REPORT

OF THE

TECHNICAL DATA REVIEW PANEL

ON THE WATER RESOURCES OF THE SOUTH CENTRAL TEXAS REGION

REPORT

OF THE

TECHNICAL DATA REVIEW PANEL

ON THE WATER RESOURCES OF THE SOUTH CENTRAL TEXAS REGION

November 1992

This effort was organized and funded by the Edwards Underground Water District

Table of Contents

1.0 INTRODUCTION

1.1 PURPOSE

1.2 ORGANIZATION

1.3 GROUND RULES

1.4 STUDY AREA

1.5 REPRESENTATIVES

1.0 INTRODUCTION

1.1 PURPOSE

The Technical Data Review Panel is an independent study group broadly representative of a large region of South Central Texas that is affected by decisions made about the Edwards Aquifer. This Panel is guided by a shared recognition of the need for dispassionate review of the validity and scope of the available data about water needs and supplies in the region as an important step facilitating any future policy choices about water management. The purpose of the Technical Data Review Panel is to assemble existing data on water needs and supplies and related issues in the study area, review it in a forum where all regional water interests have technical representatives present, compile the data in a useful collection and record the opinions, both collective and individual, of the representatives concerning the validity of the data. The final work product is a written report. This written material and the greater understanding of the accuracy and limitations of existing data comprise a resource for policy decisions to be made later in a variety of planning, policy or decision-making forums addressing water supply issues for the study area.

The Panel was initially convened by the Edwards Underground Water District as part of a larger effort that was proposed to lead to the formation of a South Central Texas Water Resources Council, which would attempt to draft a management plan for the Edwards Aquifer. Early planning discussions determined that the Technical Data Review Panel should be an independent entity and have no relation to the proposed Council. The District therefore agreed to provide funds for a technical consultant and an independent facilitator but to leave to the Panel itself the choice of the facilitator and all further decisions about its organization and ground rules.

A fundamental premise of this effort was that it would concern itself solely with data and technical questions and not consider or attempt to negotiate any policy issues. The goal was an honest assessment by all representatives of the value of the data under review.

The Panel decided to focus its attention on data that the member entities had occasion to use and test, and often contribute to gathering, in the course of their professional work with water systems, industries, farms, wildlife preserves, recreation facilities and regional planning and administration. This was <u>not</u> a scientific panel, charged with answering specific hydrologic or other technical questions or with performing original research. Rather it was a group of professionals attempting to assess the data regarding the availability and quality of water in a large region of South Central Texas.

The Panel therefore focused its review on technical issues surrounding the methods of measuring and estimating water demands for human communities and economic activities and the needs of natural systems. In addition, it examined available data regarding existing and potential water supply projects, ranging from reservoirs to enhancement of recharge, and measures for reducing water use through various conservation scenarios. Finally, it examined studies designed to quantify natural recharge to the Edwards Aquifer and data regarding water quality, in so far as quality issues affect the availability of water supplies.

Excluded from this review and the report resulting from it were many hydrologic questions which are subjects of debate in the scientific community and which depend on detailed computer modelling and test observations. Also excluded were the management models designed to test the effects of a variety of policy assumptions regarding regulation of the use of Edwards water.

The report of the Technical Review Panel is thus intended as a guide to the availability and reliability principally of water quantity, use and supply data. The report does not pretend to offer the "correct" data. Rather it familiarizes the reader with the underlying methodologies used to collect and/or to estimate data which are central to any planning or policy development efforts for the use of Edwards waters. It should be clearer from this review what the data does and does not say and what are the gaps in existing information. A concluding section makes several suggestions for further technical studies to revise particular methodologies, enhance collection efforts or review the uses to which data are put in a policy context.

1.2 ORGANIZATION

The Technical Data Review Panel is an assembly of technical representatives from a cross section of water users and related administrative agencies in the study area. (See 1.4 for a full delineation of the study area.) The Panel includes representatives from irrigation, municipal, industry and military interests. Also represented are river authorities, recreation and springflow interests and state and federal agencies. (See Section 1.5 for a complete listing of member entities and representatives.)

The responsibilities of the technical representatives are to:

1. review existing data, and methodologies used to develop that data, on historical water use, water use projections, alternative supplies, conservation, recharge and water quality;
2. present views on the relative reliability of data elements from the representatives personal knowledge and experience of the representatives in order to clarify the decree of accuracy and precision of the data;
3. list technical areas requiring further study;
4. prepare a text of technical information on water demands and supplies to serve as a resource for policy makers to use in variety of contexts, including the development of regional and local management plans for the study area;
5. inform the groups that they represent on the findings of the Panel.

1.3 GROUND RULES

The group agreed upon a set of ground rules to govern the activities of the Technical Data Review Panel. These rules were intended to support a politically unbiased atmosphere for the development of the written product. The ground rules, as adopted by the Panel, were as follows:

1. Members of the Panel were represented by persons with technical expertise who could further the Panel's aim of analyzing technical data. Elected officials and attorneys could not serve as representatives unless the entity had no alternative and would otherwise not have been represented.

2. Meetings of the Panel were open to the public and press. No rules were adopted about comments to the press. Members were asked in making comments outside the meetings to keep in mind the need for a cooperative atmosphere. An opportunity for comments by observers and members of the public was created at each meeting during a public "window." Public comments were limited to technical issues only; policy comments were not allowed.

3. The Panel considered only issues relating to technical data and did not discuss or attempt to negotiate any policy questions.

4. The goal of the discussions was to identify areas of agreement and disagreement regarding the adequacy and reliability of technical data. The group attempted to identify the specific reasons and criteria for evaluation of data, whether positive or negative.

5. Silence by a member of the Panel was not interpreted as either agreement or disagreement.

6. There was no voting in the sense of defining a single set of recommendations or conclusions of the Panel. Instead, the group recorded the full extent of agreement and disagreement, together with reasons and criteria for data evaluation.

7. The final report of the Panel was to reflect the full range of opinion on each issue.

8. John Folk-Williams was selected to serve as the Panel's facilitator and to maintain the group's mailing list.

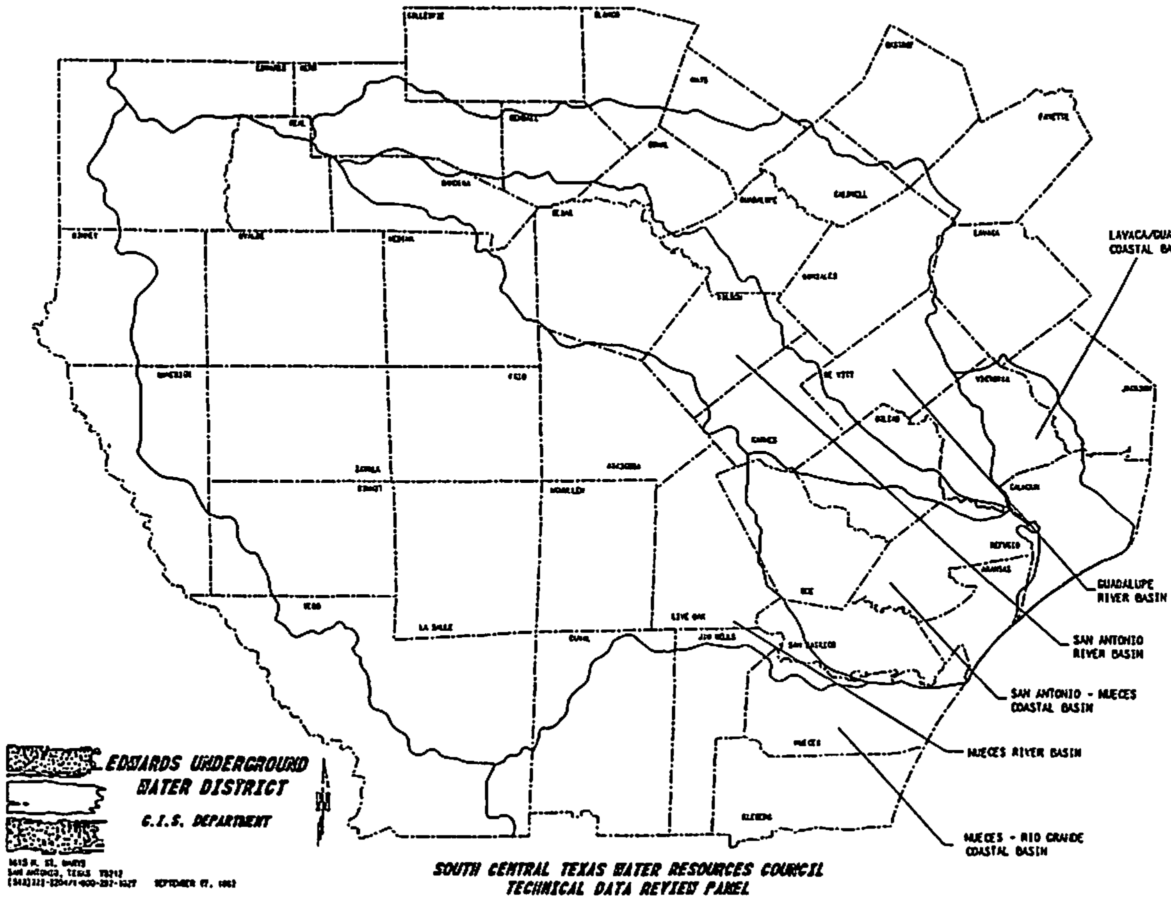
9. Greg Rothe was selected to serve as the Panel's technical consultant. He prepared background material in the form of drafts of each chapter of the report and provided this to the group one week in advance of each scheduled meeting. All members were encouraged to contact him directly with information about data sources or issues for consideration.

10. Meeting dates were selected as follows: April 29, June 3, June 24, July 22, August 26 and September 23. All meetings were scheduled from 9:30 A.M. to 5:00 P.M. and were held at the Edwards Underground Water District Office.

1.4 STUDY AREA

The study area is generally described by the area of the Guadalupe, San Antonio and Nueces river basins including and downstream of the Edwards Aquifer recharge zone. Also included are the coastal basins adjacent to these river basins: the Lavaca-Guadalupe, the San Antonio-Nueces and the northern part of the Nueces-Rio Grande in the Corpus Christi area. In addition the lower portion of the Lavaca-Navidad River basin was included for purposes of addressing Lake Texana. Figure 1.1-1 outlines the study area.

Figure 1.1-1



1.5 REPRESENTATIVES

Following is an alphabetized list of the member entities with an indication of their representatives and alternates.

Ms. Judith Austen
Air Force Military Water Coordinator
HQ ATC/DEME
Building 661
Randolph AFB, TX 78150-5001

Mr. Tom Moreno
General Manager
Bexar Metropolitan Water District
PO Box 3577
San Antonio, TX 78285

J.W. "Johnny" Ward
President
BMA Counties Water Control & Improvement Dist #1
PO Box 170
Natalia, TX 78059

Mr. Bill Couch, AICP
General Manager
BS-EACD
1124A Regal Row
Austin, TX 78748
Alternates:
(1) Ron Fiesler
(2) Stefan Schuster

Mr. David Davenport
Administrator
Canyon Regional Water Authority
PO Box 188
Marion, TX 78124

Mr. David R. Dennis
Assistant General Manager
Cibolo Creek Municipal Authority
PO Box 930
Schertz, TX 78154

Mr. Victor Medina
Water Superintendent
City of Corpus Christi
PO Box 9277
Corpus Christi, TX 78469
Alternate:
Mr. Ed Garana
Assistant Water Superintendent

Mr. Mike Rhea
City Manager
City of Hondo
1600 Avenue M
Hondo, TX 78861

Mr. Rick Cortes
City Manager
City of Kirby
112 Bauman
Kirby, TX 78219

Mr. Larry Gilley
City Manager
City of San Marcos
630 E. Hopkins
San Marcos, TX 78666

Ms. Melissa Millecam
Governmental and Comm. Affairs Coordinator
City of San Marcos
630 East Hopkins
San Marcos, TX 78666
Alternates:
(1) George Boeker, Public Works Director
(2) Ron Patterson, Planning Director

Mr. James Thurmond
City Manager
City of Uvalde
PO Box 799
Uvalde, TX 78801

Mr. Joe Fulton
Director Res. & Enviro. - Planning Division
City Public Service
PO Box 1771
San Antonio, TX 78296
Alternate:
Kim Stoker

Mr. Russell Masters
General Manager
Edwards Underground Water District
PO Box 15830
San Antonio, TX 78212

Mr. Keith Pate
Manager
Evergreen Underground Water Conservation Dist.
PO Box 155
Jourdanton, TX 78026
Alternate:
Roger Herschap

Mr. John Specht
General Manager
Guadalupe Blanco River Authority
PO Box 271
Seguin, TX 78156-0271
Alternate:
Thomas Hill

Mr. Gail Boehme
Representative
Medina County
106 Hwy. 90 West
Castroville, TX 78009

Mr. Oliver Martin
President
Medina Co. Underground Water Cons. District
1100 16th Street
Hondo, TX 78861

Mr. Bob Sohn
General Manager
New Braunfels Utilities
PO Box 310289
New Braunfels, TX 78131-0289

Mr. Con Mims
Executive Director
Nueces River Authority
PO Box 349
Uvalde, TX 78802-0349

Mr. Jack Willome
President
RayCo, Inc.
PO Box 5250
San Antonio, TX 78201
Alternate:
Herb Quiroga

Mr. Fred N. Pfeiffer
General Manager
San Antonio River Authority
PO Box 830027
San Antonio, TX 78283-0027
Alternate:
F. Blair Warren

Mr. Joe Aceves
President/CEO
San Antonio Water System
PO Box 2449
San Antonio, TX 78298-2449

Becky Cedillo
Vice President, Planning Department
San Antonio Water System
PO Box 2449
San Antonio, TX 78298-2449
Alternate:
Dwayne Rathburn

Mr. Don Pollard
San Antonio Water System
PO Box 2449
San Antonio, TX 78298-2449
Alternates:
(1) Tom Pardue
(2) Chris Powers

Mr. Jerry L. Morrisey, Ph.D
Sierra Club
19631 Encino Way
San Antonio, TX 78259
Alternate:
Mr. Fred Wills

Mr. Ray Buck
General Manager
Springhills Water Management District
PO Box 771
Bandera, TX 78003-0771

Ms. Cindy Loeffler
Inflow Coordinator
Resource Protection Division
Texas Parks and Wildlife Department
3000 S.IH 35, Suite 320
Austin, TX 78704
Alternate:
Randy Moss

Mr. Mike Personett
Texas Water Commission
PO Box 13087
Austin, TX 78711

Mr. Tommy Knowles
Director of Planning
Texas Water Development Board
PO Box 13231 - Capitol Station
Austin, TX 78711-3231
Alternates:
Butch Bloodworth
Bill Moltz
Comer Tuck
Steve Densmore
Bill Hoffman

Ms. Alisa M. Shull
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
611 East 6th Street, Room 407
Austin, TX 78701
Alternates:
(1) Mr. Leslie Cunningham
(2) Mr. Steve Cullinan
U.S. Fish and Wildlife Service
PO Box 1306
Albuquerque, NM 87103

Mr. Lawrence Friesenhahn
Uvalde County Representative
Rt. 1 Box 63
Knippa, TX 78870

Mr. A.M. Rimkus
Uvalde County Underground Water Conservation Dist. Route 1, Box 38
Knippa, TX 78870-9715

Mr. Douglas R. Miller, CIC
President
Witting & Miller, Inc.
PO Box 311508
New Braunfels, TX 78131-1508

Mr. Bob Wright
Consultant
Wright Consulting
3904 John Stockbauer
Victoria, TX 77904
Alternate:
Mr. Bob Keith
Sr. Environmental Consultant
Du Pont Chemicals

Mr. Robert Wagner
General Manager
Zavala-Dimmitt Water Improvement Dist. #1
PO Drawer 729
Crystal City, TX 78839

◆ ◆ ◆ ◆ ◆

Mr. John Folk-Williams
Facilitator
Western Network
616 Don Gaspar
Santa Fe, NM 87501

Mr. Greg Rothe
Technical Consultant
PO Box 668
1614 Avenue M
Hondo, TX 78861

2.0 WATER DEMANDS AND NEEDS

Introduction

2.1 DEMANDS AND DEMAND PROJECTIONS

2.1.1 Historical Ground Water Pumping Data

2.1.1.1 Texas Water Development Board
2.1.1.2 United States Geological Survey
2.1.1.3 Summaries and Comparisons
2.1.1.4 Panel Discussions and Conclusions

2.1.2 Historical Surface Water Diversions

2.1.2.1 Texas Water Commission
2.1.2.2 Summaries and Comparisons
2.1.2.3 Panel Discussions and Conclusions

2.1.3 Population and water Use Projections

2.1.3.1 Texas Water Development Board, 1990 Texas Water Plan
2.1.3.2 Texas Water Development Board, 1992 Draft Projections
2.1.3.3 Texas Water Development Board Per Capita Water Use
2.1.3.4 Summaries and Comparisons
2.1.3.5 Panel Discussions and Conclusions

2.2 WATER NEEDS FOR NATURAL SYSTEMS

2.2.1 Springflows

2.2.1.1 Comal and San Marcos Springs
2.2.1.2 Historical Records

2.2.2 Instream Flows

2.2.3 Bays and Estuaries

2.2.4 Panel Discussions and Conclusions

SECTION 2.0 LIST OF TABLES

SECTION 2.0 LIST OF FIGURES

2.0 WATER DEMANDS AND NEEDS

Introduction

One of the most critical needs in considering the future of the study area is to determine the historical and projected uses of its waters. This section analyzes four key elements:

- **Historical demands for groundwater by human activity in the counties overlying the Edwards Aquifer system.**
- **Historical demands for surface water below Comal and San Marcos springs and below the recharge zone generally in the Guadalupe, San Antonio and Nueces river basins.**
- **Projected future demands for these human activities.**
- **Needs of the springs, rivers and bays for water to sustain wildlife habitat and other natural systems**

The first part of the section looks at the two principal sources of historical groundwater use data: the U.S. Geological Survey and the Texas Water Development Board. After explaining the methodologies each uses for each category of data, this part offers samples of the available data to illustrate what is available from the agency. Then sample sets of data from the two sources are compared, discrepancies noted, and the methodological reasons for discrepancies accounted for in so far as this is possible. The Panel felt that it could not, given the available information, reach a definitive conclusion about which data set was most reliable. Instead, it has indicated in the tables comparing USGS and TWDB data the percentage difference between the figures. This is intended to "red flag" those differences which are especially high, indicating the need for further work to resolve discrepancies.

The next part takes the same approach to historical surface water data. There is only one major source of this data, the Texas Water Commission, which issues permits for surface water use and collects diversion reports from the permittees. This is a brief section since the Panel found little disagreement with the available data.

Following these two sections on historical water use is a long discussion concerning the projection of future demands made by the Texas Water Development Board. While this agency is the only one that makes detailed projections for the entire study area, it has two major sets of data which the Panel examined. One consists of work done in 1989 for the 1990 Texas Water Plan, and the second is work done for the 1992 Draft projections. The importance of gallons per capita per day (GPCD) calculations are a central concern of this section.

Last is a summary of available technical information concerning the needs of natural systems, including springflows, instream flow needs of rivers and freshwater requirements of the bays and estuaries of the Gulf Coast into which the streams of the study area flow. This discussion reveals that little reliable data is available, and the need for further information is reviewed in Section 7 of this Report.

2.1 DEMANDS AND DEMAND PROJECTIONS

2.1.1 Historical Ground Water Pumping Data

2.1.1.1 Texas Water Development Board

The Texas Water Development Board (TWDB) submits reporting forms to public water supply systems and industrial water users annually statewide seeking information on ground water and surface water use for the year. These forms provide for the reporting entity to report water use on a monthly basis, in addition to other pertinent information relative to the reporting entity's operation. For surface water the reported irrigation uses do not include delivery system losses and as such do not represent total diversions. For ground water use, the subject of this section, use generally equals pumpage because the reported uses are measured at the point of production from the well or at the primary pumping station to the distribution system. TWDB also estimates power, miming, livestock and irrigation uses.

TWDB compiles this data on ground water pumpage by county and by aquifer. Table 2.1-1 presents the historical ground water pumpage for the counties in the study region for the six categories of use: Municipal, Manufacturing, Power, Mining, Irrigation and Livestock.

Sample Data From Table 2.1-1
see pages 42-46 for complete table

HISTORICAL GROUND WATER PUMPAGE BY COUNTIES FOR REGION

SOURCE: TEXAS WATER DEVELOPMENT BOARD
ALL VALUES ARE REPORTED IN ACRE-FEET UNITS

COUNTY		1985	1986	1987	1988	1989
BEXAR						
MUNICIPAL & MILITARY		238,431.13	243,700.62	235,429.08	260,609.01	259,860.07
MANUFACTURING		6,176.61	7,597.16	6,581.49	8,285.61	6,836.91
POWER		1,244.05	1,219.43	1,113.71	740.96	738.51
MINING		2,564.00	1,557.99	1,370.00	1,462.00	1,319.00
IRRIGATION		16,967.00	16,610.00	12,949.00	15,595.00	23,851.00
LIVESTOCK		138.00	146.00	122.00	127.00	127.00
BEXAR	TOTAL:	265,520.79	270,831.19	257,565.29	286,820.57	292,731.49

Table 2.1-2 reports the historical ground water pumpage by aquifer for the study region, a resorting of the same data used in Table 2.1-1. The Leona gravel in Uvalde County is not reported as a separate aquifer. TWDB representatives report that pumpage from the Leona gravel is probably reported in the category of the aquifer(s) underlying the Leona.

Sample Data From Table 2.1-2
see page 47 for complete table

HISTORICAL GROUND WATER PUMPAGE BY AQUIFER FOR REGION

SOURCE: TEXAS WATER DEVELOPMENT BOARD
ALL VALUES ARE REPORTED IN ACRE FEET

AQUIFER NAME	1985	1986	1987	1988	1989
CARRIZO - WILCOX	240,539.90	207,259.45	180,792.98	264,306.95	298,725.99
EDWARDS - BFZ	504,299.20	519,262.37	475,676.80	544,872.29	592,479.59
EDWARDS - TRINITY	5,598.10	5,793.77	3,007.46	3,598.98	11,253.86
GULF COAST	82,927.02	73,846.63	78,188.66	86,329.87	83,236.05
OTHER - UNDIFF.	2,666.19	1,714.20	1,909.14	3,279.11	2,160.52
QUEEN CITY	4,169.58	1,112.39	841.91	1,258.68	1,271.69
RITA BLANCA	17.00	16.71	19.91	19.18	18.89
SEYMOUR				765.21	
SPARTA	585.91	512.15	549.57	578.11	727.68
TRINITY	8,689.18	8,974.76	9,827.62	15,480.64	11,549.59
REGIONAL TOTALS:	849,492.08	818,492.43	750,814.05	920,489.02	1,001,423.86

The derivation of the pumpage estimation for each of the six categories of use are listed below.

Municipal

Figure 2.1-1 is a sample of the survey form that TWDB submits to municipal water users. Included in the municipal category are commercial operations and institutions, prisons, military bases, residences, parks, golf courses, firewater, cemeteries, street washing and schools. TWDB representatives report an 88 percent compliance rate for submittal of reports by the 4800 public systems in the state. When reports are not furnished by known water users, the TWDB makes its own estimates based upon available information, especially prior year reports and current connection data, if available.

Table 2.1-3 presents the ground water pumpage data for municipal water users from the Edwards Aquifer for the years 1981-1990. Numbers estimated by TWDB are noted with a suffix "E." Blanks in the record indicate no report. In some cases these are new systems which started operations during the 1981-1990 period.

The TWDB report form does not provide for the water user to indicate the aquifer that is the source of its ground water use. TWDB assigns the pumpage to various aquifers based on aquifer maps, well locations and depths and other information available to TWDB.

Manufacturing

TWDB provides reporting forms to manufacturing water users similar to those furnished to municipal users. Figure 2.1-2 is a sample of the manufacturing report form. TWDB cannot compel the manufacturers to report on ground water pumpage. These reports are submitted on a voluntary basis. TWDB representatives report a 92% compliance rate for reporting. Estimates are made for known large users who do not report.

TWDB assigns the pumpage to the separate aquifers in the same manner as described above in the Municipal use section.

Power

The TWDB obtains reported pumping data from power generation stations. For steam electric plants using surface water for cooling, consumptive use is estimated based on power production and plant specific data. This ground water pumpage is assigned to separate aquifers in the same manner as described above the in Municipal use section.

Mining

The TWDB obtains reported pumpage for some mining operations. For those not reporting, estimates are made based on U. S. Bureau of Mines production data converted to water use.

Irrigation

The TWDB makes intensive surveys of irrigation use every five years. The two most recent years are 1984 and 1989. This water use information is presented in Report 329, Surveys of Irrigation in Texas-1958, 1964, 1969, 1974, 1979, 1984, 1989. The crop acreage and crop water application information is obtained for the intensive surveys from Soil Conservation Service (SCS) field office estimates. In other years, TWDB obtains irrigation acreage data from the Texas Agricultural Statistics Service and estimates of crop water application rates from the Soil Conservation Service. The Texas Agricultural Statistics Service estimates crop acres from report forms sent to farmers and returned on a voluntary basis.

TWDB reports that very few of the ground water irrigation uses are metered. The limits of accuracy are wide and not as precise as the Municipal or Manufacturing uses where reports are available from individual users. Estimates are made on an annual basis. Monthly values are not prepared. The pumpage is assigned to aquifers by the method described above for Municipal pumpage. Where multiple aquifers are available for irrigation pumpage in a particular area, some well depth information is used by TWDB for assignment of the pumpage to the separate aquifers.

Table 2.1-4 presents the 1984 and 1989 irrigation pumpage estimates for the counties in the study region. Table 2.1-5 provides the detailed calculations of the reported pumpage. This information was supplied by the Soil Conservation Service and provides crop type, acres irrigated, inches applied, and the resultant acre feet of water pumpage. Note that two total crop acres are reported in Table 2.1-5, the first, "Total Crop Acres Irrigated" is the sum of the individual crop acres. The "Acres Irrigated-County Map," total, which is also the total acres reported in Table 2.1-4, is in all cases less than the "Total Crop Acres Irrigated." TWDB reports that this difference is explained by double cropping on some acres. Note that for Uvalde County, this difference is 14,000 and 19,000 acres for 1984 and 1989, respectively, indicating that those numbers of irrigated acres were double cropped in those years.

Livestock

Estimates of livestock pumpage are based on livestock populations converted to water use.

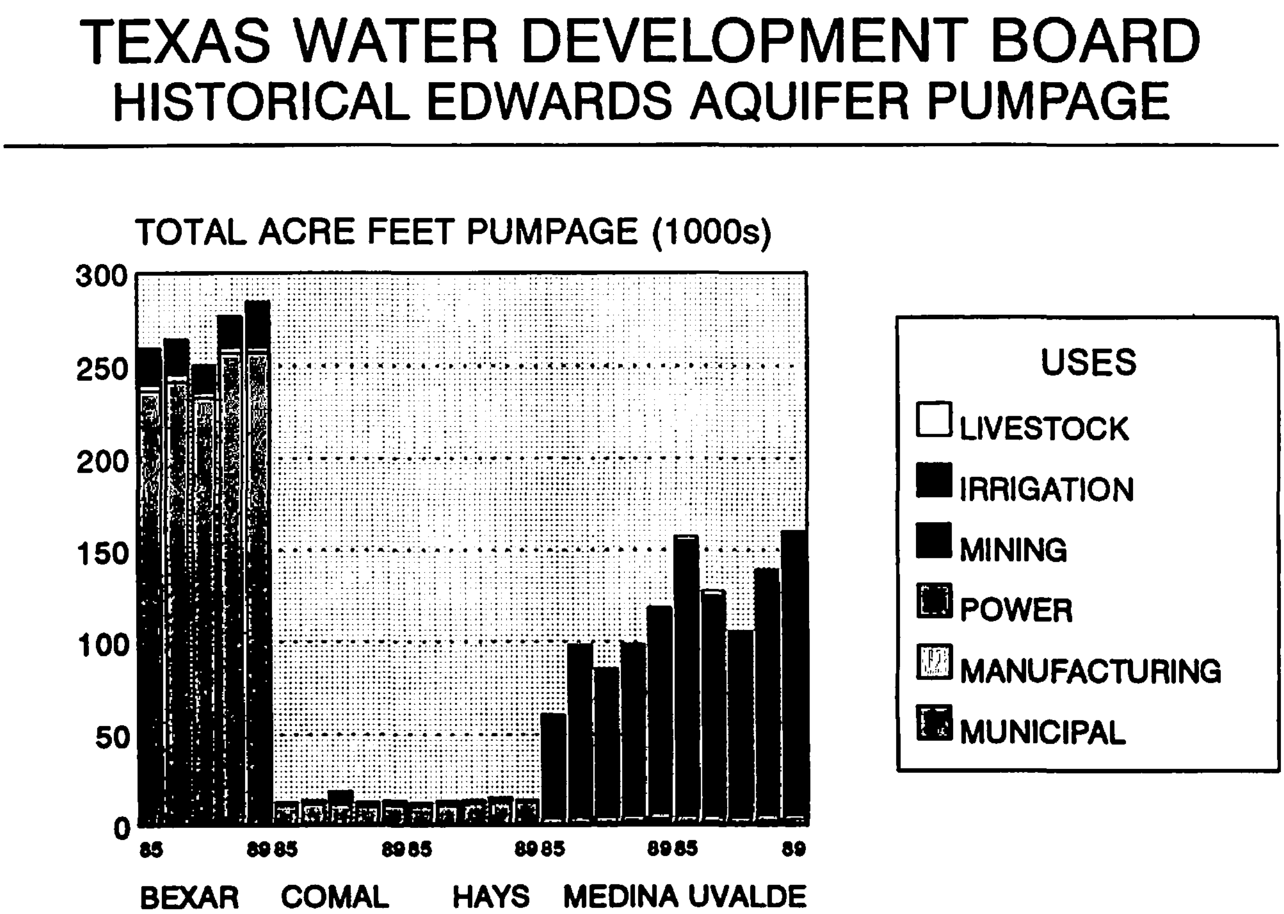
Domestic

Domestic pumpage is estimated by TWDB using per capita water use information from rural water systems in the area applied to the rural domestic population estimates. The TWDB estimates rural domestic population as follows: total rural population (not included in an incorporated area) minus total number of reported connections for existing rural systems multiplied by the U. S. Bureau of Census estimate of persons per household equals total rural population using domestic wells. This element of pumpage is combined with and reported in the Municipal pumpage category.

All Uses - Edwards Aquifer

Table 2.1-6 presents the Edwards Aquifer components of the total ground water pumpage reported in Table 2.1-1. This information is presented graphically in Figure 2.1-3.

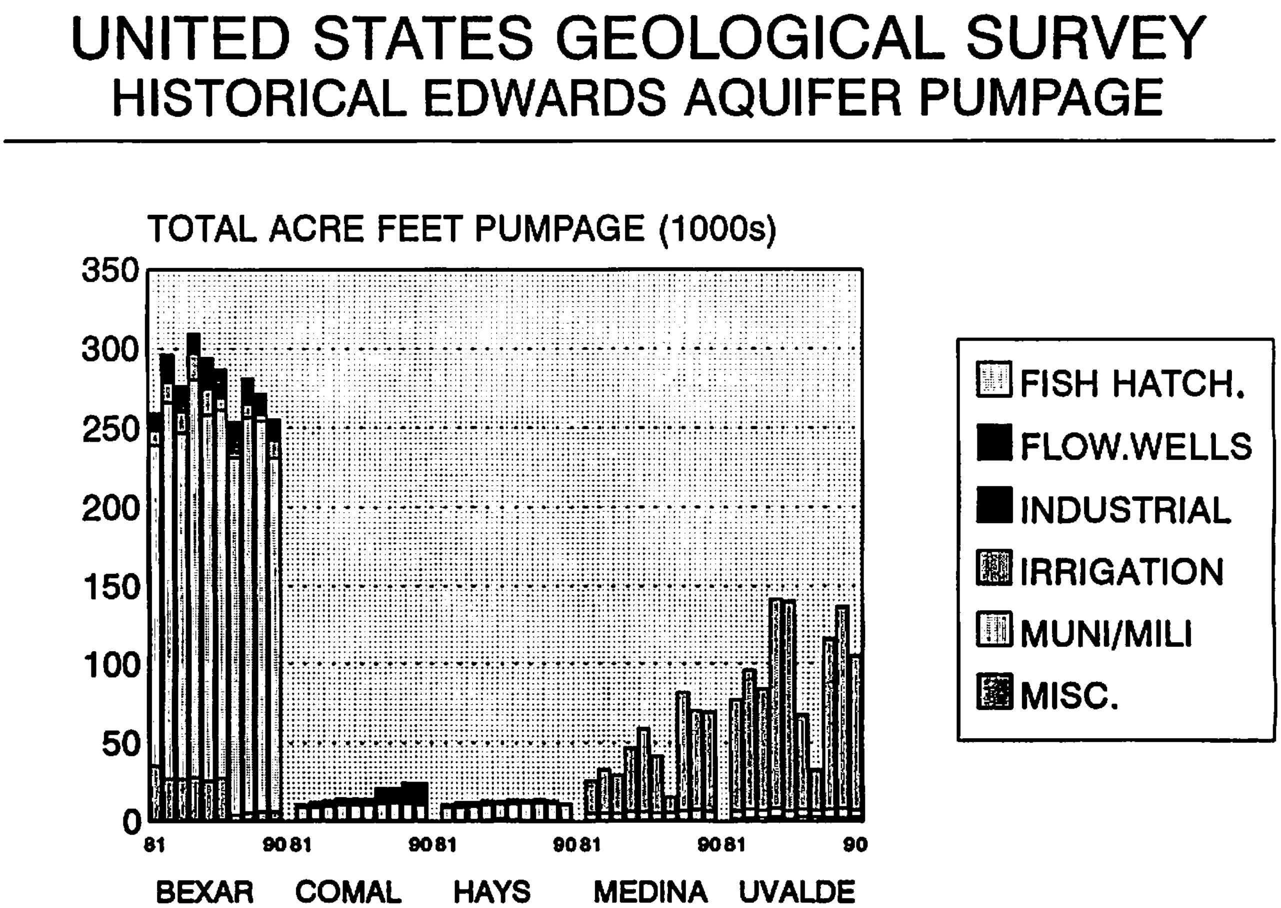
Figure 2.1-3



2.1.1.2 United States Geological Survey

The United States Geological Survey (USGS) compiles estimates of Edwards Aquifer pumpage under contract with the Edwards Underground Water District. The estimates are published annually as a bulletin including prior year's data for comparison purposes. Table 2.1-7 presents the USGS estimates for years 1981 through 1990. Records exist for 1934 through 1990. These estimates are presented graphically in Figure 2.1-4. The estimation methods used by USGS for the various uses follow.

Figure 2.1-4



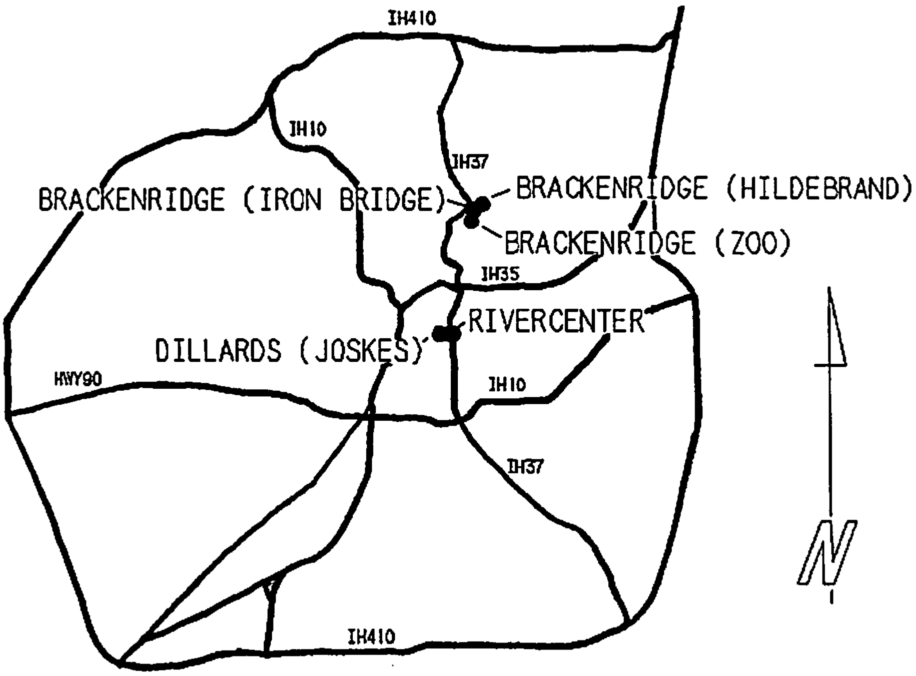
Municipal and Military

The USGS obtains municipal and military pumping records each year from the TWDB. For an explanation of how the TWDB obtains pumping records from users see the explanation in Section 2.1.1.1 above. The USGS supplements the TWDB pumping records by contacts with non-reporting entities. Generally, the non-reporting entities represent small users. The USGS recategorizes some reported TWDB municipal pumpage into the Industrial category. Hotels and other public type operations are transferred from the TWDB Municipal pumpage category to the USGS Industrial category. Likewise, the USGS separates private schools, country clubs, and cemeteries from the TWDB Municipal record, and reports these separately under Miscellaneous pumpage. This resorting of reported pumpage makes any direct comparison of the TWDB municipal pumpage and the USGS municipal and military pumpage difficult.

Figure 2.1-5 details the location of the five wells supplying water to the San Antonio River. The two Brackenridge Park wells (Hildebrand and Joske's Pavilion/ Lambert Beach/ Iron Bridge) and the Rivercenter Mall well are owned and operated by the City of San Antonio. The Brackenridge Park (Hildebrand) well discharge has been reported to the TWDB and included in the USGS annual estimate of ground water discharge. The Brackenridge Park (Joske's Pavilion/ Lambert Beach/ Iron Bridge) and the Rivercenter Mall wells discharge has not been reported to TWDB and has not been included in the USGS annual estimate of ground water discharge. This unreported discharge was estimated in May, 1992, to be approximately 2200 acre feet per year as reported by the San Antonio River Authority.

Figure 2.1-5

EDWARDS AQUIFER WELLS WHICH DISCHARGE
INTO THE SAN ANTONIO RIVER



The Dillard's (formerly Joske's) well which discharges to the San Antonio River is on the TWDB municipal roll but has not been reported since 1987. USGS has not included this discharge in annual estimates for years 1988-90 because it was not reported. This discharge was estimated in May, 1992, to be approximately 2070 acre-feet per year as reported by the San Antonio River Authority.

The San Antonio Zoological Gardens & Aquarium operates a well on the zoo grounds to supply water to the various features in the zoo. This use has been reported to TWDB and is included in the USGS estimate of ground water discharge.

Irrigation

The USGS has prepared independent irrigation water use estimates with basic information on power consumption, irrigated acres, and crop water application rates from power companies, fuel suppliers, irrigators, and state and federal agencies as explained below.

Years 1981-83. Electric power and fuel consumption for irrigation pumping were used to calculate total estimated irrigation.

Years 1984-85. Irrigated acres and water application rates were used to estimate total irrigation use. The calculations were not crop specific. Work notes for calculation of irrigation pumpage for years 1985 and previous years were not found in the USGS files.

Year 1986. Irrigated acreage information supplied by the Soil Conservation Service and the Texas Agricultural Statistics Service was used in combination with crop water application rates developed by USGS from interviews with SCS technicians and irrigators. The Texas Agricultural Statistics Service obtains irrigated acreage information from voluntary reporting forums submitted to and returned from farmers. The crop water application rates were developed based on meter readings, pumping rates, and pumping hours for selected operations.

Year 1987. Irrigated acreage information was obtained from the Texas Agricultural Statistics Service. Crop water application rates were derived in the same manner as Year 1986.

Year 1988. Irrigated acreage information was obtained from the Agricultural Stabilization and Conservation Service (ASCS). Crop water application rates were derived in the same manner as Year 1986.

Year 1989. Remote sensing (satellite photography) was used to develop crop acreage estimates. Crop water application rates were derived in the same manner as Year 1986.

Year 1990. Crop acres were estimated by USGS from ASCS records. Irrigated acres were adjusted for non-ASCS program crop acres. Crop water application rates were estimated by SCS technicians from on-farm measurements. SCS does not publish its records of on-farm measurements but furnishes the individual farm data sheets to USGS without identifying the farm.

Tables 2.1-8 and 2.1-9 present the calculations of irrigation demands and water application rates as found in the USGS working files. Where crop water application rates were estimated by USGS office personnel, the data is noted in tables with a suffix "E". Those crop water application rates noted with a suffix "A" are based on field interviews with irrigators, estimates of pumping rates and pump hours or meter readings. In some cases, only one field measurement was recorded.

Sample Data From Table 2.1-8
see pages 63-64 for complete table

UNITED STATES GEOLOGICAL SURVEY IRRIGATION DEMAND CALCULATIONS
FOR EDWARDS AQUIFER
1986 - 1991

SOURCE: USGS FILES

COUNTY	1988			1989			1990		
	ACRES	INCHES APPLIED	ACRE FEET	ACRES	INCHES APPLIED	ACRE FEET	ACRES	INCHES APPLIED	ACRE FEET
BEXAR									
ALFALFA									
CORN	2,800	12.31 A	2,872	1,000	28.31 A	2,359	3,850	20.00 E	6,417
COTTON	200	11.00 E	183	669	20.00 E	1,115	400	20.00 E	667
GRASS FARM	200	10.00 E	167				200	12.00 E	200
MILO		10.00 E	167				156	9.00 E	117
NURSERY STOCK		9.00 E	225				300	10.00 E	250
PEANUTS		19.00 A	1,742				1,100	19.63 E	1,799
VEGETABLES	500	25.00 E	1,042				680	30.00 E	1,700
WHEAT/OATS									
BEXAR TOTAL:	5,300		6,398	1,669		3,474	6,686		11,150

Industrial

The USGS obtains pumping data from the TWDB for industrial pumpage similar to that obtained for municipal and military pumpage. USGS combines TWDB mining, power, and manufacturing pumpage for this general category. USGS supplements the TWDB record of contacts with mining, power and manufacturing pumpage entities and estimates where necessary. Generally, the smaller users are the non-reporting entities.

USGS reports some public system pumpage reported as municipal by TWDB in the USGS Industrial category. Hotels operating their own wells are an example of pumpage reported by USGS in the Industrial category. This resorting by USGS of TWDB data makes direct comparisons of TWDB manufacturing, power, and mining pumpage with USGS industrial pumpage difficult.

Uncontrolled Flowing Wells

Known discharge rates and field measurements coupled with aquifer levels for the year are used by USGS to estimate uncontrolled and unreported flowing well discharges. These estimates are prepared on a well-by-well basis. For 1990 the USGS list of wells in this category was:

Farmers Well (J-21) (permanently closed in 1991)

Blue Wing	Schirmirer
Hot Wellst	O. R. Mitchell
J. W. Scott	J. L. Nelts
F. Vargas	Aldridge Nursery
Misc. Flowing Wells (21)	

The Farmers Well estimated flow was the majority of the total flow for these wells as tallied in the USGS working files.

Domestic and Livestock Use

USGS estimates domestic and livestock pumpage for each county and reports these as a lump sum. It was reported by USGS that this estimate, which has been constant for recent years, was originally made based upon rural population within the counties. USGS representatives contacted were not able to provide details on the original derivation of this estimate.

The Domestic and Livestock component of the Domestic and Livestock and Miscellaneous pumpage estimated by USGS for years 1986 and before was not detailed in the USGS work notes. The consistency of the totals for Domestic Livestock and Miscellaneous pumpage pre-1987 with 1987 and after would indicate that a similar component of Domestic and Livestock pumpage was estimated by USGS for pre-1987.

Other Miscellaneous

This category includes parks and private schools, country clubs, and cemeteries. This pumpage is estimated separately only for Bexar County and is derived from reports to the TWDB. Detailed estimates were found for years 1987 and after. For prior years, this pumpage was reported in lump sum along with Domestic and Livestock use.

Fish Hatcheries

Separate estimates are made for the fish hatcheries in Hays and Uvalde Counties. However, the sum of the Uvalde fish hatchery and domestic and livestock detailed estimates found in the USGS files do not reconcile to the total reported by USGS in the bulletins for years 1981 through 1983. For this reason, Domestic and Livestock and Fish Hatchery uses in Uvalde County are reported as one total in the Uvalde County section of Table 2.1-7.

2.1.1.3 Summaries and Comparisons

Tables 2.1-10, 2.1-11, 2.1-12 and 2.1-15 provide comparisons of USGS and TWDB reported estimates of Municipal and Military, Industrial, Irrigation and Domestic and Livestock pumpage, respectively, for the five major Edwards Aquifer counties. Figure 2.1-6 presents a graphical comparison of the total Edwards Aquifer pumpage estimates by USGS and TWDB for years 1985-1989.

A review of Table 2.1-10 or Figure 2.1-6a comparing the Municipal and Military pumpage as reported by USGS and TWDB reveals a consistent pattern of the USGS estimate for Bexar County (the major Municipal and Military use of the five counties) to be several thousand feet less than TWDB. This can be explained because USGS transfers parks, cemeteries, schools and country clubs to the Miscellaneous pumpage category and hotels and other public but corporate pumpage to the Industrial category. There are differences for the other four counties that are more significant on a percentage basis, however, the relative amounts of water are small. The USGS working files were not researched in detail to explain the differences in USGS and TWDB reported estimates for Comal, Hays, Medina, and Uvalde Counties. One would expect the USGS and TWDB Municipal and Military pumpage numbers to be very close, with the adjustments made by USGS considered, because USGS begins its reporting process with data furnished by TWDB. The TWDB data reported in these tables is the Edwards Balcones Fault Zone (Edwards Aquifer) component of total of county ground water pumping reported by TWDB in Table 2.1-2.

Table 2.1-11 compares USGS and TWDB estimates of industrial pumpage from the Edwards Aquifer. This comparison is presented in Figure 2.1-6b. The reader is reminded that USGS transfers some pumpage reported by TWDB as municipal to this category. Also USGS makes estimates of known industrial pumpers not reflected in the TWDB record. TWDB representatives report that the large increase in pumpage in the TWDB record in Comal County in 1987 comes from a first time report submitted by a quarry operation. The Comal County estimate returns to the pre-1987 level for 1988 and after because that same operation did not submit subsequent reports.

Table 2.1-12 presents a comparison of USGS and TWDB irrigation pumpage estimates from the Edwards Aquifer. Figure 2.1-6c also presents this comparison. The Edwards Balcones Fault Zone (Edwards Aquifer) component only of total county ground water pumping reported by TWDB in Table 2.1-2 is used in these comparisons. After 1985 the TWDB estimates are higher than USGS, in some years and counties significantly higher.

Sample Data From Table 2.1-12
see page 70 for complete table

COMPARISON OF TWDB AND USGS
GROUND WATER PUMPING DATA FOR EDWARDS AQUIFER COUNTIES
IRRIGATION USE

SOURCE: TABLES 2.1-1, 2.1-7 ALL VALUES REPORTED IN ACRE-FEET OR AS A PERCENTAGE

YEAR	COUNTY	USGS TABLE 2.1-7	TWDB (1) TABLE 2.1-1	PERCENT DIFFERENCE
1985	BEXAR	16,400	15,949	2.75%
	COMAL	200	0	100.00
	HAYS	200	0	100.00
	KINNEY	0	110	-100.00
	MEDINA	53,000	56,905	-6.68
	UVALDE	133,200	149,459	-10.88
	TOTAL	203,000	222,423	-8.73
1986	BEXAR	7,600	15,613	51.32%
	COMAL	300	385	-22.08
	HAYS	200	0	100.00
	KINNEY	200	119	40.50
	MEDINA	36,400	94,180	-61.35
	UVALDE	59,400	119,828	-50.43
	TOTAL	104,100	230,125	-54.76

Table 2.1-13 compares USGS and TWDB ground water pumping data for corn and cotton for 1989. This is the only year in which the TWDB intensive irrigation survey coincides with the availability of detailed data from USGS. TWDB records of crop acres and crop water application rates were not available for comparison to USGS records in years 1986-88. The USGS detailed calculations for 1984, the previous TWDB intensive survey year, were not found in the record. This subset of the USGS and TWDB detailed irrigation calculations for the major Edwards Aquifer irrigation area crops reveals that for 1989 differences in irrigated acres are more responsible for the disagreement between USGS and TWDB than are crop water application rates. A cautionary note, the data presented in Table 2.1-13 represents only one year and does not imply that differences in irrigation acres is responsible for discrepancies between TWDB and USGS irrigation use estimates in other years.

The TWDB irrigation pumpage does not fluctuate with observed rainfall as much as USGS irrigation pumpage. Table 2.1-14 is a reprint of the historical rainfall for selected rainfall reporting stations in the Edwards Aquifer area from Bulletin 50, Edwards Underground Water District, 1990. A further review of Tables 2.1-5 and 2.1-8 indicates that TWDB carries a consistently higher estimate of forage, grain sorghum and small grain acreage to account for the remainder of the difference between the USGS and TWDB estimates.

Table 2.1-15 compares the Domestic and Livestock estimates made by USGS and TWDB. Figure 2.1-6d also compares these estimates. The TWDB domestic component of the Municipal pumpage reported in Table 2.1-1 plus the TWDB Livestock pumpage reported in Table 2.1-1 is compared to the USGS estimate of Domestic and Livestock pumpage which has been consistently reported since 1987 as 21,500 acre feet per year. There is a significant disagreement between the TWDB and USGS estimates.

Figure 2.1-6

COMPARISON OF USGS AND TWDB
HISTORICAL EDWARDS AQUIFER PUMPAGE

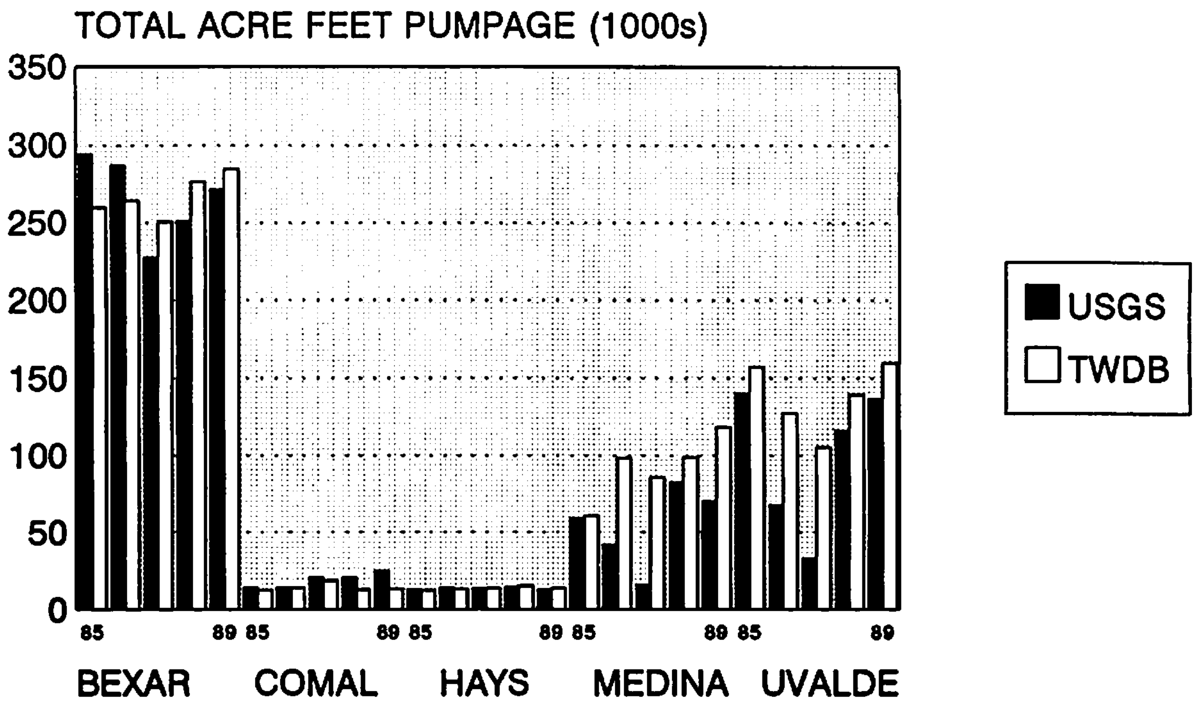


Figure 2.1-6a

COMPARISON OF TWDB AND USGS
HISTORICAL MUNICIPAL/MILITARY PUMPAGE

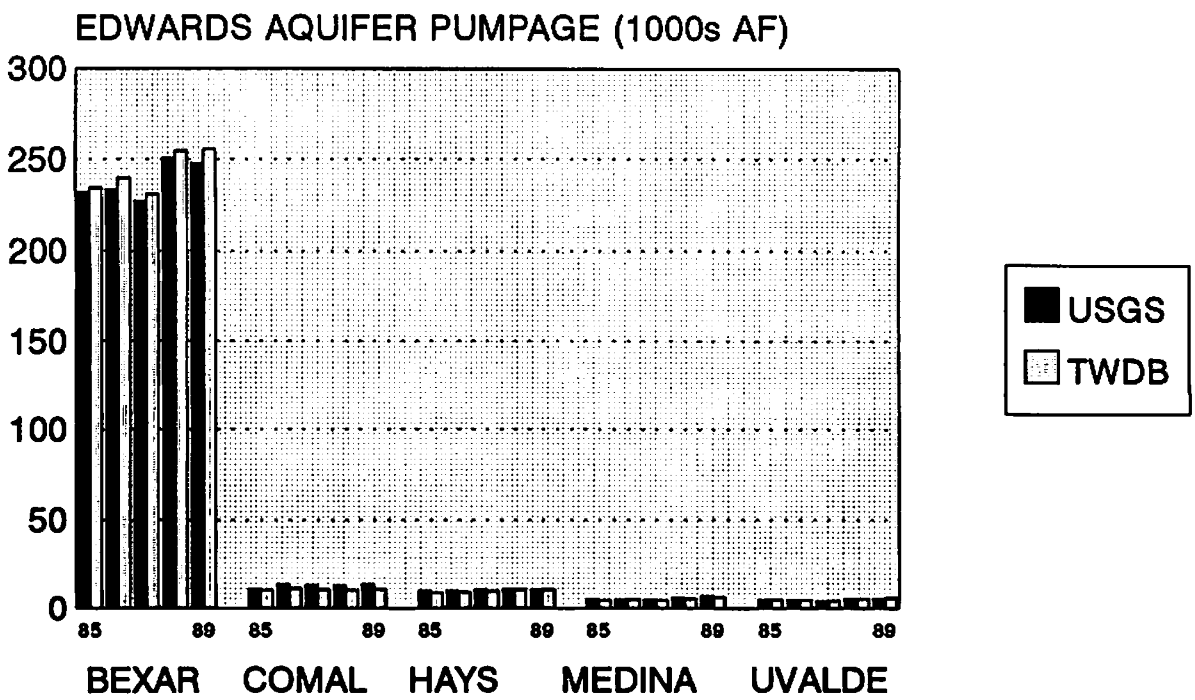


Figure 2.1-6b

COMPARISON OF TWDB AND USGS
HISTORICAL INDUSTRIAL PUMPAGE (1000s AF)

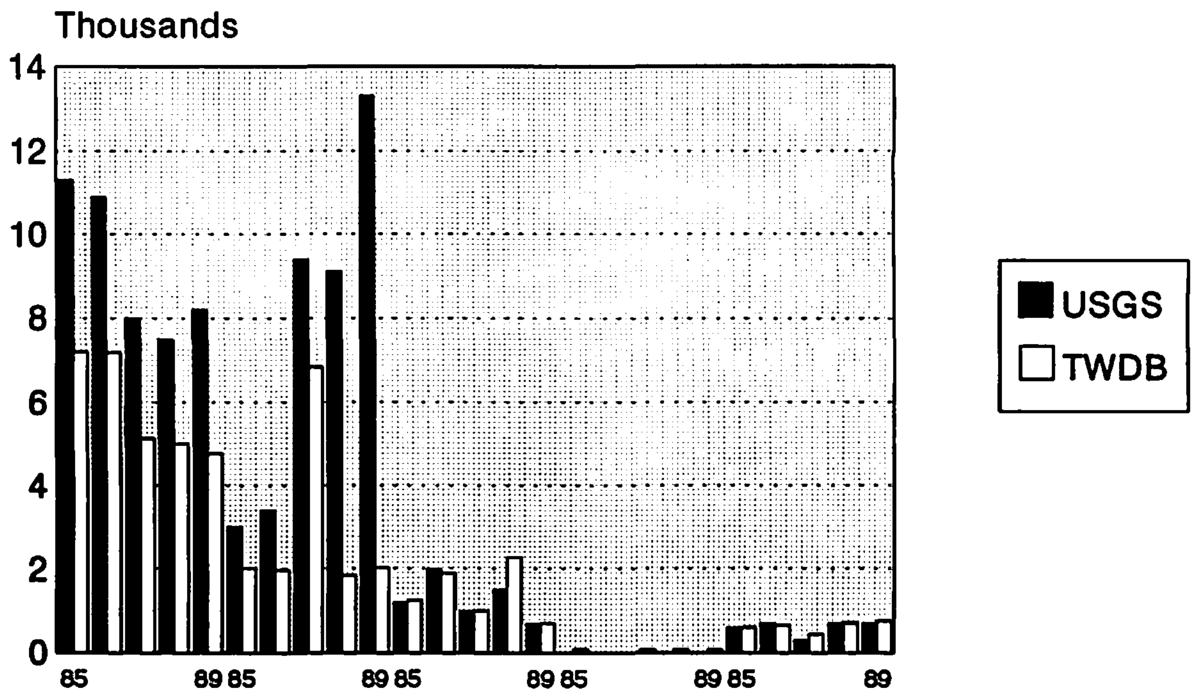


Figure 2.1-6c

COMPARISON OF TWDB AND USGS
HISTORICAL IRRIGATION PUMPAGE

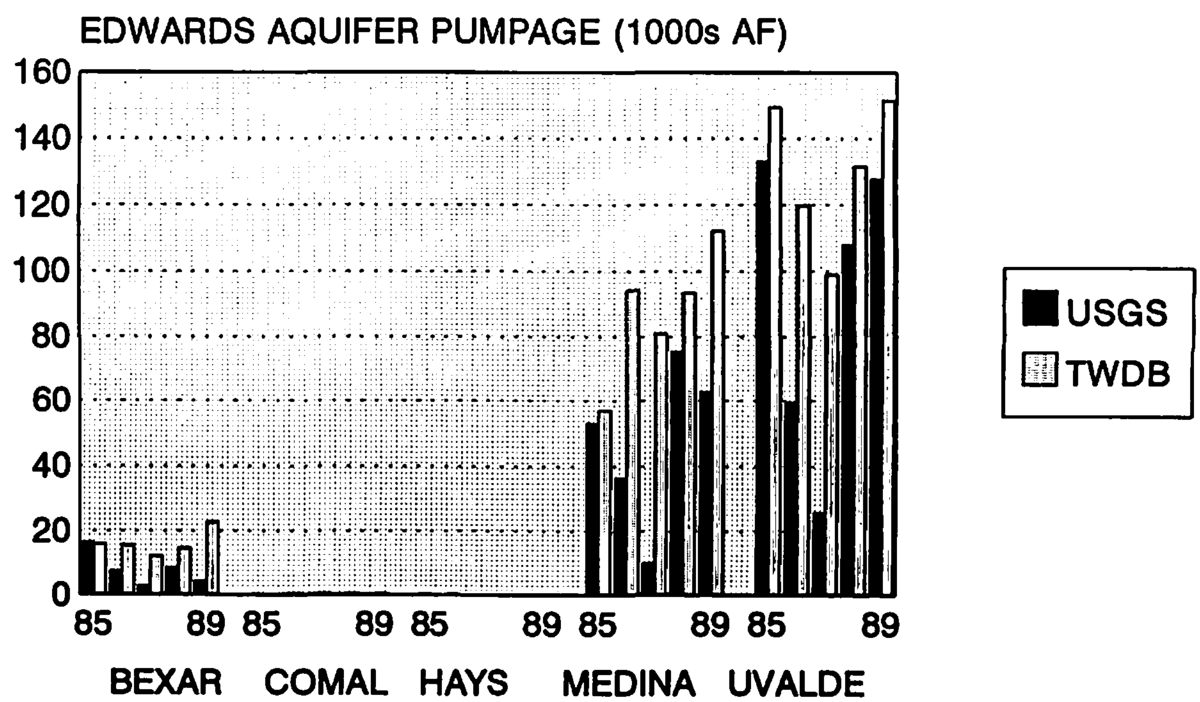
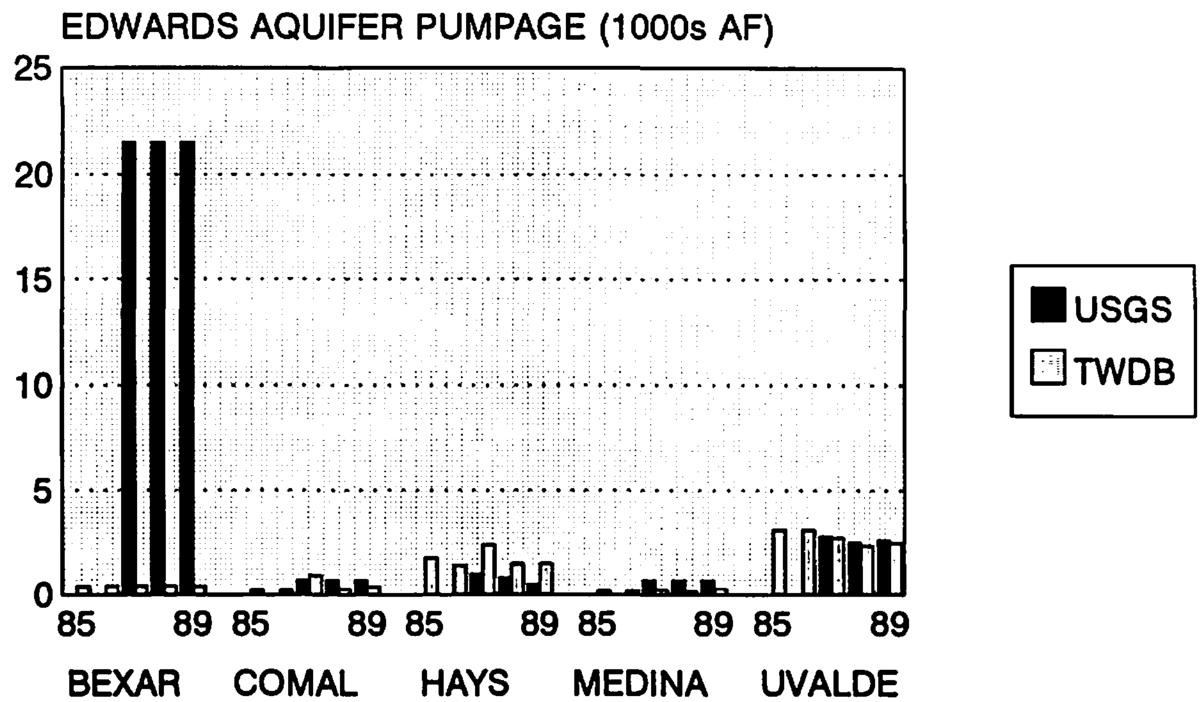


Figure 2.1-6d

COMPARISON OF TWDB AND USGS
HISTORICAL DOMESTIC/LIVESTOCK PUMPAGE



2.1.1.4 Panel Discussions and Conclusions

One member emphasized the importance of distinguishing between pumpage for use, waste discharge and free-flowing wells. He suggested a "well discharge total" as distinguished from the "total pumpage" to meet demands for specific uses. Others emphasized that it was important to identify an artificial drain on the aquifer that did not serve a beneficial use. Uncontrolled flowing wells needed to be found and closed.

Referring to the unreported San Antonio wells described above (Brackenridge Park, Rivercenter Mall and Dillard's), one member emphasized that more than 4000 acre feet, (according to one agency's estimate) of discharge from these sources is presently unreported and needs to be accounted for in any comprehensive presentation of water data.

Panel members with irrigation experience emphasized that irrigation water use depends on a multiplicity of factors, only a few of which are reflected in the data. For example, much depends on what each farmer is trying to achieve in yield per acre. Farmers' goals will differ depending on their experience and how a particular field fits into their plans. That alone can account for great variations in the same area for the same crop. In addition, there are impacts of rainfall and the distribution of rainfall across a county that are not taken into account. Government programs also play a role in planning for the irrigation season. The variations in data, then, should not necessarily be interpreted as the result of error. Many times those variations are the reality.

Some members felt that the estimates of crop water application rates prepared by SCS were the most accurate. The ASCS acres irrigated estimates were thought to be more accurate than those used in some years by TWDB. It was noted by one panel member that all crop acres are certified by all farmers participating in the government farm program and that the great majority of all farms are enrolled in the program.

Comparing USGS and TWDB pumping data for irrigation use in the Edwards Counties, many members thought the USGS data was more accurate.

One member felt that it is too gross a methodology to extrapolate applied water rates of irrigated crops for an entire county from only seven farms. He suggested that a better methodology might be proposed. The need to distinguish carefully between hard data based on direct measurements and all forms of estimated data was emphasized by another panel member. No matter how good the estimates might be, they should be identified as such and clearly set apart from actual measurements. This member suggested several steps: 1) the accuracy of all steps in data reporting and transcription need to be examined and stated, with verification tests of data accuracy by checks with the original water users, if possible; 2) the range of error in measured and estimated pumpage needs to be examined and stated, and data should be separated into categories for reporting depending on whether they are based on a) metered pumpage, b) estimated pumpage based on direct field inquiries with individual pumpers or c) estimated pumpage from all other users who were not interviewed; and 3) an effort needs to be made to determine or estimate any unreported or unaccounted for pumpage or discharge from the Edwards, including unused wells and smaller springs.

Other members expressed a similar concern about verification of suspect data. It was pointed out that the original reporting forms used by TWDB are available and can be checked to ensure that errors in summarizing data were not made or to examine reasons for unexpected figures.

Some members urged USGS and TWDB to develop a common methodology for measuring irrigation pumpage in particular.

2.1.2 Historical Surface Water Diversions

2.1.2.1 Texas Water Commission

All Uses
Surface water in Texas is the property of the State. Anyone (person, private corporation, city, etc.) desiring to use surface water must first receive a permit from the State. This permitting and use of surface water is administered by the Texas Water Commission (TWC). Each permit contains detailed information for each surface water appropriation including appropriator's name, type of use, authorized diversion amount, acres irrigated, storage capacity of reservoir, priority date, and other information. A sample page of this information is provided as Table 2.1-16. This information is available for all water rights listed in the TWC files for the Guadalupe, San Antonio and Nueces river basins and the Lavaca-Guadalupe coastal basin, San Antonio-Nueces coastal basin and the study area portion of the Nueces-Rio Grande coastal basin.

All appropriators of surface water for all purposes file annual reports of monthly diversions with the Texas Water Commission (TWC). Generally, municipal and industrial uses are metered. Irrigation uses are metered and estimated using pump hours and pumping rates. Hydroelectric uses are estimated by converting power production to water use. Table 2.1-17 presents a comparison summary of actual surface water uses in the region for 1989. Table 2.1-18 presents a summary by basin of existing surface water rights in the region to compare to the actual uses presented in Table 2.1-17.

Table 2.1-17

1989 SUMMARY LISTING OF WATER USES BY TYPE OF USE FOR GUADALUPE, SAN ANTONIO, NUECES RIVER BASINS AND ADJOINING COASTAL BASINS

Source: Texas Water Commission, Unit: Acre-Feet

BASIN	MUNICIPAL		INDUSTRIAL		IRRIGATION			MINING		HYDRO-ELECTRIC		RECREATION		RECHARGE		OTHER		TOTAL	
	No. of Permits	Div. Amt.	No. of Permits	Div. Amt.	No. of Permits	Acres	Div. Amt.	No. of Permits	Div. Amt.	No. of Permits	Div. Amt.	No. of Permits	Div. Amt.	No. of Permits	Div. Amt.	No. of Permits	Div. Amt.	No. of Permits	Div. Amt.
Guadalupe	35	18567 (1)	34	553047 (2) (3)	214	10481	55828	1	0	10	1649427 (4)	41	62	0	0	0	0	335	2,276,931
San Antonio	5	539	2	28175	180	33146	73600	1	272	0	0	20	307	1	0	4	0	213	102,893
Nueces	19	107341	5	60917	208	26437	30564	1	1	0	0	13	40	3	0	2	0	251	198,863
Lavaca-Guadalupe	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	3	0
San Antonio-Nueces	0	0	5	4084	2	110	215	0	0	0	0	4	17	0	0	0	0	11	4,316
Nueces-Rio Grande	3	5621	8	809594	48	6796	6744	0	0	0	0	9	982	0	0	4	0	72	822,941
TOTAL	62	132068	54	1455817	655	76970	166951	3	273	10	1649427	87	1408	4	0	10	0	885	3,405,944

Div. Amt. = Diversion Amount
(1) Includes 1660 acre-feet from Canyon Reservoir storage.
(2) Includes 114 acre-feet from Canyon Reservoir storage.
(3) Includes non-consumptive diversions, consumptive use is minor portion of the total.
(4) Non-consumptive.

LIMITATIONS ON USE OF THIS DATA

1. Diversion amounts for industrial uses include non-consumptive diversions. TWC records obtained do not reflect separation of consumptive and non-consumptive uses for industrial diversions.
2. Hydroelectric use is non-consumptive, reported use combines multiple plants using same water.

Table 2.1-18

SUMMARY LISTING OF WATER RIGHTS BY TYPE OF USE FOR GUADALUPE, SAN ANTONIO, NUECES RIVER BASINS AND ADJOINING COASTAL BASINS

Source: Texas Water Commission, Unit: Acre-Feet

BASIN	MUNICIPAL No. Perm.	MUNICIPAL Div. Amt.	INDUSTRIAL No. Perm.	INDUSTRIAL Div. Amt.	INDUSTRIAL Consum. Div. Amt	IRRIGATION No. Perm.	IRRIGATION Acres	IRRIGATION Div. Amt.	MINING No. Perm.	MINING Div. Amt.	HYDRO-ELECTRIC No. Perm.	HYDRO-ELECTRIC Div. Amt.	HYDRO-ELECTRIC Consum. Div. Amt	RECREATION No. Perm.	RECREATION Div. Amt.	RECHARGE No. Perm.	RECHARGE Div. Amt.	OTHER No. Perm.	OTHER Div. Amt.	TOTAL No. Perm.	TOTAL Div. Amt.	TOTAL Consum. Div. Amt
Guadalupe	46 (1)	182395 (1)	41 (2)	613534	131566 (2)	262 (3)	53399	88780 (3)	3	156	13	5288585 (4)	0	54	6959	0	0	4	850	423	6,181,259 (1)(2)(3)(4)	403,747
San Antonio	8	72032	5	48936	(5)	211	58303	102223	1	431	0	0	0	26	480	1	961	5	0	257	225,063	(5)
Nueces	27	239419	9	258112	(5)	275	48536	79311	3	17	0	0	0	17	10	3	2290	3	0	337	579,159	(5)
Lavaca-Guadalupe	1	0	0	0	0	9	3247	4560	0	0	0	0	0	0	0	0	0	1	1000	10	4,560	0
San Antonio-Nueces	0	0	5	16,017	(5)	5	606	842	0	0	0	0	0	4	7780	0	0	0	0	15	25,639	(5)
Nueces-Rio Grande	5	7738	10	1575838 (6)	(5)	54	36372	52218	0	0	0	0	0	9	10427	0	0	5	0	83	1,646,221	(5)
TOTAL	87	501584	54	2512437	131566	816	200463	327934	7	604	13	5288585	0	110	25656	4	3251	18	1850	1125	8,661,901	(5)

No. Perm. = Number of Permits
Div. Amt. = Diversion Amount
Consum. Div. Amt. = Consumptive Diversion Amount

(1) Includes 14 contracts for Canyon Reservoir Supply totalling 19,910 acre-feet for Canyon Reservoir; Canyon Reservoir included at 35,225 acre-feet; includes 106,000 acre-feet also permitted for irrigation and industrial.
(2) Includes 13 contracts for Canyon Reservoir Supply totalling 11,796 acre-feet; Canyon Reservoir included at 14,775 acre-feet; includes 5 permits with non-consumptive rights totalling 481,968 acre-feet.
(3) Includes 9 contracts for Canyon Reservoir totalling 159 acre-feet; includes 51,191 acre-feet also permitted for municipal and industrial; includes 940 acre-feet also permitted for industrial, mining and stockraising; includes 4,370 acre-feet also permitted for industrial.
(4) Largest single permit equals 796,363 acre-feet.
(5) Consumptive and non-consumptive components not separated.
(6) Includes 1,573,598 acre-feet from bays and estuaries.

LIMITATIONS ON USE OF THIS DATA

1. Separation of consumptive diversion amount from total diversion amount for industrial use is estimated.

2.1.2.2 Summaries and Comparisons

The year 1989 was selected for comparison of the permitted and actual uses because it is the most recent dry year. The comparison indicates that the permits were utilized at about 10% to 50% of the permitted amounts. The exceptions are irrigation use in all the basins which were utilized at a level of 50% to 80% and industrial use in the Guadalupe Basin, a large portion of which is once-through cooling use for power plants and industries. Hydroelectric use is a function of naturally available river flow which dictates the utilization rate.

2.1.2.3 Panel Discussions and Conclusions

Some members felt it important to add information to the table about actual water use, as reported to the TWC. They suggested that without data about water returned to the stream and available for further use, the picture is distorted. The data reported were correct, but it was suggested that information be added about return flows. It was also suggested that priority dates be added.

2.1.3 Population and Water Use Projections

2.1.3.1 Texas Water Develpment Board, 1990 Texas Water Plan

In 1989 the Texas Water Development Board prepared a projection of water use for all counties in the state and all cities over 1000 population for projection years 1990, 2000, 2010, 2020, 2030 and 2040. This information was published as the 1990 Texas Water Plan.

Projections of water use were based on projections of population using U.S. Census Bureau historical population information and reported historical water use information obtained by TWDB. Water use projection information developed by TWDB is not directly comparable to historical pumpage information because the use projections may not include delivery losses, particularly for surface water uses. These projections are for total water use within the city or county, both surface and ground water.

High and low population series were projected for all cities over 1000 population and for other county population. The historical and projected high and low population series for the counties in the region are presented in Table 2.1-19. This data for the major Edwards Aquifer counties is presented graphically in Figures 2.1-7 through 2.1-11. Population projections were developed using a cohort-survival method that project births and deaths for specific population groups and also net migration. The high series forecast reflects the levels of migration experienced during the rapid expansion of the 1970-1990 period. The low series forecast reflects lower levels of migration experienced on the average during the previous thirty year period.

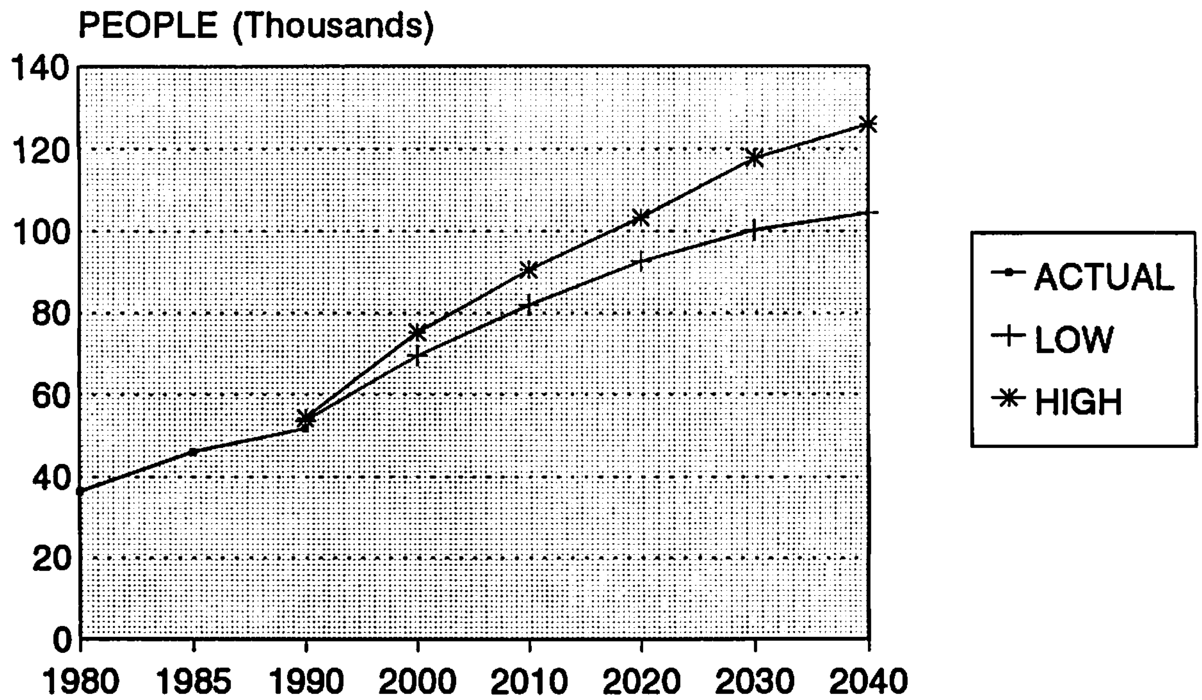
For each population series a projection of municipal, manufacturing, steam electric and irrigation use is projected. Mining and livestock uses are projected to be constant for both the high and low population series.

Within the municipal category uses are projected for all cities over 1000 population and other county population at high per capita and average per capita use rates. For the 1990 Plan, the high per capita use rate is described by TWDB as the highest per capita use rate during 1978-1988 reflecting a period of below average rainfall. The average per capita is the average for that same period, reflecting average rainfall conditions. (See Section 2.1.3.3 for additional information on TWDB per capita water use projections.) For both the high and average use rates, projections of municipal use are made with and without conservation.

TWDB projections for the "With Conservation" scenarios factor in implementation of municipal water conservation programs. For the 1990 Plan, implementation of such programs was projected to reduce municipal per capita use by 2.5 per cent by 1990, 7.5 per cent by 2000, 12.5 per cent by 2010 and 15 per cent by 2020.

Figure 2.1-8

COMAL COUNTY POPULATION PROJECTIONS
FROM TWDB 1990 TEXAS WATER PLAN



Manufacturing water use estimates are based on several factors: 1) national and state growth outlooks developed for each industrial category in Texas; 2) historical water use; 3) known facility expansions or construction; 4) the industrial base of each county; and 5) potential savings through improved water efficient technologies.

Steam-electric power generation water needs are based on projections of 1) power demands, 2) fuel sources used for generation, 3) cooling technology, 4) and plans for expanding power capacity identified by the industry.

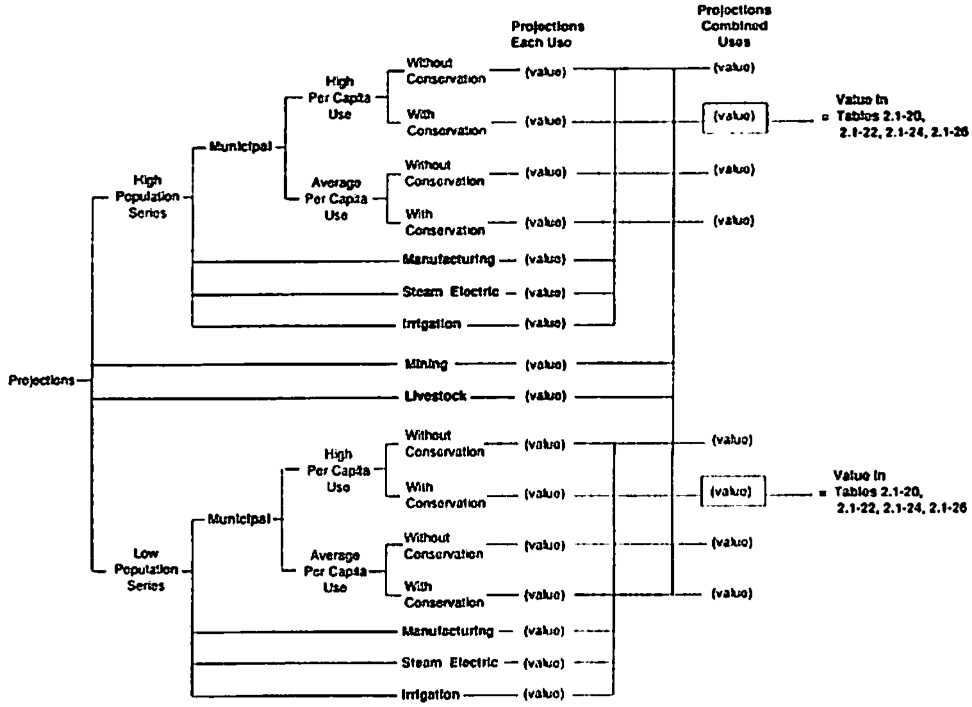
Mining water requirements are based on water use coefficients representing: 1) each type of mining in Texas, 2) historical national and state trends in mineral production, and 3) substitutions of mineral fuels for energy production.

To determine irrigated agriculture water requirements TWDB considers: 1) acreage currently in irrigated production, 2) current water use per acre, 3) water costs, 4) availability of water supplies, and 5) typical water requirements for Texas irrigation operations. In addition, TWDB for its 1990 Plan projected a 20 per cent increase in water use efficiency. Finally, TWDB projects a continuation of the historical decline in irrigated acres recorded from 1985-1989.

Livestock water use rates for the classes of livestock are derived from animal nutrition data for daily water requirements. Forecasts of livestock production as well as water use rates are the basis for estimating future livestock water demand.

Figure 2.1-12 describes the elements of the TWDB water use projection estimates by use category and their summation into the reported projection estimates for each county. The high population series with municipal use at the high per capita use rate with conservation is indicated as the estimate most representative of expected future demands and is used for further presentation in this material. To balance this estimate

Figure 2.1-12



the commensurate low population series projections are also presented. Both population series projections of water use are found in Table 2.1-20. Figures 2.1-13 through 2.1-17 graphically present this data for the major Edwards Aquifer counties. All of the elements of the estimates and their summations as described in Figure 2.1-12 for all projection years are available for further use in projecting future demands.

A review of Table 2.1-20 reveals that municipal, manufacturing, and steam electric projections vary moderately between the high and low population series. Irrigation varies significantly between the high and low series for the Edwards Aquifer counties. The high series irrigation anticipates very little change in irrigation use in the early projection years and a small decrease in irrigation use after that due to competition and moderate limitations on aquifer use. The low series varies little until the year 2000, but has significant reductions projected in later projection years due to predicted conservation and mandatory restrictions on pumpage.

Sample Data From Table 2.1-20 see pages 79-80 for complete table

TEXAS WATER DEVELOPMENT BOARD WATER USE PROJECTIONS

SOURCE: Texas Water Plan, 1990
All values reported in acre-feet

COUNTY	SERIES	1990	2000	2010	2020	2030	2040
BEXAR	LOW (1)	359729	397506	428989	472827	546094	586817
	HIGH (2)	365656	421081	462450	539687	680179	765614
COMAL	LOW	18599	21762	24046	26357	28520	29942
	HIGH	18892	23730	27108	30602	35264	38373
HAYS	LOW	18040	22300	26285	30372	34420	36834
	HIGH	18232	24732	31376	37876	44674	48658
MEDINA	LOW	61028	44966	43031	41245	39482	37544
	HIGH	76520	70675	67290	63941	60682	57290
UVALDE	LOW	86676	64544	62632	60849	59189	57048
	HIGH	108706	100843	96750	92726	88939	84751

(1) Low Population Series, High per Capita use, with Conservation
(2) High Population Series, High per Capita use, with Conservation

Table 2.1-21 presents the historical and high and low population projections for cities over 10,000 population in the region. This data is available for cities over 1000 population.

Table 2.1-22 presents the projected water uses for cities over 10,000 population for both the high and low series with high per capita use rate and with conservation, the comparable data set to that reported above in Table 2.1-20 for the counties.

Sample Data From Table 2.1-22
see pages 83-84 for complete table

TEXAS WATER DEVELOPMENT BOARD WATER USE PROJECTIONS
FOR CITIES OVER 10,000 POPULATION

Source: Texas Water Plan, 1990
All values reported in acre-feet

COUNTY/CITY	SERIES	1990	2000	2010	2020	2030	2040
BEXAR/SAN ANTONIO	HIGH (1)	224208	258827	287604	328191	385520	437894
	LOW (2)	224032	249417	271234	290177	309478	334781
COMAL/NEW BRAUNFELS	HIGH	8820	10200	11822	13236	15255	16304
	LOW	8724	9434	10704	11862	12971	13501
HAYS/SAN MARCOS	HIGH	8554	11756	15432	18881	22436	24439
	LOW	8483	10541	12707	14939	17181	18409

(1) HIGH SERIES POPULATION, HIGH PER CAPITA USE WITH CONSERVATION
(2) LOW SERIES POPULATION, HIGH PER CAPITA USE WITH CONSERVATION

2.1.3.2 Texas Water Development Board, 1992 Draft Projections

The Texas Water Development Board has made revised population projections and water use estimates dated April, 1992, using the 1990 census information. This material is available in DRAFT form. It has not been approved by the Texas Water Development Board. It should also be noted that the 1990 census is suspected of having undercounted the population. These April, 1992, projections are based on the 1990 Census and do not acknowledge the potential undercount.

Table 2.1-23 presents the historical population and the 1992 projected population for projection years 2000, 2010, 2020, 2030 and 2040 based on the 1990 Census. This data for the major Edwards Aquifer counties is presented graphically in Figures 2.1-18 through 2.1-22. These population projections can be compared to projections made in 1990 without benefit of the 1990 Census.

For the 1992 water use projections the TWDB used the same elements of projected water use as described by Figure 2.1-12 for the 1990 water use projections. In applying the expected municipal conservation savings over the projection period, credit was given to those cities that had already achieved reductions in use from conservation programs, i.e., cities with demonstrated conservation reductions in 1992 were not projected to achieve as much additional conservation savings through the projection period as those without a conservation program in place in 1992. Table 2.1-24 presents the commensurate data set for the 1992 water use projections to that offered in Table 2.1-20 for the 1990 projections. Figures 2.1-23 through 2.1-27 graphically present this data for the major Edwards Aquifer counties.

Sample Data From Table 2.1-24
see pages 87-88 for complete table

TEXAS WATER DEVELOPMENT BOARD WATER USE PROJECTIONS

SOURCE: TWDB, 1991 Projections based on 1990 Census Data
All values reported in acre-feet

COUNTY	SERIES	2000	2010	2020	2030	2040
BEXAR	LOW (1)	401372	436471	479021	537686	601360
	HIGH (2)	419253	473715	537486	635411	720569
COMAL	LOW	26022	28275	30496	32659	34489
	HIGH	27783	31696	35436	39679	42813
HAYS	LOW	20749	24654	27987	31027	32589
	HIGH	22729	28785	34119	39196	41976
MEDINA	LOW	99071	59491	59653	59977	60158
	HIGH	119240	114839	115193	115699	115990
UVALDE	LOW	100198	66114	63882	62984	64226
	HIGH	140334	131412	132341	133648	135116

(1) Low Population Series, High per Capita use, with Conservation (2) High Population Series, High per Capita use, with Conservation

Table 2.1-25 presents the 1992 population projections for the cities over 10,000 population, high and low series, as was presented in Table 2.1-21 above for the 1990 projections. Population projections are available for cities over 1000 population.

Likewise, Table 2.1-26 presents the 1992 water use projections for the cities over 10,000 population comparable to those presented in Table 2.1-22 with the above noted difference in projected conservation savings between the 1990 and 1992 projections.

Sample Data From Table 2.1-26
see pages 91-92 for complete table

TEXAS WATER DEVELOPMENT BOARD WATER USE PROJECTIONS FOR CITIES OVER 10,000 POPULATION

Source: Texas Water Development Board, 1992 Projections
All values reported in acre-feet

COUNTY/CITY	SERIES	2000	2010	2020	2030	2040
BEXAR/SAN ANTONIO	HIGH (1)	247067	282259	320833	380152	437465
	LOW (2)	240385	265940	293952	333489	369674
COMAL/NEW BRAUNFELS	HIGH	9692	11376	12693	14509	15376
	LOW	8818	9425	9949	10678	11277
HAYS/SAN MARCOS	HIGH	9357	11453	13232	14939	15819
	LOW	8711	9999	11121	12106	12614

(1) HIGH SERIES POPULATION, HIGH PER CAPITA USE WITH CONSERVATION
(2) LOW SERIES POPULATION, HIGH PER CAPITA USE WITH CONSERVATION

The comparison of the high and low population series projections described above for the 1990 projections can be observed from a review of the 1992 projections. Municipal, manufacturing, mining and power uses vary moderately in comparison to the difference in projected irrigation use which varies for the same reasons given above for the 1990 projections.

2.1.3.3 Texas Water Development Board Per Capita Water Use

Table 2.1-27 presents the projections of per capita water use rates used in the 1990 Texas Water Plan projections of water use for the cities in the region. The same per capita water use was used for both the high and low population series. As indicated previously, for the 1990 Plan high per capita is the annual highest use in the 1978-1988 period, reflecting demand during periods of below average rainfall. The average per capita use is the average for the same period and reflects demand during periods of average rainfall. From the four per capita water uses listed for each city the per capita use associated with the water use projections presented above in Tables 2.1-20 (counties) and 2.1-22 (cities) is identified as High, With Conservation.

Table 2.1.-28 presents the projections of per capita water use rates used in the 1992 Draft TWDB projections of water use for the cities in the region. For the 1992 Draft, the high per capita was the high year in the 1978-1989 period, and the average per capita was the average for this same period. The high and low population series per capita water use rates vary one or two gallons per capita per day depending on housing starts. From the four per capita water uses listed for each city the per capita use associated with the water use projections presented above in Tables 2.1-24 (counties) and 2.1-26 (cities) is identified as H-C.

Computations utilized to develop per capita water use in "Major Cities" include commercial and institutional uses. TWDB computes the per capita as follows: It subtracts from total reported water use Heavy Industrial Use and Sales to other providers and then adds Purchases of water. This revised Total Use figure is then divided by the census population. Computations utilized to develop per capita water use in "Rural" County listings exclude identifiable institutional uses. These identifiable uses are included in the computed county total "other" demands category.

Figure 2.1-13

BEXAR COUNTY WATER USE PROJECTIONS
FROM TWDB 1990 TEXAS WATER PLAN

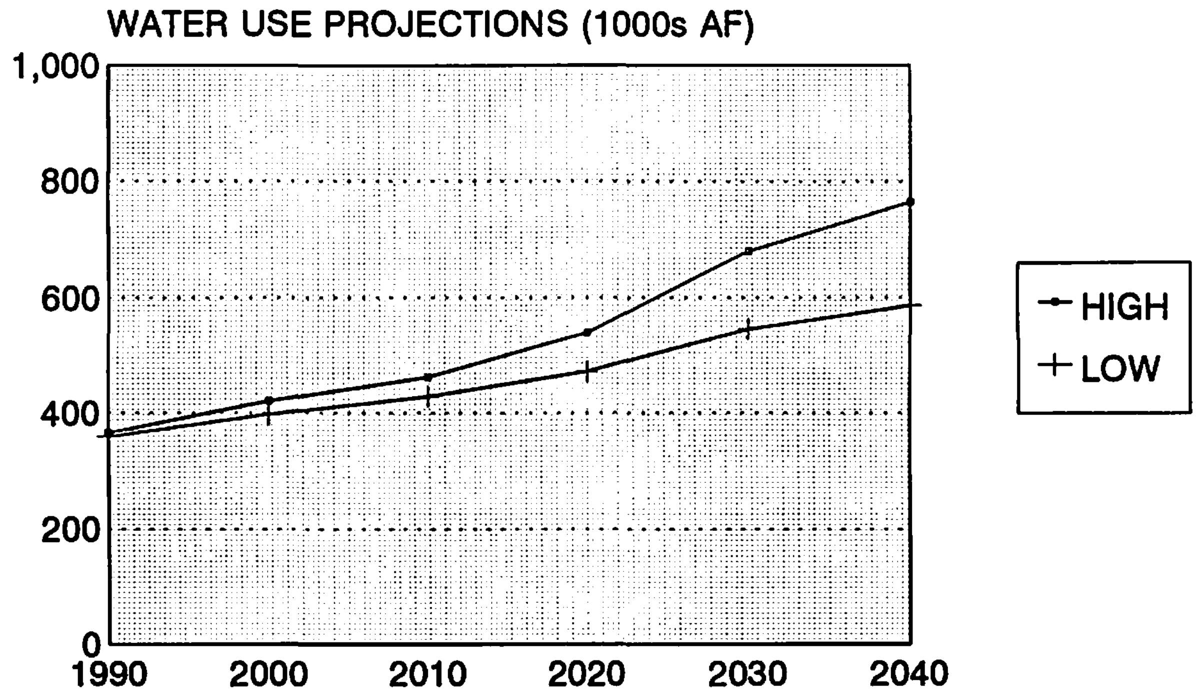


Figure 2.1-23

BEXAR COUNTY WATER USE PROJECTIONS
FROM TWDB 1992 CENSUS DATA

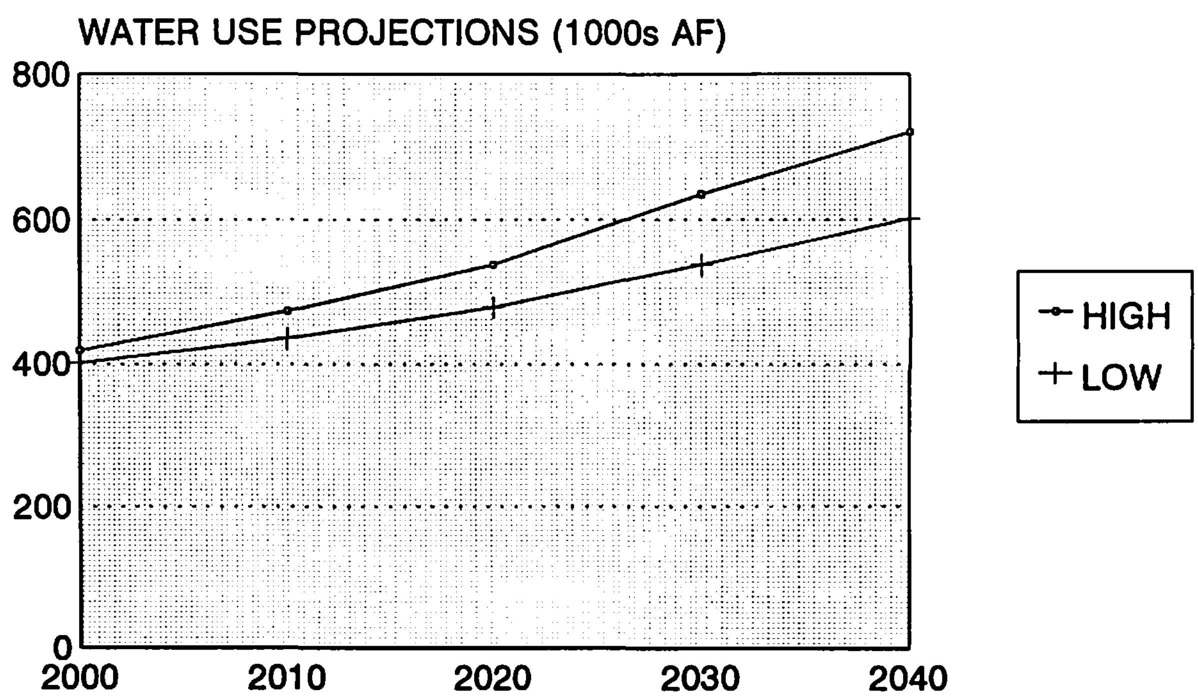


Figure 2.1-17

UVALDE COUNTY WATER USE PROJECTIONS
FROM TWDB 1990 TEXAS WATER PLAN

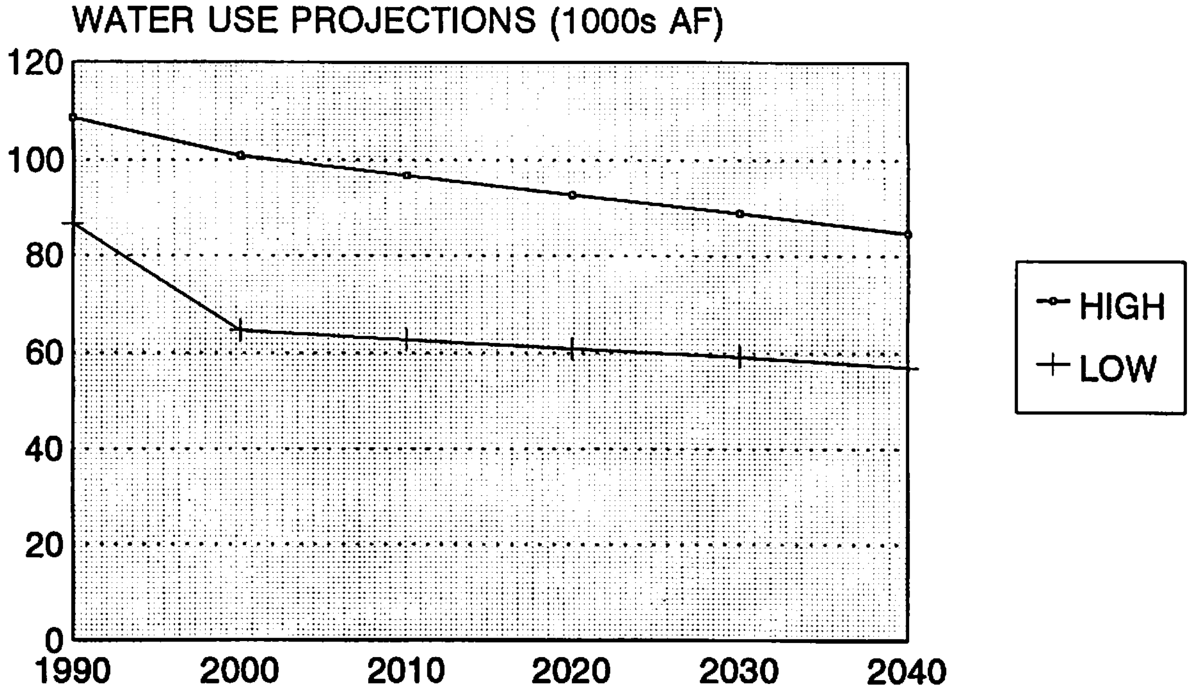
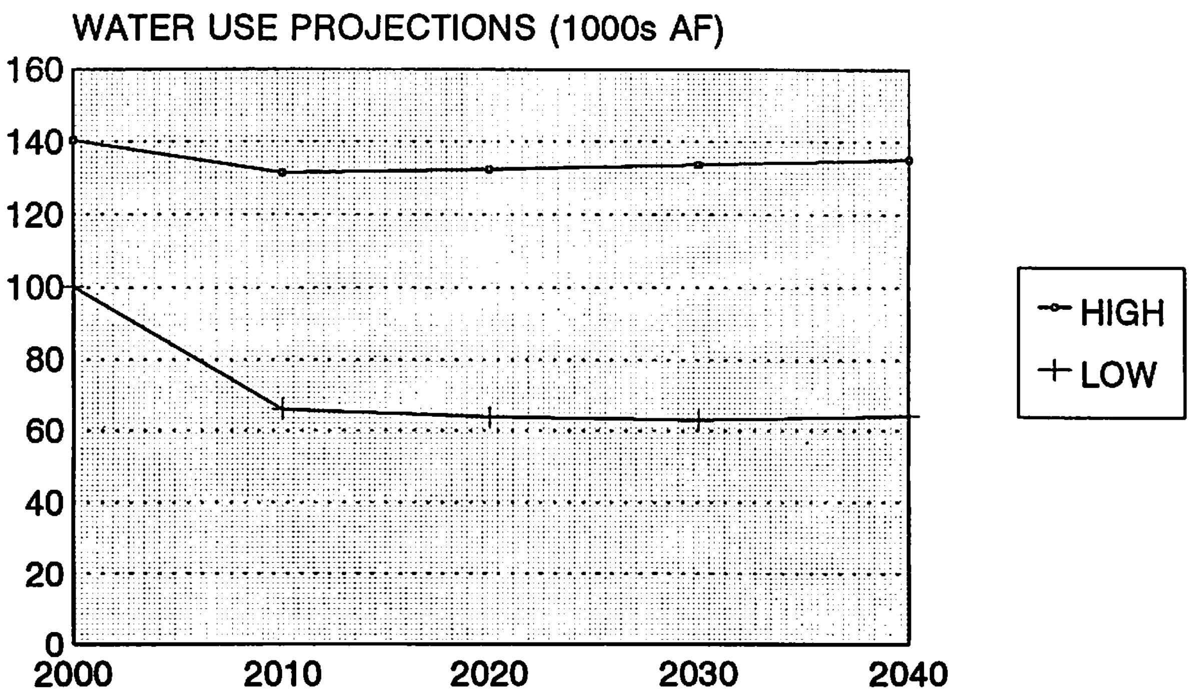


Figure 2.1-27

UVALDE COUNTY WATER USE PROJECTIONS
FROM TWDB 1992 CENSUS DATA



2.1.3.4 Summaries and Comparisons

The principal comparison presented is between the tables from the 1990 Texas Water Plan and the 1992 Draft projections of TWDB. To repeat, the 1990 Plan was an estimate of population and not based on the 1990 census figures, and the 1992 Draft is a projection based on the 1990 census. The 1992 Draft, however, does not take into account a possible undercount of the 1990 census.

For some counties and cities the 1990 Texas Water Plan projections are higher than those in the 1992 Draft, based on the 1990 census. TWDB officials indicated that if a county or city believed it had been undercounted in the 1990 census the 1990 Texas Water Plan figures would probably reflect their sense of the more likely population and water use projections.

2.1.3.5 Panel Discussions and Conclusions

Several members raised issues about the Gallons Per Capita Per Day (GPCD) concept and its uses. One member felt that it should not be used unless based on population served rather than on census-based projections. The problem is to account for the impact on water use of tourists, non-resident students and other transient or daytime demands that are not captured in population figures. Another member warned about a GPCD "numbers game" and the care needed in comparing GPCDs based on different criteria. A member suggested a standard GPCD to be used in all contexts. Another felt gallons pumped was a much more significant measure than GPCD.

In general, several members were anxious about future regulatory uses of GPCD figures. TWDB emphasized that its calculations of GPCD had only to do with projections of demand, not with a regulatory function. Some felt that the GPCD needed improvement for more accurate demand projection, but apart from the suggestion of using population served as an alternative to permanent population, a specific new formula was not offered.

One member suggested that per capita consumption be broken down by use categories. Others pointed out that this data is reported in a certain way and that new categories cannot be added for past data. Some favored a recommendation for future action that municipalities be required to report per capita usage by separate categories. Some felt that experience with GPCD tends to show that breakdown by categories tracks the experience with the composite figure and that too many categories creates a cumbersome system that might be useful for local management but not for gross projections. Others felt that further breakdown was useful for regulatory purposes, especially to deal with the different levels of conservation effort that existed in different sectors. It was not fair, for example, to impose the same conservation requirements on industries already using water saving devices as on those that were not. Some felt that the burden for conservation tends to be placed on residential use because of a composite GPCD figure which lumps Seaworld, for example, with residences. Commercial and industrial should be broken out so that conservation goals can be set separately for them. Some felt that more categories would also be helpful with projections of demand as well as possible regulatory purposes. A representative of one city pointed out that a college campus in its midst is the largest user of water and that the city has no control over it and that this can distort its water use figures.

Several members expressed concern that the Texas Water Commission would arbitrarily select a set of figures for regulatory purposes without the sort of questioning that the Technical Review Panel was doing. It was pointed out that the new TWC permit process for the Edwards Aquifer required the reporting of a great deal of data that had not previously been collected by any agency. It was suggested that this process could be the vehicle for new reporting and that the TWC should consider this.

The Panel in general agreed that more data was required for regulatory purposes of the Texas Water Commission in order to allow for anomalies and uncertainties and that additional funding should be requested to help the agency meet this need. The Panel specifically agreed that if the TWC was going to use GPCD as a regulatory tool it should first carry out a thorough study of how it is designed and incorporate a better breakdown of per capita use figures that would treat residential, commercial, industrial and other categories differently depending on their different usage.

Some members suggested that an area for future study would be to create models for residential per capita consumption conservation goals and to build comparable models for irrigation and other uses. One member felt that the data had so many flaws that they could not be used for regulatory purposes. Another felt that since there were so many uncertainties from a reporting point of view it became a problem of "which lie to tell."

The group considered a recommendation on reliability of different data sets but was not comfortable doing this with the level of information available to the members. Instead, there was agreement by the Panel that, where comparisons were possible, data should be presented with an indication of the percent difference between the data sets as a measure of reliability. Where these differences were high, as in irrigation pumpage data, this would serve as a red flag that more work was needed. Where data consists largely of estimates, the methodology for estimation and areas of uncertainty should be clearly indicated. The group felt it could note certain gaps in the data but could not fix them itself. It could recommend areas for future action and study.

Some wanted the potential area for municipal expansion to be considered in projecting demand. Sometimes, it was felt, a city is given a large projection but does not have the space in which to accommodate that much growth. In other cases, the opposite may be true and a city with large expansion area is given a modest projection. TWDB officials said that the former case is taken into account, and an effort is made to limit projections based on limited expansion area. Other members mentioned cities that are growing rapidly because of their location, as well as available area. One member suggested focusing on metropolitan areas, rather than individual cities.

2.2 WATER NEEDS FOR NATURAL SYSTEMS

2.2.1 Springflows

The major springs discharging water from the Edwards Aquifer are the Leona, San Pedro, San Antonio, Hueco, Comal and San Marcos Springs. Significant natural systems that support federally listed endangered species exist at Comal and San Marcos Springs. The other springs flow intermittently within the normal historical range of aquifer levels. Consequently, the natural system water needs of these other springs is much less significant and has not been the focus of any study attempting to identify natural system water needs there. These other springs are not addressed further in this subsection except to report estimates of flows.

2.2.1.1 Comal and San Marcos Springs

In 1975, Espey Huston and Associates performed a study and prepared a report for the Texas Water Development Board titled, INVESTIGATION OF FLOW REQUIREMENTS FROM COMAL AND SAN MARCOS SPRINGS TO MAINTAIN ASSOCIATED AQUATIC ECOSYSTEMS GUADALUPE RIVER BASIN. The stated purpose of the study was "to determine the minimum springflow required to insure the continued existence of the unique physical and biological character of the Comal and upper San Marcos Rivers." The Comal River was studied only superficially; concentration was on the San Marcos River. For San Marcos Springs the study focused on habitat maintenance for indicator species and concluded that the following flows should be maintained.

1. A minimum instantaneous (daily) flow of 40 cfs
2. A minimum monthly average flow of 80 cfs
3. A minimal annual average flow in excess of 100 cfs

In 1985 the Department of Interior, U.S. Fish and Wildlife Service developed "The San Marcos Recovery Plan for San Marcos Endangered and Threatened Species" in consultation with local experts on the endangered and threatened species in San Marcos Springs and other consultants. The "Recovery Plan" was outlined to include identifying additional information on population and habitat requirements, management of existing habitats and populations, management authority, enforcement and recommendations for changes in listed status. The "Recovery Plan" did not specify minimum flow requirements for San Marcos Springs.

The critical habitat designation by United States Fish and Wildlife Service Department of the Interior (USFWS) for San Marcos Springs does not specify a minimum springflow. USFWS reports that when Comal Springs flows are at approximately 100 cfs or less the upper spring runs cease flowing and the aquatic habitat there is lost.

Insufficient data exists to make a comprehensive presentation of water needs for natural systems at the springs in this exercise.

2.2.1.2 Historical Records

The historical record of springflows is derived from measurements made by the United States Geological Survey. Following is a history of these measurements and resultant data sets for Comal and San Marcos Springs. Refer to Table 2.2-1 for the data sets discussed in the following sections on Comal and San Marcos Springs.

Sample Data From Table 2.2-1
see page 112 for complete table

ANNUAL SPRINGFLOW DATA SETS
COMAL & SAN MARCOS SPRINGS

UNITS: ACRE-FEET

YEAR	Col. 1 USGS GAGE COMAL RIVER AT NEW BRAUN. (1)	Col. 2 USGS COMAL SPRS. AT NEW BRAUN. (2)	Col. 3 TWDB COMAL SPRINGS (3)	Col. 4 GBRA/SARA/CSA 1986 REPORT COMAL SPRS. (4)	Col. 5 USGS GAGE SAN MARCOS RIVER FLOW (5)	Col. 6 TWDB SAN MARCOS SPRINGS (6)	Col. 7 GBRA/SARA/CSA 1986 REPORT SAN MARCOS SPRINGS (7)
1950	189700	189089	189041	189700		76492	76492
1951	148860	148533	148318	148860		68600	68618
1952	162400	132102	132450	162400		75051	75102
1953	142870	139051	138905	142870		97859	97859
1954	98360	98515	98344	98360		76731	75449
1955	66820	66377	66120	66820		61162	61148
1956 (8)	27997	22367	22340	27997		47564	47564
1957	138740	103148	103386	138740	110280	110270	110270
1958	234080	226347	226452	234080	153440	153440	153440
1959	229240	227071	226992	229240	116060	116050	116050
1960	241690	228821	230479	241690	141410	141410	141410
1961	247960	241765	241715	247960	138260	138260	138260
1962	193470	192181	192054	193380	95850	95850	95850
1963	150800	150632	150290	150800	78710	78710	78710
1964	138562	136952	137137	138560	70180	70180	70180
1965	209230	188490	188585	209230	123020	123020	123020
1966	193430	193122	192969	193430	111360	111360	111360
1967	136450	131308	131044	136450	77650	77650	77650
1968	246750	230762	231387	246750	143060	143060	143060
1969	212380	210639	210547	212380	117820	117820	117820
1970	226600	221173	221176	226650	144570	144570	144570
1971	159800	158975	158978	159810	91850	91850	91850
1972	264600	225124	225127	264550	116650	116650	116650
1973	294000	279239	279243	294010	158200	158200	158200
1974	283800	275377	275381	283820	133770	133770	133770
1975	295400	286183	286187	295430	170090	167390	167390
1976	280100	268905	268909	280110	153140	153140	153140
1977	289700	282831	282835	289690	161710	161550	161550
1978	239900	233488	233492	239880	87410	87410	87410
1979	292700	287724	287728	292730	144950	144950	144950
1980	207200	206350	206353	207240	95950	95950	95950
1981	234500	228686	228690	234460	131000	131000	131000
1982	201200	198127	198130	201200	93490	93490	93490
1983	172000	171102	171105		106250	110380	
1984	91470	91087	91088		72346	72350	
1985	192540	184463	184466		132022	136880	

(1) USGS continuous recording stream gage
(2) USGS subtracts estimate of surface drainage from 130 square miles of drainage area
(3) TWDB data set used in Report 340, Model Refinement and Applications for the Edwards (Balcones Fault Zone) Aquifer in the San Antonio Region, Texas, Texas Water Development Board, July 1992, Draft.
(4) Guadalupe-Blanco River Authority, San Antonio River Authority, City of San Antonio Report, Water Availability Study for the Guadalupe and San Antonio River Basins, Espey Huston and Associates, 1986
(5) USGS continuous recording stream gage
(6) USGS subtracts estimate of surface drainage from 93 square miles of drainage area
(7) TWDB data set used in Report 340, Model Refinement and Applications for the Edwards (Balcones Fault Zone) Aquifer in the San Antonio Region, Texas, Texas Water Development Board, July 1992, Draft.
(8) Comal Springs did not flow from June 13 to November 3, 1956

Comal Springs

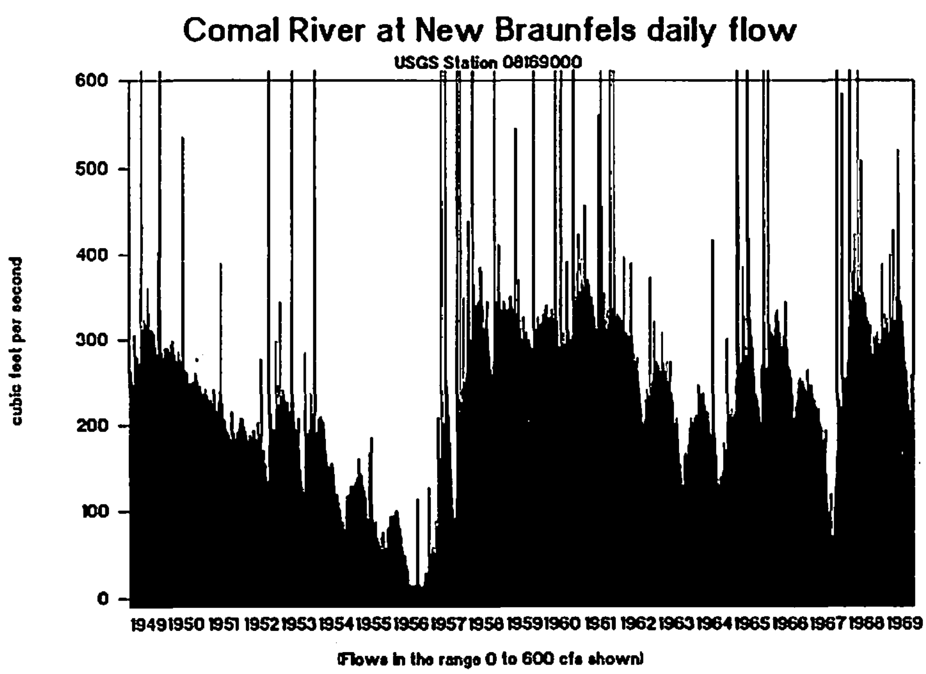
The United States Geological Survey (USGS) has maintained a continuous recording gage on the Comal River in New Braunfels to measure the Comal springflow and 130 square miles of drainage area above the gage. Column 1 in Table 2.2-1 reflects the annual totals for this gage. Daily flow values are presented in Figure 2.2-1a-c. Comal Springs did not flow from June 3 – Nov. 13, 1956. Indicated flow for that period was pumped into the river above the gage.

Column 2 is a data set of annual flows furnished by USGS representing the Comal Springs component of the Comal River flow for the period 1928-1989. This data set is derived from the gaged flows for the Comal River at New Braunfels by separating the runoff from the 130 square miles of drainage area above the gage from the Comal Springs flow. This is accomplished by examining the continous strip chart in the recording station which provides a hydrograph for any surface runoff event. The flood component of the hydrograph is separated from the springflow component assuming that the springflow component is constant through the runoff event. The flood component is then subtracted from the total gage flow to arrive at springflow.

Column 3 of the table is the data set that the Texas Water Development Board (TWDB) is currently using as historical record of Comal springflow in the operation of the TWDB Edwards (Balcones Fault Zone) Aquifer flow model which is being used to simulate the Edwards Aquifer operation. TWDB reports that this data set beginning in 1934 was furnished by USGS. The values in Columns 2 and 3 agree.

In 1986, the Guadalupe-Blanco River Authority, the City of San Antonio and the San Antonio River Authority sponsored a study reported as WATER AVAILABILITY STUDY FOR THE GUADALUPE AND SAN ANTONIO RIVER BASINS which reported monthly values for Comal springflow for the period 1940 through 1982. This report was prepared by Espey, Huston & Associates (EH&A). The annual totals from that table are reported in Column 4 of Table 2.2-1. Note that this data set agrees with the data set in Column 1 for the Comal River at New Braunfels which includes the runoff from the 130 square miles above the gage in addition to the Comal springflow.

Figure 2.2-1b



Daily flow values are presented in Figure 2.2-1a-c Comal Springs did not flow from June 3 – Nov. 13, 1956. Indicated flow for that period was pumped into the river above the gage.

San Marcos Springs

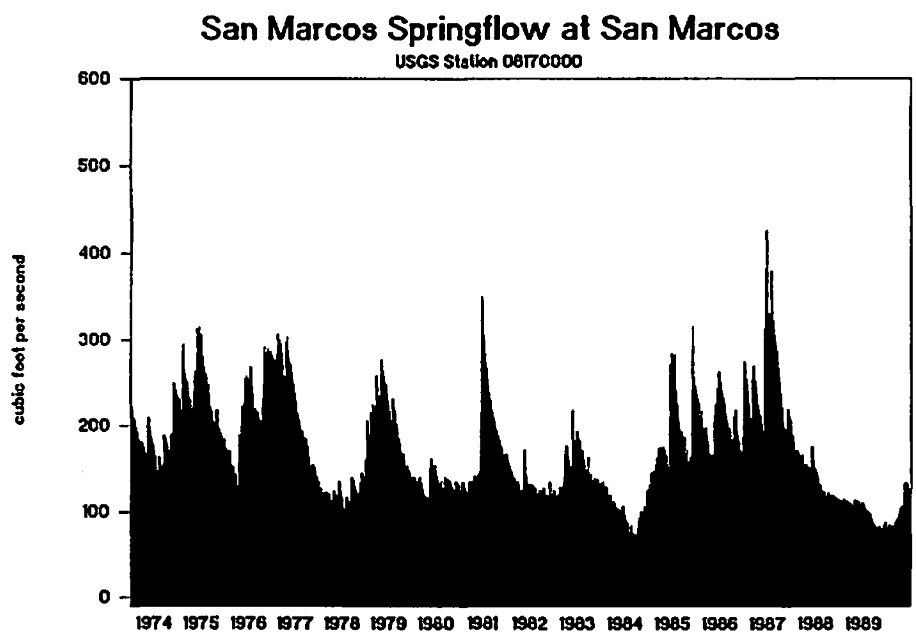
Since June, 1956, the USGS has maintained a stream gage referred to as San Marcos River Springflow at San Marcos. This gage measures the spring discharge and 93 square miles of drainage area above the gage. The floodflows are separated from the springflows in the same manner as described for Comal Springs above. The reported flows are for springflow only. The annual totals for this for San Marcos springflows are reported in Column 5 of Table 2.2-1. Daily flows are presented in Figure 2.2-2a-b

Prior to June, 1956, periodic measurements were made by USGS at the gage location. USGS personnel indicate that USGS does not have a data set for monthly or annual flows converted from these periodic measurements.

TWDB has a data set for San Marcos springflows for the period 1940 through 1990 which is presented in Column 6 of the table. For years 1957 (first full year of continuous USGS gage operation) and after, the TWDB data set agrees with the USGS data set with the exception of discrepancies in 1975, 1983 and 1985. For years prior to 1957 (1940 through 1956) TWDB reports that the data set was taken from a Guadalupe Blanco River Authority bulletin, a USGS water supply paper, and information from W.F. Guyton and Associates.

Column 7 of Table 2.2-1 reflects the data set used by EH&A in the aforementioned 1986 report. Note that for years 1957 and after, EH&A and TWDB and USGS agree, with the exception of 1975. For years 1940 through 1956, with the exception of minor differences for years 1949, 1954 and 1955, EH&A and TWDB agree, indicating that TWDB relied largely on the EH&A work reflected in the aforementioned GBRA bulletin. EH&A reports that EH&A relied upon earlier work by Forest and Cotton, a consulting engineering firm working for GBRA in the 1970s, who converted the periodic measurements recorded by USGS to estimated monthly values for San Marcos.

Figure 2.2-2b



Since 1989 USGS has used a composite coefficient for the relationship between a well level (or head in the aquifer) near the springs and the spring discharge to estimate San Marcos springflows. This composite coefficient was developed from historical records of the springflow and the well levels and is being continuously verified with periodic spring discharge measurements. This method is believed by USGS to be more accurate than using the gage record and adjusting for surface flows. The streamgage was abandoned in favor of this method for several reasons including accessibility, bank sloughing at the gage and surface flows.

All Springs

Table 2.2-2 presents a summation for years 1970-88 of the reported USGS estimates of gaged Comal and San Marcos springflows with estimates for Hueco, San Antonio, San Pedro and Leona Springs found in the USGS work notes of discharges from the Edwards Aquifer based on periodic measurements of flows at those springs. This sum has been compared to a total spring discharge reported by USGS in an annual report prepared for the Edwards Underground Water District titled COMPILATION OF HYDROLOGIC DATA FOR THE EDWARDS AQUIFER, SAN ANTONIO AREA, TEXAS, 1989 WITH 1934-1989 SUMMARY, BULLETIN 49. The difference between the sum of the estimates and the reported total springflows are probably a result of rounding or refinements in estimates for the intermittent springs reflected in the USGS work notes.

Table 2.2-2

ANNUAL SPRINGFLOW DATA – ALL SPRINGS

SOURCE: UNITED STATES GEOLOGICAL SURVEY
UNITS: ACRE-FEET

	COMAL PLUS SAN MARCOS SPRINGS (1)	HUECO SPRINGS (2)	SAN ANTONIO SPRINGS (2)	SAN PEDRO SPRINGS (2)	LEONA SPRINGS: UNDER-FLOW (2)	LEONA SPRINGS: SPRINGS (2)	LEONA SPRINGS: SPRINGS & UNDFL. (2)	TOTAL SPRINGS SUM OF ESTIMATE (3)	TOTAL REPORTED IN EUWD BULLETIN (4)	DIFFERENCE TOTAL REP. MINUS SUM OF EST. (5)
1970	385743		2431	4220	9523	15547	(6)	397463	397700	237
1971	250825		813	1175	8737	11201		272752	272700	-52
1972	341774		1381	4164			28452	375771	375800	29
1973	437439		47767	6755	9599	25705		527265	527600	335
1974	409147		32536	5687			36517	483887	483800	-87
1975	456273		34068	6024			44023	540388	540400	12
1976	422045		34399	6264			40930	503638	503900	262
1977	444541		71542	9827	9523	45076		580508	580300	-208
1978	320898		18383	4355	8350	23342		375328	375500	172
1979	432674		47009	7494	9599	26125		522902	523000	98
1980	302300		4579	2167	8550	10744		328340	328300	-40
1981	359886		17026	4818	8209	18364		408104	407300	-804
1982	291617		6162	2529	8271	24683		333262	333300	38
1983	277352		117	1062	8182	14721		301434	301600	166
1984	163433		0	224	6172	2734		172563	172500	-63
1985	316485		0	0	8102	8080		332667	334000	1333
1986	355277		4207	2860			(7)	(7)	388100	N/A
1987	446042		42909	8114	(7)	(7)		(7)	558000	N/A
1988	302598	13126	10993	3492	(7)	(7)		(7)	369800	N/A

(1) Sum of Comal Springs component of measured flow at Comal River at New Braunfels gage and San Marcos River Flow at San Marcos gage (values in Table 2.2-1, cols. 2 and 5)

(2) Values from USGS working files on water use reports, in some years

(3) Sum of previous columns

(4) Excerpted from USGS publication Compilation of Hydrologic Data for Edwards Aquifer, San Antonio Area, Texas, 1989, with 1934-89 Summary, Bulletin 49.

(5) Total reported by USGS in Bulletin 49 minus sum of estimates of individual springs

(6) In some years Leona Springs and Leona Underflow estimated separately, in other years together

(7) Leona Springs estimates not available in USGS files for years 1986, 87,88

2.2.2 Instream Flows

Instream flows is the term used to describe the water needs for natural systems. Historically, instream flows have been discussed in the context of the minimum flow that should be sustained in the stream or river downstream of an existing or proposed reservoir project or other diversion for human needs. Technical information relative to these minimum instream flow quantities is limited. No published instream flow regime for the study area streams surfaced in research for this text.

Typically, technical studies addressing minimum instream flow quantity issues are completed whenever a change to the existing system is proposed, e.g., a new reservoir. The venue for these studies is the state and federal permitting process for water use permits. Examples of this include the special conditions relative to minimum instream flows that are included in the permits for Applewhite Reservoir, Choke Canyon Reservoir and the hydroelectric right at Canyon Reservoir.

There is also a water quality aspect to instream flows. The Texas Water Commission, in consideration of a permit application for a reservoir, may impose minimum instream flow conditions that relate to water quality. In this process the TWC reviews the discharge parameters of downstream wastewater treatment plants and may set minimum instream flows that, when combined with those wastewater treatment plant discharges, will not degrade water quality below acceptable limits.

Historical information on streamflows is available from the USGS stream gage records. Table 2.2-3 lists the major stream gages and periods of record for each in the study area. Many other stream gages are maintained by USGS on streams off the main river channels and in the coastal basins between the river basins. These gage records are published annually by USGS and this data, in daily estimates, is available for any study of minimum instream flows.

2.2.3 Bay and Estuary Flows

Minimum inflows to the bays and estuaries have also been addressed on a case by case basis. Recent examples include Lake Texana and Choke Canyon Reservoir. Both reservoir permits contain special conditions that require minimum releases to their respective bay systems.

The Texas Water Development Board is developing a computer model to predict minimum bay and estuary inflows to protect the natural systems there. This model is in draft report form, presently undergoing staff and contractor review. The TWDB, the Texas Parks and Wildlife Department (TPWD), and the TWC are the agencies comprising the policy committee for the model development. The draft report uses San Antonio Bay as the example bay system in the model. Because the report is in draft form (and incomplete with respect to all bay systems in the study area) the predicted minimum bay and estuary inflow requirements of the study area are not presented in this text. The sponsoring agencies propose that the model, when complete and approved, can be used to analyze the impact of any proposed water project on the affected bay system and can be used to set special conditions for proposed permits necessary to meet minimum bay and estuary flows to protect the natural systems there. As of this writing, the draft report is in review at TWC; both TWDB and TPWD have completed their reviews and approved the report.

A 1986 study by Espey Huston and Associates prescribed minimum monthly inflows to San Antonio Bay as input to a hydrology model analyzing reservoir yields in the Guadalupe and San Antonio River Basins. The methodology developed monthly minimum inflows to the bay system required to meet certain salinity conditions. The inflow-salinity relationship was developed from historical data on inflows and salinity. Salinity criteria were developed based on known data for important species. It is not known whether this methodology was accepted outside the study sponsorship.

In 1979 the Texas Department of Water Resources (TDWR) published a series of reports (LP-107 for San Antonio Bay) on the bay systems in Texas that specified three inflow levels to meet three levels of shellfish and finfish production. Information developed in these reports has been used since that time in state agency administration of water use permit conditions.

In the case of Choke Canyon Reservoir, a post construction interpretation of the minimum bay and estuary release requirement in the permit was required. The inflow levels set out for Nueces Bay in the draft TWDB bay and estuary model described above were used as the basis for negotiation of the minimum release requirement.

2.2.4 Panel Discussions and Conclusions

The Panel discussions relative to the water needs for the natural systems at Comal and San Marcos Springs focused on the limited data available.

It was noted by one panel member that water use permits affect instream flows. Only recent permits have minimum flow requirements. On some streams in the study area the legal exercise of diversion rights could reduce flows below justifiable minimum flow requirements to support natural systems. Conversely, existing senior water rights in the downstream river reaches assist in maintaining flows by legally compelling flows to be passed downstream.

On bay and estuary water needs, the discussion centered on the TWDB model that is now in draft form. It was pointed out by one panel member that the model results were used for Nueces Bay relative to the Choke Canyon Reservoir minimum bay and estuary release recently negotiated, that the model predicted a wide range of inflows depending on the species that are to be protected and that negotiations finally set the release rate. This panel member also indicated that the reservoir yield varies with the bay and estuary release requirement.

The panel discussed water quality as a component of instream flow needs for natural systems and its relationship to volume of flow. The Texas Water Commission (TWC) authority to protect surface water quality by regulating point source discharge of pollutants was reviewed, in particular the TWC computer modelling of proposed discharges to set effluent limitations that protect specified dissolved oxygen levels. This aspect of instream flow needs was not throught by the panel to be of great significance relative to water supplies for the region.

Water needs for springs, instream flows and bay and estuaries was proposed for inclusion in Section 7.0 TECHNICAL AREAS REQUIRING FURTHER STUDY AND IMPROVEMENT.

Bibliography

SECTION 2.0 WATER DEMANDS AND NEEDS

Edwards Underground Water District, Compilation of Hydrologic Data for the Edwards Aquifer, San Antonio Area, Texas, 1990 with 1934-1990 Summary, Bulletin 50, 1991.

Edwards Underground Water District, Compilation of Hydrologic Data for the Edwards Aquifer, San Antonio Area , Texas 1989 with 1934-1989 Summary, Bulletin 49, 1990.

Espey, Huston & Associates, Inc., Water Availability Study for the Guadalupe and San Antonio River Systems, Volumes I and II, Austin, Texas, February 1986.

Texas Department of Water Resources, Guadalupe Estuary: A Study of the Influence of Freshwater Inflows, LP 107, 1979.

Texas Water Development Board, Surveys of Irrigation in Texas- 1958, 1964, 1969, 1974, 1979, 1984, 1989. Report 329, 1990.

TABLE 2.1-1
TECHNICAL DATA REVIEW PANEL
HISTORICAL GROUND WATER PUMPAGE BY COUNTIES FOR REGION

SOURCE: TEXAS WATER DEVELOPMENT BOARD
ALL VALUES ARE REPORTED IN ACRE-FEET UNITS

COUNTY		1985	1986	1987	1988	1989
ARANSAS						
MUNICIPAL		233.49	256.52	252.03	212.80	200.83
MANUFACTURING		103.64	124.65	150.20	214.68	112.32
POWER		0.00	0.00	0.00	0.00	0.00
MINING		0.02	0.00	0.00	0.00	0.00
IRRIGATION		0.00	0.00	0.00	0.00	0.00
LIVESTOCK		3.00	3.00	5.00	5.00	5.00
ARANSAS	TOTAL:	340.15	384.17	407.23	432.48	318.15
ATASCOSA						
MUNICIPAL		6,261.62	5,126.12	5,171.55	6,338.75	6,735.16
MANUFACTURING		3.00	3.00	0.00	0.00	0.00
POWER		3,950.15	5,550.48	5,626.34	6,352.47	5.75
MINING		1,752.00	1,001.72	1,373.00	1,313.00	596.79
IRRIGATION		31,571.00	43,600.00	26,783.00	35,450.00	50,914.00
LIVESTOCK		201.00	176.00	151.00	156.00	154.00
ATASCOSA	TOTAL:	43,738.77	55,457.31	39,104.89	49,610.21	58,405.70
BANDERA						
MUNICIPAL		1,153.91	1,212.45	1,223.76	1,298.11	1,397.66
MANUFACTURING		0.00	0.00	0.00	0.00	0.00
POWER		0.00	0.00	0.00	0.00	0.00
MINING		24.00	0.00	20.00	21.00	20.00
IRRIGATION		89.00	108.00	162.00	162.00	133.00
LIVESTOCK		229.00	213.00	228.00	265.00	262.00
BANDERA	TOTAL:	1,495.91	1,533.45	1,633.76	1,746.11	1,812.66
BEE						
MUNICIPAL		2,559.07	1,619.02	1,603.15	1,653.18	1,699.58
MANUFACTURING		1.11	1.11	1.11	1.11	1.11
POWER		0.00	0.00	0.00	0.00	0.00
MINING		121.00	24.89	20.00	21.00	20.00
IRRIGATION		718.00	980.00	654.00	980.00	2,232.00
LIVESTOCK		103.00	109.00	103.00	112.00	109.00
BEE	TOTAL:	3,502.18	2,734.02	2,381.26	2,767.29	4,061.69
BEXAR						
MUNICIPAL & MILITARY		238,431.13	243,700.62	235,429.08	260,609.01	259,860.07
MANUFACTURING		6,176.61	7,597.16	6,581.49	8,285.61	6,836.91
POWER		1,244.05	1,219.43	1,113.71	740.96	738.51
MINING		2,564.00	1,557.99	1,370.00	1,462.00	1,319.00
IRRIGATION		16,967.00	16,610.00	12,949.00	15,595.00	23,851.00
LIVESTOCK		138.00	146.00	122.00	127.00	127.00
BEXAR	TOTAL:	265,520.79	270,831.19	257,565.29	286,820.57	292,731.49
CALDWELL						
MUNICIPAL		2,588.31	2,784.08	2,631.72	2,716.56	2,613.18
MANUFACTURING		0.00	0.00	0.00	0.00	0.00
POWER		0.00	0.00	0.00	0.00	0.00
MINING		27.00	0.64	28.00	24.99	27.00
IRRIGATION		144.00	145.00	145.00	145.00	147.00
LIVESTOCK		74.00	81.00	80.00	84.00	82.00
CALDWELL	TOTAL:	2,833.31	3,010.72	2,884.72	2,970.55	2,869.18

COUNTY		1985	1986	1987	1988	1989
CALHOUN						
MUNICIPAL		570.65	523.00	515.82	479.15	392.95
MANUFACTURING		57.00	57.00	0.00	0.00	8.37
POWER		0.00	0.00	0.00	0.00	0.00
MINING		1.11	1.11	1.11	1.11	1.11
IRRIGATION		3,197.00	3,072.00	2,724.00	3,792.00	3,561.00
LIVESTOCK		232.00	191.00	161.00	170.00	177.00
CALHOUN	TOTAL:	4,057.76	3,844.11	3,401.93	4,442.26	4,140.43
COMAL						
MUNICIPAL		11,867.34	13,080.19	12,919.92	12,168.64	12,680.21
MANUFACTURING		1,055.34	980.51	1,013.33	898.70	1,085.05
POWER		0.00	0.00	0.00	0.00	0.00
MINING		961.00	945.69	5,830.99	5,598.00	946.00
IRRIGATION		0.00	385.00	385.00	385.00	481.00
LIVESTOCK		222.00	222.00	233.00	258.00	256.00
COMAL	TOTAL:	14,105.68	15,613.39	20,382.24	19,308.34	15,448.26
DE WITT						
MUNICIPAL		4,260.56	4,008.59	4,164.88	4,183.12	4,366.16
MANUFACTURING		0.00	0.00	0.00	0.00	0.00
POWER		0.00	0.00	0.00	0.00	0.00
MINING		125.00	110.25	134.23	141.03	129.29
IRRIGATION		285.00	125.00	188.00	187.00	275.00
LIVESTOCK		205.00	178.00	177.00	181.00	178.00
DE WITT	TOTAL:	4,875.56	4,421.84	4,664.11	4,692.15	4,948.45
DIMMIT						
MUNICIPAL		2,220.42	2,346.84	2,121.47	2,573.33	2,684.55
MANUFACTURING		0.00	0.00	0.00	0.00	0.00
POWER		0.00	0.00	0.00	0.00	0.00
MINING		582.00	74.46	587.00	498.00	506.00
IRRIGATION		20,821.00	11,529.00	6,225.00	10,497.00	7,382.00
LIVESTOCK		633.00	596.00	841.00	795.00	783.00
DIMMIT	TOTAL:	24,256.42	14,546.30	9,774.47	14,363.33	11,355.55
DUVAL						
MUNICIPAL		1,970.02	2,004.33	1,970.74	2,114.93	2,352.24
MANUFACTURING		0.00	0.00	0.00	0.00	0.00
POWER		0.00	0.00	0.00	0.00	0.00
IRRIGATION		2,042.00	2,000.00	3,000.00	2,000.00	2,233.00
LIVESTOCK		104.00	129.00	107.00	112.00	111.00
DUVAL	TOTAL:	6,064.02	5,175.52	8,492.74	7,295.93	7,745.24
FRIO						
MUNICIPAL		2,713.56	2,689.51	2,489.71	3,025.75	3,336.64
MANUFACTURING		12.00	12.00	0.00	0.00	0.00
POWER		288.65	72.76	92.46	793.61	6.96
MINING		437.99	7.07	388.00	339.00	313.00
IRRIGATION		48,460.00	67,217.00	65,970.00	86,068.00	96,369.00
LIVESTOCK		119.00	107.00	111.00	109.00	107.00
FRIO	TOTAL:	52,031.20	70,105.34	69,051.17	90,335.36	100,132.60
GOLIAD						
MUNICIPAL		808.59	836.24	864.62	891.98	931.12
MANUFACTURING		0.00	0.00	0.00	0.00	0.00
POWER		145.78	172.99	160.25	144.96	150.00
MINING		1.00	0.98	0.00	0.00	0.00
IRRIGATION		23.00	26.00	26.00	21.00	164.00
LIVESTOCK		131.00	105.00	97.00	85.00	84.00
GOLIAD	TOTAL:	1,109.37	1,141.21	1,147.87	1,142.94	1,329.12

COUNTY		1985	1986	1987	1988	1989
GONZALES						
MUNICIPAL		1,367.70	1,327.57	1,748.66	2,060.13	1,976.41
MANUFACTURING		90.00	90.00	0.00	0.00	0.00
POWER		0.00	0.00	0.00	0.00	0.00
MINING		18.00	0.00	20.00	21.00	21.00
IRRIGATION		940.00	840.00	976.00	1,429.00	1,335.00
LIVESTOCK		382.00	404.00	401.00	377.00	384.00
GONZALES	TOTAL:	2,797.70	2,660.56	3,145.67	3,889.14	3,717.41
GUADALUPE						
MUNICIPAL		1,290.92	1,077.03	478.69	1,078.94	1,568.83
MANUFACTURING		92.08	104.08	92.07	92.07	92.07
POWER		0.00	0.00	0.00	0.00	0.00
MINING		14.00	0.00	8.00	201.97	8.00
IRRIGATION		1,251.00	980.00	737.00	389.00	1,359.00
LIVESTOCK		86.00	101.00	97.00	103.00	101.00
GUADALUPE	TOTAL:	2,734.00	2,262.11	1,412.76	1,864.98	3,128.90
HAYS						
MUNICIPAL		11,810.33	12,455.36	13,086.41	13,673.87	14,132.26
MANUFACTURING		1,234.60	1,080.38	998.28	1,481.93	703.61
POWER		0.00	0.00	0.00	0.00	0.00
MINING		97.00	869.00	0.00	795.46	0.00
IRRIGATION		187.00	128.00	102.00	85.00	0.00
LIVESTOCK		1,260.00	738.00	1,485.00	827.00	734.00
HAYS	TOTAL:	14,588.51	15,270.46	15,671.40	16,863.66	15,570.36
JIM WELLS						
MUNICIPAL		2,185.29	2,226.28	2,080.03	2,229.65	2,471.96
MANUFACTURING		0.00	0.00	0.00	0.00	0.00
POWER		0.00	0.00	0.00	0.00	0.00
MINING		235.00	223.17	424.00	405.00	392.99
IRRIGATION		1,875.00	2,500.00	2,420.00	2,137.00	895.00
LIVESTOCK		86.00	82.00	80.00	80.00	79.00
JIM WELLS	TOTAL:	4,381.29	5,031.45	5,004.03	4,851.65	3,838.95
KARNES						
MUNICIPAL		2,571.53	2,434.36	2,529.68	2,225.60	2,654.91
MANUFACTURING		41.71	30.41	46.37	46.03	122.57
POWER		0.00	0.00	0.00	0.00	0.00
MINING		277.99	265.11	338.00	413.00	187.00
IRRIGATION		1,270.00	1,800.00	1,922.00	2,030.00	282.00
LIVESTOCK		133.00	127.00	131.00	133.00	131.00
KARNES	TOTAL:	4,294.23	4,656.88	4,967.05	4,847.63	3,377.48
KINNEY						
MUNICIPAL		1,051.49	1,082.51	1,057.72	1,197.86	1,409.22
MANUFACTURING		0.00	0.00	0.00	0.00	0.00
POWER		0.00	0.00	0.00	0.00	0.00
MINING		0.00	0.00	0.00	0.00	0.00
IRRIGATION		4,634.00	5,000.00	2,083.00	2,705.00	10,498.00
LIVESTOCK		375.00	454.00	506.00	544.00	496.00
KINNEY	TOTAL:	6,060.49	6,536.51	3,646.72	4,446.86	12,403.23
KLEBERG						
MUNICIPAL		5,060.31	5,300.94	4,819.10	4,919.03	5,201.03
MANUFACTURING		19.00	19.00	0.00	0.00	0.00
POWER		0.00	0.00	0.00	0.00	0.00
MINING		1,173.00	1,527.28	1,314.00	1,180.27	1,221.10
IRRIGATION		405.00	614.00	500.00	536.00	378.00
LIVESTOCK		134.00	148.00	164.00	169.00	172.00
KLEBERG	TOTAL:	6,791.31	7,609.22	6,797.10	6,804.30	6,972.13

COUNTY		1985	1986	1987	1988	1989
LA SALLE						
MUNICIPAL		964.07	952.25	1,030.12	1,161.64	1,302.28
MANUFACTURING		0.00	0.00	0.00	0.00	0.00
POWER		0.00	0.00	0.00	0.00	0.00
MINING		86.35	90.99	131.27	177.13	189.73
IRRIGATION		3,003.00	2,666.00	2,467.00	2,426.00	6,051.00
LIVESTOCK		104.00	105.00	101.00	100.00	99.00
LA SALLE	TOTAL:	4,157.42	3,814.24	3,729.39	3,864.76	7,642.01
LIVE OAK						
MUNICIPAL		625.92	766.23	754.86	791.90	977.82
MANUFACTURING		1,049.00	965.37	198.33	28.47	57.16
POWER		0.00	0.00	0.00	0.00	0.00
MINING		1,260.00	1,018.60	1,713.00	2,422.00	2,385.00
IRRIGATION		2,550.00	1,110.00	1,049.00	1,419.00	841.00
LIVESTOCK		450.00	535.00	577.00	603.00	594.00
LIVE OAK	TOTAL:	5,934.92	4,395.20	4,292.19	5,264.37	4,854.98
MAVERICK						
MUNICIPAL		455.28	212.79	297.45	33.27	329.66
MANUFACTURING		5.00	5.00	0.00	0.00	0.00
POWER		0.00	0.00	0.00	0.00	0.00
MINING		249.00	0.00	236.00	233.00	218.00
IRRIGATION		2,103.00	0.00	0.00	5266.00	600.00
LIVESTOCK		237.00	239.00	178.00	117.00	115.00
MAVERICK	TOTAL:	3,049.28	456.79	711.46	5,649.27	1,262.66
MEDINA						
MUNICIPAL		4,982.95	5,408.50	4,897.68	5,743.18	6,475.85
MANUFACTURING		0.00	0.00	0.00	0.00	0.00
POWER		0.00	0.00	0.00	0.00	0.00
MINING		140.00	0.00	124.00	129.00	120.00
IRRIGATION		57,329.00	94,882.00	81,846.00	94,050.00	113,089.00
LIVESTOCK		136.00	134.00	161.00	173.00	152.00
MEDINA	TOTAL:	62,587.95	100,424.49	87,027.69	100,095.36	119,835.84
McMULLEN						
MUNICIPAL		138.22	130.83	186.52	199.37	177.86
MANUFACTURING		0.00	0.00	0.00	0.00	0.00
POWER		0.00	0.00	0.00	0.00	0.00
MINING		229.00	237.80	266.00	268.00	239.00
IRRIGATION		0.00	0.00	93.00	116.00	0.00
LIVESTOCK		42.00	44.00	46.00	49.00	49.00
McMULLEN	TOTAL:	409.22	412.63	591.52	632.37	465.86
NUECES						
MUNICIPAL		1386.01	385.78	325.75	333.66	375.04
MANUFACTURING		199.55	206.79	201.96	202.25	201.37
POWER		0.00	0.00	0.00	0.00	0.00
MINING		26.19	30.39	15.39	69.00	39.00
IRRIGATION		2,600.00	2,134.00	1,900.00	2,600.00	540.00
LIVESTOCK		33.00	129.00	32.00	137.00	135.00
NUECES	TOTAL:	4,244.75	2,885.96	2,475.10	3,341.91	1,290.41
REFUGIO						
MUNICIPAL		1,279.93	1,343.17	1,371.36	1,244.17	1,296.91
MANUFACTURING		0.00	0.00	0.00	0.00	0.00
POWER		0.00	0.00	0.00	0.00	0.00
MINING		134.12	115.42	51.72	51.65	76.73
IRRIGATION		50.00	50.00	50.00	100.00	0.00
LIVESTOCK		53.00	42.00	53.00	67.00	57.00
REFUGIO	TOTAL:	1,517.05	1,550.59	1,526.08	1,462.82	1,430.64

COUNTY	1985	1986	1987	1988	1989
SAN PATRICIO					
MUNICIPAL	1,702.94	1,721.47	1,588.57	1,301.06	1,331.33
MANUFACTURING	1.61	1.61	1.61	0.00	1.61
POWER	0.00	0.00	0.00	0.00	0.00
MINING	55.00	30.04	37.00	61.00	57.28
IRRIGATION	1,664.00	2,000.00	1,666.00	2,050.00	1,233.00
LIVESTOCK	120.00	97.00	81.00	72.00	72.00
SAN PATRICIO TOTAL:	3,543.55	3,850.12	3,374.18	3,484.06	2,695.22
UVALDE					
MUNICIPAL	5,623.13	5,192.35	4,913.30	5,984.51	6,400.72
MANUFACTURING	306.12	328.37	334.51	334.51	362.13
POWER	0.00	0.00	0.00	0.00	0.00
MINING	300.00	333.51	104.00	381.88	399.00
IRRIGATION	149,459.00	119,828.00	98,925.00	131,566.00	151,378.00
LIVESTOCK	2543.00	2652.00	2253.00	1909.00	2016.00
UVALDE TOTAL:	158,231.63	128,333.92	106,529.41	140,175.63	160,554.45
VICTORIA					
MUNICIPAL	12,926.50	12,344.30	12,043.22	12,527.91	12,306.07
MANUFACTURING	721.53	600.01	626.79	491.48	515.12
POWER	3,707.45	3,306.43	2,779.09	2,320.67	1,472.78
MINING	3,162.99	44.54	2,814.00	2,585.00	2,409.00
IRRIGATION	11,045.00	9,216.00	10,337.00	16,863.00	18,244.00
LIVESTOCK	702.00	682.00	711.00	744.00	774.00
VICTORIA TOTAL:	32,265.47	26,193.28	29,311.10	35,532.06	35,720.97
WEBB					
MUNICIPAL	337.41	265.17	228.68	223.77	741.12
MANUFACTURING	10.74	9.94	0.00	8.01	3.68
POWER	0.00	0.00	0.00	0.00	0.00
MINING	129.44	99.56	191.65	318.00	274.00
IRRIGATION	0.00	0.00	0.00	0.00	168.00
LIVESTOCK	178.00	191.00	194.00	204.00	200.00
WEBB TOTAL:	655.59	564.67	614.33	753.78	1,386.80
WILSON					
MUNICIPAL	2,944.56	2,958.33	3,388.41	3,558.50	3,971.24
MANUFACTURING	166.96	139.29	93.00	75.79	42.63
POWER	0.00	0.00	0.00	0.00	0.00
MINING	309.00	0.00	277.00	300.00	281.00
IRRIGATION	6,174.00	6,257.00	6,734.00	8,245.00	9,139.00
LIVESTOCK	162.00	181.00	167.00	167.00	165.00
WILSON TOTAL:	9,756.52	9,535.62	10,659.41	12,346.29	13,598.87
ZAVALA					
MUNICIPAL	2,199.06	2,411.79	2,422.76	2,686.09	2,610.60
MANUFACTURING	905.02	880.37	835.02	890.51	1,213.57
POWER	0.00	0.00	0.00	0.00	0.00
MINING	143.00	0.00	127.00	124.00	116.00
IRRIGATION	94,200.00	39,865.00	34,968.00	74,621.00	92,370.00
LIVESTOCK	113.00	92.00	83.00	69.00	68.00
ZAVALA TOTAL:	97,560.08	43,249.16	38,435.78	78,390.60	96,378.17
REGIONAL TOTALS:					
MUNICIPAL	336,542.22	340,184.52	330,607.42	361,439.42	366,961.47
MANUFACTURING	12,251.62	132,365.00	11,174.07	13,051.15	11,359.28
POWER	9,336.08	103,229.00	9,771.85	10,352.67	2,374.00
MINING	16,583.20	9,652.40	21,359.36	21,359.36	2,374.00
IRRIGATION	465,056.00	435,667.00	367,986.00	503,915.00	596,142.00
LIVESTOCK	9,723.00	94,330.00	9,917.00	9,103.00	9,028.00
GRAND TOTAL	849,492.08	818,492.43	750,814.05	920,489.02	1,001,423.86

LIMITATIONS ON USE OF THIS DATA

1. This data is estimated pumpage
2. Estimation methods vary in accuracy

TABLE 2.1-2
TECHNICAL DATA REVIEW PANEL
HISTORICAL GROUND WATER PUMPAGE BY AQUIFER FOR REGION

SOURCE: TEXAS WATER DEVELOPMENT BOARD
ALL VALUES ARE REPORTED IN ACRE FEET

AQUIFER NAME	1985	1986	1987	1988	1989
CARRIZO - WILCOX	240,539.90	207,259.45	180,792.98	264,306.95	298,725.99
EDWARDS - BFZ	504,299.20	519,262.37	475,676.80	544,872.29	592,479.59
EDWARDS - TRINITY	5,598.10	5,793.77	3,007.46	3,598.98	11,253.86
GULF COAST	82,927.02	73,846.63	78,188.66	86,329.87	83,236.05
OTHER - UNDIFF.	2,666.19	1,714.20	1,909.14	3,279.11	2,160.52
QUEEN CITY	4,169.58	1,112.39	841.91	1,258.68	1,271.69
RITA BLANCA	17.00	16.71	19.91	19.18	18.89
SEYMOUR				765.21	
SPARTA	585.91	512.15	549.57	578.11	727.68
TRINITY	8,689.18	8,974.76	9,827.62	15,480.64	11,549.59
REGIONAL TOTALS:	849,492.08	818,492.43	750,814.05	920,489.02	1,001,423.86

LIMITATIONS ON USE OF THIS DATA
1. This data is estimated pumpage
2. Source aquifer is not always known, particularly where two or more aquifers exist at one location

TABLE 2.1-3
TECHNICAL DATA REVIEW PANEL
HISTORICAL MUNICIPAL PUMPAGE FROM EDWARDS AQUIFER

SOURCE: TEXAS WATER DEVELOPMENT BOARD
ALL VALUES ARE REPORTED IN ACRE-FEET UNITS

COUNTY	PUMPER NAME	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
ATASCOSA	CITY OF LYTLE	432.14	404.53	411.40	517.97	510.21	495.16	471.01	582.15	670.16	551.86
ATASCOSA TOTAL:		432.14	404.53	411.40	517.97	510.21	495.16	471.01	582.15	670.16	551.86
BEXAR	AIR FORCE VILLAGE II							137.06	147.19	148.83	139.86
	ATASCOSA RURAL WATER SYSTEM	409.61	503.79	514.94	658.97	583.95	754.30	750.83	903.80	760.33	601.71
	AUSTIN HWY WATER SUPPLY CORP.	65.51	71.18	65.79	75.67	64.65	60.61	66.20	66.54	76.32	55.13
	BAPTIST CHILDREN'S HOME	6.76	7.02	7.31	6.77	6.57	7.15	7.27	7.33	7.27	6.39
	BEXAR CO. WCID 16	643.48	740.36	511.43	52.73	697.01	623.15	694.51	689.76	629.35	559.10
	BEXAR COUNTY WCID # 10	1,158.11	1,437.58	1,309.97	1,605.79	1,327.58	1,431.00	1,437.38	1,588.78	1,636.17	1,330.32
	BEXAR METROPOLITAN WD-CASTLE HILLS	2,091.53	2,566.43	2,432.34	2,751.59	2,132.53	2,340.13	2,093.87	2,495.88	2,469.68	2,016.32
	METROPOLITAN WD-SOUTH SIDE	13,118.86	14,390.26	13,750.80	13,930.53	12,881.71	12,773.44	12,347.56	13,316.37	14,927.11	13,801.24
	BROOKDALE MHP				11.50	11.12	11.76	13.31	18.33	13.93	12.37
	CADILLAC WATER SUPPLY CORP.	45.03	54.95	53.62	63.64	50.14	55.42	55.92	74.15	75.03	57.08
	CITY OF ALAMO HEIGHTS	2,488.46	2,607.24	2,889.74	3,647.83	2,275.66	2,631.25	2,158.31	2,826.33	2,593.83	2,233.85
	CITY OF CONVERSE	551.26	802.36	1,017.14	1,271.26	1,205.69	1,216.06	1,314.05	1,498.71	1,483.25	1,226.61
	CITY OF KIRBY	757.50	935.23	1,082.10	1,323.85	1,674.34	1,334.98	1,138.56	1,247.81	1,240.75	1,079.94
	CITY OF LEON VALLEY	877.37	1,033.35	967.49	1,223.12	1,131.13	1,191.34	1,179.67	1,299.02	1,324.28	1,146.11

TABLE 2.1-3 (Continued)

COUNTY	PUMPER NAME	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	CITY OF SCHERTZ	1,476.32	1,726.58	1,567.12	2,135.58	2,079.82	2,156.71	2,125.05	2,344.16	2,414.15	2,140.40
	CITY OF SELMA									134.49	125.01
	CITY OF SHAVANO PARK	455.97	485.31	520.91	665.86	702.60	702.15	736.58	949.48	939.95	839.69
	CITY OF UNIVERSAL CITY	1,880.60	2,060.14	2,055.35	2,753.66	2,305.80	2,485.52	2,454.84	2,761.88	2,570.86	2,323.35
	COUNTRY OAKS MHP							10.31E	8.68	5.85	23.51
	DILLARDS BUYING OFFICE	305.66	305.66	259.01	173.09	181.37	163.26	153.44			
	ELM VALLEY WATER CO	12.73	17.28	22.63	47.42	49.77	50.31	47.28	61.00	49.69	44.96
	GERONIMO FOREST WATER CO	52.67E	53.95E	51.25E	54.92	48.73	55.24E	55.24E	60.76E	62.59E	63.18
	GERONIMO VILLAGE	38.12E	39.90E	37.90E	49.45	63.94	61.16	57.34	75.23	77.75	60.13
	HASKIN WATER SUPPLY. INC.	69.81	82.89	85.23	90.78	78.39	82.72	75.54	93.37	96.20	79.55
	HILL COUNTRY WATERWORKS CO. INC	1,190.79	1,611.00	1,481.15	1,606.94E	1,171.40	2,639.98	2,530.84	2,604.02	2,755.21	2,585.33
	HOLY CROSS CEMETERY	206.60	193.34	65.18	373.42	62.97	187.08	239.13	389.17	491.08	159.97
	LACKLAND CITY WC-COLUMBIA/ BIG COUNTR	2,404.13	3,323.84	3,002.03	3,135.13	3,305.46	3,402.22	3,497.12	3,716.15	3,696.84	3,371.77
	LACKLAND CITY WC-PARK VILLAGE WC	1,456.46	1,826.83	1,740.58	2,277.91	2,547.68	3,069.83	3,067.26	3,486.65	3,696.84	3,229.19
	LAKESIDE TRAILER PARK	20.30	20.30	20.30	52.08	50.84	47.19	42.14	46.15	39.15	32.05
	LIVE OAK PUBLIC UTILITY DIST.	792.29E	921.23	1,222.18E	2,388.25E	2,220.60	738.71	663.23	524.38	601.34	1,216.76
	MEADOWOOD ACRES		56.01E	42.47	63.78	57.52	50.62	47.31	48.57E	56.78E	57.91
	MENGER HOTEL			292.16E	291.54E	186.64	69.08	62.23	80.82	81.44	101.22
	MOBIL CITY WATER SYSTEM-BULVERDE	30.06	35.44	37.99	22.43	21.18	24.68	19.32	22.59	23.30E	75.63E
	NORTH BREEZE MOBILE HOME PARK								2.77	1.21	3.00
	NORTH SAN ANTONIO WATER WORKS	35.13	38.03	31.62	43.82	46.01	55.14	79.12	65.42	77.14E	55.48

TABLE 2.1-3 (Continued)

COUNTY	PUMPER NAME	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	OAK HILLS COUNTRY CLUB	193.95	198.25	188.34E	216.59E	21.00	204.69	193.03	206.54	210.83	221.94
	OUR LADY OF THE LAKE UNIVERSITY	77.28	75.40	95.25	96.11	80.93	85.01	80.48	96.69	96.78	95.37
	PARK MAINTENANCE - HILDEBRAND/WOODLAWN	941.81E	988.90E	939.46E	1,444.59	145.10	102.13	92.96	511.52	1,045.72	1,074.11
	RIO MEDINA WATER CORP.						38.52	31.80	42.15	44.11	32.88
	SAN ANTONIO CITY WATER BOARD	57,627.62(1)	182,182.53	170,497.56	191,429.79	175,313.47	179,292.19	170,115.18	190,737.65	189,159.62	170,419.39
	SAN ANTONIO COUNTRY CLUB	387.65E	425.49	444.41	434.95	439.68	437.31	438.50	174.93	267.64	242.44
	SAN ANTONIO ZOO	2,984.06	2,984.06	2,984.06	2,984.06	2,984.06	2,984.06	2,984.06	2,984.06	2,984.06	2,984.06
	SAN FERNANDO CEMETARY	14.70	39.57	23.93	40.36	20.50	12.23	16.45	47.00	47.96	18.83
	SAN FERNANDO WATER CO.	439.67	490.58	451.19	510.02	472.18	729.70	446.66	467.40	467.05	417.65
	SOUTHWEST ISD				0.77	38.32E	38.36E	38.36E	64.75E	38.36E	64.75E
	SOUTHWEST RESEARCH INSTITUTE	1,614.11				699.71	699.71	699.71	700.41	920.67	920.67
	ST. ANTHONY HIGH SCHOOL	24.77	27.71	29.37	31.98	34.02	24.65	19.40	81.99	72.64	79.52
	ST. MARYS UNIVERSITY		30.05	29.98	77.97	37.60	32.13	24.01	47.70	36.73	43.80
	SUNSET MEMORIAL PARK	169.27	271.63	222.73	318.18	233.92	183.25	73.02	273.61	282.68	263.16
	TRAILER CITY WATER CO.		24.20E	22.99E	26.43E	19.77E	18.78E		12.96E	13.61E	14.83
	U. S. AIR FORCE - KELLY	3,978.71	4,205.17	4,306.11	4,724.95	4,185.96	4,209.72	3,764.84	3,997.50	3,926.56	3,565.78
	U. S. AIR FORCE - LACKLAND	4,205.71	3,824.67	3,926.44	4,582.89	5,327.20	5,020.92	7,152.66	4,548.21	4,203.86	3,299.49
	U. S. AIR FORCE - RANDOLPH	1,267.40	1,668.66	1,472.60	1,781.37	1,144.95	1,370.37	1,639.61	1,872.10	2,016.97	1,494.21
	U. S. ARMY - FORT SAM HOUSTON	3,598.73	4,470.66	3,782.66	4,530.94	4,020.14	3,834.85	3,628.89	4,252.17	4,348.41	4,340.10
	VAIL'S MOBILE HOME PARK								0.67	0.58	0.58
BEXAR TOTAL:		110,166.56(1)	239,855.01	226,554.81	256,081.26	234,441.31	239,790.77	230,797.44	254,641.26	255,442.83	230,447.68

TABLE 2.1-3 (Continued)

COUNTY	PUMPER NAME	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
COMAL	CITY OF GARDEN RIDGE								487.44	468.11	397.25
	CITY OF MARION	5.89	149.14	128.90	140.40	163.25	181.32	191.49	187.20	183.08	150.71
	CITY OF NEW BRAUNFELS	7,956.49	7,522.25	7,859.38	8,936.95	9,053.70	9,917.70	8,846.99	8,114.67	8,544.48	7,783.00
	GREEN VALLEY WTR. SUPPLY CORP.	1,046.18	1,087.31	1,193.49	1,343.25	1,113.39	1,307.96	1,470.30	1,494.86	1,532.30	1,363.02
	NORTHWOODS WATER SYSTEM	5.02	8.02	8.14	19.09	22.73	21.17	22.89	29.52	32.66	24.76
	ROCKFORD PLACE MHP							11.45	11.20	13.26	8.78
	T BAR M TENNIS VILLAS	4.56	3.96	3.96	3.96	3.96	3.96	3.96	3.96	3.96	3.96
COMAL TOTAL:		9,018.14	8,770.68	9,193.87	10,443.65	10,357.03	11,432.11	10,547.08	10,328.85	10,777.85	9,731.48
HAYS	AQUARENA SPRINGS CORP.	20.00							447.01	776.34	595.16
	AZTEC VILLAGE WATER CO.					13.50	12.97	21.79	26.56	20.04	22.19
	CITY OF KYLE(2)	448.92	531.29	536.31	573.01	582.15	542.72	474.77	469.48	499.19	512.85
	CITY OF SAN MARCOS	5,245.19	5,661.70	5,555.93	6,238.17	6,120.62	6,082.99	6,562.16	6,761.41	6,373.60	5,464.26
	COUNTY LINE WATER SUPPLY CORP.						26.83	76.11	88.91	80.20	75.99
	CRYSTAL CLEAR WTR. SUPPLY CORP (3)	418.08	770.29	791.49	790.09	815.19	983.06	1,042.64	1,123.46	1,228.87	1,041.64
	DIAMOND PURE WATER CO.							4.00	4.40	6.55	9.85
	ELIM WATER CO. INC.	135.06	146.07	132.73	166.92	168.72	189.01	239.58	252.74	259.89	229.60
	ELIM WATER COMPANY INC.	57.85	58.99	64.48	95.03	97.72	88.48	81.88	71.55	80.79	81.12
	K & H WATER SYSTEM						2.35E	1.55	1.48E	1.66E	1.69E
	K & L WATER SUPPLY					17.97	16.18E	25.15	23.89E	24.37E	132.11
	KALLACO WATER SYSTEM						5.59	6.48	6.05	8.14	6.94

COUNTY	PUMPER NAME	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	MAXWELL WATER SUPPLY CORP.	160.78	192.25	207.99	272.34	287.58	366.23	369.67	390.69	411.95	407.30
	MEADOW WOODS WATER CO.(2)					18.48	29.63	44.91	45.83	48.64	49.08
	OAK MEADOWS									8.81	8.39
	SAN MARCOS BAPTIST ACADEMY		21.67	37.14	52.96	35.47	49.41	59.80	40.33	45.26	37.28
	SCHULLE MHP						1.55	1.84	2.19	3.31	4.44
	SOUTHWEST TEX. STATE UNIV.	1,146.33	1,131.20	994.69	970.24	831.19	797.32	726.49	694.89	707.23	943.23
	SUNNY ACRES MOBILE PARK	5.26	7.80	6.61	7.75	6.41	7.95	6.17	5.74	5.44	4.55
HAYS TOTAL:		7,656.08	8,548.98	8,359.68	9,227.71	9,059.67	9,278.94	9,825.11	10,543.62	10,673.60	9,701.36
MEDINA	CITY OF CASTROVILLE	692.25	617.43	600.83	943.93	595.17	579.61	554.75	899.14	962.54	783.52
	CITY OF DEVINE(4)	695.31	787.87	771.11	823.28	790.61	819.98	673.28	797.07	915.66	639.47
	CITY OF HONDO	1,595.55	1,894.46	1,709.09	2,091.43	1,753.25	1,796.08	1,656.17	1,920.20	2,133.57	1,770.86
	CITY OF LA COSTE	179.33	189.58	191.62	243.44	230.99	204.56	154.61	185.31	259.12	230.71
	CITY OF NATALIA	111.74	104.61E	118.05E	215.66	248.72	274.32	232.03	221.44	311.58	294.19
	CREEKWOOD WATER SUPPLY							12.02	19.66	20.02	15.80
	D'HANIS WATER SYSTEM	121.88	145.26	146.35	181.43	168.10	135.06	124.34	134.18	152.32	104.58
	EAST MEDINA COUNTY W.S.C.	380.19	380.09	316.45	478.48	393.52	600.57	495.67	577.86	596.17	529.47
	HIGHWAY 90 RANCH WATER CO.	29.53	21.99	37.81	45.38	36.71	35.45E	37.01E	34.22	62.30	47.99
	MEDINA RIVER WEST WS						53.69	130.72	84.85	106.35	45.52
	MEDINA VALLEY HIGH SCHOOL						77.95	19.95	10.73	27.39	28.52
	MEDINA VALLEY MOBILE HOME PARK	7.90	13.07	15.15	18.65	11.52	21.63	21.83	4.20	8.64	15.76E

COUNTY	PUMPER NAME	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	NEW ALSACE WATER CO.				3.44E	3.79E	11.78E	11.78E	15.47E	15.78E	18.94
	RIO MEDINA WATER CORP.								11.91	12.72	11.02
	RIO MEDINA WATER CORP.			29.03	60.65	63.16	24.59	20.93	33.00	39.00	30.27
	WEST MEDINA WSC						78.25	74.21	96.66	109.27	91.31
	YANCEY WATER SUPPLY CORP.	98.07	92.16	55.54	324.91E	406.42E	438.93E	426.27E	469.74E	493.23E	601.50E
	ZINSMEYER TRAILER PARK						2.72	3.22E	2.23E	2.27E	2.32E
MEDINA TOTAL:		3,911.75	4,246.52	3,991.03	5,430.68	4,701.96	5,155.17	4,648.79	5,517.87	6,227.93	5,261.75
UVALDE	CITY OF SABINAL	397.96	484.79	442.35	510.54	460.77	274.30	332.10	507.06	540.66	418.03
	CITY OF UVALDE	4,138.20	4,512.74	4,131.88	5,024.66	4,220.69	4,153.67	3,790.59	4,714.65	5,029.63	4,115.02
	K & D MOBILE HOME VILLAGE									3.31E	2.82E
	SLEEPY OAKS WATER SYSTEM				1.17	3.66	3.47	3.25	3.42	15.04	13.78
	SOUTHWEST TEXAS JR. COLLEGE	66.50	25.65	38.85E	39.85E	75.95	62.07	61.57	77.81	62.30	
	TOWN OF KNIPPA	251.32	298.45E	80.42	122.31	130.48	130.32	112.03	93.08	107.47	81.69
	UVALDE WATER SUPPLY INC.	71.34E	79.59E	75.61E	87.28	89.27E	72.94	99.72E	104.70E	109.94E	93.45E
UVALDE TOTAL:		4,925.32	5,401.22	4,769.11	5,785.81	4,980.82	4,696.77	4,399.26	5,500.72	5,868.35	4,724.79
TOTAL FOR EDWARDS AQUIFER:		136,059.99(1)	267,226.94	253,279.90	287,487.08	264,051.00	270,848.92	260,688.69	287,114.47	289,660.72	260,418.92

E VALUES ESTIMATED BY TWDB, USGS, OR TDWR
(1) DATA AS RECEIVED FROM TWDB
(2) PUMPAGE MAY IMPACT BARTON SPRINGS SEGMENT
(3) INCLUDES 2 CRYSTAL CLEAR WATER CORP. WELLS IN COMAL COUNTY
(4) INCLUDES WATER PUMPED FROM CARRIZO AQUIFER

LIMITATIONS ON USE OF THIS DATA
1. This data is estimated pumpage
2. All municipal uses may not be included
3. Generally, this table indicates well location; county of use may differ

TABLE 2.1-4
TECHNICAL DATA REVIEW PANEL
DATA FROM SURVEYS OF IRRIGATION IN TEXAS
1958, 1964, 1969, 1974, 1979, 1984 and 1989 (Report #329)

SOURCE: TEXAS WATER DEVELOPMENT BOARD

(DATA PRESENTED FOR 1984 AND 1989 ONLY;
1958, 1964, 1969, 1974, and 1979 AVAILABLE.)

		All Irrigation (On-Farm Use)		Surface Water Supplied (On-Farm Use)		Ground Water Supplied (On-Farm Use)		Irrigation Using Combined Supplied (On-Farm Use)		Surface Source	Irrigation Wells	Sprinkler System
County	Year	Acres	Acre Feet	Acres	Acre Feet	Acres	Acre Feet	Acres	Acre Feet	Percent	Number	Acres
Aransas	1984	0	0	0	0	0	0	0	0	0	0	0
	1989	0	0	0	0	0	0	0	0	0	0	0
Atascosa	1984	31,988	35,039	0	0	31,988	35,039	0	0	0	0	0
	1989	36,770	50,914	0	0	36,770	50,914	0	0	0	400	36,120
Bandera	1984	213	168	152	107	61	61	0	0	0	12	150
	1989	298	255	136	122	162	133	0	0	0	12	222
Bee	1984	3,930	1,373	25	38	3,905	1,335	0	0	0	54	40
	1989	3,063	2,261	150	29	2,913	2,232	0	0	0	57	1,363
Caldwell	1984	646	694	373	269	135	149	138	276	80	9	501
	1989	1,321	1,198	846	909	119	111	356	178	80	7	1,267
Calhoun	1984	9,161	28,143	8,048	24,897	1,113	3,246	0	0	0	20	0
	1989	6,371	29,311	5,150	25,750	1,221	3,561	0	0	0	8	0
De Witt	1984	445	148	60	20	385	128	0	0	0	33	250
	1989	665	287	50	12	615	275	0	0	0	37	270
Dimmit	1984	11,169	18,873	1,250	617	6,696	12,472	3,223	5,785	10	104	1,038
	1989	7,215	12,404	805	1,128	3,314	5,943	3,096	5,333	73	100	1,017
Duval	1984	2,755	2,517	0	0	2,755	2,517	0	0	0	51	2,755
	1989	3,455	2,238	0	0	3,455	2,233	0	0	0	51	3,455
Frio	1984	60,285	90,007	340	453	58,970	88,051	975	1,503	18	305	53,165
	1989	56,090	96,915	340	430	55,550	96,252	200	233	50	310	49,840

TABLE 2.1-4 (Continued)

County	Year	All Irrigation (On-Farm Use)		Surface Water Supplied (On-Farm Use)		Ground Water Supplied (On-Farm Use)		Irrigation Using Combined Supplied (On-Farm Use)		Surface Source	Irrigation Wells	Sprinkler System
		Acres	Acre Feet	Acres	Acre Feet	Acres	Acre Feet	Acres	Acre Feet	Percent	Number	Acres
Goliad	1984	992	327	912	304	80	23	0	0	0	3	430
	1989	799	546	533	382	266	164	0	0	0	12	728
Gonzalez	1984	2,395	1,636	860	498	1,405	1,008	130	130	38	45	2,265
	1989	3,312	2,225	1,400	868	1,792	1,297	120	60	35	46	3,130
Guadalupe	1984	5,728	7,443	2,520	3,487	3,208	3,956	0	0	0	35	5,080
	1989	2,488	2,397	1,052	1,038	1,436	1,359	0	0	0	38	2,136
Jim Wells	1984	5,505	2,648	0	0	5,505	2,648	0	0	0	42	3,865
	1989	1,895	895	0	0	1,895	895	0	0		53	1,875
Karnes	1984	1,109	1,775	157	107	952	1,668	0	0	0	11	1,104
	1989	1,183	619	798	337	385	282	0	0	0	11	1,178
Kleberg	1984	600	373	60	40	460	280	80	53	60	5	300
	1989	906	407	174	29	732	378	0	0	0	6	626
La Salle	1984	6,510	10,893	700	1,275	4,970	8,362	840	1,257	30	40	6,510
	1989	6,270	6,401	520	347	5,550	5,798	200	256	1	30	6,270
Live Oak	1984	1,230	1,533	260	433	970	1,100	0	0	0	8	1,230
	1989	1,911	1,859	470	1,018	1,441	841	0	0	0	21	1,897
Mc Mullen	1984	0	0	0	0	0	0	0	0	0	0	0
	1989	0	0	0	0	0	0	0	0	0	0	0
Maverick	1984	40,194	85,869	39,300	84,162	894	1,407	0	0	0	14	640
	1989	50,800	103,616	50,500	103,016	300	600	0	0	0	15	0
Nueces	1984	3,400	2,500	1,300	542	2,100	1,958	0	0	0	14	0
	1989	3,040	1,356	1,960	816	1,080	540	0	0	0	6	0
Refugio	1984	50	17	0	0	50	17	0	0	0	2	0
	1989	0	0	0	0	0	0	0	0	0	2	0
San Patricio	1984	6,428	3,555	40	13	6,388	3,542	0	0	0	100	54
	1989	3,277	1,233	0	0	3,277	1,233	0	0	0	73	50
Victoria	1984	6,293	20,334	160	133	6,133	20,201	0	0	0	65	160
	1989	4,894	18,377	160	133	4,734	18,244	0	0	0	65	200

TABLE 2.1-4 (Continued)

County	Year	All Irrigation (On-Farm Use) Acres	All Irrigation (On-Farm Use) Acre Feet	Surface Water Supplied (On-Farm Use) Acres	Surface Water Supplied (On-Farm Use) Acre Feet	Ground Water Supplied (On-Farm Use) Acres	Ground Water Supplied (On-Farm Use) Acre Feet	Irrigation Using Combined Supplied (On-Farm Use) Acres	Irrigation Using Combined Supplied (On-Farm Use) Acre Feet	Surface Source Percent	Irrigation Wells Number	Sprinkler System Acres
Webb	1984	5,400	5,400	5,400	5,400	0	0	0	0	0	0	783
	1989	5,177	5,862	5,027	5,694	150	168	0	0	0	3	1,489
Wilson	1984	12,051	8,395	1,707	1,146	10,164	7,116	180	133	28	240	11,863
	1989	13,380	10,845	2,255	1,685	10,995	9,068	130	92	24	250	12,967
Zavala	1984	57,776	95,144	1,185	658	49,091	81,777	7,500	12,708	30	550	6,780
	1989	48,390	95,351	4,885	2,442	39,705	89,317	3,800	3,592	15	555	6,730
SUBTOTAL:	1984	276,253	424,804	64,809	124,599	198,378	278,061	13,066	21,845	294	1,762	98,963
	1989	262,970	447,792	76,731	146,185	177,860	291,838	7,902	9,744	278	2,168	132,830
Bexar	1984	20,104	38,815	9,565	15,266	10,499	23,449	40	100	60	133	5,478
	1989	17,345	36,038	6,213	11,517	10,682	23,404	450	1,117	60	120	4,012
Comal	1984	523	649	115	147	408	501	0	0	0	13	397
	1989	390	490	36	9	354	481	0	0	0	13	338
Hays	1984	1,025	876	864	726	161	150	0	0	0	4	251
	1989	267	301	267	301	0	0	0	0	0	0	0
Kinney	1984	4,706	10,335	671	1,212	4,035	9,123	0	0	0	28	1,555
	1989	5,099	12,349	738	1,851	4,361	10,498	0	0	0	28	1,555
Medina	1984	46,868	126,194	13,840	37,762	30,804	81,390	2,224	7,043	50	185	10,648
	1989	53,825	160,439	18,090	43,828	33,511	109,568	2,224	7,043	50	190	10,864
Uvalde	1984	51,370	151,774	1,750	2,005	48,420	146,560	1,200	3,208	10	319	15,348
	1989	49,032	151,878	250	500	48,782	151,378	0	0	0	329	15,048
SUBTOTAL:	1984	257,426	328,643	24,805	57,118	94,327	261,173	3,464	10,351	120	682	33,677
	1989	125,958	361,495	25,594	58,006	97,690	295,329	2,674	8,160	110	680	31,817
REGIONAL TOTAL:	1984	533,679	753,447	89,614	181,717	292,705	539,234	16,530	32,196	414	2,444	132,640
	1989	388,928	809,287	102,325	204,191	275,550	587,167	10,576	17,904	388	2,848	164,647

LIMITATIONS ON THE USE OF THIS DATA

1. This data is estimated, most irrigation use is not metered

TABLE 2.1-5
TECHNICAL DATA REVIEW PANEL
TEXAS WATER DEVELOPMENT BOARD IRRIGATION INVENTORY
IRRIGATION IN TEXAS - 1958, 1964, 1969, 1974, 1979, 1984, 1989

SOURCE: TEXAS WATER DEVELOPMENT BOARD

COUNTY	SURFACE WATER SOURCE 1984 ACRES	INCHES APPLIED	ACRE FEET	SURFACE WATER SOURCE 1989 ACRES	INCHES APPLIED	ACRE FEET	GROUND WATER SOURCE 1984 ACRES	INCHES APPLIED	ACRE FEET	GROUND WATER SOURCE 1989 ACRES	INCHES APPLIED	ACRE FEET	BOTH SW & GW 1984 ACRES	INCHES APPLIED	ACRE FEET	BOTH SW & GW 1989 ACRES	INCHES APPLIED	ACRE FEET
BEXAR																		
ALL OTHER CROPS							516	50	2150	649	46	2488						
CORN	2715	30	6788	1980	30	4950	5397	30	13493	3950	30	9875						
COTTON										80	14	93						
FORAGE CROPS & ENSILLAGE	752	10	627	280	16	373	214	10	178	380	16	507				400	30	1000
GRAIN SORGHUM	131	20	218	120	24	240				296	20	493						
OTHER GRAIN	860	10	717															
OTHER PERMNT HAY, PASTURE	4307	15	5384	3543	18	5315	2696	15	3370	3820	18	5730						
PEANUTS							676	30	1690	589	30	1472	40	30	100	50	28	117
SOYBEANS										20	16	27						
VEGETABLES (DEEP)	480	25	1000	180	28	420	804(1)	25	1675	788(3)	28	1839						
VEGETABLES (SHALLOW)	320	20	533	110	24	220	536(2)	20	893	440(4)	24	880						
BEXAR TOTALS:																		
TOT CROP ACRES IRRIGATED	9565			6213			10839			11012			40			450		
ACRES IRRIGATED-CO MAP	9565			6213			10499			10682			40			450		
TOTAL ACRE FEET			15267			11518			23449			23404			100			1117
COMAL																		
ALFALFA										8	10	7						
ALL OTHER CROPS							11	16	15	7	4	2						
CORN							60	13	65	45	14	53						
FORAGE CROPS & ENSILLAGE	37	14	43				136	14	159	17	10	14						
OTHER GRAIN							80	5	33	55	4	18						
OTHER PERMNT HAY, PASTURE	78	16	104	36	3	9	176	15	220	222	21	389						
PECANS							10	2	2									
WHEAT							16	6	8									
COMAL TOTALS:																		
TOT CROP ACRES IRRIGATED	115			36			489			354								
ACRES IRRIGATED-CO MAP	115			36			409			354								
TOTAL ACRE FEET			147			9			502			483						

COUNTY	SURFACE WATER SOURCE 1984 ACRES	SURFACE WATER SOURCE 1984 INCHES APPLIED	SURFACE WATER SOURCE 1984 ACRE FEET	SURFACE WATER SOURCE 1989 ACRES	SURFACE WATER SOURCE 1989 INCHES APPLIED	SURFACE WATER SOURCE 1989 ACRE FEET	GROUND WATER SOURCE 1984 ACRES	GROUND WATER SOURCE 1984 INCHES APPLIED	GROUND WATER SOURCE 1984 ACRE FEET	GROUND WATER SOURCE 1989 ACRES	GROUND WATER SOURCE 1989 INCHES APPLIED	GROUND WATER SOURCE 1989 ACRE FEET	BOTH SW & GW 1984 ACRES	BOTH SW & GW 1984 INCHES APPLIED	BOTH SW & GW 1984 ACRE FEET	BOTH SW & GW 1989 ACRES	BOTH SW & GW 1989 INCHES APPLIED	BOTH SW & GW 1989 ACRE FEET
HAYS																		
ALL OTHER CROPS	75	30	188	75	22	138												
FORAGE CROPS & ENSILLAGE	430	5	200				45	4	15									
OTHER ORCHARD				16	12	16												
OTHER PERMNT HAY, PASTURE	359	12	359	176	10	147	116	14	135									
HAYS TOTALS:																		
TOT CROP ACRES IRRIGATED	864			267			161											
ACRES IRRIGATED-CO MAP	864			267			161											
TOTAL ACRE FEET			747			301			150									
KINNEY																		
CORN							1666	30	4165	300	32	800						
COTTON										1000	26	2167						
FORAGE CROPS & ENSILLAGE	431	24	862				2004	24	4008	2725	28	6358						
GRAIN SORGHUM							100	24	200	60	28	140						
OTHER GRAIN				360	30	900	80	18	120	80	20	133						
OTHER PERMNT HAY, PASTURE				366	30	915	127	24	254	200	24	400						
PECANS				12	36	36	12	36	36									
VEGETABLES (DEEP)	90	20	150															
VEGETABLES (SHALLOW)	150	16	200				30	16	40	300	20	500						
WHEAT							200	18	300									
KINNEY TOTALS:																		
TOT CROP ACRES IRRIGATED	671			738			4219			4665								
ACRES IRRIGATED-CO MAP	671			738			4035			4361								
TOTAL ACRE FEET			1212			1851			9123			10498						
MEDINA																		
ALFALFA							20	30	50	250	31	646						
ALL OTHER CROPS	100	40	333	250	41	854	30	40	100	80	40	267						
CORN	3000	42	10500	4000	43	14333	10353	38	32785	18419	39	59862	2224	38	7043	2224	38	7043
COTTON	100	30	250	100	30	250	1343	28	3134	4209	28	9821						
FORAGE CROPS & ENSILLAGE	2500	26	5417	3500	28	8167	4000	30	10000	4000	80	26667						
GRAIN SORGHUM	1500	26	3250	1850	28	4317	7500	22	13750	927	22	1699						
OTHER GRAIN	100	17	142	400	19	633	300	18	450	315	18	473						
OTHER ORCHARD										12	12	12						
OTHER PERMNT HAY, PASTURE	4700	34	13317	5000	20	8333	4500	30	11250	295	20	492						
PEANUTS							2080	14	2427	1105	14	1289						
PECANS	1000	34	2833	1300	34	3683	850	34	2408	950	34	2692						
SOYBEANS	400	26	867	700	27	1575	1300	24	2600	1400	25	2917						
VEGETABLES (DEEP)	200	18	300	400	18	600	300	20	500	300	20	500						
VEGETABLES (SHALLOW)	180	18	270	300	18	450	260	20	433	260	20	433						
VINEYARD							2	20	3				20						

COUNTY	SURFACE WATER SOURCE 1984 ACRES	SW 1984 INCHES APPLIED	SW 1984 ACRE FEET	SW 1989 ACRES	SW 1989 INCHES APPLIED	SW 1989 ACRE FEET	GROUND WATER SOURCE 1984 ACRES	GW 1984 INCHES APPLIED	GW 1984 ACRE FEET	GW 1989 ACRES	GW 1989 INCHES APPLIED	GW 1989 ACRE FEET	BOTH SW & GW 1984 ACRES	BOTH 1984 INCHES APPLIED	BOTH 1984 ACRE FEET	BOTH 1989 ACRES	BOTH 1989 INCHES APPLIED	BOTH 1989 ACRE FEET
WHEAT	200	17	283	400	19	633	1000	18	1500	1199	18	1799						
MEDINA TOTALS:																		
TOT CROP ACRES IRRIGATED	13980			18200			38384			33721			2224			2224		
ACRES IRRIGATED-CO MAP				18090			30804			333	81			2224		22	24	
TOTAL ACRE FEET			37762			43828			81390			107770			7043			7043
UVALDE																		
ALFALFA							50	20	83	150	30	375						
ALL OTHER CROPS							25	18	38	600	18	900						
CORN							22705	35	66223	21450	30	53625	500	35	1458			
COTTON	660	6	330				13273	30	33183	20356	30	50890	700	30	1750			
FORAGE CROPS & ENSILLAGE	200	6	100				3000	18	4500	3100	20	5167						
GRAIN SORGHUM							3200	24	6400	1529	24	3058						
OTHER GRAIN							500	16	667	7283	20	12138						
OTHER OIL CROPS							184	18	276									
OTHER ORCHARD							20	16	27	12	12	12						
OTHER PERMNT HAY, PASTURE	410	18	615				2500	18	3750	300	18	450						
PECANS	480	24	960	250	24	500	550	24	92	550	24	1100						
SOYBEANS							231	25	481	154	25	321						
VEGETABLES (DEEP)							1000	24	2000	1000	24	2000						
VEGETABLES (SHALLOW)							8000	24	16000	6000	24	12000						
VINEYARD							100	20	167									
WHEAT							7000	20	11667	5512	30	13780						
UVALDE TOTALS:																		
TOT CROP ACRES IRRIGATED	1750			250			62338			68084			1200					
ACRES IRRIGATED-CO MAP	1750			250			48420			48782			1200					
TOTAL ACRE FEET			2005			500			145554			155816			3208			
EDWARDS AQUIFER TOTALS:																		
TOT CROP ACRES IRRIGATED:	26945			25704			111884			117836			3464			2674		
ACRES IRRIGATED/CO MAP:	12965			25594			94328			97560			3464			2674		
TOTAL ACRE FEET:			57140			58007			260168			297971			10351			8160

(1) 204 ACRES DOUBLE CROPPED
(2) 136 ACRES DOUBLE CROPPED
(3) 180 ACRES DOUBLE CROPPED
(4) 120 ACRES DOUBLE CROPPED

LIMITATIONS ON USE OF THIS DATA

1. Acres are estimated, crop water application rates are estimated
2. Irrigation use is not generally metered

TABLE 2.1-6
TECHNICAL DATA REVIEW PANEL
HISTORICAL GROUNDWATER PUMPAGE FROM EDWARDS AQUIFER

SOURCE: TEXAS WATER DEVELOPMENT BOARD
ALL VALUES ARE REPORTED IN ACRE-FEET UNITS

COUNTY		1985	1986	1987	1988	1989
BEXAR						
MUNICIPAL		236,467.06	241,335.45	232,950.73	256,926.21	257,049.65
MANUFACTURING		3,610.11	4,416.89	2,832.63	2,958.46	2,863.84
POWER		1,244.05	1,219.43	1,113.71	740.96	738.51
MINING		2,357.00	1,557.99	1,187.00	1,304.00	1,172.00
IRRIGATION		15,949.00	15,613.00	12,172.00	14,659.00	22,753.00
LIVESTOCK		50.00	53.00	44.00	46.00	46.00
BEXAR	TOTAL:	259,677.22	264,195.69	250,300.19	276,634.95	284,622.59
COMAL						
MUNICIPAL		10,683.43	11,717.84	11,440.13	10,586.33	10,908.78
MANUFACTURING		1,055.34	980.51	1,013.33	898.70	1,085.05
POWER		0.00	0.00	0.00	0.00	0.00
MINING		960.64	945.69	5,830.74	945.69	945.69
IRRIGATION		0.00	385.00	385.00	385.00	481.00
LIVESTOCK		1.00	1.00	1.00	1.00	1.00
COMAL	TOTAL:	12,700.41	14,030.04	18,670.25	12,816.88	13,421.67
HAYS						
MUNICIPAL		10,335.83	10,953.11	11,775.00	12,362.79	12,465.22
MANUFACTURING		1,234.60	1,080.38	998.28	1,481.93	703.61
POWER		0.00	0.00	0.00	0.00	0.00
MINING		18.00	814.92	0.00	795.46	0.00
IRRIGATION		0.00	0.00	0.00	0.00	0.00
LIVESTOCK		834.00	675.00	1,047.00	768.00	675.00
HAYS	TOTAL:	12,422.01	13,523.11	13,819.86	15,408.94	13,844.68
MEDINA						
MUNICIPAL		3,723.09	4,101.30	4,462.19	5,296.43	6,287.93
MANUFACTURING		0.00	0.00	0.00	0.00	0.00
POWER		0.00	0.00	0.00	0.00	0.00
MINING		90.00	0.00	79.69	83.08	77.29
IRRIGATION		56,905.00	94,180.00	81,049.00	93,354.00	112,214.00
LIVESTOCK		64.00	63.00	76.00	92.00	41.00
MEDINA	TOTAL:	60,782.09	98,344.73	85,666.58	98,825.76	118,649.95
UVALDE						
MUNICIPAL		5,145.82	4,819.91	4,527.80	5,617.65	5,996.14
MANUFACTURING		306.12	328.37	334.51	334.51	362.13
POWER		0.00	0.00	0.00	0.00	0.00
MINING		300.00	333.51	104.00	381.88	399.00
IRRIGATION		149,459.00	119,828.00	98,925.00	131,566.00	151,378.00
LIVESTOCK		1,832.00	2,153.00	1,735.00	1,411.00	1,525.00
UVALDE	TOTAL:	157,043.32	127,462.49	105,625.91	139,310.77	159,659.87
REGIONAL TOTALS:						
MUNICIPAL		266,355.23	272,927.61	265,155.85	290,789.41	292,707.70
MANUFACTURING		6,206.17	6,806.15	5,178.75	5,673.60	5,014.60
POWER		1,244.05	1,219.43	1,113.71	740.96	738.50
MINING		3,725.64	3,652.11	7,201.43	7,201.43	738.50
IRRIGATION		222,313.00	230,006.00	192,531.00	239,964.00	286,826.00
LIVESTOCK		2,781.00	2,945.00	2,903.00	2,318.00	2,288.00
GRAND TOTAL		502,625.05	517,556.06	474,082.79	542,997.30	590,198.70

LIMITATIONS ON USE OF THIS DATA
1. This data is estimated pumpage
2. Estimation methods vary in accuracy

TABLE 2.1-7
TECHNICAL DATA REVIEW PANEL
ANNUAL PUMPAGE FROM THE EDWARDS AQUIFER AS
REPORTED BY UNITED STATES GEOLOGICAL SURVEY

SOURCE: EDWARDS UNDERGROUND WATER DISTRICT
BULLETINS 41-50 AND USGS FILES
ALL VALUES REPORTED IN ACRE-FEET

COUNTY	USE	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
BEXAR	Municipal and Military	203,500	238,700	219,600	252,000	232,100	233,300	227,500	250,800	248,000	224,600
	Irrigation	9,200	12,800	13,200	16,400	16,400	7,600	2,900	8,500	4,400	11,200
	Industrial	10,800	10,900	10,200	10,500	11,300	10,900	8,000	7,500	8,200	8,700
	Flowing wells (1)		6,700	6,000	2,300	8,300	7,300	11,600	9,100	4,900	4,500
	Domestic, Livestock(2)	35,500(3)	27,300	27,300	28,300	26,000	27,900				
	and Miscellaneous (2)										
	Parks and Zoo (4)							3,300	4,600	5,100	5,100
	Private Schools							100	200	300	300
	Country Clubs							600	400	500	500
	Cemeteries							100	300	200	400
	Domestic and Stock							21,500	21,500	21,500	21,500
	Total All Uses	259,000	288,400	276,300	309,500	294,100	287,000	275,600	302,900	293,100	276,800
COMAL	Municipal and Military	11,000	11,200	11,500	13,400	11,200	13,600	13,300	12,800	13,600	10,000
	Irrigation	200	200	200	400	200	300	200	200	200	200
	Industrial	1,900	2,900	3,200	3,200	3,400	3,400	9,400	9,100	13,300	13,800
	Domestic, Livestock	700	700	700	700	700	700	700	700	700	700
	Total All Uses	13,800	15,000	15,600	17,700	15,100	18,000	23,600	22,800	27,800	24,700
HAYS	Municipal and Military	8,100	8,800	9,000	10,200	10,000	9,900	10,800	11,100	10,800	9,900
	Irrigation	700	700	700	900	200	200	100	100	100	100
	Industrial	0	1,200	1,200	1,000	1,200	2,000	1,000	1,500	700	200
	Domestic, Livestock	600	600	600	800	1,500	1,300	900	900	1,000	1,000
	Fish Hatchery	1,300	900	700	500	0	700	1,000	800	500	300
	Total All Uses	10,700	12,100	12,200	13,400	12,900	14,100	13,800	14,400	13,100	11,500
KINNEY	Municipal and Military	0	0	0	0	0	0	0	0	0	0
	Irrigation	0	0	0	0	0	200	1,700	1,100	1,100	600

COUNTY	USE	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	Industrial	0	0	0	0	0	0	0	0	0	0
	Domestic, Livestock	200	200	200	200	200	200	200	200	200	200
	Total All Uses	200	200	200	200	200	400	1,900	1,300	1,300	800
MEDINA	Municipal and Military	4,300	4,600	4,300	5,800	5,400	4,800	4,900	6,100	7,100	5,800
	Irrigation	21,000	28,100	24,800	40,400	53,000	36,400	10,200	75,300	62,700	63,300
	Industrial	0	0	0	0	0	0	0	0	0	0
	Domestic, Livestock	800	700	700	700	800	700	700	700	700	700
	Total All Uses	26,100	33,400	29,800	46,900	59,200	41,900	15,800	82,100	70,500	69,800
UVALDE	Municipal and Military	4,900	5,400	4,800	5,700	4,900	4,700	4,400	5,400	5,700	4,600
	Irrigation	70,700	88,300	77,100	133,100	133,200	59,400	25,800	107,900	127,700	97,600
	Industrial	0	0	200	400	600	700	300	700	700	900
	Domestic Livestock and Fish Hatchery	1,800	2,500	2,600	2,700	1,800	3,200	2,800	2,500	2,600	2,700
	Total All Uses	77,400	96,200	84,700	141,900	140,500	68,000	33,300	116,500	136,700	105,800
ALL COUNTIES	Municipal and Military	231,800	268,700	249,200	287,100	263,600	266,300	260,900	286,200	285,200	254,900
	Irrigation	101,800	130,100	116,000	191,200	203,000	104,100	40,900	193,100	196,200	173,000
	Industrial	12,700	15,000	14,800	15,100	16,500	17,000	18,700	18,800	22,900	23,600
	Flowing wells	0	6,700	6,000	2,300	8,300	7,300	11,600	9,100	4,900	4,500
	Domestic Livestock and Miscellaneous (1)	39,900	32,900	32,500	33,900	30,900	34,700	31,800	32,800	33,300	33,400
	AQUIFER TOTAL	386,200	453,400	418,500	529,600	522,300	429,400	364,400	540,000	542,500	489,400

(1) Includes uncontrolled flowing wells not reported to Texas Water Development Board.
(2) Includes private schools, country clubs, parks and cemeteries; detail not available before 1987.
(3) Includes flowing wells for 1981.
(4) Reported amount does not include River Center Mall well or Iron Bridge (Joskes Pavillion/Lambert Beach) well discharging to San Antonio River. Estimated unreported amount equals 2000 acre-feet per year for these two wells.

LIMITATIONS ON USE OF THIS DATA

1. This data is estimated, estimation methods vary year to year and among use types.
2. Some uses are not included, industrial users are not required to report use.

TABLE 2.1-8
TECHNICAL DATA REVIEW PANEL
UNITED STATES GEOLOGICAL SURVEY IRRIGATION DEMAND CALCULATIONS
FOR EDWARDS AQUIFER
1986 - 1991

SOURCE: USGS FILES

COUNTY	1986			1987			1988			1989			1990			1991		
	ACRES	INCHES APPLIED	ACRE FEET	ACRES	INCHES APPLIED	ACRE FEET	ACRES	INCHES APPLIED	ACRE FEET	ACRES	INCHES APPLIED	ACRE FEET	ACRES	INCHES APPLIED	ACRE FEET	ACRES	INCHES APPLIED	ACRE FEET
BEXAR																		
ALFALFA																100 E	20.00 E	17
CORN	4,800	15.05 A	6,020	2,880	4.30 A	1,032	2,800	12.31 A	2,872	1,000	28.31 A	2,359	3,850	20.00 E	6,417	5,761	15.50 E	7,441
COTTON	100	11.00 E	92	200	14.00 E	233	200	11.00 E	183	669	20.00 E	1,115	400	20.00 E	667	526	7.00 E	307
GRASS FARM							200	10.00 E	167				200	12.00 E	200	200 E	12.00 E	200
MILO							200	10.00 E	167				156	9.00 E	117	476	10.00 E	397
NURSERY STOCK							300	9.00 E	225				300	10.00 E	250	300 E	10.00 E	250
PEANUTS	600	12.00 E	600	600	12.00 E	600	1,100	19.00 A	1,742				1,100	19.63 E	1,799	1,100	16.60 E	1,521
VEGETABLES	500	22.00 E	917	500	25.00 E	1,042	500	25.00 E	1,042				680	30.00 E	1,700	700 E	20.00 E	12
WHEAT/OATS																15	9.00 E	11
BEXAR TOTAL:	6,000		7,629	4,180		2,907	5,300		6,398	1,669		3,474	6,686		11,150	9,178		10,156
COMAL																		
ALL CROPS															220			
COMAL TOTAL:															220			
HAYS																		
ALL CROPS															110			
HAYS TOTAL:															110			
KINNEY																		
HAY	100	25.00 E	208	100	20.00 E	167			1,113						556			
KINNEY TOTAL:	100		208	100		167			1,113						556			
MEDINA																		
ALFALFA										217	35.00 E	634				100 E	9.10 E	76
CORN	18,000	19.22 A	28,830	4,633	5.38 A	2,077	25,400	32.00 E	67,733	9,046	38.91 A	29,331	24,977	23.54 A	48,997	14,513	8.42 A	10,183
COTTON	1,800	13.00 E	1,950	1,900	14.72 A	2,331	2,000	22.74 A	3,790	12,067	31.10 A	31,274	4,783	24.37 A	9,713	4,335	12.82 A	4,631

TABLE 2.1-8 (Continued)

COUNTY	1986			1987			1988			1989			1990			1991		
	ACRES	INCHES APPLIED	ACRE FEET	ACRES	INCHES APPLIED	ACRE FEET	ACRES	INCHES APPLIED	ACRE FEET	ACRES	INCHES APPLIED	ACRE FEET	ACRES	INCHES APPLIED	ACRE FEET	ACRES	INCHES APPLIED	ACRE FEET
HAY	2,000	20.00 E	3,333	2,000	20.00 E	3,333											0.00	163
MILO							1,369	9.00 E	1,027				1,434	9.08 A	1,085	1,508	5.47 A	687
ORCHARD													50	10.00 E	42	50 E	10.00 E	42
PASTURE 1							320	40.00 E	1,067				320	40.00 E	1,067	320	40.00 E	1,067
PASTURE 2							300	10.00 E	250				620	10.00 E	517	620	10.00 E	517
PEANUTS	1,400	12.00 E	1,400	1,400	12.00 E	1,400							150	19.63 E	245	150	16.60 E	208
SESAME										217	35.00 E	634				600 E	11.85 A	593
VEGETABLES	250	25.00 E	521	250	25.00 E	521							300	10.62 A	265	1,322	8.80 A	969
WHEAT	500	10.00 E	417				1,160	12.00 E	1,160	1,462	12.00 E	1,462						
WHEAT/OATS/RYE				700	10.00 E	583							1,958	8.00 E	1,305	417	9.00 E	313
MEDINA TOTAL:	23,950		36,451	10,883		10,245	30,549		75,027	23,010		63,335	34,592		63,236	23,935		19,449
UVALDE																		
ALFALFA							300	42.00 E	1,050	477	40.00 E	1,590	470	40.00 E	1,567	470	37.50 A	1,469
BEETS																25	5.33 A	11
BROCCOLI																50	25.33 A	106
CABBAGE																392	36.33 A	1,187
CORN	16,300	30.56 A	41,510	9,900	7.83 A	6,460	20,440	40.16 A	68,406	15,863	45.02 A	59,513	23,752	26.79 A	53,026	10,811	23.69 A	21,343
COTTON	7,900	20.50 E	13,496	6,700	20.19 A	11,273	11,900	22.65 A	22,461	18,776	31.15 A	48,740	14,300	26.50 A	31,579	4,956	26.21 A	10,825
GREEN BEANS																437	23.84 E	868
HAY	1,000	25.00 E	2,083	1,000	22.00 E	1,833										3,556	12.00 E	3,556
HAY (COASTAL)																3,556	12.00 E	3,556
MELONS*/CUCUMBER																2,511	23.14 A	4,842
MILO 1							500	8.00 E	333				1,366	17.68 A	2,013	1,828	12.00 E	1,828
MILO 2							300	12.00 E	300									
ONIONS																863	25.35 A	1,823
PASTURE													560	8.00 E	373			
POTATOES/CARROTS																352	22.66 E	665
SESAME																2,464	12.23 A	2,511
SORGHAM				1,800	8.00 E	1,200												
SOYBEANS							400	12.00 E	400				200	10.00 E	167			
SPINACH																1,291	8.00 E	861
VEGETABLES	1,000	25.00 E	2,083	1,000	25.00 E	2,083	2,000	38.78 A	6,463				1,400	22.50 A	2,625			
WHEAT	1,000	10.00 E	833				6,544	15.45 A	8,425	12,374	17.34 A	17,881	9,027	8.31 A	6,251			
WHEAT/OATS/RYE				3,500	10.00 E	2,917										2,770	11.02 A	2,544
UVALDE TOTAL:	27,200		60,005	23,900		25,766	42,384		107,838	47,490		127,724	51,075		97,601	36,332		57,995
EDWARDS AQUIFER TOTAL:	57,250		104,293	39,063		39,085	78,233		190,376	72,169		194,533	92,353		172,873	69,445		87,600

A Average field data used, see USGS Irrigation Water Application.
E Estimated by USGS.
* Watermelon and Cantaloupe.

TABLE 2.1-9
TECHNICAL DATA REVIEW PANEL
UNITED STATES GEOLOGICAL SURVEY - IRRIGATION
WATER APPLICATION CALCULATIONS BY CROP TYPES
1986 - 1991

SOURCE: USGS FILES
(ALL VALUES IN INCHES)

	CORN			COTTON			VEGETABLES			MILO			WHEAT			PEANUTS		
YEAR	UVALDE	MEDINA	BEXAR	UVALDE	MEDINA	BEXAR	UVALDE	MEDINA	BEXAR	UVALDE	MEDINA	BEXAR	UVALDE	MEDINA	BEXAR	UVALDE	MEDINA	BEXAR
1986	- Calculations of average water applications not available. --																	
1987	3.90	8.94	3.40	21.90	17.70													
	4.13	6.29	5.13	11.29	11.74													
	1.88	5.38		11.60														
	7.69	2.23		12.12														
	6.54	5.98		31.30														
	7.95	4.91		30.04														
	5.43	3.85		35.40														
	11.54	5.48		17.90														
	8.62			14.37														
	8.76			21.70														
	14.80			30.95														
	8.39			11.04														
Average	12.18			12.18														
Application																		
Rate:	7.83	5.38	4.30	20.19	14.72													
1988	73.54	36.30	21.30	46.32	25.00		38.85			4.3								17.33
	55.43	47.40	21.37	27.30	30.50		41.70											20.69
	36.46	52.60		17.70	21.67													
	61.20	36.00		24.60	21.25													
	38.70	23.40		21.70	23.37													
	11.20	17.40		11.20	19.39													
	40.40	21.30		11.40	18.00													
	31.20	21.70		21.00														
	40.10																	
	48.50																	
	22.90																	
	24.40																	
Average	38.00																	
Application																		
Rate:	40.16	32.00	21.31	22.65	22.74		38.78			4.3								19.00
1989	24.00	38.03		29.11		32.20		32.00			7.2			19.10			25.80	
	40.00	101.50		29.20	30.10		30.10						22.00					
	30.70	33.30		30.40	31.00		19.30						23.80					
	55.00	23.90		30.18			26.90						12.60					
	35.00	24.91		31.70									9.20					
	29.20	21.24		37.10														
	42.20	35.40		28.00														
	70.20	30.38		31.50														

YEAR	CORN UVALDE	CORN MEDINA	CORN BEXAR	COTTON UVALDE	COTTON MEDINA	COTTON BEXAR	VEGETABLES UVALDE	VEGETABLES MEDINA	VEGETABLES BEXAR	MILO UVALDE	MILO MEDINA	MILO BEXAR	WHEAT UVALDE	WHEAT MEDINA	WHEAT BEXAR	PEANUTS UVALDE	PEANUTS MEDINA	PEANUTS BEXAR
	78.90	39.70																
		45.01																
Average		34.62																
Application																		
Rate:	45.02	38.91		31.15	31.10		34.58			7.2			17.34				25.80	
1990	30.78	44.89		25.39	25.17		4.10	12.62		17.68	9.08		8.68					
	19.87	15.69		26.84	33.74		8.07	8.62					7.95					
	19.70	25.26		24.30	17.79		52.69											
	18.09	18.58		20.27	20.50		25.28											
	41.52	20.68		26.48	24.63													
	30.78	16.66		26.51														
		20.23		34.86														
		12.45		27.34														
		7.27																
		39.51																
		18.44																
		14.66																
		49.33																
		43.37																
		15.81																
Average		22.81																
Application																		
Rate:	26.79	23.54		26.50	24.37		22.50	10.62		17.68	9.08		8.31					
1991 (1)(2)	47.18	8.33		22.50	6.02		(1)	8.80(2)			5.47							
	37.14	9.14		24.00	13.22													
	22.67	7.07		24.00	20.44													
	28.50	8.44		24.00	19.36													
	12.00	10.93		24.00	13.97													
	12.00	11.25		46.67	23.24													
	12.00	10.37		23.79	15.80													
	18.00	5.18		20.80	6.44													
		9.78			14.20													
		9.78			12.80													
		4.00			7.78													
		10.49			6.67													
Average		4.79			5.91													
Application																		
Rate(3):	23.69	8.42		26.21	12.82			8.80			5.47							

(1) Uvalde County: Beets, 5.33; Broccoli, 25.33; Cabbage, 11.85, 60.80, Average 36.33; Carrots, 19.81, 26.14, Average 22.6; Onions, 28.40, 22.29, Average 25.35; Peppers, 30.40; Spinach, 8.0; Cantaloupe, Watermelons, Cucumbers 25.42, 24.00, 20.00, Average 23.14; Alfalfa 37.5; Sesame 16.97, 7.5, Average 12.23; Oats/Wheat/Rye 11.02.
(2) Medina County: Alfalfa 9.10; Sesame 11.85.
(3) Average computed as total of all crop water application rates divided by number of measurements

LIMITATIONS ON USE OF THIS DATA

1. Crop water application rates are estimated based on a limited sample.

TABLE 2.1-10
TECHNICAL DATA REVIEW PANEL
COMPARISON OF TWDB AND USGS
GROUND WATER PUMPING DATA FOR EDWARDS AQUIFER
MUNICIPAL AND MILITARY PUMPAGE

SOURCE: TABLES 2.1-1, 2.1-7
ALL VALUES REPORTED IN ACRE-FEET OR AS A PERCENTAGE

YEAR	COUNTY	USGS(1) TABLE 2.1-7	TWDB(2) TABLE 2.1-1	PERCENT DIFFERENCE
1981	BEXAR	203,500	110,166.56 (3)	45.86%
	COMAL	11,000	9,018.14	18.01
	HAYS	8,100	7,656.08	5.48
	MEDINA	4,300	3,911.75	9.03
	UVALDE	4,900	4,925.32	-0.51
	TOTAL	231,800	135,677.85 (3)	41.46
1982	BEXAR	238,700	239,855.01	-0.48%
	COMAL	11,200	8,770.68	21.69
	HAYS	8,800	8,548.98	2.85
	MEDINA	4,600	4,246.52	7.68
	UVALDE	5,400	5,401.22	-0.02
	TOTAL	268,700	266,822.41	0.69
1983	BEXAR	219,600	226,554.81	-3.06%
	COMAL	11,500	9,193.87	20.05
	HAYS	9,000	8,359.68	5.56
	MEDINA	4,300	3,991.03	0.02
	UVALDE	4,800	4,769.11	0.64
	TOTAL	249,200	252,868.50	-1.45
1984	BEXAR	252,000	256,081.26	1.59%
	COMAL	13,400	10,443.65	22.06
	HAYS	10,200	9,227.71	9.53
	MEDINA	5,800	5,430.68	6.36
	UVALDE	5,700	5,785.85	1.48
	TOTAL	287,100	286,969.15	0.04
1985	BEXAR	232,100	234,441.31	-1.00%
	COMAL	11,200	10,357.03	7.53
	HAYS	10,000	9,059.67	9.40
	MEDINA	5,400	4,701.96	12.93
	UVALDE	4,900	4,980.82	-1.62
	TOTAL	263,600	263,540.79	0.02
1986	BEXAR	233,300	239,790.77	-2.71%
	COMAL	13,600	11,432.11	15.94
	HAYS	9,900	9,278.94	6.27
	MEDINA	4,800	5,155.17	-6.89
	UVALDE	4,700	4,696.77	0.07
	TOTAL	266,300	270,353.76	-1.49
1987	BEXAR	227,500	230,797.44	-1.43%
	COMAL	13,300	10,547.08	20.70
	HAYS	10,800	9,825.11	9.03

YEAR	COUNTY	USGS(1) TABLE 2.1-7	TWDB(2) TABLE 2.1-1	PERCENT DIFFERENCE
	MEDINA	4,900	4,648.79	5.13
	UVALDE	4,400	4,399.26	0.02
	TOTAL	260,900	260,217.68	0.26
1988	BEXAR	250,800	254,641.26	-1.51%
	COMAL	12,800	10,328.85	19.31
	HAYS	11,100	10,543.62	5.01
	MEDINA	6,100	5,517.87	9.54
	UVALDE	5,400	5,500.72	-1.83
	TOTAL	286,200	286,532.32	-0.11
1989	BEXAR	248,000	255,442.83	-2.91%
	COMAL	13,600	10,777.85	20.75
	HAYS	10,800	10,673.60	1.17
	MEDINA	7,100	6,227.93	12.28
	UVALDE	5,700	5,868.35	-2.87
	TOTAL	285,200	288,990.56	-1.31
1990	BEXAR	224,600	230,447.68	-2.53%
	COMAL	10,000	9,731.48	2.68
	HAYS	9,900	9,701.36	2.00
	MEDINA	5,800	5,261.75	9.28
	UVALDE	4,600	4,724.79	-2.64
	TOTAL	254,900	259,867.06	-1.91

(1) USGS EXCLUDES CEMETERIES, PARKS AND COUNTRY CLUBS FROM MUNICIPAL AND REPORTS SEPARATELY UNDER MISCELLANEOUS USES.
(2) INCLUDES EDWARDS AQUIFER PUMPING DATA ONLY.
(3) DATA AS FURNISHED BY TWDB.

LIMITATIONS ON USE OF THIS DATA
1. See source tables for limitations.
2. This data is estimated pumpage.

TABLE 2.1-11
TECHNICAL DATA REVIEW PANEL
COMPARISON OF TWDB AND USGS
GROUND WATER PUMPING DATA FOR EDWARDS AQUIFER COUNTIES
INDUSTRIAL USE

SOURCE: TABLE 2.1-6 & TWDB'S EDWARDS AQUIFER COMPONENT OF TABLE 2.1-2
ALL VALUES REPORTED IN ACRE-FEET OR AS A PERCENTAGE

YEAR	COUNTY	USGS TABLE 2.1-7	TWDB (1) TABLE 2.1-1	PERCENT DIFFERENCE
1985	BEXAR	11,300	7,211.16	36.18%
	COMAL	3,000	2,015.98	32.80
	HAYS	1,200	1,252.60	-4.20
	MEDINA	0	90.00	-100.00
	UVALDE	600	606.12	-1.01
	TOTAL	16,100	11,175.86	30.58
1986	BEXAR	10,900	7,194.31	34.00%
	COMAL	3,400	1,962.20	42.29
	HAYS	2,000	1,895.30	5.24
	MEDINA	0	0.00	0.00
	UVALDE	700	661.88	5.45
	TOTAL	17,000	11,713.69	31.09
1987	BEXAR	8,000	5,133.34	35.83%
	COMAL	9,400	6,844.07	27.19
	HAYS	1,000	998.28	0.17
	MEDINA	0	79.69	-100.00
	UVALDE	300	438.51	-31.59
	TOTAL	18,700	13,493.89	27.84
1988	BEXAR	7,500	5,003.42	33.29%
	COMAL	9,100	1,844.39	79.73
	HAYS	1,500	2,277.39	-34.14
	MEDINA	0	83.08	-100.00
	UVALDE	700	716.39	-31.59
	TOTAL	18,800	9,924.67	47.20
1989	BEXAR	8,200	4,774.35	41.78%
	COMAL	13,300	2,030.74	84.73
	HAYS	700	703.61	-0.51
	MEDINA	0	77.29	-100.00
	UVALDE	700	761.13	-8.03
	TOTAL	22,900	8,347.12	63.54

(1) TWDB INDUSTRIAL USE INCLUDES MINING, MANUFACTURING AND POWER GENERATION. INCLUDES EDWARDS AQUIFER PUMPING DATA ONLY.

LIMITATIONS ON USE OF THIS DATA
1. See source tables for limitations.
2. This data is estimated pumpage.

TABLE 2.1-12
TECHNICAL DATA REVIEW PANEL
COMPARISON OF TWDB AND USGS
GROUND WATER PUMPING DATA FOR EDWARDS AQUIFER COUNTIES
IRRIGATION USE

SOURCE: TABLES 2.1-1, 2.1-7
ALL VALUES REPORTED IN ACRE-FEET OR AS A PERCENTAGE

YEAR	COUNTY	USGS TABLE 2.1-7	TWDB (1) TABLE 2.1-1	PERCENT DIFFERENCE
1985	BEXAR	16,400	15,949	2.75%
	COMAL	200	0	100.00
	HAYS	200	0	100.00
	KINNEY	0	110	-100.00
	MEDINA	53,000	56,905	-6.68
	UVALDE	133,200	149,459	-10.88
	TOTAL	203,000	222,423	-8.73
1986	BEXAR	7,600	15,613	51.32%
	COMAL	300	385	-22.08
	HAYS	200	0	100.00
	KINNEY	200	119	40.50
	MEDINA	36,400	94,180	-61.35
	UVALDE	59,400	119,828	-50.43
	TOTAL	104,100	230,125	-54.76
1987	BEXAR	2,900	12,172	-76.17%
	COMAL	200	385	-48.05
	HAYS	100	0	100.00
	KINNEY	1,700	49	97.12
	MEDINA	10,200	81,049	-87.42
	UVALDE	25,800	98,925	-73.92
	TOTAL	40,900	192,580	-63.19
1988	BEXAR	8,500	14,659	-42.02%
	COMAL	200	385	-48.05
	HAYS	100	0	100.00
	KINNEY	1,100	64	94.18
	MEDINA	75,300	93,354	-19.34
	UVALDE	107,900	131,566	-17.99
	TOTAL	193,100	240,028	-19.55
1989	BEXAR	4,400	22,753	-80.66%
	COMAL	200	481	-58.42
	HAYS	100	0	100.00
	KINNEY	1,100	257	76.64
	MEDINA	62,700	112,214	-44.12
	UVALDE	127,700	151,378	-15.64
	TOTAL	196,200	287,083	-31.65

(1) Includes Edwards Aquifer pumping data only.

LIMITATIONS ON USE OF THIS DATA
1. See source tables for limitations.
2. This data is estimated pumpage.

TABLE 2.1-13
TECHNICAL DATA REVIEW PANEL
COMPARISON OF TWDB AND USGS
GROUND WATER PUMPING DATA FOR EDWARDS AQUIFER
IRRIGATION - CORN AND COTTON - 1989

SOURCE: TABLES 2.1-5, 2.1-8
ALL VALUES REPORTED IN ACRE-FEET

		BEXAR COUNTY			MEDINA COUNTY			UVALDE COUNTY		
CROP	SOURCE	ACRES	INCHES APPLIED	ACRE FEET	ACRES	INCHES APPLIED	ACRE FEET	ACRES	INCHES APPLIED	ACRE FEET
CORN	USGS	1,000	28.31A	2,359	9,046	38.91A	29,331	15,863	45.02A	59,513
	TWDB	3,950	30.00E	9,875	18,419	39.00E	59,862	21,450	30.00E	53,625
COTTON	USGS	669	20.00E	1,115	12,067	31.10A	31,274	18,776	31.15A	48,740
	TWDB	80	14.00E	93	4,209	28.00E	9,821	20,356	30.00E	50,890

NOTE: 1989 CHOSEN FOR THIS COMPARISON BECAUSE 1989 WAS AN INTENSIVE SURVEY YEAR FOR TWDB IRRIGATION DATA.

A = AVERAGE OF FIELD DATA USED
E = ESTIMATED BY SCS FOR TWDB

LIMITATIONS ON USE OF THIS DATA
1. This data is estimated pumpage.
2. This data is for one year only, it may not be indicative of differences in USGS and TWDB estimates in other years.
3. 1989 was the year that USGS used special acreage estimation by satellite photography.

Table 2.1-14

UNITED STATES GEOLOGICAL SURVEY RAINFALL RECORD FOR SELECTED GAGES

Calendar year	Brackettville	Uvalde	Sabinal	Hondo	San Antonio	Boerne	New Braunfels	San Marcos
1934	---	16.70	18.07	23.97	27.65	26.78	30.80	35.67
1935	---	41.17	48.21	58.73	42.93	52.93	41.67	41.09
1936	22.34	24.53	26.53	35.27	34.11	47.59	30.41	33.48
1937	16.85	17.88	b/ 9.57	22.93	26.07	32.81	29.19	b/26.03
1938	19.97	13.12	15.39	27.56	23.26	24.14	28.32	28.17
1939	18.38	25.30	c/13.98	23.14	18.83	26.20	13.35	18.59
1940	22.43	27.66	27.51	28.13	30.79	32.29	38.11	43.57
1941	21.52	31.79	b/33.74	44.07	26.34	41.60	42.99	48.41
1942	21.01	19.01	b/11.37	34.83	38.46	31.12	42.08	44.65
1943	c/23.39	20.63	17.21	31.43	20.51	26.33	29.93	25.45
1944	24.76	32.76	b/27.62	32.46	33.19	42.98	43.14	47.42
1945	15.69	22.37	26.60	29.57	30.46	33.50	39.38	c/31.74
1946	19.10	26.41	b/14.16	29.65	45.17	45.62	61.60	52.24
1947	c/22.92	22.67	---	18.98	17.32	21.89	27.52	27.53
1948	b/20.02	18.31	---	28.82	23.64	23.77	c/19.88	b/21.27
1949	31.32	34.41	---	39.90	40.81	41.15	43.21	36.22
1950	17.70	18.27	b/15.28	24.91	19.86	24.94	21.13	21.10
1951	14.71	16.07	15.63	b/24.05	24.44	18.76	24.84	30.88
1952	12.26	18.24	23.16	24.56	26.24	37.54	33.87	39.91
1953	10.12	18.34	21.44	20.61	17.56	21.42	30.06	33.39
1954	19.38	15.60	14.72	11.92	13.70	10.29	10.12	13.42
1955	26.55	18.36	20.87	21.21	18.18	19.27	23.12	26.44
1956	7.58	9.29	11.29	15.54	14.31	12.05	18.41	18.37
1957	34.21	39.30	40.03	35.09	48.83	52.55	51.88	46.51
1958	45.37	39.03	41.18	41.60	39.69	40.94	36.40	39.08
1959	27.51	31.51	27.02	30.68	24.50	35.64	40.45	43.47
1960	19.12	23.98	26.24	32.37	29.76	32.55	34.28	45.48
1961	17.91	26.26	27.24	27.36	26.47	25.45	b/15.70	30.02
1962	10.87	14.12	13.58	17.85	23.90	25.26	27.40	28.47
1963	15.07	16.70	18.99	18.90	18.65	20.66	23.41	19.90
1964	20.75	22.30	23.78	28.29	31.88	27.36	30.65	30.27
1965	21.48	26.21	29.41	30.80	36.65	42.41	45.16	45.00
1966	21.63	20.87	21.54	29.46	21.44	29.05	25.98	27.12
1967	21.95	20.10	23.89	30.33	29.26	26.75	31.74	26.41
1968	17.26	25.20	c/29.88	31.91	30.40	35.14	35.97	37.13
1969	28.53	33.38	33.05	32.30	31.42	38.07	33.01	36.59
1970	16.50	13.59	22.13	30.96	22.74	27.79	35.23	32.30
1971	29.46	31.01	31.00	32.96	31.80	45.24	29.43	31.10
1972	21.21	15.49	21.10	25.43	31.49	35.09	42.02	31.90
1973	30.61	30.85	c/35.14	47.82	52.28	50.93	51.66	47.91
1974	18.25	30.94	c/20.93	c/36.41	37.00	41.80	42.85	b/37.28
1975	26.62	24.92	23.65	b/25.84	25.67	33.49	35.82	48.64
1976	34.40	46.04	40.82	45.21	39.13	45.24	49.06	47.46
1977	15.06	19.90	17.06	19.40	29.64	32.43	24.83	27.69
1978	19.04	18.48	21.28	24.64	35.99	35.17	c/36.35	33.08
1979	16.34	32.35	31.44	28.83	36.64	39.97	36.72	38.74
1980	18.33	23.05	22.67	21.27	24.23	29.02	33.69	29.56
1981	28.73	26.24	30.19	27.40	36.37	41.05	43.23	49.62
1982	19.10	23.35	18.44	21.99	22.96	27.64	21.04	c/22.47
1983	19.35	b/24.45	23.33	c/20.92	26.11	34.60	34.13	36.95
1984	16.24	c/15.33	20.67	b/21.19	25.95	26.97	20.90	b/ 8.26
1985	18.93	b/ 5.76	23.67	21.94	41.43	37.77	37.26	33.54
1986	27.44	c/29.86	c/29.62	c/36.01	42.73	43.52	47.14	42.20
1987	39.45	36.39	38.36	40.09	37.96	39.86	b/37.33	37.94
1988	12.08	15.20	13.52	c/ 9.81	19.01	19.49	c/16.27	21.50
1989	16.98	18.65	17.26	16.10	22.14	25.14	20.99	25.46
1990	c/38.24	24.73	30.06	27.01	38.31	42.51	b/24.58	c/35.14
Years of record available	92	90	73	88	117	88	95	90
Long-term average	21.16	24.15	25.14	28.27	27.37	32.82	32.07	33.60

a/ Precipitation data from the U.S. Department of Agriculture (1934-40) and U.S. Department of Commerce (1941-90).
b/ Partial record not included in long-term average; missing more than 1 month.
c/ Partial record not included in long-term average; missing 1 month.

Reprinted from Bulletin 50, Compilation of Hydrologic Data for the Edwards Aquifer, San Antonio Area, Texas, 1990 with 1934-1990 Summary, 1991, prepared for Edwards Underground Water District by United States Geological Survey

TABLE 2.1-15
TECHNICAL DATA REVIEW PANEL
COMPARISON OF TWDB AND USGS DOMESTIC AND LIVESTOCK PUMPAGE
FOR THE EDWARDS AQUIFER

SOURCE: TABLES 2.1-1, 2.1-7
ALL UNITS REPORTED IN ACRE FEET OR AS A PERCENTAGE

YEAR	COUNTY	USGS (2) DOMESTIC AND LIVESTOCK	TEXAS WATER DEVELOPMENT BOARD (1) DOMESTIC	LIVESTOCK	TOTAL	PERCENT DIFFERENCE
1985	BEXAR		248	138	386	-100%
	COMAL		0	222	222	-100
	HAYS		499	1,260	1,759	-100
	MEDINA		57	136	193	-100
	UVALDE		553	2,543	3,096	-100
	TOTAL:		1,357	4,299	5,656	-100
1986	BEXAR		262	146	408	-100%
	COMAL		0	222	222	-100
	HAYS		660	738	1,398	-100
	MEDINA		48	134	182	-100
	UVALDE		449	2,652	3,101	-100
	TOTAL:		1,419	3,892	5,311	-100
1987	BEXAR	21,500	286	122	408	98.10%
	COMAL	700	685	233	918	-23.75
	HAYS	1,000	899	1,485	2,384	58.05
	MEDINA	700	54	161	215	69.29
	UVALDE	2,800	468	2,253	2,721	2.82
	TOTAL:	26,700	2,392	4,254	6,646	75.10
1988	BEXAR	21,500	287	127	414	98.07%
	COMAL	700	0	258	258	63.14
	HAYS	800	654	827	1,481	-45.98
	MEDINA	700	0	173	173	75.29
	UVALDE	2,500	426	1,909	2,335	6.60
	TOTAL:	26,200	1,367	3,294	4,661	82.20
1989	BEXAR	21,500	266	127	393	98.17%
	COMAL	700	96	256	352	49.71
	HAYS	500	743	734	1,477	-66.15
	MEDINA	700	114	152	266	62.00
	UVALDE	2,600	465	2,016	2,481	4.58
	TOTAL:	26,000	1,684	3,285	4,969	80.88
1990	BEXAR	21,500				100%
	COMAL	700				100
	HAYS	300				100
	MEDINA	700				100
	UVALDE	2,700				100
	TOTAL:	25,900				100

(1) INCLUDES EDWARDS AQUIFER PUMPING DATA ONLY.
(2) DETAIL ESTIMATE OF USGS LIVESTOCK AND DOMESTIC NOT AVAILABLE UNTIL 1987.

LIMITATIONS ON USE OF THIS DATA
1. This data is estimated pumpage.
2. Estimation methods vary between USGS and TWDB.
3. See source tables for limitations.

TABLE 2.1-16
TECHNICAL DATA REVIEW PANEL
SAMPLE OF GUADALUPE RIVER BASIN WATER RIGHTS
SORTED BY DIVERSION AMOUNT (DESCENDING ORDER)

State Master #	County	Applicant	Priority Date	Stream name	Use	Diversion Amount	Acreage	Remarks
3846	89	CITY OF GONZALES	19800225	GUADALUPE	5	796363	0	
5488	94	GUADALUPE-BLANCO R A TP-1	19140401	GUADALUPE	5	663892	0	LAKE DUNLAP
5488	94	GUADALUPE-BLANCO R A TP-3	19140401	GUADALUPE	5	659995	0	LAKE MCQUEENEY
5488	94	GUADALUPE-BLANCO R A TP-4	19140401	GUADALUPE	5	655323	0	LAKE PLACID
5488	94	GUADALUPE-BLANCO R A TP-5	19140401	GUADALUPE	5	624781	0	LAKE NOLTE
5172	89	GUADALUPE-BLANCO R A H-4	19260916	GUADALUPE	5	585599	0	LAKE GONZALES H-4
5172	89	GUADALUPE-BLANCO R A H-5	19260916	GUADALUPE	5	574832	0	LAKE WOOD H-5
3853	62	JOHN MCNEILL	19820517	GUADALUPE	5	538560	0	
5485	235	CENTRAL POWER & LIGHT CO	19510815	GUADALUPE	2	209189	0	COOLING POND
3824	46	NEW BRAUNFELS UTILITIES	19140601	COMAL	2	139198	3418	
3824	46	NEW BRAUNFELS UTILITIES	19140601	COMAL	5	124870	0	
3859	235	SOUTH TEXAS ELECTRIC COOP INC	19640218	GUADALUPE	2	110000	1900	
5178	29	GUADALUPE-BLANCO RA ET AL	19540505	GUADALUPE	1	106000	0	IND & IRR- AMEND 4/17/91
3865	105	AQUARENA SPRINGS CORPORATION	18950904	SAN MARCOS	5	64370	0	
3861	235	E I DU PONT DE NEMOURS	19480816	GUADALUPE	2	60000	33000	
2074	46	GUADALUPE-BLANCO RIVER AUTH	19560319	GUADALUPE	1	35125	0	12/31/2000
5177	29	GUADALUPE-BLANCO RA ET AL	19440103	GUADALUPE	3	32615	21308	MUN & IND
5486	235	CENTRAL POWER & LIGHT CO	19520107	GUADALUPE	2	20000	0	COLETO CR- & CO 088

NOTE: THIS DATA IS AVAILABLE FOR ALL PERMITS IN THE GUADALUPE, SAN ANTONIO AND NUECES RIVER BASINS AND ADJOINING COASTAL BASINS.

TABLE 2.1-17
TECHNICAL DATA REVIEW PANEL
1989 SUMMARY LISTING OF WATER USES
BY TYPE OF USE FOR
GUADALUPE, SAN ANTONIO, NUECES RIVER BASINS
AND ADJOINING COASTAL BASINS

Source: Texas Water Commission, Unit: Acre-Feet

BASIN	MUNICIPAL No. of Permits	MUNICIPAL Div. Amt.	INDUSTRIAL No. of Permits	INDUSTRIAL Div. Amt.	IRRIGATION No. of Permits	IRRIGATION Acres	IRRIGATION Div. Amt.	MINING No. of Permits	MINING Div. Amt.	HYDRO-ELECTRIC No. of Permits	HYDRO-ELECTRIC Div. Amt.	RECREATION No. of Permits	RECREATION Div. Amt.	RECHARGE No. of Permits	RECHARGE Div. Amt.	OTHER No. of Permits	OTHER Div. Amt.	TOTAL No. of Permits	TOTAL Div. Amt.
Guadalupe	35	18567 (1)	34	553047 (2) (3)	214	10481	55828	1	0	10	1649427 (4)	41	62	0	0	0	0	335	2,276,931
San Antonio	5	539	2	28175	180	33146	73600	1	272	0	0	20	307	1	0	4	0	213	102,893
Nueces	19	107341	5	60917	208	26437	30564	1	1	0	0	13	40	3	0	2	0	251	198,863
Lavaca-Guadalupe	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	3	0
San Antonio-Nueces	0	0	5	4084	2	110	215	0	0	0	0	4	17	0	0	0	0	11	4,316
Nueces-Rio Grande	3	5621	8	809594	48	6796	6744	0	0	0	0	9	982	0	0	4	0	72	822,941
TOTAL	62	132068	54	1455817	655	76970	166951	3	273	10	1649427	87	1408	4	0	10	0	885	3,405,944

Div. Amt. = Diversion Amount
(1) Includes 1660 acre-feet from Canyon Reservoir storage.
(2) Includes 114 acre-feet from Canyon Reservoir storage.
(3) Includes non-consumptive diversions, consumptive use is minor portion of the total.
(4) Non-consumptive.

LIMITATIONS ON USE OF THIS DATA
1. Diversion amounts for industrial uses include non-consumptive diversions. TWC records obtained do not reflect separation of consumptive and non-consumptive uses for industrial diversions.
2. Hydroelectric use is non-consumptive, reported use combines multiple plants using same water.

TABLE 2.1-18
TECHNICAL DATA REVIEW PANEL
SUMMARY LISTING OF WATER RIGHTS BY TYPE OF USE FOR GUADALUPE, SAN ANTONIO, NUECES RIVER BASINS AND ADJOINING COASTAL BASINS

Source: Texas Water Commission, Unit: Acre-Feet

BASIN	MUNICIPAL No. Perm.	MUNICIPAL Div. Amt.	INDUSTRIAL No. Perm.	INDUSTRIAL Div. Amt.	INDUSTRIAL Consum. Div. Amt	IRRIGATION No. Perm.	IRRIGATION Acres	IRRIGATION Div. Amt.	MINING No. Perm.	MINING Div. Amt.	HYDRO-ELECTRIC No. Perm.	HYDRO-ELECTRIC Div. Amt.	HYDRO-ELECTRIC Consum. Div. Amt	RECREATION No. Perm.	RECREATION Div. Amt.	RECHARGE No. Perm.	RECHARGE Div. Amt.	OTHER No. Perm.	OTHER Div. Amt.	TOTAL No. Perm.	TOTAL Div. Amt.	TOTAL Consum. Div. Amt
Guadalupe	46 (1)	182395 (1)	41 (2)	613534	131566 (2)	262 (3)	53399	88780 (3)	3	156	13	5288585 (4)	0	54	6959	0	0	4	850	423	6,181,259 (1)(2)(3)(4)	403,747
San Antonio	8	72032	5	48936	(5)	211	58303	102223	1	431	0	0	0	26	480	1	961	5	0	257	225,063	(5)
Nueces	27	239419	9	258112	(5)	275	48536	79311	3	17	0	0	0	17	10	3	2290	3	0	337	579,159	(5)
Lavaca-Guadalupe	1	0	0	0	0	9	3247	4560	0	0	0	0	0	0	0	0	0	1	1000	10	4,560	0
San Antonio-Nueces	0	0	5	16,017	(5)	5	606	842	0	0	0	0	0	4	7780	0	0	0	0	15	25,639	(5)
Nueces-Rio Grande	5	7738	10	1575838 (6)	(5)	54	36372	52218	0	0	0	0	0	9	10427	0	0	5	0	83	1,646,221	(5)
TOTAL	87	501584	54	2512437	131566	816	200463	327934	7	604	13	5288585	0	110	25656	4	3251	18	1850	1125	8,661,901	(5)

No. Perm. = Number of Permits
Div. Amt. = Diversion Amount
Consum. Div. Amt. = Consumptive Diversion Amount

(1) Includes 14 contracts for Canyon Reservoir Supply totalling 19,910 acre-feet for Canyon Reservoir; Canyon Reservoir included at 35,225 acre-feet; includes 106,000 acre-feet also permitted for irrigation and industrial.
(2) Includes 13 contracts for Canyon Reservoir Supply totalling 11,796 acre-feet; Canyon Reservoir included at 14,775 acre-feet; includes 5 permits with non-consumptive rights totalling 481,968 acre-feet.
(3) Includes 9 contracts for Canyon Reservoir totalling 159 acre-feet; includes 51,191 acre-feet also permitted for municipal and industrial; includes 940 acre-feet also permitted for industrial, mining and stockraising; includes 4,370 acre-feet also permitted for industrial.
(4) Largest single permit equals 796,363 acre-feet.
(5) Consumptive and non-consumptive components not separated.
(6) Includes 1,573,598 acre-feet from bays and estuaries.

LIMITATIONS ON USE OF THIS DATA

1. Separation of consumptive diversion amount from total diversion amount for industrial use is estimated.

TABLE 2.1-19
TECHNICAL DATA REVIEW PANEL
POPULATION AND POPULATION PROJECTIONS

SOURCE: TWDB, TEXAS WATER PLAN 1990
UNITS: POPULATION IN NUMBER OF PERSONS

	1980 (1)	1985 (2)	1990 (3)	1990 PROJECTED		2000 PROJECTED		2010 PROJECTED		2020 PROJECTED		2030 PROJECTION		2040 PROJECTION	
COUNTY	ACTUAL	ACTUAL	ACTUAL	LOW (4)	HIGH (5)	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
ARANSAS	14,260	17,482	17,982	18,844	18,992	21,525	21,839	24,677	25,174	27,845	29,691	31,786	35,108	33,972	38,190
ATASCOSA	25,055	28,524	30,533	31,369	31,567	36,263	36,659	40,325	41,398	43,948	45,228	47,034	49,331	48,658	51,525
BEE	26,030	27,271	25,135	27,389	27,479	30,359	30,726	33,093	33,960	36,045	38,243	39,659	43,114	41,604	45,786
CALDWELL	23,637	27,338	26,392	30,302	30,490	32,857	36,725	34,724	38,818	36,686	42,749	39,752	47,564	41,379	50,175
CALHOUN	19,574	21,673	19,053	21,216	21,373	24,459	25,299	27,881	29,602	31,563	34,408	34,740	38,764	36,453	41,149
DE WITT	18,903	20,200	18,840	18,888	18,961	19,950	20,442	21,100	22,006	22,388	23,509	23,561	24,823	24,171	25,506
DIMMIT	11,367	11,889	10,433	11,558	11,616	13,582	14,197	15,900	17,465	18,467	20,611	20,962	23,634	22,338	25,313
DUVAL	12,517	13,327	12,918	13,116	13,289	14,297	14,800	15,575	16,449	16,887	17,976	18,125	19,303	18,779	20,001
FRIO	13,785	14,212	13,472	14,319	14,582	16,554	17,087	17,778	19,358	19,213	21,603	20,117	23,477	20,584	24,474
GOLIAD	5,193	5,625	5,980	6,058	6,084	6,637	7,042	7,259	7,813	7,939	8,757	8,510	9,635	8,810	10,107
GONZALES	16,883	18,840	17,205	18,598	18,821	19,138	19,417	20,105	21,049	21,974	24,760	25,194	29,157	26,982	31,651
GUADALUPE	46,708	54,606	64,873	63,201	64,156	77,299	84,576	89,735	102,987	101,224	116,356	112,736	136,924	118,986	148,575
JIM WELLS	36,498	40,330	37,679	38,939	39,550	41,232	43,235	45,434	48,674	50,033	55,353	53,937	61,936	56,005	65,525
KARNES	13,593	13,441	12,455	12,512	12,797	13,086	13,635	13,688	14,437	14,323	15,182	14,924	15,891	15,233	16,257
KINNEY	2,279	2,421	3,119	2,655	2,672	2,899	2,988	3,122	3,272	3,328	3,508	3,506	3,770	3,598	3,908
KLEBERG	33,358	34,495	30,274	32,015	32,166	34,303	35,439	37,605	40,206	42,085	47,724	48,263	56,476	51,693	61,459
LA SALLE	5,514	5,757	5,254	5,177	5,232	5,802	6,051	6,470	6,880	7,128	7,643	7,741	8,307	8,068	8,659
LIVE OAK	9,606	9,549	9,556	9,094	9,284	9,459	9,851	9,756	10,264	9,847	10,526	9,918	10,734	9,952	10,838
MAVERICK	31,398	36,895	36,378	41,418	42,704	54,825	58,147	68,635	73,257	83,567	92,106	95,937	109,759	102,817	119,857

TABLE 2.1-19 (Continued)

COUNTY	1980 (1) ACTUAL	1985 (2) ACTUAL	1990 (3) ACTUAL	1990 PROJECTED LOW	1990 PROJECTED HIGH	2000 PROJECTED LOW	2000 PROJECTED HIGH	2010 PROJECTED LOW	2010 PROJECTED HIGH	2020 PROJECTED LOW	2020 PROJECTED HIGH	2030 PROJECTION LOW	2030 PROJECTION HIGH	2040 PROJECTION LOW	2040 PROJECTION HIGH
McMULLEN	789	970	817	976	984	998	1,081	1,055	1,153	1,121	1,276	1,221	1,425	1,275	1,505
NUECES	268,215	297,018	291,145	307,637	309,530	335,274	344,767	367,720	391,953	416,112	470,625	487,213	564,753	527,362	618,915
REFUGIO	9,289	8,729	7,976	8,550	8,570	8,461	8,551	8,312	8,402	7,953	8,044	7,569	7,665	7,569	7,665
SAN PATRICIO	58,013	61,764	58,749	62,537	63,090	73,057	76,028	82,655	86,981	91,149	99,533	98,934	109,979	103,077	115,615
VICTORIA	68,807	75,499	74,361	76,006	77,292	85,702	88,524	93,439	98,212	101,802	113,229	113,482	130,439	119,832	140,029
WEBB	99,258	118,124	133,239	136,476	139,613	168,627	178,628	200,712	217,363	233,739	261,941	269,930	302,678	290,151	325,449
WILSON	16,756	18,905	22,650	20,778	21,354	24,751	26,142	26,562	28,667	28,208	31,435	30,700	35,508	32,029	37,746
ZAVALA	11,666	12,046	12,162	12,092	12,122	12,832	14,438	13,747	15,787	14,858	17,492	16,183	19,158	16,889	20,049
SUBTOTAL:	898,951	996,930	998,630	1,041,720	1,054,370	1,184,228	1,236,314	1,327,064	1,421,587	1,489,432	1,659,508	1,681,634	1,919,312	1,788,266	2,065,928
BEXAR	988,800	1,134,917	1,185,394	1,260,649	1,261,638	1,479,258	1,535,067	1,702,920	1,805,700	1,952,490	2,208,270	2,283,418	2,844,472	2,470,112	3,230,907
COMAL	36,446	46,159	51,832	53,740	54,332	69,567	75,215	81,896	90,445	92,555	103,272	100,252	117,904	104,345	126,010
HAYS	40,594	56,027	65,614	69,353	69,934	92,267	102,893	116,803	141,852	140,883	178,053	161,673	211,119	173,233	229,972
MEDINA	23,164	25,077	27,312	27,630	27,813	31,402	32,569	34,966	36,749	38,195	40,373	40,894	43,432	42,314	45,048
UVALDE	22,441	24,651	23,340	25,075	25,340	30,879	31,224	36,656	37,070	42,003	42,615	48,136	48,992	51,541	52,542
SUBTOTAL:	1,111,445	1,286,831	1,353,492	1,436,447	1,439,057	1,703,373	1,776,968	1,973,241	2,111,816	2,266,126	2,572,583	2,634,373	3,265,919	2,841,545	3,684,479
REGIONAL TOTALS:	2,010,396	2,283,761	2,352,122	2,478,167	2,493,427	2,887,601	3,013,282	3,300,305	3,533,403	3,755,558	4,232,091	4,316,007	5,185,231	4,629,811	5,750,407

(1) U.S. BUREAU OF CENSUS
(2) U.S. BUREAU OF CENSUS
(3) U.S. BUREAU OF CENSUS FROM ATTORNEY GENERAL OF TEXAS REDISTRICTING REPORT, 3/27/91
(4) LOW POPULATION SERIES
(5) HIGH POPULATION SERIES

TABLE 2.1-20
TECHNICAL DATA REVIEW PANEL
TEXAS WATER DEVELOPMENT BOARD WATER USE PROJECTIONS

SOURCE: Texas Water Plan, 1990
All values reported in acre-feet

COUNTY	SERIES	1990	2000	2010	2020	2030	2040
ARANSAS	LOW (1)	4343	4770	5144	5604	6338	6767
	HIGH (2)	4375	4850	5283	6021	7071	7690
ATASCOSA	LOW	68551	58102	56251	55551	54906	54075
	HIGH	84040	83642	80327	78002	75938	73664
BEE	LOW	7219	7575	7667	7887	8335	8565
	HIGH	7338	7736	7896	8296	8915	9246
BEXAR	LOW	359729	397506	428989	472827	546094	586817
	HIGH	365656	421081	462450	539687	680179	765614
CALDWELL	LOW	7832	8146	8191	8330	8777	9059
	HIGH	7925	8861	8932	9383	10132	10628
CALHOUN	LOW	59148	84220	85906	89369	92840	96685
	HIGH	67777	105937	112030	118844	124564	131095
COMAL	LOW	18599	21762	24046	26357	28520	29942
	HIGH	18892	23730	27108	30602	35264	38373
DEWITT	LOW	6287	6651	6637	6733	8902	8999
	HIGH	6401	6841	6902	14039	14248	14380
DIMITT	LOW	17510	13961	13872	13904	14009	13892
	HIGH	21318	20359	20089	19829	19656	19227
DUVAL	LOW	8383	8479	8161	8202	8407	8517
	HIGH	8697	8857	8599	8672	8894	9012
FRIO	LOW	92907	66099	62350	58854	55262	51726
	HIGH	118038	107529	101441	95424	89445	83522
GOLIAD	LOW	17857	19125	19135	19179	19234	19266
	HIGH	17923	19253	19284	19365	19468	19526
GONZALES	LOW	11348	12013	12180	12575	13332	13859
	HIGH	11615	12389	12781	13708	13332	15840
GUADALUPE	LOW	18946	21128	22607	24236	26278	27467
	HIGH	19557	22980	25524	27527	31270	33592
HAYS	LOW	18040	22300	26285	30372	34420	36834
	HIGH	18232	24732	31376	37876	44674	48658
JIM WELLS	LOW	13880	14110	14542	15225	16084	16531
	HIGH	14288	14843	15537	16661	18123	18933
KARNES	LOW	6320	6576	6566	10620	10735	16326
	HIGH	6570	6909	10975	16608	26833	30478
KINNEY	LOW	8440	6502	6239	6001	5774	5531
	HIGH	10344	9658	9221	8788	8392	7974

TABLE 2.1-20 (Continued) Page 2

COUNTY	SERIES	1990	2000	2010	2020	2030	2040
KLEBERG	LOW	9857	9847	9991	10502	11526	13557
	HIGH	9938	10121	10529	12078	14571	16393
LA SALLE	LOW	8660	6835	6615	6428	6261	6048
	HIGH	10568	10010	9625	9253	8898	8502
LIVE OAK	LOW	8448	7877	7415	9798	15319	15337
	HIGH	8839	8361	10443	15859	17908	22945
MAVERICK	LOW	69039	52358	51647	51347	50884	49557
	HIGH	86629	81560	79280	77780	76444	73944
MCMULLEN	LOW	1643	1766	1777	2925	3800	4821
	HIGH	1645	1780	1792	2948	3832	4857
MEDINA	LOW	61028	44966	43031	41245	39482	37544
	HIGH	76520	70675	67290	63941	60682	57290
NUECES	LOW	112204	117584	120961	130773	147461	157921
	HIGH	113618	123184	131883	149867	173263	188658
REFUGIO	LOW	2459	2439	2301	2168	2067	2033
	HIGH	2477	2469	2329	2196	2097	2063
SAN PATRICIO	LOW	21679	27016	29444	31824	34368	36622
	HIGH	22276	30207	34673	39461	43788	47992
UVALDE	LOW	86676	64544	62632	60849	59189	57048
	HIGH	108706	100843	96750	92726	88939	84751
VICTORIA	LOW	77419	79661	83104	87301	92195	96958
	HIGH	82518	87115	94713	104071	112968	121955
WEBB	LOW	43467	47545	52155	57618	65019	69113
	HIGH	46134	53015	58772	66426	74663	79179
WILSON	LOW	21859	17716	17153	16678	16412	16041
	HIGH	26571	25559	24648	23877	23421	22772
ZAVALA	LOW	71044	50423	47738	45238	42780	40308
	HIGH	90298	82543	78103	73849	69751	65766

(1) Low Population Series, High per Capita use, with Conservation
(2) High Population Series, High per Capita use, with Conservation

TABLE 2.1-21
TECHNICAL DATA REVIEW PANEL
POPULATION AND POPULATION PROJECTIONS FOR
CITIES OVER 10,000 IN POPULATION

SOURCE: TWDB 1990 WATER PLAN
POPULATION IN NUMBER OF PERSONS

COUNTY	CITY	SERIES	1980	1985	1990	2000	2010	2020	2030	2040
BEE	BEEVILLE	ACTUAL	14574	15442						
		LOW			16355	18007	19669	21071	22776	23893
		HIGH			16409	18225	20185	22356	24761	26295
BEXAR	FORT SAM HOUSTON	ACTUAL	15638	15638						
		LOW			15625	15069	14747	13826	12553	11955
		HIGH			15638	15638	15638	15638	15638	15638
BEXAR	LIVE OAK	ACTUAL	8183	9261						
		LOW			10967	15211	17488	19261	20544	22223
		HIGH			10976	15785	18544	21785	25592	29068
BEXAR	SAN ANTONIO	ACTUAL	785880	884216						
		LOW			986208	1157302	1330451	1465234	1562695	1690461
		HIGH			986982	1200965	1410751	1657183	1946662	2211124
BEXAR	UNIVERSAL CITY	ACTUAL	10720	12246						
		LOW			14066	19247	22129	24370	25993	28117
		HIGH			14078	19974	23465	27563	32380	36778
CALHOUN	PORT LAVACA	ACTUAL	10911	11968						
		LOW			11963	14690	16766	18996	20439	21199
		HIGH			12052	15195	17801	20709	22807	23930
COMAL	NEW BRAUNFELS	ACTUAL	22375	26849						
		LOW			31081	35428	42495	48478	53010	55173
		HIGH			31424	38305	46932	54092	62344	66629
GUADALUPE	SEGUIN	ACTUAL	17854	19647						
		LOW			22247	23953	25812	29132	31165	32892
		HIGH			22584	26209	29625	33487	37852	41072
HAYS	SAN MARCOS	ACTUAL	23420	27338						
		LOW			32636	42747	54472	65927	75819	81240
		HIGH			32910	47671	66154	83321	99008	107849

COUNTY	CITY	SERIES	1980	1985	1990	2000	2010	2020	2030	2040
JIM WELLS	ALICE	ACTUAL	20961	22425						
		LOW			21260	22523	25002	27459	29801	30943
		HIGH			21594	23618	26786	30379	34221	36204
KLEBERG	KINGSVILLE	ACTUAL	28808	29422						
		LOW			27344	29316	32213	35948	40829	43729
		HIGH			27473	30287	34442	40765	47777	51991
MAVERICK	EAGLE PASS	ACTUAL	21407	25255						
		LOW			29374	36565	47191	59192	69111	74067
		HIGH			30287	38781	50369	65241	79069	86343
NUECES	CORPUS CHRISTI	ACTUAL	231999	259793						
		LOW			270147	297749	329432	376396	444435	482109
		HIGH			271810	306180	351142	425706	515167	565807
NUECES	ROBSTOWN	ACTUAL	12100	13212						
		LOW			13229	13007	13673	14844	16653	18066
		HIGH			13311	13376	14575	16789	19304	21203
SAN PATRICIO	PORTLAND	ACTUAL	12023	12481						
		LOW			13100	15785	17878	19730	21427	22324
		HIGH			13216	16427	18814	21545	23820	25040
UVALDE	UVALDE	ACTUAL	14178	15945						
		LOW			17346	22772	28015	32885	36822	39363
		HIGH			17530	23027	28332	33365	37477	40128
VICTORIA	VICTORIA	ACTUAL	50695	55980						
		LOW			56772	66372	74095	78488	83829	88520
		HIGH			57733	68558	77880	87299	96356	103440
WEBB	LAREDO	ACTUAL	91449	112314						
		LOW			130136	160701	191708	223648	258429	277705
		HIGH			133128	170232	207613	250633	289782	311490

TABLE 2.1-22
TECHNICAL DATA REVIEW PANEL
TEXAS WATER DEVELOPMENT BOARD WATER USE PROJECTIONS
FOR CITIES OVER 10,000 POPULATION

Source: Texas Water Plan, 1990
All values reported in acre-feet

COUNTY	CITY	SERIES	1990	2000	2010	2020	2030	2040
BEE	BEEVILLE	HIGH(1)	2670	2814	2948	3172	3513	3730
		LOW(2)	2661	2780	2872	2989	3231	3390
BEXAR	FORT SAM HOUSTON	HIGH	4714	4472	4230	4109	4109	4109
		LOW	4710	4309	3989	3633	3299	3142
BEXAR	LACKLAND AFB	HIGH	5042	4784	4525	4396	4396	4396
		LOW	5038	4610	4267	3887	3529	3361
BEXAR	LEON VALLEY	HIGH	2166	2949	3277	3740	4393	4990
		LOW	2164	2842	3090	3306	3527	3815
BEXAR	SAN ANTONIO	HIGH	224208	258827	287604	328191	385520	437894
		LOW	224032	249417	271234	290177	309478	334781
BEXAR	UNIVERSAL CITY	HIGH	3105	4179	4644	5299	6225	7071
		LOW	3102	4027	4380	4685	4997	5406
CALHOUN	PORT LAVACA	HIGH	1856	2220	2460	2780	3062	3213
		LOW	1842	2146	2317	2550	2744	2846
COMAL	NEW BRAUNFELS	HIGH	8820	10200	11822	13236	15255	16304
		LOW	8724	9434	10704	11862	12971	13501
GUADALUPE	SEGUIN	HIGH	4933	5431	5807	6377	7208	7821
		LOW	4859	4964	5060	5547	5935	6263
HAYS	SAN MARCOS	HIGH	8554	11756	15432	18881	22436	24439
		LOW	8483	10541	12707	14939	17181	18409
JIM WELLS	ALICE	HIGH	6438	6681	7167	7896	8895	9410
		LOW	6339	6371	6690	7137	7746	8043
KLEBERG	KINGSVILLE	HIGH	5563	5819	6259	7197	8435	9179
		LOW	5537	5632	5854	6346	7208	7720
MAVERICK	EAGLE PASS	HIGH	5987	7273	8936	11243	13626	14880
		LOW	5807	6857	8372	10201	11910	12764
NUECES	CORPUS CHRISTI	HIGH	65599	70104	76053	89568	108391	119046
		LOW	65197	68174	71351	79194	93509	101435
NUECES	ROBSTOWN	HIGH	2031	1936	1996	2233	2568	2820
		LOW	2018	1883	1872	1974	2215	2403
SAN PATRICIO	PORTLAND	HIGH	1804	2128	2305	2564	2835	2980
		LOW	1788	2044	2190	2348	2550	2657
UVALDE	UVALDE	HIGH	5782	7205	8386	9594	10776	11538
		LOW	5721	7126	8292	9456	10588	11318
VICTORIA	VICTORIA	HIGH	10404	11721	12595	13714	15138	16251
		LOW	10231	11347	11983	12331	13169	13907

COUNTY	CITY	SERIES	1990	2000	2010	2020	2030	2040
WEBB	LAREDO	HIGH	31696	38451	44360	52022	60148	64654
		LOW	30984	36299	40962	46421	53640	57641

(1) HIGH SERIES POPULATION, HIGH PER CAPITA USE WITH CONSERVATION
(2) LOW SERIES POPULATION, HIGH PER CAPITA USE WITH CONSERVATION

TABLE 2.1-23
TECHNICAL DATA REVIEW PANEL
POPULATION AND POPULATION PROJECTIONS FROM
TWDB 1992 DRAFT PROJECTIONS

SOURCE: TEXAS WATER DEVELOPMENT BOARD
UNITS: POPULATION IN NUMBER OF PERSONS

	1980 (1)	1985 (2)	1990 (3)	2000 PROJECTED		2010 PROJECTED		2020 PROJECTED		2030 PROJECTION		2040 PROJECTION	
COUNTY	ACTUAL	ACTUAL	ACTUAL	LOW (4)	HIGH (5)	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
ARANSAS	14,260	17,482	17,892	20,202	21,203	22,820	25,158	25,281	29,667	27,505	34,984	29,578	39,888
ATASCOSA	25,055	28,524	30,533	36,053	37,785	40,810	44,108	44,574	49,394	48,163	54,480	49,434	59,580
BANDERA	7,084	8,905	10,562	13,012	13,820	16,612	18,638	18,173	20,563	19,293	21,848	19,959	22,507
BEE	26,030	27,271	25,135	27,128	28,402	28,575	30,519	30,032	32,686	32,148	35,485	34,366	38,532
BEXAR	988,800	1,134,917	1,185,394	1,382,381	1,422,629	1,602,708	1,705,074	1,847,822	2,034,080	2,140,752	2,449,468	2,407,168	2,860,615
CALDWELL	23,637	27,338	26,392	29,007	30,112	32,343	35,216	35,615	40,662	38,200	44,838	40,324	48,183
CALHOUN	19,574	21,673	19,053	21,978	22,548	25,024	26,493	27,274	29,832	28,971	32,633	30,352	34,827
COMAL	36,446	46,159	51,832	65,224	68,754	78,824	86,446	92,146	103,929	105,502	121,548	116,381	136,106
DE WITT	18,903	20,200	18,840	19,256	19,485	19,596	20,040	19,906	20,553	20,319	21,276	20,659	21,942
DIMMIT	11,367	11,889	10,433	10,914	11,396	11,540	12,143	12,013	12,752	12,187	13,073	12,259	13,296
DUVAL	12,517	13,327	12,918	13,657	14,137	13,823	14,599	14,029	14,934	14,565	15,512	15,238	16,230
FRIO	13,785	14,212	13,472	15,730	16,331	16,998	18,307	18,157	19,958	19,420	21,712	20,740	23,628
GOLIAD	5,193	5,625	5,980	6,506	6,618	6,969	7,182	7,337	7,627	7,830	8,246	8,258	8,805
GONZALES	16,883	18,840	17,205	17,851	18,023	18,286	18,603	18,434	18,883	18,567	19,179	18,800	19,538
GUADALUPE	46,708	54,606	64,873	78,955	86,388	96,611	110,879	111,482	128,148	116,108	141,019	122,824	153,368
HAYS	40,594	56,027	65,614	85,511	95,359	111,350	135,229	134,896	170,486	153,844	200,895	163,285	216,766
JIM WELLS	36,498	40,330	37,679	40,989	41,411	42,254	43,231	42,186	43,757	41,977	44,314	41,477	44,666
KARNES	13,593	13,441	12,455	12,588	13,116	12,860	13,564	13,016	13,797	13,228	14,085	13,312	14,207
KINNEY	2,279	2,421	3,119	3,307	3,409	3,567	3,738	3,801	4,007	3,964	4,262	4,023	4,370
KLEBERG	33,358	34,495	30,274	32,526	33,370	35,886	36,904	38,064	39,315	40,729	42,324	42,698	44,739

COUNTY	1980 (1) ACTUAL	1985 (2) ACTUAL	1990 (3) ACTUAL	2000 PROJECTED LOW (4)	2000 PROJECTED HIGH (5)	2010 PROJECTED LOW	2010 PROJECTED HIGH	2020 PROJECTED LOW	2020 PROJECTED HIGH	2030 PROJECTION LOW	2030 PROJECTION HIGH	2040 PROJECTION LOW	2040 PROJECTION HIGH
LA SALLE	5,514	5,757	5,254	5,417	5,863	6,013	6,508	6,494	7,029	6,832	7,395	7,064	7,646
LIVE OAK	9,606	9,549	9,556	10,158	10,579	10,757	11,317	10,793	11,527	10,787	11,674	10,756	11,714
MAVERICK	31,398	36,895	36,378	46,617	49,475	55,388	61,711	64,967	75,071	73,877	87,814	83,083	101,325
MEDINA	23,164	25,077	27,312	31,164	31,774	35,148	36,421	37,802	39,815	40,182	42,855	41,753	44,859
McMULLEN	789	970	817	921	998	973	1,063	915	1,041	883	1,030	858	1,013
NUECES	268,215	297,018	291,145	334,255	339,413	374,451	386,134	406,471	427,119	440,158	472,085	473,552	518,667
REFUGIO	9,289	8,729	7,976	7,457	7,939	7,904	8,415	8,147	8,780	8,440	9,096	8,609	9,278
SAN PATRICIO	58,013	61,764	58,749	68,628	70,933	78,033	83,176	86,153	94,530	92,921	103,216	98,010	109,421
UVALDE	22,441	24,651	23,340	26,729	27,518	30,027	31,662	32,970	35,462	36,212	39,637	39,682	44,132
VICTORIA	68,807	75,499	74,361	85,721	87,180	96,996	100,334	105,323	110,685	111,239	118,748	117,219	127,172
WEBB	99,258	118,124	133,239	171,958	183,912	208,966	234,972	248,763	291,521	291,805	354,938	340,095	427,117
WILSON	16,756	18,905	22,650	28,547	30,064	34,168	37,221	37,687	41,839	40,443	45,890	42,443	49,583
ZAVALA	11,666	12,046	12,162	13,266	13,607	14,130	14,939	15,071	16,164	16,135	17,672	17,406	19,416
REGIONAL TOTALS:	2,017,480	2,292,666	2,362,594	2,763,613	2,863,551	3,190,410	3,419,944	3,615,794	3,995,613	4,073,186	4,653,231	4,491,665	5,293,136

(1) U.S. BUREAU OF CENSUS
(2) U.S. BUREAU OF CENSUS
(3) U.S. BUREAU OF CENSUS FROM ATTORNEY GENERAL OF TEXAS REDISTRICTING REPORT, 3/27/91
(4) LOW POPULATION SERIES
(5) HIGH POPULATION SERIES

TABLE 2.1-24
TECHNICAL DATA REVIEW PANEL
TEXAS WATER DEVELOPMENT BOARD WATER USE PROJECTIONS

SOURCE: TWDB, 1991 Projections based on 1990 Census Data
All values reported in acre-feet

COUNTY	SERIES	2000	2010	2020	2030	2040
ARANSAS	LOW (1)	4598	4954	5256	5609	5982
	HIGH (2)	4815	5447	6135	7115	8005
ATASCOSA	LOW	70085	52678	54090	60656	61864
	HIGH	72368	65656	69782	76559	83341
BANDERA	LOW	2833	3214	3292	3396	3437
	HIGH	2982	3507	3635	3756	3816
BEE	LOW	8114	8086	8089	8271	8453
	HIGH	8293	8370	8445	8731	9012
BEXAR	LOW	401372	436471	479021	537686	601360
	HIGH	419253	473715	537486	635411	720569
CALDWELL	LOW	7725	7956	8159	8385	8588
	HIGH	7045	7509	7990	8434	8771
CALHOUN	LOW	83133	87422	93311	99396	106040
	HIGH	100953	110581	121922	130488	141337
COMAL	LOW	26022	28275	30496	32659	34489
	HIGH	27783	31696	35436	39679	42813
DEWITT	LOW	6665	6573	6460	6464	6467
	HIGH	9668	9629	9567	9645	9715
DIMMIT	LOW	14580	12786	12392	12316	12344
	HIGH	16528	16669	16194	16282	16348
DUVAL	LOW	9757	9317	9103	9089	9120
	HIGH	10863	10458	10254	10253	10294
FRIO	LOW	87192	58329	58465	58603	58870
	HIGH	97277	90938	86887	82821	78700
GOLIAD	LOW	18717	18729	18722	18764	18798
	HIGH	18929	18955	18958	19012	19067
GONZALES	LOW	11305	11423	11464	11594	11759
	HIGH	12172	12407	12625	13007	13423
GUADALUPE	LOW	22761	25199	27026	27751	28736
	HIGH	24635	28247	30615	32859	34998
HAYS	LOW	20749	24654	27987	31027	32589
	HIGH	22729	28785	34119	39196	41976
JIM WELLS	LOW	12056	11904	11557	11411	11165
	HIGH	12735	12692	12465	12466	12394
KARNES	LOW	5766	5562	5424	5408	5395
	HIGH	5860	5713	5622	5659	5669

COUNTY	SERIES	2000	2010	2020	2030	2040
KINNEY	LOW	8225	7390	7404	7421	7431
	HIGH	9848	9417	8964	8539	8096
KLEBERG	LOW	10010	10252	10259	10497	10658
	HIGH	10381	10650	10690	10986	11223
LA SALLE	LOW	8177	6990	7027	7074	7093
	HIGH	7386	7373	7333	7302	7245
LIVE OAK	LOW	8174	8191	8183	8232	8282
	HIGH	8811	8871	8895	8968	9025
MAVERICK	LOW	92726	93807	95188	96289	97660
	HIGH	100356	100487	100695	101133	101625
MCMULLEN	LOW	1772	1804	1794	1801	1805
	HIGH	1784	1817	1812	1821	1827
MEDINA	LOW	99071	59491	59653	59977	60158
	HIGH	119240	114839	115193	115699	115990
NUECES	LOW	125255	131478	138048	146054	154462
	HIGH	130241	140106	150346	162209	174738
REFUGIO	LOW	2000	1999	1968	1984	1978
	HIGH	2143	2142	2126	2142	2137
SAN PATRICIO	LOW	24822	27830	30570	34135	37947
	HIGH	28210	34047	40305	46448	51879
UVALDE	LOW	100198	66114	63882	62984	64226
	HIGH	140334	131412	132341	133648	135116
VICTORIA	LOW	89559	95924	102911	109760	117463
	HIGH	94934	106008	123778	134850	147704
WEBB	LOW	50201	56649	63379	72061	81843
	HIGH	53562	63081	73244	85881	100880
WILSON	LOW	14285	13772	14052	14407	14631
	HIGH	16438	17172	17456	17861	18189
ZAVALA	LOW	65172	48299	48531	48775	49177
	HIGH	85799	71172	66584	67203	67933

(1) Low Population Series, High per Capita use, with Conservation
(2) High Population Series, High per Capita use, with Conservation

TABLE 2.1-25
TECHNICAL DATA REVIEW PANEL
POPULATION AND POPULATION PROJECTIONS FOR
CITIES OVER 10,000 IN POPULATION

SOURCE: TWDB, 1992 DRAFT PROJECTIONS
POPULATION IN NUMBER OF PERSONS

COUNTY	CITY	SERIES	1980	1985	1990	2000	2010	2020	2030	2040
BEE	BEEVILLE	ACTUAL	14574	15442	13547					
		LOW				14835	15771	16713	18080	19514
		HIGH				15658	17027	18922	20731	22701
BEXAR	FORT SAM HOUSTON	ACTUAL	15638	15638	12000					
		LOW				11998	11928	11890	11674	11380
		HIGH				12000	12000	12000	12000	12000
BEXAR	LIVE OAK	ACTUAL	8183	9261	10023					
		LOW				11633	13648	15889	18568	21005
		HIGH				12001	14584	17593	21391	25152
BEXAR	SAN ANTONIO	ACTUAL	785880	884216	935933					
		LOW				1067670	1230136	1410880	1626882	1823333
		HIGH				1097349	1305620	1548224	1854525	2157699
BEXAR	UNIVERSAL CITY	ACTUAL	10720	12246	13057					
		LOW				14968	17492	20301	23657	26709
		HIGH				15429	18665	22435	27194	31905
CALHOUN	PORT LAVACA	ACTUAL	10911	11968	10886					
		LOW				12120	13547	14601	15395	16042
		HIGH				12387	14235	15799	17111	18138
COMAL	NEW BRAUNFELS	ACTUAL	22375	26849	27091					
		LOW				30048	33259	36403	39556	42124
		HIGH				33023	40460	46633	53747	57434
GUADALUPE	SCHERTZ	ACTUAL	7243	7805	10012					
		LOW				13404	14862	16252	18196	19507
		HIGH				13457	15212	16898	19102	20727
GUADALUPE	SEGUIN	ACTUAL	17854	19647	18853					
		LOW				20218	21370	23742	25157	26236
		HIGH				20298	21873	24686	26410	27876

COUNTY	CITY	SERIES	1980	1985	1990	2000	2010	2020	2030	2040
HAYS	SAN MARCOS	ACTUAL	23420	27338	28743					
		LOW				33810	40393	46392	51219	53624
		HIGH				36320	46477	55459	63205	67250
JIM WELLS	ALICE	ACTUAL	20961	22425	19788					
		LOW				21558	22235	22198	22100	21820
		HIGH				22479	23453	23834	24132	24220
KLEBERG	KINGSVILLE	ACTUAL	28808	29422	25276					
		LOW				27816	31168	33342	36001	37965
		HIGH				28658	32184	34590	37592	40002
MAVERICK	EAGLE PASS	ACTUAL	21407	25255	20651					
		LOW				27432	33241	35228	45486	51583
		HIGH				29457	37428	46277	54716	63665
NUECES	CORPUS CHRISTI	ACTUAL	231999	259793	257453					
		LOW				295875	335072	364905	396293	427407
		HIGH				302426	345957	384144	426040	469442
NUECES	ROBSTOWN	ACTUAL	12100	13212	12849					
		LOW				14146	15268	16162	17102	18034
		HIGH				14290	15594	16738	17993	19293
SAN PATRICIO	PORTLAND	ACTUAL	12023	12481	12224					
		LOW				13474	14794	15935	16885	17600
		HIGH				13797	15517	17111	18331	19202
UVALDE	UVALDE	ACTUAL	14178	15945	14729					
		LOW				17955	21638	24971	28787	32851
		HIGH				17984	21705	25076	28949	33091
VICTORIA	VICTORIA	ACTUAL	50695	55980	55076					
		LOW				64093	73032	79634	84324	89065
		HIGH				65250	75679	83885	90278	96956
WEBB	LAREDO	ACTUAL	91449	112314	122899					
		LOW				158180	191428	227887	267317	309748
		HIGH				169176	215252	267056	325150	391272

TABLE 2.1-26
TECHNICAL DATA REVIEW PANEL
TEXAS WATER DEVELOPMENT BOARD WATER USE PROJECTIONS
FOR CITIES OVER 10,000 POPULATION

Source: Texas Water Development Board, 1992 Projections
All values reported in acre-feet

COUNTY	CITY	SERIES	2000	2010	2020	2030	2040
BEE	BEEVILLE	HIGH(1)	2473	2556	2692	2903	3102
		LOW(2)	2360	2367	2396	2532	2667
BEXAR	FORT SAM HOUSTON	HIGH	3508	3374	3253	3199	3159
		LOW	3508	3354	3223	3112	2996
BEXAR	LIVE OAK	HIGH	2473	2842	3252	3882	4536
		LOW	2398	2660	2937	3390	3788
BEXAR	SAN ANTONIO	HIGH	247067	282259	320833	380152	437465
		LOW	240385	265940	293952	333489	369674
BEXAR	UNIVERSAL CITY	HIGH	3405	3910	4473	5361	6218
		LOW	3303	3664	4070	4664	5206
CALHOUN	PORT LAVACA	HIGH	1873	2025	2141	2262	2357
		LOW	1833	1942	1979	2052	2084
COMAL	NEW BRAUNFELS	HIGH	9692	11376	12693	14509	15376
		LOW	8818	9425	9949	10678	11277
GUADALUPE	SCHERTZ	HIGH	2804	3033	3218	3595	3854
		LOW	2793	2963	3095	3424	3627
GUADALUPE	SEGUIN	HIGH	4365	4484	4811	5059	5277
		LOW	4348	4381	4627	4847	4967
HAYS	SAN MARCOS	HIGH	9357	11453	13232	14939	15819
		LOW	8711	9999	11121	12106	12614
JIM WELLS	ALICE	HIGH	6043	6069	5954	5947	5887
		LOW	5796	5753	5545	5446	5279
KLEBERG	KINGSVILLE	HIGH	5714	6129	6316	6737	7080
		LOW	5546	5935	6088	6452	6719
MAVERICK	EAGLE PASS	HIGH	5642	6792	7983	9316	10697
		LOW	5285	6032	6116	7745	8725
NUECES	CORPUS CHRISTI	HIGH	72156	79442	85629	93537	102013
		LOW	70593	76943	81341	87006	92879
NUECES	ROBSTOWN	HIGH	2113	2183	2231	2338	2442
		LOW	2092	2138	2154	2222	2283
SAN PATRICIO	PORTLAND	HIGH	1824	1947	2032	2115	2172
		LOW	1796	1856	1892	1948	1991
UVALDE	UVALDE	HIGH	5802	6710	7444	8496	9674
		LOW	5792	6690	7412	8448	9604
VICTORIA	VICTORIA	HIGH	11548	12885	13719	14562	15422
		LOW	11415	12435	13023	13602	14167

TABLE 2.1-26 (Continued)

COUNTY	CITY	SERIES	2000	2010	2020	2030	2040
WEBB	LAREDO	HIGH	39416	47740	56837	68108	81520
		LOW	36854	42457	48501	56293	64535

(1) HIGH SERIES POPULATION, HIGH PER CAPITA USE WITH CONSERVATION
(2) LOW SERIES POPULATION, HIGH PER CAPITA USE WITH CONSERVATION

TABLE 2.1-27
TECHNICAL DATA REVIEW PANEL

PROJECTIONS OF PER CAPITA WATER USE

Source: Texas Water Development Board,
1990 Texas Water Plan
Units: Gallons Per Capita Per Day

CITY	1990	2000	2010	2020	2030	2040	
004 ALAMO HEIGHTS	308	308	308	308	308	308	AVG GPCD
	391	391	391	391	391	391	HIGH GPCD
	300	285	270	262	262	262	A/CONSERVATION
	381	362	342	332	332	332	H/CONSERVATION
034 BALCONES HGTS	186	186	186	186	186	186	AVG GPCD
	221	221	221	221	221	221	HIGH GPCD
	181	172	163	158	158	158	A/CONSERVATION
	215	204	193	188	188	188	H/CONSERVATION
070 BRACKETTVILLE	336	336	336	336	336	336	AVG GPCD
	377	377	377	377	377	377	HIGH GPCD
	328	311	294	286	286	286	A/CONSERVATION
	368	349	330	320	320	320	H/CONSERVATION
100 CASTLE HILLS	277	277	277	277	277	277	AVG GPCD
	317	317	317	317	317	317	HIGH GPCD
	270	256	242	235	235	235	A/CONSERVATION
	309	293	277	269	269	269	H/CONSERVATION
101 CASTROVILLE	284	284	284	284	284	284	AVG GPCD
	320	320	320	320	320	320	HIGH GPCD
	277	263	249	241	241	241	A/CONSERVATION
	312	296	280	272	272	272	H/CONSERVATION
107 CHARLOTTE	193	193	193	193	193	193	AVG GPCD
	250	250	250	250	250	250	HIGH GPCD
	188	179	169	164	164	164	A/CONSERVATION
	244	231	219	213	213	213	H/CONSERVATION
131 CONVERSE	130	130	130	130	130	130	AVG GPCD
	165	165	165	165	165	165	HIGH GPCD
	127	120	114	111	111	111	A/CONSERVATION
	161	153	144	140	140	140	H/CONSERVATION
162 DEVINE	155	155	155	155	155	155	AVG GPCD
	179	179	179	179	179	179	HIGH GPCD
	151	143	136	132	132	132	A/CONSERVATION
	175	166	157	152	152	152	H/CONSERVATION

TABLE 2.1-27 PAGE 2

CITY	1990	2000	2010	2020	2030	2040	
211 FT SAM HOUSTON	248	248	248	248	248	248	AVG GPCD
	276	276	276	276	276	276	HIGH GPCD
	242	229	217	211	211	211	A/CONSERVATION
	269	255	242	235	235	235	H/CONSERVATION
281 HOLLYWOOD PARK	330	330	330	330	330	330	AVG GPCD
	406	406	406	406	406	406	HIGH GPCD
	322	305	289	281	281	281	A/CONSERVATION
	396	376	355	345	345	345	H/CONSERVATION
282 HONDO	233	233	233	233	233	233	AVG GPCD
	291	291	291	291	291	291	HIGH GPCD
	227	216	204	198	198	198	A/CONSERVATION
	284	269	255	247	247	247	H/CONSERVATION
309 JOURDANTON	188	188	188	188	188	188	AVG GPCD
	248	248	248	248	248	248	HIGH GPCD
	183	174	165	160	160	160	A/CONSERVATION
	242	229	217	211	211	211	H/CONSERVATION
325 KIRBY	138	138	138	138	138	138	AVG GPCD
	175	175	175	175	175	175	HIGH GPCD
	135	128	121	117	117	117	A/CONSERVATION
	171	162	153	149	149	149	H/CONSERVATION
330 KYLE	143	143	143	143	143	143	AVG GPCD
	175	175	175	175	175	175	HIGH GPCD
	139	132	125	122	122	122	A/CONSERVATION
	171	162	153	149	149	149	H/CONSERVATION
331 LACKLAND AFB	252	252	252	252	252	252	AVG GPCD
	320	320	320	320	320	320	HIGH GPCD
	246	233	221	214	214	214	A/CONSERVATION
	312	296	280	272	272	272	H/CONSERVATION
353 LEON VALLEY	110	110	110	110	110	110	AVG GPCD
	140	140	140	140	140	140	HIGH GPCD
	107	102	96	94	94	94	A/CONSERVATION
	137	130	123	119	119	119	H/CONSERVATION
361 LIVE OAK	131	131	131	131	131	131	AVG GPCD
	166	166	166	166	166	166	HIGH GPCD
	128	121	115	111	111	111	A/CONSERVATION
	162	154	145	141	141	141	H/CONSERVATION

CITY		1990	2000	2010	2020	2030	2040	
374	LYTLE	178	178	178	178	178	178	AVG GPCD
		202	202	202	202	202	202	HIGH GPCD
		174	165	156	151	151	151	A/CONSERVATION
		197	187	177	172	172	172	H/CONSERVATION
425	NATALIA	110	110	110	110	110	110	AVG GPCD
		140	140	140	140	140	140	HIGH GPCD
		107	102	96	94	94	94	A/CONSERVATION
		137	130	123	119	119	119	H/CONSERVATION
430	NEW BRAUNFELS	231	231	231	231	231	231	AVG GPCD
		257	257	257	257	257	257	HIGH GPCD
		225	214	202	196	196	196	A/CONSERVATION
		251	238	225	218	218	218	H/CONSERVATION
440	OLMOS PARK	192	192	192	192	192	192	AVERAGE GPCD
		228	228	228	228	228	228	HIGH GPCD
		187	178	168	163	163	163	A/CONSERVATION
		222	211	200	194	194	194	H/CONSERVATION
473	PLEASANTON	110	110	110	110	110	110	AVG GPCD
		151	151	151	151	151	151	HIGH GPCD
		107	102	96	94	94	94	A/CONSERVATION
		147	140	132	128	128	128	H/CONSERVATION
483	POTEET	160	160	160	160	160	160	AVG GPCD
		210	210	210	210	210	210	HIGH GPCD
		156	148	140	136	136	136	A/CONSERVATION
		205	194	184	179	179	179	H/CONSERVATION
492	RANDOLPH AFB	300	300	300	300	300	300	AVG GPCD
		377	377	377	377	377	377	HIGH GPCD
		293	278	263	255	255	255	A/CONSERVATION
		368	349	330	320	320	320	H/CONSERVATION
526	SABINAL	203	203	203	203	203	203	AVG GPCD
		246	246	246	246	246	246	HIGH GPCD
		198	188	178	173	173	173	A/CONSERVATION
		240	228	215	209	209	209	H/CONSERVATION
530	SAN ANTONIO	185	185	185	185	185	185	AVG GPCD
		208	208	208	208	208	208	HIGH GPCD
		180	171	162	157	157	157	A/CONSERVATION
		203	192	182	177	177	177	H/CONSERVATION

CITY		1990	2000	2010	2020	2030	2040	
537	SAN MARCOS	211	211	211	211	211	211	AVG GPCD
		238	238	238	238	238	238	HIGH GPCD
		206	195	185	179	179	179	A/CONSERVATION
		232	220	208	202	202	202	H/CONSERVATION
543	SCHERTZ	143	143	143	143	143	143	AVG GPCD
		182	182	182	182	182	182	HIGH GPCD
		139	132	125	122	122	122	A/CONSERVATION
		177	168	159	155	155	155	H/CONSERVATION
600	TERRELL HILLS	185	185	185	185	185	185	AVG GPCD
		207	207	207	207	207	207	HIGH GPCD
		180	171	162	157	157	157	A/CONSERVATION
		202	191	181	176	176	176	H/CONSERVATION
614	UNIVERSAL CITY	159	159	159	159	159	159	AVG GPCD
		202	202	202	202	202	202	HIGH GPCD
		155	147	139	135	135	135	A/CONSERVATION
		197	187	177	172	172	172	H/CONSERVATION
616	UVALDE	267	267	267	267	267	267	AVG GPCD
		302	302	302	302	302	302	HIGH GPCD
		260	247	234	227	227	227	A/CONSERVATION
		294	279	264	257	257	257	H/CONSERVATION
658	WINDCREST	196	196	196	196	196	196	AVG GPCD
		228	228	228	228	228	228	HIGH GPCD
		191	181	172	167	167	167	A/CONSERVATION
		222	211	200	194	194	194	H/CONSERVATION
744	SHAVANO PARK	292	292	292	292	292	292	AVG GPCD
		361	361	361	361	361	361	HIGH GPCD
		285	270	256	248	248	248	A/CONSERVATION
		352	334	316	307	307	307	H/CONSERVATION
747	SOMERSET	110	110	110	110	110	110	AVG GPCD
		140	140	140	140	140	140	HIGH GPCD
		107	102	96	94	94	94	A/CONSERVATION
		137	130	123	119	119	119	H/CONSERVATION

RURAL		1990	2000	2010	2020	2030	2040	
007	ATASCOSA	111	111	111	111	111	111	AVG GPCD
		151	151	151	151	151	151	HIGH GPCD
		108	103	97	94	94	94	A/CONSERVATION
		147	140	132	128	128	128	H/CONSERVATION
015	BEXAR	187	187	187	187	187	187	AVG GPCD
		237	237	237	237	237	237	HIGH GPCD
		182	173	164	159	159	159	A/CONSERVATION
		231	219	207	201	201	201	H/CONSERVATION
046	COMAL	146	146	146	146	146	146	AVG GPCD
		184	184	184	184	184	184	HIGH GPCD
		142	135	128	124	124	124	A/CONSERVATION
		179	170	161	156	156	156	H/CONSERVATION
105	HAYS	129	129	129	129	129	129	AVG GPCD
		139	139	139	139	139	139	HIGH GPCD
		126	119	113	110	110	110	A/CONSERVATION
		136	129	122	118	118	118	H/CONSERVATION
136	KINNEY	182	182	182	182	182	182	AVG GPCD
		194	194	194	194	194	194	HIGH GPCD
		177	168	159	155	155	155	A/CONSERVATION
		189	179	170	165	165	165	H/CONSERVATION
163	MEDINA	120	120	120	120	120	120	AVG GPCD
		130	130	130	130	130	130	HIGH GPCD
		117	111	105	102	102	102	A/CONSERVATION
		127	120	114	111	111	111	H/CONSERVATION
232	UVALDE	118	118	118	118	118	118	AVG GPCD
		128	128	128	128	128	128	HIGH GPCD
		115	109	103	100	100	100	A/CONSERVATION
		125	118	112	109	109	109	H/CONSERVATION

TABLE 2.1-28

TECHNICAL DATA REVIEW PANEL

PROJECTIONS OF PER CAPITA WATER USE

Source: Texas Water Development Board,
1992 Draft Projections
Units: Gallons Per Capita Per Day

CITY #		2000	2010	2020	2030	2040	SERIES	CITY NAME
004	AVG	317	317	317	317	317	HIGH POP	ALAMO HEIGHTS
004	HIGH	392	392	392	392	392		
004	A-C	306	296	285	282	279		
004	H-C	379	365	352	349	347		
004	AVG	317	317	317	317	317	LOW POP	ALAMO HEIGHTS
004	HIGH	392	392	392	392	392		
004	A-C	306	296	285	282	279		
004	H-C	379	365	352	349	347		
034	AVG	187	187	187	187	187	HIGH POP	BALCONES HEIGHTS
034	HIGH	221	221	221	221	221		
034	A-C	179	171	164	161	159		
034	H-C	212	203	195	192	189		
034	AVG	187	187	187	187	187	LOW POP	BALCONES HEIGHTS
034	HIGH	221	221	221	221	221		
034	A-C	179	171	164	161	159		
034	H-C	212	203	195	192	189		
070	AVG	332	332	332	332	332	HIGH POP	BRACKETTVILLE
070	HIGH	377	377	377	377	377		
070	A-C	322	311	301	298	295		
070	H-C	365	353	341	338	335		
070	AVG	332	332	332	332	332	LOW POP	BRACKETTVILLE
070	HIGH	377	377	377	377	377		
070	A-C	321	311	301	298	295		
070	H-C	365	353	341	338	335		
761	AVG	110	110	110	110	110	HIGH POP	BUDA
761	HIGH	139	139	139	139	139		
761	A-C	103	95	90	88	87		
761	H-C	131	122	116	114	113		
761	AVG	110	110	110	110	110	LOW POP	BUDA
761	HIGH	139	139	139	139	139		
761	A-C	103	95	90	88	87		
761	H-C	131	122	116	114	113		

CITY #		2000	2010	2020	2030	2040	SERIES	CITY NAME
100	AVG	261	261	261	261	261	HIGH POP	CASTLE HILLS
100	HIGH	317	317	317	317	317		
100	A-C	253	246	239	237	234		
100	H-C	308	299	291	288	286		
100	AVG	261	261	261	261	261	LOW POP	CASTLE HILLS
100	HIGH	317	317	317	317	317		
100	A-C	253	246	240	237	234		
100	H-C	308	299	291	288	286		
101	AVG	246	246	246	246	246	HIGH POP	CASTROVILLE
101	HIGH	312	312	312	312	312		
101	A-C	235	225	215	212	210		
101	H-C	299	286	274	271	269		
101	AVG	246	246	246	246	246	LOW POP	CASTROVILLE
101	HIGH	312	312	312	312	312		
101	A-C	235	225	215	212	210		
101	H-C	299	286	274	271	269		
107	AVG	186	186	186	186	186	HIGH POP	CHARLOTTE
107	HIGH	246	246	246	246	246		
107	A-C	179	170	163	160	158		
107	H-C	237	226	217	214	212		
107	AVG	186	186	186	186	186	LOW POP	CHARLOTTE
107	HIGH	246	246	246	246	246		
107	A-C	179	170	163	160	158		
107	H-C	237	226	217	214	212		
131	AVG	121	121	121	121	121	HIGH POP	CONVERSE
131	HIGH	162	162	162	162	162		
131	A-C	113	105	99	97	96		
131	H-C	153	143	136	134	133		
131	AVG	121	121	121	121	121	LOW POP	CONVERSE
131	HIGH	162	162	162	162	162		
131	A-C	113	106	100	98	96		
131	H-C	153	144	136	134	133		

CITY #		2000	2010	2020	2030	2040	SERIES	CITY NAME
162	AVG	159	159	159	159	159	HIGH POP	DEVINE
162	HIGH	179	179	179	179	179		
162	A-C	151	144	137	134	132		
162	H-C	171	162	155	152	149		
162	AVG	159	159	159	159	159	LOW POP	DEVINE
162	HIGH	179	179	179	179	179		
162	A-C	152	144	137	134	132		
162	H-C	171	162	155	152	149		
769	AVG	198	198	198	198	198	HIGH POP	DRIPPING SPRINGS
769	HIGH	218	218	218	218	218		
769	A-C	189	180	173	171	170		
769	H-C	209	199	191	189	188		
769	AVG	198	198	198	198	198	LOW POP	DRIPPING SPRINGS
769	HIGH	218	218	218	218	218		
769	A-C	189	180	173	171	170		
769	H-C	209	199	191	189	188		
771	AVG	393	393	393	393	393	HIGH POP	FAIROAKS RANCH
771	HIGH	449	449	449	449	449		
771	A-C	380	367	355	353	352		
771	H-C	434	419	405	403	402		
771	AVG	393	393	393	393	393	LOW POP	FAIROAKS RANCH
771	HIGH	449	449	449	449	449		
771	A-C	380	367	356	353	352		
771	H-C	434	419	406	403	402		
211	AVG	235	235	235	235	235	HIGH POP	FORT SAM HOUSTON
211	HIGH	270	270	270	270	270		
211	A-C	227	219	210	207	204		
211	H-C	261	251	242	238	235		
211	AVG	235	235	235	235	235	LOW POP	FORT SAM HOUSTON
211	HIGH	270	270	270	270	270		
211	A-C	227	219	210	207	204		
211	H-C	261	251	242	238	235		

CITY #		2000	2010	2020	2030	2040	SERIES	CITY NAME
773	AVG	266	266	266	266	266	HIGH POP	GARDEN RIDGE
773	HIGH	303	303	303	303	303		
773	A-C	255	245	236	234	232		
773	H-C	291	279	269	267	265		
773	AVG	266	266	266	266	266	LOW POP	GARDEN RIDGE
773	HIGH	303	303	303	303	303		
773	A-C	256	245	236	234	232		
773	H-C	291	279	269	267	265		
777	AVG	184	184	184	184	184	HIGH POP	HELOTES
777	HIGH	208	208	208	208	208		
777	A-C	176	167	160	157	156		
777	H-C	199	189	181	179	177		
777	AVG	184	184	184	184	184	LOW POP	HELOTES
777	HIGH	208	208	208	208	208		
777	A-C	176	167	160	158	156		
777	H-C	199	190	182	179	177		
778	AVG	337	337	337	337	337	HIGH POP	HILL COUNTRY VILLAGE
778	HIGH	351	351	351	351	351		
778	A-C	326	315	306	303	301		
778	H-C	340	328	318	316	314		
778	AVG	337	337	337	337	337	LOW POP	HILL COUNTRY VILLAGE
778	HIGH	351	351	351	351	351		
778	A-C	326	315	306	303	301		
778	H-C	340	328	318	316	314		
281	AVG	375	375	375	375	375	HIGH POP	HOLLYWOOD PARK
281	HIGH	476	476	476	476	476		
281	A-C	363	350	339	337	335		
281	H-C	460	444	430	427	425		
281	AVG	375	375	375	375	375	LOW POP	HOLLYWOOD PARK
281	HIGH	476	476	476	476	476		
281	A-C	363	351	339	337	335		
281	H-C	460	444	430	427	426		

CITY #		2000	2010	2020	2030	2040	SERIES	CITY NAME
282	AVG	241	241	241	241	241	HIGH POP	HONDO
282	HIGH	291	291	291	291	291		
282	A-C	232	222	213	210	208		
282	H-C	280	268	257	255	252		
282	AVG	241	241	241	241	241	LOW POP	HONDO
282	HIGH	291	291	291	291	291		
282	A-C	232	222	213	211	208		
282	H-C	280	269	258	255	252		
309	AVG	169	169	169	169	169	HIGH POP	JOURDANTON
309	HIGH	224	224	224	224	224		
309	A-C	161	153	146	143	141		
309	H-C	214	204	195	192	190		
309	AVG	169	169	169	169	169	LOW POP	JOURDANTON
309	HIGH	224	224	224	224	224		
309	A-C	161	153	146	143	141		
309	H-C	214	204	195	192	191		
325	AVG	137	137	137	137	137	HIGH POP	KIRBY
325	HIGH	186	186	186	186	186		
325	A-C	130	122	115	113	111		
325	H-C	177	167	159	157	155		
325	AVG	137	137	137	137	137	LOW POP	KIRBY
325	HIGH	186	186	186	186	186		
325	A-C	130	122	116	113	111		
325	H-C	177	168	160	157	155		
330	AVG	118	118	118	118	118	HIGH POP	KYLE
330	HIGH	170	170	170	170	170		
330	A-C	112	105	100	97	95		
330	H-C	162	153	146	144	141		
330	AVG	118	118	118	118	118	LOW POP	KYLE
330	HIGH	170	170	170	170	170		
330	A-C	112	105	100	97	95		
330	H-C	162	154	146	144	141		

CITY #		2000	2010	2020	2030	2040	SERIES	CITY NAME
331	AVG	286	286	286	286	286	HIGH POP	LACKLAND AFB
331	HIGH	363	363	363	363	363		
331	A-C	277	267	258	255	252		
331	H-C	351	339	327	324	321		
331	AVG	286	286	286	286	286	LOW POP	LACKLAND AFB
331	HIGH	363	363	363	363	363		
331	A-C	277	267	258	255	252		
331	H-C	351	339	327	324	321		
786	AVG	197	197	197	197	197	HIGH POP	LACOSTE
786	HIGH	227	227	227	227	227		
786	A-C	188	178	171	169	167		
786	H-C	217	206	198	196	194		
786	AVG	197	197	197	197	197	LOW POP	LACOSTE
786	HIGH	227	227	227	227	227		
786	A-C	188	178	171	169	167		
786	H-C	217	206	198	196	194		
353	AVG	110	110	110	110	110	HIGH POP	LEON VALLEY
353	HIGH	139	139	139	139	139		
353	A-C	104	98	92	89	86		
353	H-C	132	124	118	115	112		
353	AVG	110	110	110	110	110	LOW POP	LEON VALLEY
353	HIGH	139	139	139	139	139		
353	A-C	104	98	92	89	86		
353	H-C	132	125	118	115	112		
361	AVG	114	114	114	114	114	HIGH POP	LIVE OAK
361	HIGH	194	194	194	194	194		
361	A-C	107	100	93	91	89		
361	H-C	184	174	165	162	161		
361	AVG	114	114	114	114	114	LOW POP	LIVE OAK
361	HIGH	194	194	194	194	194		
361	A-C	107	100	94	91	89		
361	H-C	184	174	165	163	161		

CITY #		2000	2010	2020	2030	2040	SERIES	CITY NAME
374	AVG	181	181	181	181	181	HIGH POP	LYTLE
374	HIGH	202	202	202	202	202		
374	A-C	172	164	157	154	152		
374	H-C	193	183	175	173	171		
374	AVG	181	181	181	181	181	LOW POP	LYTLE
374	HIGH	202	202	202	202	202		
374	A-C	173	164	157	154	152		
374	H-C	193	184	176	173	171		
425	AVG	110	110	110	110	110	HIGH POP	NATALIA
425	HIGH	155	155	155	155	155		
425	A-C	103	96	91	89	87		
425	H-C	146	138	131	129	127		
425	AVG	110	110	110	110	110	LOW POP	NATALIA
425	HIGH	155	155	155	155	155		
425	A-C	104	97	91	89	86		
425	H-C	147	139	132	129	126		
430	AVG	237	237	237	237	237	HIGH POP	NEW BRAUNFELS
430	HIGH	271	271	271	271	271		
430	A-C	229	220	212	210	208		
430	H-C	262	251	243	241	239		
430	AVG	237	237	237	237	237	LOW POP	NEW BRAUNFELS
430	HIGH	271	271	271	271	271		
430	A-C	229	221	213	211	208		
430	H-C	262	253	244	241	239		
440	AVG	188	188	188	188	188	HIGH POP	OLMOS PARK
440	HIGH	228	228	228	228	228		
440	A-C	180	172	165	162	160		
440	H-C	219	210	201	198	196		
440	AVG	188	188	188	188	188	LOW POP	OLMOS PARK
440	HIGH	228	228	228	228	228		
440	A-C	180	172	165	162	160		
440	H-C	219	210	201	198	196		

CITY #		2000	2010	2020	2030	2040	SERIES	CITY NAME
473	AVG	135	135	135	135	135	HIGH POP	PLEASANTON
473	HIGH	179	179	179	179	179		
473	A-C	128	120	114	112	110		
473	H-C	170	161	153	151	149		
473	AVG	135	135	135	135	135	LOW POP	PLEASANTON
473	HIGH	179	179	179	179	179		
473	A-C	128	121	114	112	110		
473	H-C	170	161	154	151	149		
483	AVG	199	199	199	199	199	HIGH POP	POTEET
483	HIGH	264	264	264	264	264		
483	A-C	190	182	175	172	170		
483	H-C	253	242	233	230	228		
483	AVG	199	199	199	199	199	LOW POP	POTEET
483	HIGH	264	264	264	264	264		
483	A-C	190	182	175	172	170		
483	H-C	253	243	233	231	228		
492	AVG	322	322	322	322	322	HIGH POP	RANDOLPH AFB
492	HIGH	377	377	377	377	377		
492	A-C	312	302	292	289	285		
492	H-C	365	353	341	338	335		
492	AVG	322	322	322	322	322	LOW POP	RANDOLPH AFB
492	HIGH	377	377	377	377	377		
492	A-C	312	302	292	289	285		
492	H-C	365	353	341	338	335		
526	AVG	189	189	189	189	189	HIGH POP	SABINAL
526	HIGH	238	238	238	238	238		
526	A-C	181	172	165	163	161		
526	H-C	228	218	209	207	205		
526	AVG	189	189	189	189	189	LOW POP	SABINAL
526	HIGH	238	238	238	238	238		
526	A-C	181	173	165	163	161		
526	H-C	228	218	210	207	205		

CITY #		2000	2010	2020	2030	2040	SERIES	CITY NAME
530	AVG	184	184	184	184	184	HIGH POP	SAN ANTONIO
530	HIGH	208	208	208	208	208		
530	A-C	178	170	164	161	159		
530	H-C	201	193	185	183	181		
530	AVG	184	184	184	184	184	LOW POP	SAN ANTONIO
530	HIGH	208	208	208	208	208		
530	A-C	178	171	164	161	159		
530	H-C	201	193	186	183	181		
537	AVG	217	217	217	217	217	HIGH POP	SAN MARCOS
537	HIGH	238	238	238	238	238		
537	A-C	209	201	194	192	191		
537	H-C	230	220	213	211	210		
537	AVG	217	217	217	217	217	LOW POP	SAN MARCOS
537	HIGH	238	238	238	238	238		
537	A-C	210	201	195	192	191		
537	H-C	230	221	214	211	210		
543	AVG	157	157	157	157	157	HIGH POP	SCHERTZ
543	HIGH	196	196	196	196	196		
543	A-C	149	142	135	133	131		
543	H-C	186	178	170	168	166		
543	AVG	157	157	157	157	157	LOW POP	SCHERTZ
543	HIGH	196	196	196	196	196		
543	A-C	149	142	135	133	131		
543	H-C	186	178	170	168	166		
744	AVG	318	318	318	318	318	HIGH POP	SHAVANO PARK
744	HIGH	404	404	404	404	404		
744	A-C	305	292	281	278	276		
744	H-C	388	372	358	355	353		
744	AVG	318	318	318	318	318	LOW POP	SHAVANO PARK
744	HIGH	404	404	404	404	404		
744	A-C	305	292	281	278	276		
744	H-C	388	372	358	355	353		

CITY #		2000	2010	2020	2030	2040	SERIES	CITY NAME
747	AVG	110	110	110	110	110	HIGH POP	SOMERSET
747	HIGH	139	139	139	139	139		
747	A-C	104	98	92	89	86		
747	H-C	132	125	118	115	112		
747	AVG	110	110	110	110	110	LOW POP	SOMERSET
747	HIGH	139	139	139	139	139		
747	A-C	104	98	92	90	86		
747	H-C	132	125	118	115	112		
802	AVG	133	133	133	133	133	HIGH POP	ST. HEDWIG
802	HIGH	145	145	145	145	145		
802	A-C	126	118	112	109	108		
802	H-C	137	129	122	120	119		
802	AVG	133	133	133	133	133	LOW POP	ST. HEDWIG
802	HIGH	145	145	145	145	145		
802	A-C	126	118	112	110	108		
802	H-C	137	129	123	121	119		
600	AVG	183	183	183	183	183	HIGH POP	TERRELL HILLS
600	HIGH	207	207	207	207	207		
600	A-C	176	168	161	158	155		
600	H-C	199	190	182	179	177		
600	AVG	183	183	183	183	183	LOW POP	TERRELL HILLS
600	HIGH	207	207	207	207	207		
600	A-C	176	168	161	158	155		
600	H-C	199	190	182	179	177		
614	AVG	169	169	169	169	169	HIGH POP	UNIVERSAL CITY
614	HIGH	206	206	206	206	206		
614	A-C	161	152	145	143	141		
614	H-C	197	187	178	176	174		
614	AVG	169	169	169	169	169	LOW POP	UNIVERSAL CITY
614	HIGH	206	206	206	206	206		
614	A-C	161	153	146	143	141		
614	H-C	197	187	179	176	174		

CITY #		2000	2010	2020	2030	2040	SERIES	CITY NAME
616	AVG	255	255	255	255	255	HIGH POP	UVALDE
616	HIGH	300	300	300	300	300		
616	A-C	245	234	225	222	220		
616	H-C	288	276	265	262	261		
616	AVG	255	255	255	255	255	LOW POP	UVALDE
616	HIGH	300	300	300	300	300		
616	A-C	245	234	225	222	220		
616	H-C	288	276	265	262	261		
658	AVG	198	198	198	198	198	HIGH POP	WINDCREST
658	HIGH	247	247	247	247	247		
658	A-C	191	184	178	175	172		
658	H-C	239	230	222	219	216		
658	AVG	198	198	198	198	198	LOW POP	WINDCREST
658	HIGH	247	247	247	247	247		
658	A-C	191	184	178	175	172		
658	H-C	239	230	222	219	216		

COUNTY		2000	2010	2020	2030	2040	SERIES	COUNTY NAME	
007	AVG	111	111	111	111	111	HIGH POP	ATASCOSA	COUNTY RURAL
007	HIGH	123	123	123	123	123			
007	A-C	104	97	92	89	88			
007	H-C	116	108	103	100	98			
007	AVG	111	111	111	111	111	LOW POP	ATASCOSA	COUNTY RURAL
007	HIGH	123	123	123	123	123			
007	A-C	105	98	92	90	88			
007	H-C	116	109	103	100	98			
015	AVG	189	189	189	189	189	HIGH POP	BEXAR	COUNTY RURAL
015	HIGH	240	240	240	240	240			
015	A-C	180	171	164	162	161			
015	H-C	229	219	210	208	206			
015	AVG	189	189	189	189	189	LOW POP	BEXAR	COUNTY RURAL
015	HIGH	240	240	240	240	240			
015	A-C	180	172	165	162	161			
015	H-C	229	219	210	208	206			
046	AVG	149	149	149	149	149	HIGH POP	COMAL	COUNTY RURAL
046	HIGH	189	189	189	189	189			
046	A-C	141	133	126	124	123			
046	H-C	179	170	162	160	159			
046	AVG	149	149	149	149	149	LOW POP	COMAL	COUNTY RURAL
046	HIGH	189	189	189	189	189			
046	A-C	141	133	126	124	123			
046	H-C	179	170	162	160	159			
105	AVG	124	124	124	124	124	HIGH POP	HAYS	COUNTY RURAL
105	HIGH	134	134	134	134	134			
105	A-C	116	108	103	101	100			
105	H-C	126	117	112	110	109			
105	AVG	124	124	124	124	124	LOW POP	HAYS	COUNTY RURAL
105	HIGH	134	134	134	134	134			
105	A-C	117	109	103	102	100			
105	H-C	126	118	112	111	109			

COUNTY		2000	2010	2020	2030	2040	SERIES	COUNTY NAME	
136	AVG	187	187	187	187	187	HIGH POP	KINNEY	COUNTY RURAL
136	HIGH	218	218	218	218	218			
136	A-C	179	171	164	161	159			
136	H-C	209	200	191	189	187			
136	AVG	187	187	187	187	187	LOW POP	KINNEY	COUNTY RURAL
136	HIGH	218	218	218	218	218			
136	A-C	180	171	163	161	159			
136	H-C	210	200	191	189	186			
163	AVG	125	125	125	125	125	HIGH POP	MEDINA	COUNTY RURAL
163	HIGH	147	147	147	147	147			
163	A-C	118	111	105	102	100			
163	H-C	139	131	124	122	120			
163	AVG	125	125	125	125	125	LOW POP	MEDINA	COUNTY RURAL
163	HIGH	147	147	147	147	147			
163	A-C	118	111	105	102	100			
163	H-C	139	131	124	122	120			
232	AVG	117	117	117	117	117	HIGH POP	UVALDE	COUNTY RURAL
232	HIGH	127	127	127	127	127			
232	A-C	111	105	99	96	92			
232	H-C	120	114	108	105	101			
232	AVG	117	117	117	117	117	LOW POP	UVALDE	COUNTY RURAL
232	HIGH	127	127	127	127	127			
232	A-C	111	105	99	96	92			
232	H-C	121	114	108	105	101			

Technical Data Review Panel
ANNUAL SPRINGFLOW DATA SETS
COMAL & SAN MARCOS SPRINGS

UNITS: ACRE-FEET

YEAR	Col. 1 USGS GAGE COMAL RIVER AT NEW BRAUN. (1)	Col. 2 USGS COMAL SPRS. AT NEW BRAUN. (2)	Col. 3 TWDB COMAL SPRINGS (3)	Col. 4 GBRA/SARA/CSA 1986 REPORT COMAL SPRS. (4)	Col. 5 USGS GAGE SAN MARCOS RIVER FLOW (5)	Col. 6 TWDB SAN MARCOS SPRINGS (6)	Col. 7 GBRA/SARA/CSA 1986 REPORT SAN MARCOS SPRINGS (7)
1928	138200						
1929	173700						
1930	146200						
1931	191000						
1932	195300						
1933	225500						
1934	230130	227939	228073				
1935	244130	236119	236280				
1936	271280	260078	260816				
1937	259190	251464	250764				
1938	265400	248279	248354				
1939	168140	218022	217872				
1940	208430	201808	202412	208430		76989	76989
1941	260720	248424	248568	260720		132776	132776
1942	265140	252839	252958	265140		111900	111900
1943	247490	246976	246789	247490		96332	96332
1944	254940	250740	251488	254940		134096	134096
1945	270840	260802	260755	270840		138043	138043
1946	276320	259716	260045	276320		150511	150511
1947	257900	255156	254828	257900		125416	125416
1948	201120	200650	201071	201070		76250	76250
1949	212020	207092	207306	212020		87061	86461
1950	189700	189069	189041	189700		76492	76492
1951	148860	148533	148318	148860		68600	68618
1952	162400	132102	132450	162400		75051	75102
1953	142670	139051	138905	142670		97859	97859
1954	98360	98515	98344	98360		76731	75449
1955	66820	66377	66120	66820		61162	61148
1956 (8)	27997	22367	22340	27997		47564	47564
1957	138740	103148	103386	138740	110280	110270	110270
1958	234080	226347	226452	234080	153440	153440	153440
1959	229240	227071	226992	229240	116060	116050	116050
1960	241690	229821	230479	241690	141410	141410	141410
1961	247960	241765	241715	247960	138260	138260	138260
1962	193470	192181	192054	193380	95850	95850	95850
1963	150800	150632	150290	150800	78710	78710	78710

TABLE 2.2-1

YEAR	Col. 1 USGS GAGE COMAL RIVER AT NEW BRAUN. (1)	Col. 2 USGS COMAL SPRS. AT NEW BRAUN. (2)	Col. 3 TWDB COMAL SPRINGS (3)	Col. 4 GBRA/SARA/CSA 1986 REPORT COMAL SPRS. (4)	Col. 5 USGS GAGE SAN MARCOS RIVER FLOW (5)	Col. 6 TWDB SAN MARCOS SPRINGS (6)	Col. 7 GBRA/SARA/CSA 1986 REPORT SAN MARCOS SPRINGS (7)
1964	138562	136952	137137	138560	70180	70180	70180
1965	209230	188490	188585	209230	123020	123020	123020
1966	193430	193122	192969	193430	111360	111360	111360
1967	136450	131306	131044	136450	77650	77650	77650
1968	246750	230762	231387	246750	143060	143060	143060
1969	212380	210639	210547	212380	117820	117820	117820
1970	226600	221173	221176	226650	144570	144570	144570
1971	159800	158975	158978	159810	91850	91850	91850
1972	264600	225124	225127	264550	116650	116650	116650
1973	294000	279239	279243	294010	158200	158200	158200
1974	283800	275377	275381	283820	133770	133770	133770
1975	295400	286183	286187	295430	170090	167390	167390
1976	280100	268905	268909	280110	153140	153140	153140
1977	289700	282831	282835	289690	161710	161550	161550
1978	239900	233488	233492	239880	87410	87410	87410
1979	292700	287724	287728	292730	144950	144950	144950
1980	207200	206350	206353	207240	95950	95950	95950
1981	234500	228686	228690	234460	131000	131000	131000
1982	201200	198127	198130	201200	93490	93490	93490
1983	172000	171102	171105		106250	110380	
1984	91470	91087	91088		72346	72350	
1985	192540	184463	184466		132022	136880	
1986	214200	209807	209811		145470	145470	
1987	271600	262522	262526		183520	183520	
1988	201000	200598	200601		102000	102020	
1989	118300		118317			72520	
1990						60850	
AVERAGES							
1928–88	209557						
1934–88	212965	206475	206523				
1940–82		204526	204581	212417		111391	111349
1957–88					121922	122113	

(1) USGS continuous recording stream gage

(2) USGS subtracts estimate of surface drainage from 130 square miles of drainage area

(3) TWDB data set used in Report 340, Model Refinement and Applications for the Edwards (Balcones Fault Zone) Aquifer in the San Antonio Region, Texas, Texas Water Development Board, July 1992, Draft.

(4) Guadalupe-Blanco River Authority, San Antonio River Authority, City of San Antonio Report, Water Availability Study for the Guadalupe and San Antonio River Basins, Espey Huston and Associates, 1986

(5) USGS continuous recording stream gage

(6) USGS subtracts estimate of surface drainage from 93 square miles of drainage area

(7) TWDB data set used in Report 340, Model Refinement and Applications for the Edwards (Balcones Fault Zone) Aquifer in the San Antonio Region, Texas, Texas Water Development Board, July 1992, Draft.

(8) Comal Springs did not flow from June 13 to November 3, 1956

Technical Data Review Panel
ANNUAL SPRINGFLOW DATA - ALL SPRINGS

SOURCE: UNITED STATES GEOLOGICAL SURVEY
UNITS: ACRE-FEET

	COMAL PLUS SAN MARCOS SPRINGS (1)	HUECO SPRINGS (2)	SAN ANTONIO SPRINGS (2)	SAN PEDRO SPRINGS (2)	LEONA SPRINGS UNDER-FLOW (2)	LEONA SPRINGS SPRINGS (2)	LEONA SPRINGS SPRINGS & UNDFL. (2)	TOTAL SPRINGS SUM OF ESTIMATE (3)	TOTAL REPORTED IN EUWD BULLETIN (4)	DIFFERENCE TOTAL REP. MINUS SUM OF EST. (5)
1970	365743		2431	4220	9523	15547	(6)	397463	397700	237
1971	250825		813	1175	8737	11201		272752	272700	-52
1972	341774		1381	4164			28452	375771	375800	29
1973	437439		47767	6755	9599	25705		527265	527600	335
1974	409147		32536	5687			36517	483887	483800	-87
1975	456273		34068	6024			44023	540388	540400	12
1976	422045		34399	6264			40930	503638	503900	262
1977	444541		71542	9827	9523	45076		580508	580300	-208
1978	320898		18383	4355	8350	23342		375328	375500	172
1979	432674		47009	7494	9599	26125		522902	523000	98
1980	302300		4579	2167	8550	10744		328340	328300	-40
1981	359686		17026	4818	8209	18364		408104	407300	-804
1982	291617		6162	2529	8271	24683		333262	333300	38
1983	277352		117	1062	8182	14721		301434	301600	166
1984	163433		0	224	6172	2734		172563	172500	-63
1985	316485		0	0	8102	8080		332667	334000	1333
1986	355277		4207	2860			(7)	(7)	388100	N/A
1987	446042		42909	8114	(7)	(7)		(7)	558000	N/A
1988	302598	13126	10993	3492	(7)	(7)		(7)	369800	N/A

(1) Sum of Comal Springs component of measured flow at Comal River at New Braunfels gage and San Marcos River Flow at San Marcos gage (values in Table 2.2-1, cols. 2 and 5)

(2) Values from USGS working files on water use reports, in some years

(3) Sum of previous columns

(4) Excerpted from USGS publication Compilation of Hydrologic Data for Edwards Aquifer, San Antonio Area, Texas, 1989, with 1934-89 Summary, Bulletin 49.

(5) Total reported by USGS in Bulletin 49 minus sum of estimates of individual springs

(6) In some years Leona Springs and Leona Underflow estimated separately, in other years together

(7) Leona Springs estimates not available in USGS files for years 1986, 87,88

TABLE 2.2-3
Technical Data Review Panel
UNITED STATES GEOLOGICAL SURVEY
STREAM GAGES IN GUADALUPE, SAN ANTONIO AND NUECES BASINS

Rivers	USGS Reference Number	Location	Drainage Area (SQ MI)	Period of Record
Nueces	1900	Nueces R., Laguna	737	10/23-pres.
	1905	W. Nueces R., Bracketville	694	10/39-9/50, 4/56-pres.
	1920	Nueces R., Uvalde	1861	10/27-pres.
	1930	Nueces R., Asherton	4082	10/39-pres.
	1940	Nueces R., Cotulla	5171	11/23-pres.
	1942	San Casimiro C., Freer	469	1/62-pres.
	1945	Nueces R., Tilden	8093	12/42-pres.
	1946	Nueces R., Simmons	8561	4/65-9/77
	1950	Frio R., Concan	389	11/23-9/29, 10/30-pres.
	1960	Dry Frio R., Reagan Wells	126	9/52-pres.
	1975	Frio R., below Dry Frio R. near Uvalde	631	9/52-pres.
	1980	Sabinal R., Sabinal	206	10/42-pres.
	1985	Sabinal R., Sabinal	241	9/52-pres.
	2000	Hondo C., Tarpley	95.6	9/52-pres.
	2005	Hondo C., Hondo	132	8/52-10/64
	2007	Hondo C., Hondo	149	10/60-pres.
	2015	Seco C.,Utopia	45.0	5/61-pres.
	2020	Seco C., Utopia	53.2	8/52-9/61
	2025	Seco C., D'Hanis	87.4	8/52-10/64
	2027	Seco C., D'Hanis	168	10/60-pres.
	2040	Leona R., Uvalde	Spring	1/39-9/65
	2055	Frio R., Derby	3429	8/15-pres.
	2066	Frio R., Tilden	4493	10/78-pres.
	2067	San Miguel C., Tilden	783	2/64-pres.
	2070	Frio R., Calliham	5491	10/24-4/26, 5/32-8/81
	2075	Atascosa R., McCoy	530	8/51-8/57
	2080	Atascosa R.,Whitsett	1171	10/25-4/26, 6/32-pres.
	2100	Nueces R., Three Rivers	15427	7/15-pres.

	2104	Lagarto C., George West	155	10/71-pres.
	2110	Nueces R., Mathis	16660	9/39-pres.
	Lake	Choke Canyon Reservoir	5490	10/82-pres.
	Lake	Lake Corpus Christi	16656	9/48-pres.
Guadalupe River	1655	Guadalupe R., Hunt	288	5/65-pres.
	1660	Johnson C., Ingram	114	10/61-pres.
	1670	Guadalupe R., Comfort	838	6/39-pres.
	1675	Guadalupe R., Spring Branch	1315	7/22-pres.
	1677	Guadalupe R., Canyon Lake	1432	7/62-pres.
	1978	Guadalupe R., Settler	1436	3/60-pres.
	1685	Guadalupe R., above Comal R.	1518	1/28-pres.
	1690	Comal R., New Braunfels	130	1/28-pres.
	1700	San Marcos R., Springflow San Marcos	93	6/56-pres.
	1710	Blanco R., Wimberley	355	7/28-pres.
	1713	Blanco R., Kyle	412	6/56-pres.
	1720	San Marcos R., Luling	838	5/39-pres.
	1724	Plum C., Lockhart	112	5/59-pres.
	1730	Plum C., Luling	309	4/30-pres.
	1746	Peach C.	460	8/59-9/79
	1750	Sandies C., Westhoff	549	8/59-pres.
	1758	Guadalupe R., Cuero	4934	1/64-pres.
	1765	Guadalupe R., Victoria	5198	12/34-pres.
San Antonio	1774	Coleto Creek Reservoir	494	2/80-pres.
	1780	San Antonio R., San Antonio	41.8	3/39-pres.
	1787	Salado C., Upper, San Antonio	137	10/60-pres.
	1788	Salado C., Lower, San Antonio	189	10/60-pres.
	1790	Medina R.	474	10/52-9/82
	1795	Medina Lake	634	4/13-pres.
	1808	Medina R., Somerset	967	10/70-pres.
	1815	Medina R., San Antonio	1317	8/39-pres.
	1818	San Antonio R., Elmendorf	1743	10/62-pres.
	1825	Calaveras C.	77.2	10/54-9/71
	1835	San Antonio R., Falls City	2113	5/25-pres.
	1839	Cibolo C., Boerne	68.4	3/62-pres.
	1850	Cibolo C., Selma	274	4/46-pres.

	1860	Cibolo C., Falls City	827	10/30-pres.
	1865	Ecleto C., Range	239	4/62-9/89
	1885	San Antonio R., Goliad	3921	3/39-pres.
Guadalupe	1888	Guadalupe R., Tivoli	10128	9/65-pres.

TEXAS WATER DEVELOPMENT BOARD

P.O. BOX 13231, CAPITOL STATION
AUSTIN, TEXAS 78711-3231

SURVEY OF GROUND AND SURFACE WATER USE FOR THE CALENDAR YEAR ENDING DECEMBER 31,

TWDB CODE NO.

DUPLICATE RETAIN FOR YOUR FILES

Figure 2.1-1

SURVEY OF GROUND AND SURFACE WATER USE
MUNICIPAL USE

CONVERSION FACTORS
1 Acre Foot = 325,851 Gallons
1 Cubic Foot = 7.481 Gallons

Please indicate any changes in name and address or ownership.

I. GROUND (WELL) WATER USE:

Please answer the following questions if you used ground water for this system (including ground water purchased from others).

A. County(ies) in which this system operates ________

B. If water wells are owned, operated, or leased for use in this system, please complete the following: Number of active wells and county(ies) where located ________; inactive (but operable) ________.

C. If you purchased well water from others for use in this system, please name supplier(s) ________.

D. Was purchased water raw ☐ or treated ☐? If both, % raw ________ % treated ________.

E. Please complete the following table. Indicate the total quantity (gallons) of ground water purchased from others and the amount that was self-supplied. Self-supplied water is the total quantity produced from wells owned, operated or leased including any water sold to others. If you purchased well water from several suppliers, please provide separate volumes for each on additional paper.

MONTH	SELF SUPPLIED	PURCHASED	MONTH	SELF SUPPLIED	PURCHASED	MONTH	SELF SUPPLIED	PURCHASED
Jan			May			Sep		
Feb			Jun			Oct		
Mar			Jul			Nov		
Apr			Aug			Dec		

F. Total ground water intake during the calendar year for: Self-Supplied ________; Purchased ________

G. How did you arrive at the ground water use figures which you provided above? master meter ☐ customer meters ☐ estimated ☐ other ☐

1	27	28 29	30-32	33 35	36 37	38 41	42 43	49 80	To be filled in by TWDB
3									
3									
4									
A									

II. SURFACE WATER USE:

Please answer the following questions if you used surface water for this system (including surface water purchased from others).

A. County(ies) in which this system operates ________.

B. If you diverted surface water from a stream, river, pond, lake and/or reservoir for use in this system, please name the county ________; stream, reservoir, etc. ________

C. If you purchased surface water from others for use in this system, please name supplier(s) ________.

D. Was purchased water raw ☐ or treated ☐? If both, % raw ________ % treated ________.

E. Please complete the following table. Indicate the total quantity (gallons) of surface water purchased from others and the amount that was self-supplied. Self-supplied water is the total quantity of raw water you diverted including any water sold to others. If you purchased surface water from several suppliers, please provide separate volumes for each on additional paper.

MONTH	SELF SUPPLIED	PURCHASED	MONTH	SELF SUPPLIED	PURCHASED	MONTH	SELF SUPPLIED	PURCHASED
Jan			May			Sep		
Feb			Jun			Oct		
Mar			Jul			Nov		
Apr			Aug			Dec		

F. Total surface water intake during the calendar year for: Self-Supplied ________; Purchased ________

G. How did you arrive at the surface water use figures which you provided above? master meter ☐ customer meters ☐ estimated ☐ other ☐

1	27	28 29	30 32	33 35	36 37	38 41	42 48	49 80	To be filled in by TWDB
3									
1									
5									

OVER

TWDB 0609A (Rev. 10-01-9?)
Municipal

III. WATER SALES: Please list the names, location [county(ies)], and the quantities of water you sold during the year to:

A. Industrial or commercial firms who purchased 10 million gallons or more from your system, (or any firm who you feel places a more than average demand on your supply), and
B. Public water systems who purchased all or part of their supply from you and operate outside your direct service area (i.e. other cities, water districts, private water companies, etc.)

Please indicate treated or raw fresh water. Use additional paper if needed. Include these amounts in questions I and II.

Name of Purchaser	Location [County(ies)]	Quantity Sold (Gallons)

C. Please indicate the total quantity billed to your customers during the past calendar year __________ (Gallons).

IV. PUBLIC WATER SUPPLIERS: Please complete parts applicable to this system. Responses should not include information for other wholesale water customers you listed in III (water sales) above.

A. Estimated total population served directly by this system__________.
B. Total number of service connections served directly by this system__________
C. Total number of service connections served directly by you outside city limits__________.
D. Percentage of total service connections that are metered__________%.
E. Percentage of the total service connections that are residential__________%; commercial__________%; industrial__________%.
F. Was it necessary to place water use restrictions into effect during the past year? Yes ☐ No ☐
If yes, what was the primary reason(s)? (1) inadequate supply ☐; (2) inadequate storage ☐; (3) inadequate treatment facilities ☐; (4) other (specify)__________.
G. Does this system's service lines extend into several counties? Yes ☐ No ☐
If yes, please indicate the estimated number of connections in each county.

County__________ No. Connections__________; County__________ No. Connections__________
County__________ No. Connections__________; County__________ No. Connections__________

H. Does this system directly serve an incorporated city(ies) not reflected in the system name as shown on page one of this report? Yes ☐ No ☐
If yes, please name the incorporated city(ies) and the estimated number of connections served in each city__________
____
I. If the primary use of water supplied by this system is not for normal municipal or residential use, please indicate its primary use (i.e. week end or non-resident use, apartment or office bldg., military installation, golf course, cemetery, etc.)__________
J. If treated wastewater (sewage effluent) from your plant is reused directly by you or is sold for other reuse, please indicate the volume in gallons that is used for:

(1) Industrial__________; (2) Irrigation (including parks, golf courses, etc.)__________;
(3) Other (specify)__________ By whom are these amounts used?__________
____

Please provide your water rate schedule in the space below, or attach a preprinted rate schedule if available.

WATER RATE SCHEDULE

Please make any additional comments you may feel will be of assistance to us in understanding your present and future water needs and water problems.__________

To assure our addressing future correspondence to the proper person, please type or print the following:
By.__________
Name Title Phone Date

TEXAS WATER DEVELOPMENT BOARD

P.O. BOX 13231, CAPITOL STATION
AUSTIN, TEXAS 78711-3231

SURVEY OF GROUND AND SURFACE WATER USE FOR CALENDAR YEAR ENDING DECEMBER 31,

TWDB CODE NO.

Figure 2.1-2

DUPLICATE RETAIN FOR YOUR FILES

SURVEY OF GROUND AND SURFACE WATER USE
INDUSTRIAL USE

CONVERSION FACTORS
1 Acre Foot = 325,851 Gallons
1 Cubic Foot = 7.481 Gallons

Please indicate any changes in name and address or ownership.

I. GROUND (WELL) WATER USE:

Please answer the following questions if you used ground water at this facility (including ground water purchased from others).

A. County(ies) in which this plant is located ______

B. If you own, operate, or lease water wells for use at this plant site, please complete the following: Number of active wells and county(ies) where located ______; inactive (but operable) ______.

C. If you purchased well water from others for this plant, please name supplier(s) ______.

D. Was purchased water raw ☐ or treated ☐? If both,% raw ______% treated ______.

E. Please complete the following table. Indicate the total quantity (gallons) of ground water purchased from others and the amount that was self-supplied. Self-supplied water is the total quantity produced from wells owned, operated or leased including any water sold to others. If you purchased well water from several suppliers, please provide separate volumes for each on additional paper.

MONTH	SELF SUPPLIED	PURCHASED	MONTH	SELF SUPPLIED	PURCHASED	MONTH	SELF SUPPLIED	PURCHASED
Jan			May			Sep		
Feb			Jun			Oct		
Mar			Jul			Nov		
Apr			Aug			Dec		

F. Total ground water intake during the calendar year for: Self-Supplied ______; Purchased ______.

G. How did you arrive at the ground water use figures which you provided above? master meter ☐ customer meters ☐ estimated ☐ other ☐

1 27 28 29 30 32 33 35 36-37 38 41 42 48 49 80 To be filled in by TWDB

II. SURFACE WATER USE:

Please answer the following questions if you used surface water at this facility (including surface water purchased from others).

A. County(ies) in which this plant is located ______.

B. If you diverted surface water from a stream, river, pond, lake and/or a reservoir for use at this plant site, please name the county ______; stream, reservoir, etc. ______

C. If you purchased surface water from others for use at this plant site, please name supplier(s) ______.

D. Was purchased water raw ☐ or treated ☐? If both, % raw ______% treated ______.

E. Please complete the following table. Indicate the total quantity (gallons) of surface water purchased from others and the amount that was self-supplied. Self-supplied water is the total quantity of raw water you diverted including any water sold to others. If you purchased surface water from several suppliers, please provide separate volumes for each on additional paper.

MONTH	SELF SUPPLIED	PURCHASED	MONTH	SELF SUPPLIED	PURCHASED	MONTH	SELF SUPPLIED	PURCHASED
Jan			May			Sep		
Feb			Jun			Oct		
Mar			Jul			Nov		
Apr			Aug			Dec		

F. Total surface water intake during the calendar year for: Self-Supplied ______. Purchased ______.

G. How did you arrive at the surface water use figures which you provided above? master meter ☐ customer meters ☐ estimated ☐ other ☐

1 27 28 29 30 32 33 35 36 37 38 41 42 48 49 80 To be filled in by TWDB

III. SALINE WATER USE:

A. Total saline water intake during the calendar year ______ (gallons).

B. Source of saline water ______. County(ies) in which water was used ______.

C. How did you arrive at the saline water figures which you provided above? meter ☐ estimated ☐

TWDB-0669B (Rev. 09 30 85)
Industrial

OVER

1 27 28-29 30-32 33-35 36-37 38-41 42-48 49-80 To be filled in by TWDB

3

8

IV. SEWAGE OR WASTEWATER USE:

Reuse of wastewater from your plant or another treatment system such as a municipal sewage treatment facility (treatment includes any process necessary to make wastewater reusable).

A. Total treated wastewater used during calendar year (excluding in-plant recirculation)____________________(gallons).

B. From your plant:________%; From other sources________%.

C. Name of other source(s)____________________.

D. How did you arrive at the treated wastewater figures which you provided above? meter ☐ estimated ☐

1 27 28-29 30-32 33-35 36-37 38-41 42-48 49-80 To be filled in by TWDB

3

9

V. WATER SALES (If Applicable):

Please list the names of water purchasers, their location [county(ies)], and the quantities of fresh water you sold to them during the calendar year. Please indicate treated or raw water. Use additional paper if necessary.

Name of Purchaser	Location [County(ies)]	Quantity Sold (Gallons)

NOTE: The above quantities should be included in the amounts you indicated in questions I and II.

VI. WATER USE CATEGORIES:

Of the fresh water, saline water, and treated wastewater you withdraw or purchase, what percent is estimated to be used in each of the following water use categories applicable to your plant?

CATEGORY	% GROUND WATER	% SURFACE WATER	% SALINE	% TREATED WASTEWATER
Cooling, Condensing & Refrigeration				
Process & Washdown				
Boiler Feed				
Air-Conditioning				
Sanitary & Drinking				
Other				
TOTAL	100%	100%	100%	100%

VII. COOLING SYSTEMS:

Please indicate the percent of cooling and condensing water described above handled by each system for each water source.

SYSTEM	% GROUND AND/OR SURFACE	% SALINE WATER	% TREATED WASTEWATER
Cooling Tower(s)			
Pond(s)			
Once Through			
Other			
TOTAL	100%	100%	100%

VIII. ADDITIONAL INFORMATION

A. Major Standard Industrial Classification Code ☐☐☐☐ (or major products manufactured)____________________.

B. Total number of employees at this facility__________. Total number of production employees__________.

C. Was fresh water recirculated at this facility? Yes ☐ No ☐

D. Was electric power generated at this facility (for in plant use or sale)? Yes ☐ No ☐

E. Please check the type(s) of wastewater disposal system(s) used at this plant: (1) onsite wastewater plant ☐; (2) septic tank(s) ☐; (3) injection well(s) ☐; (4) city or regional ☐ Please name, if (4)____________________.

F. What quantity of fresh water was consumed and therefore not returned to a wastewater treatment system (public or private) or to a water course (including loss to product, evaporation, injection, etc.).____________________(gallons).

G. Please make any additional comments that may be of assistance to us in understanding your present and future water needs and water problems. Please use additional paper if necessary.____________________

To assure our addressing future correspondence to the proper person, please complete the following:

By: ____________________

Name Title Phone Date

TEXAS WATER DEVELOPMENT BOARD
HISTORICAL EDWARDS AQUIFER PUMPAGE

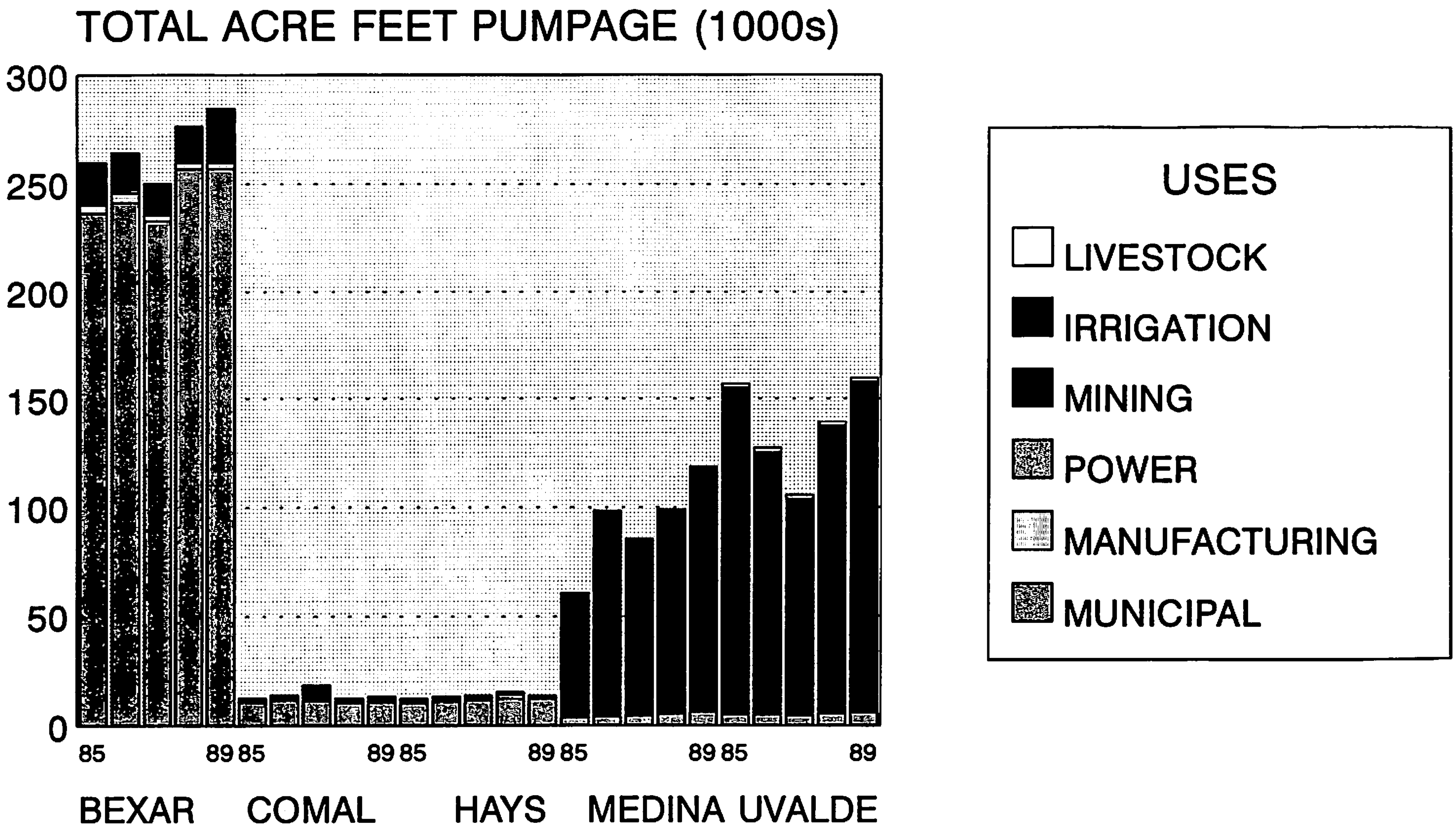


Figure 2.1-3

UNITED STATES GEOLOGICAL SURVEY
HISTORICAL EDWARDS AQUIFER PUMPAGE

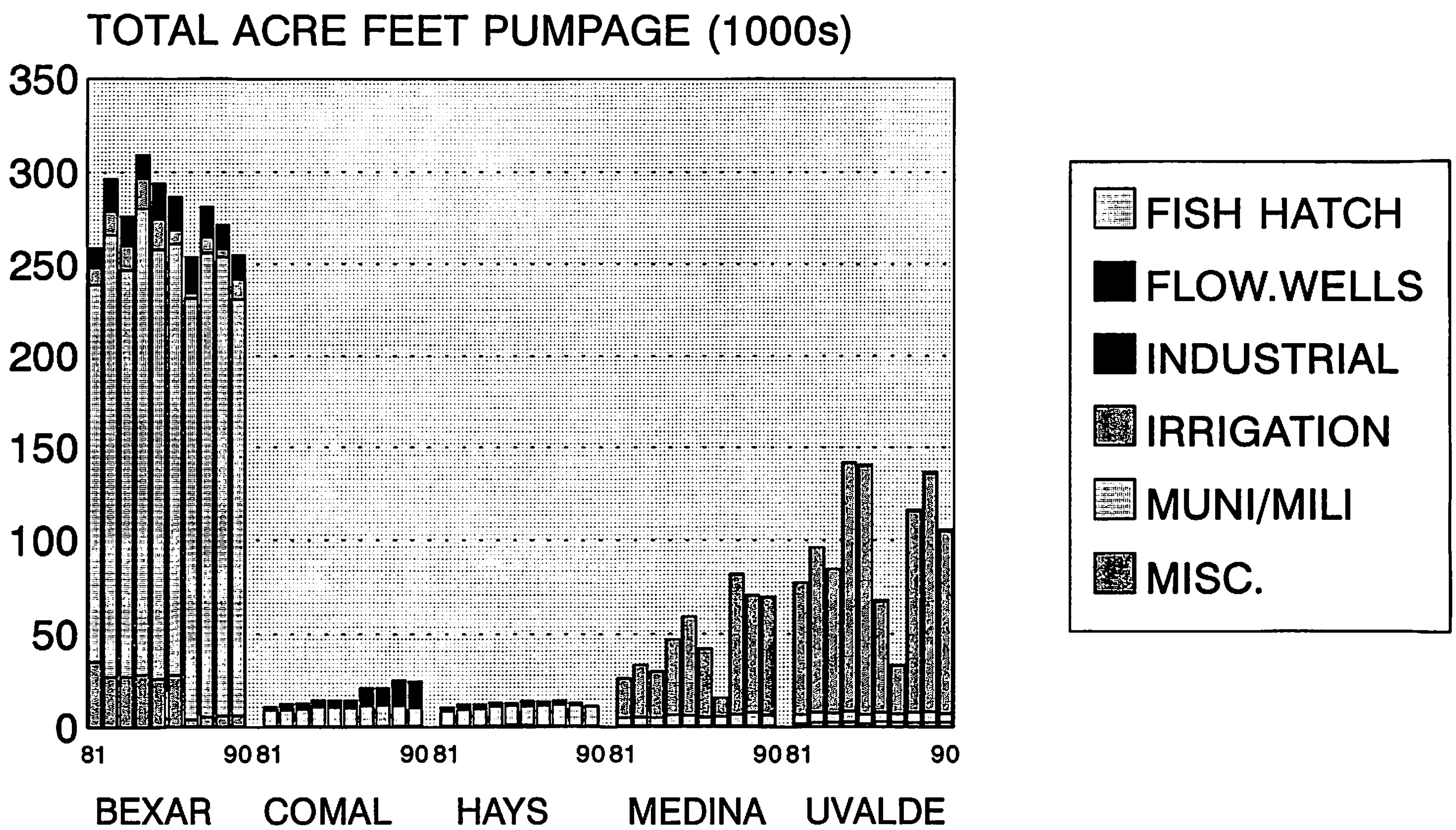


Figure 2.1-4

EDWARDS AQUIFER WELLS WHICH DISCHARGE INTO THE SAN ANTONIO RIVER

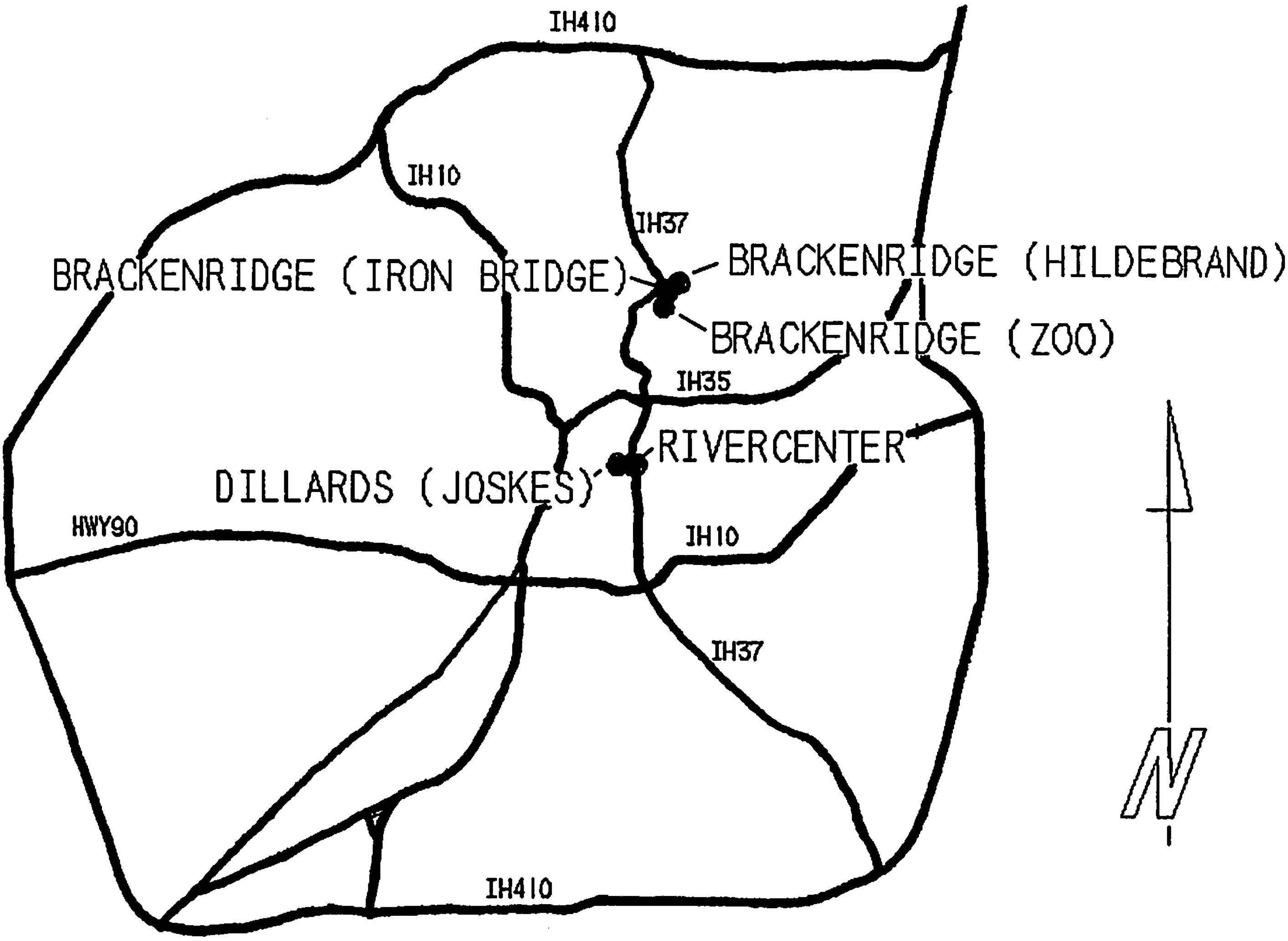


FIGURE 2.1-5

PREPARED BY THE EDWARDS UNDERGROUND WATER DISTRICT

COMPARISON OF USGS AND TWDB
HISTORICAL EDWARDS AQUIFER PUMPAGE

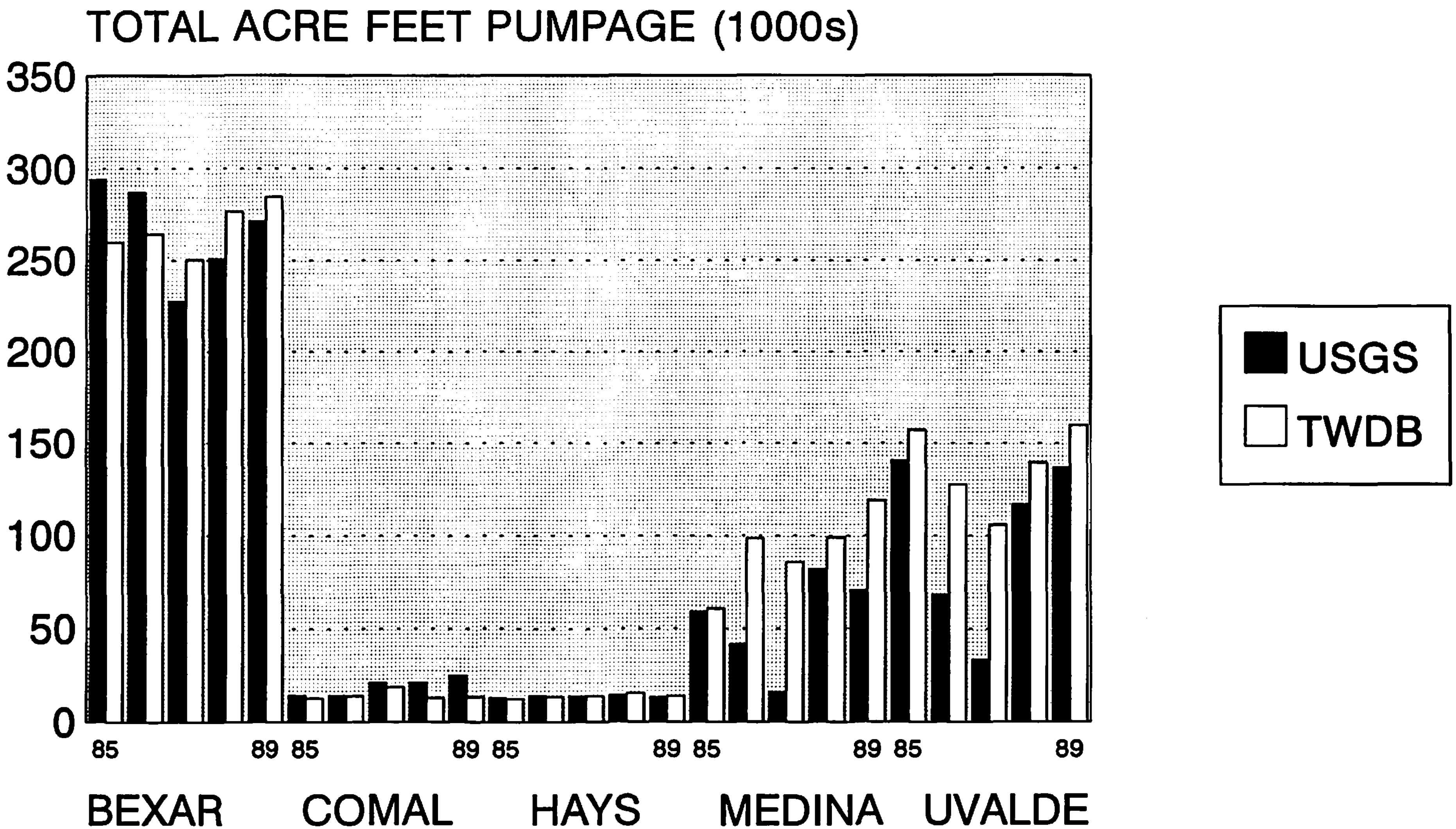


Figure 2.1-6

COMPARISON OF TWDB AND USGS
HISTORICAL MUNICIPAL/MILITARY PUMPAGE

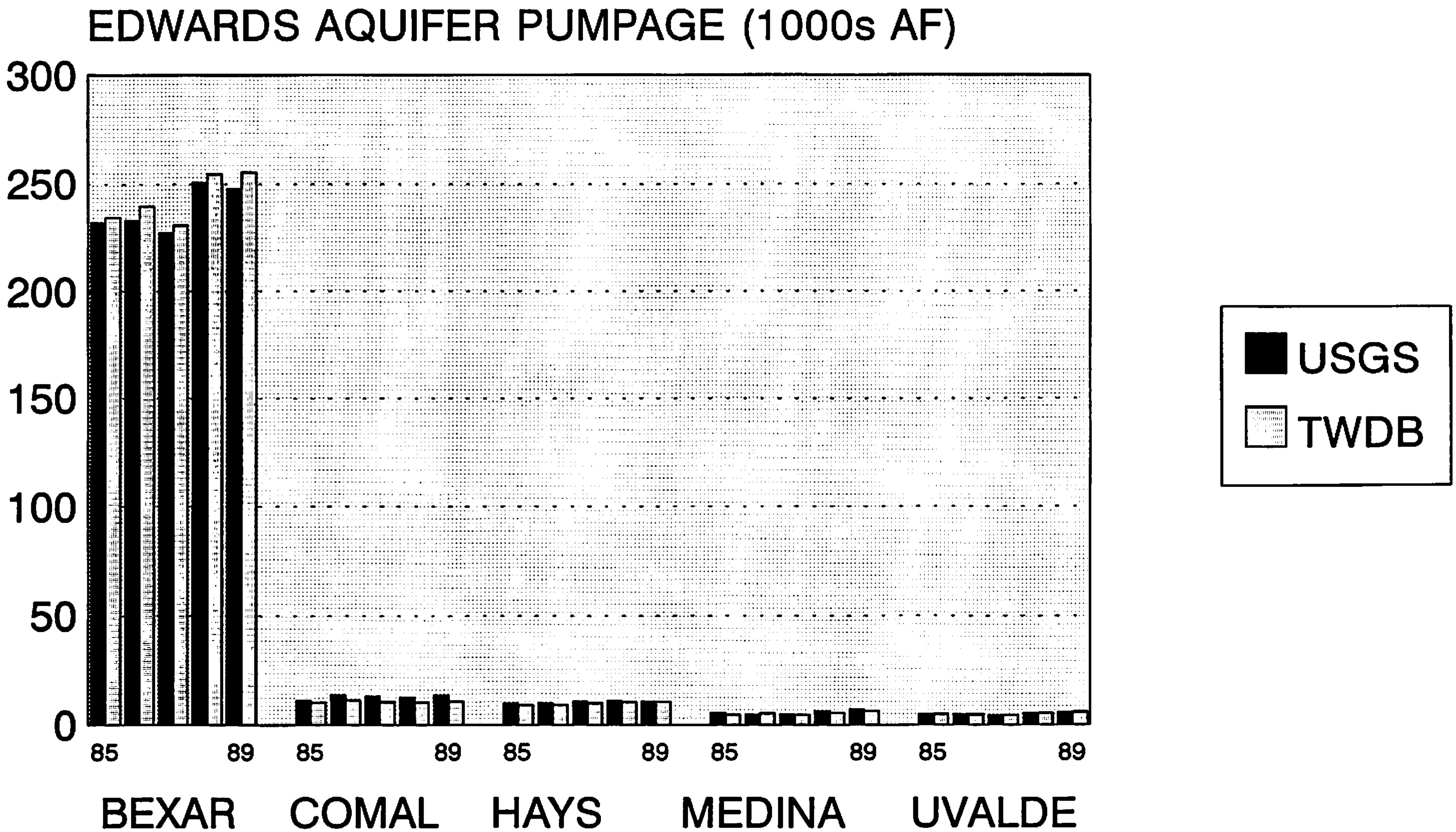


Figure 2.1-6a

COMPARISON OF TWDB AND USGS
HISTORICAL INDUSTRIAL PUMPAGE (1000s AF)

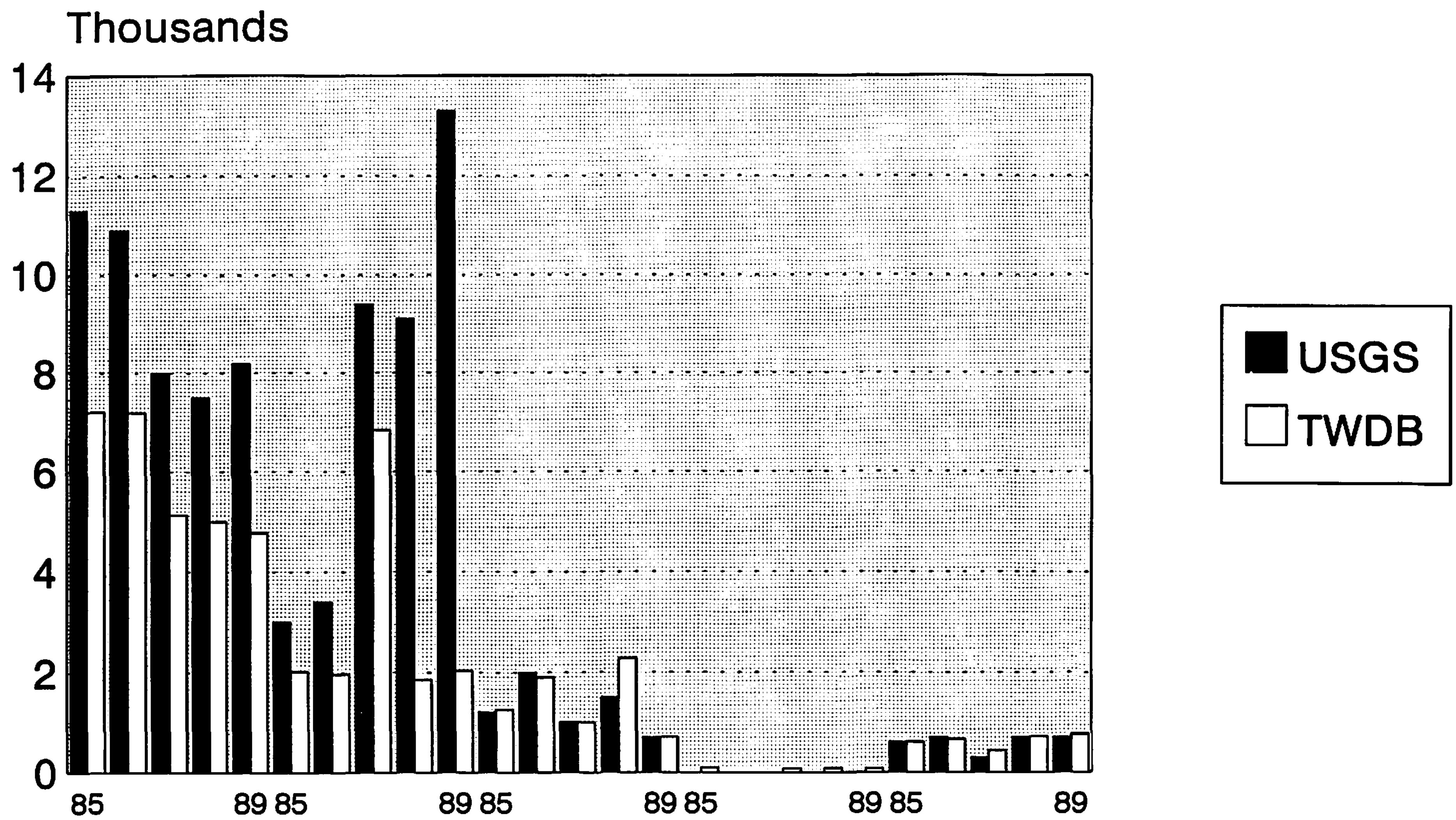


Figure 2.1-6b

COMPARISON OF TWDB AND USGS
HISTORICAL IRRIGATION PUMPAGE

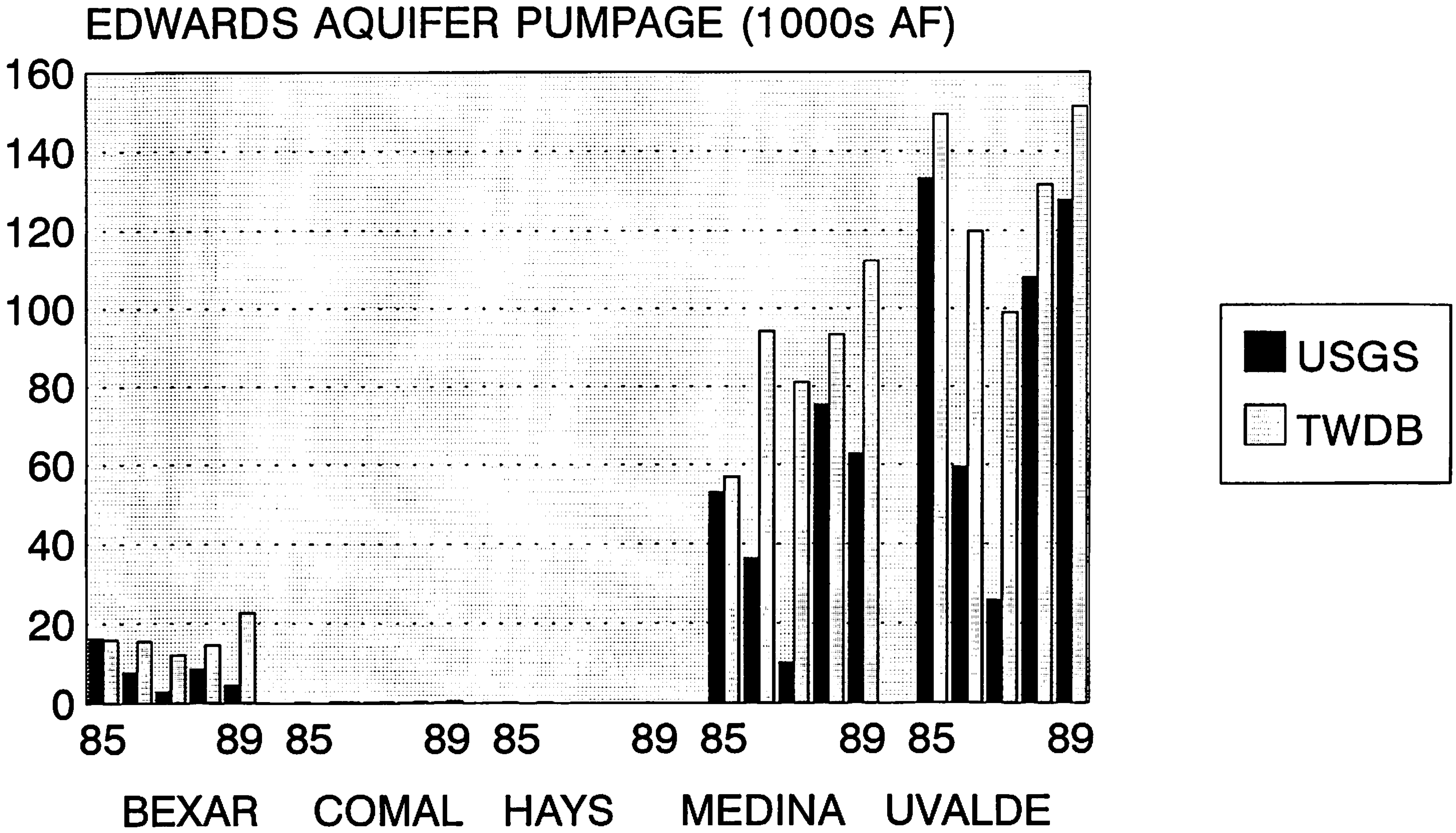


FIGURE 2.1-6C

COMPARISON OF TWDB AND USGS
HISTORICAL DOMESTIC/LIVESTOCK PUMPAGE

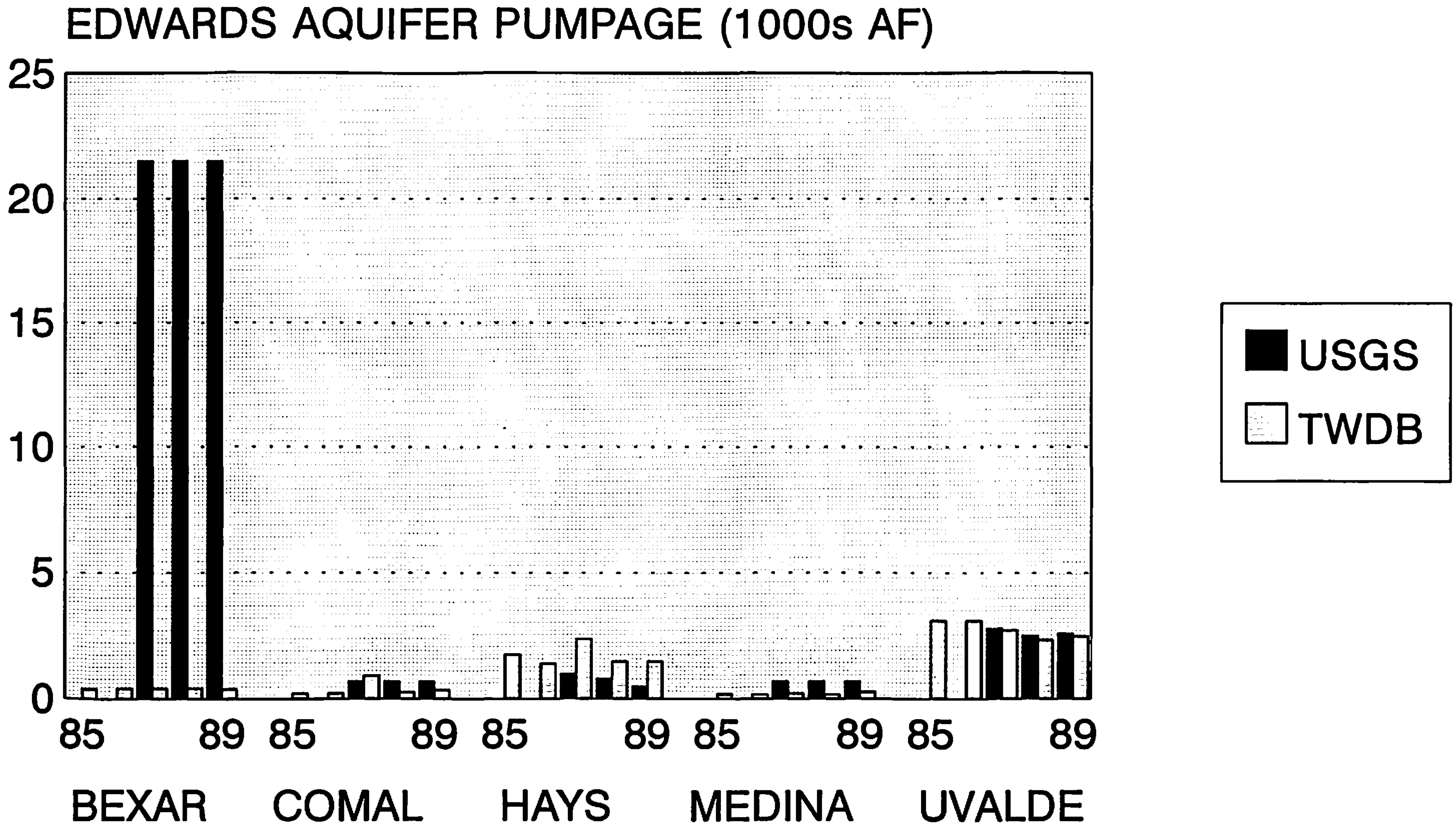


Figure 2.1-6d

BEXAR COUNTY POPULATION PROJECTIONS
FROM TWDB 1990 TEXAS WATER PLAN

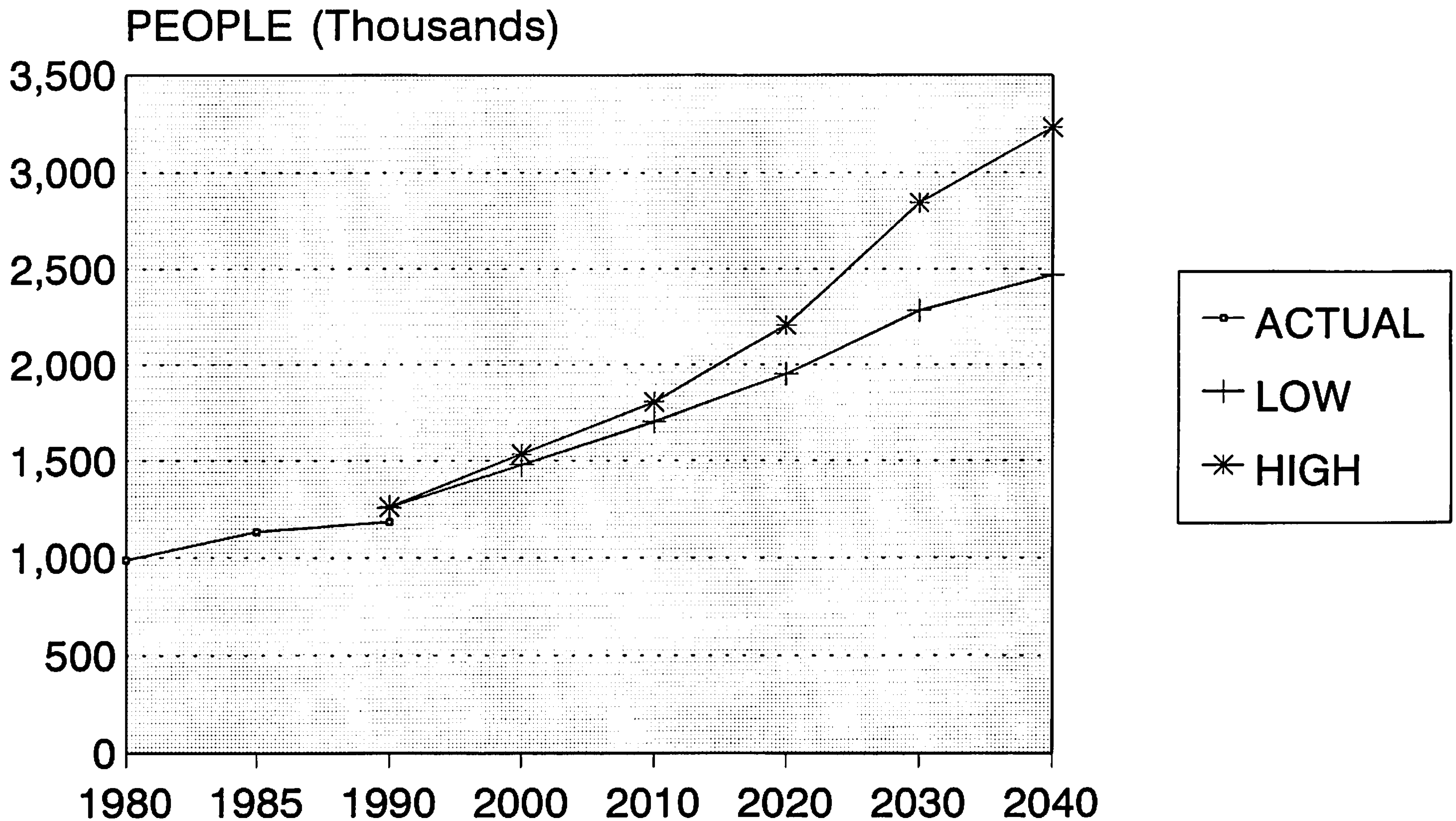


Figure 2.1-7

COMAL COUNTY POPULATION PROJECTIONS
FROM TWDB 1990 TEXAS WATER PLAN

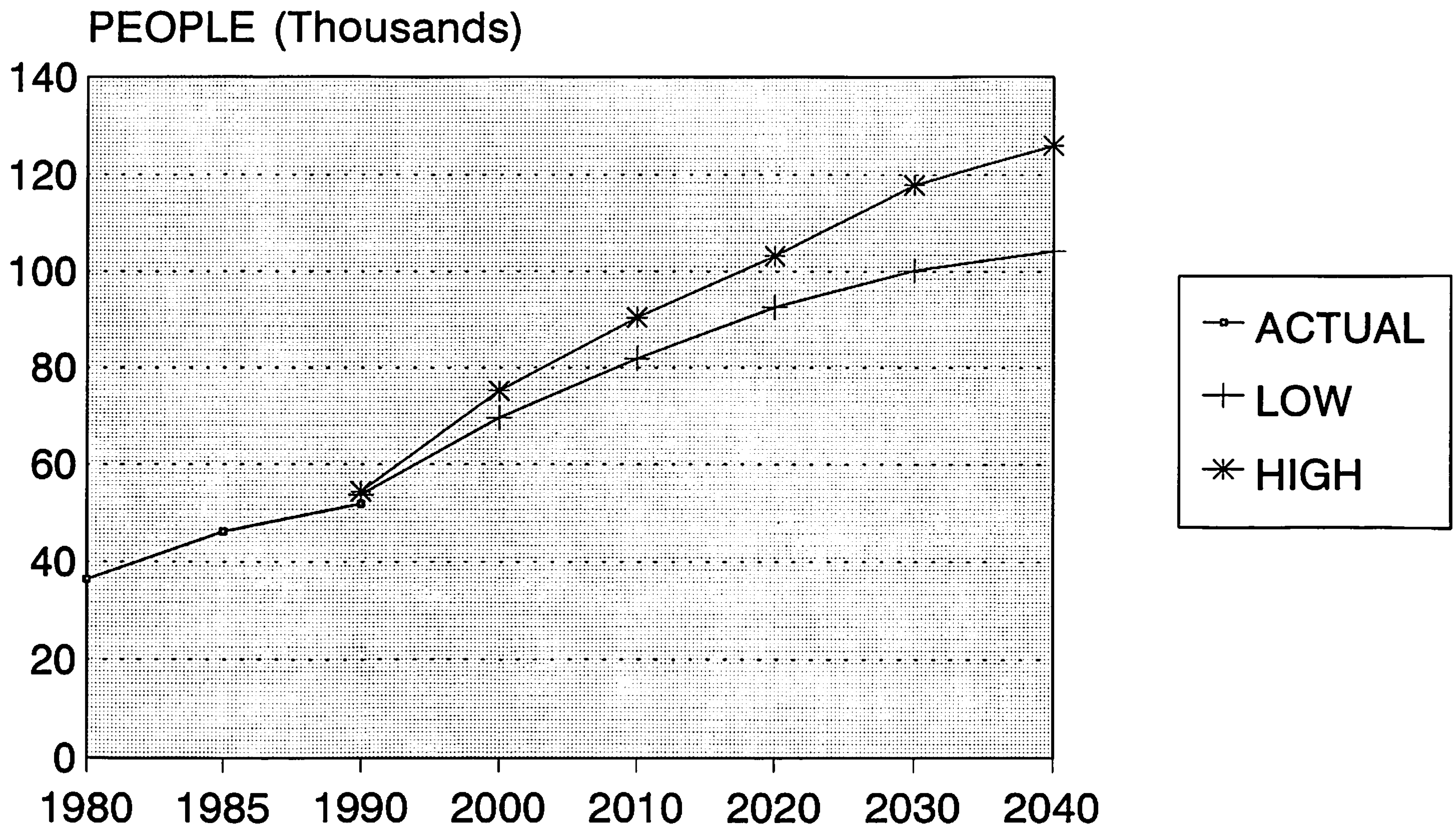


Figure 2.1-8

HAYS COUNTY POPULATION PROJECTIONS
FROM TWDB 1990 TEXAS WATER PLAN

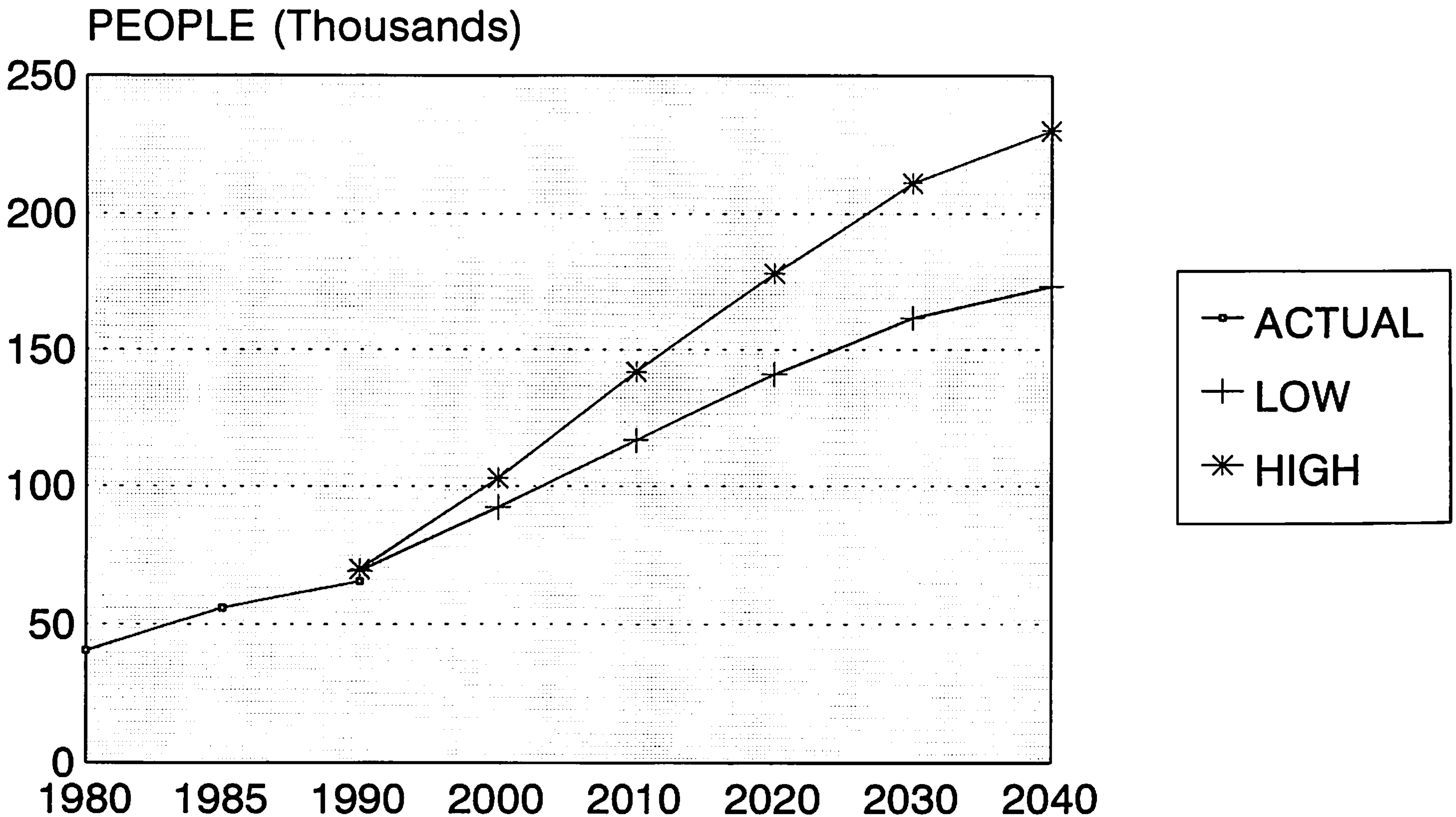


Figure 2.1-9

MEDINA COUNTY POPULATION PROJECTS
FROM TWDB 1990 TEXAS WATER PLAN

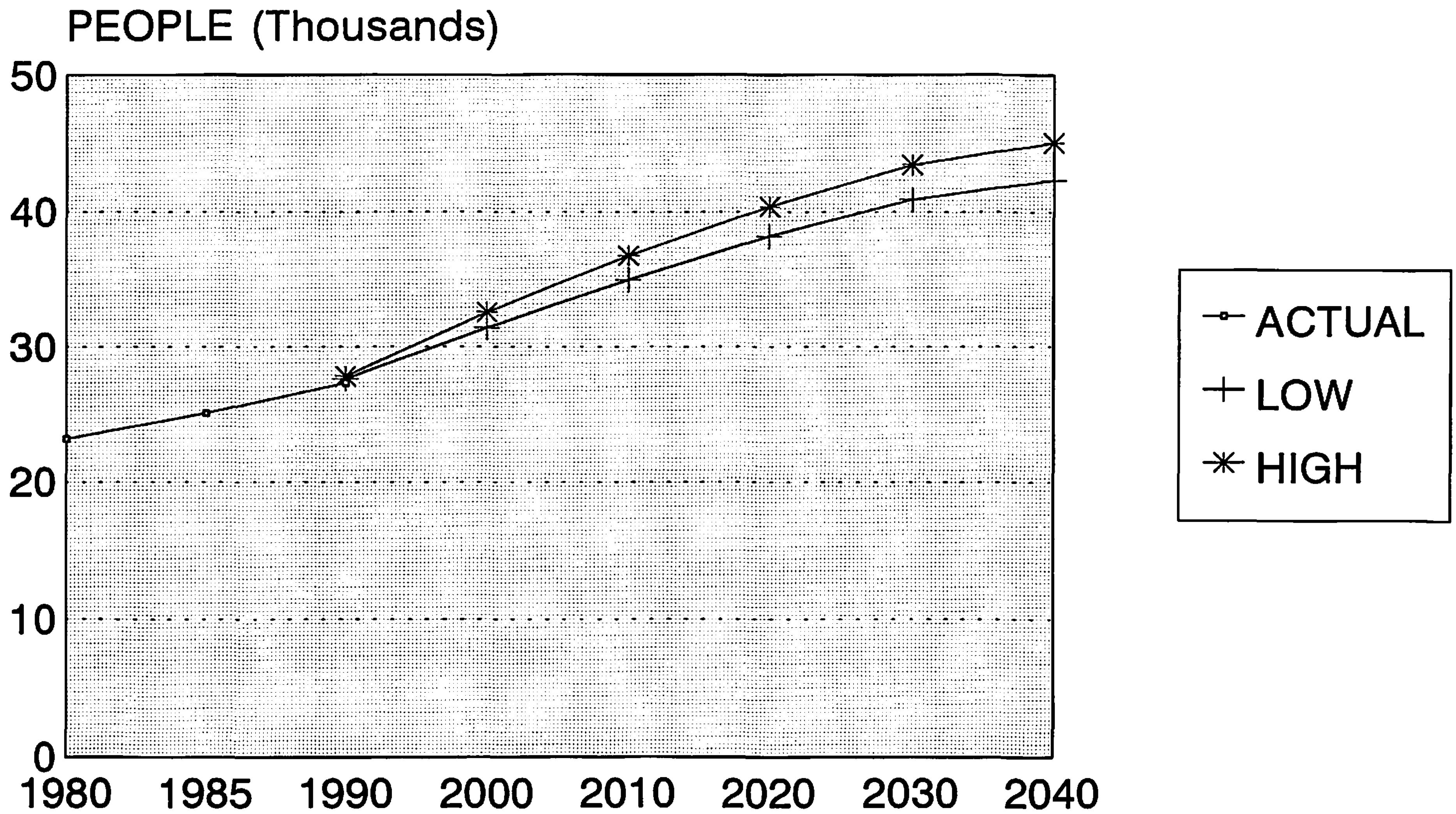
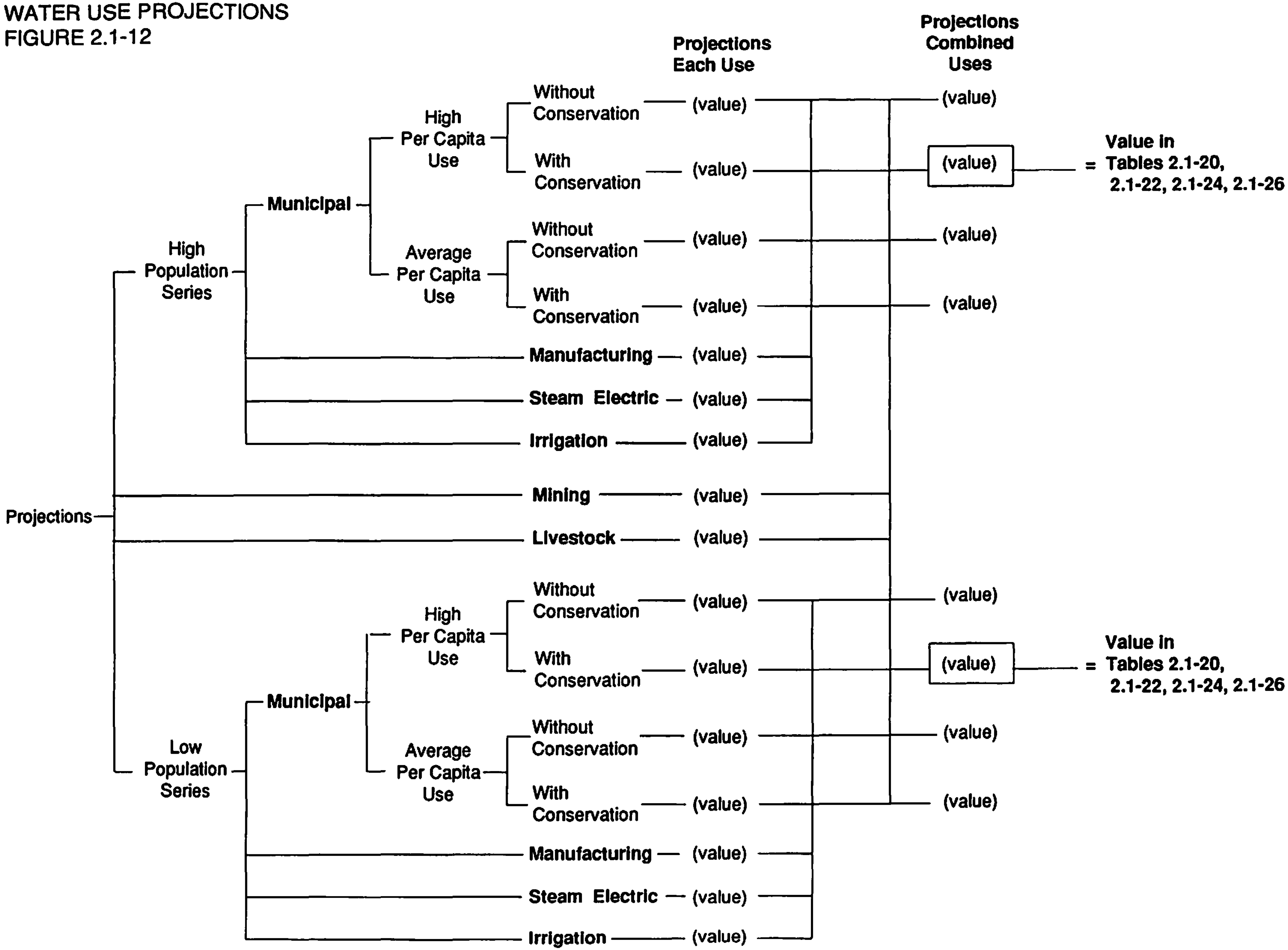


Figure 2.1-10

TEXAS WATER DEVELOPMENT BOARD
WATER USE PROJECTIONS
FIGURE 2.1-12



BEXAR COUNTY WATER USE PROJECTIONS
FROM TWDB 1990 TEXAS WATER PLAN

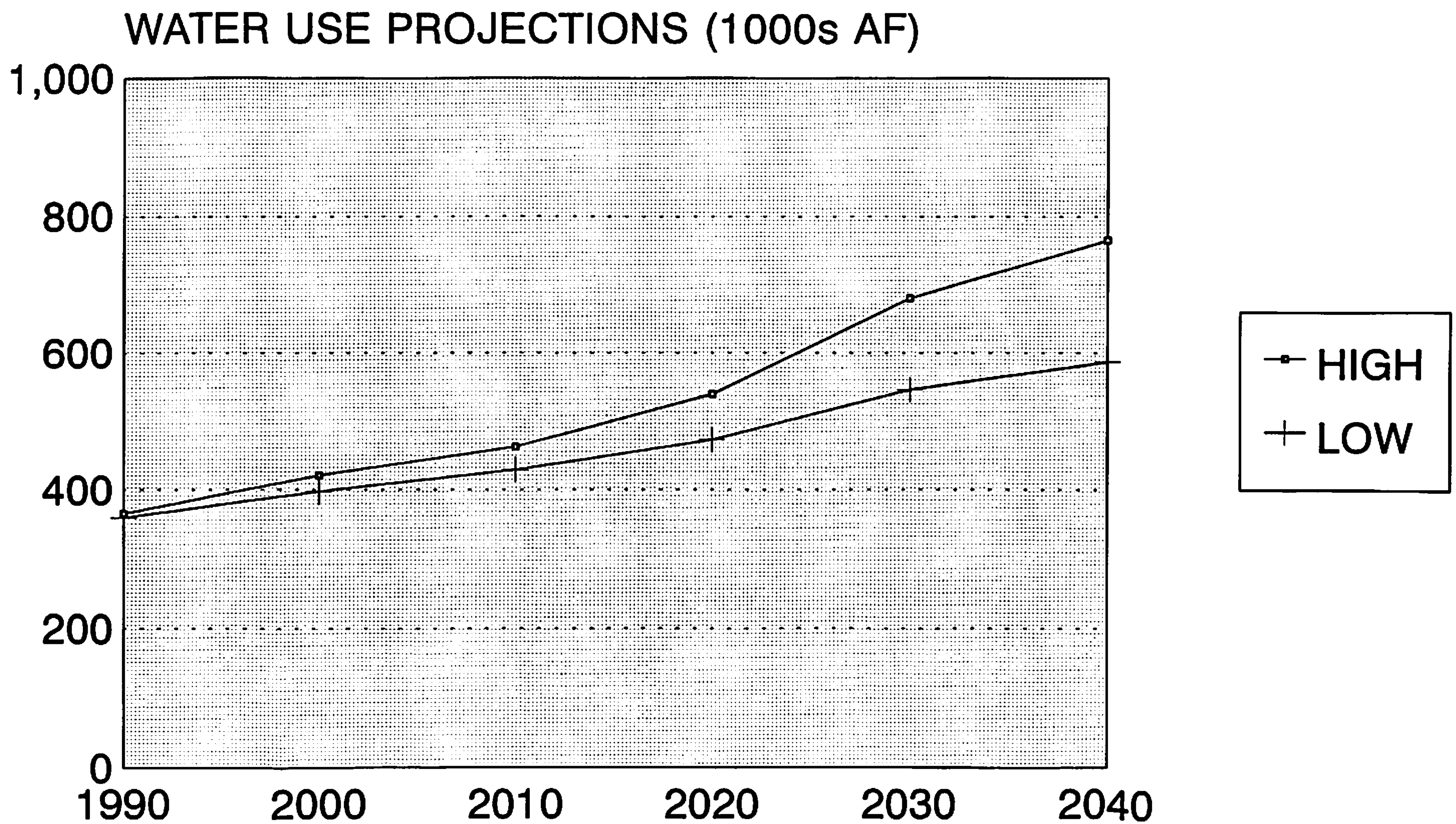


Figure 2.1-13

UVALDE COUNTY POPULATION PROJECTIONS
FROM TWDB 1990 TEXAS WATER PLAN

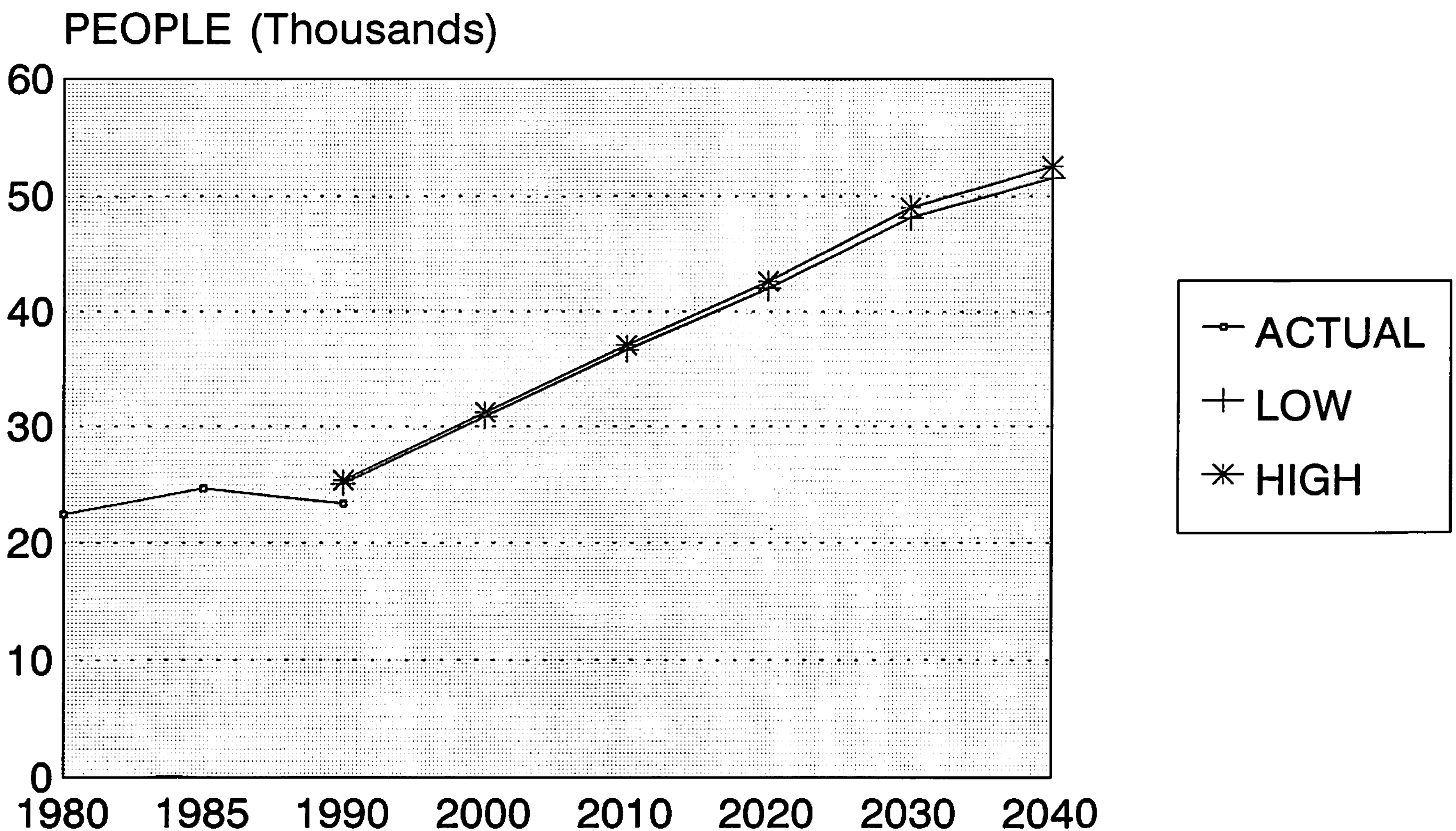


Figure 2.1-11

COMAL COUNTY WATER USE PROJECTIONS
FROM TWDB 1990 TEXAS WATER PLAN

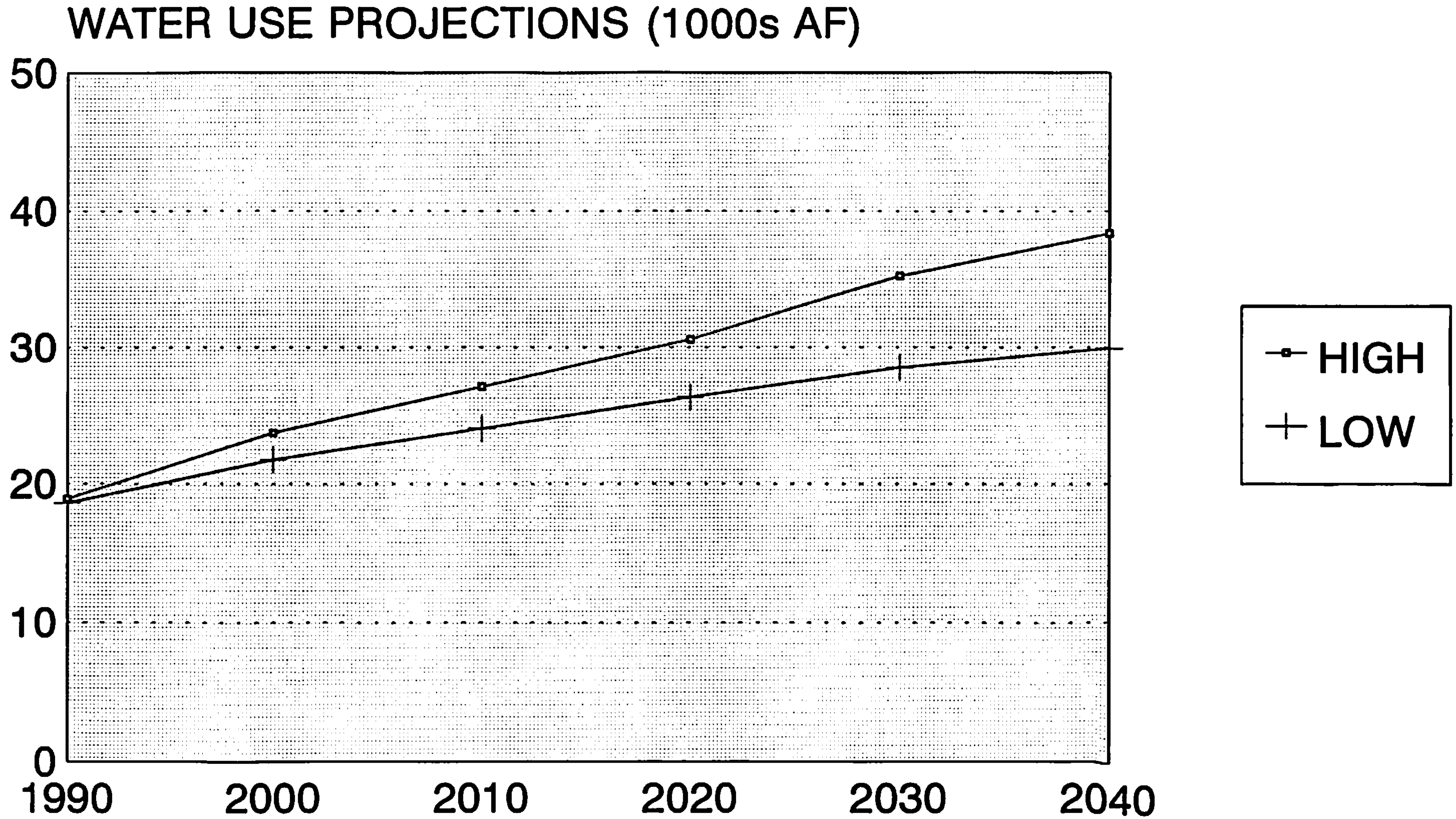


Figure 2.1-14

HAYS COUNTY WATER USE PROJECTIONS
FROM TWDB 1990 TEXAS WATER PLAN

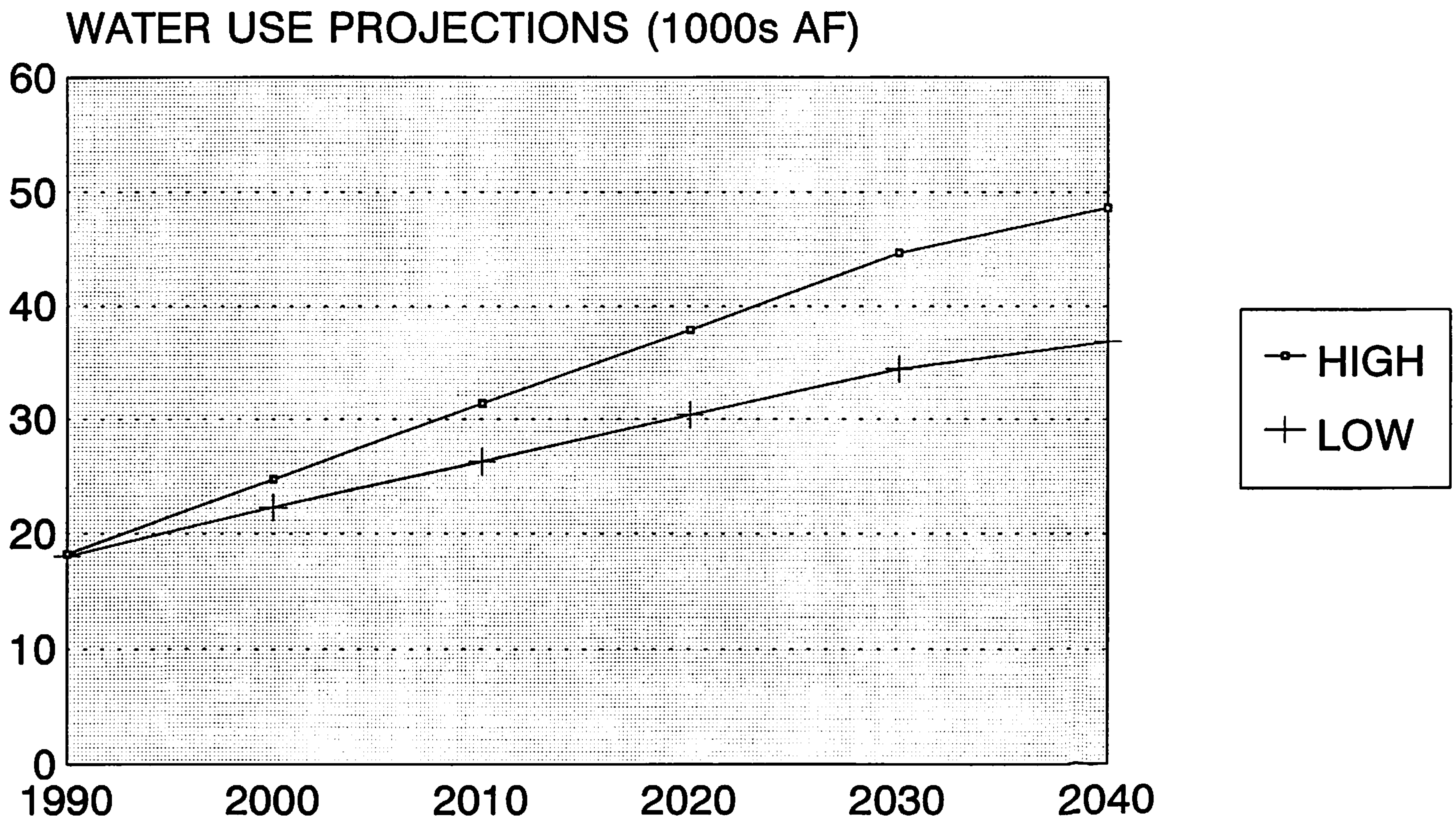


Figure 2.1-15

MEDINA COUNTY WATER USE PROJECTIONS
FROM TWDB 1990 TEXAS WATER PLAN

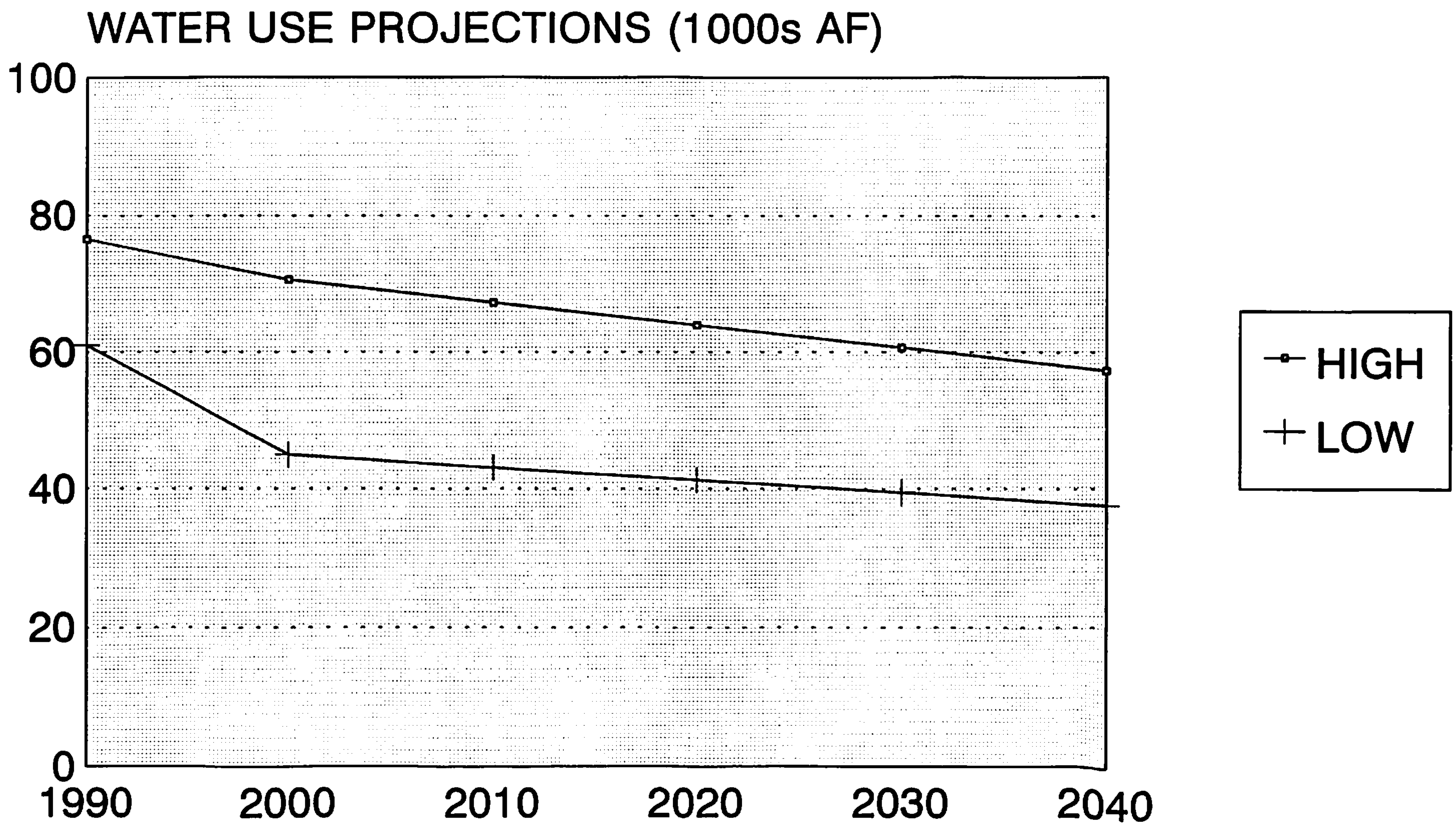


Figure 2.1-16

UVALDE COUNTY WATER USE PROJECTIONS
FROM TWDB 1990 TEXAS WATER PLAN

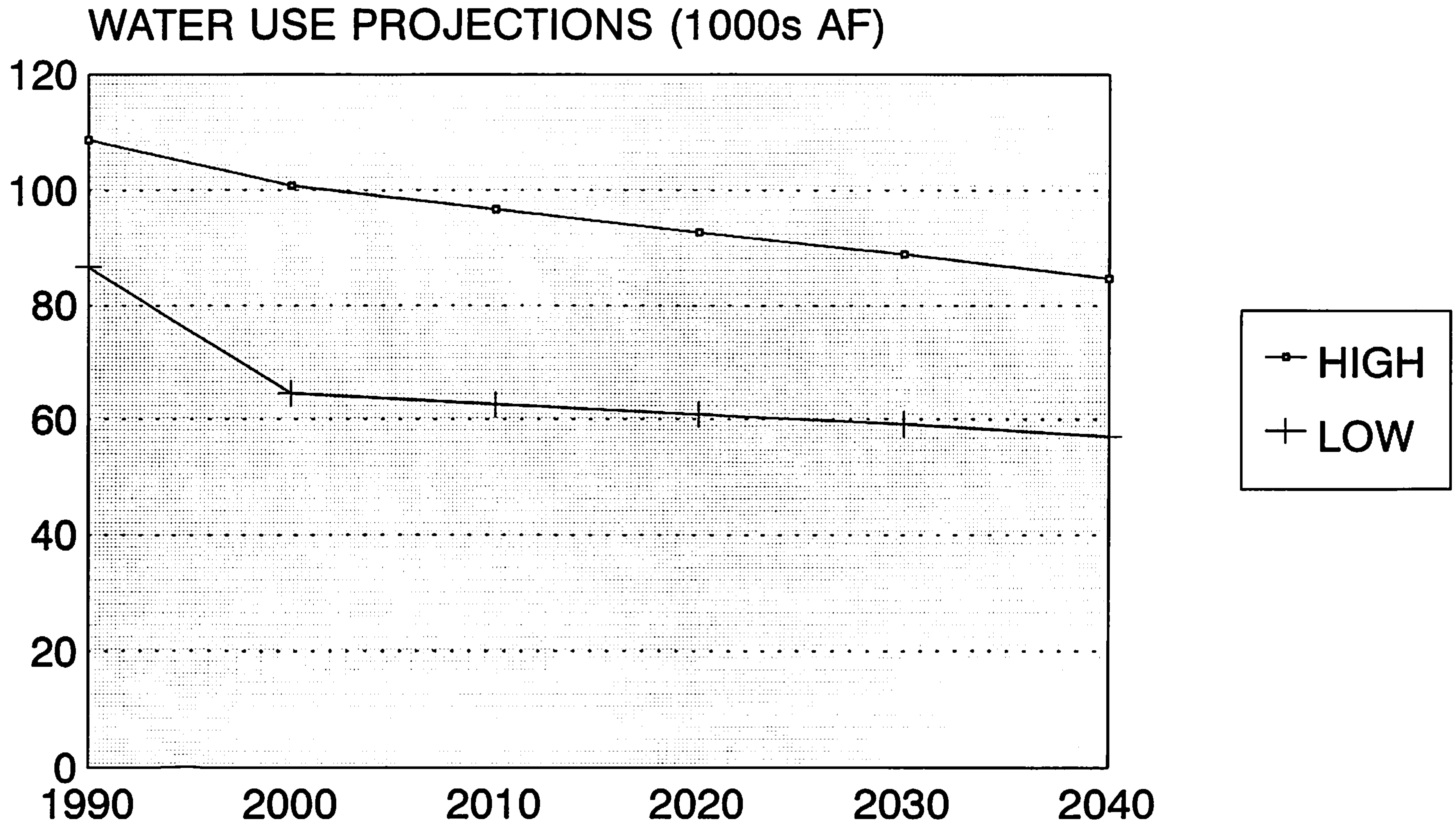


Figure 2.1-17

BEXAR COUNTY POPULATION PROJECTIONS
FROM TWDB 1992 CENSUS DATA

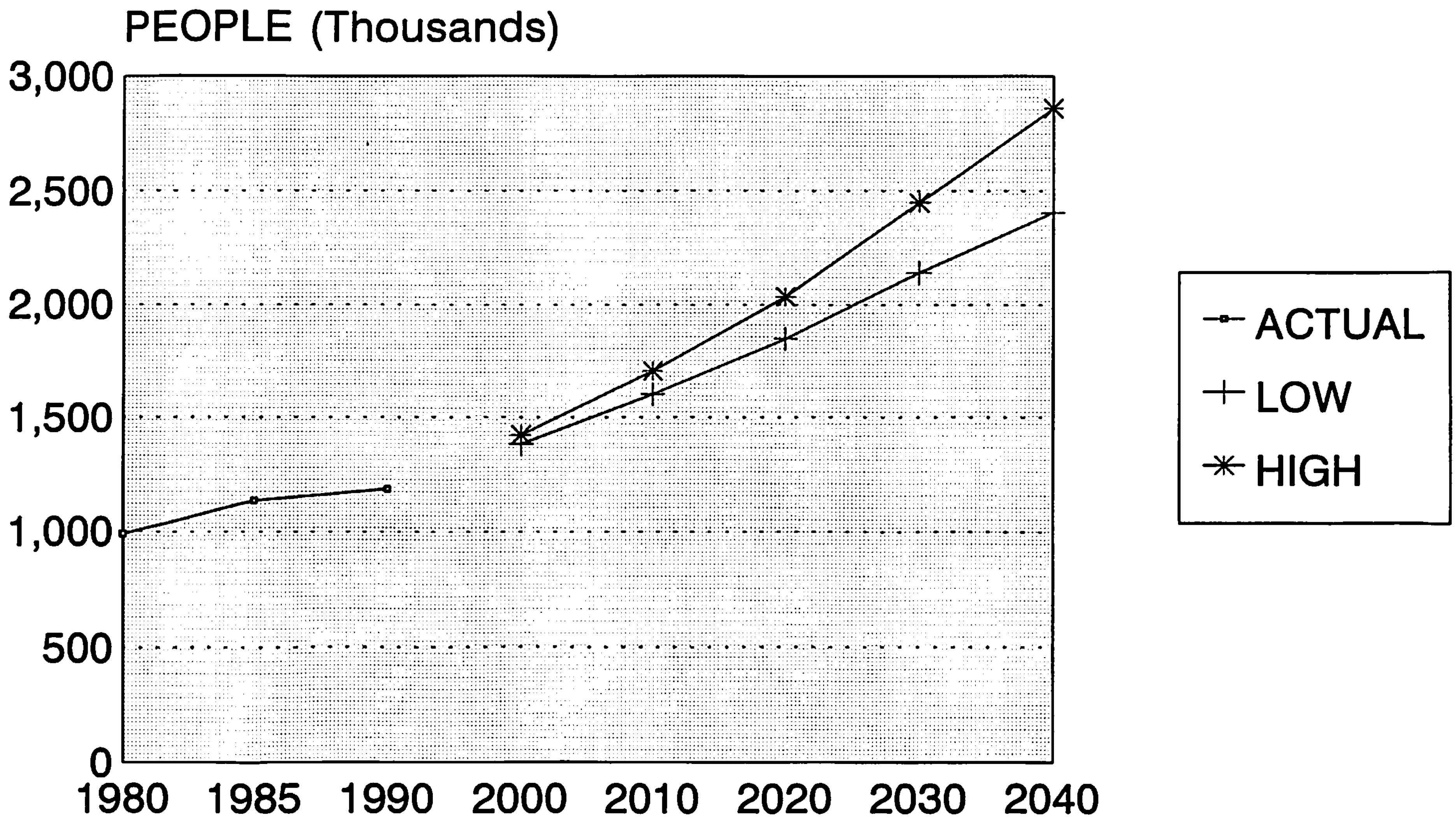


Figure 2.1-18

COMAL COUNTY POPULATION PROJECTIONS
FROM TWDB 1992 CENSUS DATA

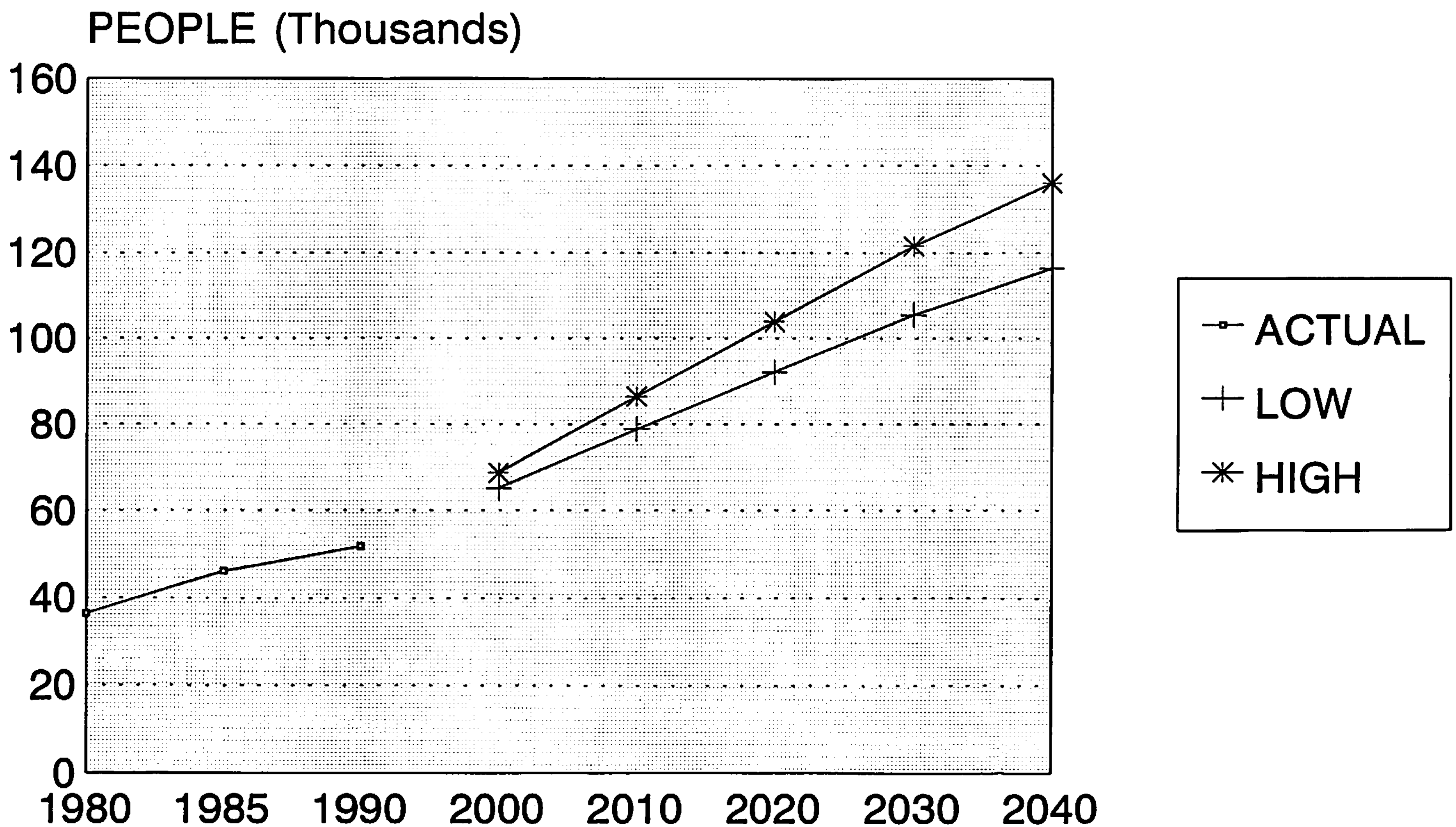


Figure 2.1-19

HAYS COUNTY POPULATION PROJECTIONS
FROM TWDB 1992 CENSUS DATA

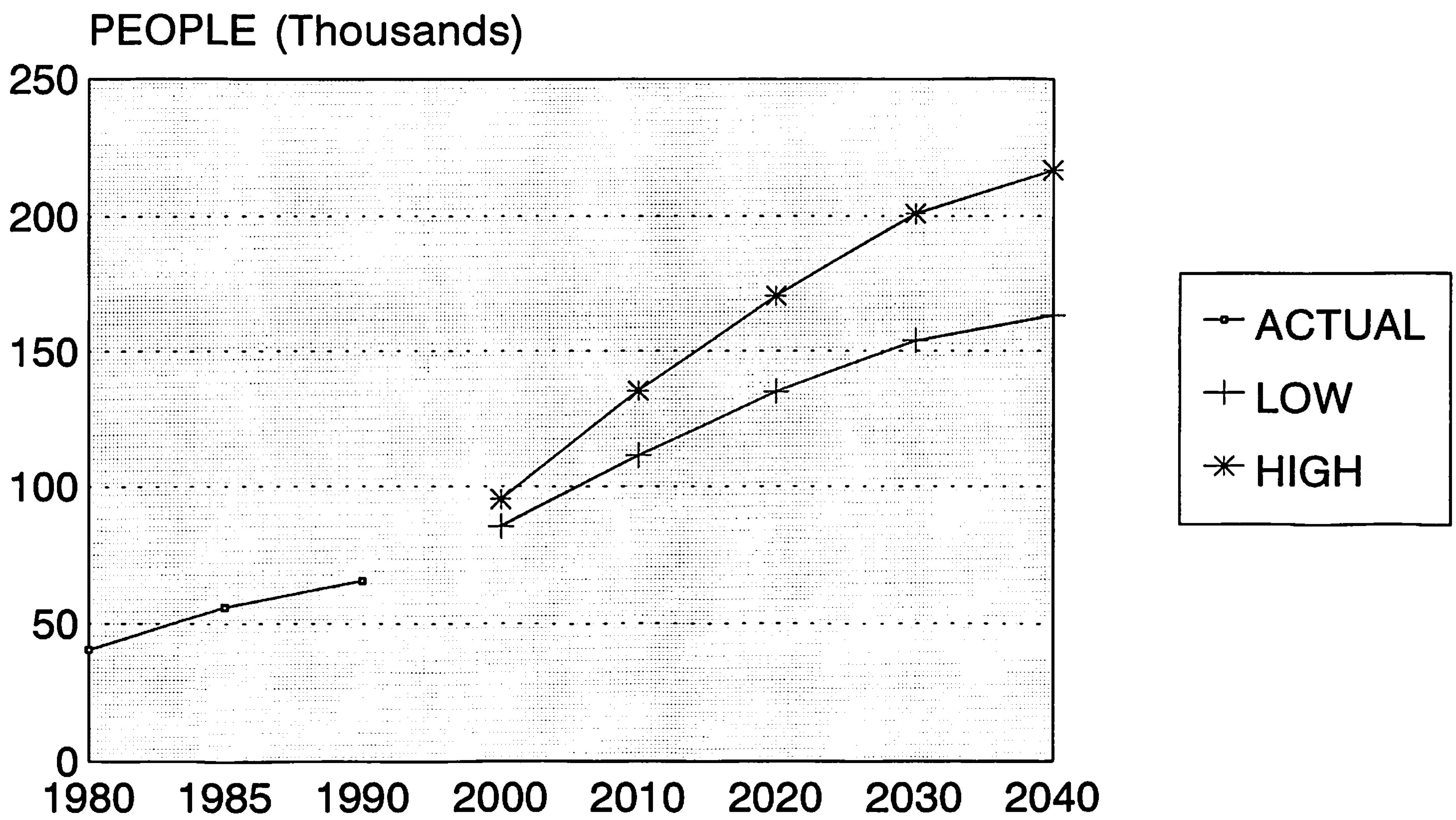


Figure 2.1-20

MEDINA COUNTY POPULATION PROJECTIONS
FROM TWDB 1992 CENSUS DATA

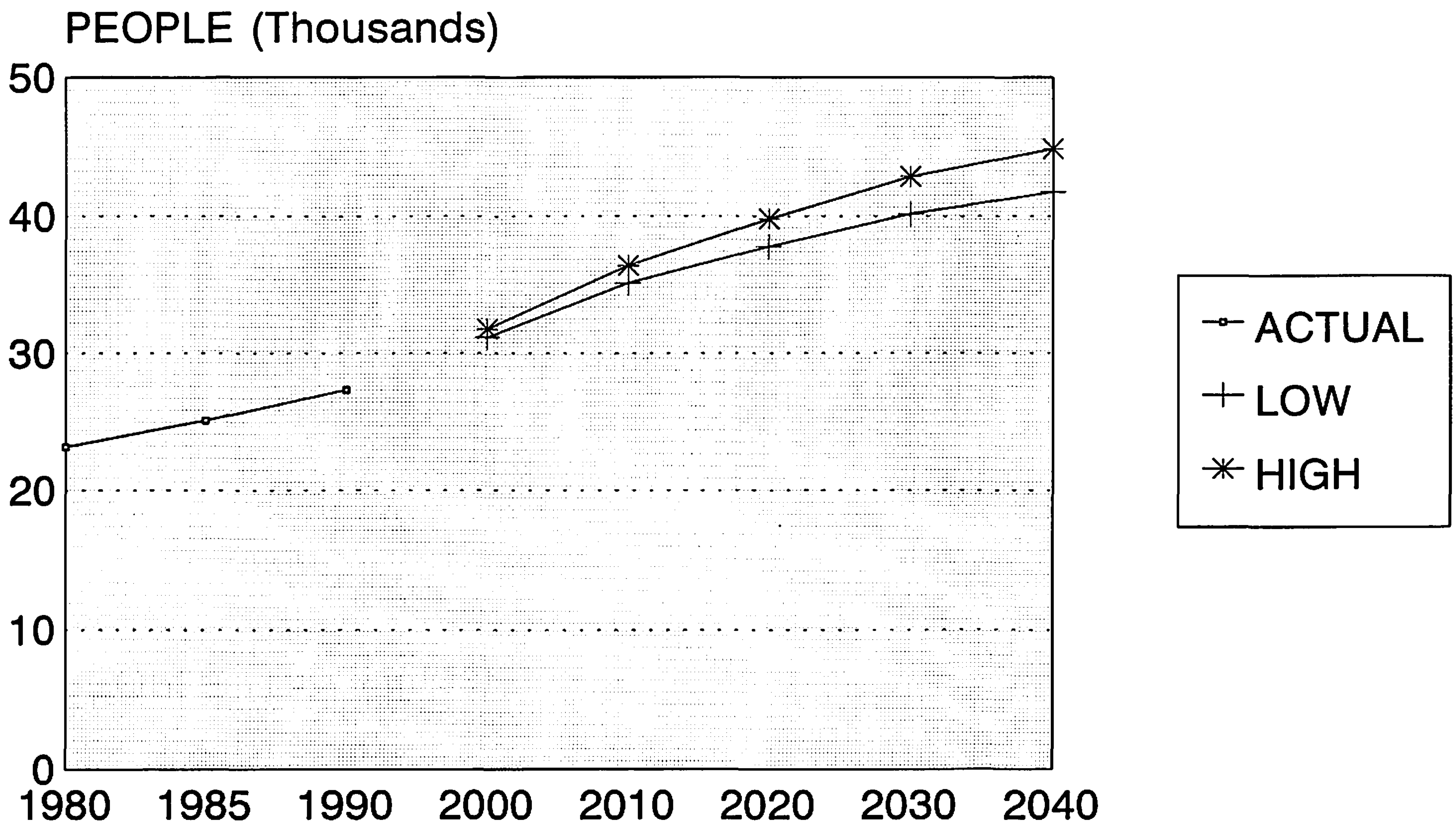


 Figure 2.1-21

UVALDE COUNTY POPULATION PROJECTIONS
FROM TWDB 1992 CENSUS DATA

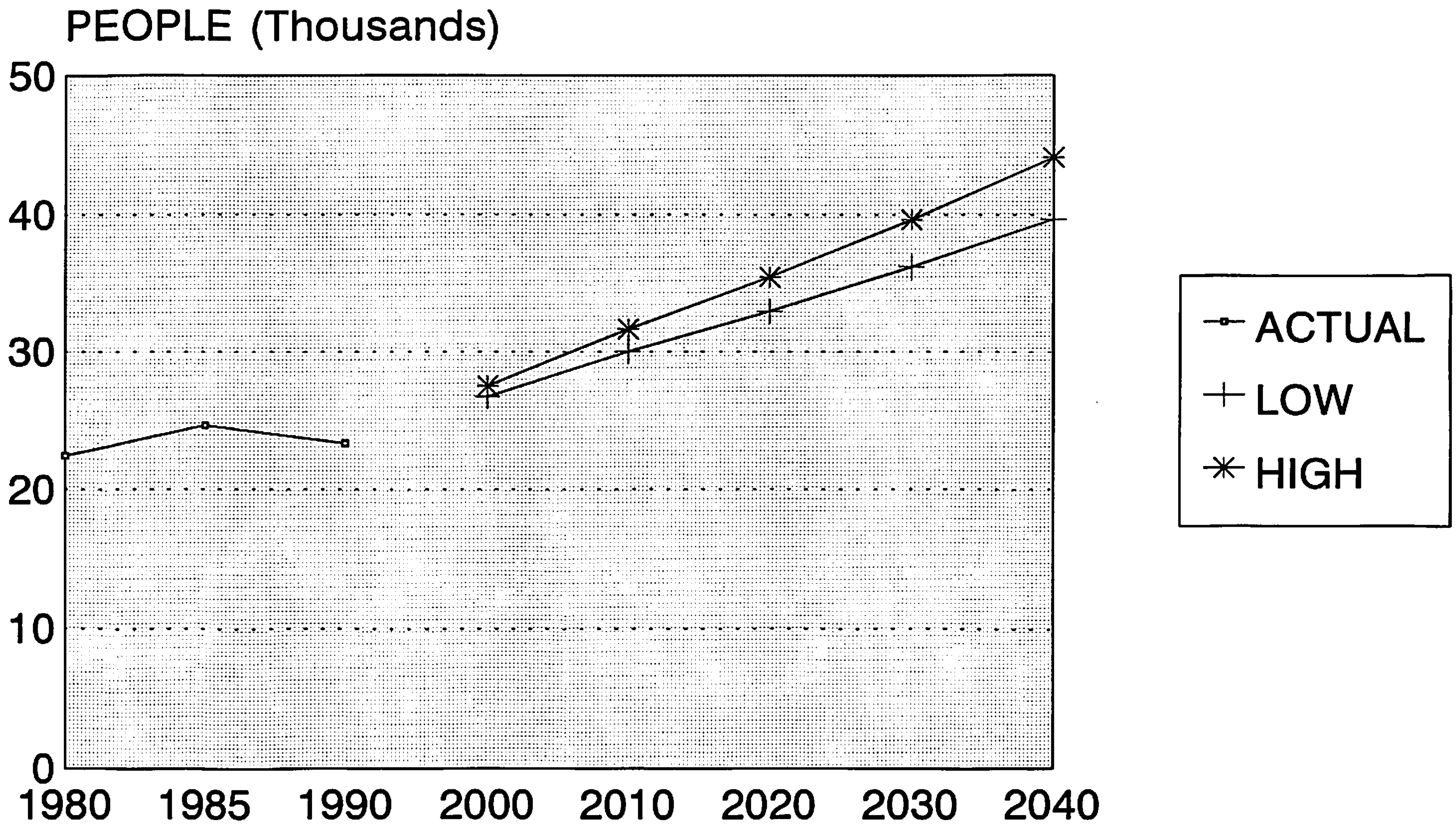


Figure 2.1-22

BEXAR COUNTY WATER USE PROJECTIONS
FROM TWDB 1992 CENSUS DATA

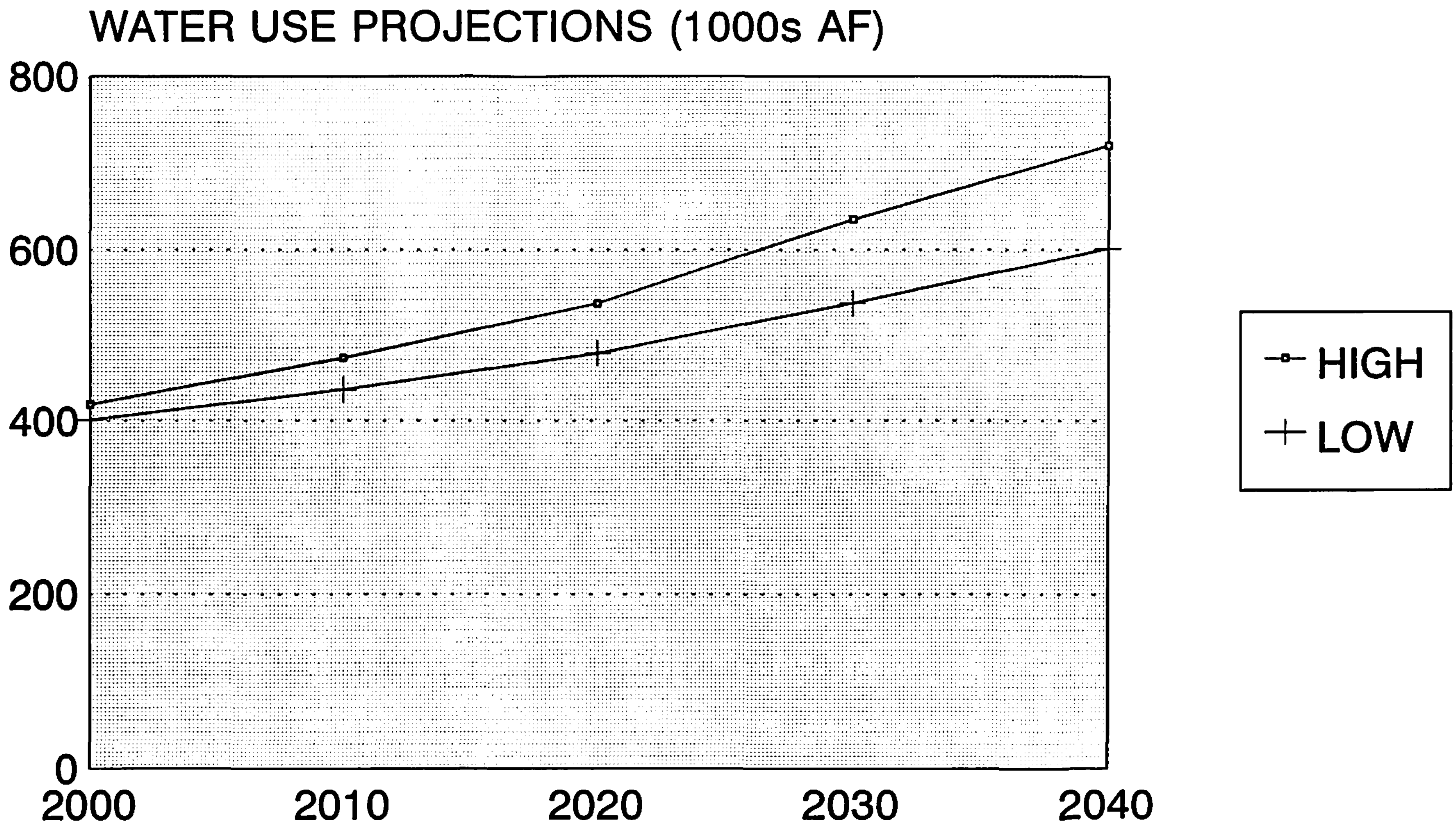


Figure 2.1-23

COMAL COUNTY WATER USE PROJECTIONS
FROM TWDB 1992 CENSUS DATA

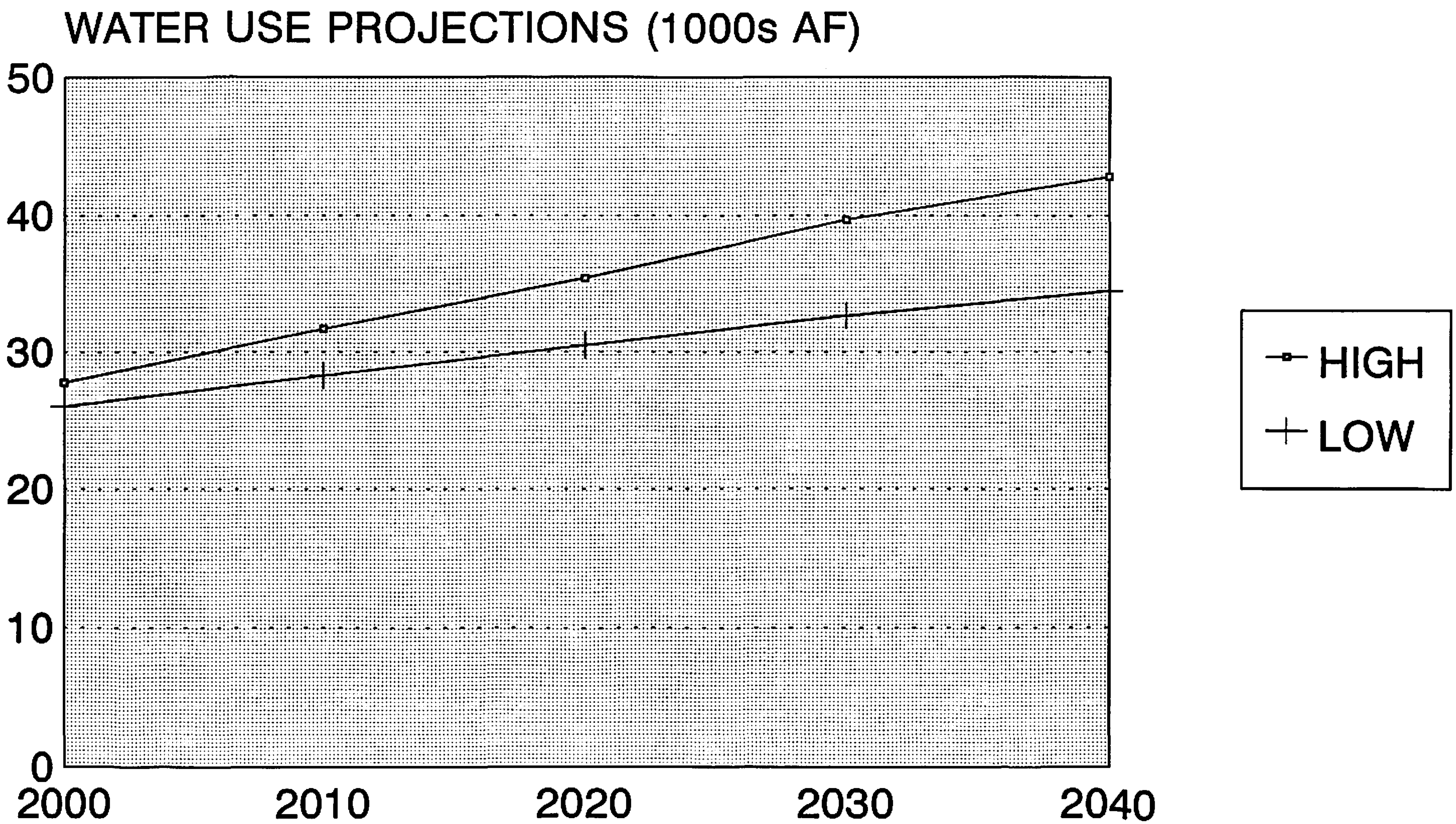


Figure 2.1-24

HAYS COUNTY WATER USE PROJECTIONS
FROM TWDB 1992 CENSUS DATA

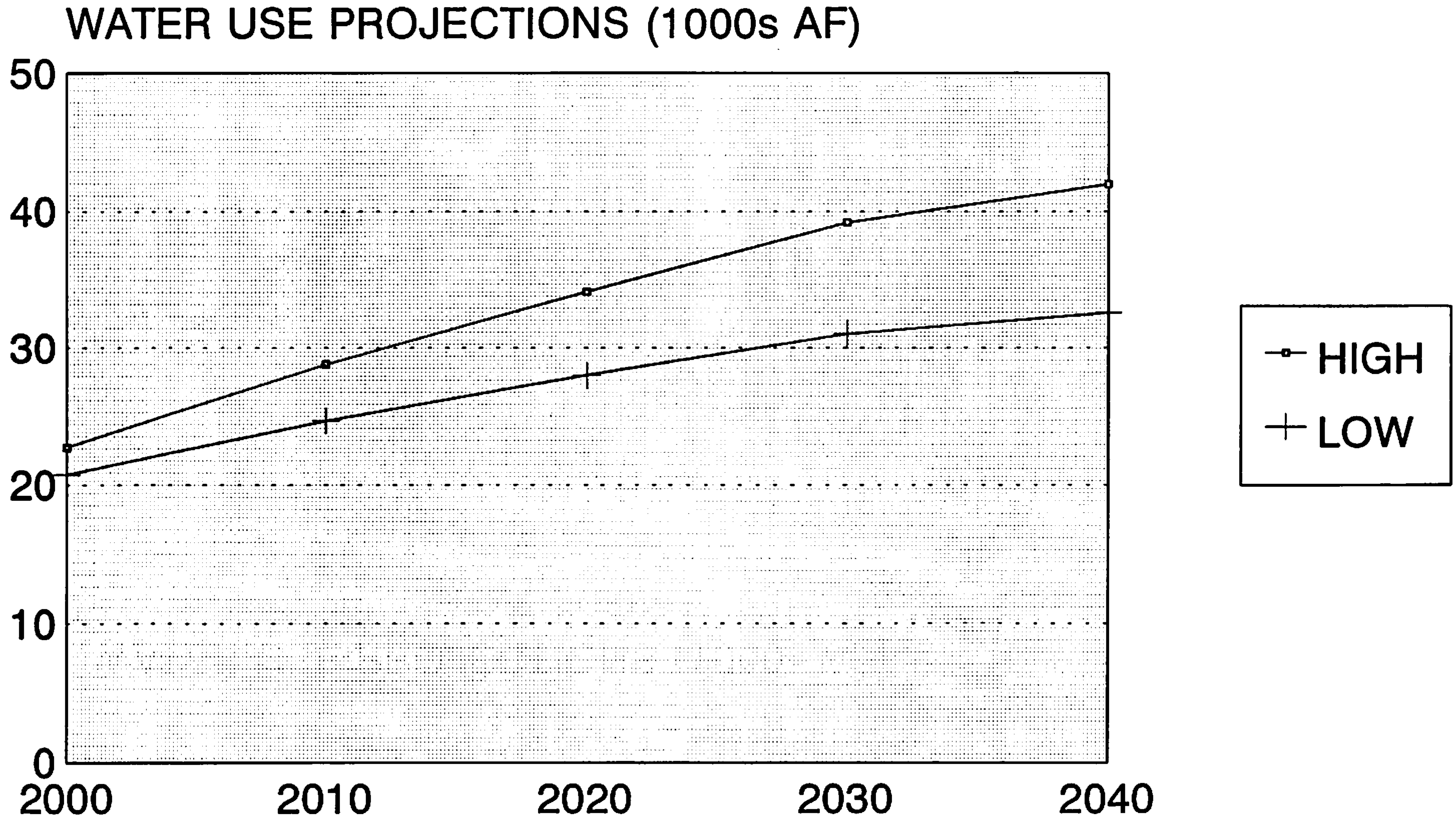


Figure 2.1-25

MEDINA COUNTY WATER USE PROJECTIONS
FROM TWDB 1992 CENSUS DATA

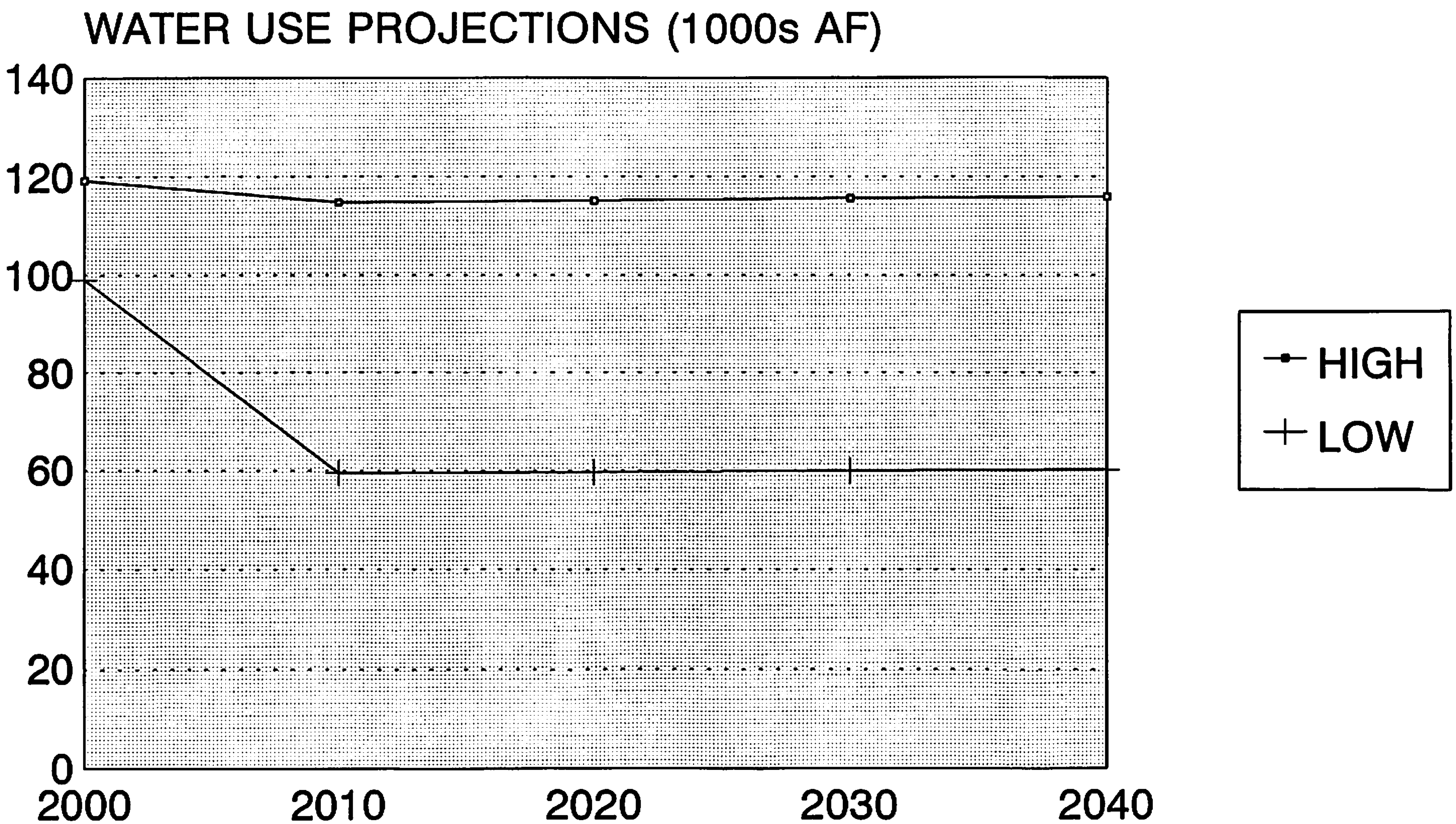


Figure 2.1-26

UVALDE COUNTY WATER USE PROJECTIONS
FROM TWDB 1992 CENSUS DATA

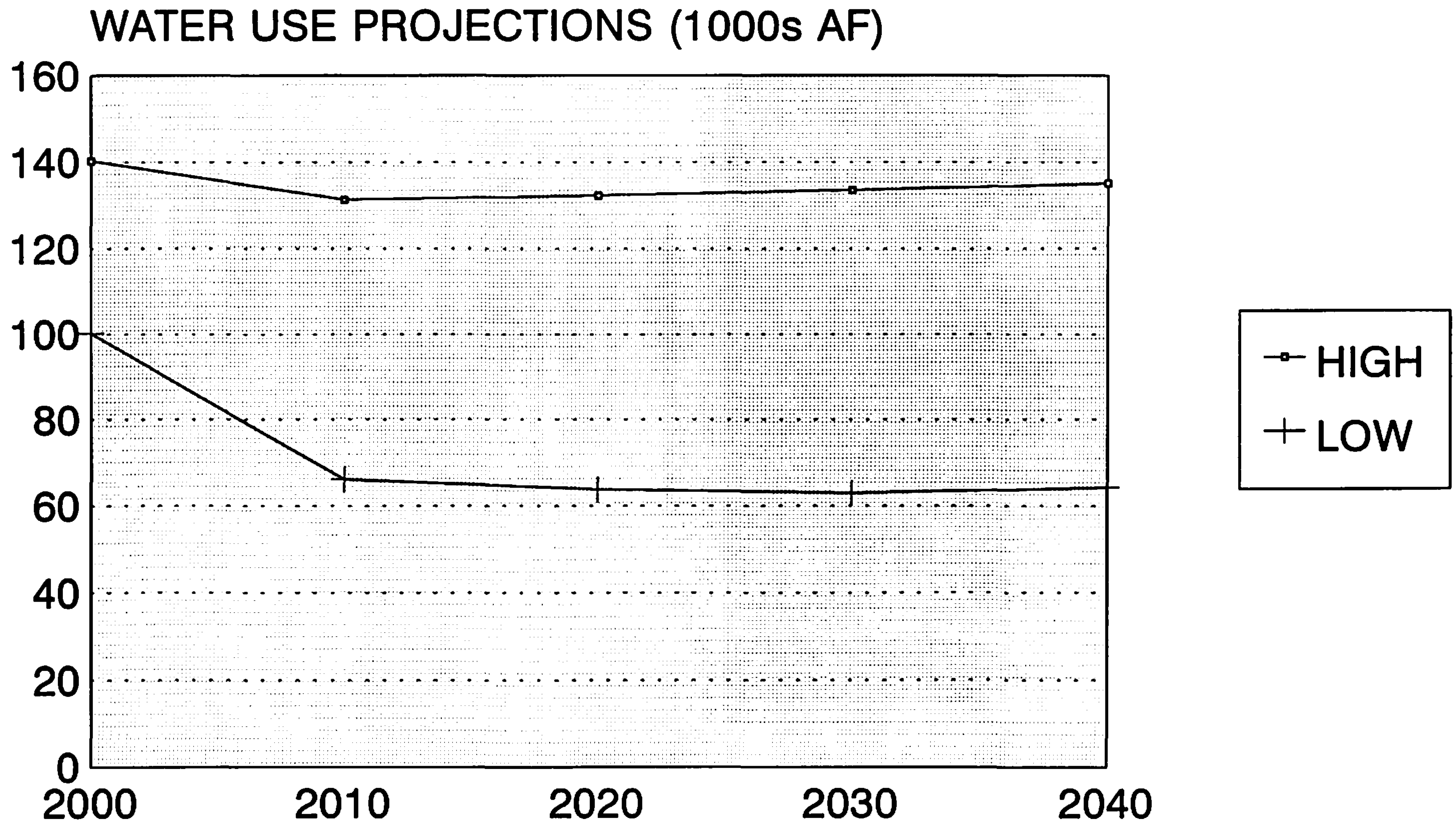


Figure 2.1-27

Figure 2.2-1a

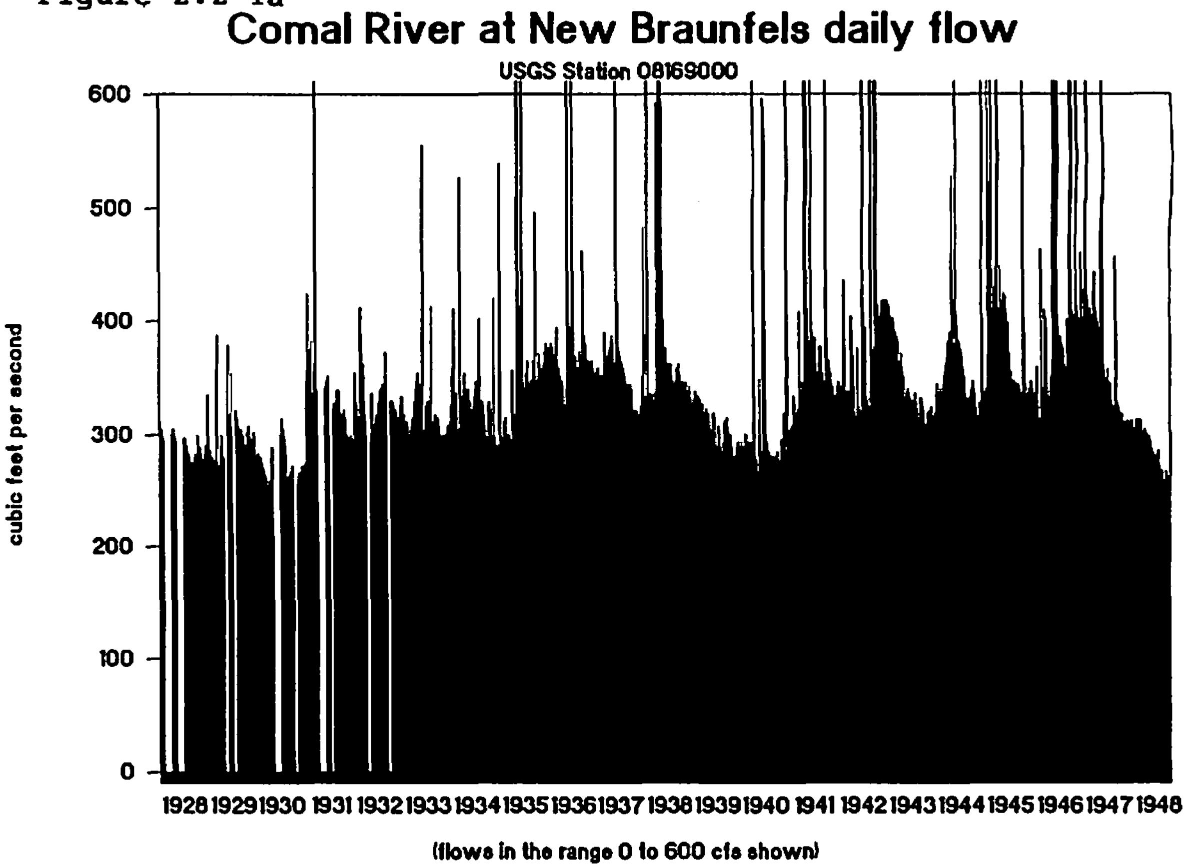
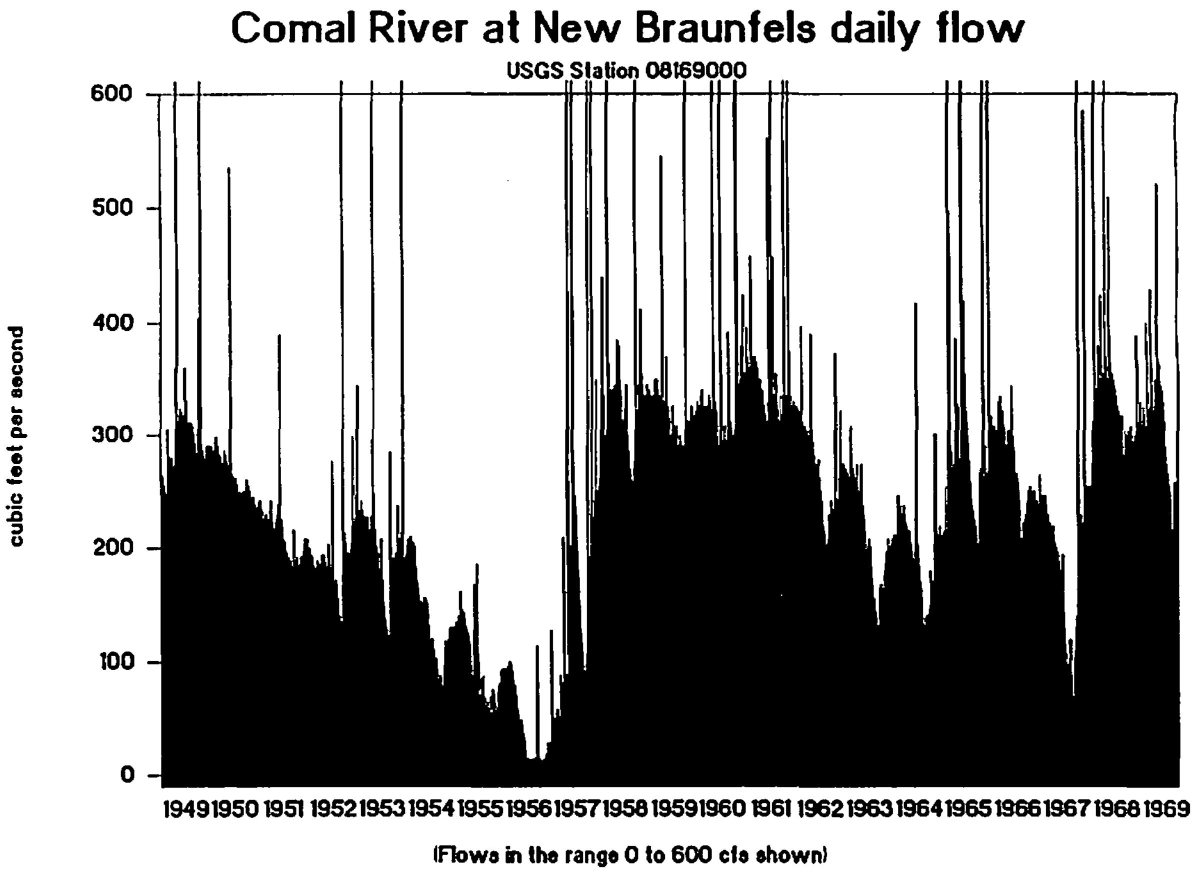

Comal River at New Braunfels daily flow
USGS Station 08169000
600
500
400
300
200
100
0
cubic feet per second
1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940 1941 1942 1943 1944 1945 1946 1947 1948
(flows in the range 0 to 600 cfs shown)

Figure 2.2-1b



Comal River at New Braunfels daily flow
USGS Station 08169000
600
500
400
300
200
100
0
cubic feet per second
1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969
(Flows in the range 0 to 600 cfs shown)

Figure 2.2-1c

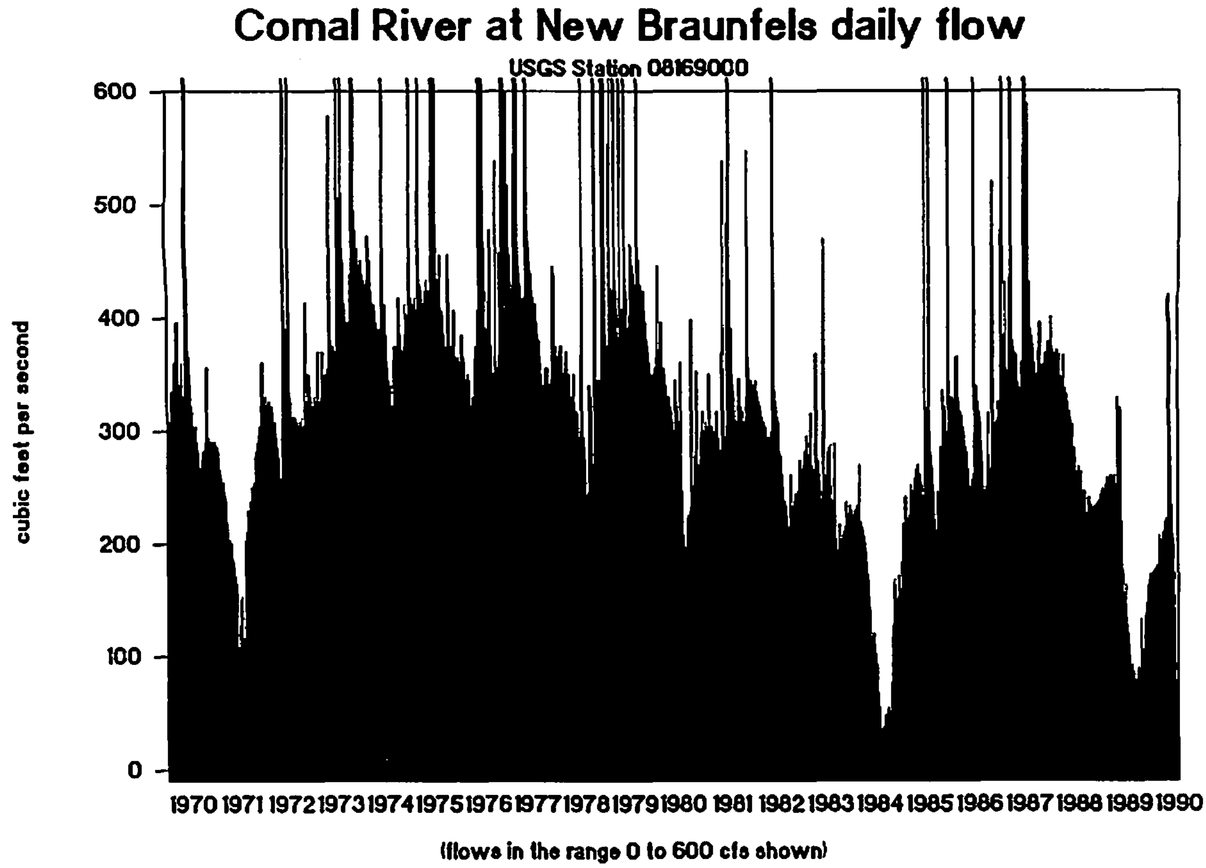

Comal River at New Braunfels daily flow
USGS Station 08169000
600
500
400
300
200
100
0
cubic feet per second
1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990
(flows in the range 0 to 600 cfs shown)

Figure 2.2-2a

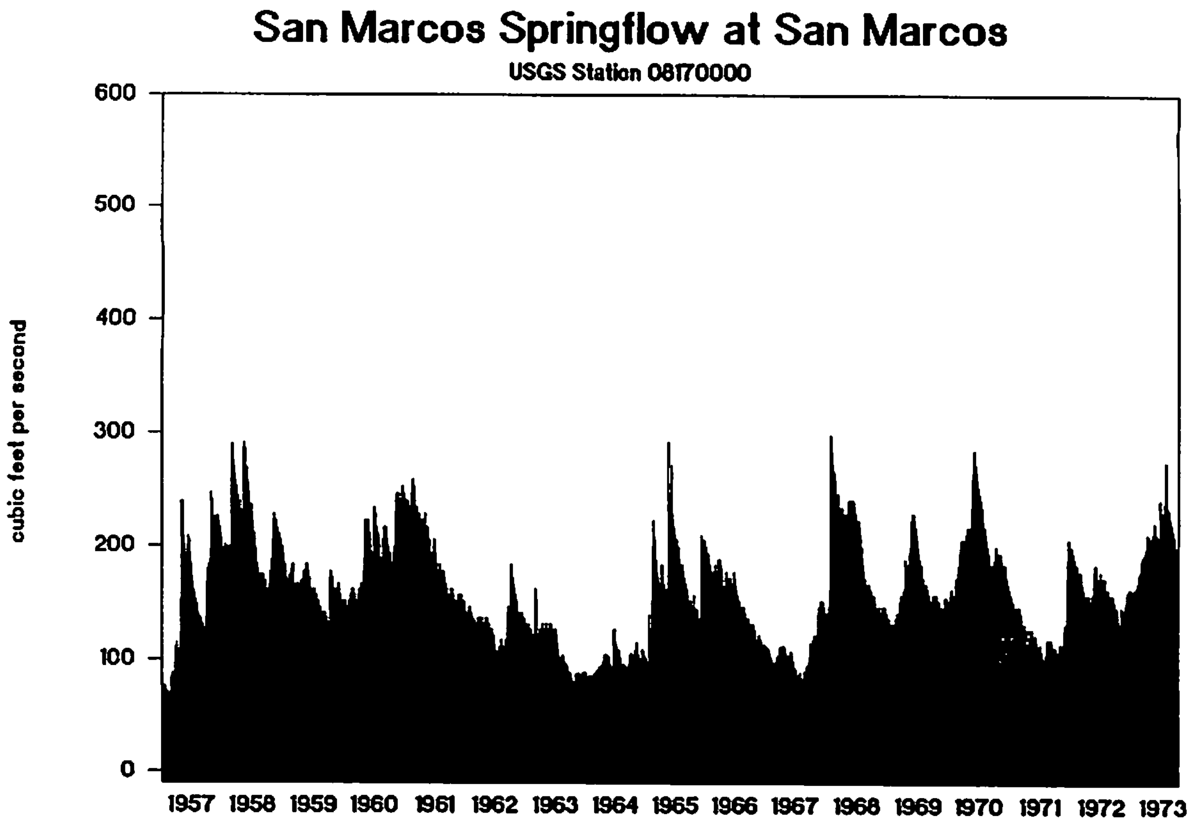
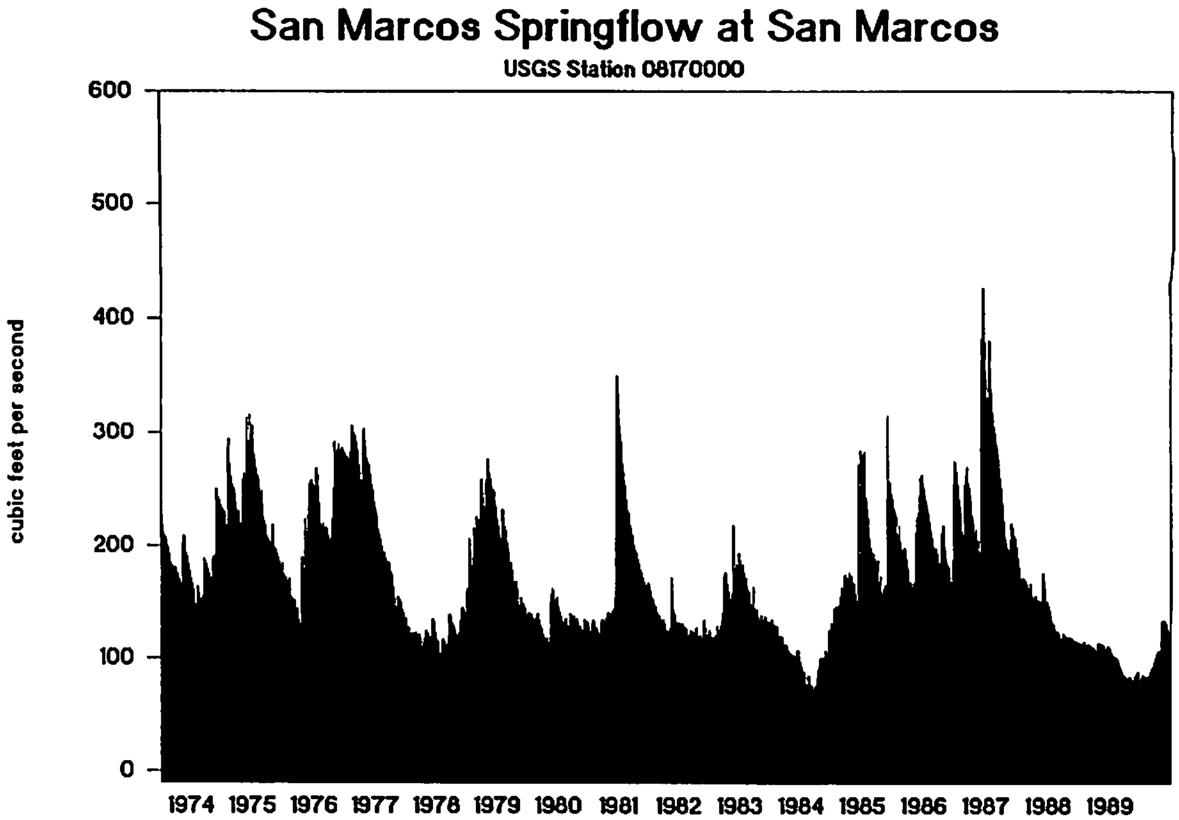

San Marcos Springflow at San Marcos
USGS Station 08170000
cubic feet per second
600
500
400
300
200
100
0
1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973

Figure 2.2-2b


San Marcos Springflow at San Marcos
USGS Station 08170000
600
500
400
300
200
100
0
cubic feet per second
1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989

3.0 SOURCES OF SUPPLY

SECTION 3.0 LIST OF TABLES

3.0 SOURCES OF SUPPLY

Introduction

This section reviews studies of specific alternative water source options and studies of policy documents that sketched broad strategies for resolving regional water needs. The goal of this examination is to present in summary form the capacities and costs of existing and potential sources of supply, in so far as these can be determined from available data. The Panel made no effort to rank or prioritize these options but did attempt to normalize the costs of all projects in order to arrive at costs per acre foot. These costs are presented in tabular form but must be read with great caution. The technical studies which provided the general cost figures from which the cost per acre foot numbers were derived varied a great deal in the factors they considered as components of project cost. Some, for example, included operation and maintenance and transmission costs; others did not. Some reviewed such limiting factors as environmental constraints, the presence of historical sites and other factors the mitigation of which would add to overall costs; many studies gave no consideration at all to such constraints. Costs cited for existing projects are the rates established by the managing entities; there may be cases in which these rates conceal subsidies or in other ways may not be strictly comparable to rates computed solely with reference to costs. These cost figures, then, would have to be the subject of much further study before they could give authoritative guidance to the policy development process.

It is important to note that the Panel members do not endorse any of the studies from which these cost figures were taken nor do they endorse any particular project cited in these studies.

3.1 REFERENCE MATERIALS

3.1.1 Technical Studies

Twenty-three technical studies were used as reference material for the data compiled in this section. Table 3.1-1 provides background information on the technical studies which addressed surface water, water reuse, aquifer storage and recovery, recharge and desalination. Generally, these studies were prepared by state and federal agencies or by consultants working for cities, river authorities or other local agencies. Information on existing projects was supplemented by contacts with the project owners for updated information on water sales, permit conditions, rates, and operating criteria.

In addition to the technical studies described above the Texas Water Development Board (TWDB) maintains a record of current data on sources of water supply in the State. This data is a compilation of information by the TWDB, in large part from the technical studies described above, relating to reservoir projects and associated delivery systems. The TWDB data includes adjustments made by TWDB staff when information is available to support those adjustments include updating costs to the current date and including additional environmental costs.

3.1.2 Master Plans

Six documents were discovered in research for this section of the report that fall in the category of "master plan." By this term we refer to policy planning documents which define broad strategies for responding to water concerns in the region. These master plans relied upon previous work, generally the technical studies noted above, and did not develop any new technical information relative to sources of supply. These master plans were prepared for purposes of investigating alternatives and recommending courses of action for a study area or entity. These reports were not relied upon for technical information to be further presented in this section. Table 3.1-2 provides information on these six master plans.

3.2 SURFACE WATER

3.2.1 Existing Surface Water Sources and Supply Systems

Five existing regional surface water sources were identified in the study area. They are Canyon Lake, Medina Lake, Lake Corpus Christi, Choke Canyon Reservoir and Lake Texana. In addition, four minor dedicated water supplies were identified. They are the Upper Guadalupe Reservoir at Kerrville, Coleto Creek Reservoir, Victor Braunig Lake and Calaveras Creek Lake. Reported yield estimates for the five regional projects are presented in Table 3.2-1 and are described in more detail below. A category of "Other Sources" is also described below.

It should be noted that the reported yields for existing and potential undeveloped reservoir projects have differing reliability as surface water sources depending upon the reservoir operation that is modelled in the calculation of the yield. Most projects are evaluated for "firm yield." Firm yield is defined as the amount of water that can be supplied (usually on an annual basis) through a repeat of the drought of record without a shortage. A reservoir may be operated to accept shortages in favor of increasing the "average annual yield." The average annual yield is defined as the long term average supply from the project that can be obtained by diverting greater amounts during abundant water periods and diverting lesser amounts during dry periods. This difference in operation generally means that average annual yield is higher than firm yield.

Canyon Lake

The property and facilities at Canyon Lake are owned and operated by the Corps of Engineers (COE). The Guadalupe-Blanco River Authority (GBRA) paid for and controls the conservation storage pool in the lake below elevation 909.0 feet MSL under Certificate of Adjudication No. 18-2074 issued by the Texas Water Commission. The federal government paid for and controls the flood control function of the lake. The flood control pool is above 909.0 feet MSL.

When the reservoir elevation is below 909.0 feet MSL, GBRA operates the conservation pool in accordance with the conditions of the certificate of adjudication for water supply purposes. When the water elevation in the reservoir is above 909.0 feet MSL (in the flood pool) the COE dictates the release rates according to the flood control criteria of the reservoir.

Canyon Lake is permitted to impound 368,000 acre-feet annually for municipal and industrial purposes from the impoundment. The priority date is 1956.

Inflows to the lake are released on a daily basis to the extent that senior downstream water rights are entitled to inflows and must be honored. The downstream water rights are honored by honoring the largest and most senior water right, the hydroelectric right on the Guadalupe River in Guadalupe and Gonzales counties, on the premise that when this largest and most senior right is met, then all the other smaller rights senior to the Canyon Lake right are also met.

Current contracts to supply water from the firm yield of Canyon Lake total 30,200 acre feet per year. The highest annual release from the lake to meet contractual commitments was 6,600 acre feet in 1991. Several of the entities which have contracts for water supply from the firm yield of Canyon Lake have run-of-river permits which serve as their primary supply. The Canyon Lake supply will be used during periods when run-of-river supplies are not available.

The research materials indicate that the yield of Canyon Lake has been calculated for historical and varying future conditions. The future conditions include variations of reduced spring flows, San Antonio return flows, San Antonio reuse and subordination of the Guadalupe River GBRA hydroelectric rights. The firm yield is reported to range from 15,900 to 61,000 acre feet per year depending upon the variables. The Guadalupe Blanco River Authority is proposing to increase the firm yield to approximately 50,000 acre feet (the permitted amount) under historical conditions by subordinating hydroelectric rights. Without this subordination, the yield under historical conditions would fall between 36,000 and 40,000 acre feet.

Sample Data From Table 3.2.1
see pages 194-197 for complete table

EXISTING SURFACE WATER SOURCES AND SUPPLY SYSTEMS IN THE STUDY AREA

Basin: Guadalupe

Project: Canyon Reservoir

Study: Espey Huston and Associates. <u>Water Availability for the Guadalupe and San Antonio River Basins</u>. 1986.

Firm Yield (acre feet/year)	Conditions
61,000	- Historical spring flows (1940 - 82) - San Antonio return flows equal 135,000 acre-feet per year - Applewhite and Coleto Creek in operation
37,500	- Historical spring flows (1940 - 82) - San Antonio return flows equal 135,000 acre-feet (present condition - 1986) - Applewhite Reservoir in operation
30,300	- Zero spring flows - San Antonio return flows equal 135,000 acre-feet per year - Applewhite and Coleto Creek in operation
27,000	- Spring flows equal 273,872 acre-feet per year - San Antonio return flows equal 170,000 acre-feet per year - City of San Antonio reuse equals 100,000 acre-feet per year
27,000	- Spring flows equal 273,872 acre-feet per year - San Antonio return flows at 116,280 acre-feet per year net - City of San Antonio reuse equals to 153,720 acre-feet
26,000	- Springs flow artificially maintained, equal 160,000 acre-feet per year - San Antonio return flows equal 90,000 acre feet per year - San Antonio reuse equals 180,000 acre-feet per year
24,500	- Spring flows equal 240,565 acre-feet - San Antonio return flows equal 135,000 acre-feet (present condition - 1986)
24,000	- Spring flows equal 240,565 acre-feet per year - San Antonio return flows equal 170,000 acre-feet per year net - San Antonio reuse equals 100,000 acre-feet per year
15,900	- Spring flows equal zero - San Antonio return flows equal 270,000 acre-feet per year

Medina Lake

Medina Lake is owned and operated by the Bexar-Medina-Atascosa Water Control and Improvement District No. 1 (BMA) under the conditions of Certificate of Adjudication No. 19-2130. The certificate of adjudication allows the diversion of 66,000 acre-feet per year from the total impoundment of 237,800 acre-feet. A minor amount of the permitted diversion is for municipal and domestic uses, the majority is for irrigation purposes. The priority date for Medina Lake is 1910.

The Medina Lake system consists of the main lake and the smaller diversion lake approximately four miles downstream from the main lake, where water is diverted into an open canal for delivery to the irrigation farmers within the BMA Irrigation District.

The normal approach to operation by BMA is to draw down reservoir storage on an as-needed basis. When the reservoir supply is depleted the irrigation farmers accept the shortage. The reservoir supply has been depleted in the history of operation of the irrigation system under this operating criteria, the diversions having varied from 0 to 62,000 acre feet per year. The average annual diversion from 1940-1986 was approximately 25,000 acre feet, although there is some question about the accuracy of the reported amounts before 1957. The reservoir was empty or near empty during the seven years in the drought period 1950-1956, with only 5850 acre feet of diversions reported in 1953.

The yield of the reservoir system has been calculated for several operating criteria. The firm yield is zero. If the system is operated in a scalping mode to maximize diversions up to the limit of the permitted annual diversions and if shortages, or no water supply in some years, are accepted, the average annual yield was calculated to be 55,704 acre feet per year.

Lake Corpus Christi

Lake Corpus Christi is owned and operated by the City of Corpus Christi. Releases from the reservoir are made downstream to the Calallen diversion facility where the water is diverted for potable treatment and raw water uses. Lake Corpus Christi is operated as a system with Choke Canyon Reservoir.

The permit for the reservoir, Certificate of Adjudication No. 21-2464, authorizes the impoundment of 300,000 acre-feet of water in Lake Corpus Christi and the Calallen Dam and Reservoir. The certificate of adjudication authorizes diversion of 4,872 acre-feet of water from Calallen Reservoir on the Nueces River, 150,000 acre-feet of water from Lake Corpus Christi for municipal purposes, 150,000 acre-feet of water from Lake Corpus Christi for industrial purposes and other minor authorizations for irrigation and mining.

The majority of the rights including the two 150,000 acre-foot amounts have a priority date of 1925.

Choke Canyon Reservoir

The permit, Certificate of Adjudication No. 3214A, for Choke Canyon Dam and Reservoir, has a priority date of 1976. The certificate of adjudication authorizes the impoundment of 700,000 acre feet of water and authorizes the use of 78,730 acre feet of water annually for industrial purposes and 59,770 acre-feet annually for municipal uses and minor amounts for irrigation use. The project is owned by the City of Corpus Christi (80%) and the Nueces River Authority (20%). A minor portion of the Corpus Christi share has been sold to the City of Three Rivers.

The permit has a special condition requiring that the owners shall provide not less that 151,000 acre feet of water per annum for the estuaries by the combination of releases and spills from the reservoir system at Lake Corpus Christi Dam and return flows to Nueces and Corpus Christi bays and other receiving estuaries. This requirement has been further addressed in recent negotiations between the City of Corpus Christi and the Texas Water Commission. These negotiations resulted in agreement on an interim five year plan now in effect under which a firm demand has been put on the LCC\CC System of 97,000 acre-feet per year to be delivered into Nueces Bay with a credit for wastewater return flows, currently 6,000 acre-feet per year. These releases are made on a monthly regimen with 70% of the release to occur in May, June, September and October.

Current water use from the LCC\CC System is 130,00 acre-feet per year. The yield of Choke Canyon Reservoir and Lake Corpus Christi varies between 187,800 and 252,000 for varying conditions and operating policies as more particularly described in Table 3.2-1 The current municipal use plus the required release to Nueces Bay less the return flows (130,000 + 97,000 - 6000) equals 221,000 acre-feet year.

Lake Texana

Lake Texana is owned and operated by the Lavaca-Navidad River Authority (L-NRA). The project was constructed by the U.S. Bureau of Reclamation. The L-NRA and the Texas Water Development Board jointly hold the water rights permit which allows diversion of 75,000 acre feet of yield annually. L-NRA presently has water sales contracts for 32,000 acre feet per year.

In June 1992, L-NRA executed an 18 month option agreement with the Port Authority of Corpus Christi for 41,288 acre-feet per year with 10,000 acre feet of that amount as interim water subject to recall by L-NRA. L-NRA also has a pending agreement with the City of Point Comfort for 11,800 acre-feet per year.

Upper Guadalupe Reservoir

The Upper Guadalupe Reservoir is dedicated for service as a water supply lake for the Upper Guadalupe River Authority potable water treatment plant which serves the City of Kerrville. No additional water supply is available from this project.

Coleto Creek Reservoir

Coleto Creek Reservoir is dedicated for service as a cooling reservoir for Central Power and Light Company's Coleto Creek Power Station. The aim of present operating criteria is to keep the reservoir as full as possible at all times, passing through flood waters as necessary, to meet the project design criteria for cooling purposes. Operation of the reservoir as a water supply for other purposes would detract from the efficiency of the cooling function of the reservoir.

Calaveras Lake

Calaveras Lake is dedicated for service as a cooling reservoir for San Antonio City Public Service Board's O.W. Summers/ J.T. Deely/ J.K. Spruce Power Station. As in the case of Coleto Creek Reservoir, no additional water supply is available from the reservoir when it is operated for its design purposes.

Victor Braunig Lake

Victor Braunig Lake is dedicated for service as a cooling reservoir for San Antonio City Public Service Board's Victor Braunig Power Station. As with the other cooling reservoirs, no additional water supply is available from the reservoir when it is operated for its design purposes.

Other Sources

One report, Hays County Water and Wastewater Study, by HDR Engineering, Inc., identified Lake Travis on the Colorado River as a source for northern Hays County and the City of Austin treated water system as a source for northeastern Hays County. This report also evaluated the Blanco River and the

San Marcos River as sources for Wimberly and San Marcos, respectively. This report analyzed facilities costs on a localized basis for specific communities in Hays County. The water sources were not evaluated for availability or dependability. For these reasons the results of this study are not reported further in this text.

3.2.2 Potential Undeveloped Surface Water Source and Supply Systems Within Study Area

Eighteen previously studied potential undeveloped reservoir projects were identified in the research material. They are:

- Clopton Crossing
- Cuero I
- Cuero I and Lindenau (combined)
- Cibolo
- Simmons
- Indian Creek
- R & M Dam and Reservoir
- Cotulla Diversion Dam
- Lake Texana-Palmetto Stage 2 (combined)
- Lockhart
- Lindenau (Cuero II)
- Applewhite
- Goliad
- Harris
- Bluntzer
- Cotulla Reservoir
- Palmetto Bend Stage 2

Pertinent information and results of yield studies for these potential undeveloped projects is presented in Table 3.2-2.

Sample Data From Table 3.2-2

see pages 199-210 for complete table

Basin:	Guadalupe
Stream:	Guadalupe River and Sandies Creek
Project:	Cuero I and Lindenau Reservoirs
Project Size:	Same as for Individual Reservoirs
Study:	Espey Huston and Associates. Water Availability Study for the Guadalupe and San Antonio River Basins. 1986.

Firm Yield (acre-feet/year)	Conditions
219,000	- Historical spring flows (1940 - 1982) - San Antonio return flows equal 135,000 acre-feet per year - Full bay and estuary requirements
207,000	- Spring flows equal 273,872 acre-feet per year - San Antonio return flows equal 170,000 acre-feet per year - San Antonio reuse equals 100,000 acre-feet per year
194,000	- Historical spring flows (1940 - 1982) - San Antonio return flows equal 135,000 acre-feet per year - Full bay and estuary requirements - Full development of Goliad, Clopton and Lockhart projects

3.3 WATER REUSE

3.3.1 Existing Water Reuse Projects

San Antonio City Public Service Board's Lakes Braunig and Calaveras were constructed as a part of San Antonio's electric power supply system to take advantage of San Antonio's wastewater return flows to shift cooling water demands for electric power generation from the Edwards Aquifer. In 1989, 28,175 acre feet were diverted from the San Antonio River for this purpose. Other existing or developing water reuse projects include the following. Because many have not yet come on line, it is not possible to say how much pumpage from the Edwards Aquifer these projects would displace. They are:

Southwest Texas State University -	Gray water reuse system
City of Uvalde	Wastewater reuse for golf course and park
Kelly AFB	Wastewater reuse for golf course
Cibolo Creek Municipal Authority -	Wastewater reuse for golf course on Randolph AFB
Cibolo Creek Municipal Authority -	Wastewater reuse for golf course in Selma
San Antonio River Authority	Recycling water through the flood control tunnel for the San Antonio River and the Rivercenter extension of the San Antonio River.

3.3.2 Potential Undeveloped Water Reuse Projects

The Master Plan 1991 written by the Alamo Water Conservation and Reuse District provides in Section V — Facilities Plan, a proposed plan of development for transmission of treated wastewater from City of San Antonio wastewater plants and others in the greater San Antonio area to points of use. The primary destinations for reuse water are golf courses, industries and the San Antonio River.

The proposed facilities consist of two transmission lines, one around the south and east sides conveying reuse water from the Salado, Leon Creek and Dos Rios plants to industrial users in the Braunig Lake area, to southside golf courses and to the San Antonio River in Brackenridge Park. The other transmission line is proposed to convey reuse water from Medio Creek north to golf course and resort operations on the northwest side of San Antonio. No additional treatment of the wastewater was proposed to improve the quality for reuse.

The Report on the Feasibility of Desalination and Wastewater Reuse for the City of Corpus Christi, Texas prepared by Stone & Webster Engineering Corporation in 1984 addressed the tertiary treatment of municipal wastewater for industrial purposes and reported that it is feasible with proven treatment methods.

The Water Management Plan using Braunig and Calaveras Lakes prepared by Black and Veatch in 1990 proposed a three phase plan for using San Antonio wastewater in a city-wide reuse program. Phase I of the plan was designed to improve the quality of water in Braunig and Calaveras Lakes by filling with Edwards Aquifer water or treated wastewater from the City's Dos Rios Plant. Phase II was designed to utilize wastewater for municipal use during periods when the aquifer supply is insufficient. Wastewater from the Dos Rios plant would be cycled through Lakes Braunig and Calaveras and a City Water Board water renovation plant for use in the City Water Board distribution system. Phase III adds Salado Creek Wastewater Treatment Plant effluent to the reuse stream described for Phase II.

3.4 UNDERGROUND STORAGE AND RECOVERY

3.4.1 Existing Underground Storage and Recovery Projects

No underground storage and recovery projects are operating in the study area.

The Alamo Water Reuse and Conservation District sponsored a study by CH2M HILL and others titled Carrizo Recharge Study to conceptualize the design of a recharge and recovery project in the Carrizo Aquifer south of San Antonio including recommendations for a pilot scale project using spreading basins and wells to accomplish the recharge. The study included the identification of sources of water for recharge and recharge sites. This report was concluded in July, 1990.

3.4.2 Potential Undeveloped Underground Storage and Recovery Projects

The Edwards Underground Water District has constructed four recharge projects in Medina County to enhance recharge to the Edwards Aquifer. One is on San Geronimo Creek, a tributary to the Medina River. The other three are on Verde Creek, Parker Creek and Seco Creek, all in the Frio River Basin. These projects have an estimated average annual recharge of 5,000 acre-feet per year.

3.5 RECHARGE

3.5.1 Existing Recharge Projects

A series of recharge features were constructed in Uvalde County in the 1950's to enhance recharge of the Edwards Aquifer. No specific information is available on the amount of recharge gained by the projects. Generally, the projects are small and in association with natural recharge features in the Edwards Aquifer Recharge Zone.

Existing flood control structures in the San Antonio and Guadalupe Basins on Salado Creek (13), Dry Comal Creek (5), York Creek (2), and the Upper San Marcos watershed (5) serve an additional function as recharge enhancement projects for the Edwards Aquifer. These projects control the runoff from approximately 300 square miles of the approximately 1760 square miles of drainage area in the two river basins above the downstream edge of the Edwards Aquifer Recharge Zone. No information was found on the annual recharge enhancement provided by these structures.

The Medina Lake system, though constructed and operated for irrigation, provides recharge enhancement to the Edwards Aquifer. Lowry (1953) developed curves of reservoir elevation vs. recharge to the Edwards Aquifer for rising and falling stages in the lake. In addition he estimated the recharge to the Edwards Aquifer for Diversion Lake downstream of the main lake. Lowry's curves have been used by USGS to estimate annual recharge to the aquifer based on end-of-month stage in Medina Lake for each month of the year. USGS reports in Bulletin 49, Compilation of Hydrologic Data for the Edwards Aquifer, San Antonio Area, Texas, 1989, with 1934-89 Summary that the average annual recharge of the Medina Lake system is 60,800 acre-feet for the 1934 - 1989 period. It should be noted that this amount is the sum of the natural recharge and recharge enhancement. The lake has been in existence since 1913. No information on pre-lake natural recharge is available for purposes of separating the recharge enhancement from the natural recharge that would occur in the Medina River without the Medina Lake system in place.

Espey Huston and Associates (1989) developed curves similar to Lowry's based on a period of record 1922 - 1933 and 1957 - 1973 as a part of the Medina Lake Hydrology Study. These curves estimate lower historical recharge to the Edwards Aquifer than Lowry's curves. The annual average recharge estimated by Espey Huston for the period 1940 - 1982 is 39,801 acre-feet per year.

3.5.2 Potential Undeveloped Recharge Projects

The Regional Water Supply Planning Study Phase III Recharge Enhancement - Nueces River Basin and the earlier Phase I report by HDR Engineering, Inc. was a comprehensive assessment of Edwards Aquifer recharge enhancement potential in the Nueces Basin. All of the drainage area of the basin above the downstream edge of the recharge zone was included in the evaluation.

Two types of projects were evaluated. For those drainages emanating above the recharge zone an impoundment structure was sited above the recharge zone to capture flood flows for later release across the recharge zone for natural recharge to the aquifer. These are referred to in the report as Type I structures. They are the proposed Montell (Nueces River), Concan (Frio River), Upper Dry Frio, Upper Sabinal, Upper Seco, Upper Hondo, and Upper Verde projects.

For those same streams a Type II project was also evaluated. These projects are proposed for construction on the recharge zone for immediate recharge of captured flood waters. These proposed projects are Indian Creek (Nueces River), Lower Frio, Lower Dry Frio, Lower Sabinal, Lower Seco, Lower Hondo, and Lower Verde. In addition, five smaller Type II projects were evaluated on tributary streams that rise on or just above the recharge zone. These are the Leona, Blanco, Elm, Little Blanco and Quihi projects.

Each of the Type I and Type II projects were evaluated under a multiplicity of varying conditions of size, runoff conditions and treatment of downstream water rights. Significant findings of the study were that unappropriated water is available in the upper Nueces Basin for recharge. Additional amounts can be made available for recharge, the study found, if the water rights of the Lake Corpus Christi\Choke Canyon System are not honored by the projects' operation. It was estimated that not honoring these rights would have a minimal impact on the yield of the LCC\CC System.

3.6 DESALINATION

3.6.1 Existing Desalination Projects

In a report titled "Desalting in Texas A Status Report: by Texas Water Development Board dated May, 1992 six desalination projects in the study area are identified. Information on these projects as excerpted from the report is presented in Table 3.6-1.

3.6.2 Potential Undeveloped Desalination Projects

The Report on the Feasibility of Desalination and Wastewater Reuse for the City of Corpus Christi, Texas prepared by Stone & Webster Engineering Corporation in 1984 addressed the desalination of seawater and brackish groundwater and reported that both are feasible with proven treatment methods.

3.7 COST OF SOURCES OF SUPPLY

3.7.1 Existing Projects

3.7.1.1 Surface Water

Table 3.7-1 presents pertinent information relative to the four existing regional surface water supply systems.

Table 3.7-1

EXISTING SURFACE WATER SOURCES

Project	Permitted Annual Yield acre-feet	Calculated Annual Yield(s) acre-feet	Committed Annual Yield acre-feet	Cost of Annual Yield $/acre-feet	Water Delivered To
Canyon Reservoir	50,000 (1)	24,000 to (2) 61,000	30,200	53.03	A
Medina Lake System	66,000	0 (2) 27,500 (3) 55,704 (4)	all (5)	(6)	B
Choke Canyon Reservoir	139,000	(7)	(7)	(7)	(7)
Lake Corpus Christi	300,000	(7)	(7)	(7)	(7)
Choke Canyon/ Lake Corpus Christi	252,000	169,700 to 252,000(2)	221,000 (8)	34.52	C
Lake Texana	75,000	82,645(2)	32,000 (9)	45.00 (10)	D

(1) See special conditions.
(2) Firm yield
(3) Firm yield at Medina Lake not considering losses at Diversion Lake
(4) Maximum average annual yield based on current operation
(5) Subject to availability
(6) Water paid for with tax rate of $10 per acre plus $8 per acre for each irrigation
(7) See Choke Canyon/Lake Corpus Christi below
(8) 130,000 acre-feet to municipal and industrial uses; 97,000 acre-feet to Nueces Bay, less return flows (6000 acre feet at present)
(9) Additional 41,288 acre-feet under contract to sell to Port Authority of Corpus Christi
(10) Program increases to $65 per acre-foot by year 2004

A	B	C	D
-New Braunfels -San Marcos -Seguin -Gonzales WSC -Spring Hill WSC -Calhoun County WSC -Union Carbide -Central Power and Light Co.	-Approximately 1800 land owners	At Lake Corpus Christi: -Mathis, Beeville & Alice At Corpus Christi WTP: -Corpus Christi, San Patricio MWD, Koch Refining Co., and Hoechst-Celanese Co. At Choke Canyon Reservoir: -Three Rivers, Diamond Shamrock, and TP&WD	-Formosa Plastics

3.7.1.2 Water Reuse

San Antonio City Public Service Board (CPSB) pays $50 per acre-foot to the City of San Antonio for wastewater delivered to the Braunig and Calaveras Lakes pumping stations. CPSB estimates energy cost for pumping at $10 per acre-foot. Information on the cost of the pumping and conveyance facilities is not available for purposes of computing a facilities component of total unit cost for the water delivered to Braunig and Calaveras Lakes.

3.7.1.3 Underground Storage and Recovery

No information on existing underground storage and recovery projects in the study area was discovered in a review of the technical reports, consequently no information on the cost *of existing* storage and recovery projects is available.

The Upper Guadalupe River Authority is operating a pilot project evaluating the feasibility of an aquifer storage and recovery project in the Lower Trinity Formation. The full scale operation of the project will use excess water treatment plant capacity during the winter months to recharge the aquifer. Recovery of water will be made by wells during peak demand periods.

3.7.1.4 Recharge

With the exception of the four recharge projects constructed by the Edwards Underground Water District and the small recharge projects constructed in Uvalde County in the 1950s, all of the other existing recharge projects identified were constructed as flood control or water supply projects and provide recharge as a secondary benefit.

The initial investment in the four Edwards Underground Water District recharge projects was $ 1,879,494. These projects have an estimated annual average recharge of 5,000 acre-feet per year, (at a cost of $38.74 per acre foot, using the assumptions of a twenty year amortization period at 8% interest). No information was discovered to relate the small Uvalde County recharge projects on a cost per acre-foot basis.

3.7.1.5 Desalination

In the report titled Desalting in Texas A Study Report by the Texas Water Development Board dated May, 1992 costs for reverse osmosis and electrodialysis-reversal treatment of brackish groundwater or surface water were reported as $.40 to $.75/1000 gallons ($130 to $230 per acre-foot). Reverse osmosis treatment of sea water was reported to cost $4.00 to $4.75/1000 gallons ($1300 to $1550 per acre-foot). The specific sources of cost information were not given in the report.

3.7.2 Potential Undeveloped Projects

3.7.2.1 Surface Water

Table 3.7-2 presents information on construction costs and annual operating and maintenance expenses for potential undeveloped surface water supplies. Table 3.7-3 presents information on construction costs and annual operating and maintenance expenses for potential undeveloped surface water delivery systems. For purposes of developing a consistent basis for comparing the estimates presented in the technical reports the construction costs have been updated to January, 1992 using Engineering News-Record Building Cost Index as reported in the March 30, 1992 edition. The base year selected is 1965 because the earliest estimate discovered in the review of the technical reports was made in that year.

For purposes of developing a consistent basis for comparing the operating and maintenance expenses estimates presented in the technical reports the costs have been updated to January, 1992 using the Consumer Price Index for all Urban Consumers: U.S. City Average, All Items. The base year selected is 1965.

Note that Tables 3.7-2 and 3.7-3 also include information from TWDB on yields and construction costs which data is used to present unit costs for project construction. This data is compiled from cost estimates and yield studies prepared by other agencies and consultants with adjustments made by TWDB for changed conditions. Examples of changed conditions include changes in construction costs and disproportionate increases in cost over time. In addition TWDB staff makes independent reservoir yield analyses. Generally, TWDB data should be reflective of previous work by others with minor adjustments in costs and yields. TWDB does not maintain a data base of operating and maintenance costs.

The reader is cautioned in using Tables 3.7-2 and 3.7-3 to compare costs for projects that:

1) The original construction and operating and maintenance expense estimates were made with varying degrees of detail not totally evident from a reading of the report. In some cases great detail is given. In others, only gross numbers are reported without detail.
2) Environmental costs have increased significantly over the period 1965 - 1992. Earlier reported estimates gave little consideration to environmental costs. Later estimates did. Likewise, yield calculations in later reports have to take into account water requirements to be met for instream flows and bays and estuaries resulting in reduced yields over those calculated in earlier estimates for comparable projects.
3) Operating and maintenance expense estimates may include different components, for example, expenses to operate mitigation areas.

3.7.2.2 Water Reuse

Alamo Water Conservation and Reuse District (1991) proposed a five year capital improvements program as Phase I of a multiphase reuse development program for the City of San Antonio. The cost of Phase I was estimated to be $30,198,000. Annual operating and maintenance costs were not reported. The amount of water to be reused by Phase I was not stated. However the proposed plan indicated that 20,000 acre-feet would be reused by year 2000. Subsequent analysis by staff resulted in a delivered cost range of $200 to $350 per acre-foot not including a commodity charge.

Stone and Webster (1984) estimated that treated effluent from selected City of Corpus Christi wastewater treatment plants could be given tertiary treatment (lime softening) and delivered to industries within the city for $1.95 to $.66 per 1000 gallons ($635 to $215 per acre-foot) for 2240 to 17,920 acre-feet per year, respectively.

Black and Veatch (1990) reported that an average of 48,000 acre-feet per year of City of San Antonio wastewater could be treated and cycled through Lakes Braunig and Calaveras and then treated to potable water standards by City Water Board for a unit cost of $425 per acre-foot. With a subsequent phase the total reuse could be boosted to an average of 84,000 acre-feet per year for a unit cost of $345 per acre-foot.

3.7.2.3 Underground Storage and Recovery

CH2M HILL (1991) reported an estimate of $464 per acre-foot for a underground storage and recovery project yielding 15,000 acre feet per year in the Carrizo Aquifer in Atascosa County. The storage function would be completed with spreader basins in the aquifer recharge zone; recovery by wells.

The same study reported an estimate of $717 per acre-foot (on a yield of 15,000 acre feet per year) for a similar project that would use wells for recharge after a water treatment plant for recharge and recovery. The proposed source of water for both systems was the Medina Lake irrigation system.

3.7.2.4 Recharge

HDR Engineering (1991) estimated the cost of a complete system of recharge projects in the Nueces Basin. Two types of projects were evaluated: Type I projects above the recharge zone of the Edwards

Aquifer and Type II projects on the recharge zone. The projects were evaluated for their recharge potential under two scenarios: 1) honoring all downstream rights, and 2) not honoring rights of the Lake Corpus Christi/ Choke Canyon System. Table 3.7-4 presents the estimated unit cost for the Type I projects honoring all downstream water rights for both 100% and optimum capacities. Unit costs vary from $330 to $5246 per acre foot for these conditions. Table 3.7-5 presents the estimated unit costs for the Type II projects honoring all downstream water rights except the Lake Corpus Christi/ Choke Canyon system for both 100% and optimum capacities. Unit costs vary from $145 to $4434 per acre foot for these conditions.

W.E. Simpson Company (1989) reported estimated capital cost of between $6.23 and $10.72 million to construct recharge wells to take up to 66,000 acre-feet per year off the Medina Lake irrigation canal and recharge the Edwards Aquifer in the artesian zone. The expected average annual recharge for this project was estimated by Espey Huston and Associates in the Medina Lake Study, (1989), to be between 40,000 and 55,000 acre-feet per year depending on the lake operating criteria established for the recharge operation. The estimate did not include any cost for the water supply, only for the recharge facilities.

3.7.2.5 Desalination

Stone and Webster (1984) estimated that brackish groundwater could be treated for the City of Corpus Christi in a reverse osmosis operation for $2.40 to $1.08 per 1000 gallons ($782 to $352 per acre-foot) for 1,120 to 22,400 acre-feet per year, respectively.

BuRec (1983) reported an estimate of desalination of seawater at Corpus Christi at $3.74 per 1000 gallons or $1218 per acre-foot.

3.7.3 Summaries and Comparisons

Table 3.7-6 presents a general comparison of unit cost estimates for water supply from the existing sources of supply. The unit costs for the surface water projects are the rates established by the project owners. The present study did not determine the precise basis for establishing these rates. It is possible that some rates reflect subsidies or profits and thus are not strictly comparable to figures for potential undeveloped projects determined solely by cost estimates.

Table 3.7-7 presents a similar comparison of unit cost estimates for potential undeveloped sources of supplies. Delivery system costs associated with surface water projects are not included in the estimates. Known limiting factors associated with projects are noted in the table.

Table 3.7-6

COMPARISON OF UNIT COSTS - EXISTING SOURCES OF SUPPLY

SOURCE TYPE	PROJECT	UNIT COST $/ACRE-FOOT	NOTES
Surface Water	Lake Texana	45.00	Established rate
	Canyon Reservoir	53.03	Established rate
	Lake Corpus Christi\ Choke Canyon Reservoir	34.52	Established rate
	Medina Lake	11.33	Based on $10 per acre flat rate plus 3 waterings @ $8 each for 3 acre-foot
Water Reuse	City of Public Service Board-Lakes Braunig and Calaveras	60.00	Includes $50 per acre foot to City of San Antonio and $10 per acre foot pumping cost--Facilities cost not inlcuded
Storage and Recovery	(no existing projects)		
Recharge	Edwards Underground Water District Projects	38.74	Construction Cost only annualized at 8%.for 20 years for average recharge of 5000 acre-foot
Desalination	(no cost information on existing projects)		

Panel members were concerned about the potential for misuse of the data presented in this section particularly, Table 3.7-7. This unit cost data should not be used for purposes of selecting alternatives for development on a least cost basis. Other factors relative to new project development to be considered as a part of alternative project selection include location of current and future demands, interaction of alternatives and impacts on other water users to name a few. The study results are presented in common units and seem comparable but consider that the studies were completed over a long period (1965 to 1990), were commissioned for different purposes, with different priorities and in some cases perhaps influenced by factors outside the technical arena.

3.8 PANEL DISCUSSIONS AND CONCLUSIONS

The yields of the project can vary with new data on hydrology (longer period of record) environmental factors (mitigation requirements) and other activities (diminution of springflows) which affect the unit cost. Cost estimates are very detailed in some reports, only general in others. Environmental costs are a larger part of construction costs at the present than earlier in the study period.

It was also noted by one panel member that some of the yield calculations were performed for existing reservoirs with different operating criteria than for the actual reservoir operation. The example given was Medina Lake which is operated as a scalping project but was modelled for a firm yield in one of the studies.

Table 3.7-7

COMPARISON OF UNIT COSTS - POTENTIAL UNDEVELOPED SOURCES OF SUPPLY

SOURCE TYPE	PROJECT	SOURCE OF DATA	UNIT COST $/AC-FT	UNIT COST INCLUDES O & M	LIMITING FACTORS/NOTES
Major Surface Water Projects	Clopton Crossing	Espey Huston 1986	287	No	No limiting factors cited/ Environmental considerations not addressed
	Cuero I Reservoir	Espey Huston 1986	141 to 255(1)	Yes	Mitigation required, no known endangered species/
		TWDB 1990	216	No	No information, data only
	Lindenau Reservoir (Cuero II)	Espey Huston 1986	296 to 327(1)	Yes	Mitigation required, no known endangered species/
		TWDB 1990	266	No	No information, data only
	Cuero I and Lindenau Reservoirs	Espey Huston 1986	301 to 339(1)	Yes	Same as for separate projects
	Applewhite Reservoir	Freese & Nichols 1988	168	No	Minimum yield during critical periods equal 7700 acre-feet per year when operated for scalping/
		TWDB 1990	639	No	No information, data only
	Cibolo Creek Reservoir (Lower)	Espey Huston 1986	834	Yes	Environmental considerations not addressed/
	Cibolo Creek Reservoir (Upper)	Lockwood Andrews & Newman 1965	208 to 323(1)	Yes	Environmental considerations not addressed/
	Goliad	Espey Huston 1986	211 to 465(1)	Yes	Environmental considerations not addressed/
		TWDB	180	No	No information, data only

Table 3.7-7
(continued)

	Bluntzer Reservoir	Rauschnber 1985	743 to 4500(1)	Yes	Reduced bay inflows, elevated bay salinity/
	R & M Reservoir	Rauschunber 1985	403 to 2891(1)	Yes	Reduced bay inflows, elevated bay salinity/
	Simmons Pump Station	Rauschunber 1985	52 to 122(1)	Yes	No limiting factors cited
	Cotulla Diversion and Canal	BuRec 1983	1303	Yes	No limiting factors cited
	Palmetto Bend-Stage II	HDR Engineering 1991	176 to 196(1)	Yes	Additional studies of bay and estuary impacts required/
	Lake Texana and Palmetto Bend-Stage II	HDR Engineering 1991	245 to 278(1)	Yes	See Palmetto Bend Stage II
	Lake Texana and Garwood Irrigation	HDR Engineering 1991	746 to 175(2)	Yes	Interbasin transfer, change in pupose of use/ Unit cost varies with varying amount directed from Garwood to Lake Texana
Water Reuse Projects	Alamo Water Conservation and Reuse District	AWCRD 1991	200 to 350(2)	Yes	These costss are reported from a staff analysis, wastewater delivered to San Antonio River in Brackenridge Park, industries, golf courses etc. -Phase I of Reuse Program, cost does not include commodity charge
	City of Corpus Christi	Stone & Webster 1984	215 to 635(2)	Yes	No limiting factors cited/ Wastewater treated for industrial use, unit cost varies with volume reused
	City of San Antonio	Black & Veatch 1990	345 to 425(2)	Yes	Wastewater effluent treated, cycled through Lakes Braunig and Calaveras and treated for potable use by City Water Board, unit cost varies with volume reused
Storage and Recovery	Alamo Water Conservation and Reuse District	CH2M HILL 1991	464	Yes	Availability of supply, transport losses, impact on receiving aquifer/ Storage by spreader basin, recovery by wells, using Medina Lake water
			717	Yes	Availability of supply, transport losses, impact on receiving aquifer/ Storage and recovery by wells using Medina Lake water

Bibliography

SECTION 3.0 SOURCES OF SUPPLY

Black and Veatch, Water Management Plan Using Braunig and Calveras Lakes, 1990.

Bureau of Reclamation, Final Environmental Impact Statement Palmetto Bend Project, Texas, 1974.

Bureau of Reclamation, Nueces River Basin, A Special Report, 1983.

Camp Dresser & McKee, Inc., Phase I Edwards Underground Water District Storage-Release Recharge Facility Evaluation, 1985.

CH2M HILL and Lee Wilson and Associates, Carrizo Recharge Study, 1991.

City Water Board of San Antonio, Applewhite Fact Sheet, 1988.

Espey, Huston & Associates, Inc. Draft, Engineering Analysis and Hydrologic Modeling to Determine the Effects of Subordination on Hydropower Rights, 1991.

Espey, Huston and Associates, Medina Lake Hydrology Study, 1989.

Espey, Huston & Associates, Inc., Water Availability Study for the Guadalupe and San Antonio River Systems, Volumes I and II, February, 1986.

Freese and Nichols. Preliminary Engineering Report on Applewhite Dam and Reservoir, 1974.

Freese and Nichols, Inc., Report on Availability of Additional Surface Water Supply from the Nueces River Between Uvalde and Three Rivers, 1982.

Guadalupe Blanco River Authority, Seguin, Texas, and HDR Engineering, Inc., Regional Water Plan for the Guadalupe River Basin, January, 1991.

HDR Engineering, Inc., Cost Update for Palmetto Bend Stage II and Yield Enhancement Alterative for Lake Texana and Palmetto Bend Stage II, 1991.

HDR Engineering, Inc., Regional Water Supply Planning Study, Phase I, Nueces River Basin, 1991.

HDR Engineering, Inc., Regional Water Supply Planning Study, Phase III, Recharge Enhancement, Nueces River Basin, 1991.

Lockwood, Andrews and Newman, Feasibility Study of Cibolo Reservoir Project With Dam Near Stockdale, 1965.

Rauschuber, D. G. and Associates, Inc., Potential for Development of Additional Water Supply from the Nueces River Between Simmons and Calallen Diversion Dam, 1985.

Simpson, W.E., Company, Inc., and Bryant McClelland Consultants and William F. Guyton and Associates, Medina Lake Study, Recharge Evaluation, 1989.

Stone and Webster, Report on Feasibility of Desalination and Wastewater Reuse for the City of Corpus Christi, Texas, 1984.

Texas Water Development Board, Water for Texas, Today and Tomorrow, July, 1990.

Wilson, Lee and Associates, Supplemental Water Plan San Antonio, Texas: Evaluation of Carrizo Recharge Project, 1990.

TABLE 3.1-1
TECHNICAL DATA REVIEW PANEL
TECHNICAL STUDIES FOR SECTION 3.0 SOURCES OF SUPPLY

Report:	TS-1	
Title:	Water for Texas	
Author:	Texas Water Development Board	
Sponsor:	Texas Water Development Board	
Date:	December, 1990	
Study Area:	State	
Purpose:	Assess current and future water needs and supplies of the State.	
Projects Addressed:	Canyon	Applewhite
	Coleto Creek	Goliad
	Lindenau	Corpus Christi
	Cuero I and Lindenau	Choke Canyon
	Medina	Texana

Report:	TS-2	
Title:	Water Availability Study for the Guadalupe and San Antonio River Basins	
Author:	Espey, Huston & Associates, Inc.	
Sponsors:	San Antonio River Authority Guadalupe-Blanco River Authority City of San Antonio	
Date:	February, 1986	
Study Area:	Guadalupe and San Antonio River Basins	
Purpose:	Evaluate surface water supplies in the Guadalupe and San Antonio Basins.	
Projects Addressed:	Canyon	Lindenau
	Clopton Crossing	Cuero I and Lindenau
	Lockhart	Cibolo
	Cuero I	Goliad

Report:	TS-3
Title:	Hays County Water and Waste Water Study
Author:	HDR Engineering, Inc.
Sponsors:	Hays County Water Development Board
Date:	May 1989
Study Area:	Hays County, Texas
Purpose:	Evaluate water supply alternatives for Hays County cities and communities
Projects Addressed:	Canyon Lake Lake Travis Blanco River City of Austin San Marcos River

---

Report:	TS-4
Title:	Medina Lake Hydrology Study
Author:	Espey, Huston and Associates, Inc.
Sponsor:	Edwards Underground Water District
Date:	March, 1989
Study Area:	San Antonio River Basin
Purpose:	Determine availability of water from Medina Lake for recharge of the Edwards Aquifer.
Projects Addressed:	Medina Lake

Report:	TS-5
Title:	Report on Availability of Additional Surface Water Supply from the Nueces River Between Uvalde and Three Rivers
Author:	Freese and Nichols, Inc.
Sponsor:	Nueces River Authority
Date:	December, 1982
Study Area:	Nueces River Basin
Purpose:	Investigate the availability of surface water supply in the Nueces River between the Balcones Fault Zone and Three Rivers.
Projects Addressed:	Simmons, Harris, and Indian Creek

Report:	TS-6	
Title:	Potential for Development of Additional Water Supply from the Nueces River Between Simmons and Calallen Diversion Dam	
Author:	Donald G. Rauschuber and Associates, Inc.	
Sponsor:	City of Corpus Christi	
Date:	December, 1985	
Study Area:	Nueces River Basin	
Purpose:	Investigate additional surface water supply in the lower Nueces River Basin.	
Projects Addressed:	Lake Corpus Christi Choke Canyon Reservoir R & M Dam and Reservoir	Bluntzer Dam Simmons

Report:	TS-7
Title:	Applewhite Project
Author:	City Water Board
Sponsor:	City Water Board
Date:	December, 1988
Study Area:	Applewhite
Purpose:	Present facts about the construction of Applewhite Reservoir and associated water treatment and delivery systems.
Projects Addressed:	Applewhite

Report:	TS-8
Title:	Regional Water Planning Study, Cost Update for Palmetto Bend Stage 2 and Yield Enhancement Alternative for Lake Texana and Palmetto Bend Stage 2
Author:	HDR Engineering, Inc.
Sponsor:	Lavaca-Navidad River Authority; Alamo Conservation and Reuse District; City of Corpus Christi; Texas Water Development Board
Date:	May, 1991
Study Area:	Lake Texana, Lavaca, and Navidad Rivers, Garwood Irrigation System and Colorado River
Purpose:	Evaluate alternatives for water supply from Lake Texana and Garwood Irrigation System.
Projects Addressed:	Lake Texana Palmetto Bend Stage 2 Garwood Irrigation District

Report:	TS-9
Title:	Special Report on San Antonio-Guadalupe River Basins Study
Author:	Bureau of Reclamation
Sponsor:	Bureau of Reclamation
Date:	November, 1978
Study Area:	San Antonio and Guadalupe River Basins
Purpose:	
Projects Addressed:	

Report:	TS-10
Title:	Nueces River Basin, A Special Report
Author:	Bureau of Reclamation
Sponsor:	Bureau of Reclamation
Date:	December 1983
Study Area:	Nueces River Basin
Purpose:	Determine the potential for water and land resources to meet long term problems and needs in the Nueces River Basin and adjacent coastal region
Projects Addressed:	Multiple projects for recharge, irrigation and municipal and industrial uses

Report: TS-11

Title: Regional Water Supply Planning Study - Phase I Nueces River Basin

Author: HDR Engineering, Inc.

Sponsor: Nueces River Authority, Edwards Underground Water District, South Texas Water Authority, Texas Water Development Board

Date: February, 1991

Study Area: Nueces River Basin

Purpose: Determine the potential for increasing artificial recharge to the Edwards Aquifer and calculate the Choke Canyon/ Lake Corpus Christi yield.

Projects Addressed:

Montell (Nueces River)	Choke Canyon Reservoir
Lower Frio River	Lower Dry Frio River
Concan (Frio River)	Upper Dry Frio River
Upper Sabinal River	Little Blanco Creek
Upper Seco Creek	Lower Seco
Upper Hondo Creek	Lower Hondo
Upper Verde Creek	Lower Verde
Indian Creek (Nueces Basin)	Elm Creek
Leona River	Quihi Creek
Lake Corpus Christi	

Report: TS-12

Title: Master Plan 1991

Author: Alamo Water Conservation and Reuse District

Sponsor: Alamo Water Conservation and Reuse District

Date: May 1991

Study Area: Bexar County

Purpose: Set out a master plan for AWCRD including a Master Facility Plan and a Business Plan for the district.

Projects Addressed: Reuse Water Distribution Facilities in San Antonio

Report:	TS-13
Title:	Water Management Plan using Braunig and Calaveras Lakes
Author:	Black & Veatch
Sponsor:	San Antonio City Public Service Board
Date:	March 1990
Study Area:	South San Antonio
Purpose:	Evaluate feasibility of using surplus Edwards Aquifer water and treated effluent as a supplementary source of water for San Antonio City Public Service Board and City Water Board
Projects Addressed:	Braunig Lake Calaveras Lake Dos Rios Wastewater Treatment Plant Salado Creek Wastewater Treatment Plant Mission Pump Station City Water Board Southside Water Treatment Plant Proposed treatment transmission and pumping facilities

---

Report:	TS-14
Title:	Carrizo Recharge Study
Author:	CHM2 HILL and Lee Wilson & Associates
Sponsor:	Alamo Water Reuse and Conservation District
Date:	July 1991
Study Area:	Carrizo Aquifer near San Antonio
Purpose:	Evaluate the potential for a storage and recovery project in the Carrizo Aquifer.
Projects Addressed:	Carrizo Recharge and Recovery Project

Report: TS-15

Title: Regional Water Supply Planning Study Phase III Recharge Enhancement Nueces River Basin

Author: HDR Engineering, Inc.

Sponsor: Nueces River Authority, Edwards Underground Water District, City of Corpus Christi, South Texas Water Authority, Texas Water Development Board

Date: November, 1991

Study Area: Nueces River Basin

Purpose: Feasibility study of Edwards Aquifer recharge projects in the Nueces Basin.

Projects Addressed:

Montell (Nueces River)	Leona River
Upper Dry Frio River	Little Blanco Creek
Concan (Frio River)	Lower Sabinal
Upper Sabinal River	Lower Seco
Upper Seco Creek	Lower Hondo
Upper Hondo Creek	Lower Verde
Upper Verde Creek	Elm Creek
Indian Creek (Nueces River)	Quihi Creek
Leona River	Lower Dry Frio River

Report: TS-16

Title: Phase I Edwards Underground Water District Storage Release Recharge Facility Evaluation

Author: Camp Dresser and McKee, Inc.

Sponsor: Edwards Underground Water District

Date: August, 1985

Study Area: Frio River upstream of Edwards Aquifer Recharge Zone

Purpose: Evaluate the feasibility of storage and release facilities above the Edwards Aquifer Recharge Zone on the Frio and Dry Frio Rivers.

Projects Addressed: Dry Frio River Concan (Frio River)

Report:	TS-17
Title:	Medina Lake Study - Recharge Evaluation
Author:	W. E. Simpson Co., Inc.
Sponsor:	Edwards Underground Water District
Date:	May, 1989
Study Area:	Medina Lake and Diversion Dam
Purpose:	Evaluate the feasibility of forced recharge of water supply from Medina Lake into the Edwards Aquifer.
Projects Addressed:	Medina Lake System

Report:	TS-18
Title:	Report on the Feasibility of Desalination and Waste Water Reuse for the City of Corpus Christi, Texas
Author:	Stone & Webster Engineering Corporation
Sponsor:	City of Corpus Christi
Date:	November, 1984
Study Area:	City of Corpus Christi
Purpose:	Describe the technical aspects of desalination and municipal waste water reuse and present capital and operating costs for each.
Projects Addressed:	Desalination and Wastewater Reuse Facilities

Report:	TS-19
Title:	Final Environmental Impact Statement Palmetto Bend Project, Texas
Author:	Department of Interior, Bureau of Reclamation
Sponsor:	Same as Author
Date:	1974
Study Area:	Lavaca-Navidad River Basin
Purpose:	Assessment of Palmetto Bend Projects, Stages I and II.
Projects Addressed:	Palmetto Bend Stage I (Lake Texana) Palmetto Bend Stage II

Report:	TS-20
Title:	DRAFT, Engineering Analysis and Hydrologic Modelling to Determine the Effects of Subordination of Hydropower Water Rights, Two Parts
Author:	Espey Huston and Associates
Sponsor:	Guadalupe Blanco River Authority
Date:	May, December, 1991
Purpose:	Investigate subordination of GBRA hydroelectric rights to Canyon Lake
Projects Addressed:	Canyon Lake

Report:	TS-21
Title:	Desalting in Texas A Status Report
Author:	Texas Water Development Board
Sponsor:	Same as Author
Date:	1992
Study Area:	State
Purpose:	Compile information on existing desalination plants in Texas
Projects Addressed:	Eighty-nine plants

Report:	TS-22
Title:	Water Management Plan Using Braunig & Calaveras Lakes
Author:	Black & Veatch
Sponsor:	San Antonio City Public Service Board, San Antonio City Water Board, Alamo Conservation and Reuse District
Date:	March, 1990
Study Area:	Braunig and Calaveras Lakes
Purpose:	Develop a plan for reusing San Antonio's wastewater

Report:	TS-23
Title:	Storage and Irrigation Facilities Technical Report
Author:	U.S. Department of Interior, Bureau of Reclamation
Sponsor:	Texas Water Development Board on behalf of Bexar-Medina-Atascosa Water Control and Improvement District Number 1, Bexar Metropolitan Water District and Canyon Regional Water Authority
Date:	August, 1992
Study Area:	Medina Lake
Purpose:	Water supply availability for sponsors

TABLE 3.1-2
TECHNICAL DATA REVIEW PANEL
MASTER PLANS

Report:	MP-1
Title:	Regional Water Plan for the Guadalupe River Basin
Authors:	Guadalupe- Blanco River Authority, HDR Engineering, Inc.
Sponsor:	Guadalupe-Blanco River Authority
Date:	January 1991
Study Area:	Guadalupe River Basin
Purpose:	Assess current and future water needs and supplies in the Guadalupe Basin.

Report:	MP-2
Title:	Bexar County Water Supply Projects
Author:	City Water Board, City Public Service, City of San Antonio, Alamo Conservation District, private well owners, Bexar County Water Perveyors and members of the local engineering community.
Sponsor:	Same as Author
Date:	August, 1990
Study Area:	Bexar County
Purpose:	Compare demands and supplies for the greater San Antonio Metropolitan Area and recommend a course of action for meeting future demands.

Report:	MP-3
Title:	Report to the Mayor and City Council
Author:	Greater San Antonio Area Citizen's Committee on Water
Sponsor:	City of San Antonio
Date:	March, 1992
Study Area:	Edwards Aquifer
Purpose:	Develop San Antonio's fundamental strategies to secure long-term water supply through the year 2040.

Report:	MP-4
Title:	Regional Water Task Force-Final Report
Author:	Coastal Bend Alliance of Mayors; Regional Water Task Force
Sponsor:	Coastal Bend Alliance of Mayors; Corpus Christi Area Economic Development Corporation for Port of Trade - Port of Corpus Christi; Texas A & I University
Date:	June, 1990
Study Area:	Lower Nueces River Basin and the joining Coastal Basins
Purpose:	Task force findings, report and recommendations on water supply issues for Coastal Bend (Corpus Christi area).

Report:	MP-5
Title:	Regional Water Resource Study
Author:	CH2M Hill
Sponsors:	City of San Antonio Edwards Underground Water District
Date:	April 1986
Study Area:	Edwards Aquifer, Nueces, Guadalupe and San Antonio River Basins
Purpose:	Develop a long term plan for meeting future demands in the Edwards Aquifer region.

Report:	MP-6
Title:	Technical Factors in Edwards Aquifer Use and Management
Author:	Technical Advisory Panel of the Joint Special Committee on the Edwards Aquifer
Sponsor:	Joint Committee on the Senate and House of Representatives
Date:	February, 1990
Study Area:	Edwards Aquifer and Nueces, San Antonio, and Guadalupe River Basins
Purpose:	Have a panel of technical experts assess technical information on the Edwards Aquifer and offer professional opinions on technical issues about the function and operation of the aquifer.

TABLE 3.1-2
TECHNICAL DATA REVIEW PANEL
MASTER PLANS

Report:	MP-1
Title:	Regional Water Plan for the Guadalupe River Basin
Authors:	Guadalupe- Blanco River Authority, HDR Engineering, Inc.
Sponsor:	Guadalupe-Blanco River Authority
Date:	January 1991
Study Area:	Guadalupe River Basin
Purpose:	Assess current and future water needs and supplies in the Guadalupe Basin.

Report:	MP-2
Title:	Bexar County Water Supply Projects
Author:	City Water Board, City Public Service, City of San Antonio, Alamo Conservation District, private well owners, Bexar County Water Perveyors and members of the local engineering community.
Sponsor:	Same as Author
Date:	August, 1990
Study Area:	Bexar County
Purpose:	Compare demands and supplies for the greater San Antonio Metropolitan Area and recommend a course of action for meeting future demands.

Report:	MP-3
Title:	Report to the Mayor and City Council
Author:	Greater San Antonio Area Citizen's Committee on Water
Sponsor:	City of San Antonio
Date:	March, 1992
Study Area:	Edwards Aquifer
Purpose:	Develop San Antonio's fundamental strategies to secure long-term water supply through the year 2040.

Report:	MP-4
Title:	Regional Water Task Force-Final Report
Author:	Coastal Bend Alliance of Mayors; Regional Water Task Force
Sponsor:	Coastal Bend Alliance of Mayors; Corpus Christi Area Economic Development Corporation for Port of Trade - Port of Corpus Christi; Texas A & I University
Date:	June, 1990
Study Area:	Lower Nueces River Basin and the joining Coastal Basins
Purpose:	Task force findings, report and recommendations on water supply issues for Coastal Bend (Corpus Christi area).

Report:	MP-5
Title:	Regional Water Resource Study
Author:	CH2M Hill
Sponsors:	City of San Antonio Edwards Underground Water District
Date:	April 1986
Study Area:	Edwards Aquifer, Nueces, Guadalupe and San Antonio River Basins
Purpose:	Develop a long term plan for meeting future demands in the Edwards Aquifer region.

Report:	MP-6
Title:	Technical Factors in Edwards Aquifer Use and Management
Author:	Technical Advisory Panel of the Joint Special Committee on the Edwards Aquifer
Sponsor:	Joint Committee on the Senate and House of Representatives
Date:	February, 1990
Study Area:	Edwards Aquifer and Nueces, San Antonio, and Guadalupe River Basins
Purpose:	Have a panel of technical experts assess technical information on the Edwards Aquifer and offer professional opinions on technical issues about the function and operation of the aquifer.

TABLE 3.2-1
TECHNICAL DATA REVIEW PANEL
EXISTING SURFACE WATER SOURCES AND SUPPLY
SYSTEMS IN THE STUDY AREA

Basin: Guadalupe

Project: Canyon Reservoir

Study: Espey Huston and Associates. Water Availability for the Guadalupe and San Antonio River Basins. 1986.

Firm Yield (acre feet/year)	Conditions
61,000	- Historical spring flows (1940-82) - San Antonio return flows equal 135,000 acre-feet per year - Applewhite and Coleto Creek in operation
37,500	- Historical spring flows (1940 - 82) - San Antonio return flows equal 135,000 acre-feet (present condition -1986) - Applewhite Reservoir in operation
30,300	- Zero spring flows - San Antonio return flows equal 135,000 acre-feet per year - Applewhite and Coleto Creek in operation
27,000	- Spring flows equal 273,872 acre-feet per year - San Antonio return flows equal 170,000 acre-feet per year - City of San Antonio reuse equals 100,000 acre-feet per year
27,000	- Spring flows equal 273,872 acre-feet per year - San Antonio return flows at 116,280 acre-feet per year net - City of San Antonio reuse equals to 153,720 acre-feet

26,000	- Springs flow artificially maintained, equal 160,000 acre-feet per year - San Antonio return flows equal 90,000 acre feet per year - San Antonio reuse equals 180,000 acre-feet per year
24,500	- Spring flows equal 240,565 acre-feet - San Antonio return flows equal 135,000 acre-feet (present condition - 1986)
24,000	- Spring flows equal 240,565 acre-feet per year - San Antonio return flows equal 170,000 acre-feet per year net - San Antonio reuse equals 100,000 acre-feet per year
15,900	- Spring flows equal zero - San Antonio return flows equal 270,000 acre-feet per year

---

Study: Texas Water Development Board. Water for Texas. 1990.

Projected Supply for Year 2000 equals 50,000 acre-feet per year. This is the original permitted water supply amount.

Study: Espey Huston and Associates. DRAFT, Engineering Analysis and Hydrologic Modelling to Determine the Effects of Subordination on Hydropower Water Rights, Espey Huston and Associates, 1991.

Firm Yield (acre-feet/year)	Conditions
52,000	- Historical recharge - Spring flows resulting from 1981-86 Edwards Aquifer pumping rates - Subordination of GBRA hydroelectric rights to Canyon Lake
41,000	- Historical spring flow - Honor all downstream rights

Basin: San Antonio

Project: Medina Lake

Study: Espey Huston and Associates, Inc. Medina Lake Hydrology Study. 1989.

Firm Yield (acre-feet/year)	Conditions
0	- Historical flows (1940-1986)

Maximum Average Annual Yield (acre-feet/year)	Conditions
55,704	- Historical flows - Reservoir operated to divert maximum amount of available water up to limit of permit each year (scalping operation)

Note: Six other alternative operating criteria (scalping operation) examined by this study reported average annual yields (not firm) of between 35,896 and 55,485 acre-feet per year.

Study: Texas Water Development Board. Water for Texas. 1990.

Projected Supply for Year 2000 equals 39,200 acre-feet. This amount was calculated as the least annual amount available under the current operation criteria for the reservoir.

Study: U.S. Department of Interior, Bureau of Reclamation. Storage and Irrigation Facilities Technical Report. 1992.

Firm Yield (acre-feet/year)	Conditions
27,500	- Irrigation demand pattern - Recharge to Edwards Aquifer simulated at average of 60,000 acre-feet/year - Losses in Diversion Reservoir and past Diversion Dam were not considered
29,500	- Municipal demand pattern - Losses in Diversion Reservoir and past Diversion Dam were not considered - Recharge to Edwards Aquifer simulated at average of 60,000 acre-feet/year

0	- Diversion at Diversion Dam - Losses in Diversion Reservoir and *past* Diversion Dam considered

---

Basin: Nueces

Project: Lake Corpus Christi/ Choke Canyon

Study: HDR Engineering, Inc. Regional Water Supply Planning Study - Phase I Nueces River Basin. 1991.

Firm Yield (acre-feet/year)	Conditions
187,800	- Phase II operating policy - All prior water rights honored - 1990 sediment condition (169,700 acre-feet firm yield at 2040 sediment conditions)
220,000	- Phase IV operating policy - All prior rights honored - 1990 sediment conditions (197,500 acre-feet firm yield at 2040 sediment conditions)

Study: Bureau of Reclamation. Nueces River Basin, A Special Report. 1983

Firm Yield (acre-feet/year)	Conditions
252,000	- Year 2010 stream flow and sediment conditions - Downstream water rights were not considered
237,000	- Year 2010 stream flow and Year 2070 sediment conditions - Downstream water rights not considered

---

Study: Texas Water Development Board. Water for Texas. 1990.

Projected Supply for Year 2000 equals 178,670 acre-feet. This amount was calculated as the permitted water supply of the reservoir less releases required for bays and estuaries plus return flows.

Basin: Lavaca-Navidad

Project: Lake Texana (Palmetto Bend - Stage I)

Study: Bureau of Reclamation. Final Environmental Impact Statement Palmetto Bend Project, Texas. 1974.

Firm Yield (acre-feet/year)	Conditions
75,000	- 100 years of sediment accumulation (33,000 acre-feet) - Initial storage capacity (estimated) of 192,000 acre-feet - Initial area (actual) of 9900 acres

---

Study: HDR Engineering, Inc. Cost Update for Palmetto Bend Stage II and Yield Enhancement Alternative for Lake Texana and Palmetto Bend Stage II. 1991.

Firm Yield (acre-feet/year)	Conditions
82,645	- 1985 conditions
105,745 to 149,645	- with varying amounts of purchase Garwood Irrigation water ranging from 30,000 acre-feet to 168,000 acre-feet per year and varying pumping rates and monthly pumping regimes.
92,345 to 105,745	- with varying amounts of supplemental diversion of unappropriated Colorado River water and varying pumping rates.
114,645 to 154,845	- with varying combinations of Garwood Irrigation purchases and diversions of unappropriated Colorado River Water

---

Study: Texas Water Development Board. Water for Texas. 1990.

Projected Supply for Year 2000 equals 75,000 acre-feet. This is the permitted water supply from the reservoir.

TABLE 3.2-2
TECHNICAL DATA REVIEW PANEL
POTENTIAL UNDEVELOPED SURFACE WATER SOURCES
IN THE STUDY AREA

Basin: Guadalupe

Stream: Blanco River

Project: Clopton Crossing Reservoir

Project Size: 285,000 Acre-Feet, 6000 Acres

Study: Espey Huston and Associates. Water Availability Study for the Guadalupe and San Antonio River Basins. 1986.

Firm Yield varies from 34,000 to 35,000 for four scenarios of varying spring flows, San Antonio reuse and San Antonio return flows.

Basin: Guadalupe

Stream: Plum Creek

Project: Lockhart Reservoir

Project Size: 55,600 Acre-Feet, 2950 Acres

Study: Espey Huston and Associates. Water Availability Study for the Guadalupe and San Antonio River Basins. 1986.

Firm Yield is 7700 acre-feet per year for three scenarios of varying spring flows, San Antonio return flows and San Antonio reuse.

Basin: Guadalupe

Stream: Guadalupe

Project: Cuero I Reservoir

Project Size: 1,150,000 Acre-Feet, 41,500 Acres, Elevation 242.0 MSL

Study: Espey Huston and Associates. Water Availability Study for the Guadalupe and San Antonio River Basins. 1986.

Firm Yield

(acre-feet/year)	Conditions
272,000	- No bay and estuary requirements - Historical spring flows (1940 - 1982) - San Antonio return flows equal 135,000 acre-feet/year
241,000	- 50% subordination of Calhoun Canal water rights - Full bay and estuary requirements - San Antonio return flows equal 135,000 acre-feet/year
186,000	- Historical springflows (1940 - 1982) - Full bay and estuary requirements - Operating with Lockhart Reservoir - San Antonio return flows equal 135,000 acre-feet/year
185,000	- Historical springflows (1940 - 1982) - Full bay and estuary requirements - Operating with Cibolo Reservoir - San Antonio return flows equal 135,000 acre-feet
173,000	- Historical springflow (1940 - 1982) - Full bay and estuary requirements - Operating with Clopton Crossing - San Antonio return flows equal 135,000 acre-feet
172,000	- Spring flows equal 273,872 acre-feet per year - San Antonio return flows equal 116,280 acre-feet per year - Full bay and estuary requirements - San Antonio reuse equals 153,720 acre-feet per year
159,000	- Historical spring flows (1940 - 1982) - San Antonio return flows equal 135,000 acre-feet per year - Full development of basin reservoirs - Full bay and estuary requirements
158,000	- Spring flows equal 240,565 acre-feet per year - San Antonio return flows equal 135,000 acre-feet per year - Full bay and estuary requirements
151,000	- Spring flows equal 240,565 acre-feet per year

- San Antonio return flows equal 170,000 acre-feet per year
- San Antonio reuse equals 100,000 acre-feet per year

Basin: Guadalupe

Stream: Sandies Creek

Project: Lindenau (Cuero II)

Project Size: 600,000 Acre-Feet, 26,900 Acres, Elevation 232.0 MSL

Study: Espey Huston and Associates. Water Availability Study for the Guadalupe and San Antonio River Basins. 1986.

Firm Yield (acre-feet/year)	Conditions
107,000	- Historical spring flows (1940 - 1982) - Full bay and estuary requirements - San Antonio return flows equal 135,000 acre-feet per year (present conditions - 1986) - Includes pumped water from Guadalupe of 108,678 acre-feet per year - Operating without Cuero I
100,000	- Spring flows equal to 273,872 acre-feet per year - Full bay and estuary requirements - San Antonio return flows equal 116,280 acre-feet per year - San Antonio reuse equals 153,720 acre-feet per year - Includes pumped water from Guadalupe of 103,085 acre-feet per year - Operating without Cuero I

Study: Texas Water Development Board. Water for Texas. 1990

Projected supply for Year 2000 equals 101,600 acre-feet per year. It was not indicated if this is a firm yield amount.

Basin: Guadalupe

Stream: Guadalupe River and Sandies Creek

Project: Cuero I and Lindenau Reservoirs

Project Size: Same as for Individual Reservoirs

Study: Espey Huston and Associates. Water Availability Study for the Guadalupe and San Antonio River Basins. 1986.

Firm Yield (acre-feet/year)	Conditions
219,000	- Historical spring flows (1940 - 1982) - San Antonio return flows equal 135,000 acre-feet per year - Full bay and estuary requirements
207,000	- Spring flows equal 273,872 acre-feet per year - San Antonio return flows equal 170,000 acre-feet per year - San Antonio reuse equals 100,000 acre-feet per year
194,000	- Historical spring flows (1940 - 1982) - San Antonio return flows equal 135,000 acre-feet per year - Full bay and estuary requirements - Full development of Goliad, Clopton and Lockhart projects

---

Study: Texas Water Development Board. Water for Texas. 1990

Projected supply for Year 2040 equals 208,000 acre-feet per year. It was not indicated if this is a firm yield amount.

Basin:	San Antonio
Stream:	Medina River
Project:	Applewhite Reservoir
Project Size:	45,250 Acre-Feet, 2500 Acres, Elevation 536.0 MSL
Study:	City Water Board. Applewhite Fact Sheet. December, 1988.

Average Yield (acre-feet/year)	Conditions
53,017	- Diversions from Leon Creek only during floods and when water quality is suitable - Reservoir operating to direct maximum amount of available water up to the limit of the permit each year (scalping operation)
48,000	- Without diversions from Leon Creek - Reservoir operating to direct maximum amount of available water up to the limit of the permit each year (scalping operation)

Study: Espey Huston and Associates. Medina Lake Study. 1989

Firm Yield (acre-feet/year)	Conditions
48,438 to 55,265	- Including Leon Creek diversions. - Reservoir operating to direct maximum amount of available water up to the limit of the permit each year (scalping operation) - Yield varies from 48,438 to 55,265 acre-feet per year for eight scenarios of operating criteria for Medina Lake

Study: Texas Water Development Board. Water for Texas. 1990

Projected supply for Year 2000 equals 7,900 acre-feet per year. This is the least annual amount available under the proposed scalping operation of the reservoir.

Basin: San Antonio

Stream: Cibolo Creek

Project: Cibolo Creek Reservoir (Lower Site)

Project Size: 404,000 Acre-Feet, 16,700 Acres, Elevation 416.0 MSL

Study: Espey Huston and Associates. Water Availability Study for the Guadalupe and San Antonio River Basins. 1986.

Firm yield was calculated to be 30,000 acre-feet per year for four scenarios of varying spring flows, San Antonio reuse and San Antonio return flows.

Basin: San Antonio

Stream: Cibolo Creek

Project: Cibolo Creek Reservoir (Upper Site)

Project Size: 173,000 Acre-Feet, 9200 Acres, Elevation 416.4 MSL

Study: Lockwood, Andrews and Newman. Feasibility of Cibolo Reservoir Project with Dam Near Stockdale. 1965.

Firm yield was calculated to be 18,000 to 24,500 acre-feet per year varying with minimum drawdown elevation.

Basin: San Antonio

Stream: San Antonio River

Project: Goliad Reservoir

Project Size: 683,000 Acre-Feet, 27,800 Acres, Elevation 200.0 MSL

Study: Espey Huston and Associates. Water Availability Study for the Guadalupe and San Antonio River Basins. 1986.

Firm Yield (acre-feet/year)	Conditions
119,000	- Spring flows equal 273,872 acre-feet per year - San Antonio return flows equal 116,280 acre-feet per year - Full bay and estuary requirements - San Antonio reuse equals 153,720 acre-feet per year
115,000	- Historical spring flows - San Antonio return flows 135,000 acre-feet per year (present condition - 1986) - Full bay and estuary requirements - Single reservoir operation
54,000	- Historical spring flows - San Antonio return flows equal 135,000 acre-feet per year (present condition - 1986) - Full bay and estuary requirements - Full development of Clopton Crossing, Cuero I, and Lindenau and Lockhart Reservoir

---

Study: Texas Water Development Board. Water for Texas. 1990

Projected supply for Year 2040 equals 148,400 acre-feet per year. It was not indicated if this is a firm yield amount.

Basin: Nueces

Stream: Nueces

Project: Simmons Reservoir

Project Size: 450,000 Acre-Feet, 26,400 Acres

Study: Freese and Nichols, Inc. Report on Availability of Additional Surface Water Supply from the Nueces River Between Uvalde and Three Rivers.

Firm Yield (acre-feet/year)	Conditions
14,400	- Honoring Choke Canyon and Lake Corpus Christi water rights
124,900	- Impounding all inflows - Loss of 120,000 acre-fees per year of firm yield in Lake Corpus Christi/Choke Canyon System

---

Basin: Nueces

Stream: Nueces

Project: Harris Reservoir

Project Size: 400,000 Acre-Feet, 21,200 Acres

Study: Freese and Nichols, Inc. Report on Availability of Additional Surface Water Supply from the Nueces River Between Uvalde and Three Rivers.

Firm Yield (acre-feet/year)	Conditions
4,400	- Honoring Choke Canyon and Lake Corpus Christi water rights
51,700 (net 9700)	- Impounding all inflows - Loss of 120,000 acre-feet per year of firm yield in Lake Corpus Christi/Choke Canyon System

---

Basin: Nueces

Stream: Nueces

Project: Indian Creek

Project Size: 165,000 Acre-Feet, 7700 Acres

Study: Freese and Nichols, Inc. Report on Availability of Additional Surface Water Supply from the Nueces River Between Uvalde and Three Rivers.

Firm Yield (acre-feet/year)	Conditions
0	- Honoring Choke Canyon and Lake Corpus Christi water rights - Honoring Lake Corpus Christi/Choke Canyon water rights

13,300	- Impounding all inflows - Loss of 11,000 acre-fees per year of firm yield in Lake Corpus Christi/Choke Canyon System

---

Basin: Nueces

Stream: Nueces

Project: Bluntzer Reservoir

Study: Rauschuber D. G., and Associates, Inc. Final Report - Potential for Development of Additional Water Supply from the Nueces River Between Simmons and Calallen Diversion Dam. 1985.

Firm Yield (acre-feet/year)	Conditions
4,500 to 27,250	- Net gain when operated as a system with Lake Corpus Christi/Choke Canyon System - Net gain varies with selected reservoir system

---

Basin: Nueces

Stream: Nueces

Project: R & M Reservoir

Project Size: 986,000 Acre-Feet, 31,000 Acres

Study: Rauschuber D. G., and Associates, Inc. Final Report - Potential for Development of Additional Water Supply from the Nueces River Between Simmons and Calallen Diversion Dam. 1985.

Firm Yield (acre-feet/year)	Conditions
9500 to 68,300	- Net gain when operated as a system with Lake Corpus Christi/Choke Canyon System - Net gain varies with selected reservoir system

Basin:	Nueces
Stream:	Nueces
Project:	Simmons Pump Facility
Study:	Rauschuber D. G., and Associates, Inc. Final Report - Potential for Development of Additional Water Supply from the Nueces River Between Simmons and Calallen Diversion Dam. 1985.

Firm Yield (acre-feet/year)	Conditions
6,000 to 14,000	- Pumping from Nueces River to Choke Canyon Reservoir - Net gain when operated as a system with Lake Corpus Christi/Choke Canyon System - Net gain varies with pump station size

Basin:	Nueces
Stream:	Nueces
Project:	Cotulla Reservoir
Project Size:	341,000 Acre-Feet, Elevation 447.5 MSL
Study:	Bureau of Reclamation. Nueces River Basin. 1983.

Firm Yield (acre-feet/year)	Conditions
2000	- 2000 acre-feet diverted at Cotulla - Total system yield is 252,000 acre-feet/year
2500 (net)	- Cotulla reservoir operated as a system with Choke Canyon and Lake Corpus Christi - All diversions from Lake Corpus Christi - Lakes operated to maintain minimum recreation use - Total system yield is 254,500 acre-feet/year
17,000	- Cotulla reservoir operated as a system with Choke Canyon and Lake Corpus Christi

	- Diversion at Cotulla - Total system yield is 269,400 acre-feet/year
18,300	- Cotulla reservoir operated as a system with Choke Canyon and Lake Corpus Christi - System is operated to maximize yield (17,000 acre-feet gained by change in operation from scenarios cited above) - Total system yield is 287,700 acre-feet/year

---

Basin: Nueces

Stream: Nueces

Project: Cotulla Diversion Dam and Canal

Study: Bureau of Reclamation. Nueces River Basin. 1983

Firm Yield (acre-feet/year)	Conditions
	- Diversion from Nueces River to Frio River
15,900 (net)	- Cotulla diversion dam and canal are operated as a system with Choke Canyon and Lake Corpus Christi - System is operated to maximize yield - Total system yield is 285,300 acre-feet/year

---

Basin: Lavaca-Navidad

Stream: Lavaca River

Project: Palmetto Bend Stage 2

Project Size: 93,000 Acre-Feet, 6900 Acres, Elevation 44.0 MSL

Study: Bureau of Reclamation. Final Environmental Impact Statement Palmetto Bend Project, Texas. 1974

Firm Yield (acre-feet/year)	Conditions
30,000	- 100 years sediment condition

Study: HDR Engineering, Inc. Cost Update for Palmetto Bend Stage II and Yield Enhancement Alternative for lake Texana and Palmetto Bend Stage II. 1991.

Firm Yield (acre-feet/year)	Conditions
48,171	- Year 2000 conditions
43,355	- Year 2040 conditions

Basin: Lavaca-Navidad

Stream: Navidad and Lavaca Rivers

Project: Lake Texana and Palmetto Bend Stage 2

Project Size: Same as Individual Reservoirs

Study: HDR Engineering, Inc. Cost Update for Palmetto Bend Stage 2 and Yield Enhancement Alternative for Lake Texana and Palmetto Bend Stage 2. 1991.

Firm Yield (acre-feet/year)	Conditions
131,785	- Year 2000 conditions
125,792	- Year 2040 conditions
163,785 to 207,085	- with varying combinations of Garwood Irrigation purchases and diversions of unappropriated Colorado River Water

---

Basin: Lavaca-Navidad

Stream: Navidad River

Project: Lake Texana and Garwood Irrigation System

Study: HDR Engineering, Inc. Cost Update for Palmetto Bend Stage 2 and Yield Enhancement Alternative for Lake Texana and Palmetto Bend Stage 2. 1991.

Firm yield enhancement varies from 23,100 to 70,100 acre-feet per year with vary amounts of diversion from Garwood Irrigation System (Colorado River) to Lake Texana.

TABLE 3.6-1
TECHNICAL DATA REVIEW PANEL

EXISTING DESALINATION PROJECTS

SOURCE: TEXAS WATER DEVELOPMENT BOARD

LOCATION	OPERATOR	CAPACITY	STATUS	TYPE	FEED	USE
Corpus Christi	Lamda Division of Veeco	216,000 gal/day	Operating	Reverse Osmosis	Inland Fresh Water	Industrial
Corpus Christi	Central Power and Light	108,000 gal/day	Operating	Reverse Osmosis	Inland Fresh Water	Power
George West	U.S. Steel Corporation	?	Operating	Reverse Osmosis	Waste-Water	Industrial
Rockport	Aransas Co. MUD No. 1	125,000 gal/day	Out of Service	Reverse Osmosis	Inland Brackish Water	Municipal
San Antonio	University of Texas Medical Center	40,000 gal/day	Operating	Reverse Osmosis	Inland Fresh Water	Industrial
Three Rivers	Wyoming Minerals Corporation	576,000 gal/day	Operating	Reverse Osmosis	Waste-Water	Industrial

TABLE 3.7-1
TECHNICAL DATA REVIEW PANEL
EXISTING SURFACE WATER SOURCES

Project	Permitted Annual Yield acre-feet	Calculated Annual Yield(s) acre-feet	Committed Annual Yield acre-feet	Cost of Annual Yield $/acre-feet	Water Delivered To
Canyon Reservoir	50,000 (1)	24,000 to (2) 61,000	30,200	53.03	A
Medina Lake System	66,000	0 (2) 27,500 (3) 55,704 (4)	all (5)	(6)	B
Choke Canyon Reservoir	139,000	(7)	(7)	(7)	(7)
Lake Corpus Christi	300,000	(7)	(7)	(7)	(7)
Choke Canyon/ Lake Corpus Christi	252,000	169,700 to 252,000(2)	221,000 (8)	34.52	C
Lake Texana	75,000	82,645(2)	32,000 (9)	45.00 (10)	D

(1) See special conditions.
(2) Firm yield
(3) Firm yield at Medina Lake not considering losses at Diversion Lake
(4) Maximum average annual yield based on current operation
(5) Subject to availability
(6) Water paid for with tax rate of $10 per acre plus $8 per acre for each irrigation
(7) See Choke Canyon/Lake Corpus Christi below
(8) 130,000 acre-feet to municipal and industrial uses; 97,000 acre-feet to Nueces Bay, less return flows (6000 acre feet at present)
(9) Additional 41,288 acre-feet under contract to sell to Port Authority of Corpus Christi
(10) Program increases to $65 per acre-foot by year 2004

A	B	C	D
-New Braunfels -San Marcos -Seguin -Gonzales WSC -Spring Hill WSC -Calhoun County WSC -Union Carbide -Central Power and Light Co.	-Approximately 1800 land owners	At Lake Corpus Christi: -Mathis, Beeville & Alice At Corpus Christi WTP: -Corpus Christi, San Patricio MWD, Koch Refining Co., and Hoechst-Celanese Co. At Choke Canyon Reservoir: -Three Rivers, Diamond Shamrock, and TP&WD	-Formosa Plastics

TABLE 3.7-2
TECHNICAL DATA REVIEW PANEL
COMPARISON OF UNIT COSTS - POTENTIAL UNDEVELOPED SURFACE WATER PROJECTS

			CONSTRUCTION COST				ANNUAL OPERATING and MAINTENANCE COST			TOTAL
Project	Source of Data (year)	Annual Firm Yield acre-feet (R)	Original Estimate $ x 1000 (R)	Updated (1/92) Estimate $ x 1000 (2) (C)	Annualized Estimate $ x 1000 (3) (C)	Annual Unit Cost Estimate $/acre-foot (C)	Original Estimate $ x 1000 (R)	Updated Estimate $ x 1000 (4)	Annual Unit Cost Estimate $ x 1000(C)	Annual Unit Cost Estimate $ x 1000(C)
GUADALUPE BASIN										
Clopton Crossing Reservoir	BuRec (1978)	40,000	71,067	114,232	11,469	287				
Cuero I Reservoir	Espey-Huston (1986)	151,000 to 272,000	317,517	362,282	36,373	241 to 133	1,683	2,120	14 to 8	255 to 141
	TWDB (1990)	145,000	304,620	312,247	31,350	216	Operating and maintenance costs not available			216 (5)
Lindenau (Cuero II) Resevoir	Espey-Huston (1986)	100,000 to 107,000	244,681	279,177	28,029	280 to 262	2,932	3,694	37 to 34	327 to 296
	TWDB (1990)	107,000	276,410	283,330	28,446	266	Operating and maintenance costs not available			266 (5)
Cuero I & Lindenau Resevoirs	Espey-Huston (1986)	194,000 to 219,000	522,481	596,142	59,853	308 to 273	4,829	6,084	31 to 28	339 to 301
SAN ANTONIO BASIN										
Applewhite Reservoir	Freese & Nichols (1988)	48,000 (1)	75,100	80,570	8,069	168 (1)				
	TWDB (1990)	14,900	92,510	94,826	9,520	639	Operating and maintenance costs not available			639 (5)
SAN ANTONIO BASIN										
Cibolo Creek Reservoir (Lower)	Espey-Huston (1986)	30,000	200,457	228,718	22,963	765	1,642	2,069	69	834

TABLE 3.7-2 (Continued)

			CONSTRUCTION COST				OPERATING and MAINTENANCE COST			ANNUAL TOTAL
Project	Source of Data (year)	Annual Firm Yield acre-feet (R)	Original Estimate $ x 1000 (R)	Updated (1/92) Estimate $ x 1000 (2) (C)	Annualized Estimate $ x 1000 (3) (C)	Annual Unit Cost Estimate $/acre-foot (C)	Original Estimate $ x 1000 (R)	Updated Estimate $ x 1000 "(4)"	Annual Unit Cost Estimate $ x 1000(C)	Annual Unit Cost Estimate $ x 1000(C)
Cibolo Creek Reservoir (Upper)	Lockwood Andrews & Newnam (1965)	18,800 to 24,500	11,300 to 13,500	50,174 to 59,943	5,037 to 6,018	205 to 320	15	66	3	208 to 323
Goliad Reservoir	Espey-Huston (1986)	54,000 to 119,000	172,424	196,733	19,752	365 to 166	4,272	5,383	100 to 45	465 to 211
	TWDB (1990)	148,400	254,490	265,987	26,705	180	Operating and maintenance costs not available			180 (5)
NUECES BASIN										
Bluntzer Reservoir	Rauschuber (1985)	4,500 to 27,250	173,413	197,942	19,873	4,416 to 729	300	379	84 to 14	4,500 to 743
R & M Reservoir	Rauschuber (1985)	9,500 to 68,300	236,322	269,750	27,083	2,851 to 397	300	379	40 to 6	2,891 to 403
Simmons Pump Facility	Rauschuber (1985)	6,000 to 14,000	6,378	7,280	731	122 to 52				
Cotulla Reservoir	BuRec (1983)	2,000 to 2,500(net)	183,142	213,871	21,472	10,736 to 8,589	83	115	57 to 46	10,791 to 8,635
Cotulla Diversion Canal	BuRec (1983)	15,900	176,290	205,869	20,669	1,300	32	44	3	1,303
LAVACA-NAVIDAD BASIN										
Palmetto Bend - Stage II	BuRec (1974)	30,000	Construction estimate not available							
	HDR Engineering (1991)	43,555 to 48,172	75,243	76,928	7,723	177 to 160	800	815	19 to 16	196 to 176

Project	Source of Data (year)	CONSTRUCTION COST: Annual Firm Yield acre-feet (R)	Original Estimate $ x 1000 (R)	Updated (1/92) Estimate $ x 1000 (2) (C)	Annualized Estimate $ x 1000 (3) (C)	Annual Unit Cost Estimate $/acre-foot (C)	OPERATING and MAINTENANCE COST: Original Estimate $ x 1000 (R)	Updated Estimate $ x 1000 "(4)"	Annual Unit Cost Estimate $ x 1000(C)	ANNUAL TOTAL: Annual Unit Cost Estimate $ x 1000(C)
Lake Texana and Palmetto Bend - Stage II	HDR Engineering (1991)	44,396 to 50,389	112,653	115,177	11,563	260 to 229	800	815	18 to 16	278 to 245
Lake Texana and Garwood Irrigation	HDR Engineering (1991)	23,100	10,450	10,684	1,073	46	640	652	28	74
		38,100	41,129	42,050	4,222	111	395	402	11	122
		70,100	109,571	111,571	11,202	160	1,046	1,065	15	175

(1) Annual average supply, not a firm yield
(2) Using Engineering News - Record Building Cost Index, March 30, 1992
(3) Interest rate 8%, 20 year payment; factor = .1004
(4) Using Consumer Price Index for all Urban Consumers:U.S. City Average, all items
(5) Operating and maintenance costs not included
(C) value calculated by Technical Data Review Panel
(R) value taken from technical report

LIMITATIONS ON USE OF THIS DATA

1. Quality of cost estimates vary greatly, from general to detailed.
2. Year of original cost estimates vary, index for updating costs may not be valid over long term.
3. Environmental costs have increased over time span of cost estimates; estimates may not include sufficient environmental costs, especially earlier estimates.
4. Variation in calculated yield causes unit costs to vary.

TABLE 3.7-3
TECHNICAL DATA REVIEW PANEL
COMPARISON OF UNIT COSTS - POTENTIAL UNDEVELOPED DELIVERY SYSTEMS

				CONSTRUCTION COST				OPERATING AND MAINTENANCE COST			TOTAL
PROJECT	Source of Data (year)	Delivered To	Annual Throughput acre-feet (R)	Original Estimate $ x 1000 (R)	Updated Estimate $ x 1000 (1) (C)	Annualized Estimate $ x 1000 (2) (C)	Annual Unit Cost Estimate $/acre-foot (C)	Original Estimate $ x 1000 (R)	Updated Estimate $ x 1000 (3)	Annual Unit Cost Estimate $ x 1000(C)	Annual Unit Cost Estimate $ x 1000(C)
Canyon Reservoir	TWDB (1990)	San Marcos	19,000	23,300(4)	23,883	2,398	126	Operating and maintenance costs not available.			126 (6)
Cuero I Reservoir	Espey-Huston (1986)	Cibolo Reservoir (Lower)	188,000	116,687	133,138	13,367	71	8,241	10,384	55	126
Cuero I Reservoir	TWDB (1990)	San Antonio	172,400	125,000(4)	179,586	18,030	105	Operating and maintenance costs not available.			105 (6)
Lindenau (Cuero II) Resevoir	Espey-Huston (1986)	Cibolo Reservoir (Lower)	107,000	70,662	80,624	8,094	75	5,252	6,618	62	127
Cuero I & Lindenau Resevoirs	Espey-Huston (1986)	Cibolo Reservoir (Lower)	219,000	103,283	117,844	11,832	54	10,257	12,424	59	113
Medina Lake	TWDB (1990)	San Antonio	28,500	44,500(4)	45,614	4,580	161	Operating and maintenance costs not available.			161 (6)
Goliad Reservoir	TWDB (1990)	San Antonio	148,400	158,600(4)	165,571	16,322	110	Operating and maintenance costs not available.			110 (6)
Lake Texana	TWDB (1990)	Corpus Christi	30,000	89,700(5)	91,946	9,231	308	Operating and maintenance costs not available.			308 (6)

(1) Using Engineering News - Record Building Cost Index, March 30, 1992
(2) Interest rate 8%, 20 year payment; factor = 0.1004
(3) Using Consumer Price Index for all Urban Consumers: U.S. city average, all items.
(4) Includes mitigation costs, costs updated to 1990 from estimate years by BuRec cost index
(5) Corpus Christi estimate is $47,200,000
(6) Operating and maintenance costs not included
(C) Value calculated by Technical Data Review Panel
(R) Value taken from technical report

LIMITATIONS ON USE OF THIS DATA

1. Quality of cost estimates vary greatly, from general to detailed.
2. Year of original cost estimates vary, index for updating costs may not be valid over long term.
3. Environmental costs have increased over time span of cost estimates; estimates may not include sufficient environmental costs, especially earlier estimates.
4. Variation in calculated yield causes unit costs to vary.

TABLE 3.7-4
TECHNICAL DATA REVIEW PANEL
SUMMARY OF NUECES BASIN RECHARGE ENHANCEMENT PROJECTS
TYPE 1 RESERVOIRS (1)

100% Conservation Capacity

Project	Percent Capacity	Recharge Enhancement (acft/yr)	Cost/Unit Recharge Enhancement ($/acft/yr)	Recharge Enhancement (acft/yr)	Cost/Unit Recharge Enhancement ($/acft/yr)
Upper Dry Frio	100	9,420	330	2,900	1,072
Upper Verde	100	4,600	339	1,390	1,120
Upper Sabinal	100	14,670	357	2,520	2,078
Upper Hondo	100	8,360	361	1,140	2,647
Montell	100	34,200	381	9,200	1,415
Upper Seco	100	3,820	398	290	5,246
Concan	100	12,210	486	3,085	1,925
Total		87,280		20,525	

Optimum Conservation Capacity

Project	Percent Capacity	Recharge Enhancement (acft/yr)	Cost/Unit Recharge Enhancement ($/acft/yr)	Recharge Enhancement (acft/yr)	Cost/Unit Recharge Enhancement ($/acft/yr)
Upper Sabinal	10	10,080	163	2,520	650
Upper Verde	25	3,990	210	1,390	603
Concan	10	8,190	217	3,085	577
Upper Dry Frio	10	5,840	221	2,630	491
Montell	10	26,370	240	9,200	688
Upper Hondo	10	4,700	248	1,140	1,024
Upper Seco	50	3,410	335	290	3,944
Total		62,580		20,255	

(1) Honoring all downstream water rights.

TABLE 3.7-5
TECHNICAL DATA REVIEW PANEL
SUMMARY OF NUECES BASIN RECHARGE ENHANCEMENT PROJECTS
TYPE 2 RESERVOIRS (1)

100% Conservation Capacity

Project	Percent Capacity	Recharge Enhancement (acft/yr)	Cost/Unit Recharge Enhancement ($/acft/yr)	Recharge Enhancement (acft/yr)	Cost/Unit Recharge Enhancement ($/acft/yr)
Lower Sabinal	100	18,400	145	2,770	965
Lower Verde	100	6,220	215	1,980	676
Lower Hondo	100	9,420	255	1,190	2,021
Lower Frio	100	14,400	267	3,180	1,211
Indian Creek	100	34,500	306	14,600	630
Lower Dry Frio	100	6,170	422	1,360	1,387
Lower Seco	100	5,420	463	290	7,632
Elm Creek	100	670	662	120	2,584
Little Blanco	100	390	811	100	2,583
Quihi Creek	100	150	911	30	4,057
Leona River	100	280	1,318	60	4,253
Blanco	100	370		110	4,434
Total		96,210		25,790	

Optimum Conservation Capacity

Project	Percent Capacity	Recharge Enhance-ment (acft/yr)	Cost/Unit Recharge Enhance-ment ($/acft/yr)	Recharge Enhance-ment (acft/yr)	Cost/Unit Recharge Enhance-ment ($/acft/yr)
Lower Sabinal	10	7,720	66	2,300	221
Lower Frio	10	5,940	114	2,020	337
Lower Verde	10	3,150	134	1,380	306
Lower Hondo	10	3,930	150	1,190	494
Indian Creek	25	26,500	213	12,920	437
Lower Dry Frio	25	4,090	216	1,360	650
Lower Seco	10	2,520	238	290	2,069
Elm Creek	100	670	463	120	2,584
Little Blanco	100	390	662	100	2,583
Quihi Creek	100	150	811	30	4,057
Leona River	100	280	911	60	4,253
Blanco	100	370	1,318	110	4,434
Total		55,710		21,880	

(1) Honoring all downstream rights except Lake Corpus Christi/ Choke Canyon System.

TABLE 3.7-6
TECHNICAL DATA REVIEW PANEL

COMPARISON OF UNIT COSTS - EXISTING SOURCES OF SUPPLY

SOURCE TYPE	PROJECT	UNIT COST $/ACRE-FOOT	NOTES
Surface Water	Lake Texana	45.00	Established rate
	Canyon Reservoir	53.03	Established rate
	Lake Corpus Christi\ Choke Canyon Reservoir	34.52	Established rate
	Medina Lake	11.33	Based on $10 per acre flat rate plus 3 waterings @ $8 each for 3 acre-feet
Water Reuse	City of Public Service Board-Lakes Braunig and Calaveras	60.00	Includes $50 per acre foot to City of San Antonio and $10 per acre foot pumping cost--Facilities cost not inlcuded
Storage and Recovery	(no existing projects)		
Recharge	Edwards Underground Water District Projects	38.74	Construction Cost only annualized at 8% for 20 years for average recharge of 5000 acre-feet
Desalination	(no cost information on existing projects)		

TABLE 3.7-7
TECHNICAL DATA REVIEW PANEL

COMPARISON OF UNIT COSTS - POTENTIAL UNDEVELOPED SOURCES OF SUPPLY

SOURCE TYPE	PROJECT	SOURCE OF DATA	UNIT COST $/AC-FT	UNIT COST INCLUDES O & M	LIMITING FACTORS/NOTES
Major Surface Water Projects	Clopton Crossing	Espey Huston 1986	287	No	No limiting factors cited/ Environmental considerations not addressed
	Cuero I Reservoir	Espey Huston 1986	141 to 255(1)	Yes	Mitigation required, no known endangered species/
		TWDB 1990	216	No	No information, data only
	Lindenau Reservoir (Cuero II)	Espey Huston 1986	296 to 327(1)	Yes	Mitigation required, no known endangered species/
		TWDB 1990	266	No	No information, data only
	Cuero I and Lindenau Reservoirs	Espey Huston 1986	301 to 339(1)	Yes	Same as for separate projects
	Applewhite Reservoir	Freese & Nichols 1988	168	No	Minimum yield during critical periods equal 7700 acre-feet per year when operated for scalping/
		TWDB 1990	639	No	No information, data only
	Cibolo Creek Reservoir (Lower)	Espey Huston 1986	834	Yes	Environmental considerations not addressed/
	Cibolo Creek Reservoir (Upper)	Lockwood Andrews & Newman 1965	208 to 323(1)	Yes	Environmental considerations not addressed/
	Goliad	Espey Huston 1986	211 to 465(1)	Yes	Environmental considerations not addressed/
		TWDB	180	No	No information, data only
	Bluntzer Reservoir	Rauschnber 1985	743 to 4500(1)	Yes	Reduced bay inflows, elevated bay salinity/
	R & M Reservoir	Rauschunber 1985	403 to 2891(1)	Yes	Reduced bay inflows, elevated bay salinity/

	Simmons Pump Station	Rauschunber 1985	52 to 122(1)	Yes	No limiting factors cited
	Cotulla Diversion and Canal	BuRec 1983	1303	Yes	No limiting factors cited
	Palmetto Bend-Stage II	HDR Engineering 1991	176 to 196(1)	Yes	Additional studies of bay and estuary impacts required/
	Lake Texana and Palmetto Bend-Stage II	HDR Engineering 1991	245 to 278(1)	Yes	See Palmetto Bend Stage II
	Lake Texana and Garwood Irrigation	HDR Engineering 1991	746 to 175(2)	Yes	Interbasin transfer, change in pupose of use/ Unit cost varies with varying amount directed from Garwood to Lake Texana
Water Reuse Projects	Alamo Water Conservation and Reuse District	AWCRD 1991	200 to 350(2)	Yes	These costss are reported from a staff analysis, wastewater delivered to San Antonio River in Brackenridge Park, industries, golf courses etc. -Phase I of Reuse Program, cost does not include commodity charge
	City of Corpus Christi	Stone & Webster 1984	215 to 635(2)	Yes	No limiting factors cited/ Wastewater treated for industrial use, unit cost varies with volume reused
	City of San Antonio	Black & Veatch 1990	345 to 425(2)	Yes	Wastewater effluent treated, cycled through Lakes Braunig and Calaveras and treated for potable use by City Water Board, unit cost varies with volume reused
Storage and Recovery	Alamo Water Conservation and Reuse District	CH2M HILL 1991	464	Yes	Availability of supply, transport losses, impact on receiving aquifer/ Storage by spreader basin, recovery by wells, using Medina Lake water
			717	Yes	Availability of supply, transport losses, impact on receiving aquifer/ Storage and recovery by wells using Medina Lake water

Recharge	Nueces Basin	HDR Engineering 1991	66 to 1318(3)	Yes	Less water (at higher cost) available during critical periods/ Honoring all downstream rights except Lake Corpus Christi/Choke Canyon; average conditions, Type II projects, optimum conservation capacity
		HDR Engineering 1991	330 to 486(3)	Yes	Less water (at higher cost) available during critical periods/ Honoring all downstream rights, average conditions, Type I projects, optimum conservation capacity
Desalination	City of Corpus Christi	Stone & Webster 1984	352 to 782(2)	Yes	Brackish groundwater, unit cost varies with volume treated
		Stone & Webster 1984	1218		Seawater

(1) Unit cost varies with varying reservoir yield
(2) Unit cost varies with varying amounts used
(3) Unit cost varies with separate recharge projects

LIMITATIONS ON USE OF THIS DATA

1. Unit cost are estimates.

2. Quality of cost estimates and yields used to compute unit costs vary greatly from report to report.

3. Refer to text of report and tables for explanation of deviation of these unit costs.

4. This table provides a general comparison of alternatives and should not be used for selection of alternatives.

4.0 REDUCTIONS IN USE

Introduction

SECTION 4.0 LIST OF TABLES

SECTION 4.0 LIST OF FIGURES

4.0 REDUCTION IN USE

Introduction

This section addresses measures available for reduction in water use in two general categories. They are conservation and drought management. Conservation measures are those measures associated with long term changes in personal lifestyle and water use habits, and long term changes in water use equipment and operations. Drought management is defined as short term measures instituted to cope with drought-caused shortages in supply. Generally, drought management measures are more drastic or "stepped up" conservation measures. Long term success in the application of conservation measures to reduce water use diminishes the opportunity for reducing water use during critical periods with drought management measures. This separation of measures to reduce water use into conservation and drought management categories is consistent with Texas Water Development Board approach to water use reductions.

This section first analyzes the conservation projections by three agencies: the Texas Water Development Board, the Texas Water Commission and the 1988 Regional Water Management Plan. It sets forth the assumptions for "mild" and "aggressive" programs and compares the results of the various projections. It then reviews briefly the impact of drought management plans as projected by the Texas Water Development Board and the Edwards Underground Water District.

4.1 GENERAL

4.1.1 RESEARCH MATERIALS

Research for this section revealed that a significant amount of resource material is available, more than can be adequately reviewed for purposes of the Technical Data Review Panel. The Panel did not make an independent analysis of the potential for reductions in use for the region. The review of the literature indicates numerous case studies, generally in the western states, where scarcity of water has been a long term problem. An adequate research of the available resource material will require an extensive analysis of these case studies and other reports which generalize the potential for reductions in water use by applying the array of conservation and drought management measures available.

Few comprehensive reduction-in-use programs are in effect in the study area to serve as a basis for projecting potential water savings there. To the extent that programs exist they probably fit more into the category of drought management measures than long term conservation programs. The City of Corpus Christi developed a program in response to the 1984 drought in that region. The 1988-89 drought in the Edwards Aquifer area caused drought management measures to be put into effect by most of the area cities. The City of San Antonio and other cities currently have in place lawn watering ordinances and emergency ordinances designed to reduce pumpage from the Edwards Aquifer when test well levels decline to certain points. The San Antonio emergency ordinance sets percentage reductions of water use as voluntary goals but requires the use of certain measures. The Edwards Underground Water District is reviewing a Demand Management Plan that follows a different strategy, setting reduction goals but flexible on the measures to be used to achieve them. Several cities in the region, including New Braunfels and San Marcos have adopted emergency plans which use the same strategy as the Edwards District plan. Leak detection programs are operating in some cities.

Specifics of the success of these programs, measured in water saved, have not been researched but, with the exception of the City of Corpus Christi's record of performance for the program there since 1984, the time frame of operation of the existing programs is too short for meaningful data, when meaningful is defined as useful for prediction of study area-wide water use reduction.

Agriculture is also an exception to this general statement on the status of conservation programs. The ground water irrigation users in the study area have applied conservation measures, principally upgrading of equipment and operations. The incentive to conserve has been economic. These measures have been applied on an individual basis so little useful historical data is available to project *future reductions* in irrigation uses in the local area. Historical information needed to make a meaningful projection of reduction in irrigation use includes application rates, metered volumes, acres, crops, types of equipment installed and records of water saved.

A researcher projecting reductions of water use over the long term associated with the application of conservation measures and over the short term associated with the application of drought management measures to cope with scarcity of supply is confronted with two conditions:

1) A significant amount of data from case studies and generalized reports outside the study area that must be discovered and researched. This data will require adjustment for applicability to local conditions of water use.

2) An insignificant amount of proven local data, with the critical period exceptions noted above, on demonstrated reductions in use from applied conservation and drought management measures.

There are a wide array of variables almost universally present in all municipalities that affect the success of measures instituted to reduce water use. This applies to both conservation and drought management measures. These variables include among others:

Pre-plan conditions:
- History of water development and use
- Climatic conditions
- Seasonal use patterns
- Per capita water use rates
- Limitations on supply
- Existing conservation program
- Mix of uses: commercial, residential, etc.
- Demography: population age and growth
- Water rates

Conditions affecting plan implementation:
- Goal of the program
- Political commitment
- Severity of need for reduction
- Measures instituted: all available or selected
- Length of time of program

This array of variables makes difficult the application of the success rates of a water use reduction program in one area for a projection of use reduction in another.

The studies which address a larger area tend to generalize savings in water to be expected and perhaps have some utility for making approximate projections of reductions in use. The applicability of the results of these studies to the study area would have to be verified.

There are significant variations in water use and climatic characteristics across the study area. Measures that will work in Port Lavaca, where seasonal uses such as lawn watering account for only 12-13% of total use, may not work as effectively in Uvalde, where seasonal use is closer to 30% of total water use. It should also be noted that suitable baseline data from which to project reductions in use may not exist. Reference is made to the earlier concerns expressed in this text about census estimates of population, per capita use rates and percentage of use by various use types (commercial, residential, etc.).

Similar difficulties exist for making projections of reductions in use for uses other than municipal, such as manufacturing, mining, power, irrigation and livestock. Less research material is available; these water uses are by individuals or corporations, information may be private or proprietary, and water savings may be driven more by economic considerations.

However, given all these problems, it is possible to make general projections of water savings anticipated from the application of use reduction measures. Such projections are made as part of a comprehensive study program by the Texas Water Development Board. The Technical Review Panel chose to focus on this body of data in light of the difficulties in carrying out its own independent study.

4.1.2 Texas Water Development Board

The Texas Water Development Board maintains an ongoing program of research on conservation programs in practice across the nation to project reductions in water use as a part of the overall water use projections published periodically as the Texas Water Plan. This ongoing research by TWDB represents the only existing comprehensive effort to apply experience in other areas (within and outside the state) to the study area on a city by city basis.

The two most recent renditions of water use projections (including projections of reductions in use associated with conservation) are the official 1990 Texas Water Plan and the recent 1992 Draft Projections. The TWDB does not make projections of reductions in water use associated with drought management as a part of the Texas Water Plan process. Its reasoning is that droughts are local and unpredictable crisis events with instant conditions dictating varying water use reduction measures. Because these measures may not continue in practice after the crisis abates, TWDB believes that they cannot and should not be incorporated with a long term projection of water demands.
In the 1990 Texas Water Plan standard state-wide percentage reductions in water use over time from conservation measures were applied to the water use projections. In the 1992 Draft Projections expected reductions in use were "personalized" for each city taking into account specifics such as per capita use rates, seasonal use rates, population growth and importantly, existing conservation programs in place. The anticipated reductions in use developed for the 1992 Draft Projections were estimated based on the knowledge gained by TWDB in the ongoing program of research on conservation. The TWDB characterizes the estimates of predicted conservation-measure-induced reduction in use as conservative, i.e., care has been taken not to overpredict reductions in use. The reductions, as specified in some cases below, assume no legislation beyond what is in place now to compel or create financial incentives for the adoption of water-saving measures.

Taken as a whole the TWDB estimates, applying knowledge gained from continuing research on conservation, represents the best information available at this writing on anticipated reductions in use associated with conservation measures for the study area. Details of the TWDB estimates of conservation savings as predicted in the 1992 Draft Projections are given later in the text of this section.

4.2 USES

4.2.1 Categories of Uses

Table 4.2-1 presents a listing of water uses that are candidates for use reduction measures. The general categories presented in Table 4.2-1 are consistent with the Texas Water Development Board's categories of historical and projected future water use. These categories are municipal (including military and domestic), manufacturing, power, mining, irrigation and livestock. The detailed listing of uses under each category is for the purpose of acquainting the reader with the range of uses that may be reduced and is not intended to be all-inclusive of every potential use.

4.3 REDUCTION MEASURES

4.3.1 Categories of Reduction Measures

Table 4.3-1 presents a listing of water use reduction measures that are in general practice. The measures are grouped in five categories: education, retrofit, ordinances/rules/laws, economic and water utility operations. This categorization of measures is for purposes of organization of the table and acquainting the reader with the array of measures available. This list may not include all available measures.

Table 4.2-1

WATER USES

MUNICIPAL	Residential	- In-Home	- Toilet - Shower/Bath - Dishwasher - Clotheswasher - Other Personal
	Residential	- Outside	- Lawn - Garden - Pools and Spas - Car Washing
	Commercial	- Building Operations	- Cooling Towers/Heating - Laundry and Food Service - Sanitary
		- Fleet Operations	- Washing
		- Operation Specific	- Car Washing - Water Parks/Recreation - Brewings - Nursery - Feedlots - Product Preparation/Washing - Other
	Public	- Aesthetic	- Fountains - Zoos - River walk
		- Firefighting - Utility and Streets	- Flushing Water and Sewer Mains - Water and Sewer Plant Process and Washdown - Construction
		- Parks and Golf Courses	
	Institutional	- Building Operations	- Cooling Towers/Heating - Laundry and Food Service - Sanitary
		- Landscape	
MANUFACTURING	Process	- Heat Transfer - Washdown - Cooling Towers/Heating	
	Building Operations	- Sanitary - Food Service - Landscape	
POWER	Cooling	- Generation	
	Process	- Boiler Feed - Environmental Control - Sanitary - Landscape	
MINING	Process	- Washing	
	Sanitary		
IRRIGATION	Crop Production		
LIVESTOCK	Livestock Watering		

Table 4.3-1

WATER USE REDUCTION MEASURES

EDUCATION	Target Specific Groups	- Schools - Organizations - Public at Large - Company Employees - Utility Customers
	Message	- Personal - General - Advice on Best Available Conservation Equipment and Services
	Media	- Print - Electronic - Water Bill
	Participation	- Voluntary
RETROFIT	Replace Fixtures, Equipment, and Landscaping With More Efficient Units	- Residential - Commercial - Manufacturing - Utility - Irrigation
	Participation	- Voluntary - Mandatory
ORDINANCES/RULES/LAWS	Change to Water Using Devices\Operations	- Plumbing - Process - Landscape
	Change Water Use Habits	- Landscape - In Home - Other
	Institute Higher Water Rates/Penalties	
	Participation	- Mandatory
ECONOMIC	Provide Incentives	- Rebates for Retrofitting - Reduction of Capital Recovery Fees - Cost Savings for Reduced Use - Payments for Reduced Use
	Provide Disincentives	- Increasing Block Water Rights - Penalties - Fines
	Participation	- Voluntary - Mandatory
WATER UTILITY OPERATIONS	Change Operations	- Leak Detection - Meter Repair - Water Audits for Customers/Utility - Pressure Reduction and Control - Treatment Processes/Washdown
	Improve Facilities	- Leak Correction - Construction Techniques
	Participation	- Voluntary

4.4 REDUCTION AMOUNTS

4.4.1 CONSERVATION

4.4.1.1 Texas Water Development Board

The 1992 Draft Projections of future water use by the Texas Water Development Board reflect a detailed analysis of the expected reductions in water use attributable to conservation measures on a city by city basis over the projection period from Year 2000 to Year 2040. Manufacturing and irrigation use projections also include estimates of conservation savings in water use. Mining, power and livestock uses are not projected to be reduced by conservation measures. Following is a description of the TWDB methodology applied to compute the expected reductions in use from conservation measures and for municipal uses the resultant prediction of water savings.

Municipal

The methodology used in calculating the expected reductions in municipal water use occurring from the application of conservation measures can be found in working papers at the Texas Water Development Board. These papers were prepared as a part of the process of developing the 1992 Draft Projections. Water use projections were presented with and without conservation in Section 2.0 Water Requirements. Refer to Figure 2.1-12 and the explanatory text in Section 2.1.3.1 for a description of the projection streams made by TWDB. Historical per capita water use rates for each city over 1000 population and for the rural area in each county were calculated based in the 1990 census. Expected reductions in water use were calculated and subtracted from the historical per capita water use rates for purposes of making projections of future water use with conservation.

Water savings attributable to installation of water conserving plumbing fixtures required by Senate Bill 587 are estimated by TWDB to save water as follows:

Fixture	Savings GPCD
Toilets	11.5
Shower heads	4.0
Faucet aerators	2.0
Urinals	.3
Fountains	.1
Total	17.9 = 18 GPCD

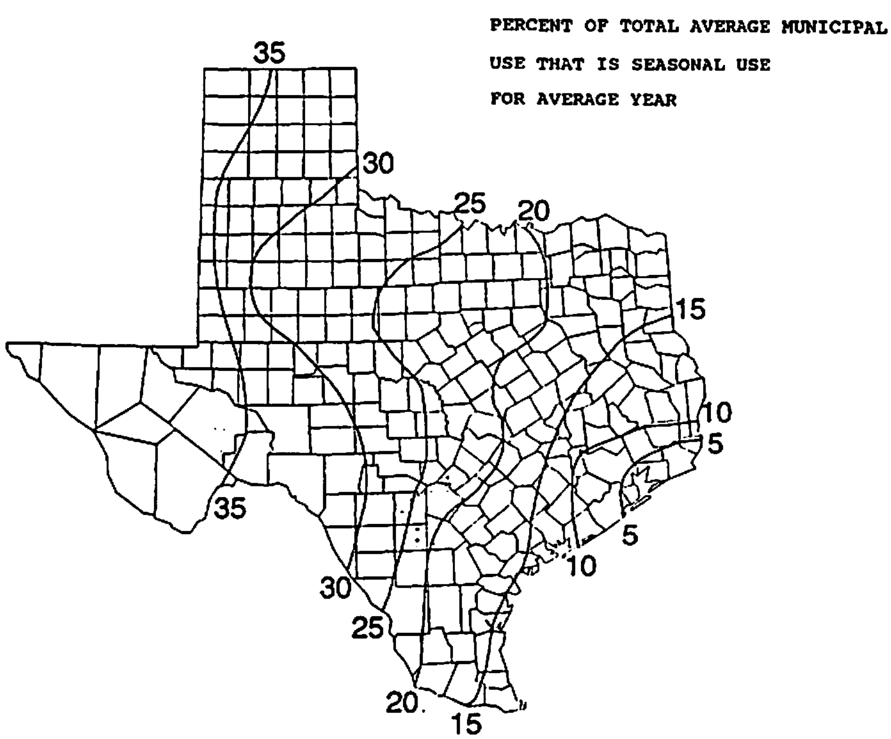
(GPCD = gallons per capita per day)

Plumbing fixtures water savings are given in GPCD rather than percentage because each city has a different beginning GPCD while the measures will reduce use equally in each city. These savings are not instantaneous but will require time for turnover of existing fixtures. TWDB assumed that new housing, which is required by law to be equipped with water saving fixtures, would increase at a rate based on the growth in population in each city and county. It assumed that existing homes would retrofit as old fixtures wore out at the rate of 20% of existing housing stock in each decade, but then used 90% of this number, according to TWDB working papers, in order "to be conservative."

Water use patterns for many cities were examined by TWDB for purposes of determining the amount of water use attributable to seasonal use. In the study area the percent of total use attributable to seasonal use varies from about 15% in the coastal or southeastern part to 30% in the western part. See Figure 4.4-1.

Education, xeriscape, irrigation audits, water rates and ordinances addressing landscape installation and irrigation practices all can be effective in reducing seasonal use. TWDB estimates that the combination of all these factors should reduce seasonal water (not total use) use in the range of 5 to 20 percent. TWDB used conservative values of 7% reduction during normal years and 10.5% during drought years. This factor was applied to the percent of use attributable to seasonal use for each city for calculation of the reduction in water use from controlling landscape watering. For these projections, it assumed that it would take 30 years, in the absence of legislation, for the full impact of these measures to be felt. To estimate this time delay, it was further assumed that one-third of the full potential would be implemented in the year 2000, two thirds in 2010 and 100 percent in 2020.

Figure 4.4-1



Commercial water use accounts for approximately 30% of all non-industrial municipal use. This percentage is higher for larger cities which tend to be regional commercial centers having a greater portion of commercial to residential water use than outlying and smaller cities. Sanitary uses are a high percentage of commercial uses thus the savings in water use associated with plumbing fixture and seasonal use is already accounted for in the predictions of GPCD reduction described above for those elements. Other savings are achievable by retrofitting water using equipment in commercial establishments, cooling and heating equipment operation, etc. TWDB adds a value of 1.5% of total municipal use that may be reduced by commercial uses other than the sanitary and seasonal use savings accounted for elsewhere.

TWDB predicts a two percent savings overall associated with changes in equipment and operations within the utility system including leak correction.

A one percent savings from changes in water use habits within the home is predicted to be achievable through education programs. A 0.5 percent savings in expected for changing dishwashing and clotheswashing equipment to more efficient models.

The sum of the commercial, utility, education and appliance savings described in the preceding three paragraphs is 5 percent. This 5 percent savings is expected to be realized in increments allowing time for retrofit, education and other factors to operate to reduce water use. One-third is expected by TWDB to occur by 2000, two-thirds by 2010 and 100 percent by 2020. This percentage was multiplied by the average GPCD rate for each city of determine the volume of water saved.

Based on TWDB knowledge of each city's conservation program, the predicted water use reduction calculated as described above for plumbing fixtures, seasonal uses and commercial, utility, education and appliances categories was adjusted to give credit for conservation practices already in place. Up to one-half of the predicted reduction was subtracted for full operation of a conservation program, lesser amounts for partial conservation programs in place. To summarize, cities with conservation programs in place were projected to have smaller reductions in water use (varying according to the status of conservation measures already in practice) in the projections of future use than those cities without conservation programs.

The TWDB projections of conservation reductions in municipal water use reflected in the 1992 Draft Projections can be expressed as a percentage by comparing the projections made with and without conservation. Refer to Figure 4.4-2 where the pair of values of projected water use for the high per capita use condition "with conservation" and "without conservation", in the high population series are identified. The "with conservation" projections of water use are the same values that were presented for projected water use in Section 2.0, Table 2.1-24 and 2.1-26. These values are used in Table 4.4-1 for calculation of the percentage reduction in municipal use projected by TWDB. Table 4.4-2 summarizes the per capita water use in the five major counties of the Edwards region based on historical data.

Table 4.4-1 presents the projected reductions associated with the combination of all municipal conservation measures as a percentage. The percentage reduction is calculated as (use "without conservation" minus use "with conservation") divided by (use "without conservation") times 100. Information is presented for the cities in the study area of over 10,000 population. The projected savings for the cities using from the Edwards Aquifer varies from 10064 to 74112 acre-feet per year for projection periods 2000 and 2040, respectively. These cities over 10,000 population represent approximately 78% of the total population using water from the Edwards Aquifer.

Sample Data From Table 4.4-1
see pages 246-247 for complete table

PROJECTIONS OF PERCENTAGE REDUCTIONS IN MUNICIPAL WATER USE
CITIES OVER 10,000 IN POPULATION

SOURCE: TWDB, 1992 Draft Projections-High Population Series
UNITS: Water Use in Acre-Feet

County	City	Water Use	2000	2010	2020	2030	2040
BEXAR	SAN ANTONIO	W/O Cons.	255671	304196	360721	432086	502722
	High per/cap	With Cons.	247067	282259	320833	380152	437465
		Difference	8604	21937	39888	51934	65257

Manufacturing

The 1992 Draft Projections of manufacturing use assume a level of conservation savings in water use. Manufacturing uses of water are separated into five categories: pulp and paper, primary metals, petroleum refining, organic chemicals and inorganic chemicals. The manufacturing plants in each county were sorted into these categories and then reduction in use coefficients for each use were applied to the predicted water uses to determine the projected water use with conservation. These numbers were presented in the 1992 Draft Projections. The co-efficients were developed for each of the five manufacturing groups mentioned above through contact with industry representatives who provided information about industrial process changes and other technical innovations. The largest reductions in water use because of such changes were projected in the pulp and paper and primary metals groups.

These projections are net of conservation savings.The pre-conservation projection values of water use are not presented in the 1992 Draft Projections. As with the municipal use credit was given for conservation programs in place at the time of the projections to reduce the total projected conservation savings.

Irrigation

The irrigation use projections in the 1992 Draft Projections also have been reduced for expected conservation measures. The pre-conservation projections of water use are not presented in the 1992 Draft Projections.

The projected irrigation uses in the 1992 are net of conservation savings. The reduction amounts were not quantified. TWDB reports that the projected reduction is approximately 20% over a twenty year period from a reduction in crop water application rates and a reduction in acreage based on historic rates (1980's).

Other Uses

TWDB did not predict reductions in water use associated with power, mining or livestock uses. TWDB does not predict reductions in power production because no improvement in the efficiency of water consumption in the production of thermodynamic power is expected over the period of the projections. Mining in the study area is generally limited to sand and gravel operations, and TWDB expects no changes in that technology. Similarly, no changes in livestock watering practices is expected.

Texas Water Development Board "Advanced Case"

TWDB projected savings over the period 1995 to 2040 from an "advanced case" water conservation program for the Edwards Aquifer in an unpublished working paper. The "advanced case" analyzed the water savings that could be accomplished for both an average and high GPCD rate. The period analyzed for the average and high GPCD rate was 1980 through 1989. The high GPCD rate was the highest monthly GPCD rate experienced during the period.

The measures in the "advanced case" include a strict landscape ordinance and steeply increasing block rates, fines, xeriscape programs and other controls on landscape water use. Also included is an aggressive plumbing retrofit code, leak detection and commercial water conservation. This program is much stricter than the program described above used by TWDB in making projections of water use reductions from conservation as programmed in the 1992 Draft Projections. In addition the "advanced case" includes a projected water savings in the manufacturing sector increasing from 2% in 1995 to 15% by 2040.

Projections of water savings in the "advanced case" for the projection period 1995-2040 are presented in Table 4.4-3 for the average and high GPCD use rates. The specific assumptions regarding ordinances and programs are listed in Table 4.4-4.

Table 4.4-3

PROJECTED WATER SAVINGS - "ADVANCED CASE" CONSERVATION

Year	Use	Average Case* Savings (1000 ac-ft)	Average Case* Savings %	High Case** Savings (1000 ac-ft)	High Case** Savings %
1995	Municipal	19.6	6.0	24.7	6.5
	Manufacturing	0.4	2	0.4	2
		20.0	8.0	25.1	8.5
2000	Municipal	41.8	11.3	53.5	12.4
	Manufacturing	1.2	5	1.2	5
		43.0	16.3	54.7	17.4
2010	Municipal	73.6	16.6	87.3	17.0
	Manufacturing	2.2	7	2.2	7
		75.8	23.6	89.5	24.0
2020	Municipal	109.5	20.2	126.2	20.6
	Manufacturing	3.8	10	3.8	10
		113.3	30.2	130.0	30.6
2030	Municipal	152.6	22.2	176.0	22.2
	Manufacturing	5.7	12	5.7	12
		158.3	34.2	181.7	34.2
2040	Municipal	173.7	22.4	201.4	22.5
	Manufacturing	9.0	15	9.0	15
		182.7	37.4	210.4	37.5

* Average case represents water use during average periods, GPCD = 188 for Edwards Aquifer users from historical information

** High case represents water use during dry periods, GPCD = 217 for Edwards Aquifer users from historical information

Table 4.4-4 ADVANCED WATER CONSERVATION MEASURES FOR THE AREA

Seasonal Use

Measure	Enact a strict landscape ordinance and programs
-	A five day watering schedule
-	Water scheduling and audits of all commercial landscapes
-	Water waste fines
-	Extensive xeriscape programs including an ordinance that requires that native and adapted plants and grasses be used in new construction
-	Limits for commercial landscapes that can be irrigated
-	Very steep residential increasing block rate schedules
-	Restrictions on cooling tower operations to require at least five cycles of concentration
-	ET index information daily in the paper and on the radio and TV
Results	Reduce seasonal use by 10% by 1995, 20% by 2000 and 2010, 21% by 2020, 22% by 2030, and 23% by 2040

Plumbing Codes

Measure	Enact Plumbing Code and Retrofit Ordinances
-	Require all buildings sold to be retrofitted with SB 587 fixtures before sale
-	Provide rebates of up to $100 per toilet and give away showerheads and faucet aerators
-	Require all apartment buildings to retrofit completely by 2010, 80% by 2000
-	conduct major education programs
-	Retrofit all government buildings by 2010
-	By 2020, 90% of all homes retrofitted and by 2030, 98% retrofitted
Results	111,000 homes and apartments by 1995 262,000 homes and apartments by 2000 504,000 homes and apartments by 2010

Other Measures

Measure	Leak detection, commercial water conservation, and education programs to change personal water use habits and encourage the purchase of effective appliances
Results	2.0 percent savings by 1995 3.0 percent savings by 2000 6.0 percent savings by 2010 7.5 percent savings by 2020 8.0 percent savings by 2030 8.0 percent savings by 2040

4.4.1.2 Texas Water Commission

In a paper titled "Avoiding Disaster: An Interim Plan to Manage the Edwards Aquifer" the Texas Water Commission estimated water savings through conservation and reuse measures for all uses at 88,000 to 125,000 acre-feet annually or 17 to 23 percent of the current estimated Edwards Aquifer water use of 538,000 acre-feet per year. The savings projected to be achieved are found in a reprint of the table from the paper providing particulars of the estimated water savings program. Table 4.4-5 is the reprint. The Texas Water Commission characterized these estimates as "rough" but indicative of reductions that are potentially achievable with aggressive regulatory conservation measures in addition to the more standard or voluntary measures.

Some of these measures underlying this projection include:

♦ All municipal and industrial water users would prepare water conservation and reuse plans, under the review of the Texas Water Commissions, including analyses of water conservation potential for all uses, quantitative and time-specific goals for conservation and reuse, and specification of policies, programs and enforcement measures to achieve the goals.

♦ An incentive program for agriculture would be created to install "best available" irrigation technology, specifically converting all existing overhead sprinkler systems and approximately 80% of existing furrow-irrigated acreage to the best available technology for each farm.

Table 4.4-5

WATER SAVINGS FROM CONSERVATION MEASURES
IMPLEMENTED IN THE EDWARDS AQUIFER BALCONES FAULT ZONE REGION

TEXAS WATER COMMISSION (1)

SECTOR	ESTIMATED ACHIEVABLE WATER SAVINGS (AC-FT)	PERCENTAGE REDUCTION	CONSERVATION MEASURES
Municipal (1) and Industry	45,000 to 68,000	17% to 25%	>plumbing retrofit/ replacement >reduce seasonal outdoor water use: -conservation pricing -xeriscape programs -media campaign >reuse
Agriculture	40,000 to 52,000	17% to 22%	>conversion to best technology >use of best management practices
Aquaculture	3,000 to 5,000	20% to 33%	>reuse
TOTAL	88,000 to 125,000	17% to 23%	

(1) Reprinted from Avoiding Disaster: An Interim Plan to Manage the Edwards Aquifer, Texas Water Commission, 1992.

(2) Additional savings potentially possible from strategies for reducing unaccounted-for water in distribution systems and from commercial/industrial audit programs.

♦ Minimum water efficiency standards would be established for all new development using water from the Edwards Aquifer.

♦ An emergency water use reduction program based on two levels of water use curtailment: 1) If aquifer level at or below 649 feet a the start of the calendar year, 25% of agricultural acreage would be withheld from irrigation (using the dry-year option method), and municipal, industrial and aquaculture use would be reduced by 20%; 2) If aquifer level is at or below 632 at the start of the calendar year, then 75% of irrigation acreage would be withheld from irrigation and municipal, industrial and aquaculture uses would be reduced by 30%.

These are a few highlights from the "aggressive" conservation and reuse further described in the TWC paper.

4.4.1.3 Regional Water Resources Plan

In 1988 the Joint Committee on Water Resources of the San Antonio City Council and the Edwards Underground Water District prepared a "Regional Water Resources Plan." A part of that effort included an analysis of the impacts of water conservation practices on the current municipal water use. Projections of water savings were made from the application of a full range of practices including education, pricing, new construction standards, retrofitting and landscape ordinances. The analysis considered existing population or units times reduction factors to compute water conserved. Costs were computed for each measure. The analysis indicated that 54,000 acre-feet of water per year could be saved in the municipal use sector at a cost of $27,232,000 annually or $504 per acre-foot. Table 4.4-6 is a reprint of the analysis from the Regional Water Resources Plan as prepared by the Joint Committee. This table specifies the particular steps to be taken with respect to education, new construction standards, retrofits, and changes in landscape irrigation and the amounts to be spent on each activity.

4.4.1.4 Summaries and Comparisons

In the 1992 Draft Projections, TWDB projects the municipal water savings for the Edwards Aquifer associated with conservation measures to vary from 10,064 to 74,112 acre-feet per year for the cities over

10,000 population using water from the Edwards Aquifer for years 2000 to 2040, respectively. These cities over 10,000 population represent approximately 78% of the total population using water from the Edwards Aquifer. TWC presents a value of 45,000 to 68,000 acre-feet per year as estimated achievable water savings for the Edwards Aquifer in the municipal and industrial sector associated with conservation and reuse. In the "advanced case" TWDB expects conservation measures could reduce municipal use from the Edwards Aquifer from an initial amount in 1995 of 26,500 to 211,800 acre-feet per year by 2040.

TWC expects agricultural use of the Edwards Aquifer to reduce by 40,000 to 52,000 acre-feet per year or 17 to 22% of current use. TWDB reported that the 1992 Draft Projections include an approximate 20% reduction in agricultural use for the Edwards Aquifer.

4.4.2 Drought Measures

4.4.2.1 Texas Water Development Board

The TWDB working papers include an analysis of the potential for reducing water use during a drought. The analysis is specific to the Edwards Aquifer area using the five county average of high (drought conditions) use of 217 gallons per capita per day (GPCD) for total municipal use. The five county average of this total GPCD that is attributable to high seasonal use is 69 GPCD. The analysis assumed that the drought condition occurs before long term conservation measures operate to reduce GPCD use rates. Actual historical data on water use in the five county area, drawn from reports filed with TWDB, is the baseline for this analysis.

Two conditions of measures were applied. Under the "mild measures" scenario limits on seasonal uses would result in a 30% reduction (21 GPCD) in seasonal use. Businesses would be required to reduce use by 10% or 5 GPCD. The sum of these reductions equals 26 GPCD for the 1.353 million people in the five counties in the 1990 Census or 39,400 acre-feet per year.

Under the "extreme measures" analysis residential use was limited to 70 GPCD, landscape watering was banned, businesses were required to reduce use by 50% and a leak detection and correction program was expected to find and correct every leak possible. This analysis indicated that water use could be reduced by 96 GPCD or 145,500 acre-feet per year in uses supplied by municipalities.

4.4.2.2 Edwards Underground Water District

The Edwards Underground Water District (EUWD) has published a Draft (4/10/92) Demand Management Plan (DMP). The DMP requires water use reduction goals of 15, 20 and 30% for three stages of declining Edwards Aquifer levels. A fourth stage, Extreme Water Emergency, will have a greater reduction requirement to be specified a the time of crisis. This regulation does not specify water use measures to be instituted. The DMP is currently in the public comment stage and has not been adopted as of July, 1992.

4.5 PANEL DISCUSSIONS AND CONCLUSIONS

One panel member pointed out that there are two levels of conservation: technically achievable in the perfect world and the achievable potential considering human factors in acceptance rates of conservation measures. The achievable potential is thought by this member to be higher than the projections of conservation savings reflected in the TWDB 1992 Draft Projections and more accurately reflected in the TWC projections given in this text. The TWDB 1992 Draft Projections do not include more stringent or regulatory induced conservation. The TWDB "advanced case" described above does include a more agressive use reduction program than the 1992 Draft Projections.

One member pointed out that conservation won't work in small towns with low GPCD rates. Systems with low initial GPCD rates have little or no potential for reductions. In effect water saved with conservation measures may cost more than other sources.

Another member thought the 7% of seasonal use savings projected by TWDB to be low.

The absence of sufficient data on irrigation use from which to make predictions of irrigation use reductions was noted.

In response to the question, are there any comprehensive municipal conservation programs in practice in the study area that will yield meaningful data on expected conservation savings that would be applicable to the region, none were pointed out. It should be noted that not all cities are represented on the panel.

Bibliography

SECTION 4.0 REDUCTIONS IN USE

City of San Antonio and Edwards Underground Water District, Joint Committee on Water Resources, San Antonio Regional Water Resources Plan, 1988.

Edwards Underground Water District, Draft, Demand Management Plan, 1992.

Texas Water Commision, Avoiding Disaster: An Interim Plan to Manage the Edwards Aquifer, 1992.

Texas Water Development Board, Draft, 1992 Water Use Projections, 1992.

Texas Water Development Board, Advanced Case Conservation for the Edwards Aquifer, Working Papers, 1992.

Texas Water Development Board, Drought Management Plan for the Edwards Aquifer, Working Papers, 1992.

TABLE 4.2-1

TECHNICAL DATA REVIEW PANEL

WATER USES

<u>MUNICIPAL</u>	Residential	- In-Home	- Toilet - Shower/Bath - Dishwasher - Clothes-washer - Other Personal
	Residential	- Outside	- Lawn - Garden - Pools and Spas - Car Washing
	Commercial	- Building Operations	- Cooling Towers/Heat-ing - Laundry and Food Service - Sanitary
		- Fleet Operations	- Washing
		- Operation Specific	- Car Washing - Water Parks/Recrea tion - Brewings - Nursery - Feedlots - Product Preparation/ Washing - Other
	Public	- Aesthetic	- Fountains - Zoos - River walk
		- Firefighting	
		- Utility and Streets	- Flushing Water and Sewer Mains - Water and Sewer Plant Process and Washdown - Construction
		- Parks and Golf Courses	
	Institutional	- Building Operations	- Cooling Towers/Heat-ing - Laundry and

		Food Service
		- Sanitary
		- Landscape
MANUFACTURING	Process	- Heat Transfer - Washdown - Cooling Towers/Heating
	Building Operations	- Sanitary - Food Service - Landscape
POWER	Cooling	- Generation
	Process	- Boiler Feed - Environmental Control - Sanitary - Landscape
MINING	Process	- Washing
	Sanitary	
IRRIGATION	Crop Production	
LIVESTOCK	Livestock Watering	

TABLE 4.3-1

TECHNICAL DATA REVIEW PANEL

WATER USE REDUCTION MEASURES

EDUCATION	Target Specific Groups	- Schools - Organizations - Public at Large - Company Employees - Utility Customers
	Message	- Personal - General - Advice on Best Available Conservation Equipment and Services
	Media	- Print - Electronic - Water Bill
	Participation	- Voluntary
RETROFIT	Replace Fixtures, Equipment, and Landscaping With More Efficient Units	- Residential - Commercial - Manufacturing - Utility - Irrigation
	Participation	- Voluntary - Mandatory
ORDINANCES/RULES/LAWS	Change to Water Using Devices\Operations	- Plumbing - Process - Landscape
	Change Water Use Habits	- Landscape - In Home - Other
	Institute Higher Water Rates/Penalties	
	Participation	- Mandatory
ECONOMIC	Provide Incentives	- Rebates for Retrofitting - Reduction of Capital Recovery Fees - Cost Savings for Reduced Use - Payments for Reduced Use
	Provide Disincentives	- Increasing Block Water Rights

		- Penalties - Fines
	Participation	- Voluntary - Mandatory
<u>WATER UTILITY OPERATIONS</u>	Change Operations	- Leak Detection - Meter Repair - Water Audits for Customers/Utility - Pressure Reduction and Control - Treatment Processes/Washdown
	Improve Facilities	- Leak Correction - Construction Techniques
	Participation	- Voluntary

TABLE 4.4-1
TECHNICAL DATA REVIEW PANEL
PROJECTIONS OF PERCENTAGE REDUCTIONS IN MUNICIPAL WATER USE
CITIES OVER 10,000 IN POPULATION

SOURCE: TEXAS WATER DEVELOPMENT BOARD, 1992 DRAFT PROJECTIONS - HIGH POPULATION SERIES
UNITS: WATER USE IN ACRE-FEET

County	City	Water Use	2000	2010	2020	2030	2040
BEE	BEEVILLE	Without Conservation	2613	2842	3158	3460	3789
	high per capita use	With Conservation	2473	2556	2692	2903	3102
		Difference	140	286	466	557	687
		Percentage Reduction	5.35	10.06	14.75	16.09	18.13
BEXAR	FORT SAM HOUSTON	Without Conservation	3629	3629	3629	3629	3629
	high per capita use	With Conservation	3508	3374	3253	3199	3159
		Difference	121	255	376	430	470
		Percentage Reduction	3.33	7.02	10.36	11.84	12.95
BEXAR	LIVE OAK	Without Conservation	2608	3169	3823	4648	5466
	high per capita use	With Conservation	2473	2842	3252	3882	4536
		Difference	135	327	571	766	930
		Percentage Reduction	5.17	10.31	14.93	16.48	17.01
BEXAR	SAN ANTONIO	Without Conservation	255671	304196	360721	432086	502722
	high per capita use	With Conservation	247067	282259	320833	380152	437465
		Difference	8604	21937	39888	51934	65257
		Percentage Reduction	3.36	7.21	11.05	12.01	12.98
BEXAR	UNIVERSAL CITY	Without Conservation	3560	4307	5177	6275	7362
	high per capita use	With Conservation	3405	3910	4473	5361	6218
		Difference	155	397	704	914	1144
		Percentage Reduction	4.35	9.21	13.59	14.56	15.53
CALHOUN	PORT LAVACA	Without Conservation	1970	2264	2513	2722	2885
	high per capita use	With Conservation	1873	2025	2141	2262	2357
		Difference	97	239	372	460	528
		Percentage Reduction	4.92	10.55	14.80	16.89	18.30
COMAL	NEW BRAUNFELS	Without Conservation	10024	12282	14156	16315	17435
	high per capita use	With Conservation	9692	11376	12693	14509	15376
		Difference	332	906	1463	1806	2059
		Percentage Reduction	3.31	7.37	10.33	11.06	11.80
GUADALUPE	SCHERTZ	Without Conservation	2954	3340	3710	4194	4551
	high per capita use	With Conservation	2804	3033	3218	3595	3854
		Difference	150	307	492	599	697
		Percentage Reduction	5.07	9.19	13.26	14.28	15.31
GUADALUPE	SEGUIN	Without Conservation	4547	4900	5530	5917	6245
	high per capita use	With Conservation	4365	4484	4811	5059	5277
		Difference	182	416	719	858	968
		Percentage Reduction	4.00	8.48	13.00	14.50	15.50

County	City	Water Use	2000	2010	2020	2030	2040
HAYS	SAN MARCOS	Without Conservation	9683	12391	14785	16850	17928
	high per capita use	With Conservation	9357	11453	13232	14939	15819
		Difference	326	938	1553	1911	2109
		Percentage Reduction	3.36	7.57	10.50	11.34	11.76
JIM WELLS	ALICE	Without Conservation	6270	6541	6648	6731	6755
	high per capita use	With Conservation	6043	6069	5954	5947	5887
		Difference	227	472	694	784	868
		Percentage Reduction	3.62	7.21	10.43	11.64	12.84
KLEBERG	KINGSVILLE	Without Conservation	5971	6705	7207	7832	8334
	high per capita use	With Conservation	5714	6129	6316	6737	7080
		Difference	257	576	891	1095	1254
		Percentage Reduction	4.30	8.59	12.36	13.98	15.04
MAVERICK	EAGLE PASS	Without Conservation	5972	7588	9382	11093	12908
	high per capita use	With Conservation	5642	6792	7983	9316	10697
		Difference	330	796	1399	1777	2211
		Percentage Reduction	5.52	10.49	14.91	16.01	17.12
NUECES	CORPUS CHRISTI	Without Conservation	74188	84867	94235	104513	115160
	high per capita use	With Conservation	72156	79442	85629	93537	102013
		Difference	2032	5425	8606	10976	13147
		Percentage Reduction	2.73	6.39	9.13	10.50	11.41
NUECES	ROBSTOWN	Without Conservation	2225	2428	2606	2802	3004
	high per capita use	With Conservation	2113	2183	2231	2338	2442
		Difference	112	245	375	464	562
		Percentage Reduction	5.03	10.09	14.38	16.55	18.70
SAN PATRICIO	PORTLAND	Without Conservation	1932	2173	2396	2567	2689
	high per capita use	With Conservation	1824	1947	2032	2115	2172
		Difference	108	226	364	452	517
		Percentage Reduction	5.59	10.40	15.19	17.60	19.22
UVALDE	UVALDE	Without Conservation	6043	7294	8427	9728	11120
	high per capita use	With Conservation	5802	6710	7444	8496	9674
		Difference	241	584	983	1232	1446
		Percentage Reduction	3.98	8.00	11.66	12.66	13.00
VICTORIA	VICTORIA	Without Conservation	12060	13987	15504	16685	17920
	high per capita use	With Conservation	11548	12885	13719	14562	15422
		Difference	512	1102	1785	2123	2498
		Percentage Reduction	4.24	7.87	11.51	12.72	13.93
WEBB	LAREDO	Without Conservation	41311	52563	65213	79399	95545
	high per capita use	With Conservation	39416	47740	56837	68108	81520
		Difference	1895	4823	8376	11291	14025
		Percentage Reduction	4.58	9.17	12.84	14.22	14.67
	TOTAL OF ALL CITIES	Without Conservation	453231	537466	628820	737446	845447
	high per capita use	With Conservation	437275	497209	558743	647017	734070
		Difference	15956	40257	70077	90429	111377
		Percentage Reduction	3.52	7.49	11.14	12.26	13.17

TABLE 4.4-2
TECHNICAL DATA REVIEW PANEL
Summary of Per Capita Water Use
in the Five Major Counties
in the Edwards Aquifer Region

County Major City	Average GPCD	High GPCD	Average Winter GPCD	Average Season GPCD	High Season GPCD
Bexar	187	217	148	39	69
San Antonio	184	208	146	40	62
Uvalde	222	259	166	56	93
Uvalde	255	300	175	80	125
Medina	173	207	130	43	77
Hondo	244	291	165	79	126
Devine	159	179	112	47	67
Comal	198	235	153	45	82
New Braunfels	237	271	173	64	98
Hays	169	185	142	27	43
San Marcos	217	238	178	39	60
Regional (Weighted Avg.	188	217	148	40	69

TABLE 4.4-3
TECHNICAL DATA REVIEW PANEL

PROJECTED WATER SAVINGS - "ADVANCED CASE" CONSERVATION

Year	Use	Average Case* Savings (1000 ac-ft)	Average Case* Savings %	High Case** Savings (1000 ac-ft)	High Case** Savings %
1995	Municipal	19.6	6.0	24.7	6.5
	Manufacturing	0.4	2	0.4	2
		20.0	8.0	25.1	8.5
2000	Municipal	41.8	11.3	53.5	12.4
	Manufacturing	1.2	5	1.2	5
		43.0	16.3	54.7	17.4
2010	Municipal	73.6	16.6	87.3	17.0
	Manufacturing	2.2	7	2.2	7
		75.8	23.6	89.5	24.0
2020	Municipal	109.5	20.2	126.2	20.6
	Manufacturing	3.8	10	3.8	10
		113.3	30.2	130.0	30.6
2030	Municipal	152.6	22.2	176.0	22.2
	Manufacturing	5.7	12	5.7	12
		158.3	34.2	181.7	34.2
2040	Municipal	173.7	22.4	201.4	22.5
	Manufacturing	9.0	15	9.0	15
		182.7	37.4	210.4	37.5

* Average case represents water use during average periods, GPCD = 188 for Edwards Aquifer users from historical information

** High case represents water use during dry periods, GPCD = 217 for Edwards Aquifer users from historical information

TABLE 4.4-4
TECHNICAL DATA REVIEW PANEL
REPRINT OF TWDB TABLE
ADVANCED WATER CONSERVATION MEASURES FOR THE AREA

Seasonal Use

Measure: Enact a strict landscape ordinance and programs

- A five day watering schedule
- Water scheduling and audits of all commercial landscapes
- Water waste fines
- Extensive xeriscape programs including an ordinance that requires that native and adapted plants and grasses be used in new construction
- Limits for commercial landscapes that can be irrigated
- Very steep residential increasing block rate schedules
- Restrictions on cooling tower operations to require at least five cycles of concentration
- ET index information daily in the paper and on the radio and TV

Results: Reduce seasonal use by 10% by 1995, 20% by 2000 and 2010, 21% by 2020, 22% by 2030, and 23% by 2040

Plumbing Codes

Measure: Enact Plumbing Code and Retrofit Ordinances

- Require all buildings sold to be retrofitted with SB 587 fixtures before sale
- Provide rebates of up to $100 per toilet and give away showerheads and faucet aerators
- Require all apartment buildings to retrofit completely by 2010, 80% by 2000
- conduct major education programs
- Retrofit all government buildings by 2010
- By 2020, 90% of all homes retrofitted and by 2030, 98% retrofitted

Results: 111,000 homes and apartments by 1995
262,000 homes and apartments by 2000
504,000 homes and apartments by 2010

Other Measures

Measure: Leak detection, commercial water conservation, and education programs to change personal water use habits and encourage the purchase of effective appliances

Results: 2.0 percent savings by 1995
3.0 percent savings by 2000
6.0 percent savings by 2010
7.5 percent savings by 2020
8.0 percent savings by 2030
8.0 percent savings by 2040

TABLE 4.4-5
TECHNICAL DATA REVIEW PANEL
WATER SAVINGS FROM CONSERVATION MEASURES
IMPLEMENTED IN THE EDWARDS AQUIFER BALCONES FAULT ZONE REGION

TEXAS WATER COMMISSION (1)

SECTOR	ESTIMATED ACHIEVABLE WATER SAVINGS (AC-FT)	PERCENTAGE REDUCTION	CONSERVATION MEASURES
Municipal (1) and Industry	45,000 to 68,000	17% to 25%	>plumbing retrofit/ replacement
			>reduce seasonal outdoor water use: -conservation pricing -xeriscape programs -media campaign
			>reuse
Agriculture	40,000 to 52,000	17% to 22%	>conversion to best technology
			>use of best management practices
Aquaculture	3,000 to 5,000	20% to 33%	>reuse
TOTAL	88,000 to 125,000	17% to 23%	

(1) Reprinted from Avoiding Disaster: An Interim Plan to Manage the Edwards Aquifer, Texas Water Commission, 1992.

(2) Additional savings potentially possible from strategies for reducing unaccounted-for water in distribution systems and from commercial/industrial audit programs.

Table 4.4-6

PROJECTED MUNICIPAL WATER SAVINGS
1988 REGIONAL WATER PLAN

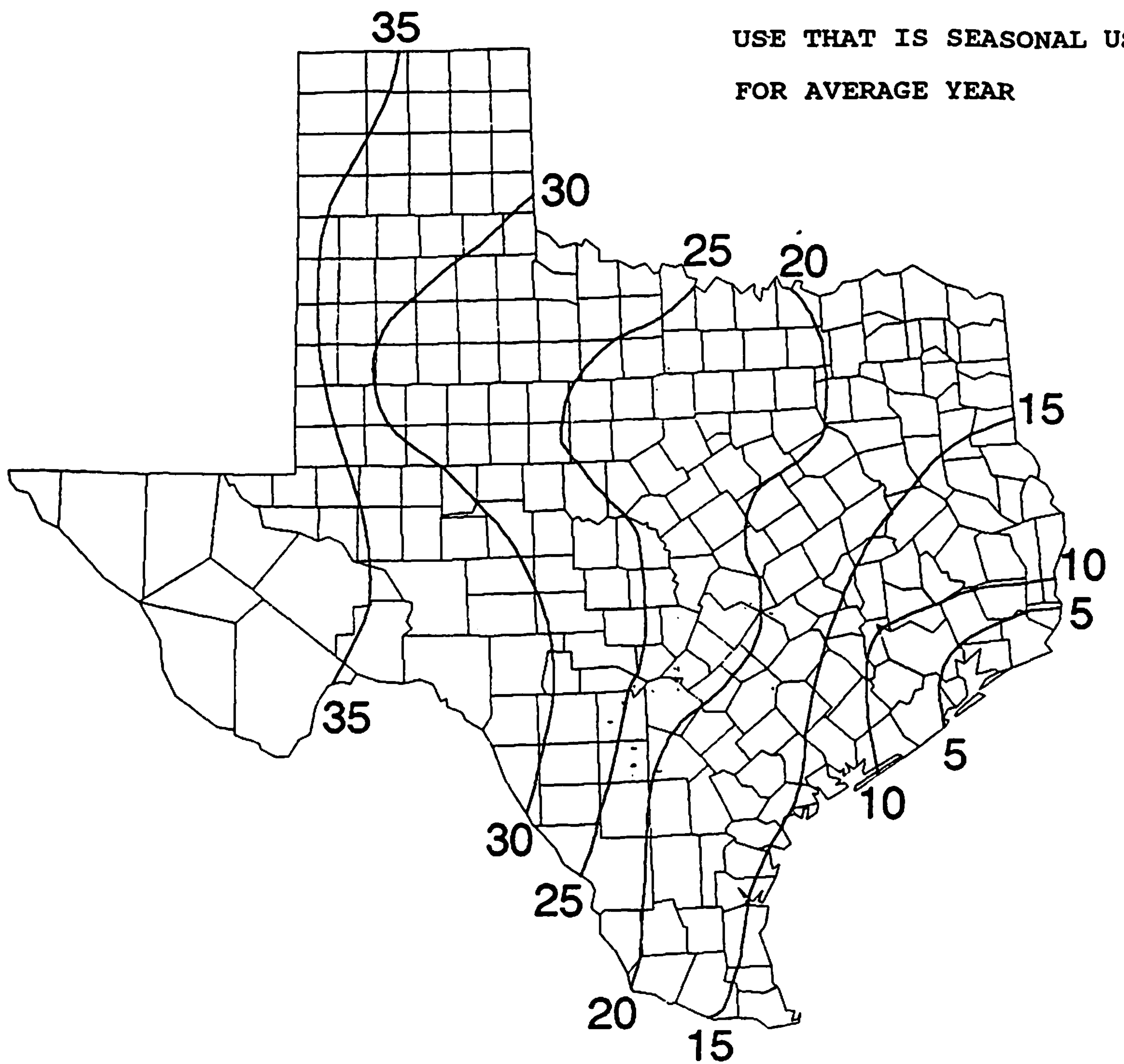
Action	Est. Unit Savings	Unit Cost or Total Cost	Target Population (EUWD)	Application Rate (EUWD)	Total Savings AF/YR	Total Cost $/YR	Cost Per AF Saved	Accomplished by
SUPPORTIVE PROGRAMS (all residents yr 2000)								
Public Ed.	1.0 gpcd	$200,000	1,636,373	75%	1,375	$200,000	$145	Education
School Ed.	1.0 gpcd	$200,000	1,636,373	75%	1,375	$200,000	$145	Education
Pricing								
Incr. Block	3.5 gpcd		1,636,373	100%	6,416	$0	$0	Policy Change
Seas. Block	2.0 gpcd		1,636,373	100%	3,666	$0	$0	Policy Change
Penalty	.5 gpcd		1,636,373	10%	91	$0	$0	Policy Change
Leak Detection Programs		$3000/mile		100%	600	$150,000	$250	Maint Policy
NEW CONSTRUCTION (housing units constructed between 1990 and 2000)								
LF Toilets	10 gpcd	$0	277,270	100%	3,106	$0	$0	Ordinance
LF Shower	6.7 gpcd	$0	277,270	100%	2,081	$0	$0	Ordinance
WE Dishwasher	2.0 gpcd	$0	277,270	100%	621	$0	$0	Ordinance
Pipe Insulation	2.0 gpcd	$0.62/ft	277,270	100%	621	$99,400	$1600	Ordinance
Pres Regulation	3.0 gpcd	$70.00	277,270	50%	465	$17,700	$380	Ordinance
Faucet Aerator	.5 gpcd	$2.00	277,270	100%	155	$7,300	$470	Ordinance
WE Washing Mach	5.0 gpcd	$70.00	277,270	75%	1,164	$66,000	$570	Ordinance
Gray Water Sys.	______	______	277,270	voluntary			______	Incentive
Landscape Measures for New Construction (housing units constructed between 1990 and 2000)								
LW Landscape	24.0 gpcd	$2000/home	277,270	75%	5,591	$10,903,000	$19,500	Ordinance
LW Irrig	13.0 gpcd	$1500/home	277,270	75%	3,028	$8,236,000	$27,200	Ordinance
M. Sensors	5.0 gpcd	$1200/home	277,270	75%	1,164	$6,600,000	$56,700	Ordinance
RETROFIT DEVICES (housing units built before 1990)								
S. Flow Rest	6.7 gpcd	$0.50	1,359,103	50%	5,100	$6,000	$12	Retrofit Ord.
Toilet Dams	4.5 gpcd	$10.00	1,359,103	50%	3,430	$48,000	$140	Retrofit Ord.
Pressure Regul.	3.0 gpcd	$70.00	1,359,103	50%	2,280	$87,000	$380	Retrofit Ord.
Faucet Aerators	.5 gpcd	$2.00	1,359,103	50%	380	$18,000	$470	Retrofit Ord.
Pipe Insulation	0.5 gpcd	$0.67/ft	1,359,103	15%	115	$9,000	$820	Retrofit Ord.
Repl Toilets	10. gpcd	$300	1,359,103	25%	3,806	$339,000	$890	Retrofit Ord.
Landscape Irrigation (housing units constructed before 1990)								
Watering Prg	3.0 gpcd	$100,000	1,359,103	50%	2,284	$100,000	$43	Education
Irrig Sched	3.0 gpcd	$100,000	1,359,103	50%	2,284	$100,000	$43	Education
PUBLIC FACILITY RETROFIT (all public facilities)								
Toilet Dams	1 g/flush	$10.00		100%	700	$9,800	$140	Govt Replace
Faucet Aerators	.5 gpm	$2.00		100%	50	$2,000	$380	Govt Replace
Auto Faucet		$25.00		100%	50	$5,000	$900	Govt Replace
LF Showers	1.5 gpm	$15.00		100%	325	$2,000	$60	Govt Replace
Public Facility Landscapes (all public facilities)								
Irrig Sched	20% reduction in seasonal UAF water			100%	2,500	$25,000	$10	Maint Policy

Reprinted from Bulletin 50, Compilation of Hydrologic Data for the Edwards Aquifer, San Antonio Area, Texas, 1990 with 1934-1990 Summary, 1991, prepared for Edwards Underground Water District by United States Geological Survey

PERCENT OF TOTAL AVERAGE MUNICIPAL

USE THAT IS SEASONAL USE

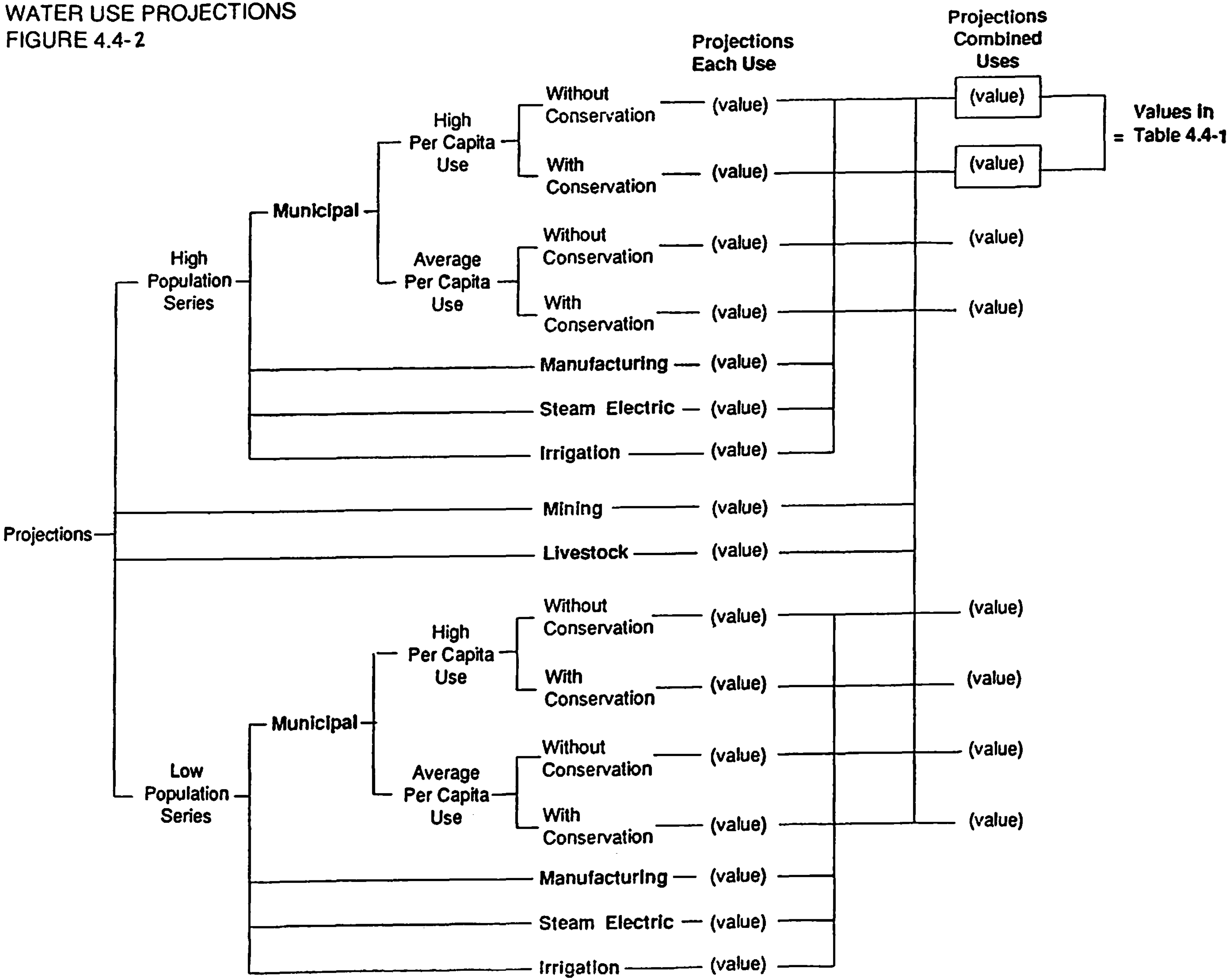
FOR AVERAGE YEAR



SOURCE: TEXAS WATER DEVELOPMENT BOARD

FIGURE 4.4-1

TEXAS WATER DEVELOPMENT BOARD
WATER USE PROJECTIONS
FIGURE 4.4-2



5.0 NATURAL RECHARGE

SECTION 5.0 LIST OF TABLES

SECTION 5.0 LIST OF FIGURES

5.0 NATURAL RECHARGE

Introduction

One of the most important sets of data regarding the Edwards Aquifer is the estimate of the annual natural recharge to the system. This section compares U.S.G.S. studies of the entire aquifer with results of studies commissioned by the Texas Water Development Board and other agencies of the Nueces Basin portion of the aquifer and by the Edwards Underground Water District of recharge from the Medina Lake system. One of the key issues associated with these studies is the range of uncertainty of the estimates of rechage. Our review found subjective estimates of uncertainty by technical staff responsible for carrying out these studies to be as high as 25% for the average annual recharge figures and as high as 50% for any particular annual estimate. All studies agreed that the range of uncertainty could be reduced by increasing the density of rainfall measuring stations and streamflow gages to improve the knowledge of the rainfall/runoff/recharge relationship throughout the aquifer recharge area.

5.1 UNITED STATES GEOLOGICAL SURVEY

5.1.1 Methods of Recharge Calculation

The United States Geological Survey (USGS) Water Resources Division subdistrict office in San Antonio has been estimating recharge to the Edwards Aquifer for over 25 years using a method first developed by Lowry (1955) and modified by Garza (1962 and 1966) and Puente (1978). This method estimates recharge to the Edwards Aquifer based on recharge to the Edwards Plateau Aquifer in the catchment area upstream of the Edwards Aquifer recharge area. Insufficient information is available on the relationship between rainfall, runoff and direct recharge to the aquifer in the Edwards Aquifer recharge area to make a direct computation of reacharge there. Therefore the method relies on better information that is available for the Edwards Plateau Aquifer translated to the Edwards Aquifer.

Several simplifying assumptions are necessary to apply this recharge estimation method used. These assumptions are:

1. Runoff characteristics of the catchment area (the area of a river basin above the recharge area) are the same as those in the recharge area (recharge zone) for each river basin.

2. Evapotranspiration is proportionally equivalent in the catchment area and the recharge area of each river basin.

3. All surface-water runoff from the catchment area of each river basin is measured at an upper streamflow gage (located at the approximate boundary of the catchment area and the recharge area).

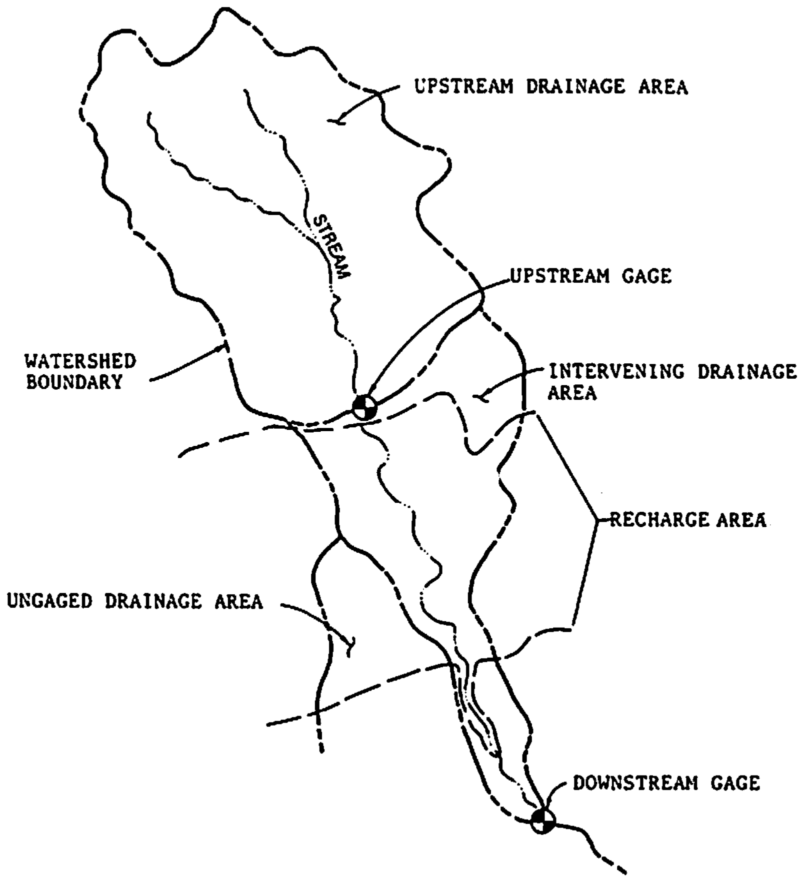
4. All surface-water runoff from the recharge area of each river basin is measured at a lower streamflow gage (at the approximate lower boundary of the recharge area).

5. Runoff characteristics of ungaged areas are the same as those of adjacent or nearby gaged areas.

Figure 5.1-1 presents the geographic arrangement of a typical river or stream, catchment area, recharge area, upstream gage, downstream gage and ungaged area.

Figure 5.1-1

Schematic of Streamflow Gages
and Gaged and Ungaged Areas



For streams that begin above and cross the recharge area, recharge to the Edwards Aquifer is estimated using the stream flow data collected at gaging stations just above and just below the recharge area, rainfall data collected in both the recharge area and catchment area, and curves of baseflow versus storage in the Edwards Plateau developed by Garza (1962 & 1966). The streams that begin above and cross the recharge area are the Nueces-West Nueces and Frio-Dry Frio river systems, Sabinal River, Seco Creek, Hondo Creek and Blanco River. These basins are sufficiently instrumented with rainfall and stream gages to apply this method.

The estimation method used for the Nueces-West Nueces and the other five major basins that cross the recharge area is a basic water budget equation. For months when no rainfall occurs in the recharge zone the equation is:

R = (Qu - Ql) CF (equ. 1)
R = Recharge
Qu = flow at upper streamflow gage
Ql = flow at lower streamflow gage
CF = factor to convert day second feet to acre-feet

Occasionally the outflow is greater than the inflow. When this occurs, the net recharge is set to zero because there is rejected recharge. Recharge that either does not infiltrate the aquifer at all or is discharged from the water table back to the stream within a short distance (less than a kilometer) is considered rejected.

For months when measurable rain produces runoff, the estimation method is considerably more complicated. The recharge equation then is:

R = (Qu + SI - Ql) CF (equ. 2)
R = Recharge
Qu = flow at upper streamflow gage
Ql = flow at lower streamflow gage
SI = flood flow and direct infiltration in the recharge area
CF = factor to convert day second feet to acre-feet

The calculation of the SI component of the equation is based upon the assumption that the runoff and direct infiltration characteristics in the catchment area are equivalent to those characteristics in the recharge area. The runoff from the catchment area measured at the upstream gage consists of two components: flood flows following rainfall events and baseflow. The baseflow component is water that recharges the Edwards Plateau Aquifer and then reappears in the stream as springflow. The Edwards Plateau Aquifer is the water table aquifer underlying the catchment area.

The USGS estimation method assumes that the floodflow component of runoff from the catchment area is the same as for the recharge area. Likewise the recharge or direct infiltration to the Edwards Plateau Aquifer, as can be estimated from the baseflow component of the total runoff at the upstream gage, is the same as the recharge or direct infiltration to the Edwards Aquifer.

Figure 5.1-2 is a hypothetical hydrograph taken from Puente (1978) that illustrates the graphical separation of the streamflow components for an upstream gage. Floodflow is the component "C." The crosshatched area represents the baseflow or the recharge to the Edwards Plateau Aquifer later emerging as springflow to the river. Puente (1978) used long term stream flow records at the upstream gages to develop recession curves from which he constructed graphs relating the increased base flow component of the hydrographs (Points D and E on Figure 5.1-2) to the total storage (recharge) to the Edwards Plateau Aquifer from a rainfall event. A hypothetical graph of this relationship was provided by USGS and is shown in Figure 5.1-3.

Figure 5.1-2

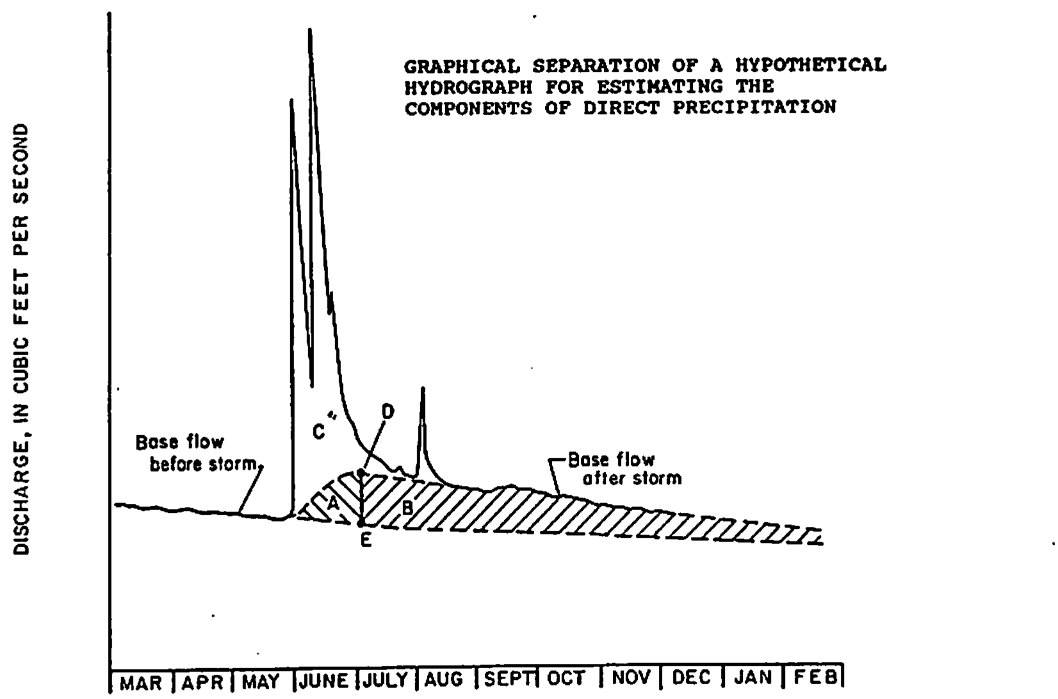
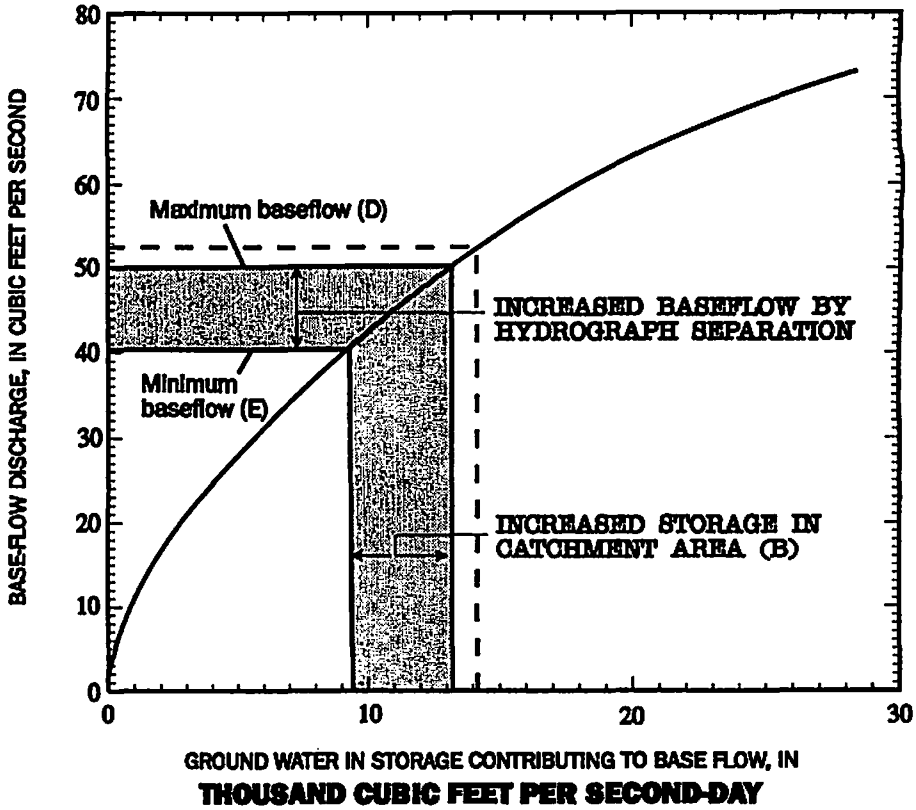


Figure 5.1-3



Thus the flood flow component from the catchment area is taken directly from the hydrograph separation in Figure 5.1-2. Recharge to the Edwards Plateau Aquifer is estimated using points D and E on Figure 5.1-2 to enter Figure 5.1-3 to determine total recharge or direct infiltration in the catchment area. The total of the flood and recharge or direct infiltration components is given as Qtu in Equation 3 following. Then SI, the floodflow and recharge or direct infiltration in the recharge area for Equation 2, is computed by adjusting Qtu for the catchment area to the recharge area for drainage area and rainfall differences by the equation:

SI = RF (Qtu)DAR (equ. 3) where:

SI = Runoff and direct infiltration in the recharge area

RF = Rainfall correction factor

$$\frac{\text{Average rainfall in the recharge zone}}{\text{Average rainfall in the catchment area}}$$

DAR = Drainage area ratio

$$\frac{\text{Drainage area of recharge zone}}{\text{Drainage area of catchment zone}}$$

Qtu = Sum of flood flow and recharge components for catchment area

Equation 2 is then solved for the gaged basins.

A second method is used in the ungaged basins and sub-basins. Recharge is estimated for these areas strictly by comparison with the nearest fully-instrumented basin—that is, the recharge for the ungaged basin is the same as that for the adjacent fully-instrumented basin proportional to the ratio of the areas of the two basins.

A third method is used in several basins that are too large for the second method but are not fully instrumented. The method used to estimate recharge for these basins is a modified version of the water-budget method. The runoff for the basin of interest is estimated by calculating a unit of runoff (estimated volume of runoff divided by the area of the contributing basin) from the nearest comparable continuous streamflow gaging station. The runoff is calculated by multiplying the unit of runoff by the area of the basin interest. The recharge is estimated as the same fraction of runoff as determined for the adjacent instrumented basin.

The recharge in the Medina River basin is estimated using a special method developed by Lowry (1953). Medina Lake and the associated downstream Diversion Lake are located in the recharge area of the Edwards Aquifer. Lowry constructed correlation curves of monthly recharge versus reservoir content. There are separate curves for rising and falling stages (to reflect the influence of bank storage). The USGS uses average monthly contents in the lake derived from reservoir stage records to enter Lowry's curves to estimate monthly recharge amounts.

Table 5.1-1 lists the stream basins that recharge the Edwards aquifer and which one of the above described methods is used to estimate the recharge contributed by that basin.

The history of the recharge estimates was described by USGS personnel as originally estimated by Petit and George in 1953 for years 1934 to 1953. Lowry's method (1955) was used for 1953-62 period. Garza developed the method in use today in 1966. It is thought, though not revealed in the report, that Garza corrected earlier estimates for 1934-66 using his method. Puente made refinements in 1978 to correct the Garza method for drainage areas and rain gages only. It was not stated whether Puente made any corrections for the pre-1978 period based on his refinements. Refer to USGS Water-Resources Investigation 78-10 Method of Estimating Natural Recharge to the Edwards Aquifer in the San Antonio Area, Texas, by Celso Puente, April, 1978 for a detailed description of the current USGS methodology for estimating recharge.

5.1.2 Results

Table 5.1-2 presents the USGS record of estimated annual recharge to the Edwards aquifer by basin for the period 1934-90 as reported in Bulletin 50, Compilation of Hydrologic Data for the Edwards Aquifer, San Antonio Area, Texas, 1990 with 1934-1990 Summary. USGS personnel, addressing the uncertainty of the recharge estimates in a presentation to the Technical Data Review Panel, provided the following information.

- Best data are streamflows:
  - 95% of the time they are within 5%.
- Rainfall measurements uncertainty ranges:
  - Up to 60% for individual storms more or less depending on density of coverage.
  - 10 to 20% for monthly data again dependent on density of data points.
- No information is available on uncertainty of:
  - Major assumptions about transferability of recharge estimates between basins/subbasins.
  - Storage versus baseflow curves of Garza.
  - Hydrograph separation technique.
  - Lowry's estimates for Medina Lake losses.

The presenter from USGS indicated that his subjective estimate (based on his experience of computing the recharge estimates using the USGS method) is that the annual recharge estimates have a probable range of accuracy of 20 to 50% or greater, and that the long term average of the annual USGS recharge estimates is within 20 - 25% of actual recharge.

5.2 TEXAS WATER DEVELOPMENT BOARD

5.2.1 Methods of Recharge Calculation

In 1991 the Texas Water Development Board, the Nueces River Authority, the City of Corpus Christi, the Edwards Underground Water District and the South Texas Water Authority engaged a consultant, HDR Engineering, Inc. (HDR) to make an independent calculation of historical recharge to the Edwards Aquifer as a part of an overall water supply planning study in the Nueces River Basin. This recharge estimation was made for two purposes:

(1) To use as a baseline for computing enhanced recharge from a series of proposed recharge projects in the Nueces Basin.

(2) To compare the results to the USGS record of historical recharge.

The results of this study were published as a report, Regional Water Supply Planning Study—Phase I, Nueces River Basin, HDR Engineering, Inc., 1991. A more detailed description of the HDR method can be found there.

The TWDB method calculated the historical recharge in the gaged areas corresponding to USGS gaged areas in accordance with the following equation:

R = QG + QI - QNA : where:
R = Recharge
QG = Upstream gage flow (USGS gage)
QI = Estimated flow in the recharge area
QNA = Downstream gage flow (USGS gage) adjusted for diversions in the recharge area

The TWDB method used a modified Soil Conservation Service method to compute QI, the estimated runoff in the recharge area that is predicted to occur from a rainfall event. This is the same component (though computed differently) identified as "SI" in the USGS methodology. The TWDB method used updated areal precipitation and drainage areas to compute "QI" for the period 1939-1989. The method of computing "QI" uses a composite factor (curve number) taking into account the soil cover complex, topography and land use characteristics and was applied on a basin by basin basis using county soil maps and aerial photographs. Antecedent moisture conditions for each rainfall event are also considered in this method of computing runoff.

In the ungaged areas, recharge was estimated utilizing rainfall data and estimated recharge in the adjacent gaged areas.

5.2.2 Results

Table 5.2-1 is a record for the period 1934 through 1989 of the estimated recharge in the Nueces Basin as calculated by HDR for the Texas Water Development Board and other study sponsors. HDR representatives in their presentation to the Technical Data Review Panel characterized the HDR estimates as having a range of uncertainty of plus or minus 15-20% for dry years and 25% for wet years. HDR believes that the long term average recharge to the Edwards Aquifer in the Nueces Basin estimated by HDR's method is within plus or minus 15% of the actual recharge.

5.3 Edwards Underground Water District

5.3.1 Method of Recharge Calculation, Medina Lake

In 1988 the Edwards Underground Water District commissioned a consultant, Espey, Huston & Associates, Inc. (EH&A) to perform a hydrology study of Medina Lake as a part of a feasibility study for converting the water supply in the lake from irrigation use to recharge of the Edwards Aquifer. The report was published as Medina Lake Hydrology Study, Espey, Huston & Associates, 1989. This report is further described in Section 3.0 SOURCES OF SUPPLY.

EH&A, after an extensive analysis described in Appendix B of the referenced report developed elevation versus monthly recharge volumes curves for Medina Lake and the associated Diversion Lake downstream similar to those developed by Lowry (1953) and described above. This analysis indicated recharge rates significantly lower than those predicted by Lowry's curves. EH&A's analysis (and

Table 5.3-1

HISTORICAL RECHARGE - MEDINA RIVER

SOURCE: EDWARDS UNDERGROUND WATER DISTRICT
UNITS : ACRE FEET

Year	Medina Lake	Diversion Lake	Total
1940	35,537.9	16,894.7	52,432.6
1941	36,115.7	16,896.0	53,011.7
1942	35,978.4	16,896.0	52,874.4
1943	34,404.4	16,827.4	51,231.8
1944	33,524.5	16,843.5	50,368.0
1945	34,802.9	16,891.8	51,694.7
1946	34,094.1	16,863.8	50,957.9
1947	35,209.1	16,874.8	52,083.9
1948	32,306.6	16,656.8	48,963.4
1949	30,322.2	16,590.9	46,913.1
1950	27,702.7	16,307.8	44,010.5
1951	23,847.4	16,020.4	39,867.8
1952	20,040.7	15,766.4	35,807.1
1953	16,689.2	15,513.1	32,202.3
1954	12,843.6	14,023.8	26,867.4
1955	4,883.9	7,375.4	12,259.3
1956	2,074.8	1,662.9	3,737.7
1957	18,510.7	12,521.9	31,032.6
1958	35,252.4	16,896.0	52,148.4
1959	36,051.0	16,896.0	52,947.0
1960	35,989.3	16,896.0	52,885.3
1961	35,781.1	16,896.0	52,677.1
1962	31,481.9	16,611.7	48,093.6
1963	22,749.4	15,925.0	38,674.4
1964	14,771.1	14,680.7	29,451.8
1965	23,457.7	16,121.9	39,579.6
1966	23,584.8	16,137.3	39,722.1
1967	19,041.5	15,730.9	34,772.4
1968	29,568.6	16,737.4	46,306.0
1969	30,137.4	16,616.7	46,754.1
1970	33,504.8	16,857.9	50,362.7
1971	32,671.1	16,670.4	49,341.5
1972	36,105.1	16,896.0	53,001.1
1973	36,196.9	16,896.0	53,092.9
1974	36,021.1	16,896.0	52,917.1
1975	36,055.4	16,896.0	52,951.4
1976	35,590.5	16,896.0	52,486.5
1977	35,773.6	16,896.0	52,669.6
1978	34,809.8	16,839.0	51,648.8
1979	35,975.7	16,896.0	52,871.7
1980	33,101.7	16,797.8	49,899.5
1981	35,628.8	16,896.0	52,524.8
1982	35,238.3	16,874.6	52,112.9
1983	31,775.7	16,675.2	48,450.9
1984	25,635.0	16,177.6	41,812.6
1985	28,583.7	16,611.5	45,195.2
1986	31,834.3	16,766.6	48,600.9
TOTAL	1,381,256.5	749,011.6	2,130,268.1
AVERAGE	30,027.3	16,282.9	46,310.2

Reprinted from Medina Lake Hydrology Study, 1989, prepared for Edwards Underground Water District by Espey Huston and Associates

LIMITATIONS ON THE USE OF THIS DATA:
HDR Engineering, Inc. reports that these estimates have a range of uncertainty of 15-20% for dry years and 25% for wet years.

Lowry's earlier analysis) was made difficult by the lack of flow data associated with the reservoir operations, i.e., inflow to the lake, downstream flows and diversions. After extensive analysis, including a re-creation of Lowry's work, EH&A eventually selected the recharge functions described by the curves cited above. These curves used in a re-creation of the historical operation of the reservoirs predicted end of month reservoir content for the period 1940-1986 which closely matched the historical record for the Lake.

5.3.2 Results

Table 5.3-1 presents the annual recharge values estimated by EH&A for the Edwards Underground Water District for Medina Lake and Diversion Lake which together span the Medina River reach of the recharge area of the Edwards Aquifer.

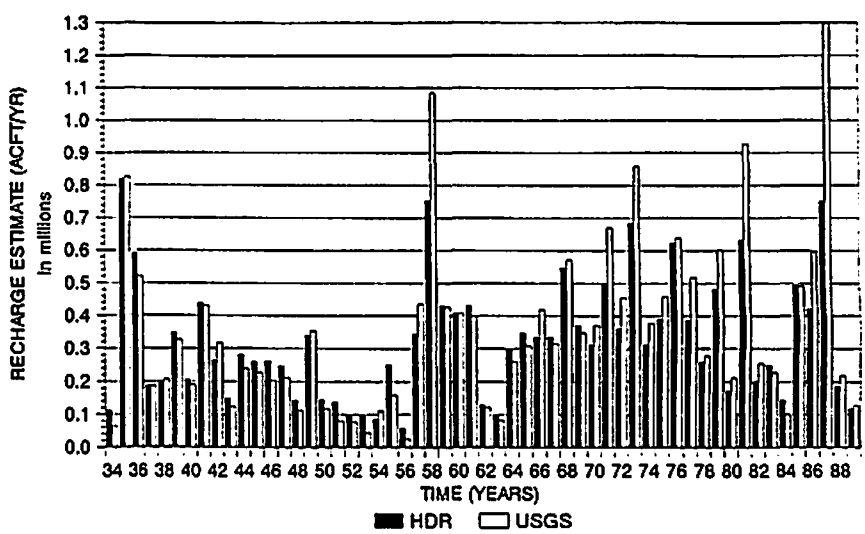
5.4 COMPARISONS

5.4.1 Nueces Basin Recharge

Figure 5.4-1 presents a comparison of the estimated recharge amounts in the Nueces River Basin as estimated by USGS and TWDB (HDR). Table 5.4-1 presents this data in tabular form. Note that for periods 1934 through 1942 and 1957 through 1970, the USGS and TWDB estimates show reasonably good agreement, the only major exception being the wet year, 1958. For the period 1943 through 1956, USGS estimates average 18.5% less than those computed by TWDB, lower than TWDB in twelve of the fourteen years. For the period 1971 through 1989, USGS has predicted an average of 26.3% more or 102,000 acre-feet of recharge, higher than TWDB in all but three of the nineteen years. The average of the USGS estimates for the period 1940 through 1989 in 31,600 acre-feet or 9.7% more than TWDB for the Nueces River Basin. Comparing the rainfall records presented in Table 2.1-14 with Table 5.4-1 indicates that the significant difference between USGS and TWDB estimates is in the wet years when USGS is substantially higher.

Figure 5.4-1

COMPARISON OF HISTORICAL EDWARDS AQUIFER RECHARGE FOR NUECES RIVER BASIN



TWDB notes in the executive summary in the Nueces Basin Study Report that the difference in USGS and TWDB estimates occurs in the estimation of runoff and direct infiltration in the recharge area. USGS and HDR personnel noted in their presentations to the Technical Data Review Panel that the estimate of runoff and recharge or direct infiltration in the recharge zone was the element of the estimates in which the USGS had the least confidence.

Both USGS and HDR expressed their major concerns about the other's method. USGS representatives indicated that the SCS method for computing runoff used in the TWDB (HDR) method for estimating recharge may not be applicable for large scale application across the recharge area. HDR representatives expressed concerns about the USGS method where estimated recharge in the Edwards Plateau Aquifer was translated to recharge in the Edwards Aquifer. Both concluded that additional data on the relationship of rainfall, runoff and recharge in the recharge area is needed to make better estimates of natural recharge to the Edwards Aquifer.

5.4.2 Medina Lake

Table 5.4-2 presents the USGS and Edwards Underground Water District (EUWD) (prepared by EH&A) annual estimates of recharge from the Medina Lake system for comparison. The average of the EUWD annual estimate is 23.7% less than the comparable USGS figure.

5.5 PANEL DISCUSSIONS AND CONCLUSIONS

The panel discussion centered on concerns about the accuracy of the recharge estimates and the dangers of misuse of those estimates in water balance calculations relative to management of the Edwards Aquifer.

One member indicated that the uncertainty of the recharge estimates should be addressed by a range of management activities. Another indicated that the USGS and TWDB methods could be combined for a better estimate of recharge. The danger of leveling out uncertainty by management was emphasized by one member, who felt that measuring recharge was "an art not a science."

One member suggested that this should be identified by the Panel as a technical area for further study. It was also noted in the discussion that the historical recharge in the Guadalupe-San Antonio basin is currently being computed with the TWDB (HDR) method, for comparison with the USGS record.

Bibliography

SECTION 5.0 NATURAL RECHARGE

Edwards Underground Water District, Compilation of Hydrologic Data for the Edwards Aquifer, San Antonio Area,Texas, with 1934-1990 Summary, Bulletin 50, 1991.

Espey, Huston & Associates, Medina Lake Hydrology Study, 1989.

HDR Engineering, Inc., Regional Water Supply Planning Study, Phase I, Nueces River Basin, 1991.

United States Geological Survey (Puente), Method of Estimating Natural Recharge to the Edwards Aquifer in the San Antonio Area, Texas, 1978.

TABLE 5.1-1
TECHNICAL DATA REVIEW PANEL

UNITED STATES GEOLOGICAL SURVEY

METHODS OF ESTIMATING RECHARGE TO THE EDWARDS AQUIFER

STREAM BASIN	METHOD USED TO ESTIMATE RECHARGE
Nueces-West Nueces Rivers	Water budget equation as outlined in text p. using upstream and downstream streamflow data
Frio-Dry Frio Rivers Leona River and Blanco Creek	Same as Nueces-West Nueces Proportional to Frio-Dry Frio recharge
Sabinal River	Same as Nueces-West Nueces
Adjacent area:	
Little Blanco, Nolton and Ranchero Creeks	Proportional to the Sabinal River recharge
Area between Sabinal River and Medina River:	
Seco Creek	Same as Nueces-West Nueces
Hondo Creek	Same as Nueces-West Nueces
Parkers and Live Oak Creeks	Proportional to Hondo Creek recharge
Verde and Quihi Creeks	Average of unit runoff from nearby gaging stations recharge is same percentage of runoff estimated for Hondo Creek
Medina River	Medina Lake and Diversion lake recharge from the method developed by Lowry (1955)
Area between Medina River and Cibolo Creek:	
San Geronimo and Leons Creeks	Unit of runoff estimated from either Guadalupe River streamflow stations or from Cibolo station below recharge zone, whichever is greater, times area minus outflow at lower station
East and West Prongs Dry Comal Creek	Unit of runoff estimated from streamflow stations on Guadalupe River times the area minus outflow of Comal River (not including Comal Spring flow)
Blanco River and adjacent area:	
Blanco River	Same as Nueces-West Nueces
Sink, Purgatory, York and Alligator Creeks	Unit of runoff from nearby streamflow stations times area and adjusted for the same proportion of runoff estimated to be recharge in Dry Comal Creeks basin

Table 5.1-2

Technical Data Review Panel

RECORD OF ESTIMATED RECHARGE TO THE EDWARDS AQUIFER
[thousands of acre-feet]

Source: United States Geological Survey

Calendar year	Nueces-West Nueces River basin	Frio-Dry Frio River basin b/	Sabinal River basin b/	Area between Sabinal River and Medina River basins b/	Medina River basin c/	Area between Medina River basin and Cibolo Creek basin b/	Cibolo Creek and Dry Comal Creek basins	Blanco River basin b/	Total
1934	8.6	27.9	7.5	19.9	46.5	21.0	28.4	19.8	179.6
1935	411.3	192.3	56.6	166.2	71.1	138.2	182.7	39.8	1,258.2
1936	176.5	157.4	43.5	142.9	91.6	108.9	146.1	42.7	909.6
1937	28.8	75.7	21.5	61.3	80.5	47.8	63.9	21.2	400.7
1938	63.5	69.3	20.9	54.1	65.5	46.2	76.8	36.4	432.7
1939	227.0	49.5	17.0	33.1	42.4	9.3	9.6	11.1	399.0
1940	50.4	60.3	23.8	56.6	38.8	29.3	30.8	18.8	308.8
1941	89.9	151.8	50.6	139.0	54.1	116.3	191.2	57.8	850.7
1942	103.5	95.1	34.0	84.4	51.7	66.9	93.6	28.6	557.8
1943	36.5	42.3	11.1	33.8	41.5	29.5	58.3	20.1	273.1
1944	64.1	76.0	24.8	74.3	50.5	72.5	152.5	46.2	560.9
1945	47.3	71.1	30.8	78.6	54.8	79.6	129.9	35.7	527.8
1946	80.9	54.2	16.5	52.0	51.4	105.1	155.3	40.7	556.1
1947	72.4	77.7	16.7	45.2	44.0	55.5	79.5	31.6	422.6
1948	41.1	25.6	26.0	20.2	14.8	17.5	19.9	13.2	178.3
1949	166.0	86.1	31.5	70.3	33.0	41.8	55.9	23.5	508.1
1950	41.5	35.5	13.3	27.0	23.6	17.3	24.6	17.4	200.2
1951	18.3	28.4	7.3	26.4	21.1	15.3	12.5	10.6	139.9
1952	27.9	15.7	3.2	30.2	25.4	50.1	102.3	20.7	275.5
1953	21.4	15.1	3.2	4.4	36.2	20.1	42.3	24.9	167.6
1954	61.3	31.6	7.1	11.9	25.3	4.2	10.0	10.7	162.1
1955	128.0	22.1	0.6	7.7	16.5	4.3	3.3	9.5	192.0
1956	15.6	4.2	1.6	3.6	6.3	2.0	2.2	8.2	43.7
1957	108.6	133.6	65.4	129.5	55.6	175.6	397.9	76.4	1,142.6
1958	266.7	300.0	223.8	294.9	95.5	190.9	268.7	70.7	1,711.2
1959	109.6	158.9	61.6	96.7	94.7	57.4	77.9	33.6	690.4
1960	88.7	128.1	64.9	127.0	104.0	89.7	160.0	62.4	824.8
1961	85.2	151.3	57.4	105.4	88.3	69.3	110.8	49.4	717.1
1962	47.4	46.6	4.3	23.5	57.3	16.7	24.7	18.9	239.4
1963	39.7	27.0	5.0	10.3	41.9	9.3	21.3	16.2	170.7
1964	126.1	57.1	16.3	61.3	43.3	35.8	51.1	22.2	413.2
1965	97.9	83.0	23.2	104.0	54.6	78.8	115.3	66.7	623.5
1966	169.2	134.0	37.7	78.2	50.5	44.5	66.5	34.6	615.2
1967	82.2	137.9	30.4	64.8	44.7	30.2	57.3	19.0	466.5
1968	130.8	176.0	66.4	198.7	59.9	83.1	120.5	49.3	884.7
1969	119.7	113.8	30.7	84.2	55.4	60.2	99.9	46.6	610.5
1970	112.6	141.9	35.4	81.6	68.0	68.8	113.8	39.5	661.6
1971	263.4	212.4	39.2	155.6	68.7	81.4	82.4	22.2	925.3
1972	108.4	144.6	49.0	154.6	87.9	74.3	104.2	33.4	756.4
1973	190.6	256.9	123.9	286.4	97.6	237.2	211.7	82.2	1,486.5
1974	91.1	135.7	36.1	115.3	96.2	68.1	76.9	39.1	658.5
1975	71.8	143.6	47.9	195.9	93.4	138.8	195.7	85.9	973.0
1976	150.7	238.6	68.2	182.0	94.5	47.9	54.3	57.9	894.1
1977	102.9	193.0	62.7	159.5	77.7	97.9	191.6	66.7	952.0
1978	69.8	73.1	30.9	103.7	76.7	49.6	72.4	26.3	502.5
1979	128.4	201.4	68.6	203.1	89.4	85.4	266.3	75.2	1,117.8
1980	58.6	85.6	42.6	25.3	88.3	18.8	55.4	31.8	406.4
1981	205.0	365.2	105.6	252.1	91.3	165.0	196.8	67.3	1,448.4
1982	19.4	123.4	21.0	90.9	76.8	22.6	44.8	23.5	422.4
1983	79.2	85.9	20.1	42.9	74.4	31.9	62.5	23.2	420.1
1984	32.4	40.4	8.8	18.1	43.9	11.3	16.9	25.9	197.9
1985	105.9	186.9	50.7	148.5	64.7	136.7	259.2	50.7	1,003.3
1986	188.4	192.8	42.2	173.6	74.7	170.2	267.4	44.5	1,153.7
1987	308.5	473.3	110.7	405.5	90.4	229.3	270.9	114.9	2,003.6
1988	59.2	117.9	17.0	24.9	69.9	12.6	28.5	25.5	355.5
1989	52.6	52.6	8.4	13.5	46.9	4.6	12.3	23.6	214.4
1990	479.3	255.0	54.6	131.2	54.0	35.9	71.8	41.3	1,123.2
AVERAGE	111.1	119.9	38.6	98.0	60.7	67.2	103.5	37.8	636.7

a/ Differences may occur due to rounding procedures.
b/ Includes recharge from gaged and ungaged areas within the basin.
c/ Recharge to Edwards aquifer from the Medina River basin consists entirely of losses from Medina Lake (Puente, 1978, p. 23).

Reprinted from Bulletin 50, Compilation of Hydrologic Data for the Edwards Aquifer, San Antonio Area, Texas, 1990 with 1934-1990 Summary, 1991, prepared for Edwards Underground Water District by United States Geological Survey

TABLE 5.2-1
TECHNICAL DATA REVIEW PANEL

RECORD OF ESTIMATED RECHARGE TO THE EDWARDS AQUIFER
NUECES RIVER BASIN

SOURCE: TEXAS WATER DEVELOPMENT BOARD
UNITS : ACRE FEET

YEAR	NUECES BASIN	FRIO BASIN	SABINAL BASIN	HONDO, SECO AND VERDE BASINS	TOTAL
1934	32889	34733	9383	35751	112756
1935	132831	321509	70191	296700	821231
1936	209504	168722	48431	164706	591363
1937	40180	72612	21505	53544	187841
1938	65582	65301	17441	53420	201744
1939	219904	70809	16369	42750	349832
1940	71156	66029	18404	50098	205687
1941	102464	143376	44657	149606	440103
1942	79296	85483	26855	70992	262626
1943	53958	45464	14284	36531	150237
1944	96031	103685	22108	59902	281726
1945	58175	96568	27181	77859	259783
1946	105067	78828	22448	55891	262234
1947	100972	81214	19759	45056	247001
1948	55926	50832	12338	24536	143632
1949	116471	111923	28351	84020	340765
1950	59750	40605	14007	30475	144837
1951	57189	35386	6326	39464	138365
1952	30359	27428	9703	28197	95687
1953	28556	30446	4619	36210	99831
1954	43278	27478	4017	11223	85996
1955	205474	30774	3206	11715	251169
1956	25319	9345	4224	19828	58716
1957	104250	92879	22490	125602	345221
1958	199766	255735	70117	228570	754188
1959	104504	172540	51863	102333	431240
1960	95579	133568	60338	118523	408008

YEAR	NUECES BASIN	FRIO BASIN	SABINAL BASIN	HONDO, SECO AND VERDE BASINS	TOTAL
1961	123931	163843	52613	91190	431577
1962	57671	53458	5202	13843	130174
1963	47126	38198	6559	7290	99173
1964	134656	67406	19902	75919	297883
1965	114710	90686	44792	98619	348807
1966	123092	100837	33251	77539	334719
1967	82245	139032	39003	75835	336115
1968	95065	183488	75500	193375	547428
1969	120252	116967	35794	97605	370618
1970	77417	124183	33424	77191	312215
1971	167028	178302	32839	124244	502413
1972	62963	126817	44298	128544	362622
1973	146650	210451	56717	269403	683221
1974	45291	142177	41640	83499	312607
1975	68271	127406	43110	152369	391156
1976	123277	250626	65417	183978	623298
1977	18157	180811	60106	127797	386871
1978	63320	80599	37764	77687	259370
1979	87809	152844	52182	188737	481572
1980	52312	68291	23481	29748	173832
1981	99236	236963	79443	216121	631763
1982	40941	100673	22684	38100	202398
1983	91758	80656	26657	51331	250402
1984	55405	46221	16221	26483	144330
1985	91366	172152	55982	175471	494971
1986	96000	134742	46738	144759	422239
1987	91216	288401	77781	294862	752260
1988	52841	97972	16541	19013	186367
1989	45222	49915	8282	13843	117262
AVERAGE	88744	111739	32581	92998	3260

Reprinted from Regime Water Supply Planning Study - Phase I Nueces River Basin, 1991, prepared for Texas Water Development Board, Nueces River Authority, Edwards Underground Water District, South Texas Water Authority and Texas Water Development Board by HDR Engineering, Inc.

LIMITATIONS ON THE USE OF THIS DATA:
HDR Engineering, Inc. reports that these estimates have a range of uncertainty of 15-20% for dry years and 25% for wet years.

TABLE 5.3-1
TECHNICAL DATA REVIEW PANEL

HISTORICAL RECHARGE - MEDINA RIVER

SOURCE: EDWARDS UNDERGROUND WATER DISTRICT
UNITS : ACRE FEET

Year	Medina Lake	Diversion Lake	Total
1940	35,537.9	16,894.7	52,432.6
1941	36,115.7	16,896.0	53,011.7
1942	35,978.4	16,896.0	52,874.4
1943	34,404.4	16,827.4	51,231.8
1944	33,524.5	16,843.5	50,368.0
1945	34,802.9	16,891.8	51,694.7
1946	34,094.1	16,863.8	50,957.9
1947	35,209.1	16,874.8	52,083.9
1948	32,306.6	16,656.8	48,963.4
1949	30,322.2	16,590.9	46,913.1
1950	27,702.7	16,307.8	44,010.5
1951	23,847.4	16,020.4	39,867.8
1952	20,040.7	15,766.4	35,807.1
1953	16,689.2	15,513.1	32,202.3
1954	12,843.6	14,023.8	26,867.4
1955	4,883.9	7,375.4	12,259.3
1956	2,074.8	1,662.9	3,737.7
1957	18,510.7	12,521.9	31,032.6
1958	35,252.4	16,896.0	52,148.4
1959	36,051.0	16,896.0	52,947.0
1960	35,989.3	16,896.0	52,885.3
1961	35,781.1	16,896.0	52,677.1
1962	31,481.9	16,611.7	48,093.6
1963	22,749.4	15,925.0	38,674.4
1964	14,771.1	14,680.7	29,451.8
1965	23,457.7	16,121.9	39,579.6
1966	23,584.8	16,137.3	39,722.1
1967	19,041.5	15,730.9	34,772.4
1968	29,568.6	16,737.4	46,306.0
1969	30,137.4	16,616.7	46,754.1

Table 5.3-1 Page 2

Year	Medina Lake	Diversion Lake	Total
1970	33,504.8	16,857.9	50,362.7
1971	32,671.1	16,670.4	49,341.5
1972	36,105.1	16,896.0	53,001.1
1973	36,196.9	16,896.0	53,092.9
1974	36,021.1	16,896.0	52,917.1
1975	36,055.4	16,896.0	52,951.4
1976	35,590.5	16,896.0	52,486.5
1977	35,773.6	16,896.0	52,669.6
1978	34,809.8	16,839.0	51,648.8
1979	35,975.7	16,896.0	52,871.7
1980	33,101.7	16,797.8	49,899.5
1981	35,628.8	16,896.0	52,524.8
1982	35,238.3	16,874.6	52,112.9
1983	31,775.7	16,675.2	48,450.9
1984	25,635.0	16,177.6	41,812.6
1985	28,583.7	16,611.5	45,195.2
1986	31,834.3	16,766.6	48,600.9
TOTAL	1,381,256.5	749,011.6	2,130,268.1
AVERAGE	30,027.3	16,282.9	46,310.2

Reprinted from Medina lake Hydrology Study, 1989, prepared for Edwards Underground Water District by Espey Huston and Associates

LIMITATIONS ON THE USE OF THIS DATA:
HDR Engineering, Inc. reports that these estimates have a range of uncertainty of 15-20% for dry years and 25% for wet years.

TABLE 5.4-1
TECHNICAL DATA REVIEW PANEL

COMPARISON OF EDWARDS AQUIFER RECHARGE ESTIMATES
NUECES RIVER BASIN

SOURCE: TABLES 5.1-2 AND 5.2-1
UNITS : ACRE FEET

YEAR	TEXAS WATER DEVELOPMENT BOARD	UNITED STATES GEOLOGICAL SURVEY	DIFFERENCE USGS - TWDB
1934	112756	63900	-48,856
1935	821231	826400	5,169
1936	591363	520300	-71,063
1937	187841	187300	-541
1938	201744	207800	6,056
1939	349832	326600	-23,232
1940	205687	191100	-14,587
1941	440103	431300	-8,803
1942	262626	317000	54,374
1943	150237	123700	-26,537
1944	281726	239200	-42,526
1945	259783	227800	-31,983
1946	262234	203600	-58,634
1947	247001	212000	-35,001
1948	143632	112900	-30,732
1949	340765	353900	13,135
1950	144837	117300	-27,537
1951	138365	80400	-57,965
1952	95687	77000	-18,687
1953	99831	44100	-55,731
1954	85996	111900	25,904
1955	251169	158400	-92,769
1956	58716	25000	-33,716
1957	345221	437100	91,879
1958	754188	1085400	331,212
1959	431240	426800	-4,440
1960	408008	408700	692
1961	431577	399300	-32,277

YEAR	TEXAS WATER DEVELOPMENT BOARD	UNITED STATES GEOLOGICAL SURVEY	DIFFERENCE USGS - TWDB
1962	130174	121800	-8,374
1963	99173	82000	-17,173
1964	297883	260800	-37,083
1965	348807	308100	-40,707
1966	334719	419100	84,381
1967	336115	315300	-20,815
1968	547428	571900	24,472
1969	370618	348400	-22,218
1970	312215	371500	59,285
1971	502413	670600	168,187
1972	362622	456600	93,978
1973	683221	857800	174,579
1974	312607	378200	65,593
1975	391156	459200	68,044
1976	623298	639500	16,202
1977	386871	518100	131,229
1978	259370	277500	18,130
1979	481572	601500	119,928
1980	173832	212100	38,268
1981	631763	927900	296,137
1982	202398	254700	52,302
1983	250402	228100	-22,302
1984	144330	99700	-44,630
1985	494971	492000	-2,971
1986	422239	597000	174,761
1987	752260	1298000	545,740
1988	186367	219000	32,633
1989	117262	127139	9,877
AVERAGE	326062	357674	31,612

LIMITATIONS ON THE USE OF THIS DATA:
See notes on Tables 5.1-2 and 5.2-1 about accuracy of data.

TABLE 5.4-2
TECHNICAL DATA REVIEW PANEL

COMPARISON OF ANNUAL RECHARGE ESTIMATES
MEDINA RIVER

SOURCE: TABLES 5.1-2 AND 5.3-1
UNITS : ACRE FEET

Year	Edwards Underground Water District	United States Geological Survey
1940	52,432.6	38800
1941	53,011.7	54100
1942	52,874.4	51700
1943	51,231.8	41500
1944	50,368.0	50500
1945	51,694.7	54800
1946	50,957.9	51400
1947	52,083.9	44000
1948	48,963.4	14800
1949	46,913.1	33000
1950	44,010.5	23600
1951	39,867.8	21100
1952	35,807.1	25400
1953	32,202.3	36200
1954	26,867.4	25300
1955	12,259.3	16500
1956	3,737.7	6300
1957	31,032.6	55600
1958	52,148.4	95500
1959	52,947.0	94700
1960	52,885.3	104000
1961	52,677.1	88300
1962	48,093.6	57300
1963	38,674.4	41900
1964	29,451.8	43300
1965	39,579.6	54600
1966	39,722.1	50500
1967	34,772.4	44700
1968	46,306.0	59900

Year	Edwards Underground Water District	United States Geological Survey
1969	46,754.1	55400
1970	50,362.7	68000
1971	49,341.5	68700
1972	53,001.1	87900
1973	53,092.9	97600
1974	52,917.1	96200
1975	52,951.4	93400
1976	52,486.5	94500
1977	52,669.6	77700
1978	51,648.8	76700
1979	52,871.7	89400
1980	49,899.5	88300
1981	52,524.8	91300
1982	52,112.9	76800
1983	48,450.9	74400
1984	41,812.6	43900
1985	45,195.2	64700
1986	48,600.9	74700
TOTAL	2,130,268.1	2,798,900
AVERAGE	46,310.2	60,845.7

LIMITATIONS ON THE USE OF THIS DATA:
See notes on Tables 5.1-2 and 5.3-1 about accuracy of data.

Figure 5.1-1

Schematic of Streamflow Gages
and Gaged and Ungaged Areas

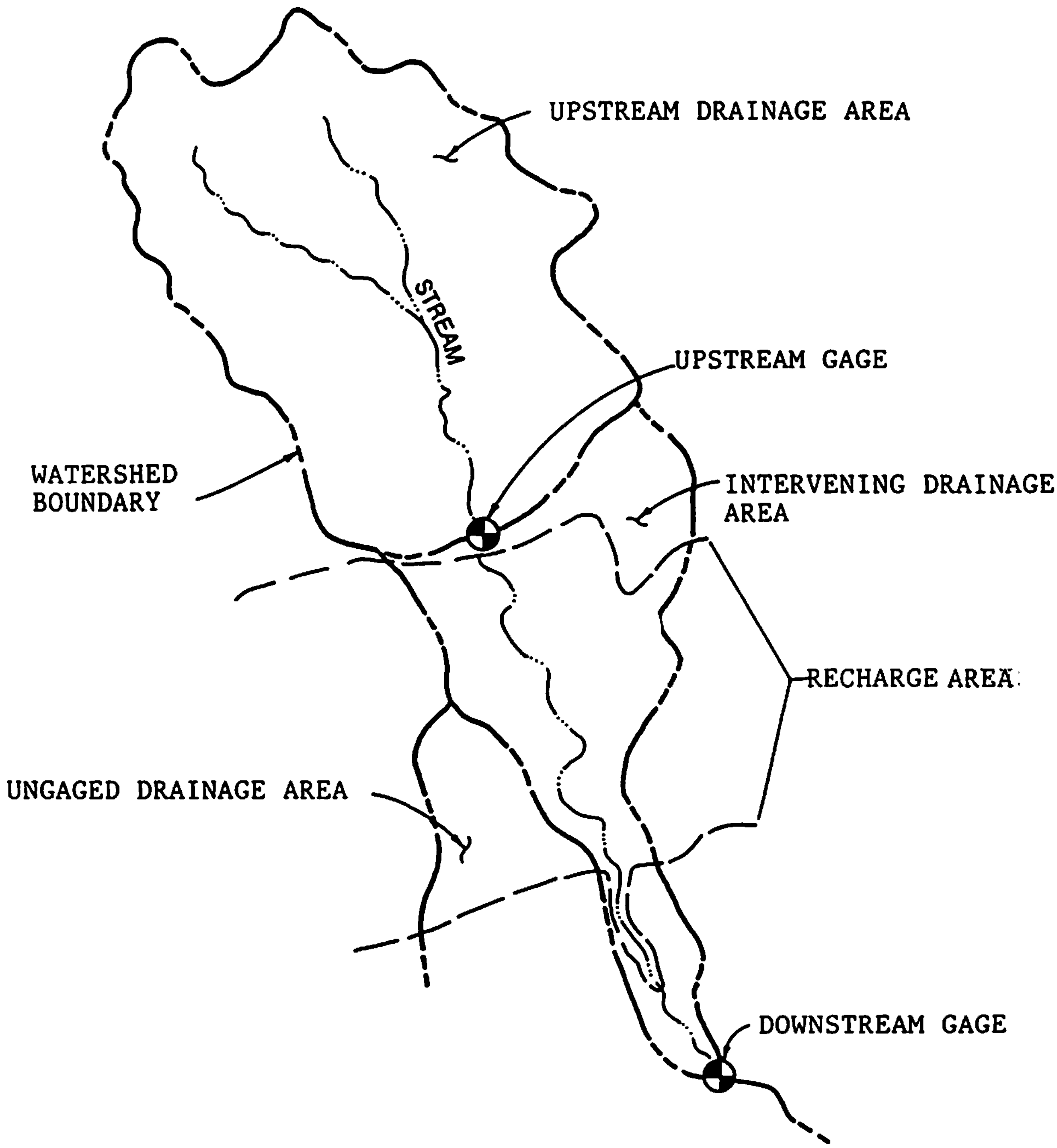


Figure 5.1-2

GRAPHICAL SEPARATION OF A HYPOTHETICAL HYDROGRAPH FOR ESTIMATING THE COMPONENTS OF DIRECT PRECIPITATION

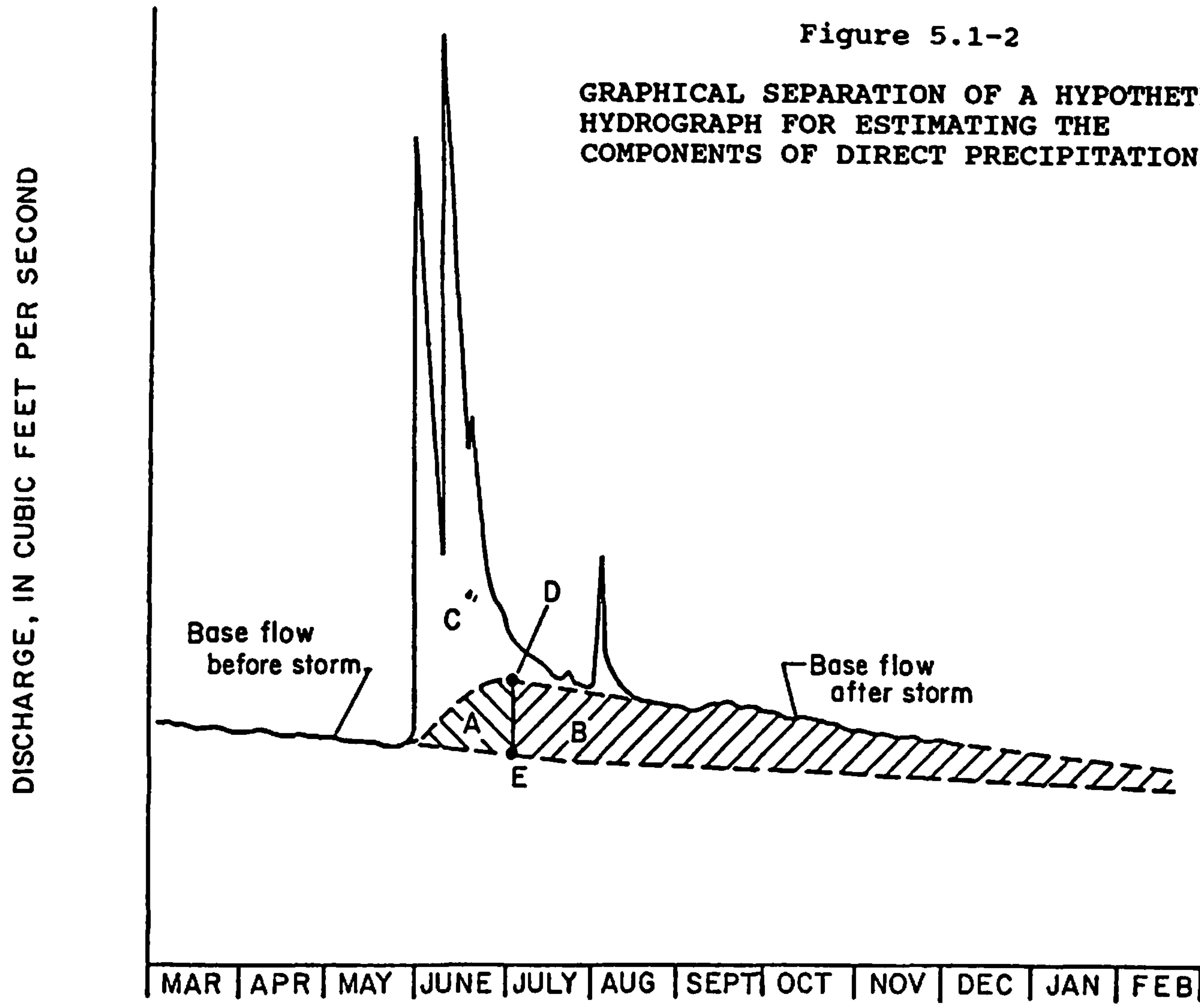
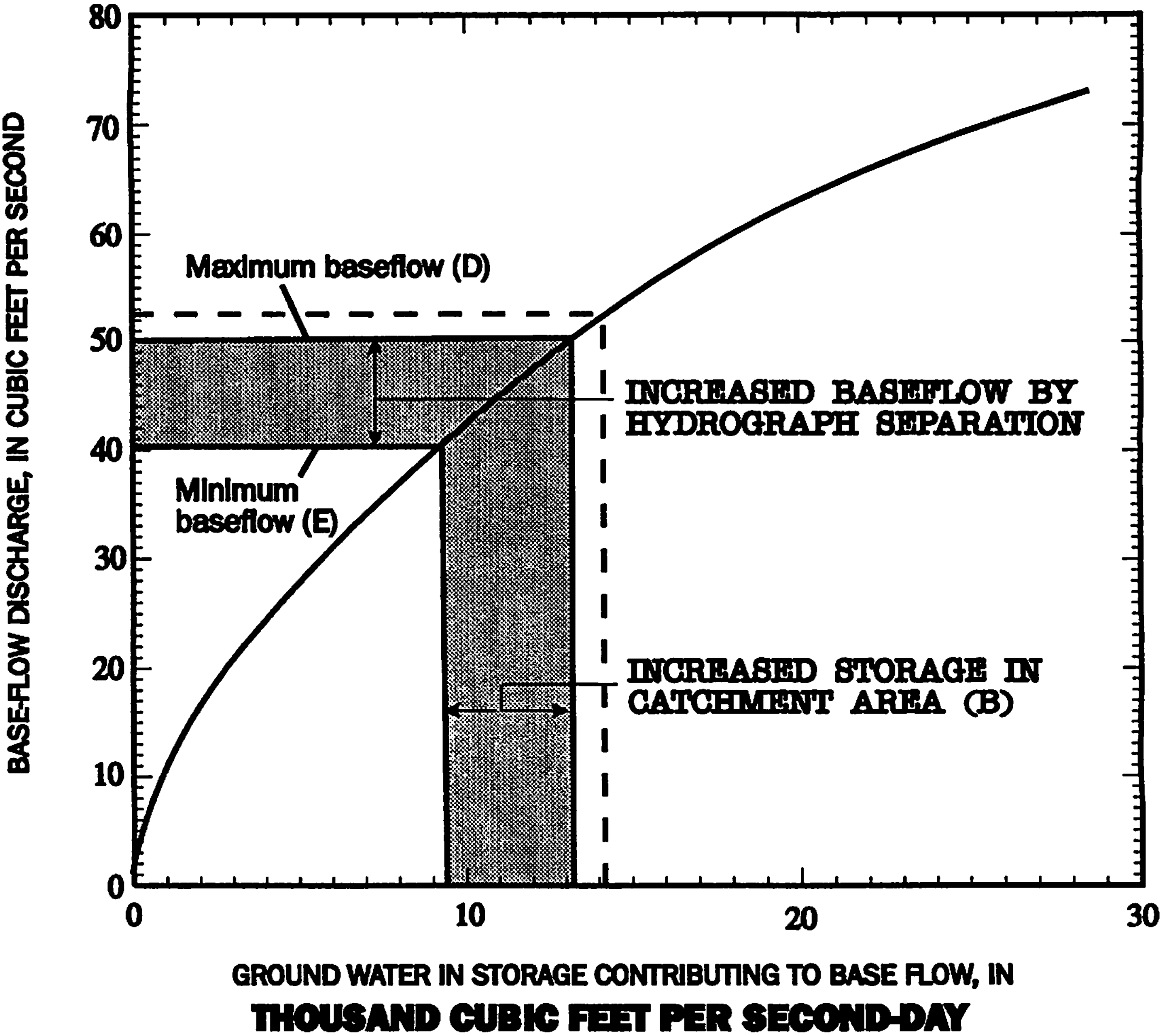


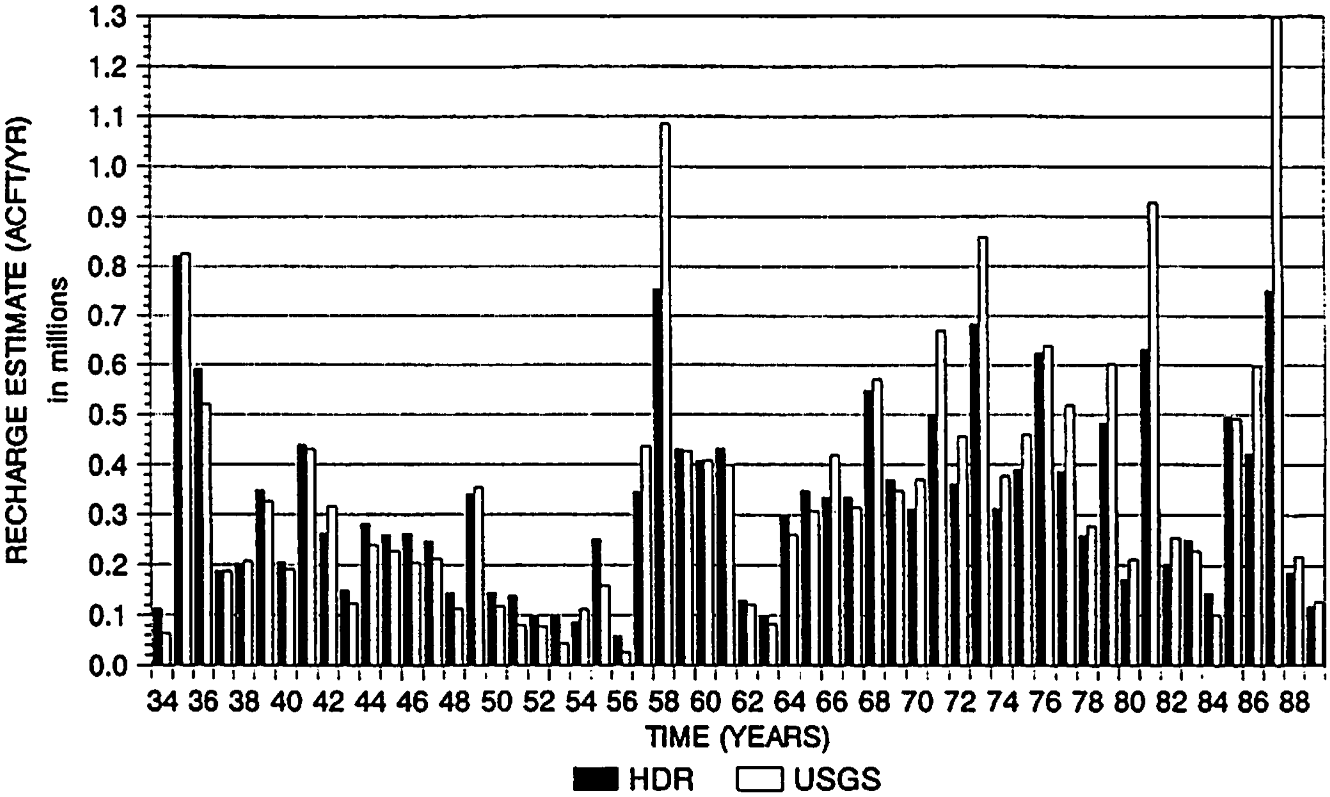
Figure 5.1-3



BASE-FLOW DISCHARGE, IN CUBIC FEET PER SECOND
80
70
60
50
40
30
20
10
0
Maximum baseflow (D)
Minimum baseflow (E)
INCREASED BASEFLOW BY HYDROGRAPH SEPARATION
INCREASED STORAGE IN CATCHMENT AREA (B)
0
10
20
30
GROUND WATER IN STORAGE CONTRIBUTING TO BASE FLOW, IN
THOUSAND CUBIC FEET PER SECOND-DAY

Figure 5.4-1

COMPARISON OF HISTORICAL EDWARDS AQUIFER RECHARGE FOR NUECES RIVER BASIN



6.0 WATER QUALITY

SECTION 6.0 LIST OF TABLES

SECTION 6.0 LIST OF FIGURES

6.0 WATER QUALITY

Introduction

This section addresses water quality in terms of potential constraints on use of water sources available for regional supplies in the study area. This effort does not attempt to compile the extensive surface and ground water quality record of sampling and testing. Emphasis is placed on the Edwards Aquifer in this section with information on the extent of water quality data available, special studies relative to water quality and general information about the condition of water quality in the aquifer.

Surface Water

An extensive record of water quality data exists for many sampling points on surface streams and rivers in the study area from sampling and testing by local, state and federal agencies. The repository of this data is the Texas Natural Resources Information System (TNRIS) at the Texas Water Development Board.

From a regional planning perspective no known surface water quality problems exist that are not treatable with conventional methods to make the water available for public uses. There are times when costs of treatment rise, but current technology has thus far proved capable of dealing with the problems. For example, during periods of low flow when San Antonio return flows predominate in the Guadalupe River below the confluence with the San Antonio River, dissolved solids levels increase, making treatment for industrial uses more expensive.

The TWC is responsible for regulation of surface water quality in the state for all point source discharges. Municipal non-point source (stormwater) regulation is imminent. Given the current condition of surface water quality and the continuing protection under the regulatory authority of the TWC, this text does not address surface water quality further.

Ground Water

The other aquifers in the study area have not been considered as sources for regional solutions, the one exception being the study by CH2M HILL identified in Section 3.0, <u>SOURCES OF SUPPLY</u>, of the potential for an aquifer storage and recovery project in the Carrizo Aquifer. Water quality data for other aquifers in the study area and water quality problems associated with those aquifers were not researched as a part of the Technical Data Review Panel effort. Groundwater quality data for the other aquifers in the study area is available from the TNRIS.

6.1 EDWARDS AQUIFER

6.1.1 GENERAL CONDITIONS OF WATER QUALITY

A review for this text of the resource material addressing the water quality of the Edwards Aquifer indicated the following general information.

1. There exists an extensive record of water quality data from numerous wells and the major springs for the Edwards Aquifer.
2. The quality of water in the aquifer meets all of the present Environmental Protection Agency drinking water standards with isolated and minor exceptions, though low levels of many contaminants have been detected.
3. Point-source contamination by pollutants has occurred.
4. Movement of the freshwater/saline-water interface has been documented by changes in dissolved solids concentrations in some wells during periods of historic low levels in the aquifer.
5. No generally accepted conclusion exists relative to the potential freshwater/saline-water interface movement at lower than historic water levels.
6. There is no long term trend of changes in the chemical quality of water in the aquifer noted from sampling since 1934.

6.1.2 Water Quality Data

This effort will not attempt to accumulate and present the extensive record of water quality data for the Edwards Aquifer. Analysis of water quality constituents have been performed over a long period for numerous wells and the major springs by several agencies in addition to the testing by municipal water purveyors. This text will identify the major sources of data on Edwards Aquifer water quality and the range of parameters analyzed.

6.1.2.1 United States Geological Survey

Beginning in 1968, the United States Geological Survey (USGS) in cooperation with the Edwards Underground Water District (EUWD) and others, has systematically collected data for determining changes in water quality and for detection of pollution of the Edwards Aquifer. For the period 1968-1977 this data is presented in two special reports, Chemical and Bacteriological Quality of Water at Selected Sites in the San Antonio Area, Texas, Edwards Underground Water District, August 1968-January 1975 and February 1975-September 1977. Subsequently, all data has been published in the annual bulletins prepared by USGS for EUWD. Several special studies and reports addressing specific water quality issues have been prepared by USGS using this data. A partial list of the data and special study reports by USGS includes:

1. Report LP-131, Hydrochemical Data for the Edwards Aquifer in the San Antonio Area, Texas, Texas Department of Water Resources, United States Geological Survey and City Water Board of San Antonio (McClay and others) October, 1980.

2. Water-Resources Investigation Report 87-4116, Relationship of Water Chemistry of the Edwards Aquifer to Hydrogeology and Land Use, San Antonio Region, Texas, United States Geological Survey, (Buzka), 1987.

3. Open File Report 85-182, Statistical Summary of Water Quality Data Collected from Selected Wells and Springs in the Edwards Aquifer near San Antonio, Texas, United States Geological Survey in cooperation with Edwards Underground Water District (Wells), 1985.

Table 6.1-1 is a list of the water quality constituents analyzed by USGS in 1990. Approximately 87 wells and three springs were sampled and analyzed from one to twelve times per year. The USGS record can be regarded as the most complete and consistent record of water quality data for the Edwards Aquifer.

6.1.2.2 Edwards Aquifer Research and Data Center

The Edwards Aquifer Research and Data Center (EARDC) has a significant but irregular program of water quality testing for the Edwards Aquifer and the San Marcos River. Studies of water quality tend to be in response to special projects, usually intensive but short term, that EARDC contracts to perform. The EARDC does not have any continuing programs in place to monitor long term water quality changes in the Edwards Aquifer.

6.1.2.3 Municipal Water Purveyors

Municipal Water Purveyors are required to sample and test water quality for purposes of determining regulatory compliance with the Environmental Protection Agency's Safe Drink Water Act (PL93-523) as administered in Texas by the Texas Water Commission. Each municipal water purveyor has a record of water quality data for that purveyor's system according to the regulatory requirements for testing. The requirements in effect for sampling and testing are continually changing, generally requiring monitoring of an increasing number of water quality constituents with time.

Table 6.1-1

WATER QUALITY CONSTITUENTS ANALYZED BY
UNITED STATES GEOLOGICAL SURVEY, 1990

SELECTED PROPERTIES, COMMON INORGANIC CONSTITUENTS, NUTRIENTS, AND DISSOLVED ORGANIC CARBON

Specific conductance	Fluoride, Dissolved
PH	Silica, Dissolved
Temperature	Nitrogen, Total
Alkalinity	Nitrogen, Ammonia, Total
Hardness, Total	Nitrogen, Nitrite, Total
Calcium, Dissolved	Nitrogen, Nitrate, total
Magnesium, Dissolved	Nitrogen, Ammonia + Organic, Total
Sodium, Dissolved	Nitrogen, NO2+NO3, Total
Potassium, Dissolved	Phosphorus, Total
Sulfate, Dissolved	Carbon, Organic, Dissolved
Chloride, Dissolved	

MINOR ELEMENTS

Arsenic, Dissolved	Lead, Dissolved
Barium, Dissolved	Manganese, Dissolved
Cadmium, Dissolved	Silver, Dissolved
Chromium, Dissolved	Zinc, Dissolved
Copper, Dissolved	Selenium, Dissolved
Iron, Dissolved	Mercury, Dissolved

PESTICIDES

Perthane, Total	Heptachlor, total
Naphthalenes, Polychlor., total	Heptachlor epoxide, total
Aldrin, total	PCB, total
Lindane, total	Malathion, total
Chlordane, total	Parathion, total
DDD, total	Diazinon, total
DDE, total	Methyl Parathion, total
DDT, total	2,4-D, total
Dieldrin, total	2,4,5-T, total
Endosulfan, total	Mirex, total
Endrin, total	Silvex, total
Ethion, total	total trithion
Toxaphene, total	Methyl trithion, total

VOLATILE ORGANIC COMPOUNDS

Dichlorobromomethane, total	1,1-Dichloroethylene, total
Carbontetrachloride, total	1,1,1-Trichloroethane, total
1,2-Dichloroethane, total	1,1,2-Trichloroethane, total
Bromoform, total	1,1,2,2 Tetrachloroethane, total
Chlorodibromomethane, total	1,2-Dichlorobenzene, total
Toluene, total	1,2-Dichloropropane, total
Benzene, total	1,2-Transdichloroethene, total
Chlorobenzene, total	1,3-Dichloropropene, total
Chloroethane, total	1,3-Dichlorobenzene, total
Ethylbenzene, total	1,4-Dichlorobenzene, total
Methylbromide, total	2-Chloroethylvinylether, total
Methylchloride, total	Dichlorodifluoromethane, total
Methylene chloride, total	CIS 1,3-Dichloropropene, total
Tetrachloroethylene, total	Vinyl Chloride, total
Trichlorofluoromethane, total	Trichloroethylene, total
1,1-Dichloroethane, total	Styrene, total
Xylene, total water whole tot rec	

ISOTOPES

Tritium, total	O-18/O-16 Stable isotope
H-2/H-1 Stable isotope	

Table 6.1-2

CITY WATER BOARD COMPOSITE CONSTITUENT LEVELS
SAN ANTONIO, TEXAS
PRIMARY DRINKING WATER STANDARDS

CONSTITUENT*	1987	1988	1989	1990	MCL**
Metal:					
Arsenic	<0.005	<0.005	<0.005	<0.007	0.050
Barium	0.018	<0.02	<0.04	<0.06	1.000
Cadmium	<0.001	<0.005	<0.005	<0.005	0.010
Chromium	<0.004	<0.01	<0.01	<0.01	0.050
Lead	<0.003	<0.005	<0.005	<0.005	0.050
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	0.002
Selenium	<3	<0.005	<0.005	<0.005	0.010
Silver	<0.5	<0.01	<0.001	<0.001	0.050
Pesticides:					
Endrin	<0.0001	<0.0001	<0.0001	<0.0001	0.0002
Lindane	<0.00005	<0.00005	<0.00005	<0.00005	0.004
Methoxychlor	<0.0001	<0.0005	<0.0005	<0.0005	0.100
Toxaphene	<0.0001	<0.001	<0.001	<0.001	0.005
2,4D	<0.01	<0.0005	<0.0002	<0.0002	0.100
2,4,5, TP	<0.001	<0.0002	<0.0001	<0.0001	0.010
Trihalomethane (Total)	<0.04	<0.02	0.011	0.011	0.100
Radioactivity:					
Gross Alpha	<2pCi	<2pCi	< 2	< 2	15 · pCi/L
Gross Beta	<3pCi	<3pCi	< 3	< 3	50 pCi/L
Organics:					
Vinyl Chloride			<0.002	<0.002	0.0002
1,1 Dichloroethylene			<0.001	<0.001	0.007
1,1,1 Trichloroethane			<0.001	<0.001	0.2
Carbon Tetrachoride			<0.001	<0.001	0.005
Benzene			<0.001	<0.001	0.005
1,2 Dichloroethane			<0.001	<0.001	0.005
Trichloroethylene			<0.001	<0.001	0.005
1,4 Dichlorobenzene			<0.001	<0.001	0.075

* Constituent Levels reported in milligrams per liter (mg/L)
** MCL is the maximum constituent level established by USEPA in compliance with PL 93-523
\+ Radioactivity is measured in pico curies per liter of water (pCi/L)

As an example, Table 6.1-2 indicates the record of water quality constituents, the maximum contaminant level for each and the composite measured level for all tests for recent years as reported by San Antonio City Water Board in WATER STATISTICS, 1990. The regulatory requirements for number, type and frequency of sampling and testing vary with the size of the municipal water purveyor. The three principal classes of purveyors are: systems serving fewer than 3,300 people, those serving between 3,300 and 50,000 and those serving more than 50,000. Regulations require *monitoring for several* classes of contaminants, including inorganic chemicals, organic chemicals, disinfection by-products, turbidity, microbiological contaminants and radionuclides.

6.1.2.4 Others

The Texas Water Development Board historically collected samples and test the water quality of the Edwards Aquifer but ceased this practice in the early 1980s. It now relies on the USGS program of sampling and testing Edwards water, as described above in 6.1.2.1. All data from previous TWDB testing and from the USGS program are available in the TNRIS computerized data bank.

The Texas Water Commission (TWC) has sampled and tested surface water since the late 1960s at selected sites on streams and rivers throughout the state. The frequency of sampling and parameter coverage varies site to site and also with time at each site. TWC performs intensive surveys in areas where water quality problems are known to exist. For example, the San Antonio River and its tributaries in Bexar County, including the Medina River have been surveyed. Results of such surveys are published as reports. In addition, every two years, TWC publishes an assessment document entitled, State Water Quality Inventory Report which details measured water quality parameters and stream standards on a steam segment by stream segment basis. All of the TWC data is included in the TNRIS system.

6.1.3 Localized Contaminant Problems

Three instances of contamination of the Edwards Aquifer by point- source pollutants have been reported. All of these areas are in the transition zone downdip of the recharge or outcrop area of the Edwards Aquifer. The transition zone of the aquifer is an area where geologic conditions permit hydraulic communication from the surface through the overlying formations to the aquifer. Figure 6.1-1 presents the geographic locations of pertinent geological features of the Edwards Aquifer referred to here and in the rest of the text.

6.1.3.1 Taylor Slough, Uvalde, Texas

In the area of Taylor Slough and Highway 90 in Uvalde, Texas, the Edwards Aquifer was contaminated with tetrachloroethylene from a site occupied by a commercial cleaning service. In this area the surface formation, the Leona Gravel, overlies and contacts the Edwards Aquifer. Site remediation occurred and a monitoring program continues in the affected area of several square miles. Many private wells were affected and may not be used for drinking water at present. No public wells were affected. This information was taken from a report, Investigation of Volatile Organic Compounds in Groundwater Uvalde, Texas, Edwards Underground Water District, 1989, and EUWD staff interviews.

6.1.3.2 West Avenue Landfill, San Antonio, Texas

Volatile organic carbon migrated, apparently though a fault, into the Edwards Aquifer from the West Avenue Landfill, an out of use landfill in a quarry pit in northern San Antonio. After the contamination was discovered the site was capped and contoured to minimize surface infiltration of water and leachate recovery wells were installed. No public or private wells are affected by this contamination. This information was reported by staff at EUWD.

6.1.3.3 Thousand Oaks Blvd. and Jones-Maltsberger Road San Antonio, Texas

A leak in an underground storage tank released approximately 10,000 gallons of gasoline at a site near the intersection of Thousand Oaks Blvd. and Jones-Maltsberger Road. The most soluble components of gasoline have been found at low levels in the Edwards Aquifer in the vicinity. No public supply wells were affected. Some private well owners switched to public supplies.

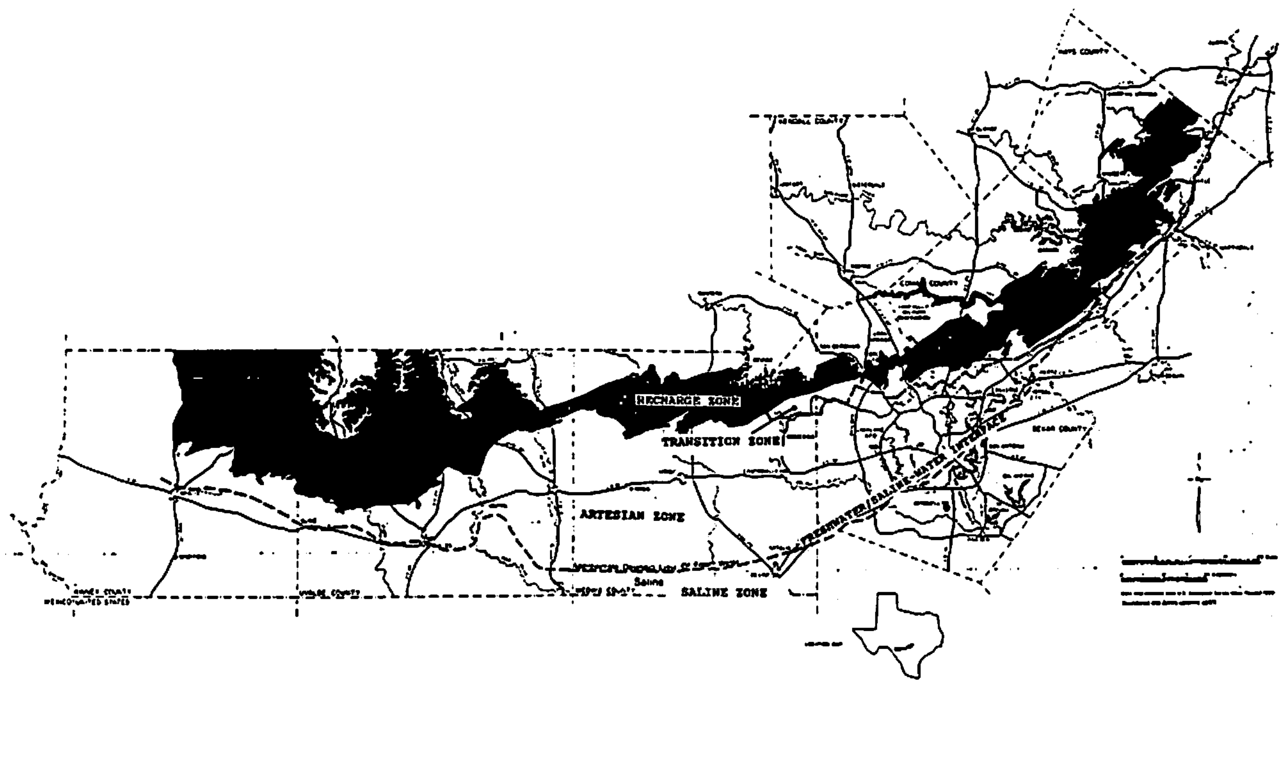
6.1.3.4 Recharge Zone

Bacteriological contamination of the water in the Edwards Aquifer is prevalent in the recharge zone and to a lesser extent is the artesian zone. Chlorination by public supply systems cures this problem where it exists in public supply wells.

6.1.4 Freshwater/Saline-Water Interface

The freshwater/saline-water interface defines the southern and southeastern limit of the freshwater zone of the Edwards Aquifer. The potential for movement of saline-water into the freshwater zone during periods of lower levels in the aquifer has been a long-standing water quality concern.

Figure 6.1-1



Historically the freshwater/saline-water interface has been defined as the "bad water line," a line drawn where dissolved solids levels in the aquifer equal 1000 mg/l, generally a level of dissolved solids above which the water is unusable for human or agricultural uses. The normal dissolved solids levels in the aquifer are 250-300 mg/l. Recent studies described later in this text indicate that the freshwater/saline-water interface is an irregular zone where dissolved solids levels increase vertically with the thickness of the Edwards formation and horizontally down gradient.

Significant studies of the freshwater/saline-water interface are described following.

6.1.4.1 Bad Water Line Experiment, San Antonio, Texas

In this study seven wells were drilled at three sites located in a line normal to the freshwater/saline-water interface, this transect extending from the freshwater to the saline water zone. At each location wells were drilled to different depths in the aquifer. Water was sampled at different levels in the wells. The results indicated increasing dissolved solids with depth in the wells. One well in the freshwater zone yielded water from the bottom of the Edwards Aquifer with a dissolved solids concentration of 4800 mg/l.

Aside from the information gained in the initial drilling, these wells were constructed as long term monitoring wells to gather data on movement of water from areas of higher dissolved solids to areas of lower dissolved solids. Reference material describing this study can be found in Drilling, Construction and Testing of Monitor Wells for the Edwards Aquifer Bad Water Line Experiment, William F. Guyton and Associates, Inc., November 1986, and Hydrologic Data from a Study of the Freshwater Zone/ Saline-Water Zone Interface in the Edwards Aquifer, San Antonio Region, Texas, U.S. Geological Survey, (Pavlicek and others), Open-File Report 87-389, 1987.

6.1.4.2 New Braunfels and San Marcos Freshwater/Saline-Water Interface Study

In the 1989-91 period the EUWD constructed three monitoring wells in a transect across the freshwater/saline-water interface near both Comal and San Marcos Springs. Significant findings from this effort are reported in the Executive Summary of Report 92-02, Investigation of Freshwater/Saline-Water Interface in the Edwards Aquifer in New Braunfels and San Marcos, Texas, Edwards Underground Water District, May 1992, and are summarized following.

At New Braunfels and San Marcos the saline water (1000 mg/l or greater dissolved solids levels) was discovered nearer to the springs than previously thought. At New Braunfels all of the wells contained saline water in the lower portion of the Edwards Group, indicating the presence of a transition zone of higher levels of dissolved solids to lower levels across the transect from the saline zone to the Comal Springs Fault near Comal Springs. At San Marcos all transect wells had high salinity levels, the nearest well within 300 feet of the springs, indicating the absence of a transition zone in this area.

Pump test and sampling at New Braunfels indicated increasing salinity over time in one well. Strong conclusions about the movement of saline water to the freshwater zone were not drawn from this test because this well is in the transition zone. However the test did reveal the movement of water from an area of higher salinity to a pump in production.

6.1.4.3 Other Special Studies/ Reports

In Water Resources Investigation Report 86-4032, Potential for Updip Movement of Saline Water in the Edwards Aquifer, San Antonio, Texas, U.S. Geological Survey, (Perez), 1986, a computer modelling effort to estimate the magnitude of potential saline water intrusion to the freshwater area of the Edwards Aquifer was reported. With several simplifying assumptions concerning the geohydrology of the aquifer, the maximum movement of the "salinity front" predicted by the model was 854 feet over a 10 year simulation period drawing water levels to lower than the historical minimum.

Report 92-03, Using Geophysical Logs in the Edwards Aquifer to Estimate Water Quality along the Freshwater/Saline-Water Interface (Uvalde to San Antonio, Texas), Edwards Underground Water District, (Schultz), March, 1992 describes a analysis of geophysical logs near the freshwater/saline-water interface in the Edwards Aquifer. The purpose of the study was to more clearly delineate the limits of the freshwater/saline-water interface. The conclusions of the study are summarized as follows:

1) The freshwater/saline-water interface is irregular and extends further south than previously thought.

2) The separation between the freshwater and saline water is not a straight vertical plane. Variation in water quality may occur vertically from zone to zone at one location.

EUWD staff members reported that a review of the water quality data will indicate increases in dissolved solids levels associated with historic periods of lower Edwards Aquifer levels. These increases occurred in wells within the freshwater/saline-water interface where elevated dissolved levels occur at normal aquifer levels.

6.1.5 Special Regulation

Beginning in 1970 in response to a perceived public need, limitations on development in the recharge zone were imposed to protect the water quality of the Edwards Aquifer. Currently and after periodic revisions the responsibility for enforcement of the "Edwards Aquifer Rules" resides with the TWC. The rules require submittal of pollution abatement plans for all regulated activities, which are inclusive of all development related works except single unit residential development on more than five acres.

6.1.6 Panel Discussions and Conclusions

In 1986, in part because of the special problems described above in subsection 6.2.3, the "Edwards Aquifer Rules" were amended to include regulation of hydrocarbon hazardous material storage and landfills in the "transition zone." The transition zone, as defined by the Edwards Aquifer Rules includes an area from eastern Medina County east and northeast to the limit of the Edwards Aquifer (San Antonio Pool) in eastern Hays County. It includes the outcrop areas of the Austin Chalk and other formations between the Austin Chalk and the Edwards. The transition zone exists geologically in the western part of the Edwards Aquifer but has not received legal designation under the "Edwards Aquifer Rules" for regulation of development. The extension of the legal definition of the transition zone to include this area is currently being proposed.

One panel member felt that the inclusion of bad water line (freshwater/saline-water interface) information in this text was not relevant. Others disagreed and stated that the potential for movement of the saline water during periods of low water levels in the Edwards Aquifer has a bearing on the management to the aquifer.

Another panel member indicated that the movement of the freshwater/saline-water interface historically has been slight and that the studies indicate little additional movement when water levels fall below historical lows. The near proximity of the saline water to Comal and San Marcos Springs was noted by others indicating that even a small movement of the freshwater/saline-water interface could cause water quality problems in those areas.

The panel generally concurred that surface water quality problems could be addressed with treatment processes and further discussion in this text was not necessary. One member suggested that a good gage of surface water quality could be developed by comparing historical water quality data with the stream standards for water quality set out in the TWC regulatory program.

Bibliography

SECTION 6.0 WATER QUALITY

Edwards Underground Water District, Chemical and Bacteriological Quality of Water at Selected Sites in the San Antonio Area, Texas, August 1968-January 1975 and February 1975-September 1977, 1978.

Edwards Underground Water District, Investigation of Volatile Organic Compounds in Groundwater Uvalde, Texas,1989.

Edwards Underground Water District, Executive Summary of Report 92-02, Investigation of Freshwater/Saline-Water Interface in the Edwards Aquifer in New Braunfels and San Marcos, Texas, 1992.

Edwards Underground Water District, Report 92-03, Using Geophysical Logs in the Edwards Aquifer to Estimate Water Quality along the Freshwater/Saline-Water Interface (Uvalde to San Antonio, Texas), 1992.

Guyton, William F., and Associates, Inc., Drilling, Construction and Testing of Monitor Wells for the Edwards Aquifer Bad Water Line Experiment, 1986.

San Antonio City Water Board, Water Statistics, 1990.

Texas Water Commission, State Water Quality Inventory Report, 1991.

United States Geological Survey and City Water Board of San Antonio (McClay and others), Report LP-131, Hydrochemical Data for the Edwards Aquifer in the San Antonio Area, Texas, Texas Department of Water Resources, 1980.

United States Geological Survey, Water Resources Investigation Report 87-4116, Relationship of Water Chemistry of the Edwards Aquifer to Hydrogeology and Land Use, San Antonio Region, Texas, 1987.

United States Geological Survey in cooperation with Edwards Underground Water District (Wells), Open File Report 85-182, Statistical Summary of Water Quality Data Collected from Selected Wells and Springs in the Edwards Aquifer near San Antonio, Texas, 1985.

United States Geological Survey, (Pavlicek and others), Open File Report 87-389, Hydrologic Data from a Study of the Freshwater Zone/Saline-Water Region, Texas, 1987.

United States Geological Survey, (Perez), Water Resources Investigation Report 86-4032, Potential for Updip Movement of Saline Water in the Edwards Aquifer, San Antonio, Texas, 1986.

TABLE 6.1-1
TECHNICAL DATA REVIEW PANEL

WATER QUALITY CONSTITUENTS ANALYZED BY
UNITED STATES GEOLOGICAL SURVEY, 1990

SELECTED PROPERTIES, COMMON INORGANIC CONSTITUENTS, NUTRIENTS, AND DISSOLVED ORGANIC CARBON

Specific conductance	Fluoride, Dissolved
PH	Silica, Dissolved
Temperature	Nitrogen, Total
Alkalinity	Nitrogen, Ammonia, Total
Hardness, Total	Nitrogen, Nitrite, Total
Calcium, Dissolved	Nitrogen, Nitrate, total
Magnesium, Dissolved	Nitrogen, Ammonia + Organic, Total
Sodium, Dissolved	Nitrogen, NO2+NO3, Total
Potassium, Dissolved	Phosphorus, Total
Sulfate, Dissolved	Carbon, Organic, Dissolved
Chloride, Dissolved	

MINOR ELEMENTS

Arsenic, Dissolved	Lead, Dissolved
Barium, Dissolved	Manganese, Dissolved
Cadmium, Dissolved	Silver, Dissolved
Chromium, Dissolved	Zinc, Dissolved
Copper, Dissolved	Selenium, Dissolved
Iron, Dissolved	Mercury, Dissolved

PESTICIDES

Perthane, Total	Heptachlor, total
Naphthalenes, Polychlor., total	Heptachlor epoxide, total
Aldrin, total	PCB, total
Lindane, total	Malathion, total
Chlordane, total	Parathion, total
DDD, total	Diazinon, total
DDE, total	Methyl Parathion, total
DDT, total	2,4-D, total
Dieldrin, total	2,4,5-T, total
Endosulfan, total	Mirex, total

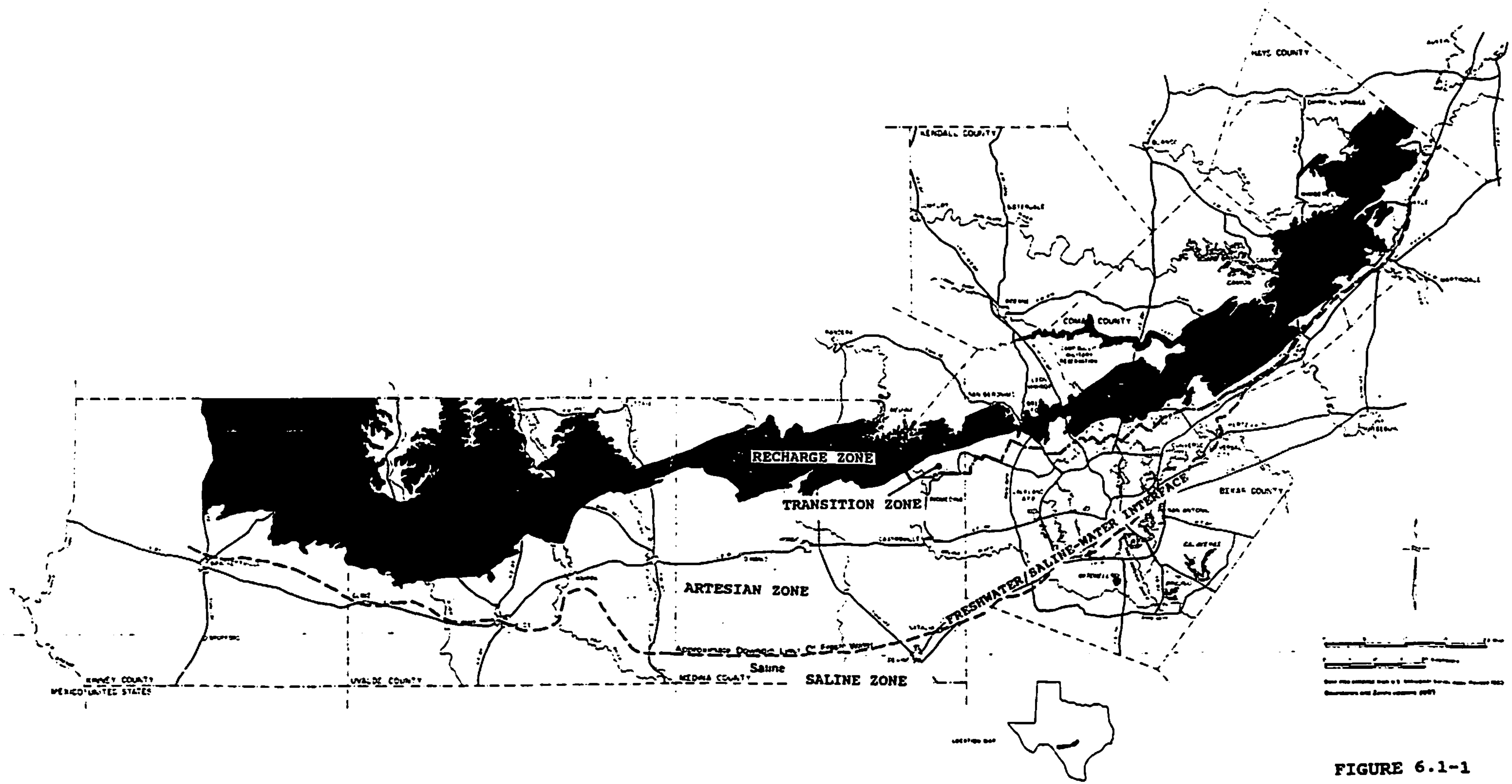
Endrin, total	Silvex, total
Ethion, total	total trithion
Toxaphene, total	Methyl trithion, total

VOLATILE ORGANIC COMPOUNDS

Dichlorobromomethane, total	1,1-Dichloroethylene, total
Carbontetrachloride, total	1,1,1-Trichloroethane, total
1,2-Dichloroethane, total	1,1,2-Trichloroethane, total
Bromoform, total	1,1,2,2 Tetrachloroethane, total
Chlorodibromomethane, total	1,2-Dichlorobenzene, total
Toluene, total	1,2-Dichloropropane, total
Benzene, total	1,2-Transdichloroethene, total
Chlorobenzene, total	1,3-Dichloropropene, total
Chloroethane, total	1,3-Dichlorobenzene, total
Ethylbenzene, total	1,4-Dichlorobenzene, total
Methylbromide, total	2-Chloroethylvinylether, total
Methylchloride, total	Dichlorodifluoromethane, total
Methylene chloride, total	CIS 1,3-Dichloropropene, total
Tetrachloroethylene, total	Vinyl Chloride, total
Trichlorofluoromethane, total	Trichloroethylene, total
1,1-Dichloroethane, total	Styrene, total
Xylene, total water whole tot rec	

ISOTOPES

Tritium, total	O-18/O-16 Stable isotope
H-2/H-1 Stable isotope	



HAYS COUNTY
KENDALL COUNTY
COMAL COUNTY
RECHARGE ZONE
TRANSITION ZONE
ARTESIAN ZONE
FRESHWATER/SALINE-WATER INTERFACE
BEXAR COUNTY
Saline
SALINE ZONE
UVALDE COUNTY
MEDINA COUNTY
MEXICO UNITED STATES

FIGURE 6.1-1

TABLE 6.1-2
TECHNICAL DATA REVIEW PANEL

CITY WATER BOARD COMPOSITE CONSTITUENT LEVELS
SAN ANTONIO, TEXAS
PRIMARY DRINKING WATER STANDARDS

CONSTITUENT*	1987	1988	1989	1990	MCL**
Metal:					
Arsenic	<0.005	<0.005	<0.005	<0.007	0.050
Barium	0.018	<0.02	<0.04	<0.06	1.000
Cadmium	<0.001	<0.005	<0.005	<0.005	0.010
Chromium	<0.004	<0.01	<0.01	<0.01	0.050
Lead	<0.003	<0.005	<0.005	<0.005	0.050
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	0.002
Selenium	<3	<0.005	<0.005	<0.005	0.010
Silver	<0.5	<0.01	<0.001	<0.001	0.050
Pesticides:					
Endrin	<0.0001	<0.0001	<0.0001	<0.0001	0.0002
Lindane	<0.00005	<0.00005	<0.00005	<0.00005	0.004
Methoxychlor	<0.0001	<0.0005	<0.0005	<0.0005	0.100
Toxaphene	<0.0001	<0.001	<0.001	<0.001	0.005
2,4D	<0.01	<0.0005	<0.0002	<0.0002	0.100
2,4,5, TP	<0.001	<0.0002	<0.0001	<0.0001	0.010
Trihalomethane (Total)	<0.04	<0.02	0.011	0.011	0.100
Radioactivity:					
Gross Alpha	<2pCi	<2pCi	< 2	< 2	15 pCi/L
Gross Beta	<3pCi	<3pCi	< 3	< 3	50 pCi/L
Organics:					
Vinyl Chloride			<0.002	<0.002	0.0002
1,1 Dichloroethylene			<0.001	<0.001	0.007
1,1,1 Trichloroethane			<0.001	<0.001	0.2
Carbon Tetrachoride			<0.001	<0.001	0.005
Benzene			<0.001	<0.001	0.005
1,2 Dichloroethane			<0.001	<0.001	0.005
Trichloroethylene			<0.001	<0.001	0.005
1,4 Dichlorobenzene			<0.001	<0.001	0.075

* Constituent Levels reported in milligrams per liter (mg/L)
** MCL is the maximum constituent level established by USEPA in compliance with PL 93-523
+ Radioactivity is measured in pico curies per liter of water (pCi/L)

7.0 TECHNICAL AREAS REQUIRING FURTHER STUDY OR IMPROVEMENT

7.0 TECHNICAL AREAS REQUIRING FURTHER STUDY OR IMPROVEMENT

7.1 *Introduction*

In the process of reviewing the data presented in this text, the Technical Data Review Panel made a listing of those technical areas requiring further study or improvement in data collection techniques. Except where it is specifically noted that the proposed report grew out of the consensus of the Panel, this listing consists of suggestions made by individual members of the Panel. No attempt was made to prioritize or rank these suggestions. This listing is set out below with a discussion of each item for purposes of guiding future study efforts to appropriate technical areas that will most benefit water management and planning for the region. The items are organized according to the previous technical sections in this report.

Recommendations for technical studies are not to be interpreted as motivated by policy choices. They were developed in response to the perceived need for additional information that would enable policy processes in the future to evaluate accurately the technical data in question.

7.2 WATER DEMANDS AND NEED

7.2.1 Irrigation Acres and Water Application Rates

Historically there has not been any legal requirement for reporting groundwater irrigation use acres or water application rates. Most irrigation wells are not metered, and no consistent or comprehensive record of irrigated acres exists. Some members felt that the methods for estimating groundwater use for irrigation need improvement. The record of groundwater irrigation use can be improved with metering and reporting of groundwater irrigation use and acres irrigated, some members noted.

7.2.2 Unreported Industrial Use

The reporting of groundwater use for industrial purposes is also not required by law. The record of industrial groundwater use examined in this effort indicates that most industries report water use on a voluntary basis; still, it was noted that some industries have a sporadic record of reporting, indicating that a less than complete record of industrial groundwater use exists. Some members felt that metering and reporting would improve the record of industrial groundwater use.

7.2.3 Other Unreported Pumping

The Panel effort concluded that two Edwards Aquifer wells pumping water into the San Antonio River have not been included in the historical record of groundwater discharge from the Edwards Aquifer. These wells are alternately free-flowing and pumped. A one time estimate of 4270 acre feet per year was made in 1992. The historical record of discharge for these wells is not known. A complete record of historical water use is necessary for effective management, some members felt, and it was suggested that these wells be included in future estimates of groundwater use.

7.2.4 Accuracy of Estimates

The utility of water use estimates for planning purposes can be improved, it was suggested, if the accuracy of the estimates is stated by the estimator when the data is presented. The precise methodologies should be specified, estimations noted where they replace measurements, and the range of uncertainty associated with either measuring devices or estimation methodologies should be explicitly stated.

7.2.5 Separation of Reporting of Groundwater Use by Aquifer

In some areas of the study region, two aquifers exist and both are being used as groundwater sources. A good example is in Uvalde County where the Leona Gravel overlies the Edwards Aquifer. In that area, wells are drilled in both aquifers. The Panel could not ascertain that the entities preparing estimates of groundwater use for that area have properly separated the use between the aquifers. The Texas Water Development Board groundwater estimates do not include an estimate for the Leona Gravel and probably, according to TWDB, report that use as Edwards Aquifer groundwater discharge. Some members wanted to see this reporting separated as a way of improving future studies.

7.2.6 Reporting of Water Use

A standardized and detailed mandatory water use reporting system providing consistent and detailed data would be of great benefit to water management and planning efforts, several members suggested. This reporting system should include standardized metering and units of measurement with reporting to a centralized point. Uses should be separated for purposes of better projections of future needs and the potential for reductions in use. An example of this is municipal use, which could be reported in categories of residential, commercial, apartment, recreation and other uses.

7.2.7 Water Needs for Natural Systems

This is a broad area where relatively little technical information exists. It includes water needs for natural systems at Comal and San Marcos springs, instream flows in all the study area streams, and bay and estuary requirements. Definition of these needs is of significance to water management and planning for the region. The Panel urged that studies be completed on all natural system needs.

The Panel also agreed that an independent scientific study of augmentation of springflows at Comal and San Marcos springs should be completed. The Panel emphasized that this should be an unbiased study carried out by hydrologists and biologists and capable of looking in a detailed manner at the question and that the purpose of the augmentation study would be to examine the feasibility of augmentation as a method of preserving existing uses, including both the endangered species and recreational uses of water. The source and amount of water that could be used to augment springs is an important factor in regional planning efforts, some members felt. Another member expressed the strong belief that an augmentation study would have to include a detailed biological analysis of the environment supporting the endangered species, including the narrow levels of temperature, water quality and water chemistry within which the species can survive. One member suggested the study also include examination of the feasibility of injecting Canyon Lake water into natural channels that might carry water to Comal Springs.

7.2.8 Edwards Aquifer Groundwater Divides

More information is needed, some members felt, to define the boundaries of the Edwards Aquifer at the west end near Brackettville in Kinney County and at the northeast end near Kyle in Hays County. Additional study is necessary to determine if these groundwater divides move and if they are recharge or pumpage dependent.

7.3 SOURCES OF SUPPLY

7.3.1 Interbasin Transfers

Potential sources of supply from outside the study area that might be tapped in an interbasin transfer program should be identified and investigated, some members proposed. No technical studies of region-wide solutions proposing the use of water from outside the study area were identified in the Panel effort, though mention of such alternatives has been made in policy studies.

7.3.2 Recharge Enhancement

The recharge enhancement potential for the Edwards Aquifer in the Guadalupe and San Antonio River basins should be investigated as it was in the Nueces Basin, several members urged. A study for that purpose is currently in progress. One member noted that any assessment of recharge enhancement should consider the relative location of projects. He mentioned as an example that an acre foot of recharge in the western part of the aquifer available to all users and the springs may be more valuable than an acre foot in the eastern part that only benefits the springs. Another member emphasized the need to evaluate the environmental impact of recharge projects.

7.3.3 Aquifer Storage and Recovery

Some members proposed studies to evaluate the potential for storage of freshwater in the saline zone of the Edwards Aquifer for later recovery.

7.3.4 Desalination

An evaluation of the potential for treatment of saline water from the Edwards Aquifer for freshwater use was proposed by some members.

7.3.5 Knippa Gap – Edwards Aquifer

Further study of the geology of the aquifer and groundwater movement in the area of the Knippa Gap was proposed by one member in order to evaluate the potential for using that natural feature coupled with engineering solutions for "across the gap' movement of water to facilitate storage and delivery options that will improve the utility of the Edwards Aquifer.

7.3.6 Environmental Limitations on Reservoir Development

One member proposed a study of environmental limitations on proposed reservoir developments where such studies had not been done in the past. This would enable the full costs of all the projects to be compared more accurately, that member felt, and the likelihood of development to be assessed in the current framework of increased concern for environmental factors.

7.3.7 Control of Springflow from Edwards Aquifer

Some members proposed a study on the technical feasibility of controlling the flow of water from Comal and San Marcos springs as a means of enhancing groundwater availability while meeting the needs of the endangered species and the downstream users. This study would focus solely on the technical and engineering feasibility of regulating springflow.

7.3.8 Transfers From Below Springs to San Antonio

One member suggested a technical study of the engineering feasibility of capturing water below the springs during periods of high springflow for transfer to San Antonio for municipal use or for recharge at some distal point to the springs.

7.4 REDUCTIONS IN USE

7.4.1 Water Markets

Water marketing techniques for transferring water between Edwards Aquifer users should be evaluated, some members proposed. This evaluation should include institutional arrangements and constraints and economic analysis.

7.4.2 Incentives for Conservation

Incentive programs to effect conservation of water use were proposed by some members with emphasis on conservation in agriculture. Some felt this especially important since farmers had already installed water conserving technologies to the extent justified for economic reasons.

7.4.3 Gallons Per Capita Per Day Water Use

The Panel felt that if water use as measured in gallons per capita per day (GPCD) is to be used as a baseline for regulatory reductions in water use, better data on GPCD rates should be developed. A consistent methodology with proper adjustments for varying conditions between municipalities should be devised for this purpose. Several Panel members agreed that the desire for better GPCD data did not mean that existing data is not reliable.

7.4.4 Reductions in Seasonal Demands

One member felt that more attention should be given to short term and more drastic demand management measures. He reasoned that historically steep declines in water levels during critical periods occur in two to three months coinciding with the irrigation and lawn watering season. Actions during that period would have a significant impact on springflows. He therefore recommended a study of the feasibility of demand management measures that could meet such short term needs.

7.5 NATURAL RECHARGE

7.5.1 Method for Calculating Natural Recharge

The Panel recognized the value of current data on natural recharge but proposed that improvements in the methods for calculating natural recharge for the Edwards Aquifer should be developed, following the suggestions of USGS staff and TWDB consultants who have worked on this problem. Improvements will require more and better data on rainfall, recharge and runoff characteristics in the recharge area of the aquifer. Several members noted that the need for better estimates did not negate the value of the existing estimates for planning purposes.