	100%
542.02	88%
543.00	100%

MDA 26 W	
CENSUS TRACT	PERCENT INCLUDED
530.01	100%
530.02	5%
530.03	50%
540.01	80%
540.02	64%
541.00	100%

MDA 31	
CENSUS TRACT	PERCENT INCLUDED
449.00	100%
450.00	100%
451.01	100%
451.02	100%
452.01	100%
452.02	100%

MDA 32	
CENSUS TRACT	PERCENT INCLUDED
544.00	100%
545.01	100%
545.02	100%
546.00	100%
547.00	100%
548.00	100%
549.00	100%

MDA 33 W	
CENSUS TRACT	PERCENT INCLUDED
550.00	100%
551.01	100%
551.02	100%
552.00	100%

TABLE 5

AVERAGE DAILY WATER PUMPAGE IN WHCSWSC PLANNING AREA, 1980 - 1986

	AVERAGE DAILY PUMPAGE (MGD)						
	1980	1981	1982	1983	1984	1985	1986
MDA 24W	1.77	2.56	4.15	4.32	5.53	5.97	6.12
MDA 25W	1.70	2.02	2.91	3.18	3.87	4.57	4.29
MDA 26W	3.30	3.76	5.08	5.08	6.17	6.79	6.66
MDA 31	5.51	6.19	8.46	8.88	10.28	11.32	10.39
MDA 32	2.03	2.33	2.99	3.19	3.91	4.20	4.25
MDA 33W	1.83	1.84	2.61	2.82	3.30	3.49	4.09
TOTAL WHCSWSC	16.14	18.70	26.20	27.47	33.06	36.34	35.80
WHCSWSC Industry*	0.61	0.81	0.75	0.67	0.74	0.80	0.66

*Available total for industrial and commercial consumers.

FIGURE 8

HISTORIC GROUNDWATER PUMPAGE

IN MDA 24W

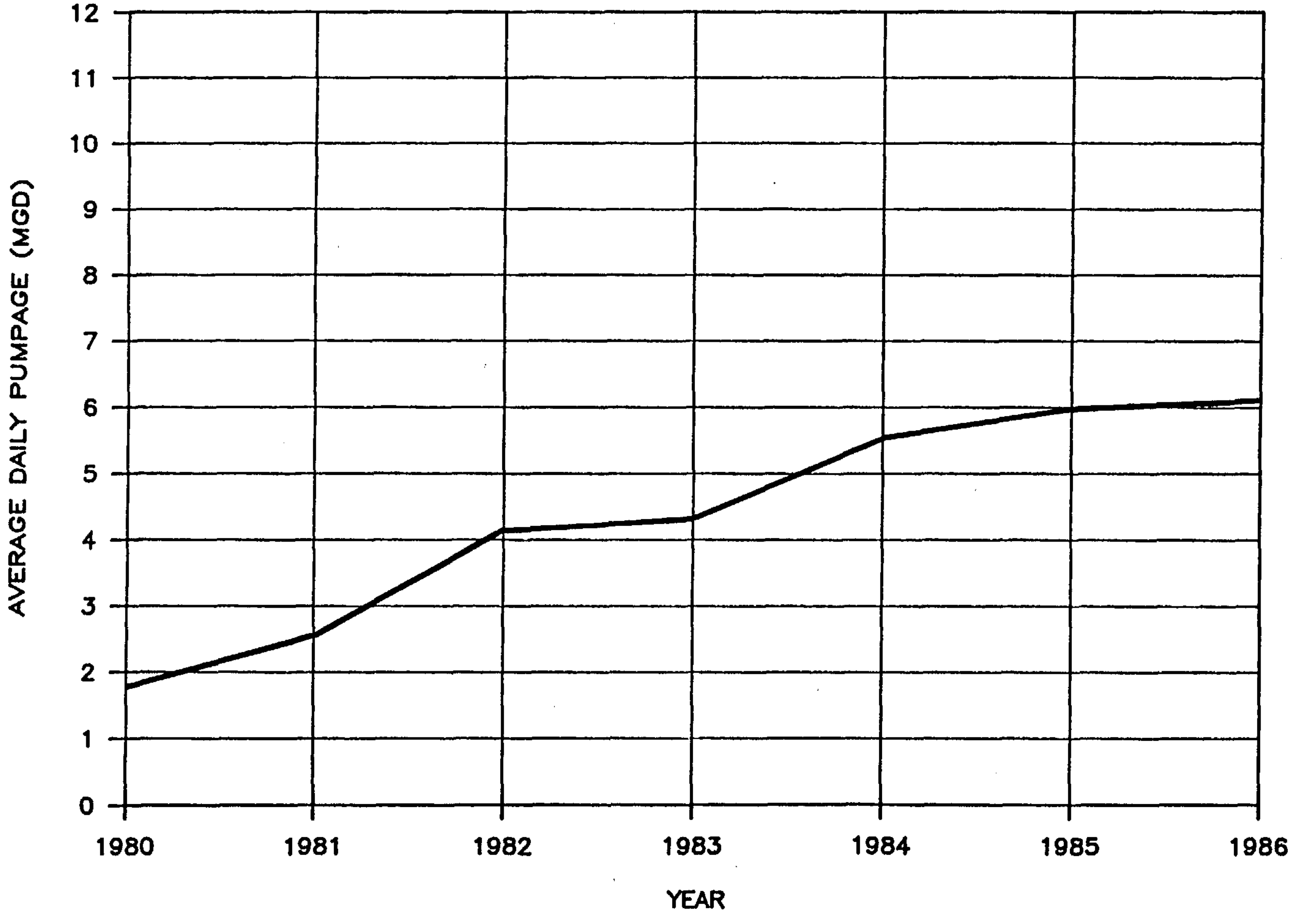


FIGURE 8
(CONT.)
HISTORIC GROUNDWATER PUMPAGE
IN MDA 25W

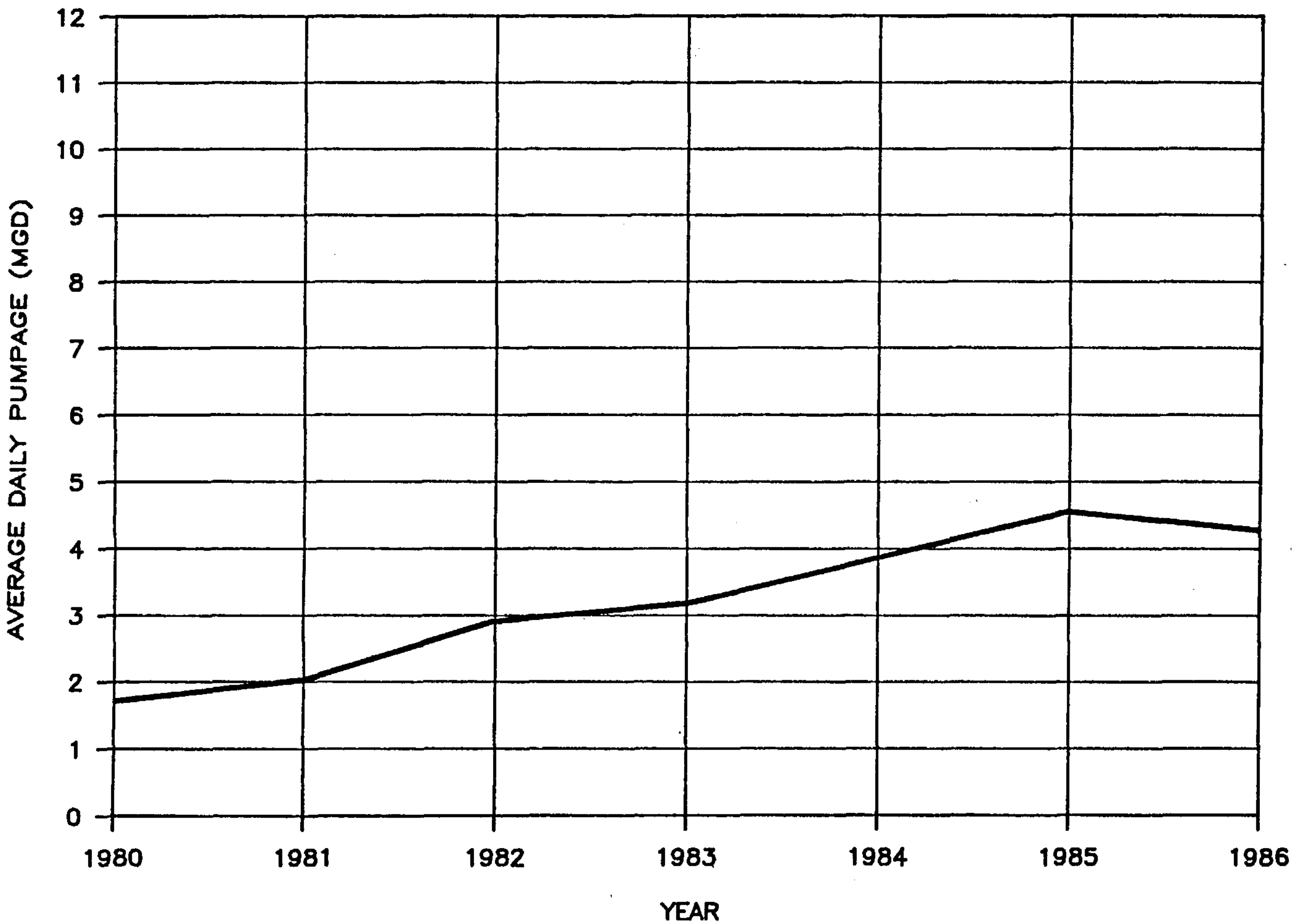


FIGURE 8
(CONT.)
HISTORIC GROUNDWATER PUMPAGE
IN MDA 26W

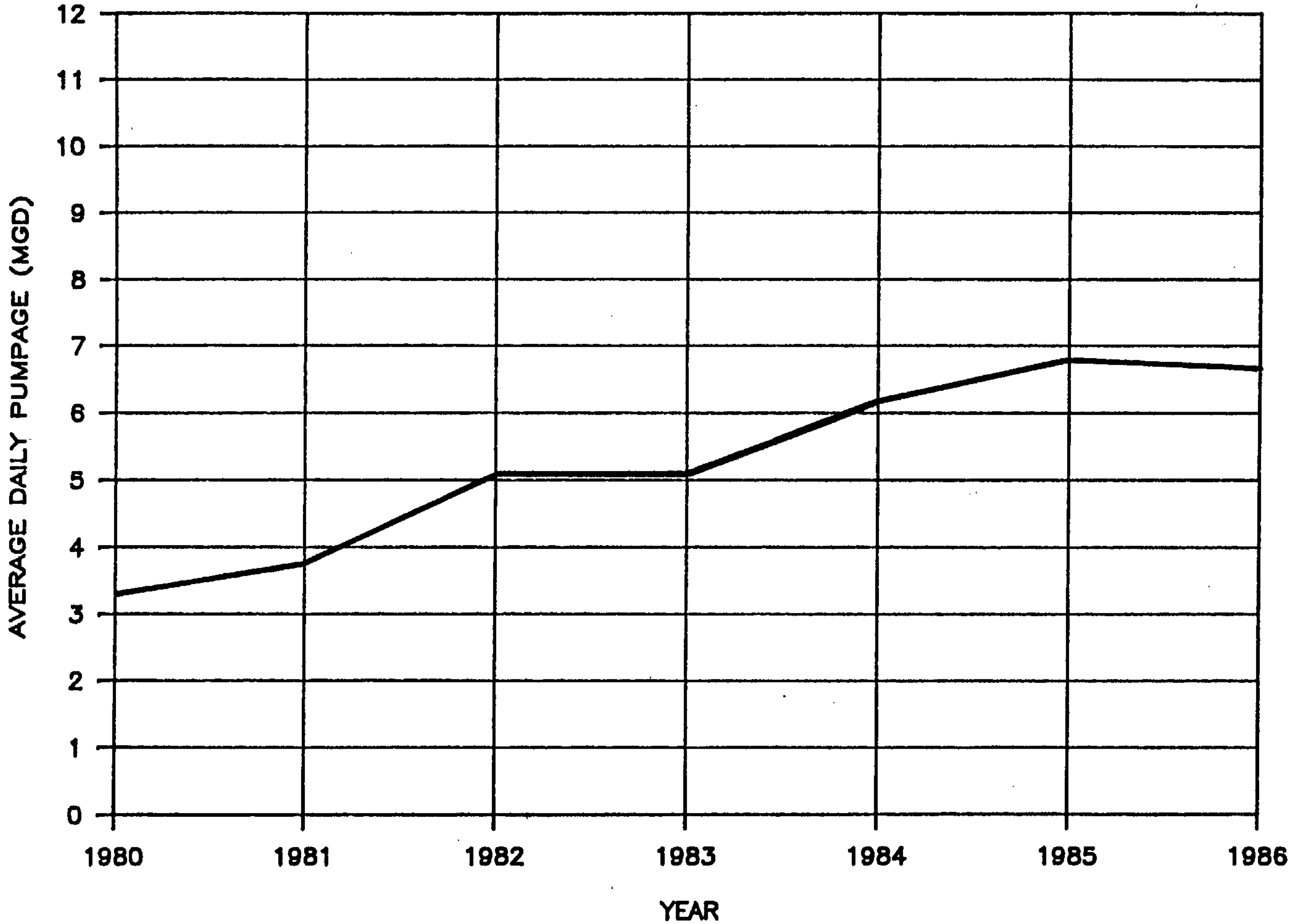


FIGURE 8
(CONT.)
HISTORIC GROUNDWATER PUMPAGE
IN MDA 31

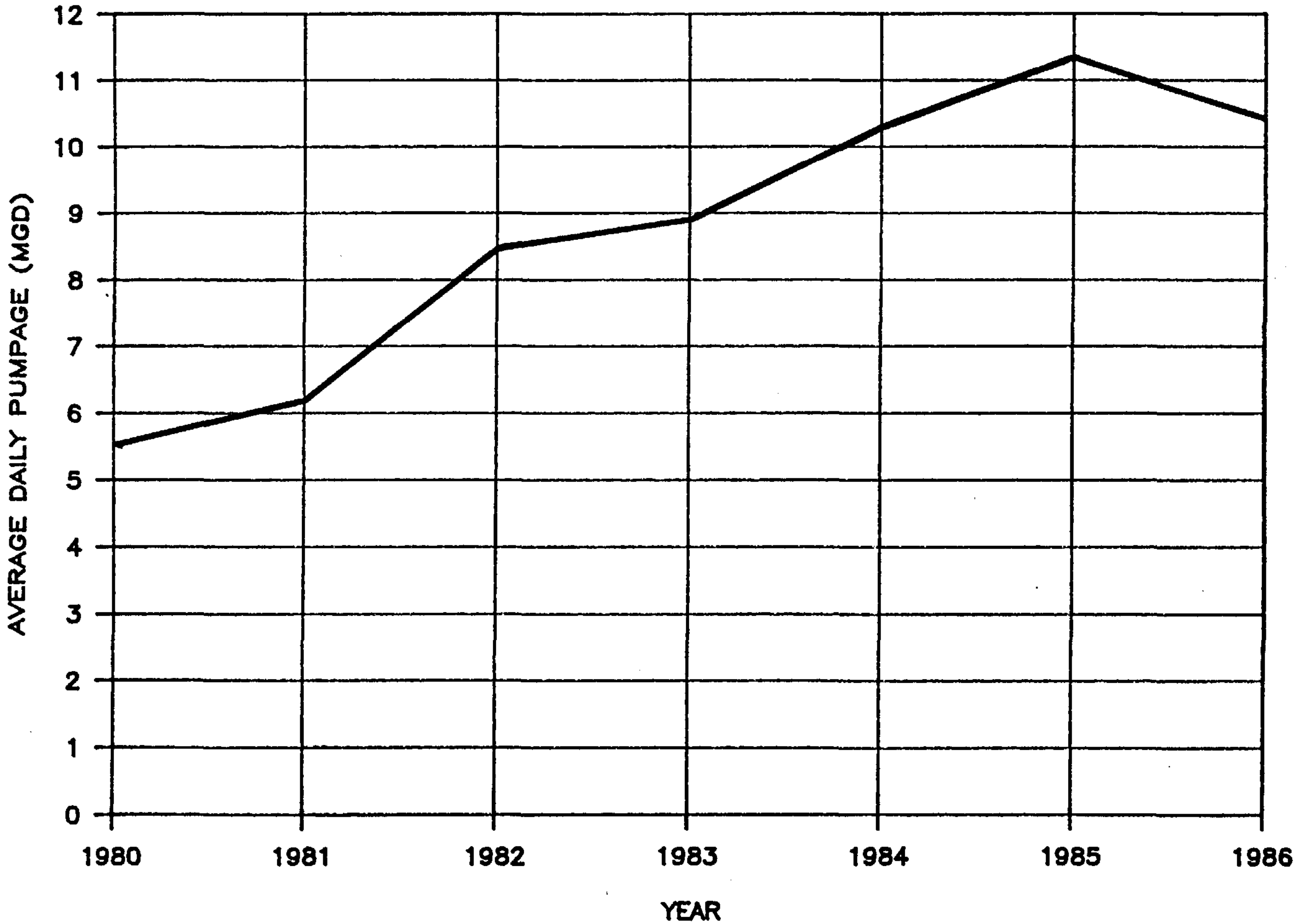


FIGURE 8
(CONT.)
HISTORIC GROUNDWATER PUMPAGE
IN MDA 32

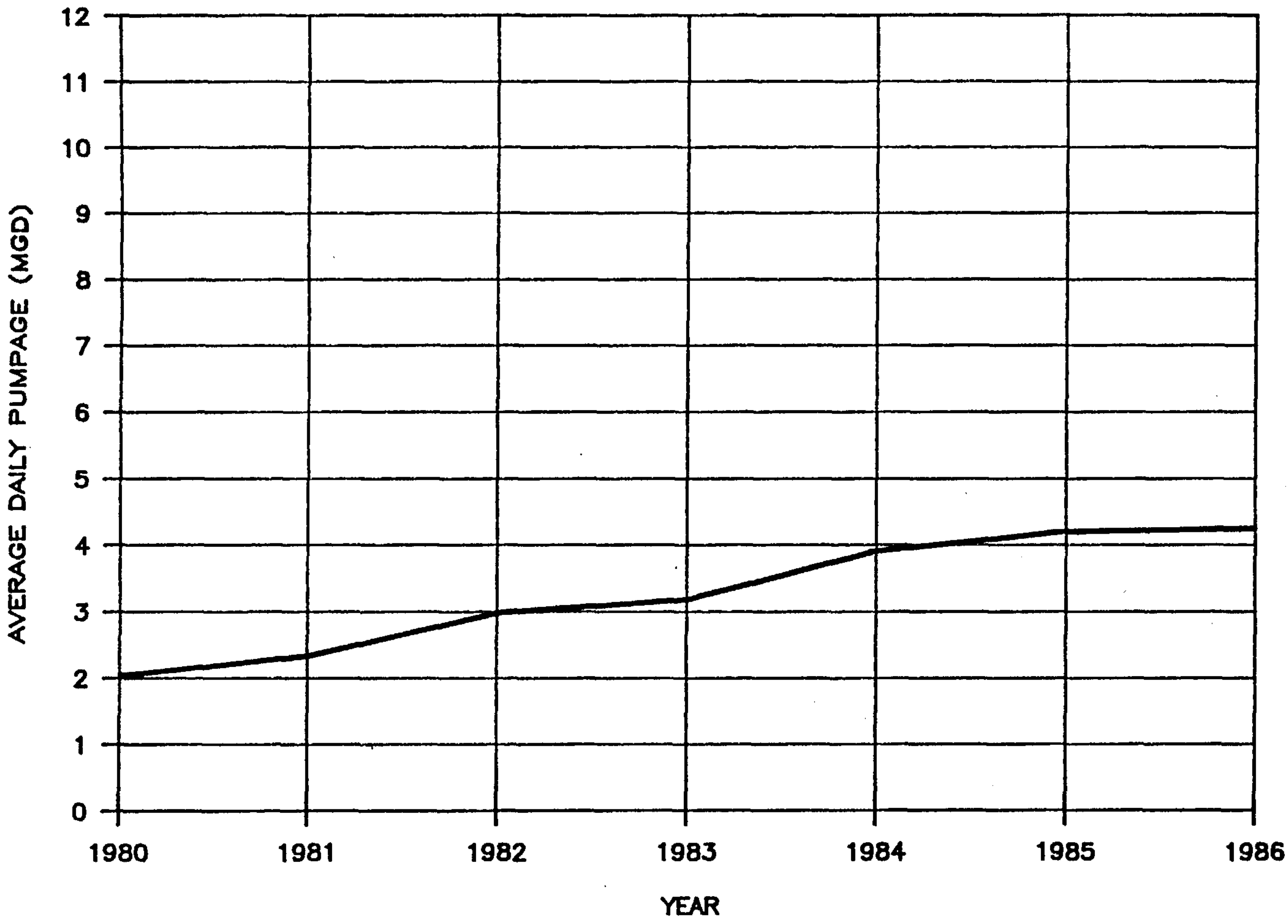
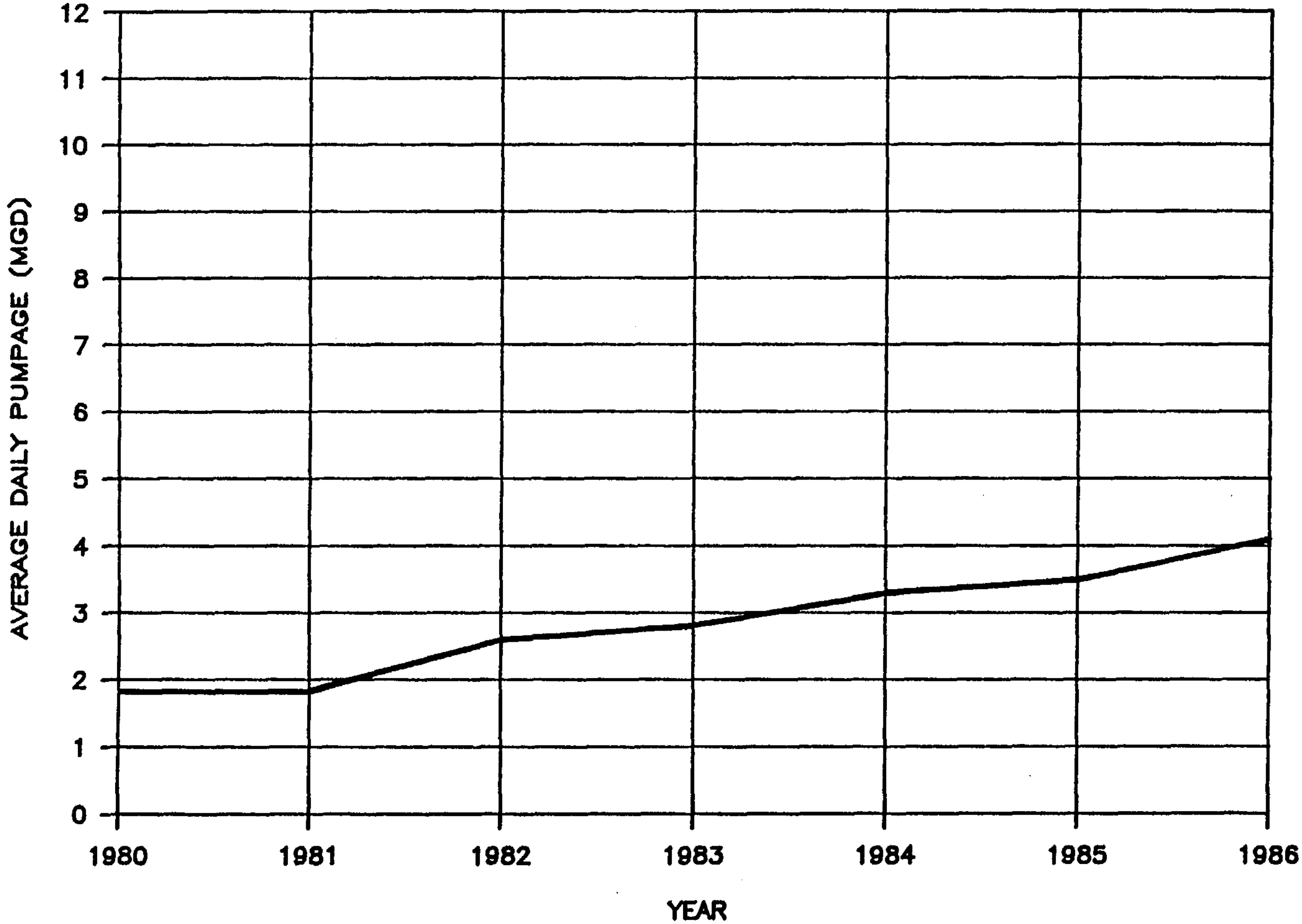


FIGURE 8
(CONT.)
HISTORIC GROUNDWATER PUMPAGE

IN MDA 33W



A complete list of industrial and commercial water users within the WHCSWSC service area cannot be compiled, but a list exists of 17 users that have well permits but are neither municipal utility districts nor cities. Of these, six are utilities providing municipal water supply. If these are eliminated, eleven industries and commercial users remain. Water pumpage trends in this group are shown on previously presented Table 5. Pumpage increased from 1980 to 1981, then fell until 1983. In 1984, water pumpage began to increase, and this continued through 1985. In 1986, water use dropped nearly to 1980 levels.

Water Usage in the City of Houston and CWA

The City of Houston serves mainly residential and commercial customers, while CWA supplies mostly industries. Table 6 shows the average daily water demands for the City of Houston and CWA and Figure 9 graphs the total demands of the two entities. During the time frame of Appendix C of the HWMP, 1980 to 1984, the total water billed by the City of Houston and by CWA varied by only 7%, so water demand was fairly steady. Combined demands peaked at 490 MGD in 1982, followed in 1983 by the low value of 453 MGD. Demand began to rise by 1984. When only the City of Houston is considered, the same pattern of increase and decrease is noted as for the combined Houston and CWA usage. However, the decline in demand in 1983 is not so severe. When CWA water demands are examined, a different sequence is observed. Beginning in 1982, demand for CWA declined, leveling off somewhat by 1984.

TABLE 6

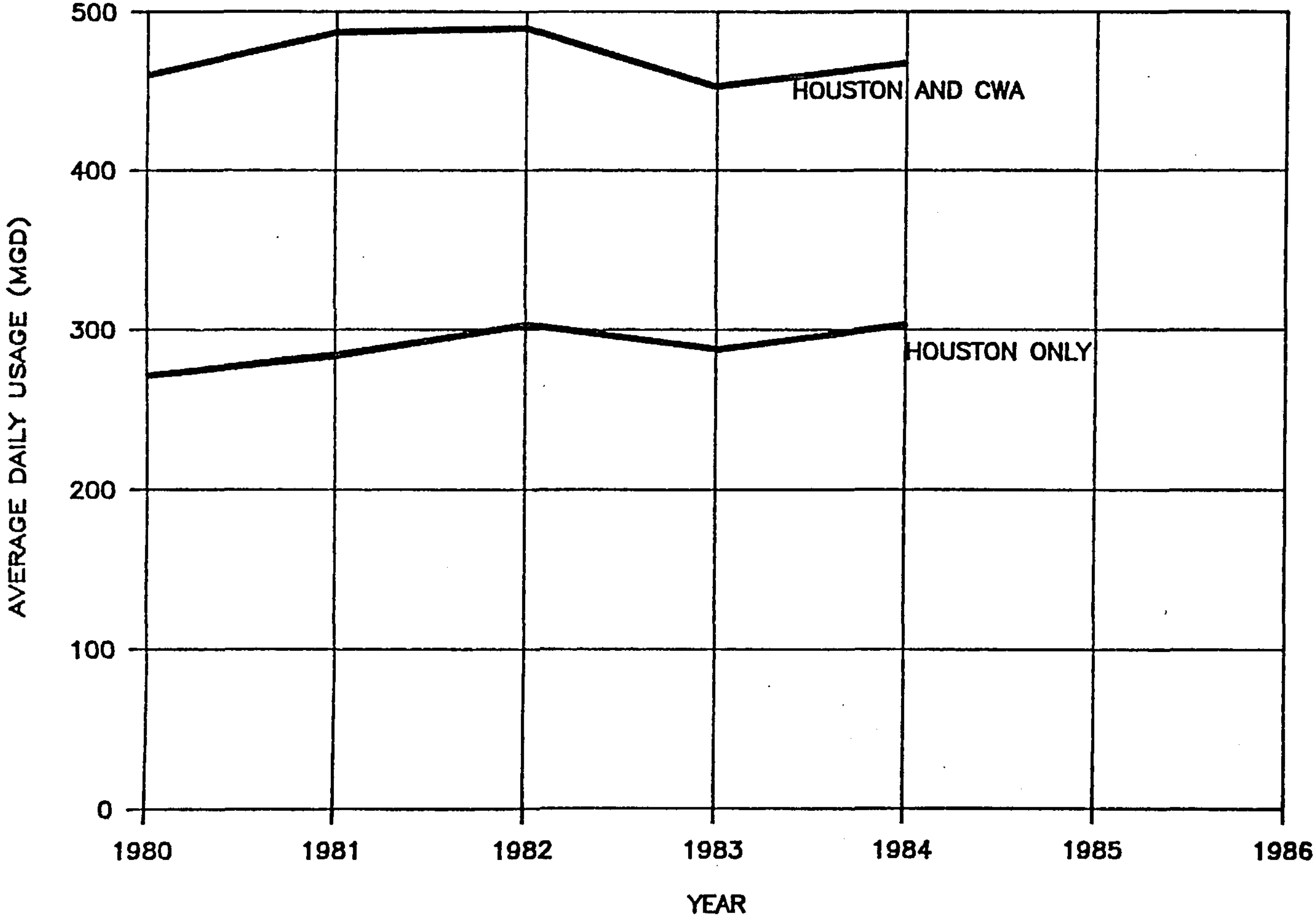
AVERAGE DAILY WATER USAGE IN HOUSTON, 1980 - 1984

	AVERAGE DAILY USAGE (MGD)				
	1980	1981	1982	1983	1984
Houston	271.31	285.08	302.96	287.36	303.24
CWA	189.96	202.88	187.34	165.68	164.48
TOTAL HOUSTON	461.27	487.96	490.30	453.04	467.72

FIGURE 9

HISTORIC WATER USAGE IN HOUSTON

BASED ON BILLING RECORDS



It is interesting to compare water demands in the City of Houston with those in the WHCSWSC study area. Since West Harris County has little heavy industry compared to the total Houston system, it might be expected that historic usage in the WHCSWSC area would more closely resemble that of Houston without CWA. A comparison of Figures 6 and 9 and of Tables 5 and 6 shows this to be true. The City of Houston use showed growth in all years except 1983. In the western region, no demand reductions occurred between 1980 and 1984. Instead, the WHCSWSC study area shows decreased demand growth in 1983. With two additional years of data for the WHCSWSC service area, it is seen that in 1986 demand actually decreased by 1.5%. However, over the seven year period, the water demand in the WHCSWSC service area increased an average of 17% annually. The City demand without CWA increased about 2.4% annually, while during the same period total City use increased by only 1% over five years.

From Appendix C of the HWMP it is evident that industrial water use suffered larger declines and experienced less growth than other uses. Although the historical WHCSWSC data on industrial and commercial users is limited, the figures on Table 5 may be compared to the CWA totals on Table 6. It is seen that years of growth and decline coincide until 1984 when CWA use held steady while WHCSWSC demands increased. From these comparisons it is clear tnat while WHCSWSC water use trends mirror those in Houston to a degree, municipal growth in the western portions of the county is faster and steadier than in the City.

Projected Water Demands

Appendix H of the HWMP gives average daily, maximum daily and peak hour water demands for each MDA at ten year intervals from 1990 to 2030. The following describes the process used to calculate projected water demands and compare them to historic data to evaluate their accuracy.

To compute projected demands, the HWMP required three separate steps. First, demand criteria in gallons per capita (or per employee) per day were determined. Inside the City of Houston, billing records for September 1984 through August 1985 were used along with 1985 populations to compute these criteria for several user categories, including single-family residential, multi-family residential, commercial and light industrial, and heavy industrial. These demand criteria are not consistent, but vary in each MDA. Next, demand criteria were assigned to the MDAs outside the city limits based on similarity of land usage. Table 7 summarizes the criteria used for the WHCSWSC MDA's. Finally, the population and employment figures from Appendix D were used as the basis of projecting total average daily water demands for each MDA. Maximum daily and peak hour demands were computed by multiplying the average daily demands by the appropriate factors.

In the MDAs outside the city limits, the accuracy of the HWMP projections depends on the assignment of correct demand criteria. Since the WHCSWSC service is entirely outside of the City of Houston, with the exception of Addicks and Barker Reservoirs, this is an important consideration. The HWMP

TABLE 7

DEMAND CRITERIA USED IN WHCSWSC PLANNING AREA

MDA	Single-Family Residential (GPCD)	Multi-Family Residential (GPCD)	Commercial and Light Industrial (GPED)	Heavy Industrial (GPED)
24	105	80	70	3500
25	100	75	70-140*	3500
26	95	75	70-140*	3500
31	105	80	70-140*	3500
32	105	80	70-140*	3500
33	105	80	70	3500

*70 GPCD in 1985, increasing linearly to 140 GPCD in 2030.

Reproduced from Appendix H, Table 3-1 of the HWMP.

made no comparisons with existing water use for the outer MDAs. Therefore, groundwater pumpage records from 1980 to 1986 were checked against the HWMP projections in this study. Direct comparison of the average daily water demand projections developed in Appendix H of the HWMP with groundwater pumpage records in the WHCSWSC service area is not possible for two reasons. First, four of the MDAs used in the HWMP did not fall completely within the planning boundaries of the WHCSWSC; namely, MDAs 24, 25, 26 and 33. Second, the water useage projections used in the HWMP did not include losses (unaccounted-for water).

Both data inconsistencies were addressed so that the accuracy of the HWMP projections could be checked. In order to apply the water demand projections in Appendix H of the HWMP to the partial MDAs, the total demand for a given MDA was split based on the census tracts shown on previously presented Table 4. For each WHCSWSC MDA, the water demands for the included census tracts were multiplied by the percentage of the tract area in the MDA and added to yield a total MDA water demand. Adjustments were made to the WHCSWSC pumpage data in order to estimate water usage. Billed versus pumped information in 1986 for 79 utility districts in the planning area was obtained from district water plant operators. Average losses of 17% were computed from this data. Groundwater pumpages for the entire study period were reduced by 17% for comparison to the HWMP water usages. Table 8 gives the historic and projected data, while Figure 10 shows it graphically. The historic and projected data overlapped in 1985 and 1986. Table 9 compares the historic usage to the projected for these years. Note that the estimated historic water use is lower than the projected water use in half of the MDAs. This is

TABLE 8

HISTORIC AND PROJECTED AVERAGE DAILY WATER USAGE BY MDA

	MDA 24W		MDA 25W		MDA 26W	
YEAR	HISTORIC USAGE (MGD)	PROJECTED USAGE (MGD)	HISTORIC USAGE (MGD)	PROJECTED USAGE (MGD)	HISTORIC USAGE (MGD)	PROJECTED USAGE (MGD)
1980	1.47		1.41		2.74	
1981	2.12		1.68		3.12	
1982	3.44		2.42		4.22	
1983	3.59		2.64		4.22	
1984	4.59		3.21		5.12	
1985	4.96	4.38	3.79	5.48	5.64	6.95
1986	5.08	4.58	3.56	5.69	5.53	7.18
1990		5.39		6.52		8.11
2000		8.34		9.49		12.11
2010		9.79		12.20		16.23
2020		9.86		14.53		18.28
2030		9.59		15.94		20.63

	MDA 31		MDA 32		MDA 33W	
YEAR	HISTORIC USAGE (MGD)	PROJECTED USAGE (MGD)	HISTORIC USAGE (MGD)	PROJECTED USAGE (MGD)	HISTORIC USAGE (MGD)	PROJECTED USAGE (MGD)
1980	4.57		1.68		1.52	
1981	5.14		1.93		1.53	
1982	7.02		2.48		2.17	
1983	7.37		2.65		2.34	
1984	8.53		3.25		2.74	
1985	9.40	8.37	3.49	4.09	2.90	2.99
1986	8.62	8.96	3.53	4.40	3.39	3.11
1990		11.32		5.64		3.61
2000		21.53		9.37		6.06
2010		32.98		14.30		8.76
2020		42.47		18.92		10.60
2030		53.86		24.47		11.84

NOTE: Historic water usages computed based on average 1986 losses. 1986 projected usages determined by straight-line interpolation.

FIGURE 10

AVERAGE WATER USAGE IN MDA 24W

HISTORIC AND PROJECTED

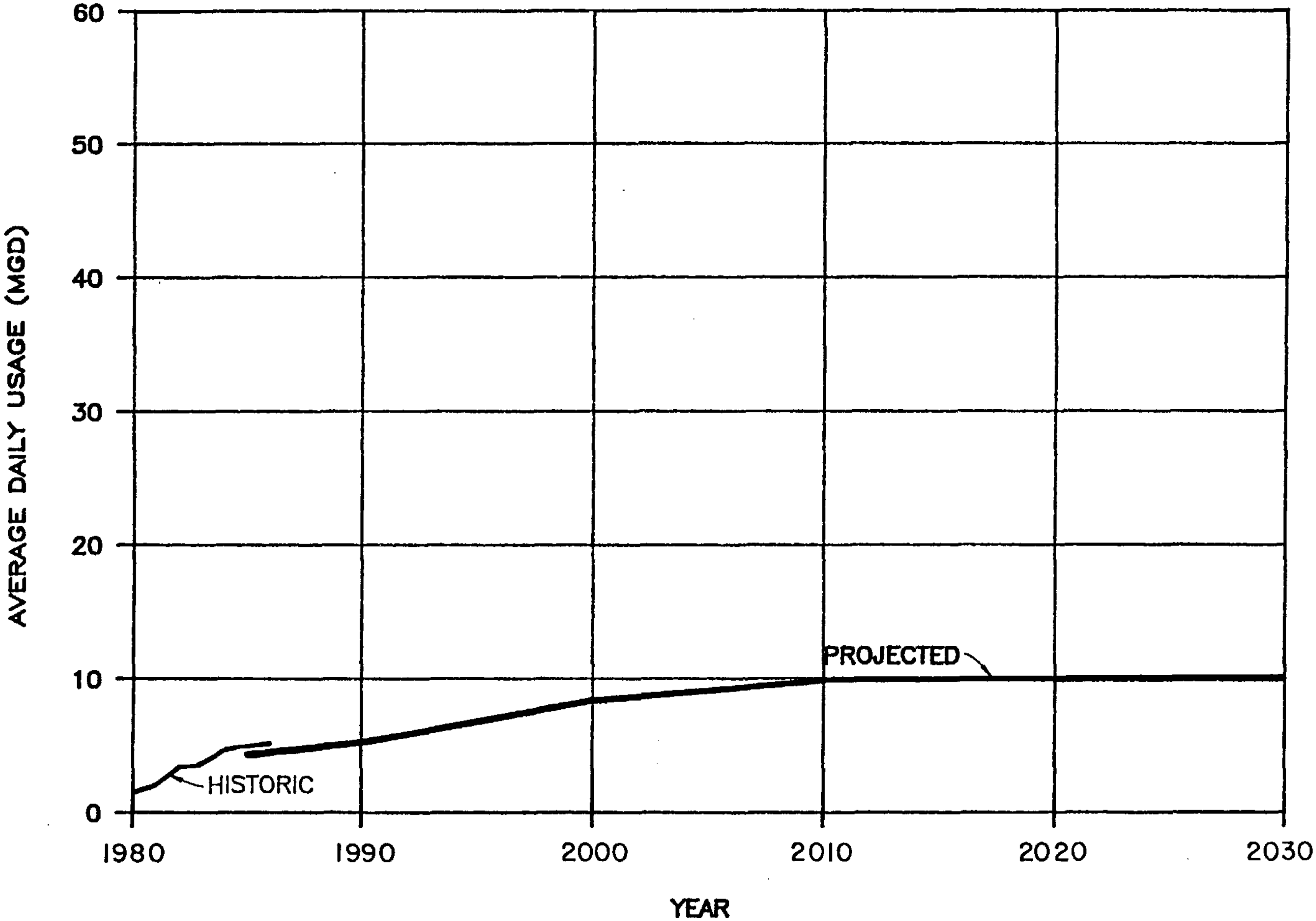


FIGURE 10
(CONT.)
AVERAGE WATER USAGE IN MDA 25W

HISTORIC AND PROJECTED

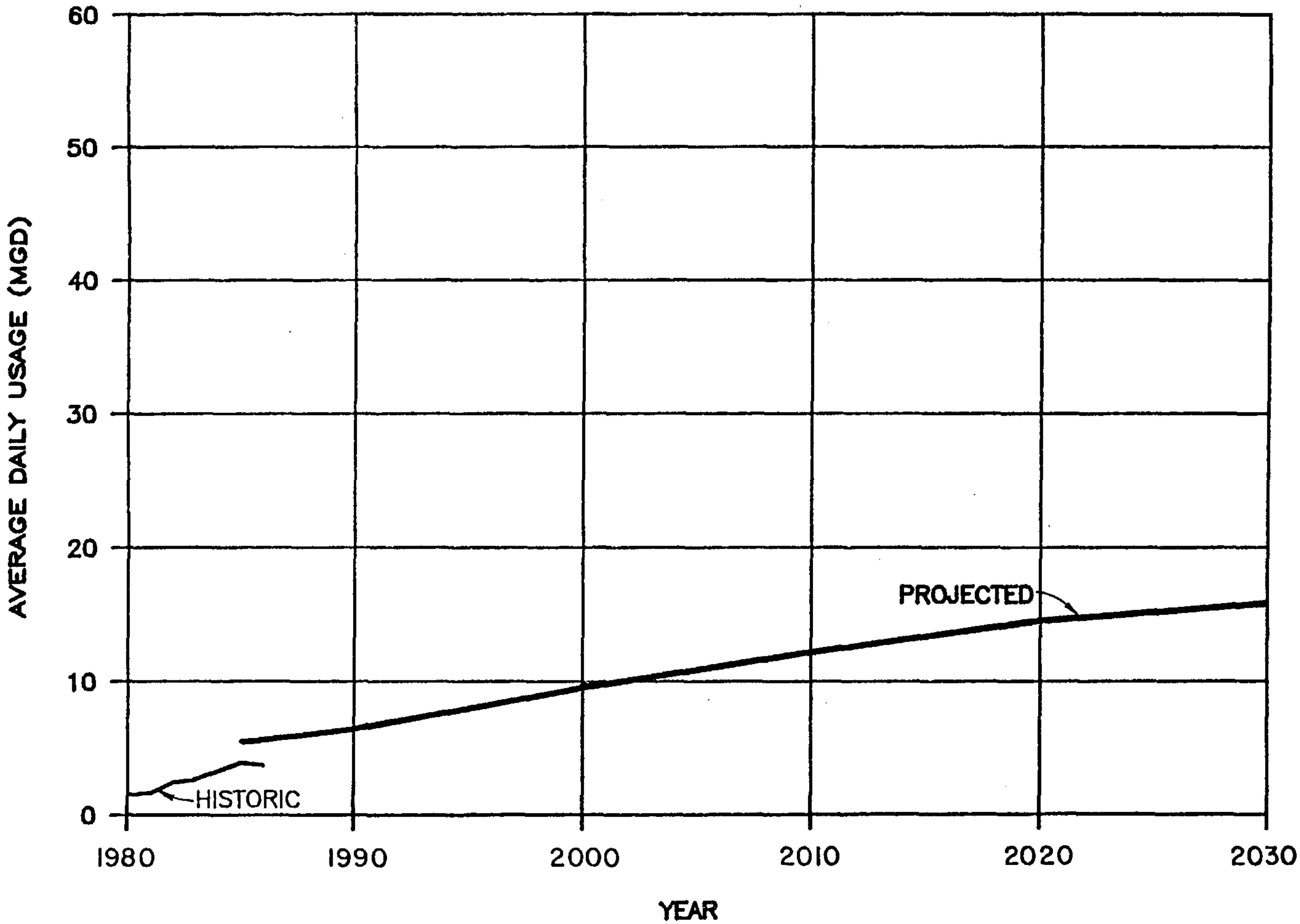


FIGURE 10
(CONT.)
AVERAGE WATER USAGE IN MDA 26W
HISTORIC AND PROJECTED

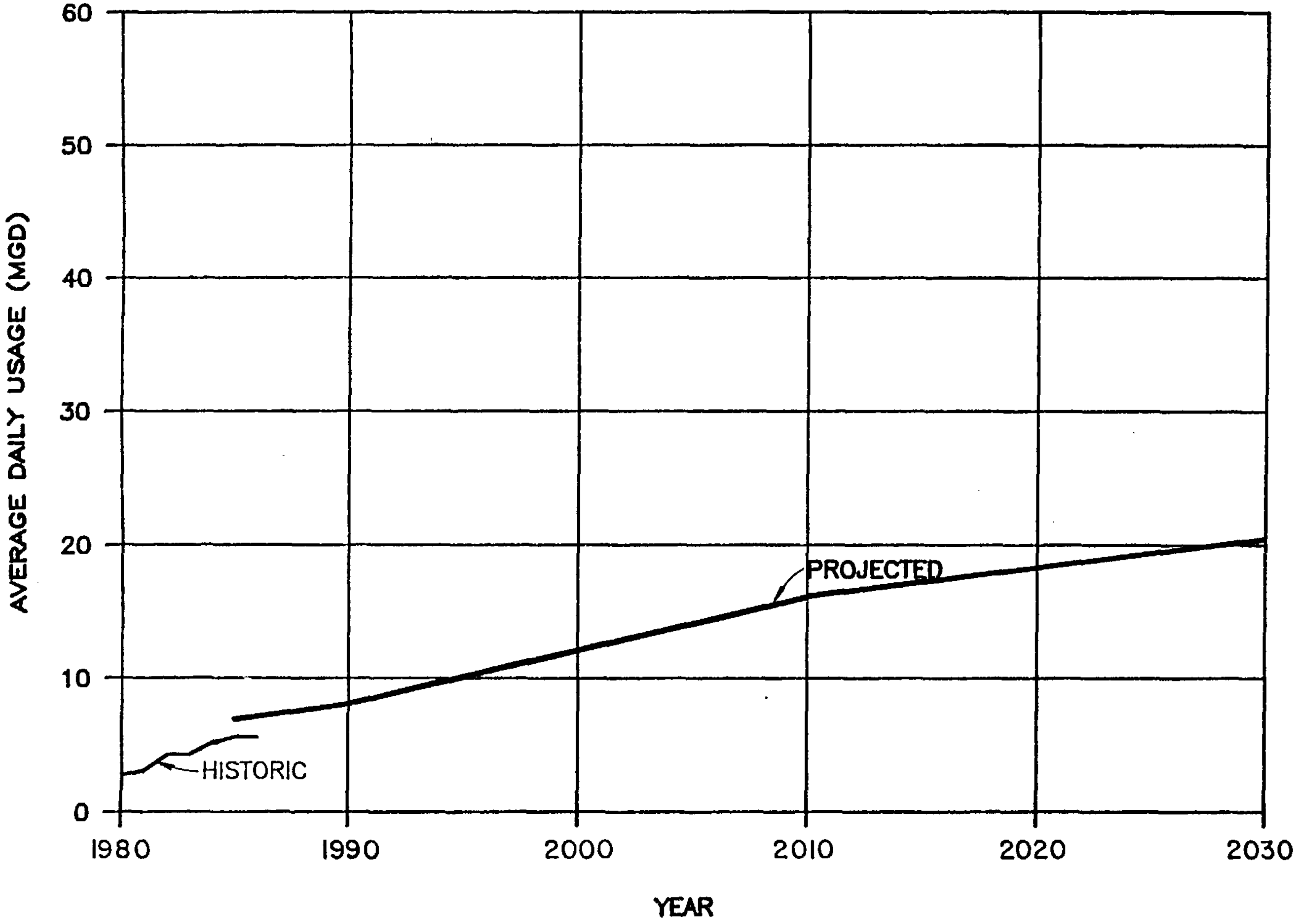


FIGURE 10
(CONT.)
AVERAGE WATER USAGE IN MDA 31

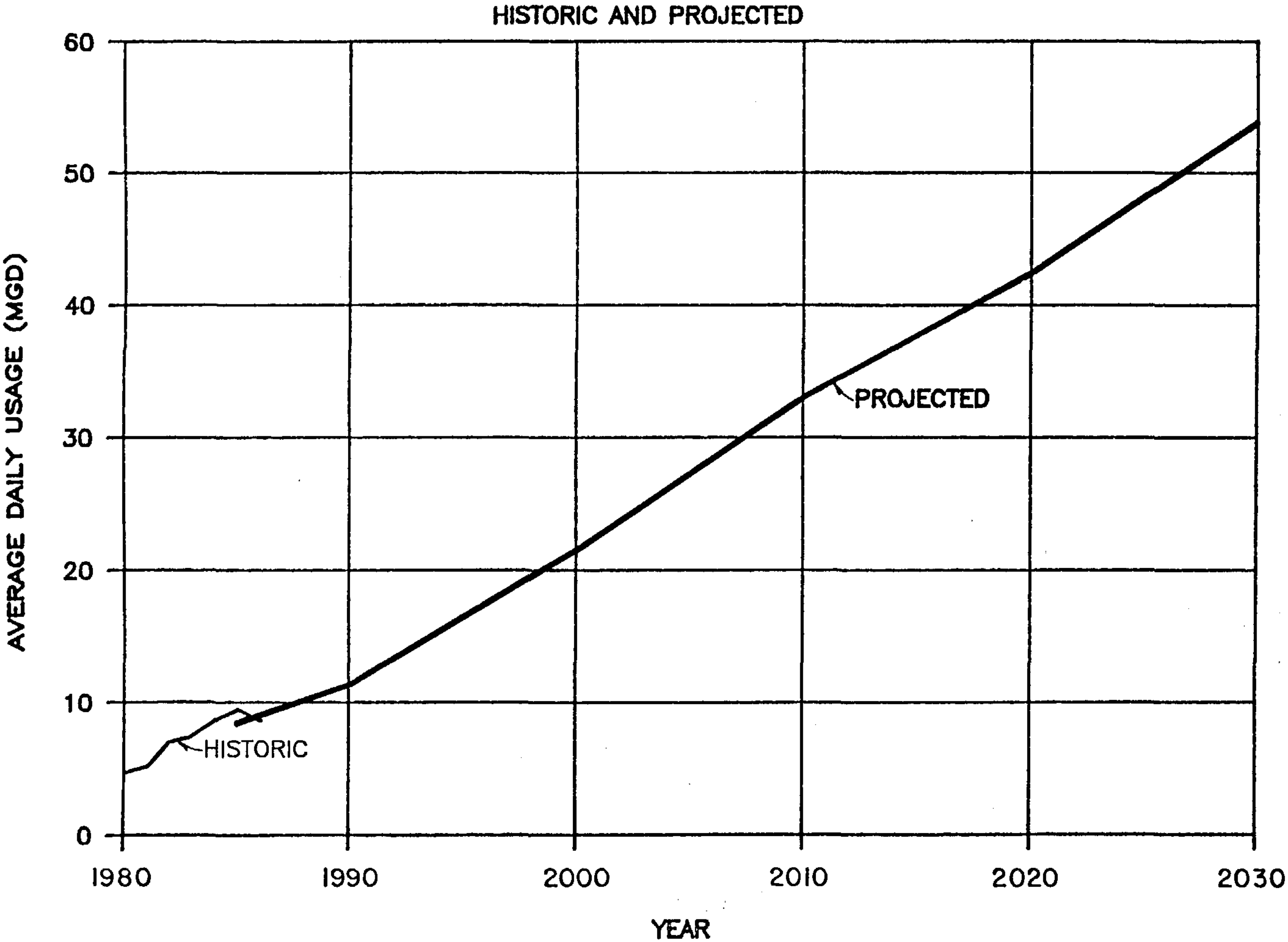


FIGURE 10
(CONT.)
AVERAGE WATER USAGE IN MDA 32
HISTORIC AND PROJECTED

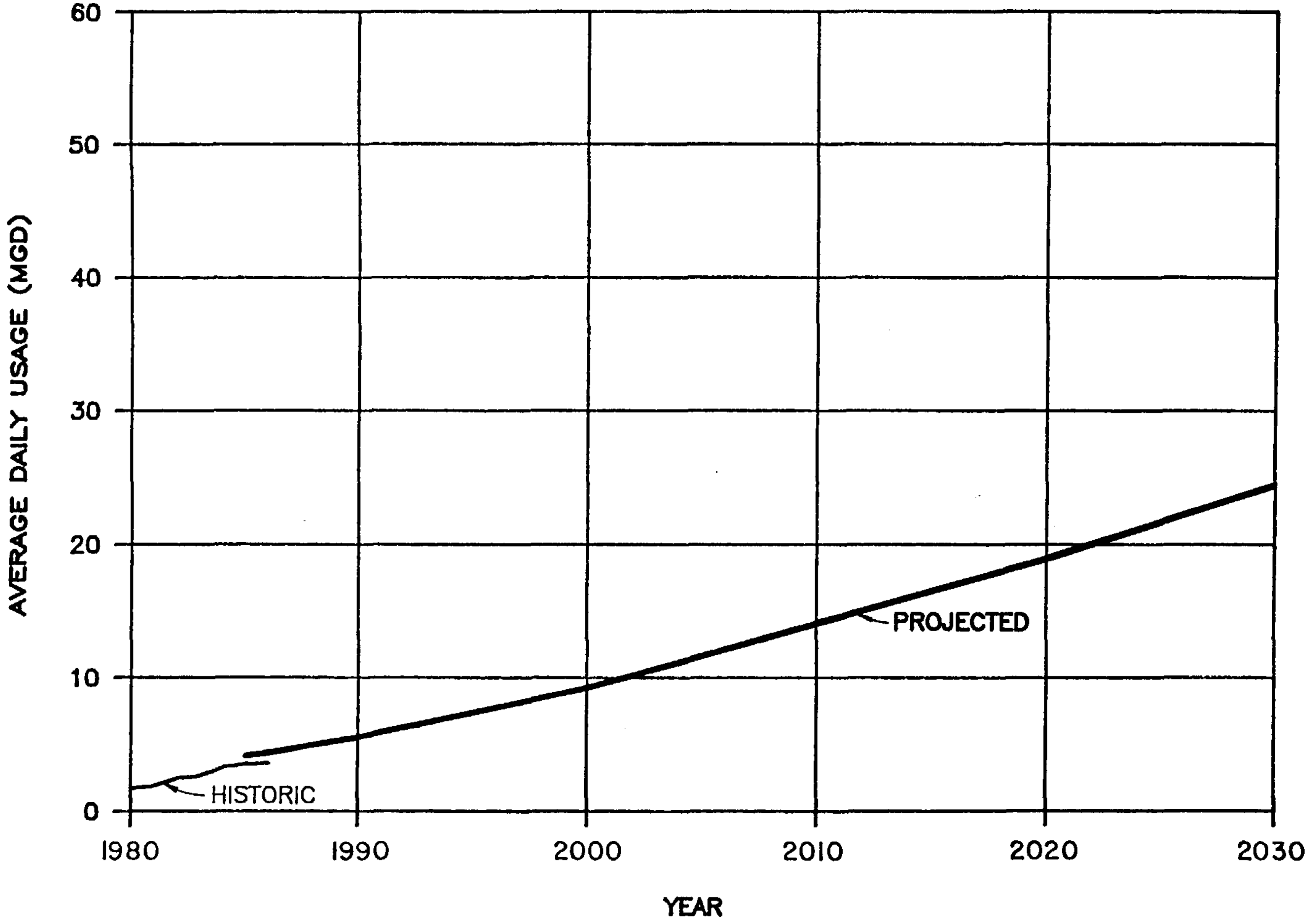


FIGURE 10
(CONT.)
AVERAGE WATER USAGE IN MDA 33W
HISTORIC AND PROJECTED

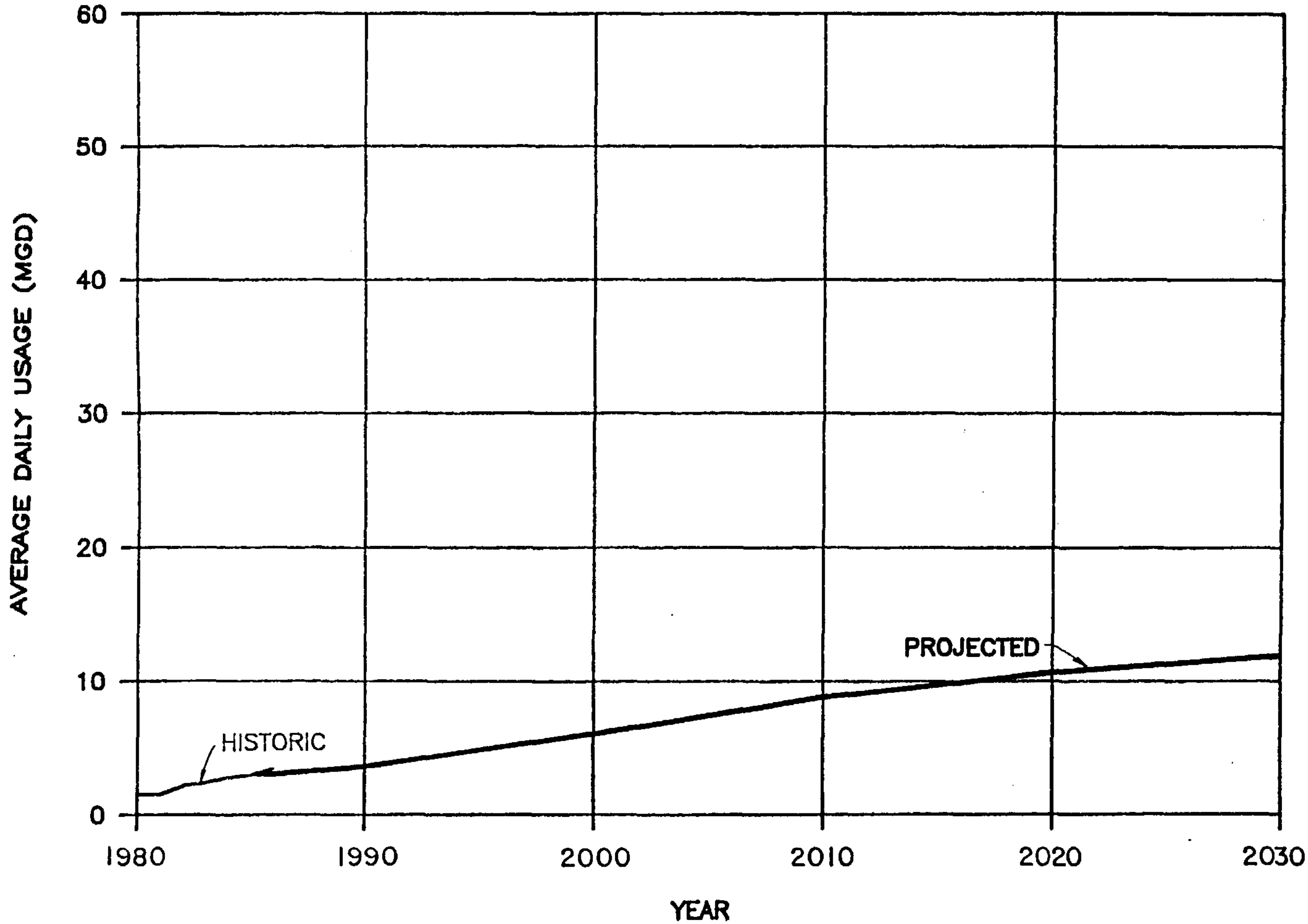


TABLE 9

COMPARISON OF HISTORIC TO PROJECTED WATER USE, 1985 - 1986
(AVERAGE DAILY USAGE)

	ACTUAL DIFFERENCE IN HISTORIC USE FROM PROJECTED USE (MGD)			PERCENT DIFFERENCE IN HISTORIC USE FROM PROJECTED USE (%)		
MDA	1985	1986	AVG	1985	1986	AVG
24W	0.58	0.50	0.54	13.1	10.9	12.0
25W	-1.69	-2.13	-1.91	-30.8	-37.4	-34.1
26W	-1.31	-1.65	-1.48	-18.9	-23.0	-21.0
31	1.03	-0.34	0.35	12.3	- 3.8	4.2
32	-0.60	-0.87	-0.74	-14.8	-19.8	-17.3
33W	-0.09	0.28	0.10	-3.1	9.0	2.9

(-) Negative number indicates historic usage less than projected usage.

to be expected, considering that pumpage from wells smaller than five inches in diameter, agricultural wells, and commercial wells with annual pumpage less than three million gallons was excluded. Three MDAs have estimated water usage greater than projected, but the differences are small, 0.1 to 0.5 mgd, on the average. Examination of the graphs in Figure 10 reveals that the HWMP projections appear to be reasonable extensions of the historic water use. It should be mentioned that a best-fit line passed through the plot of historic data would fall above the HWMP projections for all MDAs except MDA 32 and 33W. In other words, the HWMP predicts rates of water demand growth slower than the historic rates for MDAs 24W, 25W, 26W, and 31. However, the estimated historic water usage data supports the HWMP projections overall and justifies the use of the higher growth scenario as presented in Appendix D of the HWMP. This also indicates that demand criteria were accurately assigned to the six WHCSWSC MDAs and that the supply system for the area may safely be planned using the HWMP water demand projections.

Using computed demands for residential, commercial and industrial user categories, the HWMP presents per capita average daily demands. These were obtained by dividing total demand for a category by total population in the eight county study area. Although they were not used by the HWMP to calculate total demands, it is interesting to consider them. For residential and commercial demands combined, per capita demands of 140-146 GPCD were reported. When industrial water demands were included, per capita figures rose to 243-254 GPCD. However, these amounts apply to a large region, not specifically to any area.

Per capita figures were computed for each of the six MDAs overlapping the WHCSWSC study area throughout the study period. This was accomplished by dividing the total MDA average daily demand by its projected population. The results are given on Table 10. Note that since the HWMP does not provide a breakdown of total demand by user categories, only the total per capita demand could be computed. These average 121-135 GPCD, much lower than the total per capita demands computed by the HWMP and somewhat lower than even the combined residential and commercial per capita demands given by the HWMP. Since there is not a great deal of heavy industry in the WHCSWSC supply area, the per capita values would not be expected to be as high as the totals including industrial for the entire eight county region.

The HWMP used maximum day demands to size required water supply systems, and the WHCSWSC study uses the same criterion. Projected maximum daily demands for the study period are found in Table 11. The maximum demands for the four partial MDAs were computed by adding the maximum daily demands of the included census tracts. The HWMP computed the maximum daily demands for each tract by multiplying the average daily demand for each census tract by a peak day factor. This factor was constant for each individual MDA and varied between MDAs depending on the amount of the average daily demand for the entire MDA. The source of the peak day factor was a regression curve based on data from numerous cities and utility districts, which showed that the peak day factor decreases with increasing average daily demand. In the WHCSWSC study area, this factor ranges from about 1.6 to 2.0, decreasing through time. For instance, in MDA 24W, the average daily demands computed

TABLE 10

COMPUTATION OF AVERAGE DAILY PER CAPITA DEMANDS

	MDA 24	MDA 25	MDA 26	MDA 31	MDA 32	MDA 33	TOTAL
1985							
Avg. Daily Use (MGD)	23.51	5.77	11.31	8.37	4.09	3.33	56.38
Population	190693	25292	93899	68466	32630	30096	441076
Per Capita Use (GPD)	123	228	120	122	125	111	128
1990							
Avg. Daily Use (MGD)	27.42	6.85	12.85	11.32	5.63	4.04	68.11
Population	240618	36843	114334	86863	44183	38741	561582
Per Capita Use (GPD)	114	186	112	130	127	104	121
2000							
Avg. Daily Use (MGD)	35.74	9.93	18.01	21.53	9.38	6.81	101.40
Population	306423	61514	162651	164001	72338	64880	831807
Per Capita Use (GPD)	117	161	111	131	130	105	122
2010							
Avg. Daily Use (MGD)	40.93	12.76	23.05	32.98	14.30	9.91	133.93
Population	344035	81880	207517	244850	105724	94016	1078022
Per Capita Use (GPD)	119	156	111	135	135	105	124
2020							
Avg. Daily Use (MGD)	42.56	15.22	25.53	42.47	18.94	12.11	156.83
Population	352391	96030	224689	303252	131356	114279	1221997
Per Capita Use (GPD)	121	158	114	140	144	106	128
2030							
Avg. Daily Use (MGD)	42.61	16.80	28.24	53.86	24.46	13.82	179.79
Population	344915	99475	241381	360673	159029	128758	1334231
Per Capita Use (GPD)	124	169	117	149	154	107	135

TABLE 11

PROJECTED MAXIMUM DAILY WATER USAGE BY MDA

MDA	MAXIMUM DAILY USAGE (MGD)					
	1985	1990	2000	2010	2020	2030
24W	7.52	9.28	14.36	16.83	16.97	16.50
25W	10.52	12.51	18.23	22.08	26.30	28.86
26W	12.48	14.56	21.80	27.81	31.30	35.32
31	16.05	20.50	37.04	56.71	73.20	86.20
32	8.34	10.80	18.02	25.89	34.28	42.08
33W	6.12	7.36	11.65	16.84	19.21	21.44
TOTAL WHCSWSC	61.03	75.01	121.10	166.16	201.26	230.40

remain relatively steady throughout the study period, and the peak day factor stays about 1.7. In MDA 31, where explosive growth was predicted, the peak day factor decreases from 1.9 to 1.6 from 1985 to 2030. It is important to observe that even the lowest peak day factor results in a maximum day water supply that is more than adequate to meet average daily demands plus estimated losses of 15% to 20%.

Overall, the estimated historic water usage data supports the HWMP projections. Therefore, planning for the WHCSWSC supply system utilized the HWMP projections of maximum daily water usage.

3.0 SURFACE WATER SUPPLY

3.0 SURFACE WATER SUPPLY

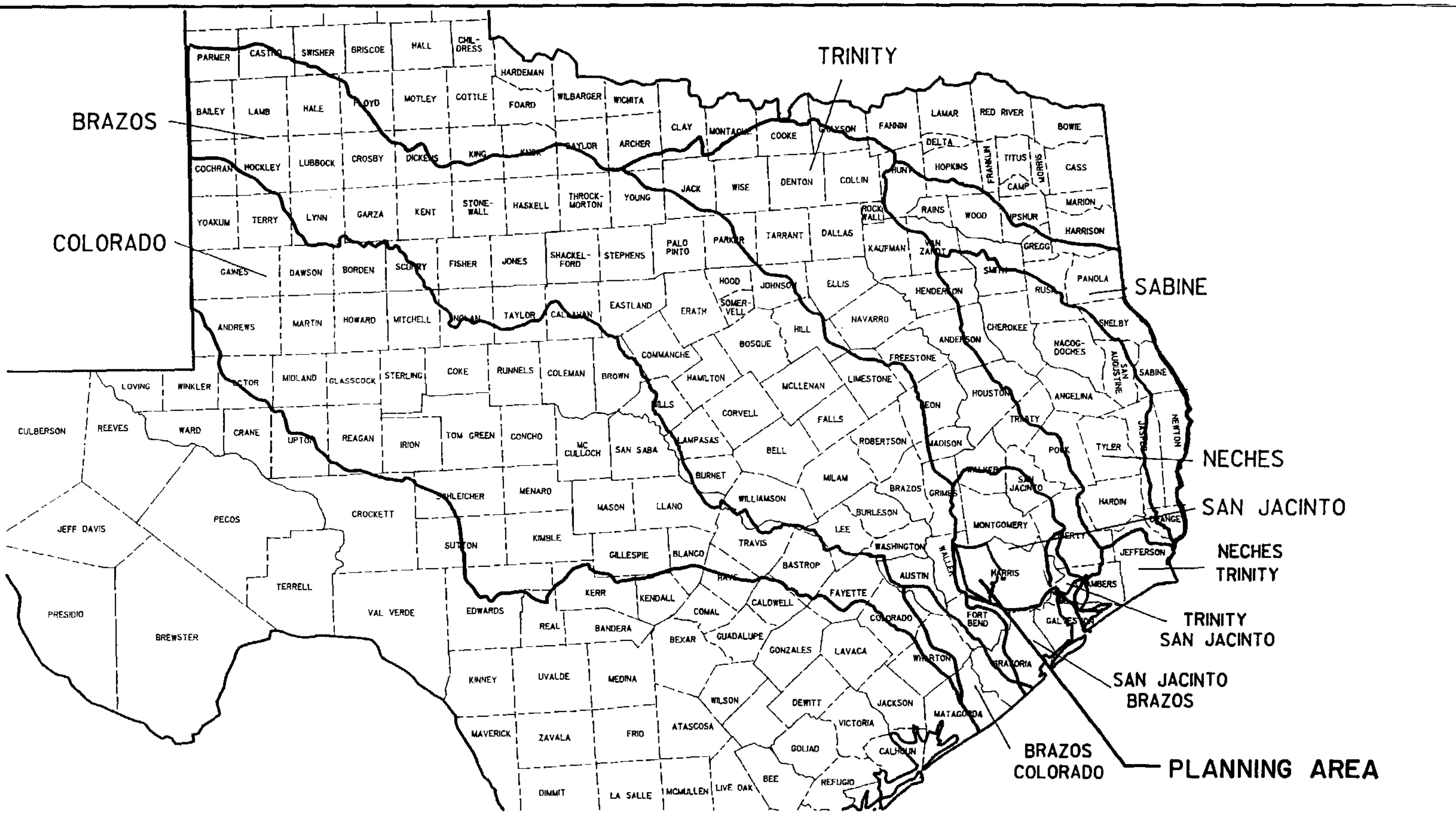
Area River Basins

Numerous surface water supply sources are potentially available for use by the WHCSWSC. Three river basins: namely, the Brazos River Basin, the Trinity River Basin and the San Jacinto River Basin; along with two coastal basins, the Trinity-San Jacinto Coastal Basin and the San Jacinto-Brazos Coastal Basin, are in close proximity to the planning area as shown on Figure 11. The WHCSWSC planning area is located within the San Jacinto River Basin which is situated in the upper Gulf Coast region. The San Jacinto River Basin is bounded on the north and northeast by the Trinity River Basin and on the southeast by the Trinity-San Jacinto Coastal Basin. The San Jacinto-Brazos Coastal Basin borders the basin on the south, and on the west it is bordered by the Brazos River Basin. The major rivers and reservoirs within these basins are shown on Figure 12.

San Jacinto River Basin

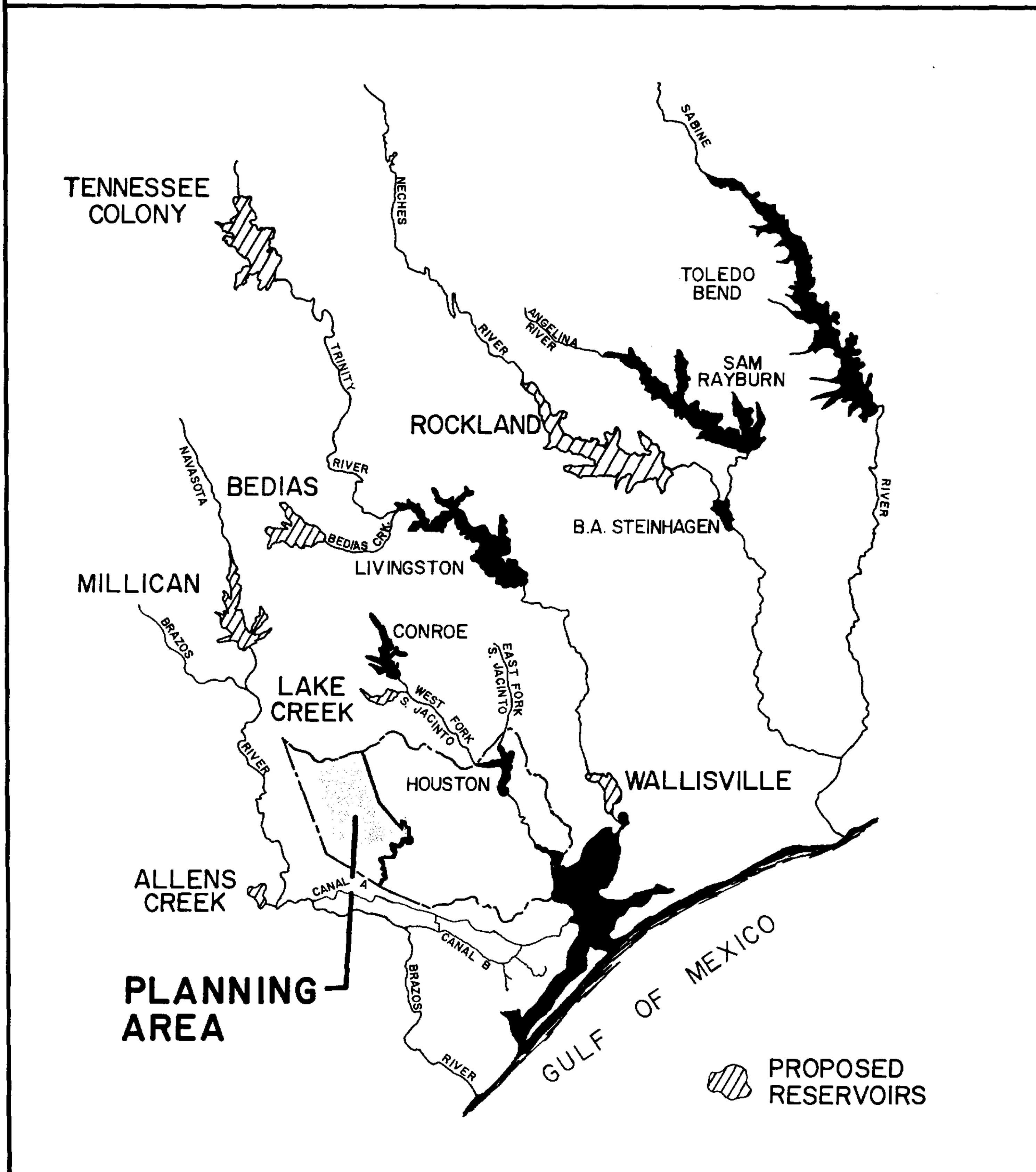
The San Jacinto River Basin is approximately 85 miles long with an average width of 50 miles. In Harris County, the east and west forks of the river converge to form Lake Houston. The San Jacinto River discharges into the upstream end of the Houston Ship Channel. The total drainage area of the San Jacinto River Basin is approximately 5600 square miles.

FIGURE 11



WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION
PLANNING AREA RIVER BASINS

FIGURE 12



WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION

PLANNING AREA – RIVERS & RESERVOIRS

Physical and chemical quality of the water within the basin is quite good based on water quality characteristics of the two existing reservoirs, Lake Conroe and Lake Houston. As the San Jacinto River flows downward to the Ship Channel, the water quality is poorer due to industrial and sewage treatment plant discharges. The San Jacinto River Authority (SJRA) is a co-owner of Lake Conroe along with the City of Houston and the Texas Water Development Board. The SJRA also owns water rights in Lake Houston equal to the low flow yield of the San Jacinto River at the Lake Houston dam site prior to its construction in 1952. The City of Houston owns and operates Lake Houston. The two existing reservoirs, Lake Conroe and Lake Houston, have an available yield of 100,600 acre-feet (90 MGD) and 199,300 acre-feet (178 MGD) respectively. Table 12 is a summary of water rights and available water in the San Jacinto River Basin. One additional smaller reservoir, Lake Creek, is proposed south of Lake Conroe with an estimated safe yield of approximately 55,100 acre-feet per year (48 MGD).

Trinity River Basin

The Trinity River Basin covers all or parts of 37 counties including the Dallas-Fort Worth area. The total drainage area of the basin is approximately 18,000 square miles. Bedias Creek and the Trinity River converge to form Lake Livingston, approximately 50 miles north of the City of Houston. The general overall quality of water in the Trinity River Basin is good. The quality of water in Lake Livingston has been a concern in the past because of the effluent dominated upstream watercourses;

TABLE 12

SAN JACINTO RIVER BASIN WATER RIGHTS AND AVAILABLE WATER

	TOTAL PERMITS (MGD)	ALLOCATED (MGD)	UNCOMMITTED (MGD)	AVAILABLE YIELD (MGD)	
Lake Conroe	90				
City of Houston		59	0	59	90
SJRA		22	9	31	
Lake Houston	199				
City of Houston		150	0	129*	178
SJRA		49	0	49	
				268 MGD	

*Estimated safe yield.

however, measures are underway to improve the river basin quality through improvements to area wastewater treatment plants. The southern portion of the Trinity River Basin is affected by salt water intrusion from the Gulf of Mexico during periods of low flow. Flushing water is periodically released from Lake Livingston to minimize this problem. The Trinity River Authority (TRA) owns 30% of the water rights in Lake Livingston with the City of Houston owning the remaining 70%.

Lake Livingston total storage capacity is 1,750,000 acre-feet (1563 MGD) with a safe yield of approximately 1,538,000 acre-feet (1374 MGD). The actual available yield for municipal use is complicated due to fixed downstream water rights obtained prior to construction of the reservoir in 1968 and the need to release water to control upstream salt water intrusion during periods when water is being withdrawn from the reservoir for irrigation. Table 13 is a summary of water rights and available water in the Trinity River Basin. Two smaller reservoirs are proposed in the area - Bedias Reservoir with an estimated yield of 109,758 acre-feet (98 MGD) and Wallisville Reservoir with an estimated yield of 89,600 acre-feet (80 MGD).

TABLE 13

TRINITY RIVER BASIN WATER RIGHTS AND AVAILABLE WATER

	TOTAL PERMITS (MGD)	ALLOCATED (MGD)	SALTWATER INTRUSION CONTROL (MGD)	UNCOMMITTED (MGD)	AVAILABLE YIELD (MGD)
Lake Livingston	1,374				
City of Houston		806	-126	0	680 *
TRA		314	-54	0	260 *
Downstream Commitments					
Dayton Canal Company		35	0	0	35
Chambers-Liberty Co. Navigation District		127	0	0	127
Denvers Canal System		52	0	0	52
Barbers Hill Canal		40	0	0	40
					1194

*A combined total of 180 MGD is required to control saltwater intrusion.

Brazos River Basin

The Brazos River Basin is the second largest river basin in the state with a total drainage area of 45,573 square miles. The basin is over 600 miles long and varies in width from 110 miles around Waco to only about 1 mile at its mouth at the Gulf of Mexico. The quality of water in the Brazos River Basin varies considerably along the extent of the basin. The water available to the Harris County area is of lower quality than water from either the San Jacinto or Trinity River Basins. Currently, there are no existing reservoirs adjacent to the WHCSWSC study area. Future plans call for a proposed reservoir on the Navasota River, Lake Millican. Safe yield of Lake Millican has been estimated to be 252,000 acre-feet (225 MGD). Allen's Creek Reservoir, originally proposed by HL&P as a cooling water supply, is also planned on the Brazos River. This smaller reservoir will have an estimated safe yield of 75,000 acre-feet (67 MGD). The Brazos River Authority (BRA) has permits for the diversion of 236,936 acre-feet (212 MGD) from the Brazos River through two canals called Canal A and Canal B. Municipal, industrial and irrigation commitments total 164 MGD, leaving 48 MGD presently uncommitted.

Northeast Supply System

Northeast Water Purification Plant

The City of Houston has indicated that their intentions are to build a Northeast Water Purification Plant. The proposed location for the plant will be adjacent to existing Lake Houston near the proposed Beltway 8. Raw water supply for this plant will be from Lake Houston, supplemented by water from the Trinity and Sabine River Basins as outlined in the HWMP. The HWMP presents two "eastern water" and one "western water" alternative to be considered for development of a future water supply for the City of Houston. In these alternatives, the ultimate capacity of a Northeast Water Treatment Plant ranges from 625 MGD maximum day capacity (eastern alternative) to 425 MGD maximum day capacity (western alternative). The WHCSWSC will present its surface water demand to the City of Houston which will size the Northeast Water Purification Plant to accommodate this requirement.

Southwest Supply System

Brazos River:

The headwaters of the Brazos River originate in New Mexico at an elevation of approximately 4,700 feet above mean sea level. From there, the river travels approximately 800 miles in a southeast direction to empty into the Gulf of Mexico near Freeport. The Brazos River is the only existing surface water source in close proximity to the WHCSWSC study area. Advantages of utilizing this source is that major conveyance systems can be eliminated and pumping across the City from east side treatment plants can be reduced.

Brazos River Authority Canals

The Brazos River Authority (BRA) owns and operates a dual canal system which flows southeast through Fort Bend County to Galveston and Brazoria Counties. Canal A draws water from the Brazos River near Fulshear through a 353 MGD capacity pumping station. From there, water flows through Jones and Oyster Creeks to just south of River Bend where it is pumped into the System A canal. Canal B draws water from the Brazos River six miles west of Arcola through a 302 MGD capacity pump station. Water then flows southeast along Highway 6. Canals A and B are interconnected at two locations, the first near Manvel and the second west of Santa Fe. Canal B presently supplies the Galveston County Water Authority's reservoir and 16 MGD treatment plant. The

BRA has permits for the diversion of 212 MGD from the Brazos River into these canals. Municipal, industrial and irrigation commitments total 164 MGD leaving 48 MGD available for use. The Galveston County Water Authority is in the process of purchasing Canals A and B from the BRA. Acquisition of these canals should be complete in 1-1/2 to 2 years.

Allen's Creek Reservoir

Allen's Creek is a reservoir originally proposed by Houston Lighting and Power to supply cooling water for a proposed power plant. The proposed location of the reservoir is approximately 25 miles west of Houston with an estimated yield of 75,000 acre-feet (67 MGD). Water rights and property for the reservoir have been purchased by HL&P; however, a re-evaluation of future power needs in the service area has postponed indefinitely the project and enabled this proposed reservoir to become a potential surface water source.

Under contracts which have been in place for several years, the Brazos River Authority has committed a substantial amount of water to HL&P that can be diverted from the Brazos River at any desired location downstream of the mouth of the Navasota River. Much of this water was to be used as make-up water for the planned Allen's Creek Reservoir. HL&P, after re-evaluation of area power needs, has recently offered the BRA a proposal including both the Allen's Creek Reservoir site along with the opportunity to recapture up to 87,400 acre-feet (78 MGD) of water presently contracted to HL&P from Lake Limestone. The opportunity to recapture this water now committed to HL&P and to acquire the Allen's Creek reservoir site, places the BRA in a position to offer a permanent supply of Brazos River water up to an estimated 160,000 acre-feet (143 MGD). Of the estimated 160,000 acre-feet (143 MGD), approximately 85,000 acre-feet (76 MGD) is available for immediate diversion from the Brazos River with the remaining 75,000 acre-feet (67 MGD) available upon completion of the Allen's Creek Reservoir. Upon request to construct the reservoir, the BRA estimates approximately 3 years to complete final planning, updating yield analyses, obtain permits and receive construction bids with an estimated 2 years additional for financing and actual construction of the reservoir.

Southwest Water Purification Plant

The proposed location of a Southwest Water Purification Plant would be in the vicinity of Highway 6 and U.S. Highway 90A near the Fort Bend-Harris County line. This plant would treat raw water taken from the Brazos River and/or the BRA canal system. The HWMP gives an estimated ultimate capacity of the plant as 100 MGD. Final ultimate capacity of the plant could be as much as 200 MGD depending on negotiations with the Brazos River Authority and/or the Galveston County Water Authority.

North Supply System

Trinity/Brazos/San Jacinto River Supply

This supply system consists of surface water from the Trinity, Brazos and San Jacinto River Basins. The development of two water supply sources, Lake Millican and Bedias Reservoir, would be a vital part of this supply system along with conveyance systems from these sources to Lake Conroe. Present available uncommitted water at the Lake Conroe is 9 MGD. Evaluation of the North Water Supply System will be accomplished under Phase III of this study which will allow the City of Houston time to decide if a western alternative is to be selected for the HWMP.

Northwest Water Purification Plant

Upon selection of a western alternative and development of Lake Millican and Bedias Reservoir and conveyance systems to Lake Conroe, the City of Houston proposes construction of a Northwest Water Purification Plant. The proposed location of this plant would be just south of Lake Conroe from which it will get its raw water supply. Preliminary sizing of this plant as presented in the HWMP is 350 MGD at ultimate capacity.

4.0 ALTERNATE SERVICE AREAS

4.0 ALTERNATE SERVICE AREAS

Approach and Methods

This section examines the possibilities for supplying the WHCSWSC study area with surface water from the sources discussed in Section 3.0. Several alternative service areas are proposed, and each is evaluated in terms of water demand versus supply and the possibility of meeting the conversion schedule as outlined in the HGCSD Plan. The alternates will be further tested for economic feasibility in Appendix IV of this study.

All three water supply scenarios considered by the HWMP include the Northeast Water Purification Plant (NEWPP) at Lake Houston and the Southwest Water Purification Plant (SWWPP) near the Brazos River. Only one, the western alternative, proposes a water treatment facility at Lake Conroe, the Northwest Water Purification Plant (NWWPP). Since the SWWPP and the NEWPP are included in all scenarios of the HWMP, they are used in four of the five alternates addressed in this study. The North Supply System can only be used if Houston elects to bring water from the west, and is included in only one alternate.

Evaluation of the adequacy of surface water supplies is based on the minimum surface water required to meet the HGCSD conversion goals, not the full maximum daily requirements. It is unlikely that surface water conversion will take place before the HGCSD target dates unless water production problems make groundwater supplies unacceptable. Since some districts have already experienced problems with their wells, such as natural gas intrusion, lowered water tables or excess radioactivity, it is possible that surface water will be required in advance of the HGCSD conversion dates. This study does not contain any alternatives designed to deal with groundwater quality problems, but should they occur, it would be possible to make surface water available at an earlier date.

Each alternate consists of two sources of supply: The Southwest System combined with a Northeast or North System. The Southwest System will supply surface water to portions of the City of Houston as well as the WHCSWSC service area. A tentative City of Houston service area was defined based on conversations with officials at the City's Public Works Department. The City of Houston's portion of the Southwest System is bounded by Fondren and Blalock Roads on the east, Clay Road on the north, the Houston City Limits on the west and the Harris County boundary on the south. This proposed service area falls into HGCSD regulatory areas three and four.

For each alternate, the boundaries of the two service areas were defined and the projected water demands for both areas were determined. This was accomplished by summing the maximum daily demands for each census tract in the service area to yield a total service area demand. Demands for census tracts partly in both service areas were split based on tributary area. Maximum daily water demands for the Houston service area were computed in a similar fashion and range from about 100 MGD in 1985 to 146 MGD in 2030. These are assumed constant for all alternates.

The surface water required by the HGCSD conversion plan was calculated as follows. First, the total service area demands were broken out by HGCSD regulatory area by adding census tract demands as described above. Since only extremely small portions of regulatory areas three and six are included in the study area, they were lumped with areas four and seven, respectively. Next, for each regulatory area, the amount needed at the conversion date, 80% of the total demand, was computed. The regulatory areas will not be required to increase surface water usage unless another conversion date is reached, so the previously calculated amount was maintained until that time or the end of the study in year 2030. When the totals for all regulatory areas in a service area were added at each conversion date, a stair-step pattern was revealed. Note that at no time does the required surface water total 80% of the total for a service area, since regulatory areas do not have the same conversion dates.

The HGCSD plan ends at 2020, with the latest conversion date at 2015, while the WHCSWSC investigated conditions to 2030. It is probable that as subsidence trends become better known, the HGCSD will extend its surface water conversion plan, adding conversion dates beyond 2015. The only regulatory area currently not required to utilize surface water is area eight. For purposes of computing surface water requirements in 2030, it was assumed in this study that area eight will be given a conversion requirement of 80% in that year.

Alternate Service Areas

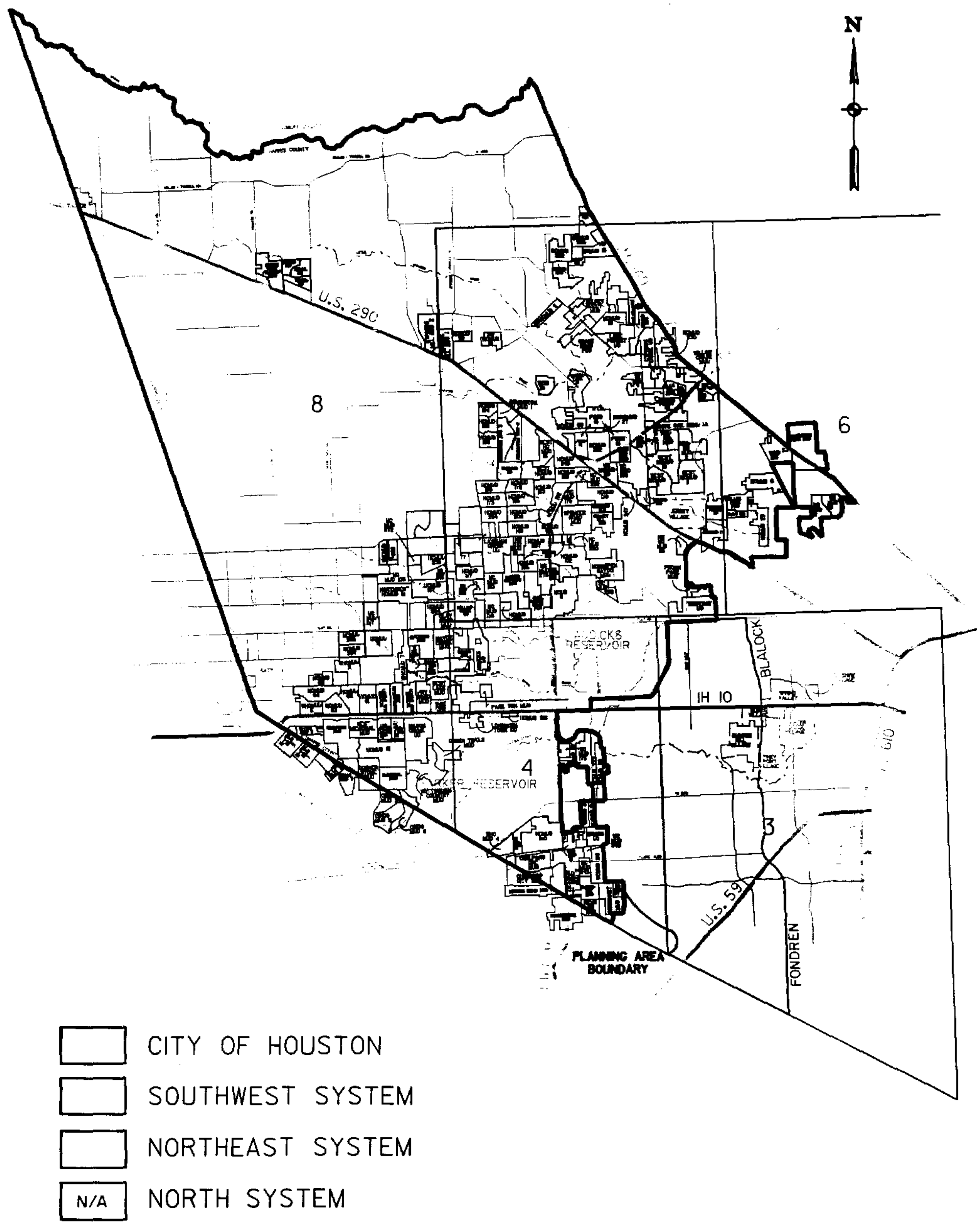
Five alternate service areas are detailed below. Two criteria are applied to each. First, the supply is compared to the HGCSD surface water requirements at each conversion date. Second, consideration is given to whether the water sources will be available in time to meet the conversion dates. Three tables are provided for reference in this section. Table 14 gives total maximum daily usage for both systems in each alternate. Table 15 details the calculation of surface water requirements described above, and Table 16 summarizes this information.

Alternate No. 1

In Alternate 1, the portion of the WHCSWSC planning area south of U.S. 290 would be served by the Southwest Supply System, while the remainder of the planning area would be supplied from the Northeast Supply System. Figure 13 shows the service area boundaries for this alternate. Using these boundaries, 59% of the total WHCSWSC maximum daily demand is located in the Southwest Service area increasing to 67% by 2030.

The HGCSD minimum surface water requirements on Table 16 reveals that the City of Houston will require 69 MGD from the Southwest System in 1995. WHCSWSC has no mandate in 1995. In the year 2000, the Southwest System will require a total of 117 MGD, or 97 MGD for Houston and 20 MGD for the WHCSWSC. The Southwest System yield of 143 MGD would be adequate until

FIGURE 13



WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION
ALTERNATE I SERVICE AREAS

2010, when 149 MGD of surface water would be required. Of this total, 97 MGD would be used by the City of Houston, while WHCSWSC would need 52 MGD. After 2010, the supply deficiency in the Southwest System would have to be made up from another source.

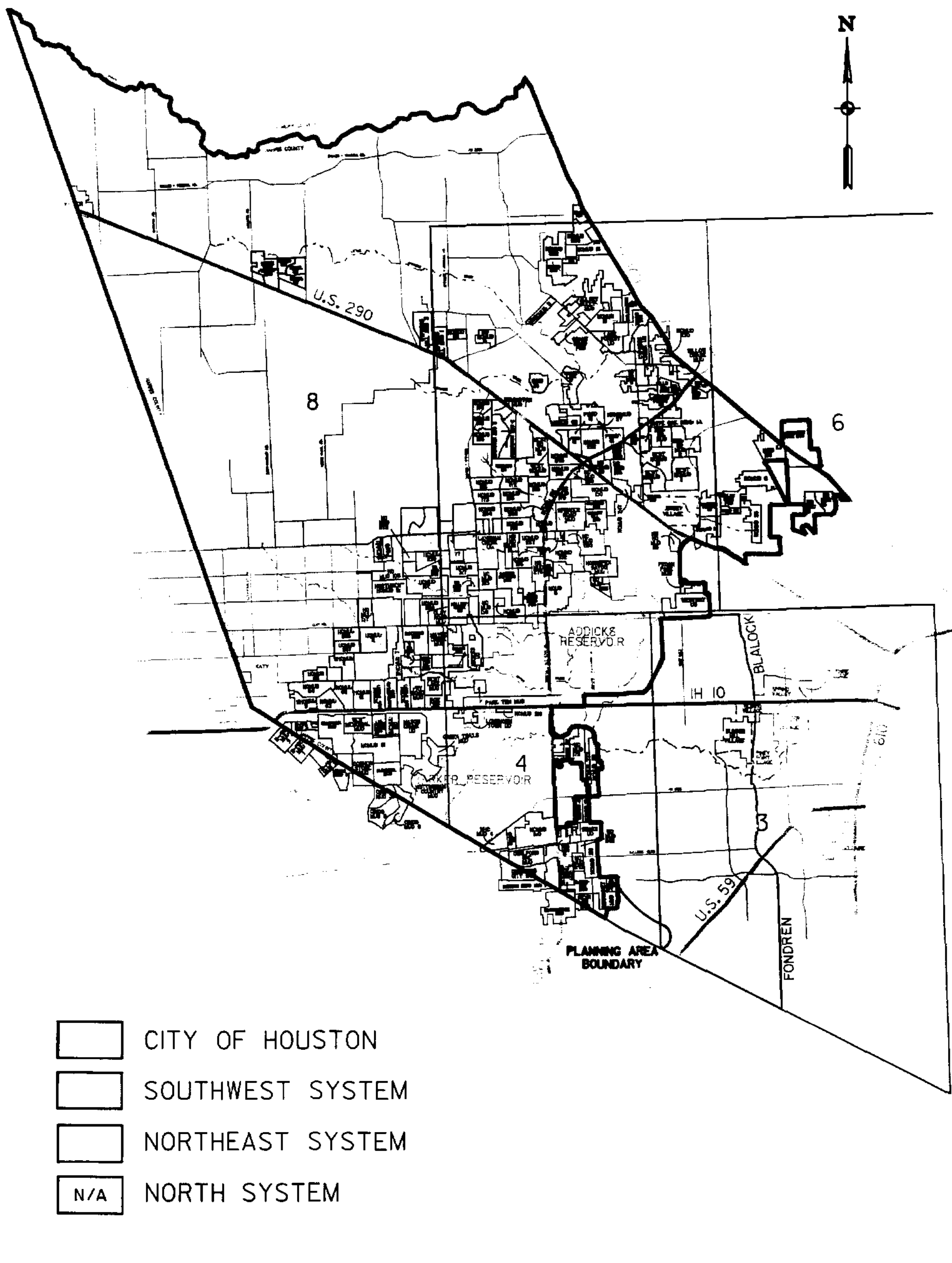
The Northeast Supply System has three conversion dates for this alternate: 2005, 2010 and 2030. At the first conversion date of 2005, 11 MGD will be required. Beginning in 2010, 41 MGD will be needed, remaining constant until 2030. At that time it is considered that HGCSD regulatory area eight will require conversion to surface water, increasing the Northeast System requirements to 50 MGD.

Alternate No. 2

In Alternate 2, the portion of the WHCSWSC planning area south of F.M. 529 from the western boundary of Harris County to Highway 6, then northeast along Highway 6 to U.S. 290 would be served by the Southwest Supply System, while the remainder of the planning area would be supplied from the Northeast Supply System. Figure 14 shows the service area boundaries for this alternate. Using these boundaries, 56% of the total WHCSWSC maximum daily demand is located in the Southwest Service area throughout the study period.

The HGCSD minimum surface water requirements on Table 16 reveals that the City of Houston will require 69 MGD from the Southwest System in 1995.

FIGURE 14



WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION

ALTERNATE 2 SERVICE AREAS

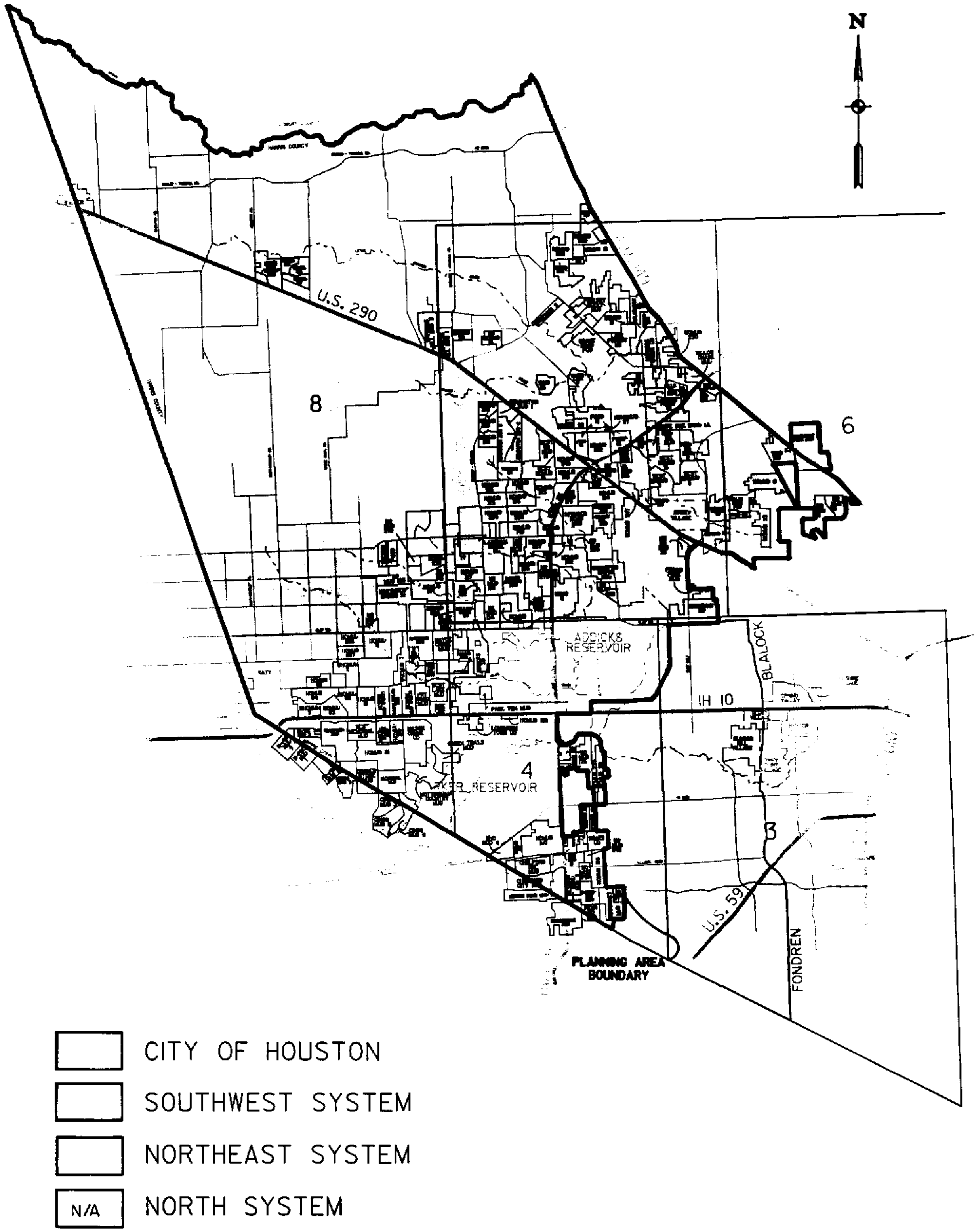
WHCSWSC has no mandate in 1995. In the year 2000, the Southwest System will require a total of 117 MGD, or 97 MGD for Houston and 20 MGD for the WHCSWSC. The Southwest System yield of 143 MGD would be adequate until 2010, when 143 MGD of surface water would be required. Of this total, 97 MGD would be used by the City of Houston, while WHCSWSC would need 46 MGD. After 2010, the supply deficiency in the Southwest System would have to be made up from another source.

The Northeast Supply System has three conversion dates for this alternate: 2005, 2010 and 2030. At the first conversion date of 2005, 11 MGD will be required. Beginning in 2010, 48 MGD will be needed, remaining constant until 2030. At that time it is considered that HGCSD regulatory area eight will require conversion to surface water, increasing the Northeast System requirements to 62 MGD.

Alternate No. 3

In Alternate 3, the portion of the WHCSWSC planning area south of Clay Road would be served by the Southwest Supply System, while the remainder of the planning area would be supplied from the Northeast Supply System. Figure 15 shows the service area boundaries for this alternate. Using these boundaries, 30% of the total WHCSWSC maximum daily demand is located in the Southwest Service area throughout the study period.

FIGURE 15



WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION
ALTERNATE 3 SERVICE AREAS

The HGCSD minimum surface water requirements on Table 16 reveals that the City of Houston will require 69 MGD from the Southwest System in 1995. WHCSWSC has no mandate in 1995. In the year 2000, the Southwest System will require a total of 116 MGD, or 97 MGD for Houston and 19 MGD for the WHCSWSC. The Southwest System yield of 143 MGD would be almost adequate until 2030, when 151 MGD of surface water would be required. Of this total, 106 MGD would be used by the City of Houston, while WHCSWSC would need 44 MGD. After 2030, the supply deficiency in the Southwest System would have to be made up from another source. The first conversion date for the Northeast Supply System is 2000, when 0.5 MGD would be needed.

The Northeast Supply System has four conversion dates for this alternate: 2000, 2005, 2010 and 2030. The earliest conversion date is 2000, when 0.5 MGD would be necessary for a portion of HGCSD regulatory area four. At the next conversion date of 2005, 11 MGD would be required. Beginning in 2010, 74 MGD would be needed, remaining constant until 2030. At that time it is considered that HGCSD regulatory area eight will require conversion to surface water, increasing the Northeast System requirements to 104 MGD.

Alternate No. 4

In Alternate 4, the portion of the WHCSWSC planning area south of I.H. 10 would be served by the Southwest Supply System, while the remainder of the planning area would be supplied from the Northeast Supply System.

Figure 16 shows the service area boundaries for this alternate. Using these boundaries, 20% of the total WHCSWSC maximum daily demand is located in the Southwest Service area decreasing to 16% by 2030.

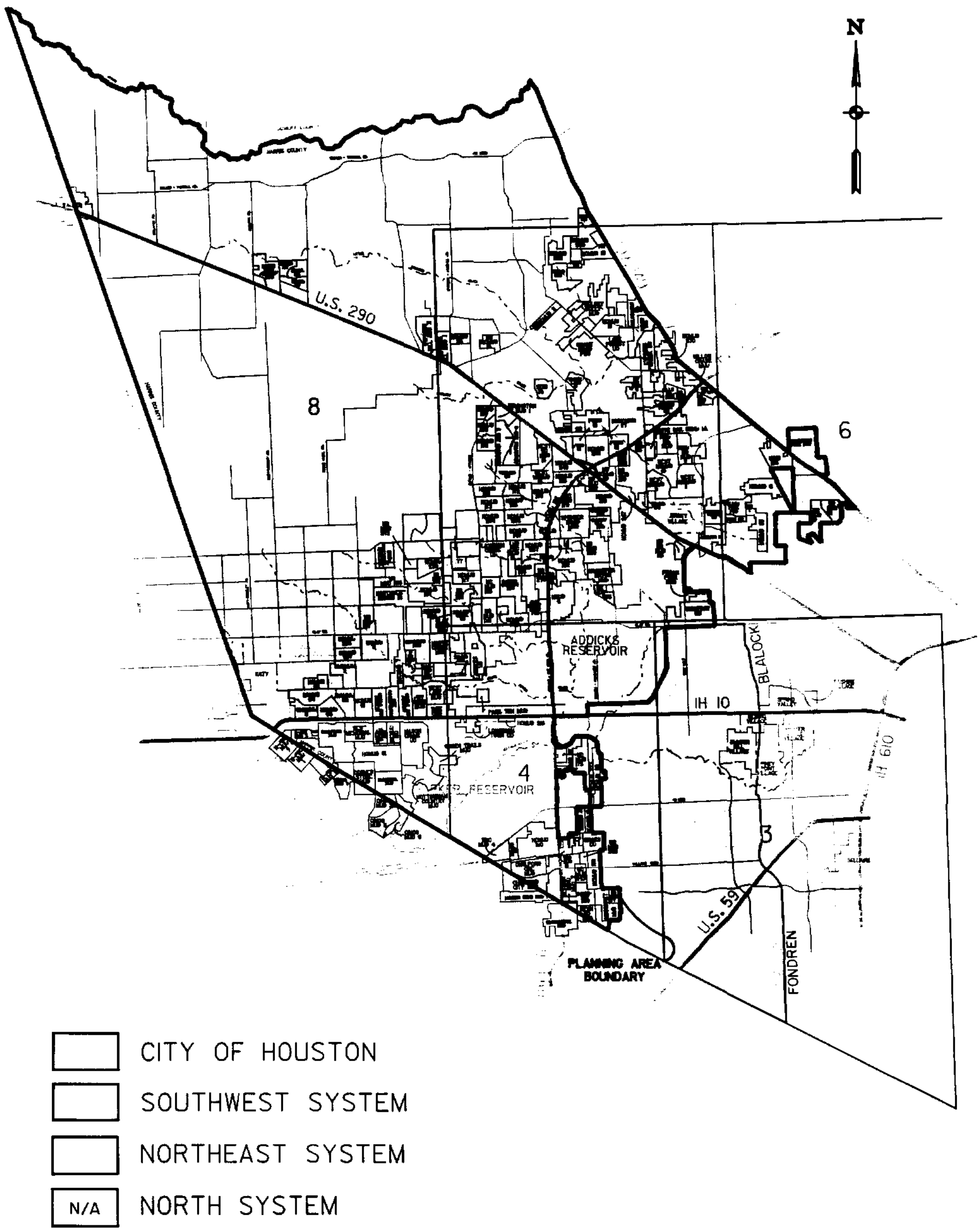
The HGCSD minimum surface water requirements on Table 16 reveals that the City of Houston will require 69 MGD from the Southwest System in 1995. WHCSWSC has no mandate in 1995. In the year 2000, the Southwest System will require a total of 112 MGD, or 97 MGD for Houston and 15 MGD for the WHCSWSC. The Southwest System yield of 143 MGD would be more than adequate until 2030, when 129 MGD of surface water would be required. Of this total, 106 MGD would be used by the City of Houston, while WHCSWSC would need 23 MGD.

The Northeast Supply System has four conversion dates for this alternate: 2000, 2005, 2010 and 2030. The earliest conversion date is 2000, when 5 MGD would be necessary for a portion of HGCSD regulatory area four. At the next conversion date of 2005, 15 MGD would be required. Beginning in 2010, 78 MGD would be needed, remaining constant until 2030. At that time it is considered that HGCSD regulatory area eight will require conversion to surface water, increasing the Northeast System requirements to 125 MGD.

Alternate No. 5

In Alternate 5, the portion of the WHCSWSC planning area south of Clay Road would be served by the Southwest Supply System, while the remainder

FIGURE 16



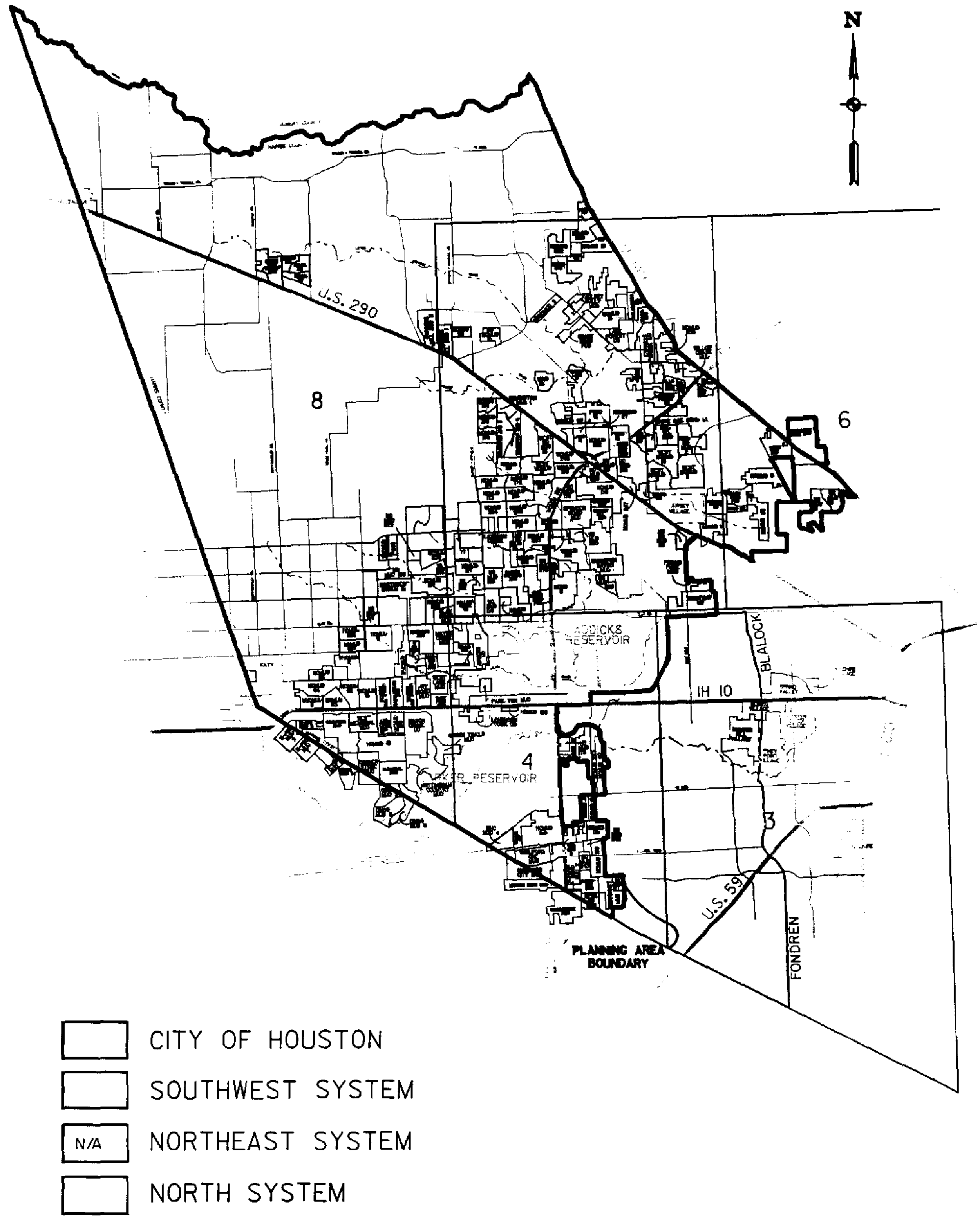
WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION
ALTERNATE 4 SERVICE AREAS

of the planning area would be supplied from the North Supply System. Figure 17 shows the service area boundaries for this alternate. Using these boundaries, 30% of the total WHCSWSC maximum daily demand is located in the Southwest Service area throughout the study period.

The HGCSD minimum surface water requirements on Table 16 reveals that the City of Houston will require 69 MGD from the Southwest System in 1995. WHCSWSC has no mandate in 1995. In the year 2000, the Southwest System will require a total of 116 MGD, or 97 MGD for Houston and 19 MGD for the WHCSWSC. The Southwest System yield of 143 MGD would be almost adequate until 2030, when 151 MGD of surface water would be required. Of this total, 106 MGD would be used by the City of Houston, while WHCSWSC would need 44 MGD. After 2030, the supply deficiency in the Southwest System would have to be made up from another source.

The North Supply System has four conversion dates for this alternate: 2000, 2005, 2010 and 2030. The earliest conversion date is 2000, when 0.5 MGD would be necessary for a portion of HGCSD regulatory area four. At the next conversion date of 2005, 11 MGD would be required. Beginning in 2010, 74 MGD would be needed, remaining constant until 2030. At that time it is considered that HGCSD regulatory area eight will require conversion to surface water, increasing the North System requirements to 104 MGD.

FIGURE 17



WEST HARRIS COUNTY SURFACE WATER SUPPLY CORPORATION
ALTERNATE 5 SERVICE AREAS

TABLE 14

MAXIMUM DAILY WATER DEMANDS BY ALTERNATE

YEAR	CITY OF HOUSTON SOUTHWEST (MGD)	WHCSWSC SOUTHWEST (MGD)	TOTAL SOUTHWEST (MGD)	TOTAL NORTHEAST* (MGD)	TOTAL ALL AREAS (MGD)
ALTERNATE 1 - BOUNDARY AT U.S. 290					
1985	99.59	35.96	135.55	25.10	160.65
1990	108.36	45.83	154.19	29.18	183.37
1995	117.37	61.25	178.62	36.81	215.42
2000	126.38	76.66	203.04	44.43	247.47
2005	131.37	91.82	223.19	51.78	274.96
2010	136.36	106.97	243.33	59.12	302.45
2012	137.48	112.17	249.65	60.94	310.59
2020	141.97	132.98	274.95	68.20	343.15
2030	146.38	152.68	299.06	77.65	376.71
ALTERNATE 2 - BOUNDARY AT F.M. 529					
1985	99.59	34.10	133.69	26.96	160.65
1990	108.36	42.28	150.64	32.74	183.38
1995	117.37	55.96	173.33	42.10	215.43
2000	126.38	69.64	196.02	51.45	247.47
2005	131.37	82.63	214.00	60.97	274.97
2010	136.36	95.62	231.98	70.48	302.46
2012	137.48	99.79	237.27	73.33	310.60
2020	141.97	116.47	258.44	84.72	343.16
2030	146.38	131.55	277.93	98.77	376.70
ALTERNATE 3 OR 5 - BOUNDARY AT CLAY ROAD					
1985	99.59	17.95	117.54	43.10	160.64
1990	108.36	22.37	130.73	55.66	183.39
1995	117.37	29.64	147.01	68.43	215.43
2000	126.38	36.90	163.28	84.19	247.47
2005	131.37	44.12	175.49	99.48	274.97
2010	136.36	51.34	187.70	114.76	302.46
2012	137.48	53.43	190.91	119.69	310.60
2020	141.97	61.78	203.75	139.40	343.15
2030	146.38	69.44	215.82	160.89	376.71
ALTERNATE 4 - BOUNDARY AT I.H. 10					
1985	99.59	12.33	111.92	48.73	160.65
1990	108.36	14.73	123.09	60.30	183.39
1995	117.37	19.21	136.58	78.85	215.43
2000	126.38	23.69	150.07	97.40	247.47
2005	131.37	27.34	156.71	116.25	274.96
2010	136.36	30.99	167.35	135.10	302.45
2012	137.48	31.77	169.25	141.34	310.59
2020	141.97	34.89	176.86	166.29	343.15
2030	146.38	36.02	182.40	194.30	376.70

*In Alternate 5, the Northeast System is replaced by the North System.

TABLE 15

SURFACE WATER REQUIREMENTS PER HGCSD PLAN
TOTAL WHCSWSC
(MAXIMUM DAILY DEMANDS)

ALTERNATE 1 - SUPPLY TO U.S. 290

Regulatory Area	Surface Water (MGD) 1985	2000	2005	2010	2030
SOUTHWEST SYSTEM					
4	0.00	19.83	19.83	19.83	19.83
7	0.00	0.00	0.00	32.62	32.62
8	0.00	0.00	0.00	0.00	46.07
SOUTHWEST TOTAL	0.00	19.83	19.83	52.45	98.52
NORTHEAST SYSTEM					
6	0.00	0.00	10.68	10.68	10.68
7	0.00	0.00	0.00	30.55	30.55
8	0.00	0.00	0.00	0.00	8.68
NORTHEAST TOTAL	0.00	0.00	10.68	41.24	49.92
ALT. No. 1 TOTAL	0.00	19.83	30.52	93.68	148.44

ALTERNATE 2 - SUPPLY TO F.M. 529

Regulatory Area	Surface Water (MGD) 1985	2000	2005	2010	2030
SOUTHWEST SYSTEM					
4	0.00	19.83	19.83	19.83	19.83
7	0.00	0.00	0.00	25.94	25.94
8	0.00	0.00	0.00	0.00	40.86
SOUTHWEST TOTAL	0.00	19.83	19.83	45.77	86.62
NORTHEAST SYSTEM					
6	0.00	0.00	10.68	10.68	10.68
7	0.00	0.00	0.00	37.24	37.24
8	0.00	0.00	0.00	0.00	13.89
NORTHEAST TOTAL	0.00	0.00	10.68	47.92	61.81
ALT. No. 2 TOTAL	0.00	19.83	30.52	93.69	148.44

TABLE 15 (Cont'd)

SURFACE WATER REQUIREMENTS PER HGCSD PLAN
TOTAL WHCSWSC
(MAXIMUM DAILY DEMANDS)

ALTERNATE 3 OR 5 - SUPPLY TO CLAY ROAD

Regulatory Area	Surface Water (MGD) 1985	2000	2005	2010	2030
SOUTHWEST SYSTEM					
4	0.00	19.31	19.31	19.31	19.31
8	0.00	0.00	0.00	0.00	25.17
SOUTHWEST TOTAL	0.00	19.31	19.31	19.31	44.48
NORTHEAST SYSTEM					
4	0.00	0.52	0.52	0.52	0.52
6	0.00	0.00	10.68	10.68	10.68
7	0.00	0.00	0.00	63.17	63.17
8	0.00	0.00	0.00	0.00	29.58
NORTHEAST TOTAL	0.00	0.52	11.20	74.37	103.96
ALT. No. 3 OR 5 TOTAL	0.00	19.83	30.52	93.68	148.44

ALTERNATE 4 - SUPPLY TO I.H. 10

Regulatory Area	Surface Water (MGD) 1985	2000	2005	2010	2030
SOUTHWEST SYSTEM					
4	0.00	15.32	15.32	15.32	15.32
8	0.00	0.00	0.00	0.00	7.62
SOUTHWEST TOTAL	0.00	15.32	15.32	15.32	22.94
NORTHEAST SYSTEM					
4	0.00	4.51	4.51	4.51	4.51
6	0.00	0.00	10.68	10.68	10.68
7	0.00	0.00	0.00	63.17	63.17
8	0.00	0.00	0.00	0.00	47.12
NORTHEAST TOTAL	0.00	4.51	15.20	78.36	125.48
ALT. No. 4 TOTAL	0.00	19.83	30.52	93.68	148.43

TABLE 16

SUMMARY OF SURFACE WATER REQUIREMENTS BY ALTERNATE
(MAXIMUM DAILY DEMANDS)

YEAR	CITY OF HOUSTON SOUTHWEST	WHCSWSC SOUTHWEST	TOTAL SOUTHWEST	TOTAL NORTHEAST*	TOTAL ALL AREAS
ALTERNATE 1 - BOUNDARY AT U.S. 290					
1985	0.00	0.00	0.00	0.00	0.00
1995	69.35	0.00	69.35	0.00	69.35
2000	97.02	19.83	116.85	0.00	116.85
2005	97.02	19.83	116.85	10.68	127.53
2010	97.02	52.45	149.47	41.24	190.71
2012	106.33	52.45	158.78	41.24	200.02
2020	106.33	52.45	158.78	41.24	200.02
2030**	106.33	98.52	204.85	49.92	254.77
ALTERNATE 2 - BOUNDARY AT F.M. 529					
1985	0.00	0.00	0.00	0.00	0.00
1995	69.35	0.00	69.35	0.00	69.35
2000	97.02	19.83	116.85	0.00	116.85
2005	97.02	19.83	116.85	10.68	127.53
2010	97.02	45.77	142.79	47.92	190.71
2012	106.33	45.77	152.10	47.92	200.02
2020	106.33	45.77	152.10	47.92	200.02
2030**	106.33	86.62	192.95	61.81	254.76
ALTERNATE 3 OR 5 - BOUNDARY AT CLAY ROAD					
1985	0.00	0.00	0.00	0.00	0.00
1995	69.35	0.00	69.35	0.00	69.35
2000	97.02	19.31	116.33	0.52	116.85
2005	97.02	19.31	116.33	11.20	127.53
2010	97.02	19.31	116.33	74.37	190.70
2012	106.33	19.31	125.64	74.37	200.01
2020	106.33	19.31	125.64	74.37	200.01
2030**	106.33	44.48	150.81	103.96	254.77
ALTERNATE 4 - BOUNDARY AT I.H. 10					
1985	0.00	0.00	0.00	0.00	0.00
1995	69.35	0.00	69.35	0.00	69.35
2000	97.02	15.32	112.34	4.51	116.85
2005	97.02	15.32	112.34	15.20	127.54
2010	97.02	15.32	112.34	78.36	190.70
2012	106.33	15.32	121.65	78.36	200.01
2020	106.33	15.32	121.65	78.36	200.01
2030**	106.33	22.94	129.27	125.48	254.75

*In Alternate 5, the Northeast System is replaced by the North System.

**Harris-Galveston Coastal Subsidence District plan for surface water use ends at 2020. Required surface water for 2030 was estimated assuming that Area 8 will be required to convert to 80% surface water in that year.

Comparison of Alternates

In this section, the five alternates will be compared on the basis of the previous discussion. No alternates will be eliminated, since only the questions of supply versus required surface water and timing of water availability have been considered. However, general conclusions can be made after this preliminary investigation.

Total Maximum Daily Demands

An examination of the total maximum daily water demands on Table 14 reveals several things. Three factors remain constant for each alternate. First, the City of Houston Southwest service area total demand increases from about 100 MGD in 1985 to 146 MGD in 2030. Second, the total WHCSWSC demand grows from 61 MGD to 230 MGD during the study period. Third, for all areas combined, the total demand is 161 MGD in 1985 and 377 MGD in 2030. The variable figures are the WHCSWSC portion of the Southwest System and the Northeast or North maximum daily water demands, which depend on the placement of the service area boundaries. For Alternate 1, the Southwest service area contains most of the total WHCSWSC demand, and the percentage increases throughout the study period. The reverse is true of Alternate 4, in which the Northeast service area holds an increasing majority of the total demand. For Alternates 2, 3 and 5, the demand split remains fairly constant during the period of interest. A summary of the demand proportions is found in Table 17.

TABLE 17

COMPARISON OF ALTERNATES

	ALTERNATE 1	2	3	4	5
Southwest Demand (% of Total)	59-67*	56	30	20-16*	30
Northeast or North Demand (% of Total)	41-33*	44	70	80-84*	70
Year Southwest Supply** Deficit Begins	2010	2012	2030	None	2030
Southwest Supply Deficit (Surplus) Year 2030 (MGD)	62	50	8	(14)	8
Year of First Southwest Conversion	1995	1995	1995	1995	1995
Amount of First Southwest Conversion (MGD)	69	69	69	69	69
Year of First Northeast or North Conversion	2005	2005	2000	2000	2000
Amount of First Northeast or North Conversion (MGD)	11	11	0.5	5	0.5

*1985 Percentage Increasing or Decreasing to 2030 Percentage.

**Based on an Available Southwest Supply of 143 MGD

All Demands are Based on Maximum Daily Requirements.

Total Available Surface Water Supply

All considerations of supply adequacy were based on the minimum surface water required to meet the HGCSD conversion plan, previously shown on Table 15. As opposed to the total maximum daily demands, the minimum requirements climb in a stair-step fashion rather than linearly. However, the minimum requirements for the City of Houston Southwest Supply System, the total for the WHCSWSC supply area and the overall totals do not vary by alternate.

The total supply available from the SWWPP is assumed to be 143 MGD. Alternate 1 and Alternate 2 require more than 143 MGD in the Southwest service area fairly early in the planning period, and have large supply deficits by 2030. The Southwest Service area for Alternate 3 and Alternate 5 shows a small deficit after 2029. A surplus supply is developed in the Southwest area through 2030 for Alternate 4. In the cases where supply deficits are noted, the service area for the Northeast or North Supply System will have to be extended to make up the difference after the deficit occurs. As a result, the actual amount supplied by the Northeast or North System will be greater than the amount needed by the northern service area for these four alternates. Table 17 as previously presented contains the year in which the Southwest Supply System will no longer be able to meet the Southwest service area minimum requirement and a deficit occurs. Note that the northern service area minimum surface water requirement plus the deficit for the southern service area makes up the actual amount to be supplied by the NWWPP or the NEWPP, as shown on Table 18. The HWMP projects treatment capacities for the two water treatment plants which would be adequate to meet these demands and those of adjacent areas.

Feasibility of Meeting HGCSD Plan

Some consideration must be given to the timing of the availability of the surface water and whether it would be possible to meet the HGCSD conversion plan with the five alternatives. In the Southwest service area, the first conversion requires 69 MGD in 1995. This is the same for all alternates since the area which is required to convert to surface water is in HGCSD regulatory area three in the City of Houston. It may be estimated that the SWWPP will take around ten years to bring on-line from design to completion. This makes it unlikely that surface water conversion can take place until at least 1998. Since the next conversion date for the area is 2000, it would be more efficient to design the plant based on the requirement for that year, which varies from 112 MGD to 117 MGD, depending on the alternate.

Timing issues are more complex in the North and Northeast service areas. The first conversion date is either 2000 or 2005. Alternates 1 and 2 both require about 11 MGD at 2005. Alternates 3 and 5 call for 0.5 MGD in 2000, and Alternate 4 requires 5 MGD at the same date. The quantities of surface water needed in 2000 or 2005 for any alternate are small. In

TABLE 18

SYSTEM SURFACE WATER REQUIREMENTS
PER HGCSD PLAN
(MAXIMUM DAILY DEMAND)

YEAR	TOTAL SOUTHWEST (MGD)	WHCSWSC* NORTHEAST (MGD)	TOTAL ALL AREAS (MGD)
ALTERNATE 1 - BOUNDARY AT U.S. 290			
1985	0.00	0.00	0.00
1995	69.35	0.00	69.35
2000	116.85	0.00	116.85
2005	116.85	10.68	127.53
2010	143.00	47.71	190.71
2012	143.00	57.02	200.02
2020	143.00	57.02	200.02
2030**	143.00	111.77	254.77
ALTERNATE 2 - BOUNDARY AT F.M. 529			
1985	0.00	0.00	0.00
1995	69.35	0.00	69.35
2000	116.85	0.00	116.85
2005	116.85	10.68	127.53
2010	142.79	47.92	190.71
2012	143.00	57.02	200.02
2020	143.00	57.02	200.02
2030**	143.00	111.76	254.76
ALTERNATE 3 OR 5 - BOUNDARY AT CLAY ROAD			
1985	0.00	0.00	0.00
1995	69.35	0.00	69.35
2000	116.33	0.52	116.85
2005	116.33	11.20	127.53
2010	116.33	74.37	190.70
2012	125.64	74.37	200.01
2020	125.64	74.37	200.01
2030**	143.00	111.77	254.77
ALTERNATE 4 - BOUNDARY AT I.H. 10			
1985	0.00	0.00	0.00
1995	69.35	0.00	69.35
2000	112.34	4.51	116.85
2005	112.34	15.20	127.54
2010	112.34	78.36	190.70
2012	121.65	78.36	200.01
2020	121.65	78.36	200.01
2030**	129.27	125.48	254.75

*In Alternate 5, the Northeast System is replaced by the North System.

**Harris-Galveston Coastal Subsidence District plan for surface water use ends at 2020. Required surface water for 2030 was estimated assuming that Area 8 will be required to convert to 80% surface water in that year.

addition, the regulatory area using surface water at these dates is area four, which is in the most southern part of the service area. It is likely that this regulatory area would be supplied from the Southwest Supply System until 2005 or 2010, when most of the northern area will then convert to surface water. If the NEWPP is completed in ten years, it seems certain that water could be provided by either 2000 or 2005, so the early conversion dates could be met from either system. The WHCSWSC has been asked to provide the City with an amount of surface water needed from the NEWPP so that it can be designed for the additional capacity. It appears from Table 18 that the amount of surface water required from the proposed Northeast Plant would be approximately 50 MGD by 2010 if Alternate 1 or Alternate 2 is chosen, and 75 to 80 MGD if one of the other alternates is considered. While the NEWPP can be completed in time to provide these substantial water requirements, it is not clear whether the City of Houston will have sufficient water availability from Lake Houston. The HWMP appendices currently available do not address the subject of construction phasing.

The preceding discussion has dealt with the Northeast Supply System. For Alternate 5, the North Supply System must be considered. As mentioned in the description of Alternate 5, the NWWPP is proposed to have a capacity of 350 MGD in 2030, easily enough to supply the needs of the North Supply System and the surrounding areas. However, the majority of the surface water for this plant is to originate in two proposed reservoirs, Lake Millican and Bedias Reservoir. Construction of these sources would probably take about thirty years, yielding a completion date of 2018. Using this alternate, it would be unlikely to meet the HGCSD conversion dates for regulatory areas six and seven. The areas could not be temporarily supplied from the Southwest System, since the total demand exceeds 143 MGD beginning in 2010.

5.0 CONCLUSIONS

5.0 CONCLUSIONS

Several conclusions may be drawn from the previous comparisons. From the facts presented it is apparent that by the year 2030, the boundary between the Northeast or North and the Southwest Supply Systems will fall just south of Clay Road, since that is the boundary for Alternate 3 and Alternate 5, the two which produced the closest demand to the 143 MGD supply available from the SWWPP. However, the ultimate boundary need not be the same as the boundary used for interim conditions. For instance, Alternates 1 and 2 showed large deficits in 2030, but smaller ones at earlier dates. Table 16 presented the actual amounts supplied by each of the Northeast and North Systems. When closely examined the data reveals that Alternates 1 and 2 maximize the use of the Southwest Supply System capacity at an early date. This could be useful if the supply from the northern alternatives is reduced or delayed. Alternate 4 is the only one which produces a supply surplus for the Southwest Supply System in 2030, and this might prove important under some conditions. The main objection to any alternate raised is that water from the North System in Alternate 5 may not be available in time to meet HGCSD target dates. However, a cost analysis of the major sources and distribution systems will be necessary before any alternate can be eliminated. This will be described later in Appendix IV.

ATTACHMENTS

ATTACHMENT 1

ACKNOWLEDGEMENTS:

Prior reports and studies dealing with water demands and supplies in the City of Houston and surrounding areas were utilized as needed in preparing this study. Materials reviewed during the course of this project are as follows:

1. Houston Water Master Plan - Appendices A through M, August 1985 to March 1987, by Metcalf and Eddy, Inc.

2. District Plan - Adopted November 1985, by Harris-Galveston Coastal Subsidence District.

3. Subsidence '87 - February 1987, by Harris-Galveston Coastal Subsidence District.

4. Proposal to City of Houston on sale of Brazos River water, August 1987, by the Brazos River Authority.

5. Utility District Listing, Creation and Bond Issue Reports - Texas Water Commission Records, January 1987.

6. Yearly Groundwater Pumpage Records - Harris Galveston Coastal Subsidence District.

ATTACHMENT 2

HARRIS-GALVESTON COASTAL SUBSIDENCE DISTRICT
PROPOSED DISTRICT PLAN
JULY 16, 1985

Area One

a. Through 1989, as a general rule, increases in groundwater withdrawal will not be permitted.

b. Beginning in 1990 groundwater withdrawal must be reduced so that no more than 10% of the total water use is from groundwater.

Area Two

a. Through 1989, as a general rule, increases in groundwater withdrawal may be permitted so long as surface-water use is not reduced.

b. In 1990 groundwater withdrawal must be reduced so that no more than 20% of the total water use is from groundwater.

c. Thereafter through 1998 increases in groundwater withdrawal may be permitted so long as surface-water use is not decreased. Then in 1999 groundwater withdrawal again must be reduced so that no more than 20% of the total water use is from groundwater.

d. Thereafter through 2006 increases in groundwater withdrawal may be permitted so long as surface-water use is not decreased. Then in 2007 groundwater withdrawal again must be reduced so that no more than 20% of the total water use is from groundwater.

e. Thereafter through 2014 increases in groundwater withdrawal may be permitted so long as surface water use is not decreased. Then in 2015 groundwater withdrawal again must be reduced so that no more than 20% of the total water use is from groundwater.

f. Thereafter through 2020 increases in groundwater withdrawal may be permitted so long as surface-water use is not decreased.

Area Three

a. Through 1994, as a general rule, increases in groundwater withdrawal may be permitted.

b. In 1995 groundwater withdrawal must be reduced so that no more than 20% of total water use is from groundwater.

c. Thereafter through 2011 increases in groundwater withdrawal may be permitted so long as surface-water use is not decreased. Then in 2012 groundwater withdrawal again must be reduced so that no more than 20% of the total water use is from groundwater.

d. Thereafter through 2020 increases in groundwater withdrawal may be permitted so long as surface-water use is not decreased.

Area Four

a. Through 1999, as a general rule, increases in groundwater withdrawal may be permitted.

b. In 2000 groundwater withdrawal must be reduced so that no more than 20% of the total water use is from groundwater.

c. Thereafter through 2020 increases in groundwater withdrawal may be permitted so long as surface-water use is not decreased.

Area Five

a. Through 1999, as a general rule, increases in groundwater withdrawal may be permitted.

b. In 2000 groundwater withdrawal must be reduced so that no more than 20% of the total water use is from groundwater.

c. Thereafter through 2020 increases in groundwater withdrawal may be permitted so long as surface-water use is not decreased.

Area Six

a. Through 2004, as a general rule, increases in groundwater withdrawal may be permitted.

b. In 2005 groundwater withdrawal must be reduced so that no more than 20% of the total water use is from groundwater.

c. Thereafter through 2020 increases in groundwater withdrawal may be permitted so long as surface-water use is not decreased.

Area Seven

a. Through 2009, as a general rule, increases in groundwater withdrawal may be permitted.

b. In 2010 groundwater withdrawal must be reduced so that no more than 20% of the total water use is from groundwater.

c. Thereafter through 2020 increases in groundwater withdrawal may be permitted so long as surface-water use is not decreased.

Area Eight

a. As a general rule, increases in groundwater withdrawal may be permitted.

b. Groundwater withdrawal in this area shall not be supplied to areas outside of the boundaries of Area Eight except for compelling reasons as determined by the District.

ATTACHMENT 3

ANNUAL GROUNDWATER PUMPAGE IN MILLIONS OF GALLONS

NO.	NAME OF DISTRICT	MDA	1980 PUMPAGE	1981 PUMPAGE	1982 PUMPAGE	1983 PUMPAGE	1984 PUMPAGE	1985 PUMPAGE	1986 PUMPAGE	MAXIMUM PUMPAGE	1986 LOSSES
1	ADDICKS UD	31	20.681	25.819	37.393	38.614	45.373	46.000	46.643	46.643	11.0%
2	BARKER-CYPRESS MUD	31	0.000	0.000	0.000	0.000	0.000	40.469	55.544	55.544	3.0%
3	BEECHNUT MUD	24	0.000	0.000	0.000	1.718	27.600	35.500	44.266	44.266	>30%
4	BISSONET MUD	24	65.033	78.110	101.646	104.155	125.903	142.857	169.407	169.407	<30%
5	BRAES UD	24	0.517	24.041	54.833	49.524	36.906	69.274	52.204	69.274	<30%
6	CAMFIELD MUD	25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
7	CASTLEWOOD MUD	31	0.000	0.272	9.344	27.045	52.182	37.701	27.229	52.182	6.3%
8	CHELFORD CITY MUD	24	250.000	275.000	300.000	352.827	302.443	409.807	316.620	409.807	
9	CHELFORD ONE MUD	24	52.900	112.192	84.633	129.958	226.438	227.221	208.721	227.221	
10	CHIMNEY HILL MUD	25	57.562	90.851	121.274	136.824	141.802	114.891	115.128	141.802	
11	CIMARRON MUD	31	0.000	0.000	84.242	105.789	75.405	76.158	86.047	105.789	16.9%
12	CINCO MUD 3	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
13	CINCO MUD 5	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
14	CINCO MUD 6	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
15	CINCO MUD 9	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
16	CLAY ROAD MUD	31	11.650	29.252	67.566	77.396	88.871	88.161	85.573	88.871	4.6%
17	CORNERSTONE MUD	31	0.120	28.496	59.602	59.339	55.050	85.186	62.740	85.186	23.0%
18	CYPRESS CREEK UD	33	144.033	137.625	156.773	98.173	158.337	141.707	218.686	218.686	
19	CYPRESS HILL MUD 1	32	0.000	0.000	0.000	0.000	0.119	13.156	14.651	14.651	
20	CYPRESS HILL MUD 2	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
21	EMERALD FOREST UD	33	86.346	114.498	189.837	155.768	165.870	180.431	179.764	189.837	18.5%
22	FAULKEY GULLY MUD	33	18.046	28.378	46.215	57.967	82.398	97.549	102.975	102.975	
23	FRY ROAD MUD	31	0.015	29.000	58.326	80.035	100.755	91.832	128.977	128.977	39.5%
24	GRANT RD. PUD	33	0.000	0.000	0.000	9.375	22.913	21.825	23.814	23.814	
25	GREEN TRAILS MUD	31	1.500	5.171	28.088	41.633	46.017	53.657	59.330	59.330	16.0%
26	HARRIS CO. FWSD 61	32	376.250	386.411	431.494	296.644	296.514	335.310	313.717	431.494	
27	HARRIS CO. MUD 006	26	145.594	163.987	184.445	171.540	169.982	152.636	185.852	185.852	<30%
28	HARRIS CO. MUD 018	33	71.436	58.338	110.000	142.461	195.970	192.551	205.639	205.639	
29	HARRIS CO. MUD 023	26	63.624	76.057	107.059	119.665	141.195	149.292	136.097	149.292	
30	HARRIS CO. MUD 025	26	28.541	33.249	58.396	46.812	44.895	41.588	37.267	58.396	18.9%
31	HARRIS CO. MUD 029	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
32	HARRIS CO. MUD 052	33	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
33	HARRIS CO. MUD 061	31	62.761	118.162	141.930	156.232	196.105	199.580	199.654	199.654	3.8%
34	HARRIS CO. MUD 062	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
35	HARRIS CO. MUD 063	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
36	HARRIS CO. MUD 064	31	82.509	59.156	107.555	72.294	75.001	61.188	57.779	107.555	15.4%
37	HARRIS CO. MUD 065	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
38	HARRIS CO. MUD 069	32	0.000	0.000	0.000	134.033	151.286	162.189	148.927	162.189	
39	HARRIS CO. MUD 070	32	11.218	10.168	18.093	38.631	37.667	57.248	33.374	57.248	13.5%
40	HARRIS CO. MUD 071	31	3.735	7.603	14.782	26.198	30.232	41.061	41.194	41.194	30.6%
41	HARRIS CO. MUD 081	31	307.784	374.258	379.076	315.529	454.059	480.434	441.234	480.434	10.1%
42	HARRIS CO. MUD 090	24	1.845	14.275	122.330	131.453	157.465	125.723	127.069	157.465	3.5%
43	HARRIS CO. MUD 102	25	41.498	50.269	114.338	129.204	143.733	174.234	167.450	174.234	
44	HARRIS CO. MUD 105	31	28.672	19.089	20.462	28.258	44.306	38.075	32.722	44.306	
45	HARRIS CO. MUD 107	24	64.863	60.375	101.018	41.496	86.799	84.209	76.570	101.018	26.3%
46	HARRIS CO. MUD 118	26	0.000	0.000	0.000	156.141	188.737	176.172	174.250	188.737	27.1%
47	HARRIS CO. MUD 119	26	120.268	174.722	229.328	165.573	132.980	177.639	171.246	229.328	6.4%
48	HARRIS CO. MUD 120	24	67.144	111.306	221.690	168.566	129.239	158.353	249.553	249.553	15.6%
49	HARRIS CO. MUD 127	31	0.000	0.000	0.000	0.000	14.415	29.370	28.411	29.370	13.0%
50	HARRIS CO. MUD 130	25	0.000	0.000	0.000	0.000	22.091	39.610	31.465	39.610	4.8%

ANNUAL GROUNDWATER PUMPAGE IN MILLIONS OF GALLONS

NO.	NAME OF DISTRICT	MDA	1980 PUMPAGE	1981 PUMPAGE	1982 PUMPAGE	1983 PUMPAGE	1984 PUMPAGE	1985 PUMPAGE	1986 PUMPAGE	MAXIMUM PUMPAGE	1986 LOSSES
51	HARRIS CO. MUD 136	31	95.345	94.696	156.008	139.917	113.345	122.080	106.959	156.008	5.2%
52	HARRIS CO. MUD 137	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
53	HARRIS CO. MUD 144	31	15.469	26.216	26.800	24.160	35.979	38.046	28.303	38.046	0.0%
54	HARRIS CO. MUD 147	24	51.358	54.672	111.712	80.967	89.147	74.242	69.592	111.712	10.3%
55	HARRIS CO. MUD 149	32	46.891	59.498	97.506	107.656	109.578	142.927	131.562	142.927	13.3%
56	HARRIS CO. MUD 155	32	0.000	0.000	0.000	0.000	0.000	10.549	18.156	18.156	22.7%
57	HARRIS CO. MUD 156	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
58	HARRIS CO. MUD 157	31	3.463	9.169	18.737	45.966	46.982	36.138	34.601	46.982	26.5%
59	HARRIS CO. MUD 158	24	5.000	17.134	29.662	26.960	61.000	66.392	75.356	75.356	12.6%
60	HARRIS CO. MUD 162	32	46.544	60.896	138.813	134.087	196.099	140.551	83.861	196.099	45.8%
61	HARRIS CO. MUD 163	32	0.000	0.000	0.000	0.000	0.000	0.000	190.330	190.330	7.6%
62	HARRIS CO. MUD 165	32	0.000	0.000	0.000	3.500	15.710	31.423	24.354	31.423	0.5%
63	HARRIS CO. MUD 166	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
64	HARRIS CO. MUD 167	31	0.000	0.000	0.000	0.000	0.000	2.120	6.630	6.630	70.6%
65	HARRIS CO. MUD 168	26	7.836	10.459	62.193	104.894	193.662	234.326	213.074	234.326	4.4%
66	HARRIS CO. MUD 170	26	0.000	8.000	47.605	59.154	42.869	48.745	56.623	59.154	8.0%
67	HARRIS CO. MUD 172	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
68	HARRIS CO. MUD 173	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
69	HARRIS CO. MUD 175	24	0.000	0.000	0.000	0.000	8.586	19.118	27.787	27.787	15.1%
70	HARRIS CO. MUD 177	24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
71	HARRIS CO. MUD 179	25	0.000	0.000	6.538	92.956	48.237	71.717	67.424	92.956	16.6%
72	HARRIS CO. MUD 183	31	0.000	0.000	0.000	14.294	69.481	72.527	69.858	72.527	15.2%
73	HARRIS CO. MUD 185	25	1.550	14.000	49.830	44.583	74.983	96.573	100.384	100.384	
74	HARRIS CO. MUD 186	25	0.000	0.000	0.000	0.000	138.356	155.410	147.242	155.410	64.3%
75	HARRIS CO. MUD 188	32	0.000	0.000	1.268	53.200	71.195	80.733	72.666	80.733	9.2%
76	HARRIS CO. MUD 190	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
77	HARRIS CO. MUD 194	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
78	HARRIS CO. MUD 195	32	0.000	0.000	0.000	0.000	0.000	0.000	0.735	0.735	
79	HARRIS CO. MUD 196	32	0.000	0.000	0.000	0.000	5.400	3.000	1.840	5.400	
80	HARRIS CO. MUD 197	25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
81	HARRIS CO. MUD 199	26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	10.0%
82	HARRIS CO. MUD 208	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
83	HARRIS CO. MUD 216	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
84	HARRIS CO. MUD 222	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
85	HARRIS CO. MUD 223	24	0.000	0.000	0.000	0.000	9.261	29.138	39.272	39.272	13.0%
86	HARRIS CO. MUD 225	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
87	HARRIS CO. MUD 229	26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
88	HARRIS CO. MUD 230	33	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
89	HARRIS CO. MUD 237	26	0.000	0.000	0.000	0.000	0.000	0.830	1.576	1.576	41.8%
90	HARRIS CO. MUD 238	31	0.000	0.000	0.000	0.000	0.000	12.348	11.858	12.348	41.4%
91	HARRIS CO. MUD 239	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	73.3%
92	HARRIS CO. MUD 240	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
93	HARRIS CO. MUD 243	24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
94	HARRIS CO. MUD 246	24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
95	HARRIS CO. MUD 247	26	0.000	0.000	0.000	0.000	0.500	6.501	10.270	10.270	
96	HARRIS CO. MUD 248	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
97	HARRIS CO. MUD 250	25	0.000	0.000	0.000	0.000	1.770	9.889	13.013	13.013	35.5%
98	HARRIS CO. MUD 252	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
99	HARRIS CO. MUD 255	25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
100	HARRIS CO. MUD 256	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%

ANNUAL GROUNDWATER PUMPAGE IN MILLIONS OF GALLONS

NO.	NAME OF DISTRICT	MDA	1980 PUMPAGE	1981 PUMPAGE	1982 PUMPAGE	1983 PUMPAGE	1984 PUMPAGE	1985 PUMPAGE	1986 PUMPAGE	MAXIMUM PUMPAGE	1986 LOSSES
101	HARRIS CO. MUD 257	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
102	HARRIS CO. MUD 259	25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
103	HARRIS CO. MUD 261	26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
104	HARRIS CO. MUD 263	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
105	HARRIS CO. MUD 264	32	0.000	0.000	0.000	0.000	0.000	0.000	35.964	35.964	10.3%
106	HARRIS CO. MUD 268	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
107	HARRIS CO. MUD 272	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
108	HARRIS CO. MUD 273	33	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
109	HARRIS CO. MUD 276	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
110	HARRIS CO. MUD 277	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
111	HARRIS CO. MUD 280	33	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
112	HARRIS CO. MUD 281	33	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
113	HARRIS CO. MUD 282	33	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
114	HARRIS CO. MUD 263	33	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
115	HARRIS CO. MUD 284	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
116	HARRIS CO. MUD 286	33	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
117	HARRIS CO. MUD 287	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
118	HARRIS CO. MUD 288	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
119	HARRIS CO. MUD 289	33	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
120	HARRIS CO. MUD 306	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
121	HARRIS CO. MUD 317	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
122	HARRIS CO. MUD 318	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
123	HARRIS CO. MUD 319	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
124	HARRIS CO. MUD 325	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
125	HARRIS CO. UD 6	25	255.584	243.110	323.494	332.844	362.402	453.849	448.946	453.849	15.8%
126	HARRIS CO. WCID 113	32	35.560	35.346	39.759	35.002	40.899	40.034	35.712	40.899	
127	HARRIS CO. WCID 133	26	257.409	209.398	254.884	187.730	207.763	215.430	231.920	257.409	
128	HARRIS-FT. BEND MUD 1	31	0.000	0.000	0.000	0.000	0.000	4.728	5.970	5.970	8.0%
129	HARRIS-FT. BEND MUD 3	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
130	HARRIS-FT. BEND MUD 4	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
131	HARRIS-FT. BEND MUD 5	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
132	HORSEPEN BAYOU MUD	25	0.000	3.932	24.826	39.610	70.873	89.698	103.811	103.811	
133	INTERSTATE MUD	31	0.000	0.000	0.000	0.000	2.713	44.032	42.405	44.032	22.9%
134	JACKRABBIT ROAD PUD	31	350.548	339.197	407.277	396.467	416.830	419.323	376.378	419.323	
135	KINGSBRIDGE MUD	24	0.000	0.000	0.000	17.908	116.731	146.220	135.880	146.220	12.2%
136	LAKE FOREST UD	33	61.492	67.310	75.395	85.292	96.545	116.830	121.095	121.095	
137	LANGHAM CREEK UD	31	27.078	59.347	147.946	149.324	160.827	160.049	150.004	160.827	10.6%
138	LONGHORN TOWN UD	31	0.000	0.000	0.000	0.000	1.867	15.500	30.975	30.975	12.0%
139	MALCOMSON ROAD UD	33	143.482	137.056	175.921	199.014	225.270	272.603	282.556	282.556	
140	MASON CREEK UD	31	200.843	211.474	261.051	304.784	395.372	418.282	349.537	418.282	
141	MAYDE CREEK MUD	31	1.501	7.166	31.106	48.271	82.999	59.093	27.590	82.999	
142	MEMORIAL MUD	31	0.030	7.124	14.900	14.835	13.763	17.037	15.685	17.037	23.0%
143	MILLS ROAD MUD	33	75.092	37.774	107.202	164.464	119.101	95.598	132.183	164.464	
144	MISSION BEND MUD 1	24	1.928	91.324	101.044	92.519	232.264	148.333	148.253	232.264	
145	MISSION BEND MUD 2	24	29.069	50.800	129.132	107.589	209.043	216.673	258.338	258.338	
146	MORTON ROAD MUD	31	8.933	24.489	50.133	59.974	66.627	62.423	50.314	66.627	0.6%
147	NORTHWEST FREEWAY MUD	32	34.476	34.151	66.594	70.440	80.083	71.374	56.272	80.083	0.0%
148	NORTHWEST PARK MUD	26	162.405	168.157	227.170	128.693	278.609	296.660	286.120	296.660	
149	NOTTINGHAM COUNTRY MUD	31	0.000	0.000	0.000	0.000	0.000	13.129	35.158	35.158	27.6%
150	NW HARRIS CO. MUD 05	33	31.021	30.000	33.881	35.878	36.290	33.485	32.768	36.290	3.0%

ANNUAL GROUNDWATER PUMPAGE IN MILLIONS OF GALLONS

NO.	NAME OF DISTRICT	MDA	1980 PUMPAGE	1981 PUMPAGE	1982 PUMPAGE	1983 PUMPAGE	1984 PUMPAGE	1985 PUMPAGE	1986 PUMPAGE	MAXIMUM PUMPAGE	1986 LOSSES
151	NW HARRIS CO. MUD 09	32	17.545	18.642	33.629	45.648	126.095	145.448	105.689	145.448	10.5%
152	NW HARRIS CO. MUD 10	32	0.000	19.191	19.000	19.000	19.852	20.068	20.664	20.664	37.8%
153	NW HARRIS CO. MUD 12	31	0.534	3.263	9.632	16.382	24.722	38.728	20.285	38.728	
154	NW HARRIS CO. MUD 15	33	4.554	5.760	5.921	14.791	28.972	40.777	31.155	40.777	11.6%
155	NW HARRIS CO. MUD 16	31	15.392	18.572	23.151	22.074	29.910	31.009	27.808	31.009	14.8%
156	NW HARRIS CO. MUD 25	25	0.000	0.000	4.730	0.026	3.275	6.500	10.875	10.875	
157	NW HARRIS CO. MUD 27	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
158	NW HARRIS CO. MUD 29	26	0.000	0.000	0.000	0.000	0.000	31.653	39.370	39.370	93.1%
159	PARK TEN MUD	31	99.117	107.559	135.311	146.278	206.517	219.476	230.855	230.855	11.2%
160	PECAN PARK MUD	25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
161	REID ROAD MUD 1	26	0.000	96.013	103.606	125.000	148.178	191.501	209.091	209.091	11.0%
162	REID ROAD MUD 2	26	0.000	0.000	0.000	3.773	51.663	40.282	35.939	51.663	5.0%
163	REMINGTON MUD 1	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
164	REMINGTON MUD 2	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
165	REMINGTON MUD 3	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
166	RENN ROAD MUD	24	0.000	2.085	76.127	121.218	64.222	64.148	62.776	121.218	7.5%
167	RICEWOOD MUD	31	0.000	0.000	0.000	0.000	0.000	64.647	70.970	70.970	33.0%
168	ROLLING CREEK UD	31	0.000	0.000	0.000	0.000	0.000	11.679	5.443	11.679	
169	ROLLING FORK PUD	26	91.681	72.940	82.851	75.926	87.150	113.675	85.219	113.675	12.7%
170	SPENCER ROAD PUD	25	118.165	118.492	177.058	147.677	142.474	170.009	146.262	177.058	
171	TIMBERLAKE ID	32	84.044	88.645	109.857	98.248	121.379	129.632	132.520	132.520	
172	WEST HARRIS CO. MUD 01	26	28.541	33.249	58.396	46.812	44.895	41.588	37.267	58.396	
173	WEST HARRIS CO. MUD 02	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
174	WEST HARRIS CO. MUD 04	24	0.000	0.000	7.200	46.140	29.960	27.090	23.977	46.140	15.3%
175	WEST HARRIS CO. MUD 05	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
176	WEST HARRIS CO. MUD 06	24	18.916	28.368	48.492	57.246	62.752	77.266	75.097	77.266	28.7%
177	WEST HARRIS CO. MUD 07	31	0.000	0.000	0.000	0.000	0.000	31.023	25.667	31.023	
178	WEST HARRIS CO. MUD 08	26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
179	WEST HARRIS CO. MUD 09	26	0.000	3.044	40.819	75.724	103.087	52.152	57.320	103.087	2.8%
180	WEST HARRIS CO. MUD 10	26	0.000	0.000	0.000	0.000	5.508	97.915	88.152	97.915	5.4%
181	WEST HARRIS CO. MUD 11	26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
182	WEST HARRIS CO. MUD 14	32	0.000	0.000	4.559	0.000	0.000	0.000	0.000	4.559	
183	WEST HARRIS CO. MUD 15	32	0.000	0.000	0.000	25.259	28.500	32.450	29.899	32.450	23.5%
184	WEST HARRIS CO. MUD 16	24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
185	WEST HARRIS CO. MUD 17	31	0.000	0.000	0.000	4.028	15.560	15.328	16.650	16.650	34.9%
186	WEST HARRIS CO. MUD 20	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0%
187	WEST MEMORIAL MUD	31	226.257	170.010	214.766	171.705	217.654	216.423	184.018	226.257	8.4%
188	WESTLAKE MUD 1	31	88.274	114.324	161.501	132.830	150.432	134.070	164.431	164.431	16.3%
189	WESTON MUD	31	57.134	62.442	67.948	66.094	58.923	98.505	42.225	98.505	6.8%
190	WESTPARK MUD	31	0.000	0.418	5.785	23.000	42.608	90.454	43.432	90.454	8.0%
191	WESTWAY UD	25	33.970	55.375	92.670	97.489	113.171	126.389	104.567	126.389	
192	WHITE OAK BEND MUD	26	25.217	31.993	47.987	57.895	64.653	62.793	58.773	64.653	3.0%
193	WHITE OAK/1960 MUD	26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
194	WILLOW CHASE MUD	33	0.000	0.487	7.340	25.398	26.958	27.495	47.833	47.833	
195	WINDFERN FOREST UD	26	40.454	52.675	77.123	75.997	85.969	86.851	56.071	86.851	10.6%
196	JERSEY VILLAGE	26	218.7	224.4	262.8	244.6	250.6	247.7	249.1	262.8	
197	KATY, CITY OF	31	301.9	307.3	346.8	427.8	311.8	304.3	258.6	427.8	
198	BAKER SERVICE TOOLS	26	13.4	15.8	11.1	6.9	8.0	10.9	11.9	15.8	
199	BAKER TUBULAR SERVICS	25	7.8	9.2	11.2	7.1	5.0	6.9	7.8	11.2	
200	BEAR CREEK GOLF WORLD	24	39.2	16.0	25.4	44.9	41.3	59.0	72.1	72.1	

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201	BRITMORE UTILITY CO	25	33.1	35.1	40.9	50.9	62.3	58.1	56.9	62.3	
202	CAMERON IRON WORKS	32	45.7	85.6	73.2	57.4	59.7	40.1	35.5	85.6	
203	ENCHANTED VALLEY W/S	33	10.3	9.2	15.1	11.0	8.8	14.4	75.9	75.9	
204	GIFFORD-HILL & CO	25	17.2	13.5	20.6	9.8	11.9	12.4	22.2	22.2	
205	HEARTHSTONE COUNTRYCLUB	25	34.9	75.6	57.2	57.2	63.6	76.8	17.8	76.8	
206	NATIONAL STEEL PRODUCTS	25	20.1	26.3	18.5	14.4	6.4	5.7	5.3	26.3	
207	N.W. WATER SYSTEMS, INC	33	17.2	15.8	18.8	17.1	17.2	15.8	15.3	18.8	
208	PEEK ROAD UTILITIES	31	0.0	0.0	0.0	3.4	8.8	8.9	6.7	8.9	
209	TALL PINES UTILITY	33	6.4	8.5	10.5	8.9	9.6	9.2	9.2	10.5	
210	TEXAS INSTRUMENTS	32	24.0	35.6	30.1	26.7	43.9	50.8	38.3	50.8	
211	TOWER OAK BEND WAT.SUP.	32	0.1	0.0	0.0	2.0	7.0	12.1	11.6	12.1	
212	TREELINE GOLF CLUB, INC	33	0.0	0.0	0.0	4.0	12.0	14.0	15.8	15.8	
213	TRUMIX CONCRETE COMPANY	32	3.3	2.5	5.5	4.8	2.1	0.8	0.5	5.5	
214	TRUNKLINE GAS COMPANY	32	16.2	14.8	20.5	12.5	15.3	12.8	15.3	20.5	