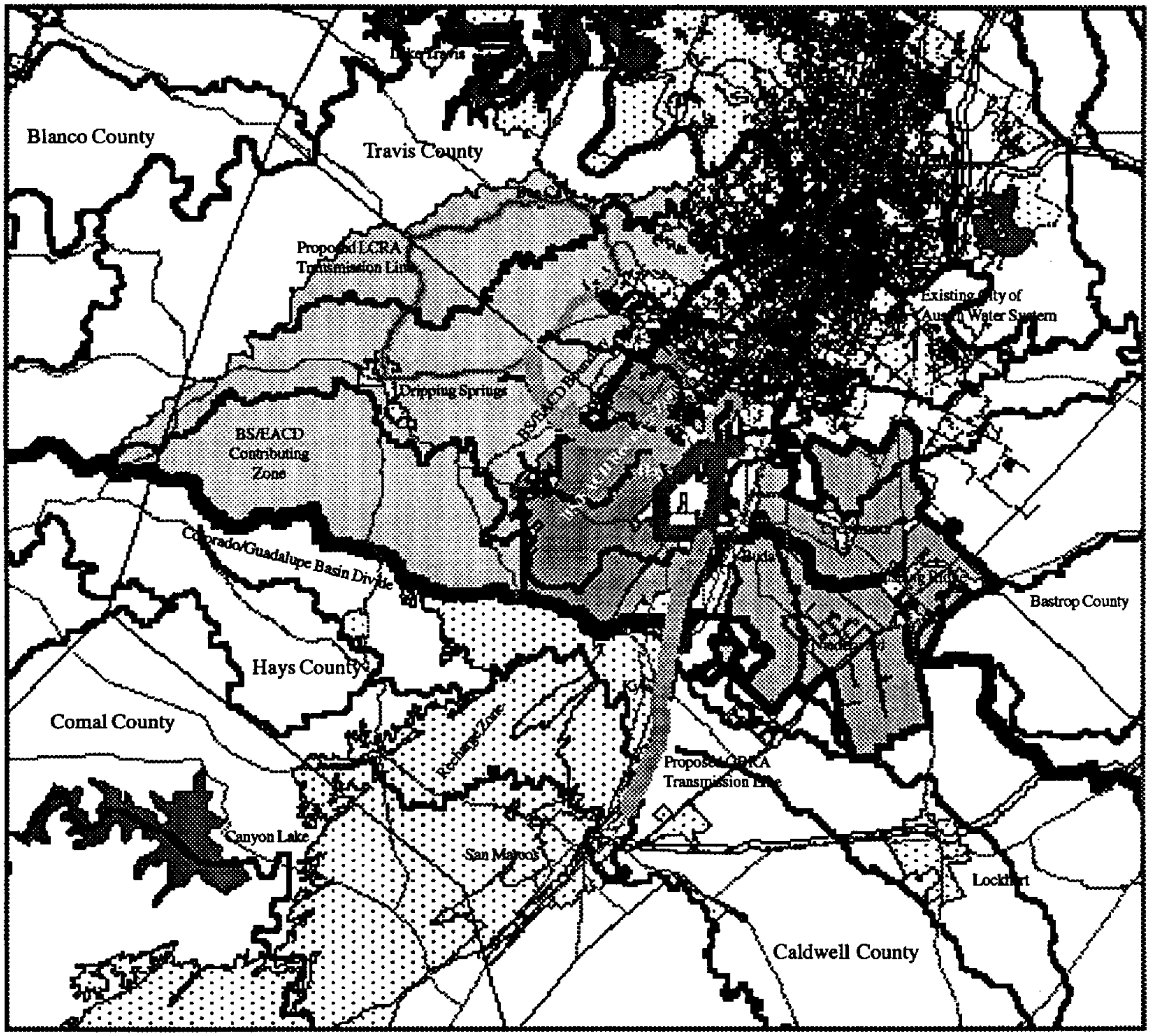
Alternative Regional Water Supply Plan

for the
Barton Springs Segment of the Edwards Aquifer
April 1997
(TWDB Grant Contract No. 95-483-079)



FINAL REPORT

Prepared for the:

Texas Water Development Board
Research and Planning Grants Assistance Program

Submitted by the:

Barton Springs / Edwards Aquifer Conservation District
April 30, 1997

LIST OF TABLES

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ACKNOWLEDGMENTS

This research has been undertaken to identify alternative water supply sources to better serve the groundwater users in the Barton Springs segment of the Edwards Aquifer. We realize that time is a precious commodity and gratefully acknowledge the input from the individual District permittees who completed the water use survey and whose response confirmed and supported the need to develop alternative sources of water to reduce the present and growing demand on our groundwater resources. We appreciate the residents of the District who have participated in the numerous public forums conducted as part of this research and for their comments which are summarized in Appendix VI.

Thanks to our consulting engineer, Don Rauschuber, and to his staff for their time and effort in developing the alternatives presented herein. The City of Austin; HDR Engineering; Espey, Huston and Associates; the Lower Colorado River Authority and the Guadalupe-Blanco River Authority have each contributed significantly to the results reported in this study. As the effort to move forward with any of the proposed alternatives continues, the cooperation and interaction of these and other appropriate entities and the input we have currently received, and will continue to receive as the process progresses, from the general public will play an integral role in the long-term and overall success of any selected project.

We would also like to express our thanks to the Texas Water Development Board for their financial support for this project. We support their continued participation in this and similar water resource planning efforts across the state as new and innovative solutions to regional water problems are explored.

Numerous other individuals in the public and private sectors were involved in this project in various capacities. If not mentioned specifically, we also extend our thanks to them. Finally, thanks to the technical and administrative staff of the Barton Springs/Edwards Aquifer Conservation District for their hard work and diligence in the preparation of this report. Special thanks to Shu Liang, who has been responsible for the development of the majority of the report graphics and data analysis utilizing the District's comprehensive GIS. For the insightful review of the District's Technical Advisory Committee for Hydrogeologic Studies whose input is evident in this report. Joe Vickers of WellSpec Co. assisted in the design and data collection of many of the aquifer tests discussed in this report. Technical review and insightful comments were provided by Robert E. Mace of the Bureau of Economic Geology, Dr. Arleigh H. Laycock, David Johns of the City of Austin Drainage Utilities Division, Michael Barrett of the Center for Research in Water Resources, Raymond Slade of the U.S. Geological Survey, Bill Kaiser, and Dr. George Veni for portions of the report. Insofar as possible, all comments of an engineering or technical nature have been incorporated into the body of the report.

Our sincere appreciation goes to the District Board of Directors and Policy Advisory Committee for their continued support in this effort and concern for the protection of our groundwater resources for the benefit of all who depend upon them.

COVER

The graphics presented on the cover depict the extent of the Barton Springs/Edwards Aquifer Conservation District in relation to the potential alternative sources of water presented in this report. Alternatives 1-3 are surface water supplies. Alternative 4 is a groundwater alternative. Each alternative would connect to a proposed internal distribution network (shown in pink - in the approximate center of the District). Alternative 1 would take water from the Guadalupe-Blanco River Authority as transmission mains are put in place to extend infrastructure to the northern reaches of their service area out of Lake Dunlap on the Guadalupe River, from water conveyed through Canyon Lake (shown in green - extending from San Marcos to the internal distribution network). Alternative 2 would entail taking water from a proposed Lower Colorado River Authority transmission main on US 290 as the LCRA extends service toward Dripping Springs from Lake Travis (shown in beige - extending southeast from the LCRA loop system to the internal distribution network). Alternative 3 would be for the City of Austin to extend service southward into the groundwater dependent areas of southern Travis and northern Hays counties (shown in dark blue just north of the proposed internal distribution network). Alternative 4 would be to construct a well field outside of the three demand centers identified in the report and pump water back into these demand centers in an effort to make more efficient use of the existing and available groundwater (shown in light blue just north of the proposed internal distribution network).

Note: Both color and geographic references are given to enable report reviewers to orient themselves with either a color or a black-and-white report copy.

EXECUTIVE SUMMARY

The Barton Springs/Edwards Aquifer Conservation District, with a supporting grant from the Texas Water Development Board, has studied potential alternative water supplies for areas of the District that currently rely on groundwater as their sole source. This study is a major first step in evaluating the potential for developing a District-wide water supply system capable of providing supplemental water to augment Edwards Aquifer resources, particularly during drought conditions.

This draft planning document presents three potential scenarios that bring surface water into the District and one scenario that involves drilling wells into the aquifer and pumping water into areas of heavy use.

The surface water alternatives discussed are:

- Purchase of water from the Guadalupe-Blanco River Authority.
- Purchase of water from the Lower Colorado River Authority.
- Purchase of water from the City of Austin.

Under each of these surface alternatives, the District would act as a water wholesaler, operating distribution lines and reselling the purchased water to existing public water supply corporations within the District.

Likewise, under the groundwater alternative, the District would contract for well-drilling, then operate a distribution system that would deliver water to wholesale customers.

The District Board and staff would like to emphasize that this is a planning document for purposes of gathering public comment. No decisions have been made. Information has been gathered from existing water supply corporations -- and is detailed in the report -- concerning the desirability of augmenting existing water supplies. However, these entities were presented with the abstract concept of supply augmentation. Their ideas and comments may change once they evaluate the details of the alternatives presented in this report.

The District Board understands that augmentation of the current water supply is more than an engineering decision. This draft document is an important step in a discussion that will encompass political, economic, environmental and social considerations, as well as refinement of the engineering possibilities.

Several potential funding sources are examined in this report, but they, too, must be more fully explored through public debate and additional analysis.

Background

In September 1994, the Barton Springs / Edwards Aquifer Conservation District (BS/EACD or District) applied for matching funds from the Texas Water Development Board (TWDB) Regional Water Supply and Wastewater Planning Grant Fund for the development of an Alternative Regional Water Supply Study. TWDB Contract No. 95-483-079 was executed in January 1995, with a $65,523 project total, of which the TWDB provided $32,761 and the District provided $32,761 as a 50 percent match, including $25,778 in-kind services and $6,983 cash. At the time of this publication, the District's expenditures for this phase of the study are projected to exceed our proportional 50 percent match by approximately $20,000.

The planning area for the study includes the area lying within the jurisdictional boundaries of the District. The extent of these boundaries is delineated in Figure 1.1. A large portion of the study area relies exclusively upon groundwater as the sole source of water. This sole-source area is a federally designated area and is the only drinking water supply for more than 40,000 people. Presently, no readily available and reasonably priced alternative drinking water supply exists.

The City of Austin provides water in areas with the highest population density in the northern reaches of the District. From the northern District boundary, Town Lake on the Colorado River, surface water is available through Austin's service area southward to a line approximated by Slaughter Creek. Surface water service also extends along the eastern edge of the District to an interconnection with the Creedmoor-Maha Water Supply Corporation. South of these areas, surface water is not available inside the District boundaries.

Although this study will account for the entire BS/EACD, the primary focus of the study will be to outline alternative water supplies for the rural areas of southern Travis and northern Hays counties lying within the groundwater dependent area. An analysis of the existing groundwater use defined by District permitted well locations reveals three demand centers (Figure 2.2). These demand centers clearly fall within the groundwater dependent area and can be further defined by their geographic locations. For purposes of this planning effort, demand centers generally identified as near San Leanna, Hays and Buda will be given particular attention for preliminary engineering design and cost evaluations.

The study has been undertaken to address several critical areas of research: the need to compile existing water management data and information, to plan for the effective and efficient allocation of groundwater resources, and to identify potential alternative water supplies to meet the increasing demands being placed on the Barton Springs segment of the Edwards Aquifer. Project tasks were to locate and synthesize existing documentation concerning alternative water supplies for the planning area, enter this and other pertinent information into the District GIS, perform preliminary engineering evaluations on alternative water supplies, and to prepare a final study report.

To complete the tasks set forth for the project, District staff relied on several methods of data collection. A comprehensive review of existing documents -- such as water supply plans and engineering reports -- were evaluated, focusing on areas within the District jurisdictional boundaries. Hardcopy graphics such as Public Water Supply distribution systems and existing and proposed surface water systems were requested and the maps collected were digitized for analysis. Electronic information such as Geographic Information System (GIS) graphic and database files were collected, and insofar as possible, have been incorporated into the District GIS. Data has been compiled from a water use survey developed by the District and distributed to permitted water users from the District. The detailed results from these planning efforts are presented in Appendix I of this report. Personal interviews were conducted and a series of public meetings were held by District staff to receive input from local governments, water supply corporations, District permittees and concerned citizens. Public comments are summarized in Appendix VI.

The initial public meeting to present this planning effort was held in February 1995. At that time, we began to request information from groundwater users within the District. The remainder of 1995 was focused on data acquisition and data entry into the District's GIS. Additional hard drive storage capacity was added to the existing District GIS and a computer memory upgrade was incorporated to facilitate the analysis of the information that was being collected for the project.

Late in 1995, the District was asked to provide input on two concurrent regional water supply planning efforts. The first was a plan being developed and funded by the Lower Colorado River Authority with the assistance of Espey, Huston & Associates. The second planning effort was funded through the TWDB and sponsored by the Guadalupe-Blanco River Authority with HDR Engineering as the consulting engineer for the project. Both plans would potentially bring surface water to service groundwater dependent areas within the District jurisdictional boundaries.

BS/EACD Regional Water System

Three alternative surface water supply options will be considered as potential water supply sources for the purposes of this planning effort. A fourth alternative is evaluated that explores the potential of the District drilling wells north of the identified demand centers and pumping the groundwater to District-owned storage facilities centrally located to the groundwater-dependent areas. This study will discuss each of these alternative water supplies regarding their relation to and ability to meet the water needs of the demand centers in the existing groundwater-dependent area. The District introduced these options at a public meeting held at the District office on June 27, 1996 -- an outline of the presentation is attached as Appendix II at the end of this report. Also included is a chronology of the planning process attached as Appendix III.

Included in this study are preliminary engineering design and cost estimates for a regional water system. Each of the alternatives discussed above has been evaluated, given the best available data the District had access to at the time of this publication. An internal distribution network has been designed to connect each of the three demand centers; this network will service each alternative. The primary difference between alternatives is the source of the water. As will become apparent, the variations in the cost estimates are a function of the length of the transmission mains and related infrastructure and the actual cost of the treated water.

Aquifer Yield Study

One phase of the study estimates the existing water yield across the Barton Springs Edwards Aquifer. Geologic mapping and well log information was incorporated into a geologic framework of the aquifer (Figures 3.1 and 3.2). The highly fractured geological framework was generalized in gross faulted blocks (Figure 3.3). The elevation of the top of the Barton Springs Edwards Aquifer (top of Georgetown Formation) and the base of the aquifer (top of Walnut Formation) was estimated for each generalized fault block (Figure 3.4 and 3.5). Historical water levels were compiled for three monitor wells for the period of record to observe long-term trends (Figure 3.6). Water levels were measured across the aquifer during low-flow periods represented by May through November 1996 (Figure 3.7).

The saturated thickness was estimated across the aquifer based on the measured water levels and estimated elevation of the base of the aquifer (Figure 3.8). The saturated thickness of the Edwards Aquifer on the western side of the recharge zone was generally less than 120 feet and is generally insufficient to support heavy water uses. A number of aquifer tests, most of which were required by the BS/EACD for many of the large water systems, were performed and compiled to estimate the local aquifer transmissivity of the well at the time of the test (Figure 3.9). These aquifer tests involve the pumping of a large discharge well and measuring the drawdown response in area wells. Based on the saturated thickness the aquifer and measured transmissivity from aquifer tests, a high yield zone was estimated across the aquifer. The saturated thickness and transmissivity maps will help predict the availability of water across the Barton Springs segment. The volume of water that can be discharged from the aquifer is about 100 billion gallons (300,000 acre-feet) based on the geological framework presented here, 1996 low flow water levels, and a specific yield of about 0.015 (or 1.5 percent effective porosity).

Current pumpage demand (5,000 acre-feet/year) constitutes about 14 percent of the total aquifer discharge. During the low-flow aquifer conditions experienced in August of 1996, pumpage from wells made up about 30 percent of the total aquifer discharge. Based on pumpage projections for the year 2016, the annual pumpage will constitute approximately 2 percent of the total aquifer resources. Despite the relatively low volume of pumpage compared to springflow, extended droughts may contribute to lower water levels in wells and reduced springflows.

Several factors were identified that could influence the volume of available groundwater within the Barton Springs segment. Growth and aquifer demand could exceed the estimates used in the total pumpage projections presented in Section 2 of this report. Heavy pumpage south of the Barton Springs segment could shift the groundwater divide further north. Potential movement of the bad-water line or intrusion of Glen Rose waters resulting from increased pumpage or drought may reduce the quality of groundwater on the eastern side of the Barton Springs segment. The quality of groundwater resources may diminish due to water-quality degradation as urbanization advances over the recharge zone and consequently may reduce the volume of groundwater available without expensive treatment. The rate of recharge may diminish due to increasing impervious cover which results in more rapid movement (flashy streamflow) of water across areas where recharge would normally be expected to occur. Recharge enhancement efforts, if strategically placed and properly constructed, could be used to increase the volume of available groundwater in storage.

Survey Results

As part of the comprehensive effort to identify alternative water supplies to the Barton Springs segment of the Edwards Aquifer, the District developed a *Permitted User Water Use Survey* to determine existing public perceptions concerning water use. The data collected from this survey has been compiled and is summarized in this report. It supports the perceived need for an alternative(s) or supplemental source(s) to the groundwater use in the study area.

Two separate surveys were developed and distributed. The first targeted public water suppliers and the second was written for permitted users. Of the 78 original surveys distributed, 43 were completed and used in this analysis. The 43 completed surveys represent an overall response rate of 55 percent. More significant, however, is the total permitted volume these 43 responses represent. At the time of the preparation of this report, the District has currently issued permits for a total of 1,465,172,177 gallons. Of this figure, 1,266,482,000 gallons are accounted for by the 43 respondents to the survey -- or simply stated, more than 86 percent of the total permitted volume can be accounted for in this analysis. The top 12 District permittees use more than 78 percent of the total permitted volume. This analysis includes 100 percent of these top 12 users, which represents the largest majority of the groundwater users in the groundwater dependent areas of the Barton Springs segment of the Edwards Aquifer.

The following are several of the most significant responses from the survey. The existing growth rate of the respondents varied from between 0 and 30 percent. Public Water Suppliers indicated the fastest growth rate to supply new residential customers with service. Factors influencing growth limitations included: (#1- 44 percent) availability of dependable and safe drinking water; (#2 - two responses tied at 28 percent) availability of alternative sources of water and the lack of wastewater treatment facilities. Two other factors identified as influencing growth were: (1) the current economic environment and (2) available land to expand current operations. 76 percent of permitted users and an overwhelming majority of 94 percent of the Public Water Suppliers agreed that an alternative source of water was needed. 28 percent of the permitted users and 88 percent of the Public Water Suppliers said they considered surface water as a viable alternative for themselves and 40 percent of the permitted users and 6 percent of the Public Water Suppliers said surface water was not viable for themselves but considered it as a viable source for other permittees. Only 20 percent of the permitted users and 6 percent of the Public Water Suppliers said that surface water should not be considered as an option for either themselves or for others. A summary of the complete survey results is presented in Appendix I at the end of this report.

Guadalupe Blanco River Authority

The GBRA proposal brings water north from Lake Dunlap on the Guadalupe River, south of New Braunfels, to a water treatment plant on the San Marcos River, approximately 17 miles. The City of San Marcos has entered into an Interlocal Agreement with GBRA to begin construction on the diversion system from Lake Dunlop to the treatment plant, construction of the treatment plant capable of processing up to 6 million gallons per day (MGD), and for the operations of the treatment facility. Currently, 4.5 MGD is tentatively allocated to the City of San Marcos, based on the evaluation of current water demands. The additional 1.5 MGD is available to interested parties wanting to participate in the surface water project. One alternative being discussed at this stage of planning is the possibility of upgrading the plant to treat up to 8 MGD, depending upon the number of participants and the total volume of water to which these participants are willing to commit.

GBRA began the planning effort by inviting several of the largest public water supply (PWS) corporations in their service area, basically east of I-H 35, to participate in the project. Three PWS's from this original group are permitted users in the District: Creedmoor-Maha, Goforth, and Plum Creek water supply corporations. The original proposed water line layout would have brought a transmission main up the Missouri Pacific Railroad easement from the San Marcos treatment plant to the Creedmoor-Maha well fields in the northernmost demand center near San Leanna, approximately 20 miles, as displayed in Figure 5.1.

The original cost projections (as much as $4.00/1000 gallons wholesale), made participation unlikely for the three PWS's in the District. The District began negotiations with GBRA to evaluate the possible advantages of the District acting as a regional wholesaler of surface water. Several benefits became apparent. First, financing rates for a local government entity like the District may be lower than the rates available for either non-profit or investor owned PWS's. The District could qualify for lower rates, and by participating in a regional project like this, the financing of the total project could be reduced. Second, if the District could represent a core group of permittees, the wholesale water rate may be more attractive, rather than if individual PWS's were to negotiate the rates separately. Third, the District could potentially represent enough total volume to make the project feasible. Any combination of these factors would possibly make it realistic for individual District permittees to participate in a regional water system, when it might not be feasible to do so independently. The latest cost analysis, completed in September, estimates treated water rates for the City of Kyle at $2.03/1000 gallons wholesale.

The GBRA is looking for potential participants to step forward and make a formal commitment to participate in the project. If the District is unable to make the commitment for actual water delivery at this time, the possibility exists in this stage of planning to size the diversion system from Lake Dunlap to San Marcos to accommodate for future expansion of the treatment plant. By oversizing the initial facilities during the first phase of construction, future water distribution to other entities is feasible without having to improve the intake structure and the transmission line from Lake Dunlop to the plant at San Marcos. The District's proportionate share of debt service on the 19-mile transmission main from Lake Dunlap to the San Marcos WTP (water treatment plant) is estimated at $143,915 per year. This yields a total annual cost (excluding operation and maintenance costs associated with the 30-inch diameter - 19-mile raw water pipeline) of $216,950 per year.

The cost of GBRA contract water is estimated at $53.03 per acre-foot per year plus $0.75/1000 gallons for water treatment. The District would need to purchase a minimum of 1,378 acre-feet (i.e. 30 percent of year 2000 demands for the three water demand centers) at an annual cost of $553,703. The total projected capital cost for all required water improvements to supply Kyle and the District's initial water needs for this alternative is $7.3 million, as shown in Table 5.1. The District's portion of this capital cost for improvements extending from San Marcos to the three water demand centers is estimated at **$5.6 million**. The annual revenue requirement for this alternative is projected at **$1,325,966** as shown in Table 5.2.

Lower Colorado River Authority

The LCRA plan has been developed to address water supply needs inside their jurisdiction, which includes areas immediately west of the District. This proposal would bring Lake Travis water from the Uplands Water Treatment Plant southward in a loop system extending as far south as Dripping Springs (Figure 5.2). The northwesternmost section of the loop system is currently under construction to extend service to the Village of Bee Cave. Completion of subsequent phases of this design is contingent upon the identification of a customer-support base sufficient to meet the fiscal requirements of the project.

The southeastern leg of this loop system will run along US 290 approximately 3.5 miles from and paralleling FM 1826, the approximate western edge of the District. Our proposal would run a water transmission line through a District easement between FM 1826 and US 290 to tie into the proposed water main. The water would then be brought from the western edge of the recharge zone approximately 6 miles to the demand centers located on the artesian zone to the east, near I-35 and the Missouri Pacific Railway. If pursued, one option would be to build the District water transmission line parallel to proposed roads or utility easements that will extend from within the groundwater dependent areas to FM 1826, south of Mopac.

The cost of LCRA contract water is estimated at $105 per acre-foot per year plus $1.60/1,000 gallons for water treatment. The District would need to purchase a minimum of 1,378 acre-feet (i.e. 30 percent of year 2000 demands for the three water demand centers) at an annual cost of $853,005. The projected capital cost for this alternative, shown in Table 5.4, is **$5.7 million**. The annual revenue requirement for this alternative is projected at **$1,507,696** as shown in Table 5.5.

City of Austin

As previously mentioned, the COA supplies water to the majority of the population north of Slaughter Creek, which is in the City of Austin's extra-territorial jurisdiction (ETJ). Creedmoor-Maha Water Supply Corporation also has an interconnect with the COA east of I-35, also inside the ETJ. Austin's current water supply improvements focus on the rapidly expanding northern edge of the COA service area through Cedar Park, Pflugerville and Round Rock into Williamson County.

The COA 5-mile ETJ extends southward to just north of the City of Kyle. The ETJ's of the cities of Buda, Hays, San Leanna, Creedmoor, Niederwald and Mustang Ridge are currently enveloped by or are adjacent to the COA 2-or 5-mile ETJ. Although the COA is concentrating infrastructure improvements further north, long-range water plans are scheduled to address the water needs for other potential customers within their ETJ, primarily to the Travis-Hays county line. As was discussed at the BS/EACD Board of Directors meeting on September 12, 1996, the COA would consider extending service to customers south of their existing water distribution system if they were approached to do so. Their primary focus is extending service to areas that could potentially be annexed by the COA.

COA infrastructure is nearing its capacity to treat and distribute water to its entire service area. There are scheduled facility improvements between now and the year 2001, but until some of these improvements are completed, they are pushing the existing treatment plant capacities to supply peak demand water needs. Another issue to consider is the fact that at the current COA growth rate, the city could exhaust its Colorado River firm water rights as early as the year 2015, a relatively near-term problem when put in the context of water resource or financial planning. The COA is willing to negotiate with any entity inside their service area wishing to connect to their water system. They can also provide water outside of their service area by entering into a wholesale water contract with interested parties. To extend service further south from where they currently serve will require the construction of additional facilities.

The COA's treated water cost is estimated at $1.90 per 1,000 gallons. There is no raw water cost associated with this option. The District would need to purchase a minimum of 1,378 acre-feet (i.e. 30 percent of year 2000 demands for the three water demand centers) at an annual cost of $853,005. The projected capital cost for this alternative, shown in Table 5.7, is **$4.7 million**. The annual revenue requirement for this alternative is projected at **$1.5 million** as shown in Table 5.8.

District Well Field Alternative

Under this alternative, the District would construct a well field, located near Slaughter Lane and Manchaca Road, and connect to the internal distribution network at the southern end of Manchaca Road. This alternative addresses the concerns of several District permittees that we "utilize" the groundwater resources in the Barton Springs segment of the Edwards aquifer. The proposed well field would be north of the existing demand centers and therefore would present little, if any, direct influence on existing users through the adverse effects of pumpage drawdown. By capturing a larger percent of the groundwater and recirculating it through the regional system, more of the resource will be utilized.

There would be no raw water or treated water costs associated with this option. The cost analysis for this alternative includes the construction of all necessary improvements to provide 1,378 acre-feet (i.e. 30 percent of year 2000 demands for the three water demand centers). The projected capital cost for this alternative is estimated at **$5.0 million** dollars, as shown in Table 5.10. The annual cost of service (O&M and debt service), is estimated at **$781,581** (Table 5.11).

1.1 Barton Springs/Edwards Aquifer Conservation District

The BS/EACD was created in 1987 by the 70th Texas Legislature under Senate Bill 988 and Chapter 52 of the Texas Water Code with a mandate to conserve, protect, and enhance the groundwater resources of the Barton Springs segment of the Edwards aquifer and other groundwater resources located within its boundaries. The District has the power and authority to undertake various studies and to implement structural facilities and non-structural programs to achieve its statutory mandate. The District has rule-making authority to implement its policies and procedures. The planning studies described in the Executive Summary and accompanying report were performed by the BS/EACD as partial fulfillment of its statutory mandate.

The BS/EACD's jurisdictional area is delineated in Figure 1.1. It is bounded on the west by the western edge of the Edwards aquifer outcrop and on the north by the Colorado River. The eastern boundary is formed by the most easterly service area limits of the Creedmoor-Maha, Goforth, and Plum Creek Water Supply Corporations. The District's southern boundary is generally along the established groundwater divide or "hydrologic divide" between the Barton Springs and the San Antonio segments of the Edwards Aquifer. This area encompasses approximately 255 square miles, estimated to be 10 percent urban / suburban, 45 percent ranchland, and 45 percent farmland. The Edwards Aquifer is either a sole source or primary source of drinking water for approximately 40,000 people residing within the BS/EACD boundaries and provides significant recreational opportunities at Barton Springs Pool in Austin's Zilker Park. Some wells in the BS/EACD also produce water from the Taylor, Glen Rose, and Trinity Formations, as well as various alluvial deposits along stream banks. The area has a long history of farming, ranching, and rural domestic use of groundwater.

1.2 Project Background

In September 1994, the Barton Springs / Edwards Aquifer Conservation District applied for matching funds from the Texas Water Development Board Regional Water Supply and Wastewater Planning Grant Fund for the development of an Alternative Regional Water Supply Study. TWDB Contract No. 95-483-079 was executed in January of 1995 with a \$65,523 project total, of which the TWDB provided \$32,761 and the District provided \$32,761 as a 50 percent match, including \$25,778.50 in-kind services and \$6,983 cash. At the time of the publication of this report, the District's contribution to the project is estimated to be approximately \$20,000 in excess of the original 50 percent match.

A comprehensive review of existing documents -- such as water supply plans and engineering reports -- were evaluated, focusing on areas within the District jurisdictional boundaries. Hardcopy graphics such as Public Water Supply distribution systems and existing and proposed surface water systems were requested and the maps that have been collected were digitized for analysis. Electronic information such as GIS graphic and database files have been collected, and insofar as possible, have been incorporated into the District GIS. Personal interviews have been conducted and public meetings have been held by District Directors and staff to receive input from local governments, water supply corporations, District permittees and concerned citizens. Finally, data has been compiled from a water use survey developed by the District and distributed to permitted water users from the District. The detailed results from these planning efforts are presented in body of this report.

The initial public meeting to present this planning effort was held in February 1995. At that time, we began to request information from groundwater users within the District. The remainder of 1995 was focused on data acquisition and data entry into the District's GIS. Additional hard drive storage capacity was added to the existing District GIS and a computer memory upgrade was incorporated to facilitate the analysis of the information that was being collected for the project.

Late in 1995, the District was asked to provide input on two concurrent regional water supply planning efforts. The first was a plan being developed and funded by the Lower Colorado River Authority with the assistance of Espey, Huston & Associates. The second planning effort was funded through the TWDB and sponsored by the Guadalupe-Blanco River Authority with HDR Engineering, Inc. as the consulting engineer for the project. Both plans would potentially bring surface water to service groundwater dependent areas within the District jurisdictional boundaries. Three alternative surface water supply options: the LCRA, the GBRA and the COA, and one groundwater supply will be considered as potential water supply sources for the purposes of this planning effort. This study will discuss each of these alternative water supplies with regards to their relation to and ability to meet the growing water needs of the demand centers in the groundwater dependent area.

1.3 Objectives of the Study

Although this study will account for the entire BS/EACD, the focus of the study will be to outline alternative water supplies for the rural areas of southern Travis and northern Hays counties lying within the groundwater - dependent area. An analysis of the existing groundwater use defined by District - permitted well locations reveals several demand centers (Figure 2.2). These demand centers clearly fall within the groundwater - dependent area and can be further defined by their geographic locations. For purposes of this planning effort, demand centers in areas near San Leanna, Buda and Hays will be given particular attention regarding to preliminary engineering design and cost evaluations.

Another purpose of this project was to locate and synthesize existing documentation concerning alternative water supplies for the planning area, enter this and other pertinent information into the District GIS, perform preliminary engineering evaluations on alternative water supplies, and to prepare a final study report. The study will address the need to compile existing information, to plan for the effective and efficient allocation of groundwater resources, and to identify potential alternative water supplies to meet the increasing demands being placed on the Barton Springs segment of the Edwards aquifer.

1.4 Study Area

The planning area for this study encompasses the BS/EACD's jurisdictional boundaries, which include the entire Barton Springs segment of the Edwards aquifer. A large portion of the study area relies exclusively upon groundwater as its sole source of water. This sole-source area is a federally designated area and is the only drinking water supply for more than 40,000 people. The sole source area is emphasized on Figure 1.1.

This segment is part of the Edwards (Balcones Fault Zone) Aquifer system that lies within northern Hays and southern Travis counties in Central Texas. The entire Edwards (Balcones Fault Zone) Aquifer, which is comprised of massive, highly-fractured limestone, extends approximately 250 miles along a narrow, arc-shaped band that crosses Southwestern and Central Texas in parts of ten counties from Kinney, near the Rio Grande, through Uvalde, Medina, Bexar, Comal, Guadalupe, Hays, Travis, Williamson and Bell counties to the northeast. Figure 1.2 delineates the hydrologically significant regions of the Barton Springs segment of the Edwards Aquifer. These areas include the contributing zone, recharge zone, artesian zone (both potable and non-potable), and extended service area.

Generally, the areal extent of the Barton Springs segment of the Edwards Aquifer is considered to be bounded on the north by Town Lake on the Colorado River, on the west by its contact with the Glen Rose Formation of the Trinity Group, on the east by the dividing line between fresh and saline water, i.e. the "bad-water" line that distinguishes those parts of the aquifer with less than and more than 1,000 mg/L of total dissolved solids, and on the south by the groundwater divide (high water level) near the Blanco River or FM 150. This area covers about 155 square miles, with most of the northern third of the area generally developed and urbanized as part of the City of Austin and several other outlying communities.

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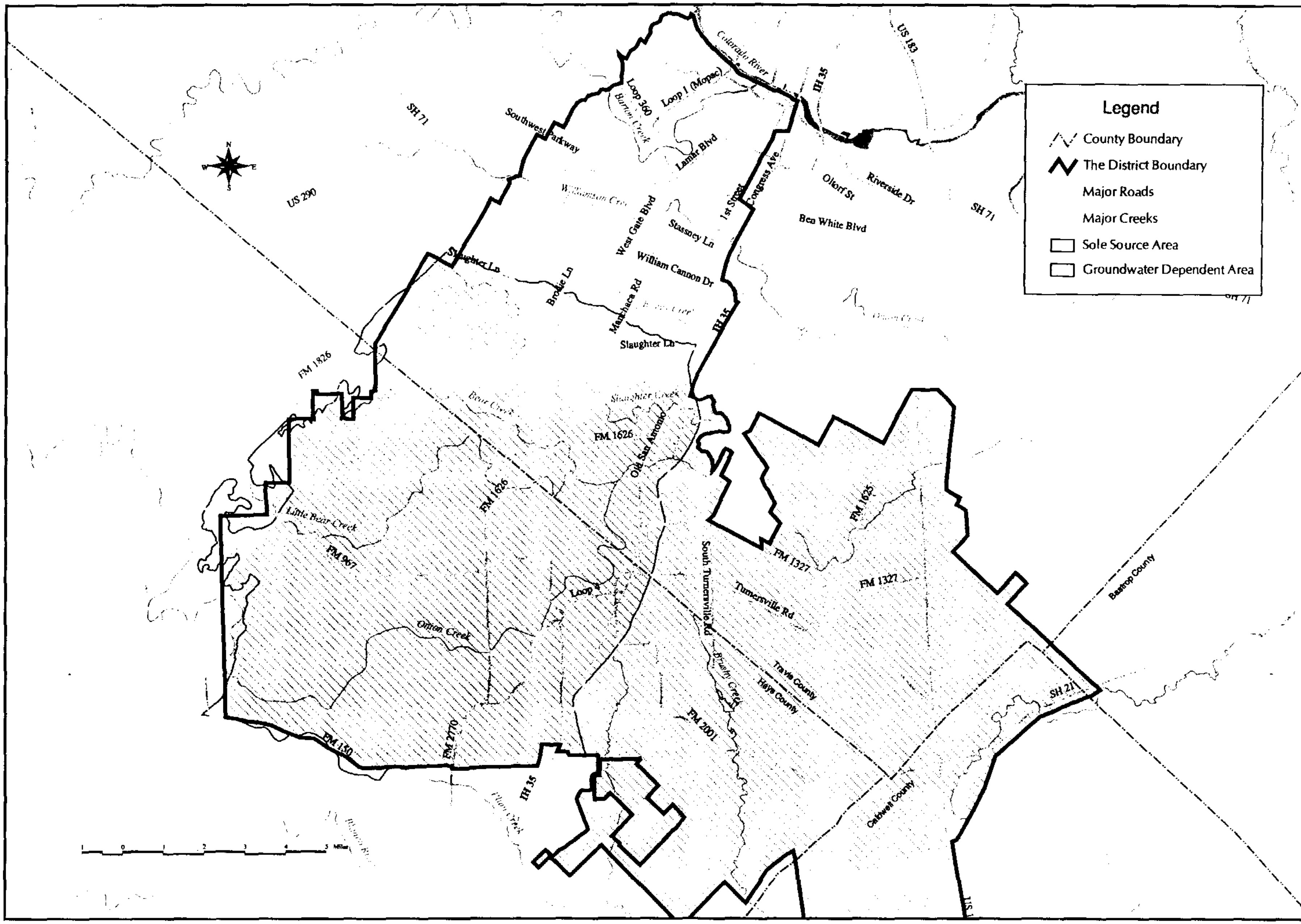


Regional Water Supply Study Area

Figure 1.1

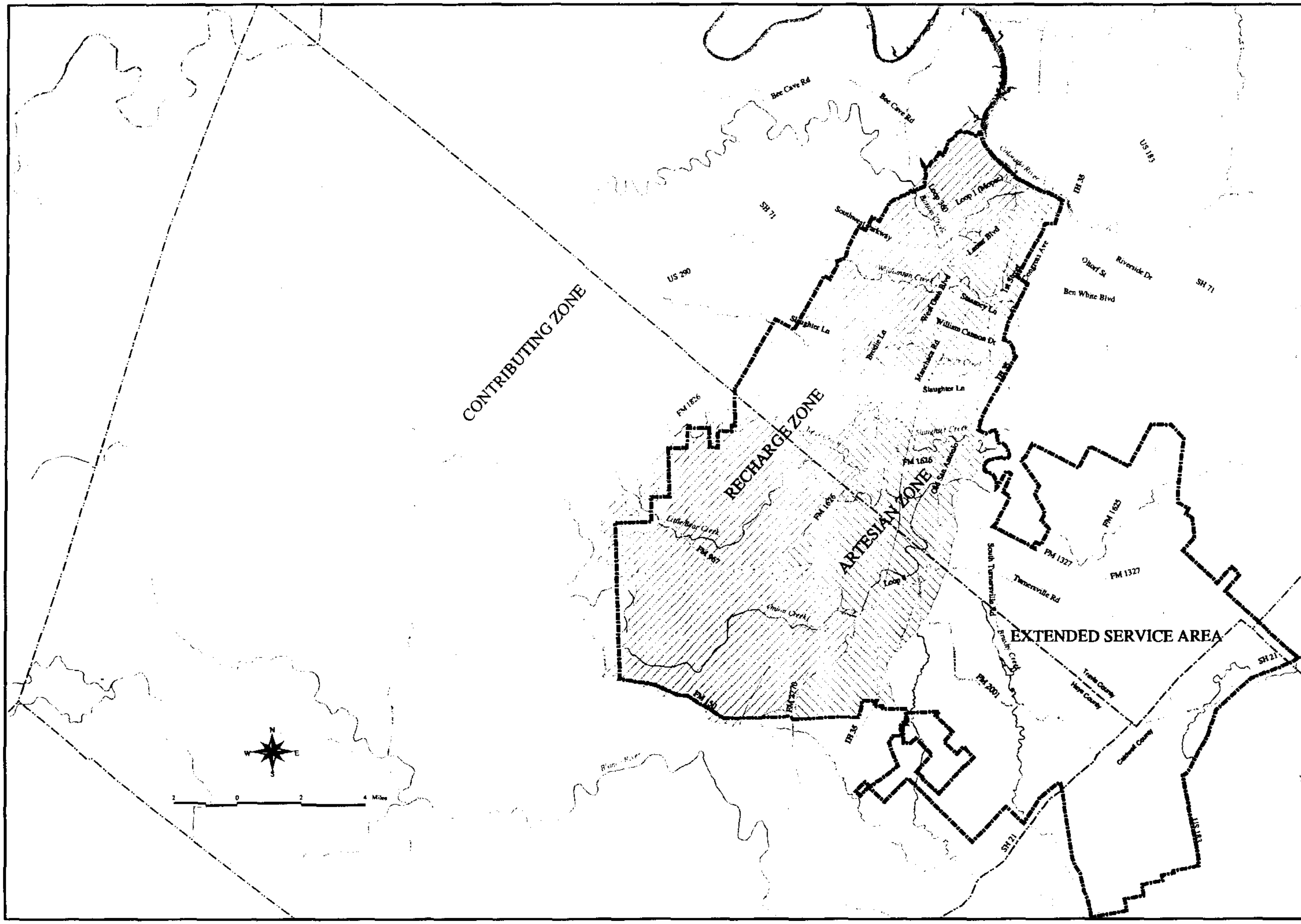
Date: 1/30/97

Created By: Shu Liang

File Name: wsfig11.eps

Location: /home4/maps/prj.rws

Source:
TxDoT Data -- Roads, Creeks and Counties
District Data -- Groundwater Water Dependent Area, Sole Source Area and District Boundaries



Hydrological Zones

Figure 1.2

Date: 2/12/97
Created By: Shu Liang
File Name: wsfig12.eps
Location: /home4/maps/prj-rwa
Source:
TxDoT Data – Roads, Creeks, Counties and Railroad
District Data – District Boundaries, Hydrological Zone

II. WATER USE ANALYSIS

2.1 Introduction

Section 2.2 is an estimate of the population within the Barton Springs/Edwards Aquifer Conservation District and subsets of the District, which include the sole source area and the non-sole source areas. Section 2.2 also describes our efforts to project population through 2015, and includes a description of the methods we used to arrive at these numbers. Our projections are, as are all population projections, subject to the vagaries of population change and growth.

Section 2.3 considers groundwater demand within prescribed areas, referred to here as demand centers. These demand centers do not reflect groundwater demand throughout the district. They do, however, reflect areas within the District that use large amounts of groundwater and where groundwater use will continue to increase. Furthermore, these demand centers represent some of the highest potential for offsetting groundwater demand with surface water.

Water use is to a great extent driven by increases in population within our area. Section 2.3 accounts for groundwater use throughout the planning horizon largely in terms of these increases, especially as they pertain to public water supply companies or corporations. It also describes groundwater use within the District in general terms and outlines our methodology to project groundwater use throughout the planning horizon.

2.2 Population Estimates

Population estimates were based on published sources and on 1990 US Census Bureau data. Estimates were made for the District and sole source area, which is within the District's statutory boundaries and for this discussion includes the extended service area.

Using the District GIS, a geographic information system, block group boundary data from the Census was overlaid on the District and sole source area boundaries. For block groups not wholly within the District or sole source area, a factor corresponding to the percentage of the block group within the District and sole source area boundaries was developed to estimate its population. Block groups, whether wholly or partially within the District or sole source area, were then summed to determine the 1990 population.

The District population in 1980 was approximately 49,000 (BHS, 1988), while in 1990 it was an estimated 132,000. This population change translates into a District wide annual growth rate of approximately 9.9 percent, which is consistent with other rates in and adjacent to the District over the same period of time (CAPCO, 1990). In September 1987, an estimated 30,600 people lived in the sole source area (BS/EACD, 1988), while our 1990 determination yielded an estimate of 30,000. Hays Consolidated School District, whose boundaries overlap the sole source area, experienced similar declines in enrollment at approximately the same time (CAPCO, 1990). Growth rates, unless otherwise noted, were developed using the following formula:

$P = P_0e^{rt}$, where a population of P_0 grows to a population P after t years at an annual rate of r.

It is unlikely that the 9.9 percent growth rate for the District was sustained between 1990 - 1995. Much of the rapid growth that occurred during the last decade took place between 1980 - 1985. Growth during the later part of the decade slowed dramatically because of declining oil and real estate prices. CAPCO demographers believe that average annual growth between 1985 - 1990 "better represent[s] anticipated annual growth for the 1990 - 1995 period (CAPCO, 1990)."

An annual growth rate could not be developed explicitly for the sole source area; however, based on this analysis, a rate of 7.45 percent may approximate growth between 1990 and 1995. This figure is based on a weighted average of growth rates from 1985 - 1990 for the cities of Buda, Hays, and Mountain City, as well as the unincorporated portions of Hays County. Furthermore, using these areas to make population projections is consistent with CAPCO's recognition that the greatest amount of growth in Hays County occurred "north of Onion Creek between Dripping Springs and Buda (CAPCO, 1990)." The majority of the sole source area is in Hays County. However, portions within Travis County are rapidly developing and growth in Hays County should be indicative of growth in Travis County. In 1995 an estimated 44,000 people lived in the sole source area.

An annual growth rate of 2.70 percent may approximate growth within the non-sole source area of the District (CAPCO, 1990). Growth within the non-sole source area is, primarily, in the more densely populated City of Austin. Percent growth rates would be small even though, in absolute terms, the number of new people living there might be much larger. In 1995 an estimated 116,000 people lived in the non-sole source area of the District, up from the estimated 102,000 people who lived there in 1990. Combined, approximately 160,000 people lived in the Barton Springs/Edwards Aquifer Conservation District in 1995.

Applying the above rates yields population estimates from 1995 through 2015 for each area plus the District as a whole:

Table 2.1
Estimated Population 1995 - 2015

Year	Sole Source[1]	District (non Sole Source)[2]	Combined
1995	44,000	116,000	160,000
2000	64,000	132,000	196,000
2005	93,000	150,000	243,000
2010	135,000	171,000	306,000
2015	196,000	195,000	391,000

[1]Annual Sole Source growth rate is 7.45%.
[2]Annual District (non Sole Source) is 2.70%.

2.3 Water Demand Projections

Water demand projections cover the 20-year period between 1996 - 2016. These projections were made for each demand center and are based on estimated growth within individual water systems listed in Table 2.2. Water use within the District is not limited to the demand centers described in this report; however, the systems within each demand center do account for the majority of water use within the Barton Springs segment of the Edwards Aquifer.

2.3.1 Methodology

Growth within each demand center is based on the number of public water supply system connections. Each center also contains other water systems including institutional wells, like Marbridge Foundation, or commercial and industrial wells, like Crestview RV and Centex Materials. For planning purposes, these other water uses were held constant throughout the planning horizon.

System growth, and thus projected water use, is based on information obtained from the TNRCC for 1991 - 1995 and from the BS/EACD. An annual growth rate was developed for each system based on the change in the number of connections between 1991 - 1995. Growth rates were developed using a least squares regression model. A factor of 2.9 persons per connection per system was used to determine the number of individuals within a system (BS/EACD, 1990). Population projections for individual systems within each Demand Center are listed in Tables 2.3 - 2.5. An average rate of water use per connection was used to project demand for individual water systems. These projections were summed for all systems within each demand center throughout the planning horizon. If system buildout was indicated, then water use was held constant from the projected buildout point forward. Also, for report purposes, per connection water use was held constant and thus any savings attributable to conservation were not taken into account. However, as the District continues to implement our existing, and plans for new conservation programs, it is hoped that there will be a measurable reduction in current water use consumption. System and demand center water use projections are listed in Tables 2.6 - 2.8 and depicted in Figures 2.3 - 2.5.

TABLE 2.2

WATER SUPPLY ENTITIES BY DEMAND CENTERS

DEMAND CENTER NO. 1	DEMAND CENTER NO. 2	DEMAND CENTER NO. 3
Barton Properties	Chaparral Water Co.	Arroyo Doble WS
City of Buda	Cimarron Park WSC	Bear Creek Park
Centex Materials	Copper Hills Sub.	Creedmoor-Maha WSC
Crestview RV	Dahlstrom M.S.	Village Of San Leanna
Goforth WSC	City of Hays	Malone WSC
Hays High School	Huntington Estates	Mooreland WS
Texas Lehigh	Leisurewoods WS	Mystics Oaks Water Co.
Mountain City Oaks	Marbridge Farms	Onion Creek Meadows
Plum Creek WSC	Shady Hollow Est. WSC	Slaughter Creek Acs.
Sosebee WS	Southwest Territory WC	Twin Creek Water Co.
		Onion Creek C.C.[1]

1 The water demands for Onion Creek Country Club were not considered in this evaluation since their use is limited to golf course irrigation.

Table 2.3
Demand Center 1 Population Projections

Year	Barton Properties	City of Buda	Centex Materials	Crestview RV	Goforth WSC	Hays High School	Texas Lehigh	Mountain City Oaks	Plum Creek Water	Sosebee Water Well	GROUP 1 TOTAL
1991	58	1,581	—	—	3,503	—	—	400	1,950	44	**7,536**
1992	58	1,589	—	—	3,576	—	—	409	1,960	44	**7,636**
1993	58	1,630	—	—	3,674	—	—	447	2,169	44	**8,022**
1994	58	1,630	—	—	3,967	—	—	551	2,308	44	**8,558**
1995	58	1,636	—	—	4,260	—	—	568	2,442	44	**9,008**
1996	58	1,647	—	—	4,298	—	—	563	2,642	44	**9,252**
1997	58	1,659	—	—	4,446	—	—	592	2,799	44	**9,597**
1998	58	1,670	—	—	4,594	—	—	621	2,952	44	**9,939**
1999	58	1,682	—	—	4,742	—	—	653	3,106	44	**10,284**
2000	58	1,694	—	—	4,889	—	—	682	3,263	44	**10,629**
2001	58	1,705	—	—	5,037	—	—	711	3,416	44	**10,971**
2002	58	1,717	—	—	5,185	—	—	740	3,570	44	**11,313**
2003	58	1,728	—	—	5,333	—	—	769	3,724	44	**11,656**
2004	58	1,740	—	—	5,481	—	—	798	3,880	44	**12,001**
2005	58	1,752	—	—	5,629	—	—	829	4,034	44	**12,346**
2006	58	1,763	—	—	5,777	—	—	858	4,188	44	**12,688**
2007	58	1,775	—	—	5,925	—	—	887	4,341	44	**13,030**
2008	58	1,786	—	—	6,073	—	—	916	4,498	44	**13,375**
2009	58	1,798	—	—	6,221	—	—	945	4,652	44	**13,718**
2010	58	1,810	—	—	6,368	—	—	977	4,805	44	**14,063**
2011	58	1,821	—	—	6,516	—	—	1,006	4,962	44	**14,408**
2012	58	1,833	—	—	6,664	—	—	1,035	5,116	44	**14,750**
2013	58	1,844	—	—	6,812	—	—	1,064	5,269	44	**15,092**
2014	58	1,856	—	—	6,960	—	—	1,093	5,423	44	**15,434**
2015	58	1,868	—	—	7,108	—	—	1,125	5,580	44	**15,782**
2016	58	1,879	—	—	7,256	—	—	1,154	5,733	44	**16,125**

Table 2.4
Demand Center 2 Population Projections

Year	Chaparral Water Co.	Cimarron Park WC	Copper Hills Subdivision	Dahlstrom Middle School	Estate Utilities	Huntington Estates	Leisurewoods Water	Marbridge	Shady Hollow Estates WSC	Southwest Territory WC	GROUP 2 TOTAL
1991	392	1,224	3	—	154	7	1,185	364	365	304	**3,997**
1992	392	1,238	6	—	171	13	1,194	364	365	308	**4,051**
1993	421	1,305	9	—	197	20	1,209	364	365	312	**4,202**
1994	406	1,418	12	—	218	26	1,230	364	522	316	**4,512**
1995	421	1,499	15	—	232	33	1,245	364	641	320	**4,769**
1996	421	1,566	18	—	252	40	1,260	364	722	323	**4,966**
1997	421	1,641	21	—	270	46	1,260	364	832	327	**5,182**
1998	421	1,720	24	—	290	53	1,260	364	945	331	**5,408**
1999	421	1,795	27	—	307	59	1,260	364	1,056	335	**5,624**
2000	421	1,871	48	—	325	70	1,260	364	1,166	339	**5,863**
2001	421	1,946	52	—	345	77	1,260	364	1,276	339	**6,079**
2002	421	2,024	55	—	363	84	1,260	364	1,389	339	**6,299**
2003	421	2,100	59	—	383	91	1,260	364	1,499	339	**6,515**
2004	421	2,175	62	—	400	98	1,260	364	1,610	339	**6,729**
2005	421	2,253	66	—	421	105	1,260	364	1,723	339	**6,951**
2006	421	2,329	70	—	438	112	1,260	364	1,833	339	**7,165**
2007	421	2,404	73	—	458	119	1,260	364	1,943	339	**7,381**
2008	421	2,480	77	—	476	126	1,260	364	2,053	339	**7,595**
2009	421	2,558	80	—	493	133	1,260	364	2,166	339	**7,814**
2010	421	2,633	84	—	513	140	1,260	364	2,277	339	**8,031**
2011	421	2,709	87	—	531	147	1,260	364	2,387	339	**8,244**
2012	421	2,787	91	—	551	154	1,260	364	2,500	339	**8,466**
2013	421	2,862	94	—	568	161	1,260	364	2,610	339	**8,679**
2014	421	2,938	98	—	589	168	1,260	364	2,720	339	**8,896**
2015	421	3,013	101	—	606	175	1,260	364	2,830	339	**9,109**
2016	421	3,091	105	—	626	182	1,260	364	2,944	339	**9,332**

Table 2.5
Demand Center 3 Population Projections

Year	Arroyo Doble Water System	Bear Creek Park	Creedmoor-Maha WSC	Hicks, Harold, & Schuster	Village of San Leanna	Malone WSC	Mooreland Water System	Mystic Oaks Water Co-op	Onion Creek Meadows	Slaughter Creek Acres	Twin Creek	GROUP 3 TOTAL
1991	757	229	3,909	160	377	142	200	137	603	207	145	6,867
1992	757	229	3,909	160	383	144	200	139	626	212	145	6,904
1993	760	232	3,909	160	383	146	200	141	632	216	145	6,924
1994	763	235	4,000	160	394	148	200	143	635	220	145	7,044
1995	774	238	4,086	160	406	150	200	145	641	225	145	7,170
1996	771	238	4,158	160	403	152	200	147	653	229	145	7,256
1997	774	238	4,228	160	409	154	200	149	658	233	145	7,349
1998	780	241	4,304	160	412	156	200	151	667	238	145	7,453
1999	783	241	4,379	160	418	158	200	153	676	242	145	7,554
2000	786	244	4,454	160	423	160	200	156	684	247	145	7,659
2001	792	247	4,530	160	426	162	200	156	693	251	145	7,761
2002	795	247	4,605	160	432	164	200	156	699	255	145	7,858
2003	798	249	4,681	160	435	166	200	156	708	260	145	7,957
2004	803	249	4,756	160	441	168	200	156	716	264	145	8,059
2005	806	252	4,831	160	447	170	200	156	725	268	145	8,161
2006	809	252	4,907	160	450	172	200	156	734	273	145	8,257
2007	812	255	4,982	160	455	174	200	156	740	277	145	8,356
2008	818	255	5,058	160	458	176	200	156	748	281	145	8,455
2009	821	258	5,133	160	464	178	200	156	757	286	145	8,557
2010	824	258	5,206	160	467	180	200	156	763	290	145	8,648
2011	829	261	5,281	160	473	182	200	156	763	294	145	8,744
2012	832	264	5,356	160	479	184	200	156	763	299	145	8,838
2013	835	264	5,432	160	481	186	200	156	763	303	145	8,925
2014	841	267	5,507	160	487	188	200	156	763	307	145	9,022
2015	844	267	5,583	160	490	190	200	156	763	312	145	9,109
2016	847	270	5,658	160	496	192	200	156	763	316	145	9,202

Table 2.6

Demand Center 1 Projected Annual Water Use

Year	Barton Properties	City of Buda	Centex Materials	Crestview RV	Goforth WSC	Hays High School	Texas Lehigh	Mountain City Oaks	Plum Creek Water	Sosebee Water Well	**GROUP 1 TOTAL (gallons)**	**GROUP 1 TOTAL (af)**
1996	402,267	65,575,527	159,960,000	1,184,000	155,125,246	15,284,450	75,300,000	32,272,323	103,094,311	667,634	**608,865,759**	**1,869**
1997	402,267	66,035,439	159,960,000	1,184,000	160,381,273	15,284,450	75,300,000	33,927,384	108,962,806	667,634	**622,105,253**	**1,909**
1998	402,267	66,495,352	159,960,000	1,184,000	165,637,299	15,284,450	75,300,000	35,582,445	114,831,301	667,634	**635,344,748**	**1,950**
1999	402,267	66,955,264	159,960,000	1,184,000	170,893,326	15,284,450	75,300,000	37,237,506	120,699,795	667,634	**648,584,242**	**1,990**
2000	402,267	67,415,176	159,960,000	1,184,000	176,149,352	15,284,450	75,300,000	38,892,567	126,568,290	667,634	**661,823,737**	**2,031**
2001	402,267	67,875,089	159,960,000	1,184,000	181,405,378	15,284,450	75,300,000	40,547,628	132,436,784	667,634	**675,063,231**	**2,072**
2002	402,267	68,335,001	159,960,000	1,184,000	186,661,405	15,284,450	75,300,000	42,202,690	138,305,279	667,634	**688,302,726**	**2,112**
2003	402,267	68,794,914	159,960,000	1,184,000	191,917,431	15,284,450	75,300,000	43,857,751	144,173,774	667,634	**701,542,220**	**2,153**
2004	402,267	69,254,826	159,960,000	1,184,000	197,173,458	15,284,450	75,300,000	45,512,812	150,042,268	667,634	**714,781,714**	**2,194**
2005	402,267	69,714,738	159,960,000	1,184,000	202,429,484	15,284,450	75,300,000	47,167,873	155,910,763	667,634	**728,021,209**	**2,234**
2006	402,267	70,174,651	159,960,000	1,184,000	207,685,511	15,284,450	75,300,000	48,822,934	161,779,257	667,634	**741,260,703**	**2,275**
2007	402,267	70,634,563	159,960,000	1,184,000	212,941,537	15,284,450	75,300,000	50,477,995	167,647,752	667,634	**754,500,198**	**2,315**
2008	402,267	71,094,475	159,960,000	1,184,000	218,197,563	15,284,450	75,300,000	52,133,056	173,516,247	667,634	**767,739,692**	**2,356**
2009	402,267	71,554,388	159,960,000	1,184,000	223,453,590	15,284,450	75,300,000	53,788,117	179,384,741	667,634	**780,979,187**	**2,397**
2010	402,267	72,014,300	159,960,000	1,184,000	228,709,616	15,284,450	75,300,000	55,443,178	185,253,236	667,634	**794,218,681**	**2,437**
2011	402,267	72,474,213	159,960,000	1,184,000	233,965,643	15,284,450	75,300,000	57,098,239	191,121,730	667,634	**807,458,175**	**2,478**
2012	402,267	72,934,125	159,960,000	1,184,000	239,221,669	15,284,450	75,300,000	58,753,300	196,990,225	667,634	**820,697,670**	**2,519**
2013	402,267	73,394,037	159,960,000	1,184,000	244,477,696	15,284,450	75,300,000	60,408,361	202,858,720	667,634	**833,937,164**	**2,559**
2014	402,267	73,853,950	159,960,000	1,184,000	249,733,722	15,284,450	75,300,000	62,063,422	208,727,214	667,634	**847,176,659**	**2,600**
2015	402,267	74,313,862	159,960,000	1,184,000	254,989,748	15,284,450	75,300,000	63,718,483	214,595,709	667,634	**860,416,153**	**2,641**
2016	402,267	74,773,774	159,960,000	1,184,000	260,245,775	15,284,450	75,300,000	65,373,544	220,464,203	667,634	**873,655,648**	**2,681**

Table 2.7
Demand Center 2 Projected Annual Water Use

Year	Chaparral Water Co.	Cimarron Park WC	Copper Hills Subdivision	Dahlstrom Middle School	Estate Utilities	Huntington Estates	Leisurewoods Water	Marbridge	Shady Hollow Estates WSC	Southwest Territory WC	GROUP 2 TOTAL (gallons)	GROUP 2 TOTAL (af)
1996	18,082,026	95,100,741	26,716,602	2,257,050	22,388,802	608,637	66,002,958	17,597,255	69,486,985	17,710,208	**335,951,264**	**1,031**
1997	18,082,026	99,629,594	2,660,326	2,257,050	24,000,070	788,688	66,002,958	20,358,581	79,467,790	17,947,835	**331,194,918**	**1,016**
1998	18,082,026	104,158,448	2,864,967	2,257,050	25,611,338	887,790	66,002,958	20,358,581	89,448,594	18,227,397	**347,899,148**	**1,068**
1999	18,082,026	108,687,302	3,069,607	2,257,050	27,222,605	978,633	66,002,958	20,358,581	99,429,398	18,604,804	**364,692,966**	**1,119**
2000	18,082,026	113,216,156	3,274,248	2,257,050	28,833,873	1,036,443	66,002,958	20,358,581	109,410,202	18,940,278	**381,411,816**	**1,171**
2001	18,082,026	117,745,010	3,478,888	2,257,050	30,445,141	1,135,545	66,002,958	20,358,581	119,391,007	18,954,256	**397,850,462**	**1,221**
2002	18,082,026	122,273,864	3,683,529	2,257,050	32,056,409	1,234,647	66,002,958	20,358,581	129,371,811	18,954,256	**414,275,131**	**1,271**
2003	18,082,026	126,802,718	3,888,169	2,257,050	33,667,677	1,333,749	66,002,958	20,358,581	139,352,615	18,954,256	**430,699,799**	**1,322**
2004	18,082,026	131,331,572	4,092,810	2,257,050	35,278,945	1,432,851	66,002,958	20,358,581	149,333,420	18,954,256	**447,124,468**	**1,372**
2005	18,082,026	135,860,426	4,297,450	2,257,050	36,890,212	1,531,953	66,002,958	20,358,581	159,314,224	18,954,256	**463,549,136**	**1,423**
2006	18,082,026	140,389,279	4,502,091	2,257,050	38,501,480	1,631,055	66,002,958	20,358,581	169,295,028	18,954,256	**479,973,805**	**1,473**
2007	18,082,026	144,918,133	4,706,731	2,257,050	40,112,748	1,730,157	66,002,958	20,358,581	179,275,832	18,954,256	**496,398,473**	**1,523**
2008	18,082,026	149,446,987	4,911,372	2,257,050	41,724,016	1,829,260	66,002,958	20,358,581	189,256,637	18,954,256	**512,823,142**	**1,574**
2009	18,082,026	153,975,841	5,116,012	2,257,050	43,335,284	1,928,362	66,002,958	20,358,581	199,237,441	18,954,256	**529,247,811**	**1,624**
2010	18,082,026	158,504,695	5,320,653	2,257,050	44,946,551	2,027,464	66,002,958	20,358,581	209,218,245	18,954,256	**545,672,479**	**1,675**
2011	18,082,026	163,033,549	5,525,293	2,257,050	46,557,819	2,126,566	66,002,958	20,358,581	219,199,049	18,954,256	**562,097,148**	**1,725**
2012	18,082,026	167,562,403	5,729,934	2,257,050	48,169,087	2,225,668	66,002,958	20,358,581	229,179,854	18,954,256	**578,521,816**	**1,775**
2013	18,082,026	172,091,257	5,934,574	2,257,050	49,780,355	2,324,770	66,002,958	20,358,581	239,160,658	18,954,256	**594,946,485**	**1,826**
2014	18,082,026	176,620,110	6,139,215	2,257,050	51,391,623	2,423,872	66,002,958	20,358,581	249,141,462	18,954,256	**611,371,153**	**1,876**
2015	18,082,026	181,148,964	6,343,855	2,257,050	53,002,891	2,522,974	66,002,958	20,358,581	259,122,266	18,954,256	**627,795,822**	**1,927**
2016	18,082,026	185,677,818	6,548,496	2,257,050	54,614,158	2,622,076	66,002,958	20,358,581	269,103,071	18,954,256	**644,220,490**	**1,977**

Table 2.8
Demand Center 3 Projected Annual Water Use

Year	Arroyo Doble Water System	Bear Creek Park	Creedmoor-Maha WSC	Hicks, Harold, & Schuster	Village of San Leanna	Onion Creek Country Club	Malone WSC	Mooreland Water System	Mystic Oaks Water Co-op	Onion Creek Meadows	Slaughter Creek Acres	Twin Creek	GROUP 3 TOTAL (gallons)	GROUP 3 TOTAL (af)
1996	41,548,921	10,107,170	180,841,259	2,661,568	21,544,519	71,499,996	12,020,686	4,588,986	7,868,403	29,809,614	12,266,201	27,077,600	**421,834,923**	**1,295**
1997	41,750,735	10,173,969	184,090,388	2,368,704	21,788,307	71,499,996	12,176,798	4,671,889	7,178,388	30,183,471	12,497,094	27,077,600	**425,457,340**	**1,306**
1998	41,952,548	10,240,767	187,339,517	2,368,704	22,032,095	71,499,996	12,332,911	4,671,889	7,278,088	30,546,332	12,727,988	27,077,600	**430,068,436**	**1,320**
1999	42,154,361	10,307,566	190,588,646	2,368,704	22,275,883	71,499,996	12,410,968	4,671,889	7,377,788	30,909,194	12,958,881	27,077,600	**434,601,476**	**1,334**
2000	42,356,174	10,374,364	193,837,776	2,368,704	22,519,671	71,499,996	12,489,024	4,671,889	7,477,488	31,283,051	13,189,774	27,077,600	**439,145,512**	**1,348**
2001	42,557,988	10,441,163	197,086,905	2,368,704	22,763,459	71,499,996	12,645,137	4,671,889	7,477,488	31,667,904	13,420,667	27,077,600	**443,678,899**	**1,362**
2002	42,759,801	10,507,961	200,336,034	2,368,704	23,007,247	71,499,996	12,801,250	4,671,889	7,477,488	32,030,765	13,651,560	27,077,600	**448,190,296**	**1,375**
2003	42,961,614	10,574,760	203,585,163	2,368,704	23,251,035	71,499,996	12,957,362	4,671,889	7,477,488	32,393,627	13,882,454	27,077,600	**452,701,692**	**1,389**
2004	43,163,428	10,641,559	206,834,292	2,368,704	23,494,822	71,499,996	13,113,475	4,671,889	7,477,488	32,767,484	14,113,347	27,077,600	**457,224,084**	**1,403**
2005	43,365,241	10,708,357	210,083,421	2,368,704	23,738,610	71,499,996	13,269,588	4,671,889	7,477,488	33,141,341	14,344,240	27,077,600	**461,746,476**	**1,417**
2006	43,567,054	10,775,156	213,332,551	2,368,704	23,982,398	71,499,996	13,425,701	4,671,889	7,477,488	33,515,198	14,575,133	27,077,600	**466,268,869**	**1,431**
2007	43,768,868	10,841,954	216,581,680	2,368,704	24,226,186	71,499,996	13,581,814	4,671,889	7,477,488	33,878,060	14,806,026	27,077,600	**470,780,265**	**1,445**
2008	43,970,681	10,908,753	219,830,809	2,368,704	24,469,974	71,499,996	13,737,926	4,671,889	7,477,488	34,251,917	15,036,920	27,077,600	**475,302,657**	**1,459**
2009	44,172,494	10,975,552	223,079,938	2,368,704	24,713,762	71,499,996	13,894,039	4,671,889	7,477,488	34,614,778	15,267,813	27,077,600	**479,814,053**	**1,472**
2010	44,374,308	11,042,350	226,329,067	2,368,704	24,957,550	71,499,996	14,050,152	4,671,889	7,477,488	34,702,745	15,498,706	27,077,600	**484,050,555**	**1,485**
2011	44,576,121	11,109,149	229,578,196	2,368,704	25,201,338	71,499,996	14,206,265	4,671,889	7,477,488	34,702,745	15,729,599	27,077,600	**488,199,090**	**1,498**
2012	44,777,934	11,175,947	232,827,325	2,368,704	25,445,126	71,499,996	14,362,378	4,671,889	7,477,488	34,702,745	15,960,492	27,077,600	**492,347,625**	**1,511**
2013	44,979,748	11,242,746	236,076,455	2,368,704	25,688,914	71,499,996	14,518,490	4,671,889	7,477,488	34,702,745	16,191,386	27,077,600	**496,496,160**	**1,524**
2014	45,181,561	11,309,544	239,325,584	2,368,704	25,932,701	71,499,996	14,674,603	4,671,889	7,477,488	34,702,745	16,422,279	27,077,600	**500,644,695**	**1,536**
2015	45,383,374	11,376,343	242,574,713	2,368,704	26,176,489	71,499,996	14,830,716	4,671,889	7,477,488	34,702,745	16,653,172	27,077,600	**504,793,230**	**1,549**
2016	45,585,187	11,441,082	245,823,842	2,368,704	26,420,277	71,499,996	14,986,829	4,671,889	7,477,488	34,702,745	16,884,065	27,077,600	**508,939,705**	**1,562**

2.3.2 Existing Water Supplies

Public water supply wells use the majority of permitted groundwater withdrawn from the Barton Springs segment of the Edwards Aquifer. They accounted for approximately 79 percent of the permitted use in fiscal year 1996 (September 1995 - August 1996). The remainder of the permittee use is withdrawn by industrial, commercial, and irrigation wells. Table 2.9 describes the type of permitted use, number of users, volume pumped, and percent use.

Table 2.9

Well Classifications - Fiscal Year 1996

Type of Use	Number	Volume (gallons)	Percent (rounded)
Public Water Supply	37	**1,087,290,762**	79
Irrigation	8	**82,673,191**	6
Industry	8	**186,093,005**	14
Commercial	31	**11,461,058**	1
Total	**84**	**1,367,518,016**	

In 1990, non-permitted domestic wells were estimated to number approximately 1090 (U.S. Census Bureau, 1990). From September 1990 to June 1996 another 161 non-permitted domestic wells were drilled. Assuming a per capita consumption of 170 gallons per day (Botto, 1994), yields a total of approximately 225,000,000 gallons (691 acre feet) withdrawn by non-permitted domestic wells in fiscal year 1996.

Combined use from permitted and non-permitted domestic wells totaled approximately 1.6 billion gallons in fiscal year 1996. Agricultural withdrawals are not reported to the District; however, the most current estimated use ranges from 13,000,000 to 16,000,000 gallons (BS/EACD, 1990). Holding agricultural use constant from 1990, in fiscal year 1996, agricultural withdrawals and non-permitted domestic wells accounted for approximately 14 percent and permitted wells accounted for approximately 86 percent of the total water pumped from the aquifer. The total estimated pumpage from the Barton Springs segment during 1996 is approximately 1.61 billion gallons (5,000 acre-feet).

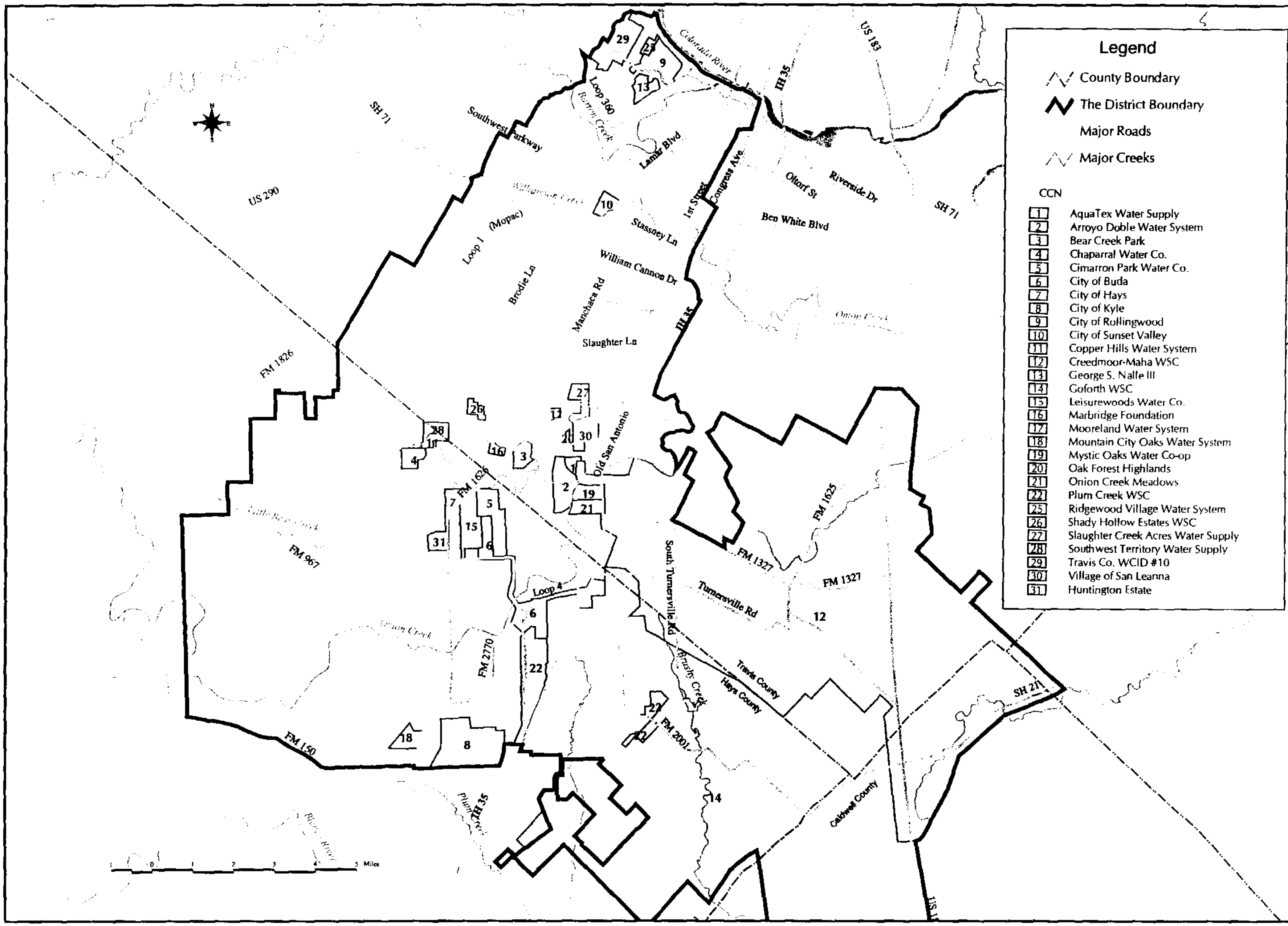
2.3.3 Demand Center Water Use (1996-2016)

Total demand center use as depicted in Table 2.10 is expected to increase by approximately 47 percent from 4195 acre-feet/year in 1996 to 6,157 acre-feet/year by 2016 (compared to approximately 6,900 acre-feet/year total demand) at an average annual rate of 1.72 percent. This increase in water use does not take into account consumption by residential domestic wells or permitted wells outside of the demand centers. Demand Center 2 leads with an estimated increase in use of 91.8 percent at an average annual rate of 3.1 percent, followed by Demand Center 1 and Demand Center 3 with increases of 43 percent and 20.62 percent, and average annual increases of 1.72 percent and 0.9 percent, respectively.

TABLE 2.10

WATER DEMAND PROJECTIONS FOR EACH DEMAND CENTERS

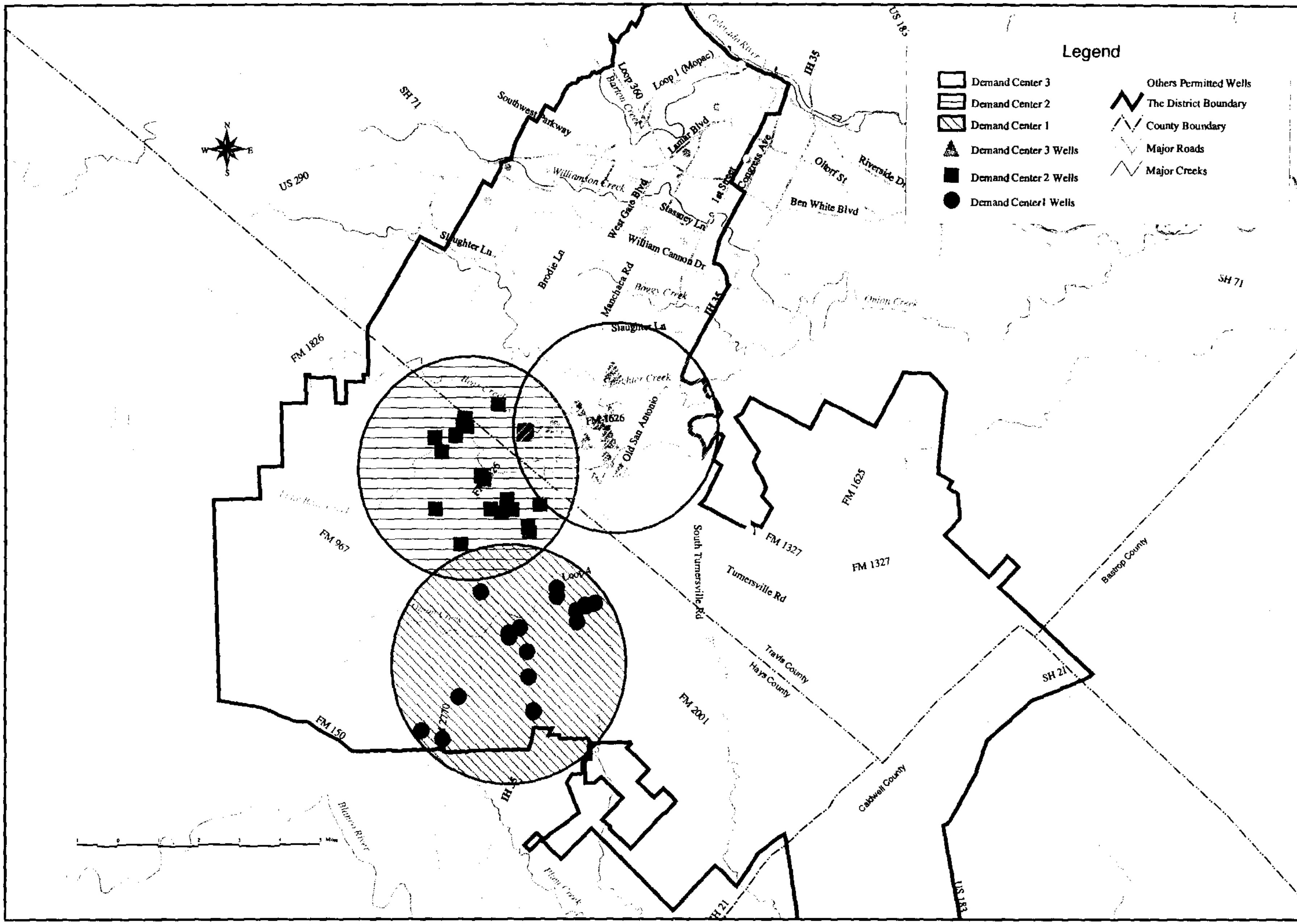
YEAR	WATER DEMAND NO. 1		WATER DEMAND NO. 2		WATER DEMAND NO. 3		WATER DEMAND TOTALS	
	AF/YR	MGD	AF/YR	MGD	AF/YR	MGD	AF/YR	MGD
1996	1,869	1.7	1,031	0.9	1,295	1.2	4,195	3.7
1997	1,909	1.7	1,016	0.9	1,306	1.2	4,231	3.8
1998	1,950	1.7	1,068	1.0	1,320	1.2	4,338	3.9
1999	1,990	1.8	1,119	1.0	1,334	1.2	4,443	4.0
2000	2,031	1.8	1,171	1.0	1,348	1.2	4,550	4.1
2001	2,072	1.9	1,221	1.1	1,362	1.2	4,655	4.2
2002	2,112	1.9	1,271	1.1	1,375	1.2	4,758	4.2
2003	2,153	1.9	1,322	1.2	1,389	1.2	4,864	4.3
2004	2,194	2.0	1,372	1.2	1,403	1.3	4,969	4.4
2005	2,234	2.0	1,423	1.3	1,417	1.3	5,074	4.5
2006	2,275	2.0	1,473	1.3	1,431	1.3	5,179	4.6
2007	2,315	2.1	1,523	1.4	1,445	1.3	5,283	4.7
2008	2,356	2.1	1,574	1.4	1,459	1.3	5,389	4.8
2009	2,397	2.1	1,624	1.5	1,472	1.3	5,493	4.9
2010	2,437	2.2	1,675	1.5	1,485	1.3	5,597	5.0
2011	2,478	2.2	1,725	1.5	1,498	1.3	5,701	5.1
2012	2,519	2.2	1,775	1.6	1,511	1.3	5,805	5.2
2013	2,559	2.3	1,826	1.6	1,524	1.4	5,909	5.3
2014	2,600	2.3	1,876	1.7	1,536	1.4	6,012	5.4
2015	2,641	2.4	1,927	1.7	1,549	1.4	6,117	5.5
2016	2,618	2.3	1,977	1.8	1,562	1.4	6,157	5.5



Certificate of Convenience and Necessity (CCN) Boundaries

Figure 2.1

Date: 2/4/97
Created By: Shu Liang
File Name: wsfig21.eps
Location: /home4/maps/prj-rws
Source:
TxDoT Data -- Roads, Creeks and County Boundaries
TWDB Data -- CCN's
District Data -- District Boundaries



BS/EACD Groundwater Demand Centers

Figure 2.

Date: 2/4/97

Created By: Shu L

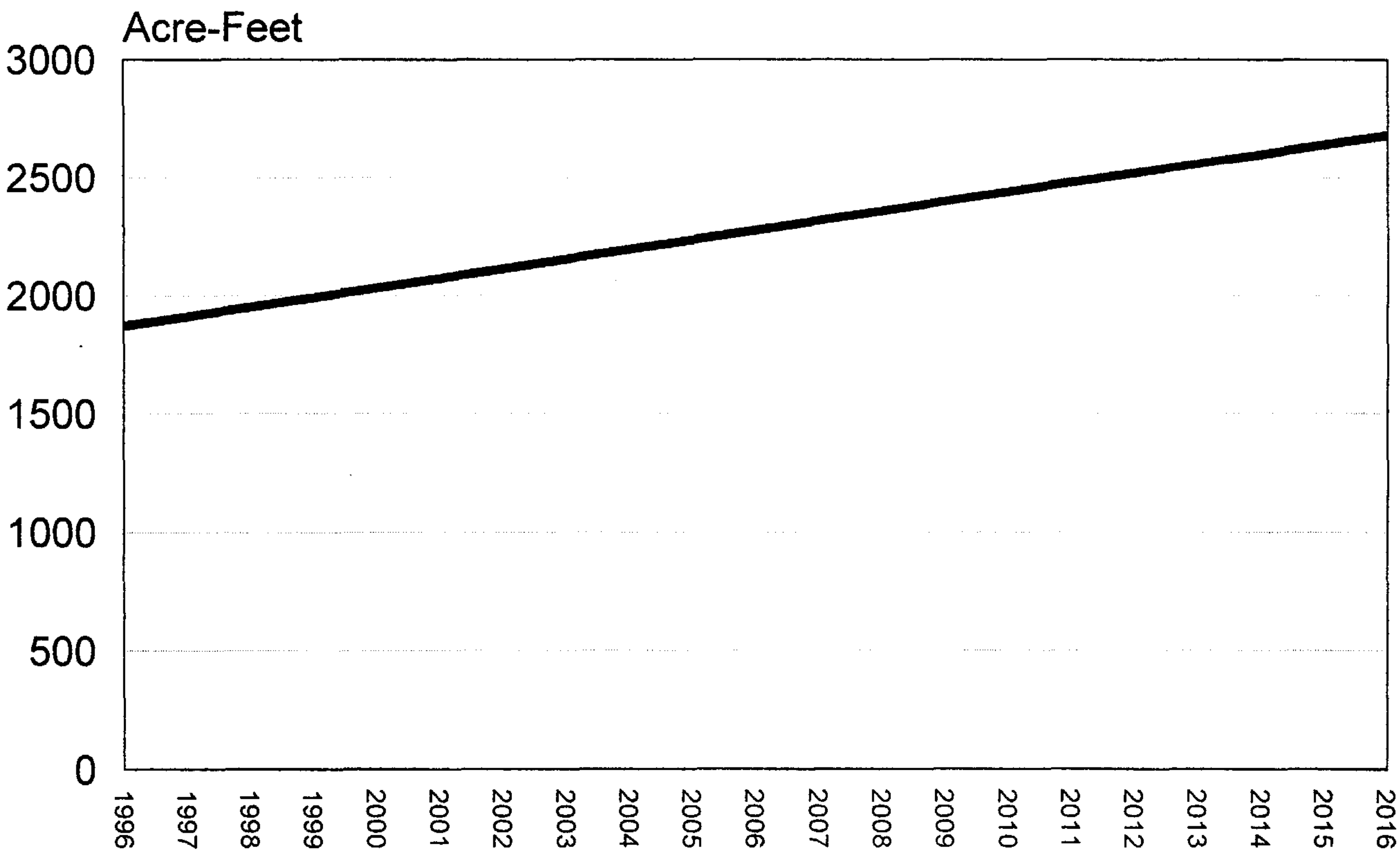
File Name: wsFig2

Location: /home4/maps/prj

Source:
TxDoT Data – Roads, Creeks and Counties
District Data – Demand Center, Wells and District Boundary

Figure 2.3
Demand Center 1 Projected Water Use By Year

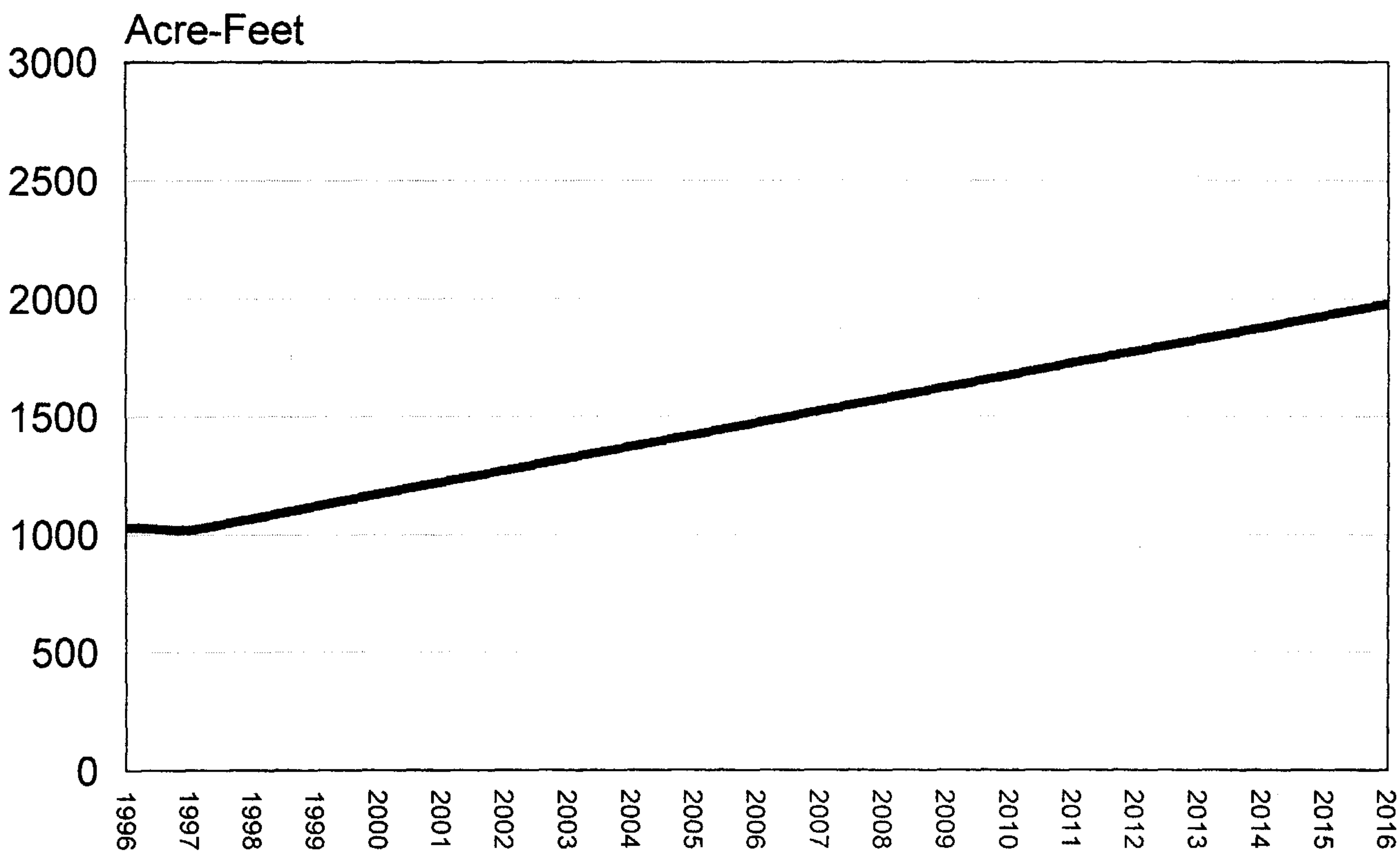
1996 to 2016



Demand Center 1 - Barton Properties, Buda, Centex Materials, Crestview RV Center, Goforth WSC, Hays High School, Texas Lehigh, Mountain City Oaks, Plum Creek, Sosebee Water Well

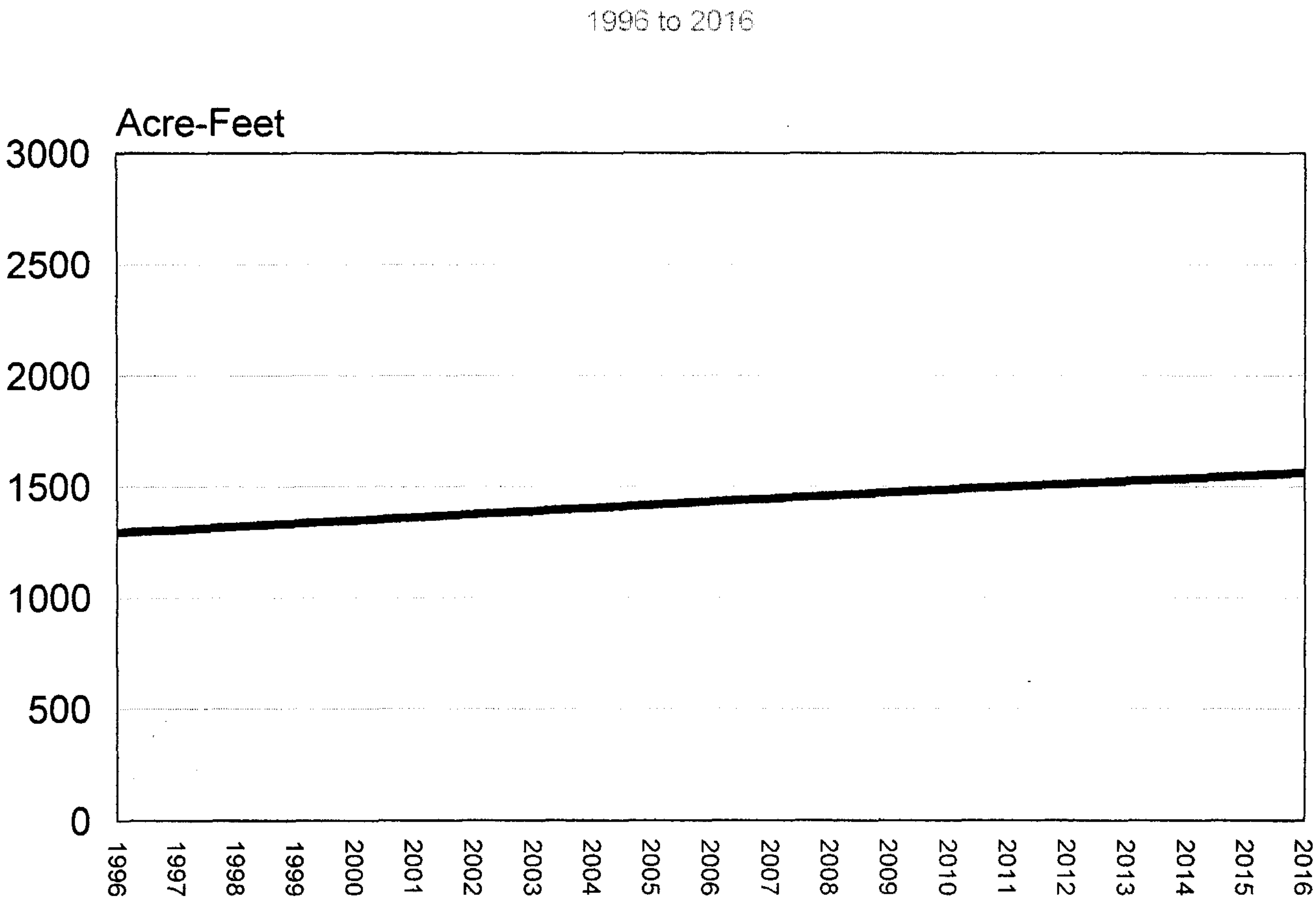
Figure 2.4
Demand Center 2 Projected Water Use By Year

1996 to 2016



Demand Center 2 - Chaparral Water Company, Cimarron Park WC, Copper Hills Subdivision, Dahlstrom Middle School, Estates Utilities, Huntington Estates, Leisurewoods Water, Marbridge, Shady Hollow Estates, and Southwest Territory

Figure 2.5
Demand Center 3 Projected Water Use By Year



Demand Center 3 - Arroyo Doble, Bear Creek Park, Creedmoor-Maha, Hicks Harold and Schuster, San Leanna, Onion Creek Country Club, Malone, Mooreland Water System, Mystic Oaks Water Co-op, Onion Creek Meadows, Slaughter Creek Acres, and Twin Creek

Demand Center 1 will have the greatest estimated absolute increase in water use. Demand Center 2's projected water use will surpass Demand Center 3's by 2005.

2.4 BS/EACD Conservation and Drought Management Programs

The District administers both a conservation and drought program. All non-exempt well users (permittees) who consume groundwater are required to develop User Conservation Plans (UCP) and User Drought Contingency Plans (UDCP) that are adopted by the District's Board of Directors. There are several classes of permitted groundwater use, these include: public water supply, industrial, commercial, and irrigation wells. Other non-exempt wells include earth-coupled heat exchange closed loop (ECHE) and monitor wells. At present, there are 84 permittees whose annual permitted pumpage is 100,000 gallons or more. While public water supply companies number fewer than 50% of those permittees, they account for approximately 80% of the total permitted groundwater withdrawal.

2.4.1 Conservation

Each permittee is required to prepare, adopt and implement a UCP, which is consistent with the *Rules and Bylaws of the Barton Springs/Edwards Aquifer Conservation District (Rules).* These plans require permittees to consider, as a minimum, the following:

- implementation of a conservation-oriented rate structure
- promotion and encouragement of voluntary conservation measures
- promotion and encouragement, installation, and use of water saving devices
- promotion and encouragement of water efficient landscape practices
- financial measures which encourage conservation
- distribution for conservation information and other educational efforts, and
- provision for ordinances, regulations or contractual requirements necessary for the permittee to enforce the UCP.

The *Rules* also describe other mechanism's that the District can use to encourage permittees to reduce consumption. Appendix V contains these rules, which includes descriptions of the Conservation-Oriented Rate Structure (Rule 3-6.1), Contract Agreement For New Connections (Rule 3-6.2), Ultra Low Flow Plumbing Fixtures In New Construction (Rule 3-6.3), Landscape Irrigation (Rule 3-6.4), Low Flow Services In Homes For Resale (Rule 3-6.5), and Conservation Policy (Rule 3-6.6).

As a conservation measure, all newly drilled, exempt wells are required to install a meter. Exempt wells do not pay water use fees. The meter allows homeowners to evaluate their groundwater use, and with this knowledge use water more wisely. The District produces it own, and uses water conservation literature from a number of State and local agencies including the TWDB. Residents throughout the District receive information describing how to save water including an annual 5-day lawn watering schedule distributed to permittees, local newspapers and is included in the Austin

Environmental Guide. The District offers a financial incentive for permittees to conserve water in the form of Conservation Credits. In this program, permittees accounts are credited with the difference in their actual annual usage and their annual permitted volume. Since the inception of the program, the District has issued approximately $225,000 in Conservation Credits.

2.4.2 Drought

Drought, or other uncontrollable circumstances, can disrupt the normal availability of groundwater. The District's drought program establishes procedures intended to preserve the availability and quality of water during such conditions.

The District monitors groundwater levels in ten wells -- five of which are used to indicate drought water level trigger conditions. Monitor wells were selected for the length of time that they have been observed and their location within the District. These include: Mountain City, Buda, San Leanna, South Austin, and Barton Creek/Springs. Figure 2.6 depicts the location of these monitor wells.

Groundwater declines may trigger a drought declaration when water levels fall below predetermined points in one or more of the District's monitor wells. These levels are outlined in a table *entitled Water Level Elevation Monitor Wells and Drought Severity Stage Parameters,* which is contained in Appendix V. There is one no-drought stage and three drought stages, which must be declared in succession starting with least severe: Alert, Alarm and Critical.

Stage I, or Alert status, drought is the least severe drought stage. It signifies that the District is in a local or regional drought. A local or regional drought Alert commences when water level elevations fall below a historical median level for 14 consecutive days in one or more of the District's monitor wells and the District's General Manager determines that conditions warrant the execution of this stage.

A Stage II, or Alarm status, drought is the second most severe stage and signifies a local or regional drought. This stage commences when water level elevations in at least two of the District's monitor wells decline below the historical lower quartile level elevation for 14 consecutive days and the District's Board of Directors determines that conditions warrant its execution.

Stage III, Critical status, drought is the next and most severe drought stage. This stage commences when water level elevations in at least two of the District's monitor wells fall below the lowest observed historical levels (drought of record) for each well for 14 consecutive days and the District's Board of Directors determines that conditions warrant its execution.

UDCPs are developed in conjunction with each permittee and outline specific actions to reduce groundwater consumption during each drought stage. They contain a number measures to reduce consumption. These include: the prohibition of water waste; development of alternative and/or supplemental water supply sources; adjustment of water rates and use of water saving devices; implementation of financial measures to encourage compliance with the plan; provisions to develop ordinances; regulations or contractual requirements; and provisions for reporting pumpage. Appendix V contains a copy of Rule 3 - 7, which discusses drought, drought stage and triggers, and the District's and a permittee's responsibilities.

Each UDCP contains monthly baseline pumpage and target reduction goals. Baseline pumpage is a system's monthly historical average for a selected three year period. Target reduction goals are based on a 10%, 20%, and 30% reduction in groundwater usage from each permittees monthly baseline for each drought stage, respectively. Stage I reductions, 10%, are voluntary, while Stage II and III are mandatory.

The District does not require private residential well owners to develop baselines and comply with the demand reduction measures outlined above. However, they are also encouraged to reduce consumption along with permitted well owners. As it is, private residential well owners may suffer the most when their wells begin to run dry.

The following is a list of the District's drought declaration history:

- August 1993 - July 1994 — Stage I
- July 1994 - October 1994 — Stage II
- October 1994 - December 1994 — Stage I
- December 1994 — Normal Conditions
- January 1996 - April 1996 — Stage I
- April 1996 - March 1997 — Stage II
- March 1997 — Normal Conditions

Between July 1994 and October 1994, forty-three percent of the permittees met or exceeded the twenty percent reduction goal, based on reported pumpage. When considered together, permittees achieved a twenty-one percent reduction in groundwater use during that same period. Heavy rains that Autumn, coupled with appropriate drought plan implementation, contributed to the overall reduction.

Drought and conservation plans help reduce demand on the aquifer, extending groundwater supplies and mitigating drought's impact. Our experience with implementing the drought program indicates that we can realize a reduction in groundwater use during a formal drought. With some modifications regarding baseline pumpage calculations, these plans provide a dynamic and effective tool allowing the District and our permittees to reach targeted conservation goals.

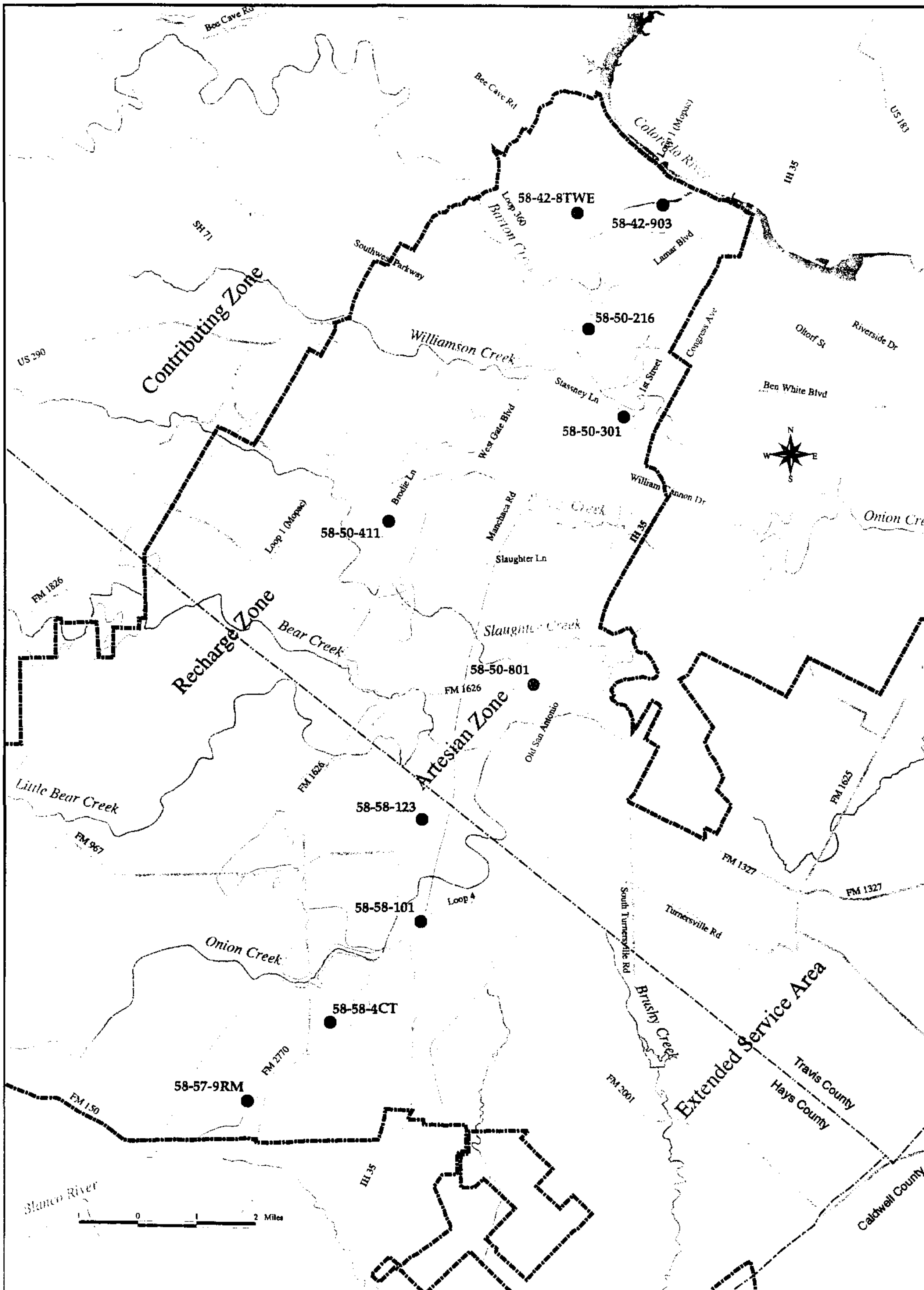


Figure 2.

Monitor Well Locations

III. BARTON SPRINGS EDWARDS AQUIFER YIELD ANALYSIS (LOW FLOW CONDITIONS)

Table 3.1 Summary of the Geologic Units of the Barton Springs Edwards Aquifer, northern Hays and southern Travis Counties, Texas. (From Small, Hanson, and Hauwert, 1996)

Hydrogeologic subdivision	Group	Formation	Member	Thickness (feet)	Porosity/ permeability characteristics
	Taylor Group			600	Low permeability
Upper	Austin Group			130-150	Low permeability, minor springs
Confining	Eagle Ford Group			30-50	Low permeability
Unit		Buda Limestone		40-50	Low permeability, minor springs and rare caves
	Washita Group	Del Rio Clay		50-60	Low permeability
		Georgetown Formation		40-60	Low permeability
			Cyclic and Marine	0-70	Cavernous, moderate to high permeability
		Person Formation	Leached and Collapsed	20-80	Cavernous, moderate to high permeability
Edwards	Edwards Group		Regional Dense	20-30	Low permeability, vertical shafts
Aquifer*			Grainstone	45-60	Moderate permeability
		Kainer Formation	Kirschberg	65-75	High permeability, extensive cave development
			Dolomitic	110-150	Locally high but generally moderate permeability
		Walnut Formation	Basal Nodular	45-60	Low perm., cave development seen other areas
Lower		Glen Rose	upper member	350-500	Low permeability, producing some springs
Confining	Trinity Group				
Unit					
	* As used in this study. Others may group the Walnut Formation/Basal Nodular Member into the Edwards Aquifer				

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	Washita Group	Del Rio Clay		50-60	Low permeability
		Georgetown Formation		40-60	Low permeability
			Cyclic and Marine	0-70	Cavernous, moderate to high permeability
		Person Formation	Leached and Collapsed	20-80	Cavernous, moderate to high permeability
Edwards	Edwards Group		Regional Dense	20-30	Low permeability, vertical shafts
Aquifer*			Grainstone	45-60	Moderate permeability
		Kainer Formation	Kirschberg	65-75	High permeability, extensive cave development
			Dolomitic	110-150	Locally high but generally moderate permeability
		Walnut Formation	Basal Nodular	45-60	Low perm., cave development seen other areas
Lower		Glen Rose	upper member	350-500	Low permeability, producing some springs
Confining	Trinity Group				
Unit					
	* As used in this study. Others may group the Walnut Formation/Basal Nodular Member into the Edwards Aquifer				

3.0 Barton Springs Edwards Aquifer Yield Analysis (Low Flow Conditions)

As indicated in Section 2.2, the growth rate within the sole source portion of the study area is expected to increase from an estimated 44,000 persons in 1995 to 196,000 in the year 2015. The demand for groundwater resources is increasing. Until now, there has been no published delineation of groundwater across the aquifer segment. This section delineates the availability of groundwater from the Barton Springs segment of the Edwards Aquifer during periods of low rainfall and low aquifer flow, by incorporating recent geological data, water-level measurements, and aquifer test results, as well as revisiting the results of previous studies.

3.1 The Geological Framework

The framework of the geology of the Barton Springs segment was used to construct a conceptual model of the aquifer, from which the availability of water was estimated. Previous conceptual models for the framework and hydrogeology of the Barton Springs segment were developed by Brune (and Duffin 1983) for Travis County, as well as those developed by Baker (and others, 1986) and Slade (Dorsey and Stewart, 1986) for the entire Barton Springs segment. Previous geological interpretations of the study area were mapped by a number of geologists including Hill (and Vaughan 1896-7), the Bureau of Economic Geology (Rhodda, Garner, and Dawe 1979; unpublished maps by Keith Young and Ed Garner), the City of Austin (Snyder, 1985), the U.S. Geological Survey (DeCook, 1963), and the University of Texas (Young, Caran, and Ewing 1982; Kolb, 1981; Smith, 1978, Strong, 1957; McReynolds, 1958; Dunaway, 1962; Grimshaw, 1976), and others. Recently the U.S. Geological Survey (USGS) and Barton Springs/Edwards Aquifer Conservation District (BS/EACD) has mapped the surface outcrops over the entire Barton Springs segment with partial funding by the Texas Water Development Board (TWDB) (Small, Hanson, and Hauwert, 1996). The mapping results of the USGS, BS/EACD, and TWDB study were used as the geological framework for this study. The rock layer characteristics (*lithology*), the faults and fracturing (*geologic structure*), and potential for cave and sinkhole development (*karst*) are major factors influencing the local yield of the aquifer. In the following sections, the influences on groundwater flow are described.

3.1.1 The Hydrogeological Characteristics of the Lithologic Units

The major factor affecting the *porosity* (percentage of openings in the rock) and *permeability* (ability of the rock to transmit water) within the Barton Springs segment is the lithology (Small, Hanson, and Hauwert, 1996). The sediments that make up the Edwards Aquifer were deposited in a shallow marine environment during the Cretaceous period. The Edwards south of the Colorado River was defined as a rock group by Rose (1972). In the Barton Springs segment of the Edwards Aquifer, the Edwards Group can be distinguished into the members: Marine, Leached and Collapsed undivided, Regional Dense, Grainstone, Kirschberg, Dolomitic, and Basal Nodular (Table 3.1, Rose, 1972). Figure 3.1 shows the surface geology for the Barton Springs segment. Control points, such as geophysical logs, drillers logs, core descriptions, and measured sections were compiled to estimate the vertical extent of the geological units (Figure 3.2).

Table 3.1 Summary of the Geologic Units of the Barton Springs Edwards Aquifer, northern Hays and southern Travis Counties, Texas. (From Small, Hanson, and Hauwert, 1996)

Hydrogeologic subdivision	Group	Formation	Member	Thickness (feet)	Porosity/ permeability characteristics
	Taylor Group			600	Low permeability
Upper	Austin Group			130-150	Low permeability, minor springs
Confining	Eagle Ford Group			30-50	Low permeability
Unit		Buda Limestone		40-50	Low permeability, minor springs and rare caves
	Washita Group	Del Rio Clay		50-60	Low permeability
		Georgetown Formation		40-60	Low permeability
			Cyclic and Marine	0-70	Cavernous, moderate to high permeability
		Person Formation	Leached and Collapsed	20-80	Cavernous, moderate to high permeability
Edwards	Edwards Group		Regional Dense	20-30	Low permeability, vertical shafts
Aquifer*			Grainstone	45-60	Moderate permeability
		Kainer Formation	Kirschberg	65-75	High permeability, extensive cave development
			Dolomitic	110-150	Locally high but generally moderate permeability
		Walnut Formation	Basal Nodular	45-60	Low perm., cave development seen other areas
Lower		Glen Rose	upper member	350-500	Low permeability, producing some springs
Confining	Trinity Group				
Unit					
	* As used in this study. Others may group the Walnut Formation/Basal Nodular Member into the Edwards Aquifer				

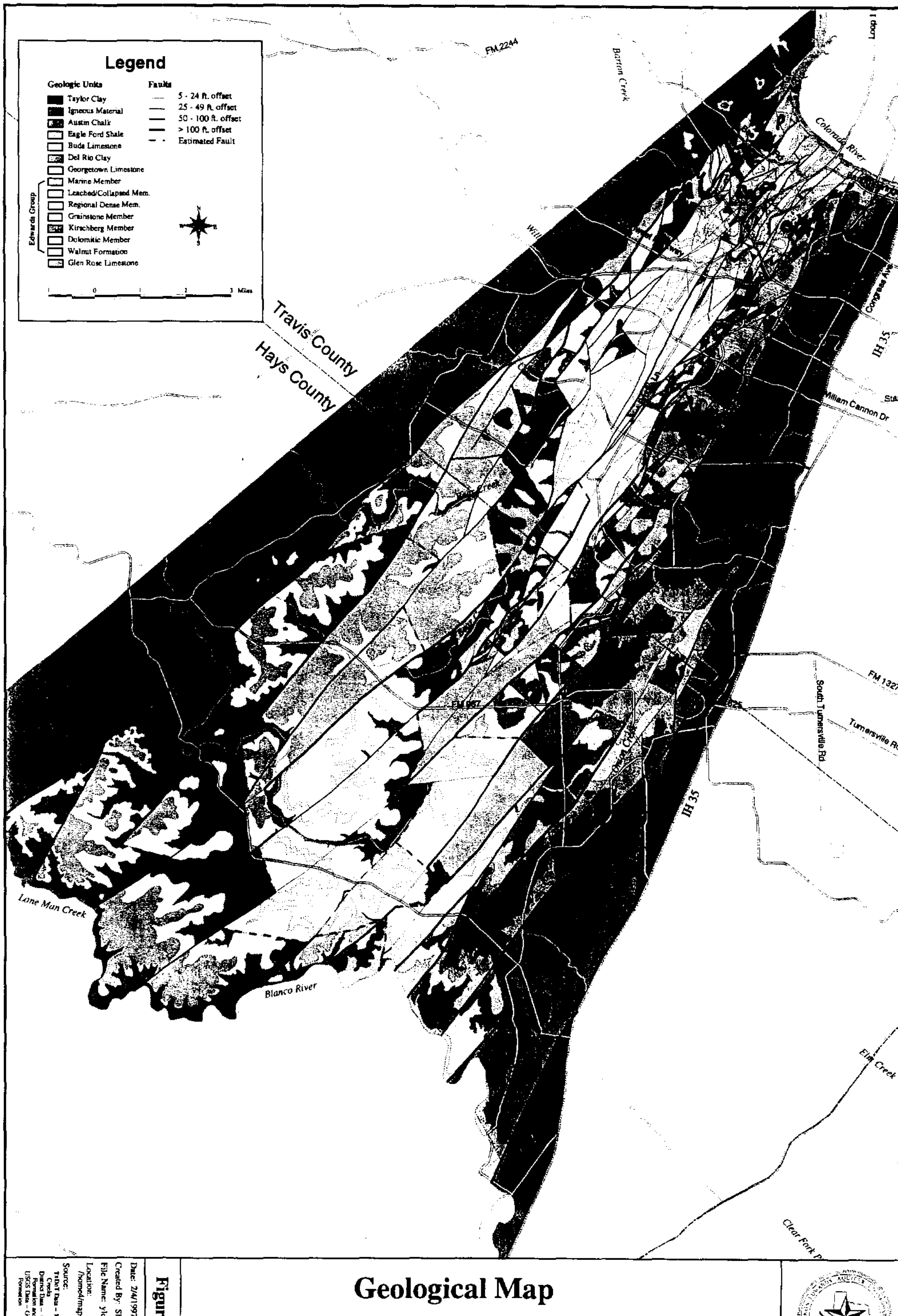

Figure 3.1

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Geological Map

Barton Springs segment of the Edwards Aquifer
Northeast Hays and Southwest Travis Counties, Texas

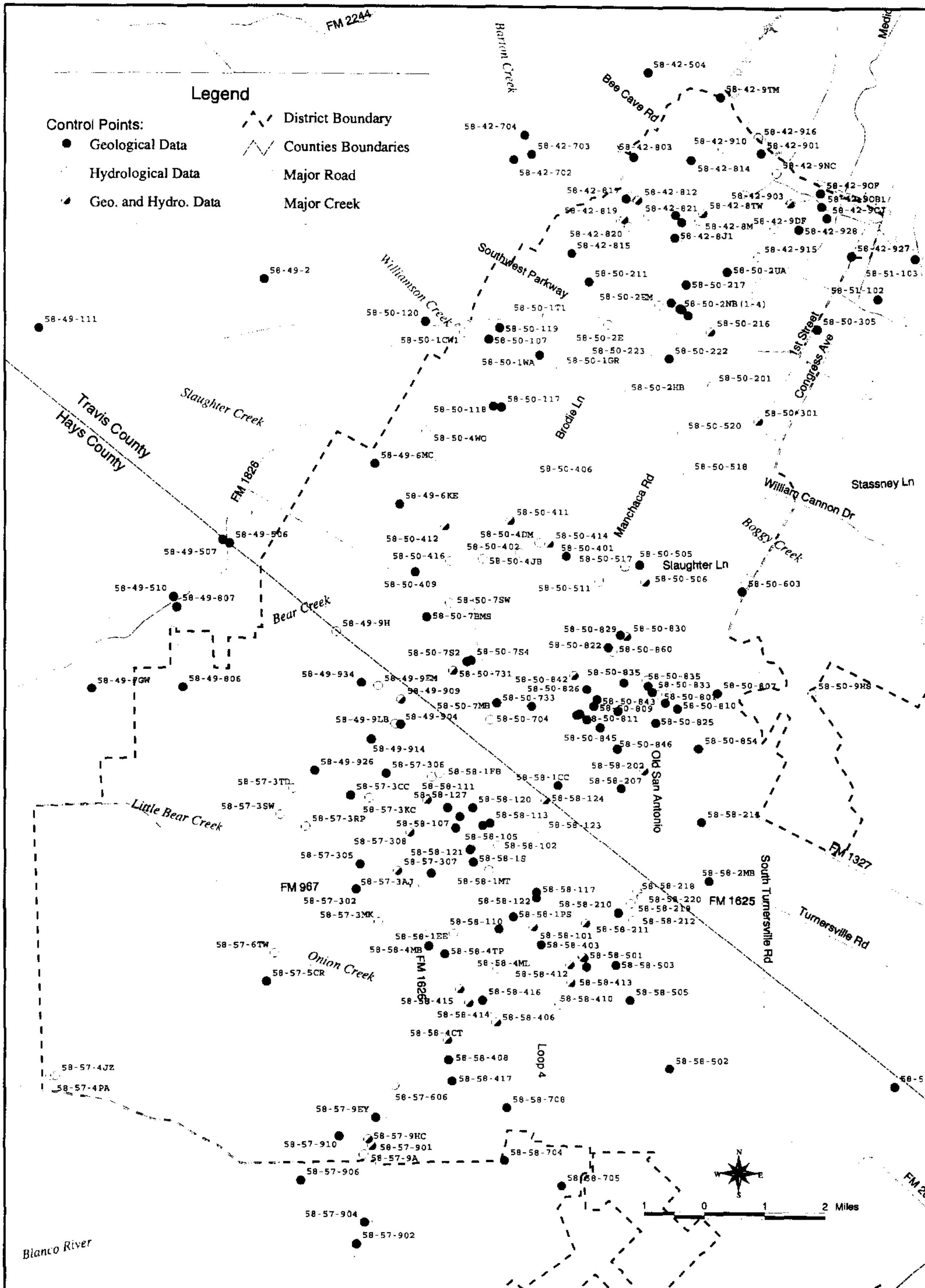

Figure 3.2

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Geologic and Hydrogeologic Control Points

Barton Springs segment of the Edwards Aquifer
Northeast Hays and Southwest Travis Counties, Texas

Based on the surface geology map and control point information, the faulted blocks were lumped into larger generalized blocks. These generalized blocks were selected to represent the configuration of top and bottom aquifer elevations, the aquifer thickness, and fault barriers. In some cases the generalized blocks were not completely bounded by faults, but by hydrologic or water-quality boundaries such as the northern edge of the study area along the Colorado River and at the poor-quality water interface along the eastern edge of the usable Barton Springs segment. The actual blocks do not change thickness abruptly at the boundary faults, but rather the thickness of the aquifer will vary within the blocks. For the purposes of estimating the aquifer yield, the Edwards Aquifer is assumed to include the interval from the top of the Georgetown Limestone to the top of the Walnut Formation (or Basal Nodular Member of the Edwards Group). Where complete sections are present, the thickness of the Edwards Aquifer thins from about 500 feet in the southeast to about 315 feet in the northwest portion of the study area (Figure 3.3). This thinning can be attributed to erosion of the top of the Edwards Group prior to deposition of the overlying Georgetown Limestone (Rose, 1972, p. 27). The Edwards Aquifer thins towards a thickness of zero on the far western side, due to more recent erosion of the Edwards Group and its overlying units. The geological units of the mapped area and their water-bearing characteristics are briefly described below.

The upper Glen Rose is characterized as a low permeable unit containing a few low productivity water-bearing units (Abbott, 1973). The upper Glen Rose consists of alternating beds of marls and resistant dolomitic beds that give a characteristic step-like appearance to slopes. As with any carbonate rock unit, localized permeability can occur. Numerous perennial springs discharge from the upper Glen Rose just west, north, and south of the Barton Springs segment. These springs supply a large potion of the baseflow to the Barton Springs segment. No caves are known in the upper Glen Rose within the mapped area.

The lowermost member of the Edwards Group, or Walnut Formation (Rodda and others, 1979), is essentially indistinguishable from the Basal Nodular Member of the San Antonio area. The Walnut Formation (includes Bee Cave and Bull Creek members) is a marly, nodular limestone with a thickness of about 45 to 60 feet in the Barton Springs segment. The lithologic characteristics of the Basal Nodular Member of the San Antonio area appear to be essentially the same as the Walnut Formation of the Austin area. The Walnut Formation contains few, if any, minor caves in the study area and appears generally to act as an aquitard upon which the groundwaters of the Edwards Aquifer are perched. It should be noted that some caves have been breached through the Walnut Formation and developed at the top of the Glen Rose in areas to the south of the study area, in Natural Bridge Caverns and Bracken Bat Cave (Abbott, 1973), as well as to the north of the study area in Buttercup Creek Cave (Russell, 1993). Based on examination of the outcrop of the Walnut and upper Glen Rose in the study area, as well as limited information from water wells in the study area, the Walnut and upper Glen Rose generally do not appear to be capable of producing large volumes of water and therefore were not considered in estimates of the available water within the Barton Springs segment of the Edwards Aquifer. The elevation of the top of the Walnut was estimated and generalized within gross blocks, based on data from control points and mapping of the rock outcrops (Figure 3.4).

The Kainer Formation includes the Dolomitic, Kirschberg, and Grainstone Members. The Dolomitic Member has a thickness that is typically about 120 feet in the Barton Springs segment. Solution cavity development within the Dolomitic Member appears to be highly influenced by bedding layers, which vary in permeability. A thick, fossiliferous bed, which begins about 35 feet above the base of the Dolomitic Member, appears to be high in permeability. The seven-feet thick rhythmic beds, positioned near the middle of the Dolomitic Member, behave as limited flow barriers. Although the permeability of the Dolomitic Member can be very high locally, restrictions by the less permeable bedding generally give it only moderate permeability. Therefore, in areas on the western and southern sides of the Barton Springs segment where the water levels have only saturated the Dolomitic Member (or where the more permeable beds above are dry), the groundwater yield can be expected to be limited.

Overlying the Dolomitic Member is the Kirschberg Member, a 65-to 75-feet thick evaporitic limestone consisting of crystalline rock and chalky mudstone with chert nodules and lenses. The name "Kirschberg" was derived from the original German name for Cherry Mountain near Fredericksburg, where a gypsum horizon is present (Barnes, 1944). The Kirschberg was probably formed in a highly saline, tidal flat (Rose, 1972). This member appears to be the most porous and permeable of the entire Edwards Aquifer within the Barton Springs segment. The porosity and permeabilty of the Kirschberg generally originated from the dissolution of gypsum and other easily soluble or soft minerals. This dissolution left open spaces (voids) that often resulted in the collapse of the overlying beds. Consequently, the Kirschberg contains the majority of the known cave and sinkhole development in the study area (William Russell, Texas Speleological Survey, personal communication, 1996).

The Grainstone Member overlies the Kirschberg Member and is the uppermost member of the Kainer Formation. The Grainstone Member is about 45-to 60-feet thick and consists of a hard, resistant, thickly bedded, and tightly cemented grainstone. Fracturing and local dissolution can contribute locally high porosity and permeability, particularly in the lower half of this member. Many caves in the Barton Springs segment have entrances in the lower grainstone member, although most of the caves have developed within the underlying Kirschberg Member.

Across the Barton Springs segment, the Person Formation thins from a thickness of about 180 feet in the southeastern portion of the study area to less than 50 feet on the northwestern section near the Colorado River. As discussed previously, this thinning may be attributed to erosion prior to deposition of the overlying Georgetown Formation (Rose, 1972).

The Regional Dense Member is the lowermost member of the Person Formation, consisting of a dense, fine-grained mudstone. This member has a thickness of 20 to 30 feet in the Barton Springs segment. The Regional Dense Member has little porosity or permeability except that contributed by fractures and limited dissolution. This member is probably the least porous and permeable within the Edwards Aquifer, and locally perches groundwater. However, faults, fractures, caves, and solution cavities can locally reduce the confining effects of this subdivision. Only a few caves are known to be developed within or breach the Regional Dense Member, and these are generally vertical shafts.

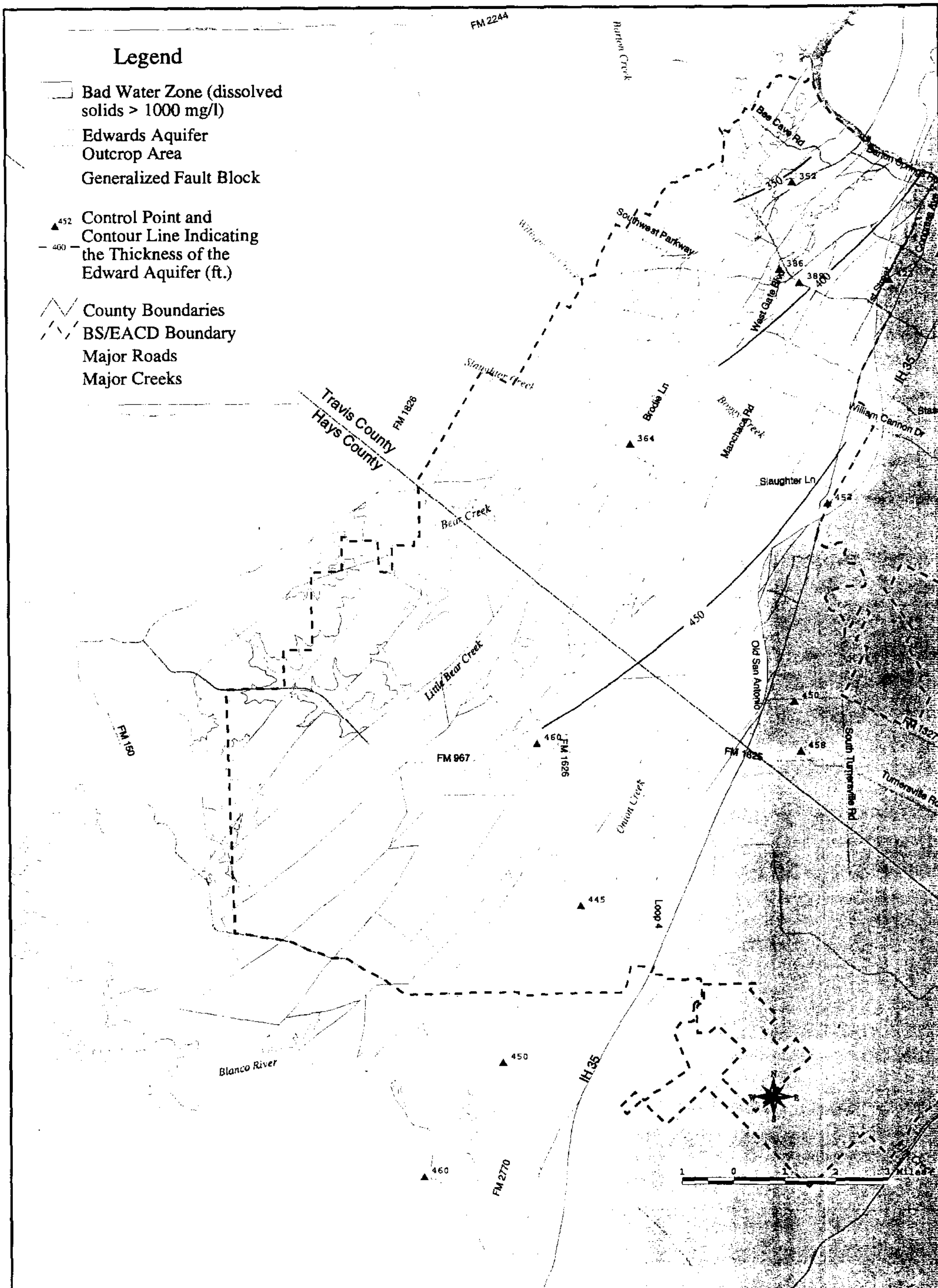

Figure 3.3

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File Name: yldstd13.eps
Location:
/home4/maps/prj nws
Source:
TxDoT Data – Roads, Creeks
TWDB Data – Bad Water Zone
District Data – Thickness of Edwards, Locations of Geological Logs

Generalized Thickness of Edwards Aquifer

Barton Springs segment of the Edwards Aquifer
Northeast Hays and Southwest Travis Counties, Texas

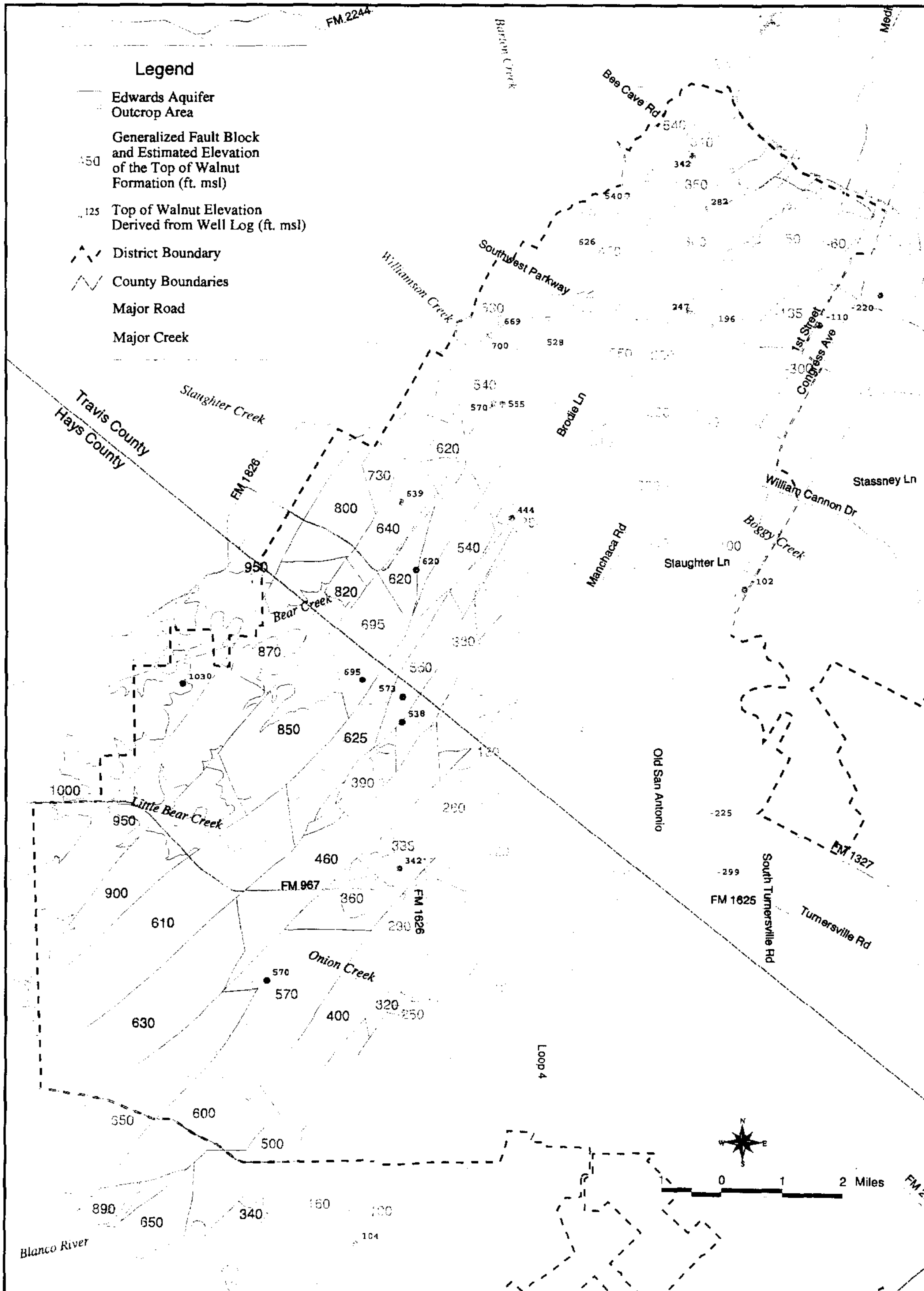

Figure 3.4

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Elevation of the Top of the Walnut Formation

Barton Springs segment of the Edwards Aquifer
Northeast Hays and Southwest Travis Counties, Texas

The Leached and Collapsed Members, undivided, overlie the Regional Dense Member. The combined thickness of the two members ranges from about 80 feet near the Blanco River to less than 20 feet near the Colorado River. The Leached and Collapsed Members, undivided, have porosity and permeability associated with dissolution along faults and other fractures, collapsed bedding, and dissolved burrows and fossil molds. The porosity and permeability of the Leached and Collapsed Members are second only to the Kirschberg in the study area. The Leached Member thins from south to north within the Barton Springs segment, and consequently experiences a decrease in transmissivity. A large number of caves have developed in this interval, possibly perched above the Regional Dense Member.

The Marine Member is present only in the southern portion of the study area in Hays County, where its maximum thickness is less than about 70 feet. The thickness of the Marine Member can be observed to be only about five feet thick on Bear Creek in the southern edge of Travis County. The Marine Member has similar hydrogeological characteristics to the Leached and Collapsed Members, and its porosity and permeability seem to result from dissolved fossils and solution enlargement along fractures. The Marine Member is the uppermost unit of the Edwards Group in the study area.

The Georgetown Formation generally has a low porosity and permeability based on outcrop observations. This subdivision is not water-yielding in the Barton Springs segment, and generally serves as a semi-confining layer in the artesian zone of the Edwards Aquifer. A few vertical shafts, including Antioch Cave, breach through the Georgetown into the underlying Edwards Group. No wells are known to produce from the Georgetown Formation alone in the study area. A USGS investigation of the Georgetown Formation north of the study area near Georgetown, measured hydraulic conductivities (a measure of aquifer permeability) of 0.0003 to 0.00006 gallons per day per foot squared, in four out of six test wells (Land and Dorsey, 1988). This range of permeability would be considered comparable to a clay-type media. A fifth well contained water only erratically and a sixth well seemed to respond to a nearby water reservoir. Based on the four aquifer tests, along with streamflow, long-term water level correlations, and water-quality information, the USGS investigators concluded that the Georgetown Formation could show a high degree of hydraulic connection with the underlying Edwards Group, but that the Georgetown did not demonstrate the uniform yield characteristics of an aquifer unit. However, because of the potential for solution-cavity development along fractures, as well as the uncertainty in distinguishing the units on drillers logs and geophysical logs, the Georgetown is generally considered part of the Edwards Aquifer. The elevation of the top of the Georgetown Formation across the study area is generalized in Figure 3.5, based on geological control points and mapping of the outcrop surface.

Overlying the Edwards Aquifer are the Del Rio Clay, Buda Limestone, Eagle Ford Shale, Austin Chalk, and Taylor Clay of the Upper Cretaceous (Table 3.1). The Del Rio Clay probably serves as an effective aquitard considering its 60-feet thickness and its tendency to smear rather than fracture. Overlying the Del Rio Clay, the Buda has a thickness of about 40 to 50 feet in the Barton Springs segment. The Buda Limestone typically contains solution-enlarged fractures, burrows, and bedding planes in outcrops, and produces a number of minor springs. Because of its limited thickness as well as its limited porosity and permeability, the Buda does not yield sufficient water to be considered an aquifer. Few caves are known to have formed within the Buda over the Barton Springs segment. The Eagle Ford Group overlies the Buda Limestone and is a calcareous, sandy shale unit, with a thickness of about 30 to 50 feet.

The Austin Group, which overlies the Eagle Ford Group, is a chalky limestone with a thickness of about 230 to 260 feet. The Austin Chalk generally shows very low permeability, but locally can develop solution-enlarged fractures and conduits that may be capable of producing limited amounts of water.

The Taylor Group consists of a dark calcareous clay that is present only to a limited extent on the eastern edge of the usable portion of the Barton Springs segment. The Taylor Clay is not known to be water-bearing over the Barton Springs segment.

3.1.2 The Influence of Geologic Structure on Hydrogeology

Faults and fracture zones can influence groundwater flow and water quality in the Edwards Aquifer (Baker and others, 1986 and Kastning, 1986). Faults and other fractures represent zones of weakness along which solution is enhanced. The influence of fractures is particularly apparent for solutional enlargement within the less permeable strata. As a result, the permeability distribution in the Edwards Aquifer is typically not equal in all directions (anisotropic). Drawdown from the draining of the Barton Springs Pool can be observed in wells up to 2.5 miles away along the direction of faulting (Slade and others, 1986). Many of the springs discharge along or near faults, including Barton Springs. Some faults may place permeable water-bearing units against lower permeable units and may act as a barrier or boundary, and locally restrict the groundwater flow and productivity of the Edwards Aquifer (Maclay and Small, 1983). In addition, faults may place two normally isolated aquifers adjacent to one another, resulting in the mixing of different water types. Elevated levels of sulfate, strontium, and fluoride found in the Edwards Aquifer along the eastern side of the potable Barton Springs segment probably represent lateral leakage across major faults from the Glen Rose (Senger and Kreitler, 1984). It is believed that these major faults place water-producing intervals of the Glen Rose adjacent to the lower section of the Edwards Aquifer.

As depicted in Figure 3.1, a number of major faults were mapped subparallel to the Blanco River. These faults are imprecisely located due to lack of access but are based on large changes in surface rock types across this area. These faults may present major barriers to southward groundwater flow (Stein, 1995) and should be verified in future studies as site access becomes available.

3.1.3 Karst Development

Karst terranes are areas characterized as containing caves, sinkholes, sinking streams, and springs. Karst features are typically found where carbonate rocks, such as limestone and dolomite, are present, due to the greater relative solubilities of these rock types. A karst aquifer consists of two zones: the vadose (or unsaturated) and water-filled phreatic (or saturated) zones.

The Edwards Aquifer and other karst aquifers demonstrate groundwater flow that varies from slow, uniform diffuse-type (continuum) flow to rapid, flashy conduit (discrete) flow (White, 1969; Quinlan and Ewers, 1985). Diffuse flow occurs as flow between small pores or as a tributary of smaller conduit networks. As karst systems develop and mature, they shift

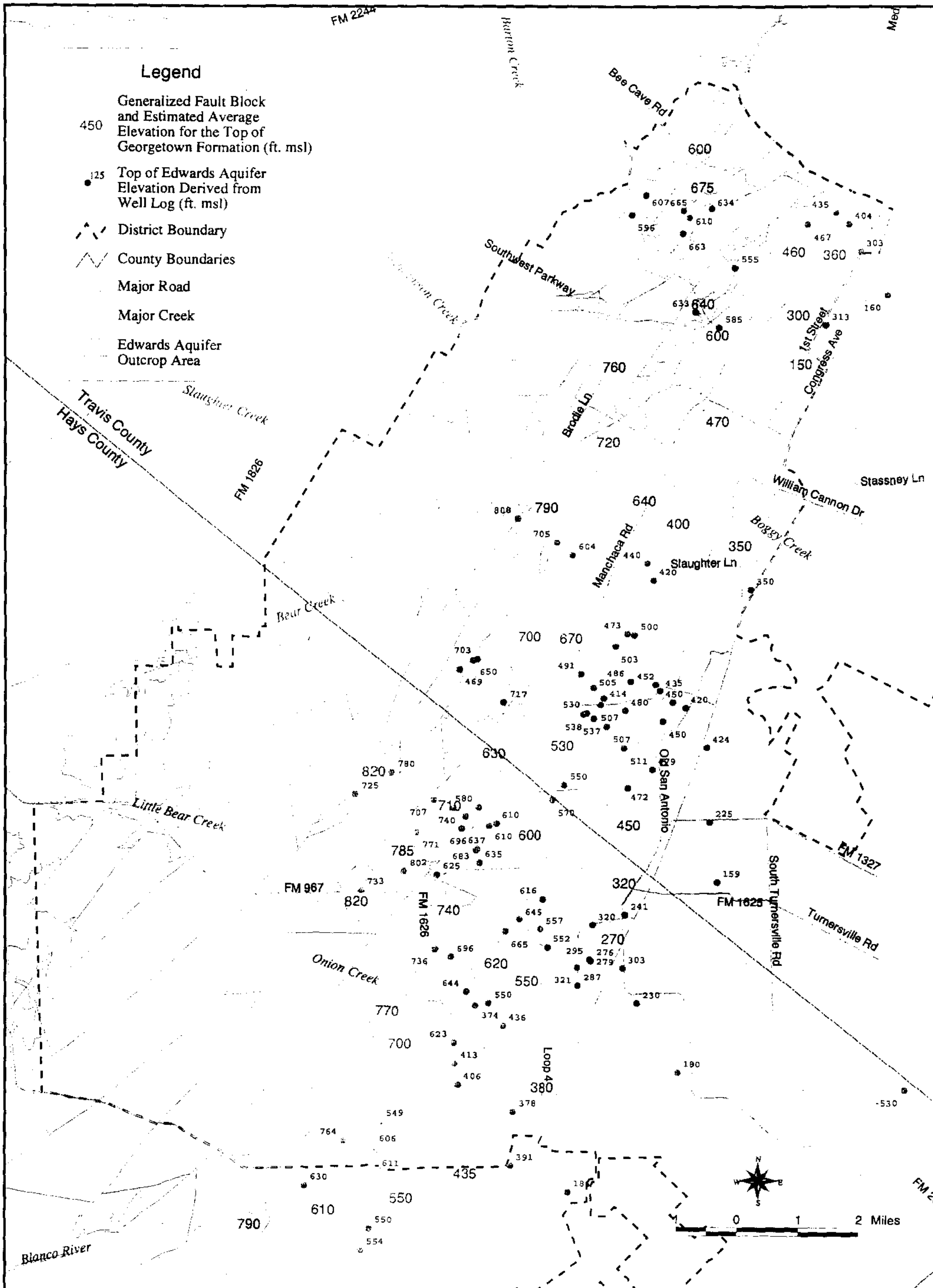


Figure 3.5

Date: 2/5/1997
Created By: Shu Liang

Elevation of the Top of the Edwards Aquifer

Barton Springs segment of the Edwards Aquifer
Northeast Hays and Southwest Travis Counties, Texas

toward more conduit-type flow as preferred pathways develop. The conduit systems become integrated with time into well organized underground drainage systems that resemble surface streams in behavior (White, 1977, p. 182). As a consequence, groundwater flow through karst aquifers is anisotropic.

The conduit development is influenced by the lithology, as described in 3.1.1. Veni (1992) noted that vertical shafts developed along fractures within beds of low primary permeability and solubility within the Austin area, as predicted by White (1988, p. 21). Vertical shafts may also occur within beds of high primary permeability where perched above beds of that low primary permeability that have been breached by solution-enlarged fractures (Veni, 1992). Horizontal caves tend to develop along strata with a high primary permeability or solubility. A detailed correlation of known cave locations and their volumes within the study area to the underlying geologic unit has not been performed.

3.2 Assessment of Available Water (Low-Flow Conditions)

With the geological framework of the aquifer established, the availability of groundwater was estimated by measuring the height of groundwater in the aquifer (saturated thickness) and through aquifer testing, where the aquifer response to pumping is measured.

3.2.1 Basic Hydrogeology of the Barton Springs Edwards Aquifer

Recharge to the Barton Springs segment occurs within a 90-square-mile *outcrop area*. The *recharge zone* encompasses the outcrop area of the Edwards Aquifer. Recharge to the Barton Springs segment occurs within the watersheds of Onion, Little Bear, Bear, Slaughter, Williamson, and Barton creeks. Some recharge occurring in Barton Creek, Eanes (Dry) Creek and Bee Creek is believed to flow through the Rollingwood subsegment and discharge through springs along the south side of the Colorado River. Flow path and groundwater divides within the Barton Springs segment are largely based on indirect measurements, such as water levels, geochemistry and creek flow, and are not well defined. Direct measurement of groundwater flow paths and travel times through groundwater tracing is currently being conducted by the BS/EACD and City of Austin on two of the five watersheds.

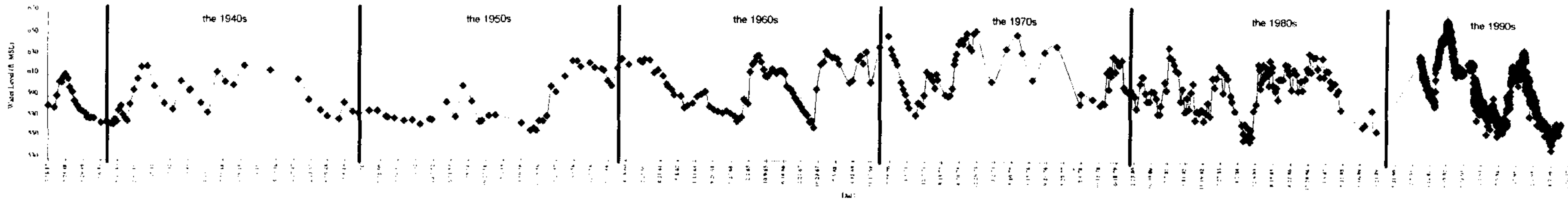
The outcrop area is bounded by: the Colorado River to the north; the *contributing zone*, or the outcrop of the underlying Walnut and Glen Rose Formations to the west, and the outcrop of the Del Rio Clay and other overlying units to the east. A groundwater divide, which is believed to fluctuate around the Buda and Kyle areas between Onion Creek and the Blanco River (Garza, 1962; Stein, 1994), separates flow directed toward Barton Springs from flow towards San Marcos Springs. The southern groundwater divide may fluctuate because it may be influenced by the combination of pumping by major water systems (including the City of Kyle), recharge along Onion Creek, changes in rainfall and water levels, and inferred barrier faults that subparallel the Blanco River (Stein, 1994). The usable portion of the Barton Springs segment is limited to the east by a zone of highly mineralized groundwater (or the *bad-water zone*), containing total dissolved solid concentrations greater than 1,000 mg/l. For the remainder of this report, the Barton Springs segment of the Edwards Aquifer (or Barton Springs Edwards Aquifer) refers only to the usable portion west of the bad-water line, which was approximated to extend along South Congress Avenue south of Town Lake and Interstate Highway 35 south of Austin.

A long-term average of 50 cubic feet per second discharges from Barton Springs, which makes up the largest volume discharge of the Barton Springs segment (Slade, Dorsey, and Stewart, 1986). Smaller discharge occurs at Cold Springs, which is partially submerged by the Colorado River. Flow from the exposed portion of the spring has been measured to be about two to four cubic feet per second (Brune, 1981). Bee Springs discharges near the mouth of Bee Creek on the far northwestern edge of the Barton Springs segment. The exposed portion of Bee Springs flow has been measured at a rate of at least 0.2 cubic feet per second (Brune, 1981).

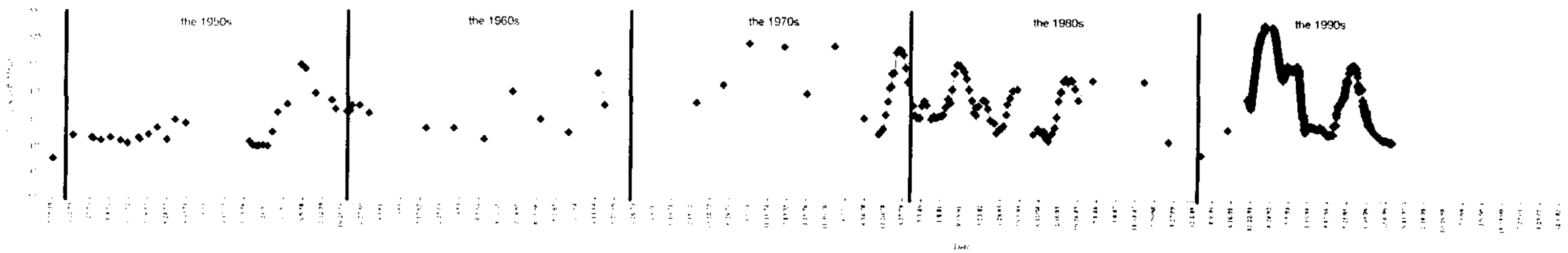
Groundwater flows generally northward under *confined* conditions within the artesian zone, which is positioned east of the recharge zone. Under confined conditions, the water level measured in a well will rise above the top of the aquifer, or in this case the Georgetown Formation. In some locations within the artesian zone, the groundwater within the Edwards Aquifer is held under sufficient pressure so that water in a well (or other conduit) connected to the Edwards Aquifer will flow to the surface. In this instance the water is under *flowing artesian conditions*. Hill (and Vaughn, 1896-7) noted that some of the springs within the Balcones Fault zone flowed from the Edwards Aquifer under artesian conditions while others flowed under the force of gravity. East of the Edwards Aquifer outcrop, springs along Onion, Slaughter, Bear, Boggy, and Williamson creeks contribute to the creekflow. Many of these springs discharge from thick alluvial deposits, Austin Chalk, and Buda Limestone that are present here, although it has not been determined whether or not some of these springs may actually originate from the Edwards Aquifer. As indicated in Figure 3.7, there are a few areas near the eastern edge of the usable Barton Springs Edwards Aquifer where the water level in a well or other conduit can rise to the land surface during low aquifer-flow conditions, whereas, during higher aquifer-flow conditions, flowing artesian conditions are possible across a wider area. For the remainder of this report, any artesian flows on the eastern side or unmeasured springflows from the Edwards Aquifer into the Colorado River are assumed to be insignificant in the water budget of the aquifer.

3.2.2 Historical Water-Level Fluctuations and Low-Flow Water Level Elevations

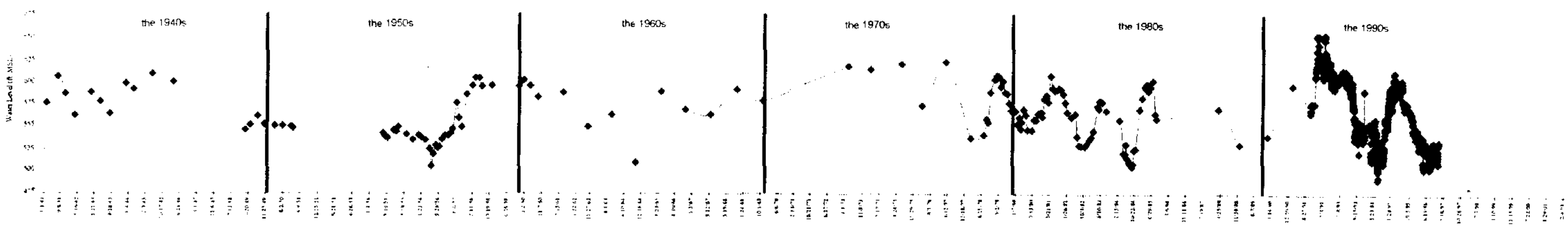
Historical water level data from the Texas Water Development Board and U.S. Geological Survey were compiled from three monitor wells with a long history of measurement. These three wells, 58-50-101 in Buda, 58-50-801 in San Leanna, and 58-50-301 in southeast Austin, have been equipped with continuous (daily-maximum) water-level monitoring probes and maintained by the BS/EACD since 1991 (Figure 3.2). The three monitoring wells only penetrate the top of the aquifer. As indicated in Figure 3.6, water levels can fluctuate more than 100 feet from wet to dry years. Natural fluctuations can be expected to be greater, further from the discharge points (further in the recharge zone), and along areas that are well-connected hydraulically to recharge and discharge points. High fluctuations can also be expected near pumping wells. The three charts presented show daily maximum water levels since 1991 to minimize the effects of nearby pumping and to show daily levels that are more representative of the aquifer



58-58-101



58-50-301



58-50-801

Historic Water Levels Measured in Three Primary Monitor Wells

Barton Springs Segment of the Edwards Aquifer
Northeast Hays and Southwest Travis Counties, Texas

Figure 3.6

system. The Franklin monitor well (58-58-101) shows sharper oscillations in seasonal and yearly cycles with time. Sharp oscillations in water-level cycles may reflect intensified groundwater abstraction (Mandel and Shiftan, 1981). Note that the Franklin well is located in close proximity to the City of Buda municipal supply well, so the sharper oscillations may reflect greater usage by the municipality rather than aquifer-wide changes. Water level cycles from the other two wells are not as clear due to varying frequencies of measurement. The amplitude of the water-level cycles remained high during the early 1990s as they have measured historically, suggesting that the aquifer is capable of being fully replenished by natural recharge, given sufficient rainfall. The dramatic response of the aquifer to recharge, the variation in measurement for the three wells and the change in measurement style (from random measurements to continuous recording of the daily maximum level) complicate attempts to determine the "average" trend of the water levels. In mid-1996, daily maximum water levels from these three wells temporarily reached or dropped below historical water levels measured during the drought of the 1950s.

Water levels were measured across the aquifer from May 1996 to October 1996 to map the water-level surface during low-flow aquifer conditions (Figure 3.7). For the purposes of this study, low-flow conditions are considered to be in effect when the flow at Barton Springs is less than 35 cubic feet per second for an extended period. A similar water-level map for low-flow aquifer conditions from August 1978, was presented by the USGS (Slade, Dorsey, and Stewart, 1986). A number of wells in the outcrop area of the Barton Springs segment encountered perched water flowing within the unsaturated or vadose zone above a deeper saturated or phreatic zone. Wells with perched water were distinguished by significantly higher water-level elevations than other nearby wells in all directions, and were usually associated with audible cascading water where the well penetrated through a perched zone to the actual water table. Water-level measurements from perched water zones were excluded from Figure 3.7. Low-flow conditions were selected in order to conservatively estimate the groundwater available when the yield is relatively low. Historical water level measurements collected by BS/EACD, the U.S. Geological Survey, and Guyton and Associates (Stein, 1994) at wells during other low-flow periods were also considered.

3.2.3 Saturated Thickness and Estimated Aquifer Yield

As the well is being pumped at a sufficient rate, the water level in the pumping well and nearby wells will show a decline in water levels known as *drawdown*. For any aquifer, as the discharge rate increases, the drawdown will also tend to increase. The ratio of the pumping discharge rate to the amount of drawdown that results is known as the *specific capacity*. The specific capacity for a well will tend to decrease as the pumping rate or pumping period is increased. If the well is pumped at a higher rate than the aquifer can replenish, the water level will drop below the level of the pump and the well will not be able to discharge until sufficient time has passed for the aquifer to replenish the well. The well construction characteristics may limit the rate of water entering the well. When the well pump is shut off, the water levels will immediately rise in the pumping well during the *recovery* phase as the aquifer replenishes the well. Like the term permeability, *hydraulic conductivity* is a measure of the ease which fluids move through a media, although hydraulic conductivity considers the fluid type as well as the permeability of the rock matrix. This study is concerned with water at standard temperatures, and for simplicity the hydraulic conductivity and permeability are used interchangeably. The rate at which groundwater flows through the entire water-saturated thickness of the aquifer to a well is quantified as the *transmissivity*. The transmissivity represents the hydraulic conductivity divided by the thickness of the aquifer. Because transmissivity varies with the water-saturated thickness of the aquifer, it will decrease with lowering of the aquifer water levels. The change in transmissivity due to water-level fluctuations is anticipated to be particularly apparent where water-filled caves high in the well section become dry (Raymond Slade, USGS, 1995, BS/EACD Technical Advisory Committee for Hydrogeologic Studies discussion). Portions of the aquifer where the transmissivity is less than about 1,000 gallons per day for each foot of drawdown (gpd/ft) are sufficient only for a limited number of domestic wells or other low-yield applications (Driscoll, 1986). Transmissivities of 10,000 gpd/ft are generally required for municipal supplies or other large supply uses. Naturally, where a large number of wells utilize the same aquifer, *well interference* may limit the amount of water available for each system. The volume of water available within an unconfined aquifer consists of the *specific yield*, or the fraction of water within the rock matrix that can be readily drained under the force of gravity, and the *specific retention*, or the remaining fraction of water that is held by the aquifer. In confined portions of the aquifer, the water is held under pressure by the compression of the aquifer matrix. Drawdown measured in pumping wells in confined areas results from the release of pressure and expansion of the aquifer matrix, until the aquifer is dewatered below the top of the aquifer. In confined aquifers, the *storativity* is the volume of water released by the aquifer over an area per unit of drawdown that results. The storativity is less than about 0.001 (Driscoll, 1986, p.68) in confined aquifers. The storativity equals the specific yield in unconfined aquifers.

Several previous studies have assessed the porosity characteristics and available yield of the Barton Springs segment of the Edwards Aquifer. The results of these studies are summarized below:

The U.S. Geological Survey estimated a mean specific yield of 0.017 (1.7 percent) based on the volume of water discharged from Barton Springs from the highest (110 cfs) to lowest (10 cfs) aquifer flow conditions (Slade, Dorsey, and Stewart, 1986). As noted in their report, this measurement of specific yield is based on only 3% of the water-saturated aquifer and may not be representative of the entire aquifer, although it is probably the best estimate to date. Using the estimate for specific yield and the water levels during average springflow conditions (50 cfs), the USGS estimated about 306,000 acre-feet of groundwater stored within the aquifer. They estimated that 204,000 acre-feet is present above the elevation of Barton Springs during these conditions. The volume of water discharged from high to low conditions, or the maximum potential transient storage, was estimated to be about 31,000 acre-feet. The storativity of the confined portion of the aquifer was computed to range from 0.00003 to 0.00006. During low flow conditions of 25 cfs at Barton Springs, the volume of saturated rock was estimated by the USGS to be 17,300,000 acre-feet across the Barton Springs segment.

The U.S. Geological Survey developed a two-dimensional numerical model to simulate flow in the Barton Springs Edwards Aquifer and predict the effects of future pumpage (Slade, Ruiz, and Slagle, 1985). The model predicted declines in water level of up to 100 feet in places across the aquifer, based on increases in pumpage to 12.3 cfs (9,000 acre-ft/yr), which equals 25 percent of the long term recharge, and resulting in complete dewatering of the

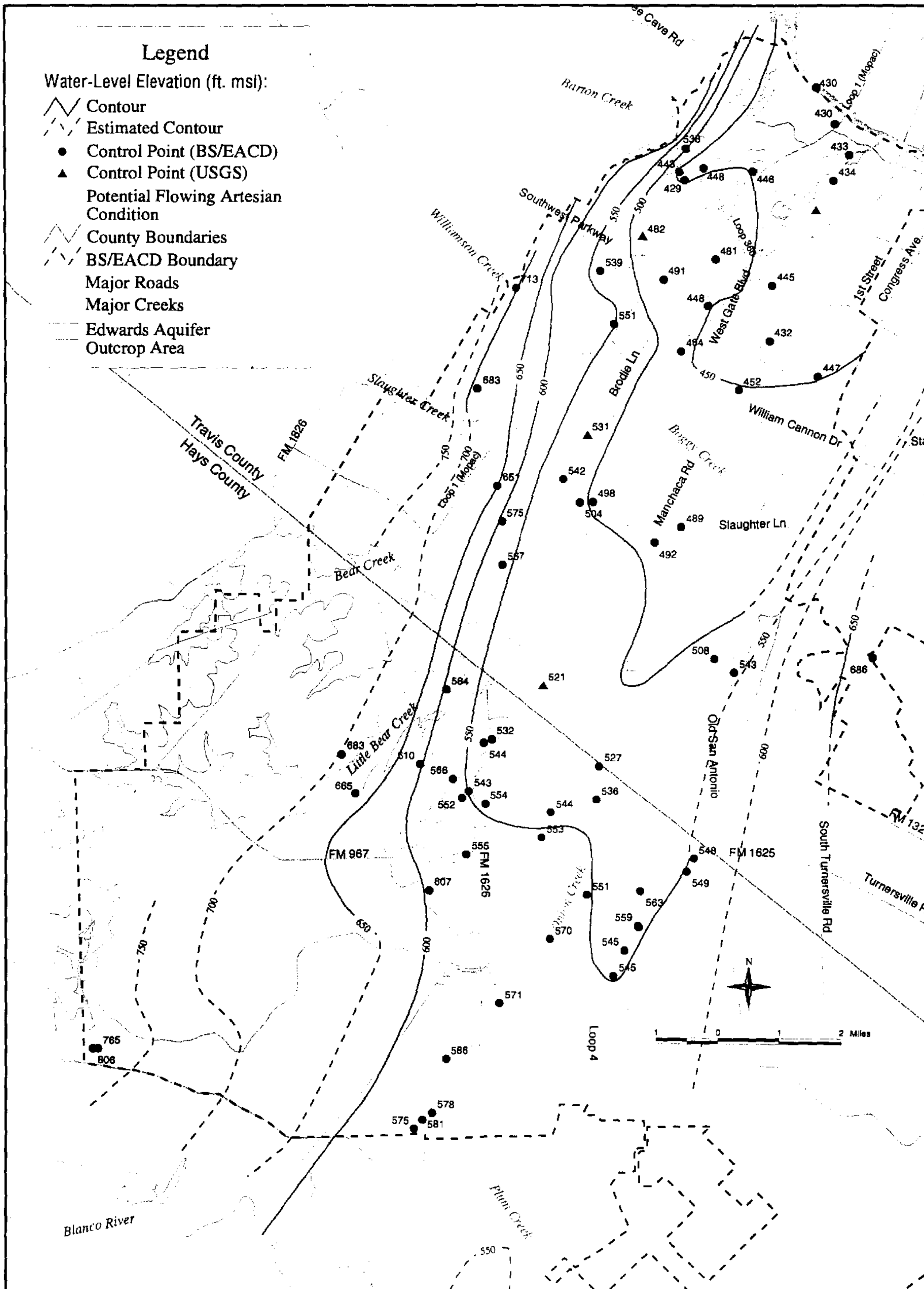


Figure 3.7

Low-Flow Water Level Elevations (May - Nov. 1996)

Barton Springs segment of the Edwards Aquifer
Northeast Hays and Southwest Travis Counties, Texas

Date: 2/5/1997
Created By: Shu Liang

southwestern portion of the study area. They found that a mean specific yield of 0.014 best simulated measured water-level responses in a numerical groundwater model of the Barton Springs segment.

Senger and Kreitler (1984) estimated the volume of water above the baseflow level of Barton Springs using a springflow recession curve as springflow dropped from the average flow of 50 cfs to 34 cfs. This volume of transient storage groundwater was estimated to be 21,300 acre-feet during average Barton Spring flow (50 cfs). Senger (1983) had estimated the average storativity of the aquifer to be 0.0075 (0.75 percent) based on springflow recession and water-level recession curves, but qualified that this figure could be too high based on the wide variation in average annual discharge (Senger and Kreitler, 1984).

The Edwards Aquifer Research and Data Center utilized the data set of the USGS in a Texas Water Development Board finite difference model (Wanakule, 1989). Like the USGS model, this model predicted that a significant area (4.23 to 5.1 square miles) on the western side of the Barton Springs segment of the Edwards Aquifer would become dewatered following pumpages of 4,900 to 9,000 acre-feet/year.

The University of Texas Center for Research in Water Resources (Barrett and Charbeneau, 1996) constructed a lumped parameter model. In this model each watershed was simulated as a tank connected by pipes. The water level of each tank represented groundwater levels of a well in each watershed with a long historical record. The researchers found that continuum (water moving gradually through small pores) model of the aquifer matched water level responses to recharge events much better that a discrete turbulent pipe flow model. The specific yield values input into the model ranged from 0.02 to 0.09. Barrett believes that these specific yield values exceed the aquifer-wide average because the simulated water levels were all along the most porous section of the aquifer (Barrett, 1996, personal communication). Although the model was not run for 1996, during similar low aquifer flow conditions of October 1984, the model simulated 180,000 acre-feet of transmittable water. In October 1984, Barton Springs flow was 25 cfs. Based on data presented in their study, the volume of water stored above the elevation of Barton Springs was estimated to be 45,000 acre-feet during low-flow conditions of October 1984.

The saturated thickness of the Barton Springs segment of the Edwards Aquifer was estimated across the study area, based on the low-flow water levels, and the elevation of the top of the base and top of the Edwards Aquifer (Figure 3.8). The saturated thickness represents the thickness of the Edwards Aquifer (above the Walnut Formation and below the top of the Georgetown Formation) that is saturated with groundwater. Many of the blocks on the far western and southern sides of the study area are expected to be unsaturated or contain only a limited saturated thickness. Where the saturated thickness of the Barton Springs Edwards Aquifer is less than about 120 feet, only the moderately permeable Dolomitic Member is saturated. A significant increase in aquifer yield can be expected where the saturated thickness exceeds about 120 feet and the highly permeable Kirschberg Member begins to fill with groundwater. The volume of saturated thickness, or the volume of rock material and groundwater, within the usable portion of the Barton Springs segment of the Edwards Aquifer during low-flow conditions of May to November 1996 was estimated to be 21,252,000 acre-feet. This volume is similar to the value of 17,300,000 acre-feet estimated by the USGS (Slade, Dorsey, and Stewart, 1986) for spring discharge conditions of about 25 cfs. This volume of saturated thickness is not be confused with the volume of available water, which makes up a small fraction. In order to estimate the amount of available water within the aquifer from the volume of saturated thickness, the specific yield must be known.

Aquifer tests have been conducted within the study area to measure or estimate the aquifer characteristics, including transmissivity, storativity, and specific yield at specific sites across the aquifer (Figure 3.9). Aquifer tests involve the measurement of drawdown associated with the pumping of a test well. Generally the best data was obtained from tests conducted over a long period (8 to 24 hours or more) at a high rate of discharge (500 gallons per minute or more) with numerous local observation wells. Following the pumping phase of the test, the recovery of water levels was often measured for verification of the pumping results. The pumping drawdown and recovery response were compared to analytical models of ideal response using Aqtesolv for Windows software developed by Geraghty and Miller, Inc. (Duffield, 1996). Adjustments were made to account for pumping or observation wells where the interval known to be open to the aquifer did not extend through the aquifer (*partially penetrating wells*), as described by Hantush (1961). This adjustment considers the ratio of vertical to horizontal permeability. For the purposes of correcting for partial penetrating wells, the horizontal permeability was assumed to be five times greater than the vertical permeability, based on outcrop observations. Most discharge measurements were based on readings from meters with unverified accuracies. A few discharge measurements were measured using a graduated bucket. In many tests verified by BS/EACD or reported by the well owner representative, the pumping rate was not constant throughout the test. Where variations in pumping rates were documented, the analytical solution was adjusted to account for the unsteady flow (Birsoy and Summers, 1980). In some cases, the well construction may limit the yield that can be withdrawn from the aquifer. None of the aquifer tests performed included step-drawdown tests from which the well efficiency could be determined. Consequently, the aquifer test results were not corrected for well efficiency. Mathematical corrections incorporated within the Aqtesolv software were made to account for the well-bore storage. The four basic analytical models that were used are described below:

1) A confined solution for the pumping and recovery of a homogeneous, isotropic aquifer of uniform thickness and infinite areal extent (Theis, 1935) was applied to each aquifer test. This model assumes that flow occurs through small connected pores (continuum flow) as described mathematically by Darcy, and that the flow approached the well equally in all directions as *radial flow*. Because the Edwards Aquifer is anisotropic, some discrete flow occurs through solution-enlarged caves, enlarged bedding planes, and fractures, while some continuum flow occurs more slowly through small pore spaces. Consequently in many of the aquifer tests where multiple observation wells were monitored, flow to the well was uneven, as areas connected to the well by openings and fractures experienced greater drawdown while other sites that were separated by faults or were not well connected showed less drawdown. The distribution of drawdown may also be influenced by the presence of hydrologic barriers (such as faults that place lower permeable geologic units adjacent to the aquifer in which the well is pumped) or recharge boundaries (such as recharging creeks, ponds, or large water-filled caves).

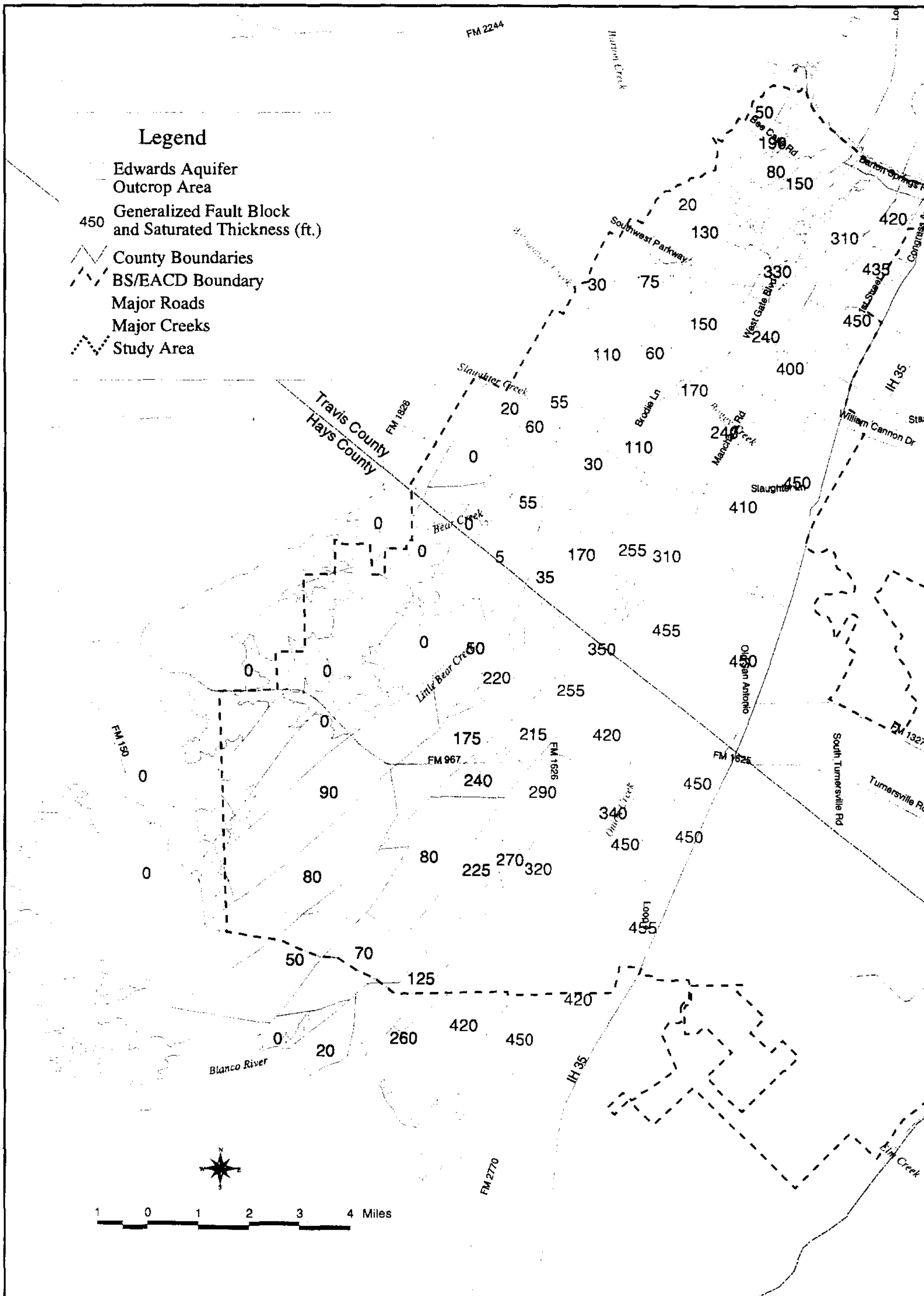


Figure 3.8

Saturated Thickness (May - Nov., 1996)

Barton Springs segment of the Edwards Aquifer
Northeast Hays and Southwest Travis Counties, Texas

2) A modified straight-line solution for the pumping of a homogeneous, isotropic aquifer of uniform thickness and infinite areal extent (Cooper and Jacob, 1946) was applied to each aquifer test. This solution is a generalized approximation of Theis (1935), which allows an estimation of the transmissivity and storativity during different portions of the test.

3) Solution for a double-porosity system in a fractured aquifer system of infinite areal extent with uniform thickness (Moench, 1984) was compared to the results from each test. This model assumes that the aquifer consists of slab-shaped blocks. The rock matrix is assumed to consist of a lower permeability material, while the fractures are of higher permeability. The thickness of the slab blocks was assumed to be 50 feet.

4) Solutions for homogeneous unconfined aquifers of infinite areal extent and uniform thickness were applied to aquifer tests performed in unconfined areas. A correction to Theis (1935) or Cooper-Jacob (1946) allows the modeling of an unconfined aquifer response, assuming no delayed response of the aquifer matrix. A solution by Neuman (1974) that considers the effects of delayed gravity response was also utilized. An insufficient number of aquifer tests were conducted under unconfined conditions, consequently few measurements of local specific yield were measured in this study. Future studies should attempt to perform aquifer tests on the recharge zone, as large capacity test wells become available.

From the differing solutions for the pumping and observation wells, a single value or range was selected. In general, the water-level response toward the end of the aquifer test was matched more closely than in the initial portion of the test. Note that the withdrawal during some of the better aquifer tests typically amounts to about 1 or 2 acre-feet, and consequently the results represent only a small fraction (about 0.5%) of the entire aquifer. The aquifer tests are reflective of local yields and hydrogeological conditions. The aquifer parameters measured during an aquifer test may vary between differing aquifer flow conditions (Raymond Slade, 1995, USGS, BS/EACD Technical Advisory Committee for Hydrogeologic Studies discussion). The aquifer test results presented in this study were collected over a wide period of time and not collected to necessarily reflect low-flow aquifer conditions. As indicated in Figure 3.9, the transmissivity varies across the aquifer from less than 20 gpd/ft to 600,000 gpd/ft or more. A three to five mile wide high yield zone was estimated where the saturated thickness exceeds 120 feet and transmissivity exceeds 1,000 gallons per day per foot across the Barton Springs segment.

The American Society for Testing and Materials standards for groundwater monitoring systems in karst aquifers (ASTM, 1995, p.5) describe several criteria to evaluate how closely a karst aquifer can be simulated using a continuum analytical model of aquifer test results, although this guide primarily focuses on characterizing groundwater contaminant sites. Because of the aquifer variability, the values for transmissivity derived from aquifer tests will underestimate the groundwater flow rates measured by groundwater tracing or similar techniques. Senger (1983) estimated transmissivity values for six wells (58-50-216, 58-50-301, 58-50-518, 58-50-704, 58-50-801, and 58-50-219; see Figure 3.2) across the Barton Springs segment, based on regression-curve analysis of water-level declines measured by the U.S. Geological Survey. In well 58-50-704, the transmissivity estimated by specific capacity (77,000 gpd/ft) differed tenfold from the transmissivity estimated by Senger (970,000 gpd/ft) from different periods. Although aquifer test information will underestimate travel times for karst aquifers, it remains one of the best available methods for estimating local aquifer productivity. The results of aquifer tests are estimated to be accurate within one order of magnitude (Robert Mace, 1995, Bureau of Economic Geology, BS/EACD Technical Advisory Committee for Hydrogeologic Studies discussion).

For areas where long-term aquifer tests could not be performed or where tests were performed but not sufficiently documented, specific capacity measurements were used to estimate the transmissivity. The USGS mapped values of transmissivity based on specific capacity values reported on 60 well drilling logs (Slade, Ruiz, and Slagle, 1985; De La Garza and Slade, 1986). Alexander (1990) made additional measurements of specific capacity within the Barton Springs segment. An empirical relationship was used by the Bureau of Economic Geology to estimate the transmissivity from the specific capacity, based on about 100 aquifer tests conducted within the San Antonio and Barton Springs segments of the Edwards Aquifer (Robert Mace, in press). The accuracy of specific capacity tests are probably about two orders of magnitude within the actual yield of the aquifer at that scale (Robert Mace, 1995, Bureau of Economic Geology, BS/EACD Technical Advisory Committee for Hydrogeologic Studies discussion). The BS/EACD measured specific capacity from additional wells, compiled these values with previous measurements, and estimated the values of transmissivity from the empirical relationship described by Mace. These estimated transmissivity values are presented in Figure 3.9.

The analytical solutions from aquifer tests performed in the artesian zone indicated that the storativity generally ranged from about 1×10^{-3} to 1×10^{-10}, typically about 1×10^{-5} (Figure 3.10). The very low values for storativity may be inaccurate because they were generally based on tests with unverified measurements using less accurate air lines, or wells with slotted screens. Only one of the aquifer tests was conducted on the outcrop area of the Edwards Aquifer (58-57-6TW) which had an estimated specific yield of about 10^{-4}. Four aquifer tests that were conducted on sites near the recharge zone that were overlain by confining layers, but represented unconfined conditions west of the artesian zone, measured specific yield values of 0.05 (well 58-42-821), 0.02 (well 58-58-127), and 0.005 (58-57-9HC), and about 10^{-4} to 10^{-5} (58-57-308). Only a limited number of aquifer tests have been conducted on the outcrop area to measure the local specific yield. Currently, the best estimate of the specific yield aquifer-wide, is the 0.014 to 0.017 estimated by the U.S. Geological Survey, based on springflow recession curves and simulation responses in their numerical model. Based on this range of specific yield and the volume of saturated aquifer estimated earlier in this section (21,252,000 acre-feet), the volume of water that can be discharged from the aquifer is about 100 billion gallons (300,000 acre-feet). This estimate for water that can be released from the aquifer is not a safe or sustained yield estimate, but represents all of the groundwater that can be released under gravity, and excludes the specific retention. The volume of groundwater that lies above the elevation of Barton Springs (427 feet elevation) in 1996 was estimated to be about 94,000 acre-feet. As noted in Figure 3.4, the elevation of the base of the Edwards Aquifer lies above this 427 feet elevation within almost all of the recharge zone. Our estimate of volume above the elevation of Barton Springs (94,000 acre feet) in 1996 lies between estimates by the lumped parameter model of the Center for Research in Water Resources (45,000 acre-feet) at Barton springflows of 24 cfs, but is less than the estimate by the USGS estimates (204,000 acre-feet) for average-flow conditions (Barton Springs flow at 50 cfs) from 1981. This

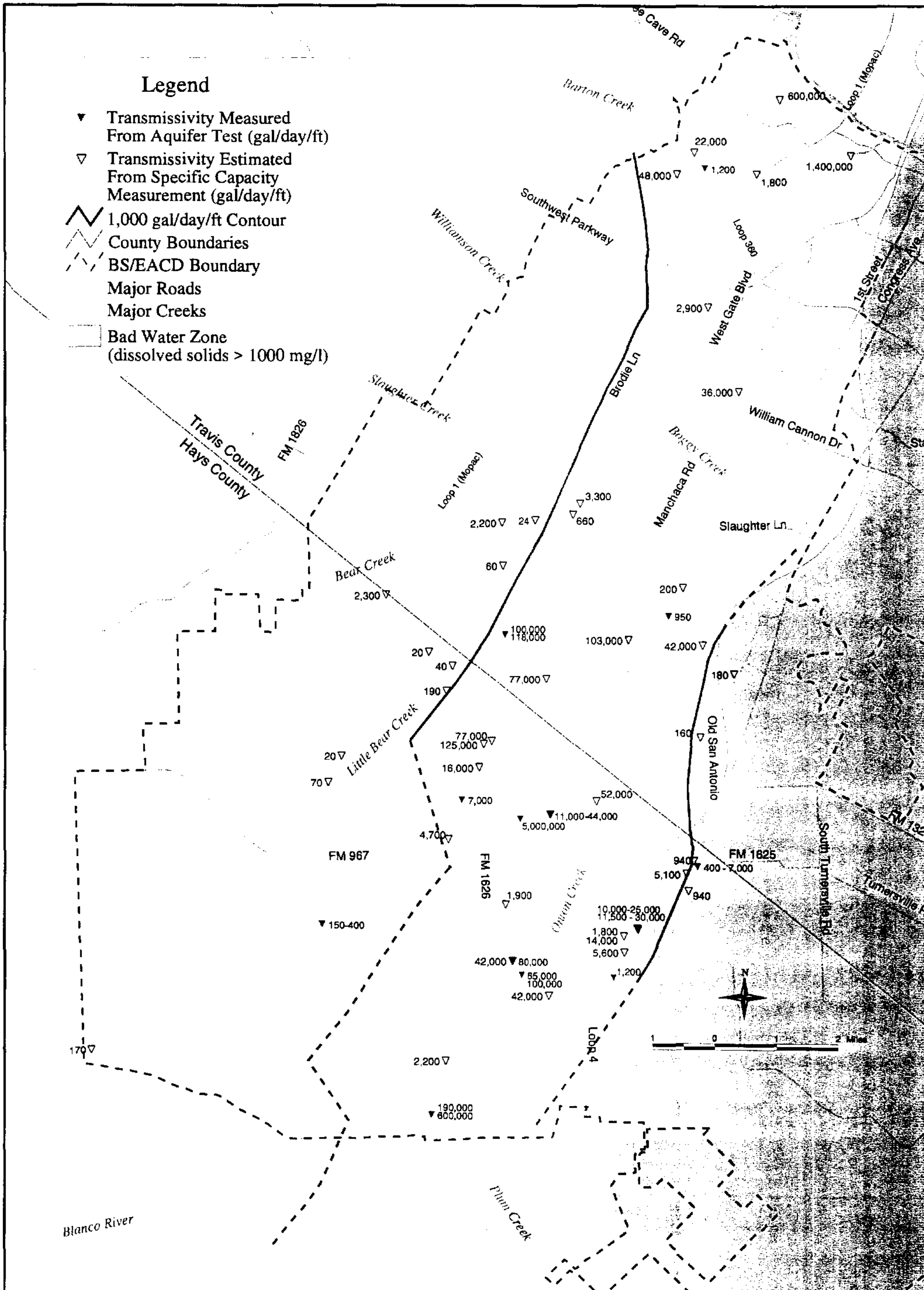


Figure 3.9

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Created By: Shu Liang
File Name: yldsld39.eps
Location: /home4/maps/prj-ravs
Source:
TxDoT Data – Roads, Creeks
TWDB Data – Bad Water Zone (Flores, 1990)
District Data – Locations of Aquifer Test

Transmissivity Calculated from Aquifer and Specific Capacity Tests

Barton Springs segment of the Edwards Aquifer
Northeast Hays and Southwest Travis Counties, Texas

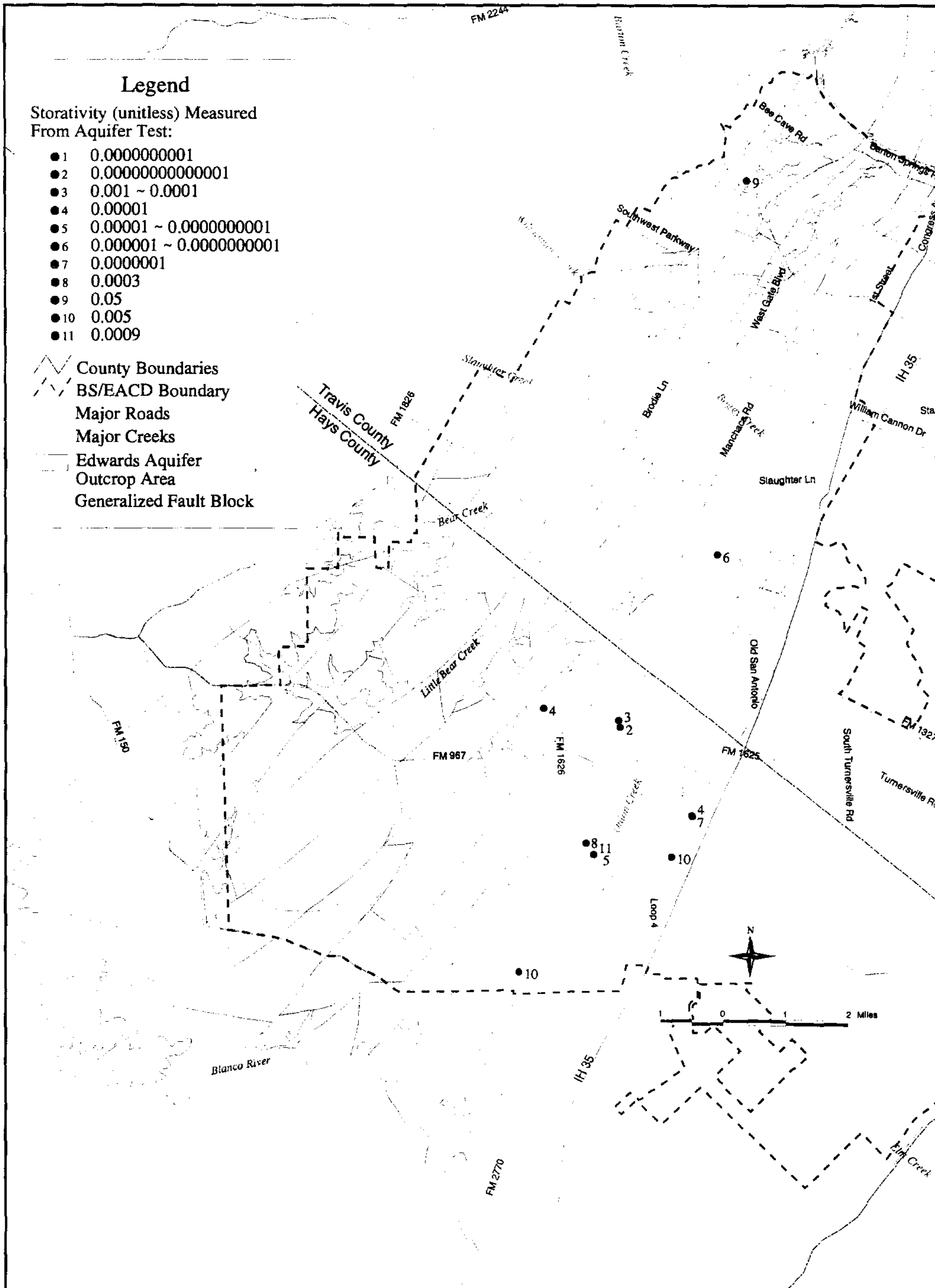


Figure 3.10

Date: 2/5/1997
Created By: Shu Liang
File Name: yldstd310.eps
Location:
/home4/maps/prj-maps
Source:
TxDoT Data -- Roads, Creeks
District Data -- Locations of Aquifer Test

Storativity Values Measured from Aquifer Tests

Barton Springs segment of the Edwards Aquifer
Northeast Hays and Southwest Travis Counties, Texas

difference between the USGS estimates and the estimates calculated in this study may be due to several factors, including: (1) the USGS estimate was for average-flow rather than low-flow and therefore should be higher, and (2) the estimated saturated thicknesses on the southwestern side of the Barton Springs segment are less than those in the USGS study due to recent revisions in the interpretation of the geological framework.

The total volume of rock matrix and groundwater within the usable Barton Springs segment of the Edwards Aquifer during 1996 low-flow conditions was estimated from the saturated thickness and compared to values derived from other studies and methods (Table 3.2). The fiscal year 1996 (September 1995 to August 1996) estimated pumpage of about 1.61 billion gallons (5,000 acre-feet) compares to about 14 percent of the long-term average flow of Barton Springs (50 cubic feet per second or 36,000 acre-feet per year). The 1996 annual pumpage accounted for about 5 percent of the groundwater volume above the elevation of Barton Springs (94,000 acre-feet) and less than 2 percent of the total estimated groundwater in the Barton Springs segment (300,000 acre-feet). However, during extended dry periods the proportion of pumping represents a higher portion of the transient storage than during high aquifer flow conditions. From May to September 1996, the average daily springflow from Barton Springs ranged from 17 to 35 cubic feet per second (up to 41 cfs in short-term response to storms in September) with a daily mean of about 24 cubic feet per second (USGS Water Resources Data Water Year 1996). The monthly August 1996 pumpage consisted of about 127,000,000 gallons (390 acre-feet) reported pumpage, an estimated 19,000,000 gallons (58 acre-feet) domestic well pumpage, and an estimated 1,250,000 gallons (4 acre-feet) of agricultural withdrawals. The total estimated monthly pumpage for August 1996 was 147,250,000 gallons (450 acre-feet), which averaged 8 cubic feet per second distributed over the month. Prior to a major rainfall event in August 1996 that immediately recharged Barton Springs flow, pumpage compared to about 45 percent of the lowest discharge of Barton Springs measured in August 1996 (or about 30 percent of the total aquifer discharge). Note that this short-term proportion between pumpage and springflow does not suggest that pumpage is measurably influencing springflow, but rather the significant impacts of prolonged drought or low recharge conditions. Numerical groundwater models are necessary in order to estimate the relationship between pumpage and springflow under various aquifer flow and pumpage scenarios.

Sections 2 and 5 of this report describe the projected demands from the Barton Springs segment of the Edwards Aquifer. It is projected that by the year 2016, total pumpage demands will require about 6,900 acre-feet per year, which averages about 9.6 cubic feet per second. On an average, the total projected pumpage is estimated to constitute about 17 percent of the current average aquifer discharge of springflow and pumpage. In 2016, the total annual pumpage is projected to withdraw about 2 percent of the total volume of groundwater available within the Barton Springs segment (300,000 acre-feet), or about 7 percent of the groundwater above the elevation of Barton Springs (94,000 acre-feet), under low flow conditions similar to 1996

3.2.4 Other Factors That May Influence the Available Aquifer Yield

It has been long hypothesized that heavy mining of the usable Edwards Aquifer groundwater resources could result in a shifting of the high saline (sodium-chloride) zone to the west. The Texas Water Development Board (Flores, 1990) re-assessed the position of the saline water zone and noted that it was further west than was previously indicated (Baker and others, 1986). This apparent "shift" could be the result of new data available or an actual movement of the bad-water line. The lowering of water levels in the freshwater portion of the Edwards could also result in greater leakage from the underlying Glen Rose, which is typically high in sulfate, fluoride, and strontium (Senger and Kreitler, 1984).

Heavy pumpage in the Kyle area to the south could draw some of the available groundwater from the Barton Springs segment. Water-level measurements and pumpage information collected and presented by Guyton and Associates (Stein, 1994) suggest that the groundwater divide between the Barton Springs and San Antonio segments may have shifted north due to pumpage in the vicinity of the City of Kyle.

The available yield of potable water in the Barton Springs Edwards Aquifer may be further diminished by the effects of growth over the recharge zone, which can be expected to diminish the quality of the underlying groundwater available for use without treatment. Studies by the City of Austin (1990) and the Center for Research in Water Resources (Barrett and others, 1996) measured water quality of runoff from varying levels in impervious cover, population density, and traffic densities on roadways. The Barton Springs/Edwards Aquifer Conservation District measured groundwater-quality degradation under urban areas of the Barton Springs segment (Hauwert and Vickers, 1984, and addendum 1995) in samples collected after rain events. Several water systems in urban areas, including water-supply wells originally reliant on the Edwards Aquifer in the Westlake area, have been abandoned due to groundwater-quality degradation.

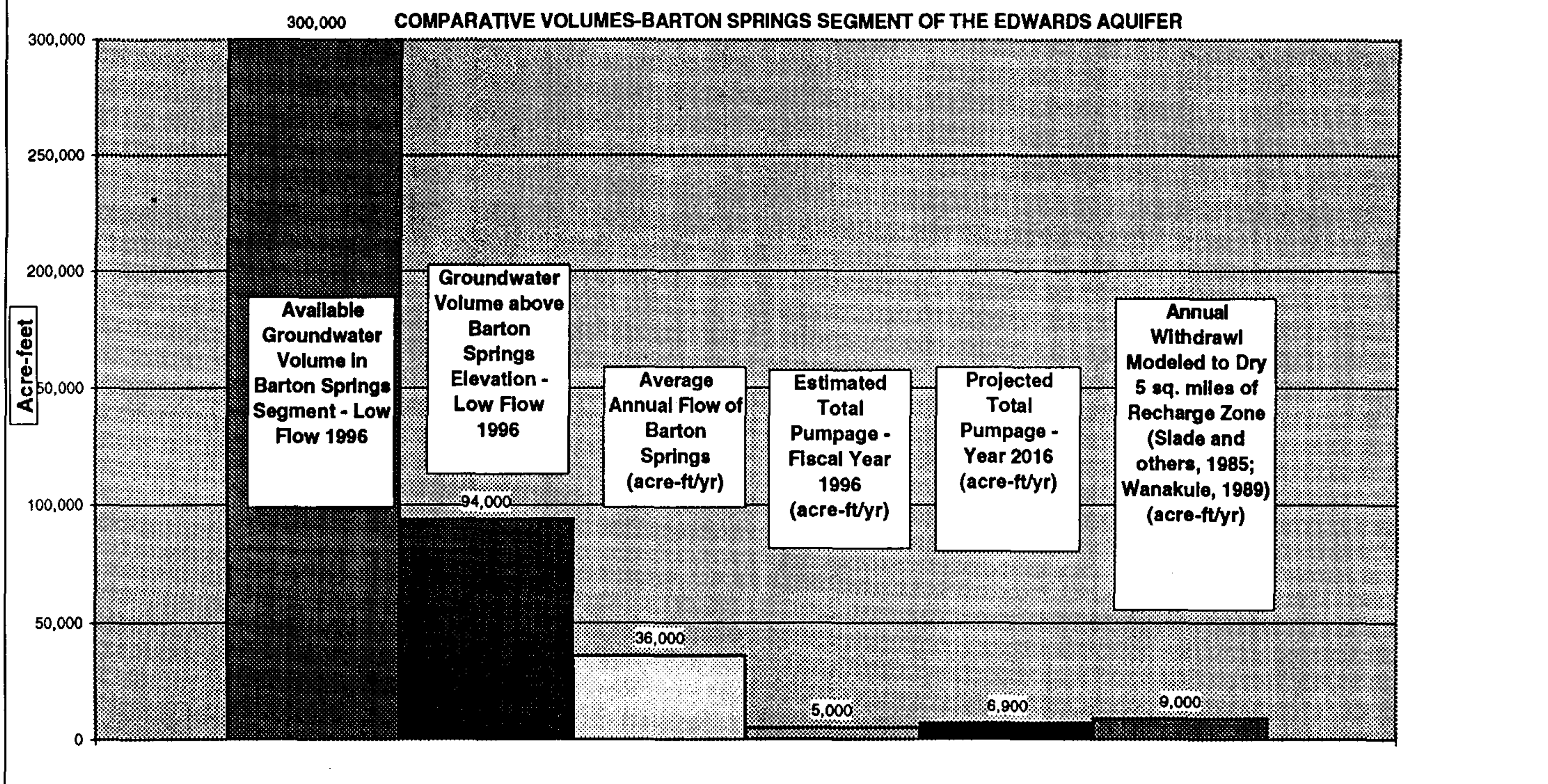
Increases in impervious cover over the recharge zone may further limit the recharge volume needed to replenish water levels. The Center for Research in Water Resources (Barrett and Charbeneau, 1996) lumped parameter model for the Barton Springs segment simulated the effects of impervious cover development on water levels and springflow. The model predicted a 12 percent reduction in springflow from moderate development (20 percent impervious cover) across the aquifer, and a 19 percent reduction in springflow from an intense development (45 percent impervious cover). The effects of impervious cover on the rate and volumes of recharge requires further study and field measurements.

Properly placed recharge enhancement efforts could potentially increase the availability of groundwater in the Barton Springs segment. The previously discussed groundwater model developed by the USGS suggested that properly placed recharge enhancement structures could raise water levels along Onion Creek as much as 120 feet along the western side of the recharge zone and as much as 40 feet near Buda. Flow measurements taken by the USGS from 1979 to 1982 suggested that about 52,000 acre-feet recharged in the Onion Creek watershed and that as much as 88,000 acre-feet of runoff was measured downstream of the recharge zone. Note that during the period of measurement, rainfall was about 25% higher than normal, and that some creek sites may not receive significant recharge over long dry periods. However, recharge enhancement could potentially be used to offset some of the effects of pumpage projected in the previous section. Further study involving groundwater tracing, detailed flow measurement, and numerical modeling is necessary to evaluate potential sites of recharge enhancement.

Table 3.2 - Summary Comparison of Volumes Derived from Various Studies Associated with the Barton Springs Segment of the Edwards Aquifer

Referenced Source	Saturated Rock Volume (acre-feet)	Specific Yield Range (unitless)	Specific Yield Average (unitless)	Volume of Groundwater During Low Flow (acre-feet)	Volume of Ground-water Above Barton Springs Elevation (acre-feet)	Estim. Total Pumpage FY 1996 (acre-feet/yr)	Projected Total Pumpage Year 2016 (acre-ft/yr)
Barrett and Charbeneau, 1996		0.2 to 0.9		180,000 (24 cfs)	45,000		
Senger and Kreitler, 1984		0.001-0.023	0.007				
Slade and others, 1985/1986	17,300,000	0.008-0.064	0.014-0.017	275,000-306,000 (10-50 cfs)	204,000		
This Study (BS/EACD 1997)	**21,250,000**		**0.015***	**300,000 (17-35 cfs)**	**94,000**	**4,900**	**6,900**

*averaged from Slade (and others, 1985 & 1986), and not derived in this study



3.3 Conclusions

A conceptual model of the Barton Springs Edwards Aquifer framework was created, based on recent detailed geological mapping. For the purposes of this study, the water-bearing portion of the aquifer was assumed to be held between the top of the Georgetown Limestone and the top of the Walnut Formation. The aquifer was separated into generalized fault blocks separated by major fault planes. The elevation of the top of the Georgetown Limestone and top of the Walnut Formation was estimated within each generalized block.

Water-level measurements taken during low-flow aquifer conditions from May to October 1996 were used to estimate the saturated thickness across the aquifer. In areas where the 70-feet thick Kirschberg Member of the Edwards Group is saturated, the local transmissivity is expected to dramatically increase. The base of the Kirschberg Member is about 120 feet above the top of the Walnut Formation. During this low aquifer flow period, the volume of saturated thickness (rock matrix and groundwater) within the usable portion of the Barton Springs Edwards Aquifer was estimated to be 21,252,000 acre-feet. Information from 16 aquifer tests and 42 specific capacity tests was used to estimate the transmissivity and storativity across the aquifer. Yield is highly variable across the aquifer; however, a three to five mile wide area of generally high yield, where the saturated thickness exceeds 120 feet and transmissivity exceeds 1,000 gallons per day per foot, extends across the Barton Springs segment. Upthrown blocks on the southwestern side of the Barton Springs segment are anticipated to have little (less than 120 feet) saturated thickness. The eastern side of the Barton Springs segment has a high saturated thickness of about 450 feet, but a low transmissivity, less than 1,000 gpd-ft along the bad-water line. An insufficient number of aquifer tests were conducted in the unconfined portion of the aquifer to measure representative specific yields across the aquifer. The estimated mobile volume of groundwater stored within the aquifer is about 100 billion gallons (300,000 acre-feet), based on the geological framework presented here and specific yield estimated by the U.S. Geological Survey. During 1996 conditions, about 94,000 acre-feet of water was stored above the level of Barton Springs. Table 3.2 compares various aquifer volumes from previous studies and summarizes the results of this study.

Current and projected pumpage presented in Section 2 was compared to low-flow groundwater volumes of 1996. In 1996, annual pumpage (5,000 acre-feet) compares to be about 14 percent of the long-term discharge at Barton Springs (50 cfs or 36,000 acre-feet/year), about 5% of the groundwater storage above Barton Spring's elevation (94,000 acre-feet), and less than 2% of the total groundwater stored in the Barton Springs segment under 1996 conditions (300,000 acre-feet). During extended dry periods in 1996, demands on the aquifer from pumpage constituted about 30 percent of the total aquifer discharge until subsequent rains increased aquifer flows. Based on projected pumpage for the year 2016, total pumpage will utilize about 6,900 acre-feet per year (averaging 9.6 cubic feet per second) which compares to about 19 percent of the long-term average aquifer discharge at Barton Springs, about 2 percent of the groundwater available during low-flow conditions similar to 1996, or about 7 percent of the groundwater present above the elevation of Barton Springs under low-flow conditions. Previous groundwater models by EARDC (Wanakule, 1989) and the USGS (Slade, Ruiz, and Slagle, 1985) indicate that long-term pumpages averaging 9,000 acre-feet per year will result in the dewatering of about 5 square miles in the southwest recharge zone of the Barton Springs segment. The model by EARDC indicates that the current

IV. ALTERNATIVE WATER SUPPLIES / DATA COLLECTION

4.1 Permitted User Water Use Survey

As part of the comprehensive effort to identify alternative water supplies to the Barton Springs segment of the Edwards Aquifer, the District developed a *Permitted User Water Use Survey* to determine the existing public perception concerning existing water use. The data collected from this survey instrument has been compiled and is presented here to detail the consensus to pursue alternatives or supplemental sources to the groundwater use in the study area. A summary of the complete survey results are presented in Appendix I at the end of this report.

Two separate surveys were developed and distributed. The first targeted Public Water Supplies and the second was written for Permitted Users. Public Water Supplies can be defined as permittees pumping groundwater to provide potable water to typically to homeowners and related municipal and domestic type uses in the study area. For the purposes of this analysis, Permitted Users are defined as other than Public Water Supplies; such as commercial and industrial water well users.

There are currently 111 permitted well owners with the Barton Springs/Edwards Aquifer Conservation District. Of that number, 86 wells are used to produce groundwater for some form of consumptive purpose. The other 25 are either closed-loop-heat-exchange systems, groundwater monitor wells, or are permitted for zero volume, meaning that the wells are capable of producing the minimum volume necessary to be classified as a permitted District well, but are currently not used and are inactive.

The 86 permitted wells in the District are owned and operated by 78 unique entities. Thus the total number of surveys sent out by the District (78). Of the 78 original surveys distributed, 43 were completed and used in this analysis (Figure 4.1). The 43 completed surveys represent an overall response rate of 55 percent.

More significant, however, is the total permitted volume these 43 responses represent. The District has currently issued permits for a total of 1,465,172,177 gallons. Of this figure, 1,266,482,000 gallons are accounted for by the 43 respondents to the survey -- or simply stated, more than 86 percent of the total permitted volume can be accounted for in this analysis. A complete summary is shown in the following table.

TABLE 4.1 - SURVEY RESPONSE

PUBLIC WATER SUPPLY WATER USE SURVEY RESPONSE	
27 Surveys	1,180,328,250 Total Permitted Volume (TPV)
17 Responses	1,085,272,000 (92%) Permitted Volume Accounted for in Survey
63% Response Rate	
PERMITTED USERS WATER USE SURVEY RESPONSE	
51 Surveys	284,843,927 Total Permitted Volume (TPV)
26 Responses	181,210,000 (64%) Permitted Volume Accounted for in Survey
51% Response Rate	
OVERALL SURVEY RESPONSE	
78 Surveys	1,465,172,177 Total Permitted Volume (TPV)
43 Responses	1,266,482,000 (86%) Permitted Volume Accounted for in Survey
55% Response Rate	

Of special note in this discussion is the fact that the top 12 District permittees use more than 78 percent of the total permitted volume. These users are permitted for between approximately 53 million and 200 million gallons each. This analysis includes 100 percent of these top 12 users and thereby is an accurate reflection of the consensus from the largest majority of the groundwater users in the sole source area of the Barton Springs segment of the Edwards Aquifer. If there is another significant trend that can be identified at this point, it would simply be that the largest number of non-responses came from either users permitted for fewer than 1 million gallons or from those outside the groundwater dependent area.

Growth Limitations

One of the primary objectives in the survey was to evaluate the existing water use in the Barton Springs segment of the Edwards Aquifer and to ask permittees if there were any identifiable trends that would facilitate an analysis of current growth and future groundwater use. The existing growth rate of the respondents operations varied from between 0 and 30 percent. As a general rule, Public Water Supplies indicated the fastest growth rate to supply the demand of new residential customers with service. Respondents were asked to identify factors that were limitations to growth of their business. Factors, listed in order of significance, included: (#1- 44 percent) availability of dependable and safe drinking water; (#2 - two responses tied at 28 percent) availability of alternative sources of water and the lack of wastewater treatment facilities. Two other factors that were identified as influencing growth were (1) the current economic environment and (2) available land to expand current operations.

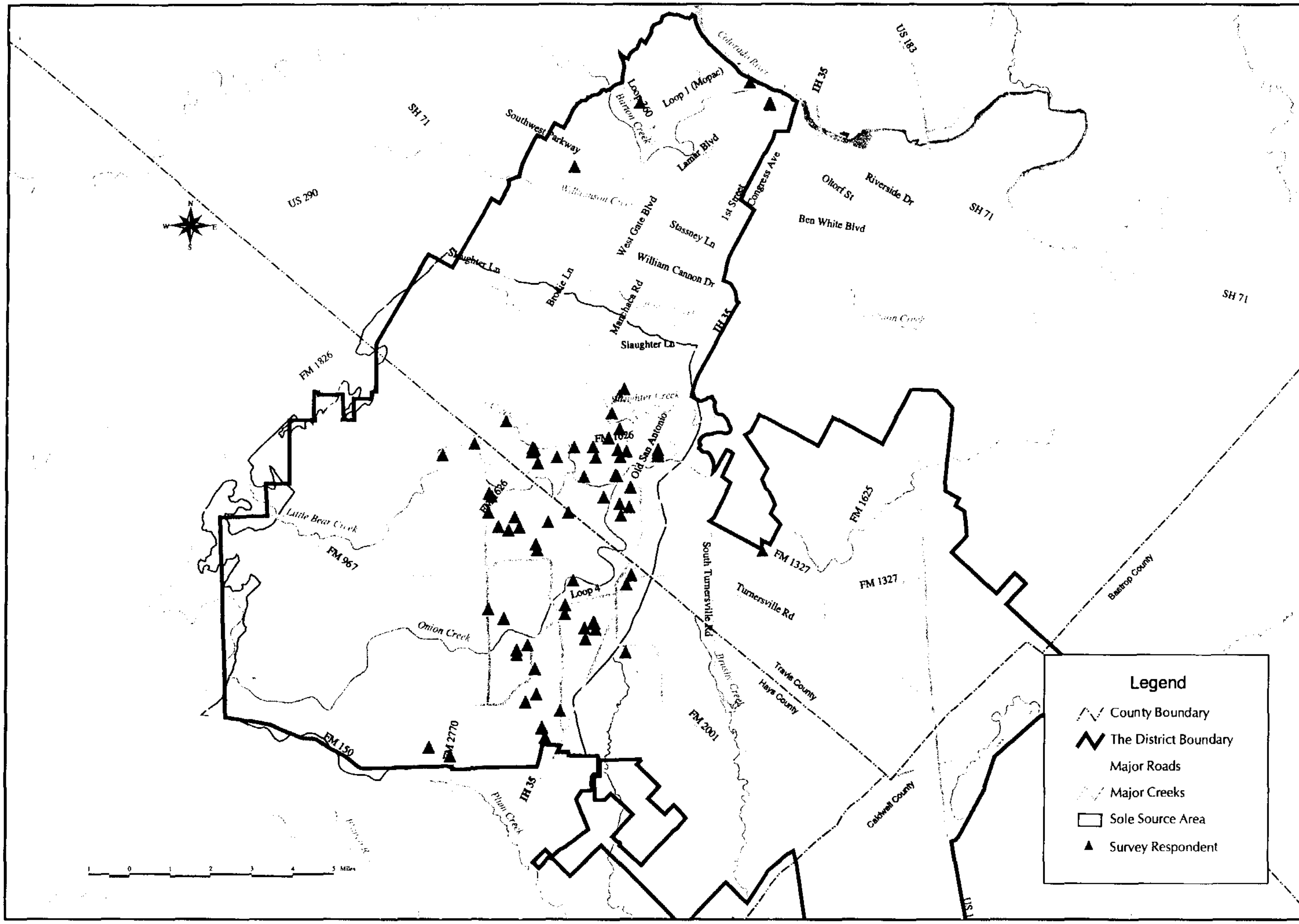
Alternative Sources of Water

Another primary objective in the survey was to determine the perceived need and acceptability of using an alternative source of water to supplement existing groundwater use. When asked if an alternative source of water would help to ensure the quantity and quality of water at the permitted well location, 76 percent of permitted users and an overwhelming majority of 94 percent of the public water supplies agreed that an alternative source of water was needed. When asked if surface water should be considered as an alternative source of water, 28 percent of the permitted users and 88 percent of the public water supplies said they considered surface water to be a viable alternative for themselves. Forty (40) percent of the permitted users and 6 percent of the public water supplies said surface water was not viable for themselves but considered it to be a viable source for other permittees. Twenty (20) percent of the permitted users and 6 percent of the public water supplies said surface water should not be considered to be an option for either themselves or for others.

Several questions were asked to determine the perceived economic viability of pursuing surface water. When asked what they would be willing to pay for surface water, 60 percent of the permitted users and 53 percent of the public water supplies said they would be willing to pay the existing rate they pay for groundwater. Twenty-four (24) percent of the permitted users and 35 percent of the public water supplies said they would pay a comparable rate for surface water costs in similar areas.

Other Survey Conclusions

Several respondents identified the need for more information before an informed decision could be made about the most appropriate management practices for the aquifer and for the pursuit of an alternative source of water to supplement the use



Survey Response Distribution

Figure 4.1

Date: 2/4/97
Created By: Shu Lian
File Name: wsfig41.c
Location: /home4/maps/prj-rw
Source:
TxDoT Data -- Roads, Creeks and Counties
District Data -- Sole Source Area and District Boundaries

of groundwater. Specific areas identified needing further study included current groundwater availability or sustainable yield of the aquifer, and an engineering evaluation of the physical and fiscal feasibility of a surface water alternative. Both of these issues are integral to and are being addressed within the context of this report. The District is applying the scientific research findings from previous studies to the evaluation of the volumetric capacity of the Barton Springs segment of the Edwards Aquifer. Likewise, preliminary engineering evaluations are being presented herein that will address initial capital costs and the pipeline and facilities design, including an internal District distribution system.

4.2 Summary of Previous Studies

Several previous studies have investigated the feasibility of regional water systems for northern Hays and southwest Travis counties or have dealt with other aspects related to water supplies in this area. This review is intended to emphasize the diversity in proposed solutions. Following are the reports that have been reviewed:

"Water for Texas" was created by the Texas Department of Water Resources in 1984.

"Water For Texas" is a comprehensive water plan produced by the Texas Department of Water Resources in November 1984. The water problems within Texas are identified and discussed in the report. The following recommendations are provided by the Texas Department of Water Resources in their comprehensive plan: Water conservation should be adopted by all municipal, commercial, industrial, and agricultural practices. Public education should play an important role in adopting water conservation measures. Recommendations for legislative changes that are involved with state water financing projects could help in conservation methods. Legislation should be enacted to create a water quality management program.

"Alternative Source Water Supply Study" was written by the Guadalupe- Blanco River Authority in February 1987.

The Guadalupe-Blanco River Authority created the "Alternative Source Water Supply Study" in February of 1987. The study area consists of Hays, Caldwell, and Guadalupe counties. The primary objective of the study was to select alternative water sources and supply systems and analyze the economic feasibility of each. There is potential for six alternative sources to be used for raw water supply. One alternative could be to use Canyon Reservoir, which would be able to meet study design requirements. Another alternative could be the Lockhart Reservoir, which would be located on Plum Creek. Clopton Crossing Reservoir could be used at a diversion point along the Blanco River to meet the need of the delivery systems. The Wilcox Aquifer could be another alternative because it has the capability of producing large amounts of water. The Colorado River, upstream of Town Lake dam, also has the ability to meet the standard requirements of the delivery systems. The construction of a water treatment plant along the San Marcos River could also serve as another alternative raw water source. There were also two treated water sources that were considered for alternative water supply systems. The Luling Water Treatment Plant was considered to be a water source for one of the water systems in the immediate area. Another source that could meet the supply systems demands would be the City of Austin municipal system.

"Regional Water System Study for the City of Dripping Springs," which was completed by Turner Collie and Braden Inc. (TC&B) in 1988.

The planning area for the 1988 study prepared by Turner Collie and Braden Inc. (TC&B) entitled "Regional Water System Study for City of Dripping Springs" consisted of approximately 100 square miles. The planning area, located mostly in Hays County, included the corporate boundaries of the City of Dripping Springs and the region from F.M. 150, located south of the City, to approximately Hamilton Pool Road. The westerly limits were located along County Roads 187 and 188, and the easterly limits were located in the general vicinity of Fitzhugh Road and F.M. 1826. The planning population was determined to be 7,000 connections, based on landowners that petitioned the City for service.

Although the city was currently using groundwater as the source of its water, it was concluded in the TC&B report that aquifers within the planning area could not be anticipated to produce individual wells capable of yielding large quantities of high quality water.

Three alternative water supply systems were investigated in the 1988 study. Alternative 1 consisted of obtaining raw water from Lake Travis and constructing a treatment facility. Alternative 2 consisted of obtaining potable water through an extension of City of Austin water system facilities. Alternative 3 was based on obtaining potable water from the Uplands Water System (WTCRWS). TC&B recommended Alternative 1, the Lake Travis supply system. The Lake Travis option allowed the operational authority to belong to the City of Dripping Springs while the other options were dependent on the future plans of other entities and had undefined costs.

The cost of this regional system was estimated to be $2,800 per connection for providing wholesale water service to the anticipated 7,000 connections. A retail system was also required to convey the treated water from the wholesale provider to the consumers. The report noted that this retail system could be provided by a Municipal Utility District, a private supplier or the City of Dripping Springs. The retail system cost would consist of planning, designing, and constructing water distribution facilities required to serve each tract from the regional water supply system. The estimated average cost of the internal distribution systems within typical subdivisions in the vicinity of the planning area was $1,700 per connection. Estimated costs of approach mains varied for each property requesting service and were as much as $12,000 per connection for properties located long distances from the wholesale system. Total probable system costs (wholesale and retail) ranged from $4,500 to $16,600 per connection, with an average connection cost of approximately $7,300.

"Lake Travis (West) Water Supply System" was created by Turner Collie and Braden Inc. in 1988 for LCRA

The "Lake Travis (West) Water-Supply System" report, which was completed in June 1988, studies an area west of Lake Travis. The purpose of the study is to develop an economically feasible short-term and long-term water treatment program for the following: Hill Country Water Supply, Bee Cave-FM 2244, Hamilton Pool Road - FM 12, and Lakeway-Hurst Creek. The material that immediately follows is recommendations that are provided by the Water Resources Development. The fourth demand center, "Lakeway-Hurst Creek," should be studied and the impact of the service for this area should be determined. The sale and purchase of potable water should be negotiated with potential candidates in the area. LCRA's involvement with the project is very important, therefore formal requests should be obtained from subdivisions and water supply corporations. The development of an economic plan which is most feasible for the consumer/user should also be adopted for the project. Contracts for the sale and purchase of the potable water should also be developed. The final recommendation offered by the Water Resources Development is to obtain approval by the LCRA Board for the design and implementation of the project.

"Hays County Regional Water and Wastewater Study," which was undertaken by HDR Engineering, Inc. in 1989 for the Hays County Water Development Board (HCWDB) to develop a regional water supply and wastewater service plan for Hays County.

HDR Engineering, Inc. produced the "Hays County Regional Water and Wastewater Study" in 1989. The Hays County Water Development Board (HCWDB) was founded in 1986 for the purpose of developing a countywide plan to provide dependable future water resources for Hays County. The Board included representatives from the cities of San Marcos, Hays, Buda, Kyle, Dripping Springs, Woodcreek, Niederwald, and Mountain City and the Goforth and Wimberley water supply corporations, which represented the rural water supply corporations in the county. At the time of the report, Hays County obtained all of its water supply from groundwater sources. The Trinity group was the principal water-bearing unit underlying the planning area and this group supplied most of the water for the county. Most of the wells in the county produced low yield, poor quality water.

Population studies showed the City of Dripping Springs together with its ETJ accounting for 9 percent of the county's population. The only significantly populated area within Hays County that is covered under this study is the City of Dripping Springs. The HDR report considered two alternatives to supply Dripping Springs. They were determined to be approximately equal based on cost. Alternative 1 was to serve the City of Dripping Springs from a new reservoir to be constructed on Onion Creek. A treatment plant and transmission lines would be required to deliver treated water to the city. Preliminary studies indicated the yield of the new reservoir would meet the surface water requirements of Dripping Springs until about 2015. Following 2015, a supplemental supply would be required from Lake Travis, but it is possible that Lake Dripping Springs could be used as a balancing reservoir to receive raw water deliveries from Lake Travis at average demand rates, thereby reducing the size of the pipeline to Lake Travis. This system was estimated to cost $20,380,000, with an annual cost of approximately $2,400,000, resulting in an average cost per connection of $49 per month.

An alternative to the Dripping Springs reservoir was to construct an intake on Lake Travis, a water treatment plant, and a transmission pipeline to the Dripping Springs area. This system was estimated to cost $15,740,000, with an annual cost of approximately $2,500,000, resulting in an average cost per connection of $51 per month. Although the capital costs for this alternative were less than that of Alternative I, this alternative has a raw water cost that results in a higher annual cost.

"Village of Bee Cave, Texas Lower Colorado River Authority Regional Water Supply Planning Study" by TUMCO Consultants, Inc., 1989.

TUMCO Consultants, Inc. produced the 1989 report entitled "Village of Bee Cave, Texas, Lower Colorado River Authority Regional Water Supply Planning Study." During the 1950s, a portion of the Bee Cave area was incorporated into the Travis County Water Control and Improvement District No. 14. This was adequate until growth in the 1980s absorbed virtually all of the WCID 14 service capacity west of the Oak Hill area. Additional growth in the Bee Cave area was supported by private wells. In 1988, many of the wells began going dry. The purpose of the TUMCO report was to prepare a regional water supply planning study for the Village of Bee Cave.

The planning area included West Travis County MUDs 3,4, and 5, and the Homestead subdivision as well as the area between Bee Cave and the boundaries of WCID No. 17. At the time of the report, there were 200 Living Unit Equivalents in the study area. The study expected 6,000 LUEs in the planning area by the year 2020, with most of the growth occurring in the Bohls Ranch and Homestead areas. This growth estimate was based on centralized wastewater service not being available. LUEs would be expected to increase to 8,400 with the advent of wastewater service. Therefore, it was recommended that the future system would need to serve between 8,000 to 10,000 LUEs by the year 2020. It was recommended that the Village of Bee Cave and the LCRA jointly enter the public utility water business with the LCRA being the wholesale supplier of treated water and Bee Cave being the retail distributer.

Bohls Ranch, Homestead, Uplands Water System and WCID 17 all had raw water contracts with LCRA at the time of the study. Any one or combination of these systems could provide short term or long term water to the Village. The recommended immediate solution to Bee Cave's water problem was to install an eight-inch transmission main from the WCID 17 standpipe located behind Lake Travis High School, to the Bee Cave city limits and onto the Bee Cave West subdivision. A distribution system consisting of six-inch and four-inch diameter lines was expected to provide enough capacity for domestic flow and fire protection. The approximate total project cost for this short-term solution was determined to be $480,000. The planning study recommended that once the Village of Bee Cave addressed its immediate problem, mid-term and long-term water system alternatives could then be developed.

"Evaluation of Water Resources in Part of Central Texas" was completed by Texas Water Development Board in 1990.

The Texas Water Development Board created the "Evaluation of Water Resources on Part of Central Texas" in January 1990. The area of interest included the Brazos, Colorado, and Trinity river basins. The purpose of the study was to determine the geohydrologic conditions of the Trinity Group and other aquifers, and to recognize the problems or potential problems that could occur from pumping and groundwater contamination. One of the major problems discovered was the constant decline in artesian pressure within the Trinity Group Aquifer. The contamination of groundwater from organic material and possibly the high mineral content of the water in the Glen Rose formation is a continuing problem for the Antlers and Travis Peak formations. Water storage within the Brazos River Basin will be able to meet the demands through the year 2010, and the availability of more water is possible with the development of reservoir projects at Lake

Bosque and Paluxy Reservoir. The amount of groundwater being pumped out of the Trinity Group Aquifer exceeds the recharge amount, which could result in localized shortages by 1990.

"Groundwater Evaluation in and Adjacent to Dripping Springs, Texas" was produced by Texas Water Development Board in 1990.

"Groundwater Evaluation in and Adjacent to Dripping Springs, Texas" is a report created by the Texas Water Development Board in March 1990. The report was requested by the town of Dripping Springs to address their continuing problems with groundwater contamination, which are believed to be results of septic systems. The following are recommendations provided by the Texas Water Development Board. A groundwater monitoring network should be established throughout the Dripping Springs area, primarily in the upper Glen Rose Aquifer. The Texas Water Development Board will provide monitoring sites throughout the upper Glen Rose area and will monitor future sites in the Lower Glen Rose area. A bacteria analysis should be developed with the combined service of the Texas Department of Health for more dependable results. The plugging of unused wells within the Lower Glen Rose formation should be completed in a proper manner. To avoid further contamination, septic systems should be in compliance with established construction and operating standards.

Murfee Engineering Company and Dannenbaum Engineering Corporation produced the "Preliminary Engineering Report West Travis County Water Supply Project" in 1990 for the LCRA, Village of Bee Cave, Shield Ranch, Barton Creek West, First State Bank property, Lost Creek MUD, Bohls Ranch, and Travis County Water Control and Improvement Districts nos. 10, 19, 20, and 21.

Murfee Engineering Company and Dannenbaum Engineering Corporation produced the "Preliminary Engineering Report, West Travis County Water Supply Project" in 1990. The area studied was located primarily along R.M. 2244 extending from approximately 2.5 miles east of Loop 360 westward to the Village of Bee Cave along S.H. 71. From the Village of Bee Cave, the study area extended to the southwest along Hamilton Pool Road to encompass Shield Ranch. Ten parties participated in the study, including the Village of Bee Cave, Shield Ranch, Barton Creek West, First State Bank property, Lost Creek MUD, Bohls Ranch, and Travis County Water Control and Improvement Districts Nos. 10, 19, 20 and 21.

The primary objective of this study was to provide a preliminary design of a regional water system to meet current and projected demands of the participants as well as the projected demands for future participants. The proposed system was intended to allow participants to become wholesale treated water customers of the LCRA. Results of the initial planning concluded that two distinct water demand centers existed within the study area. These two areas were geographically separated and had significantly different demand schedules. The western area, which included Shield Ranch, Village of Bee Cave, and Bohls Ranch, had a small immediate demand, whereas the eastern system, which included the remainder of the participants, had a relatively large immediate demand. Barton Creek West and the First State Bank property could belong to either demand center.

The western system was designed based on the water demand projections of 150 gal/person/day and 3 persons per household. It was proposed that the western system be developed in two phases and that the first phase would utilize the existing Uplands (WTCRWS) 1.8 MGD treatment facility. The first phase was anticipated to meet the western demands for a 10-year period. Phase Two would consist of a 3.0 MGD expansion to the existing treatment plant and pumping facilities and a 100,000 gallon storage tank and 1.5 MGD booster pump station located along Hamilton Pool Road near the western edge of the Village of Bee Cave service area. It was estimated that an initial wholesale water rate of $2.24 per 1000 gallons would be sufficient to recover all costs.

"Regional Water Plan for the Guadalupe River Basin" was produced by Guadalupe- Blanco River Authority in 1991.

The "Regional Water Plan for the Guadalupe River Basin" was a study completed by the Guadalupe-Blanco River Authority in January 1991, which covers 10 counties in the GBRA District. The study was conducted in order to: identify and quantify water usage throughout the district; get a population projection and future water demands until the year 2040; locate and identify areas that have potential water shortages; identify regional water supply systems, and obtain the estimated cost of the operations and maintenance of the regional water plan over a 30 year period. What follows are recommendations that the GBRA provided in order to help maintain an adequate water supply. The withdrawal of water from the Edwards Aquifer should be regulated for the protection of the Comal and San Marcos springs. The adoption of conservation and drought management plans by the cities within the Guadalupe Basin are highly recommended by the GBRA. The use of runoff water for storage purposes, which would be used in low flow or drought conditions should remain in effect. Studies on potential reservoir sites should continue to be conducted and reviewed. Downstream senior rights should continue in order to provide water to the Boerne area. Construct a water treatment system that would deliver water to an area from Canyon Lake to Bulverde. The delivery of treated water from Port O'Connor and Seadrift should be expanded. Increase the yield of Canyon Reservoir with the demand for downstream water rights. Protection and review of groundwater quality should persist. The surface water flow of the Guadalupe River Basin and the San Antonio River should continue to be monitored. The City of Victoria should convert to the use of surface water instead of the dependence of groundwater to meet their water demands. The Canyon Regional Water Authority and the Hays County Water Development Board should continue to work together.

"Technical Data Review Panel" was a report produced by Western Network in 1992.

The Technical Data Review Panel developed a study within the South Central Texas region that would determine water demands and needs, develop alternative water source options, determine effective water conservation and drought management measures, and examine the water quality of the Edwards Aquifer. The Technical Data Review Panel compiled data from the Texas Water Development Board on water use projections and population projections. Alternative water sources were determined and the comparison of the unit costs of each supply were compared. The conservation measures developed by the Texas Water Development Board, the Texas Water Commission and the 1988 Regional Water Management Plan were analyzed by the Technical Data Review Panel. The drought management plan created by the Texas Water Development Board and the Edwards Underground Water District are also reviewed by the Technical Data Review Panel. The report also compares the natural recharge studies of the USGS with other studies conducted by the

Texas Water Development Board, agencies along the aquifer in the Nueces Basin region, and the Edwards Underground Water District. Reports and surveys conducted by USGS, Edwards Aquifer Research and Data Center, and Municipal Water Purveyors, about the water quality of the Edwards Aquifer were also compared by the Technical Data Review Panel.

"Water Supply and Demand Assessment of Travis County" was produced by the LCRA on February 2, 1992.

The Travis County area was the focal point for LCRA's report "Water Supply and Demand Assessment of Travis County." LCRA's objective was to determine if surface water and groundwater supplies will be able to meet the projected annual demands for Travis County. What follows are recommendations that LCRA proposes that could help in the prevention of water shortages. Water conservation measures can be adopted for agriculture, industry, and municipal water usage that could achieve long term reductions in water demand. Public information and education is a way to relay information to consumers about conservation and economic strategies. Regulatory programs could be implemented by a governmental authority that would encourage the consumer to perform water conservation measures. Retrofit programs could be enforced to decrease the amount of wastewater to be treated at treatment facilities. Incentive programs could also help influence consumers to cut down on water usage.

"Water Management Plan for the Lower Colorado River Basin" was completed by the LCRA on June 6, 1993.

"The Water Management Plan for the Lower Colorado River Basin" was produced by the Lower Colorado River Authority. The report explains the water management programs and policies and the drought management programs that were created by the LCRA. The LCRA used the following goals and guidelines to determine an appropriate water management plan. The Highland Lakes and the Colorado River will be managed together for water supply purposes. The use of the water derived from the inflows below Highland Lakes will be managed by LCRA. The waters within the Highland Lakes will require conservation measures that are governed by LCRA. What follows are the goals of the drought management plan developed by the LCRA. The LCRA wants to extend the available water supplies so that drought conditions do not have a detrimental effect on current water supplies. During extreme shortages the LCRA wants to protect the health and safety of the public. The goal of the drought management plan is to have an equal distribution of water for LCRA's customers during major drought conditions.

"Uplands Water System: Land Use Assumptions, Capital Improvement Plan and Impact Fee Calculation for Improvements Attributed to Development Between 1995 and 2004" 1994 report prepared by EH&A:

EH&A produced the 1994 study for the WTCRWS to determine the impact fee for the water system over the next 10-year period. At the time of the report, the water system served 435 LUEs, which included existing homes in Barton Creek West and two existing schools of the Eanes Independent School District. Capital improvements were proposed to expand service to Senna Hills MUD, Lake Point (West Travis County MUDs 3 and 5), the Homestead, Barton Creek Bluffs and the Village of Bee Cave. For the purposes of calculating the impact fee, it was assumed that there would be 2,394 LUEs in the proposed service area by the year 2004. This LUE projection was based on information received from the developers, engineers, the Village of Bee Cave and on population projections from the Capital Area Planning Council (CAPCO).

Proposed improvements to the existing system to meet the 2004 water demands included larger raw water pumps, a treatment plant expansion, an additional clearwell, additional higher head potable water service pumps, and hydropneumatic pumping systems. The maximum allowable impact fee that could be charged for connections to the system between 1995 and 2004 was calculated to be $2,501/LUE.

4.3 Summary of Concurrent Studies

"GBRA Regional Water Supply Study - San Marcos Area" - December 1995

Due to increasing growth in population and water demands, impending groundwater pumpage limits, and water quality concerns, the Guadalupe-Blanco River Authority initiated a regional water supply study to evaluate the potential of meeting current and future water supply needs for cities and rural water supply corporations located primarily in Hays, Caldwell, Travis, and Guadalupe counties. The overall objective of this study is to provide a plan to conserve existing water supplies and to develop alternative water supply plans for the region to meet existing and future water supply needs of the study participants. The City of San Marcos is in the process of implementing a surface water supply system. One of the main objectives of this study is to determine the cost of enlarging the proposed City of San Marcos treatment facilities into a regional facility that would economically provide surface water to San Marcos and the participants outside the City of San Marcos. The region is expected to have a year 2020 surface water supply need of 13,379 ac.ft./yr during normal conditions and 16,433 ac.ft./yr during drought conditions.

The study area includes the service areas of the eleven study participants; City of San Marcos, City of Kyle, City of Lockhart, Crystal Clear WSC, Elim WSC, Maxwell WSC, County Line WSC, Plum Creek WSC, Goforth WSC, Creedmoor-Maha WSC, and Martindale WSC. The study participants are located primarily in the Guadalupe-Blanco River Basin, with a portion of the Creedmoor-Maha WSC service area located in the Colorado River Basin. The eleven study participants currently serve a total population of about 84,000 people and have predominantly met their water supply needs from wells in the Edwards Aquifer (San Antonio portion), Barton Springs segment of the Edwards Aquifer, Carizzo-Wilcox Aquifer, and alluvium sources. The current primary sources of surface water supply to the region are the Guadalupe River, including Canyon Lake, and the San Marcos River below its confluence with the Blanco River. Significant flow occurs at both of these sources during normal conditions and each river serves as an important water supply and recreational resource for the region.

The GBRA proposal brings water north from Lake Dunlap (on the Guadalupe River south of New Braunfels), to a water treatment plant on the San Marcos River, approximately 17 miles. The City of San Marcos has entered into an Interlocal Agreement with GBRA to begin construction on the diversion system from Lake Dunlap to the treatment plant, construction of the treatment plant capable of processing up to 6 million gallons per day, and for the operations of the treatment facility. Currently, 4.5 MGD is allocated to the City of San Marcos. The additional 1.5 MGD is available to interested parties wanting to participate in the surface water project. One alternative being discussed at this stage of planning is the possibility of upgrading the plant to treat up to 8 MGD, depending upon the number of participants and the total volume of water these participants are willing to commit to the project.

GBRA began the planning effort by inviting several of the largest public water supply corporations in their service area to participate in the project. Three PWS's from this original group are permitted users in the District: Creedmoor-Maha, Goforth, and Plum Creek water supply corporations. The preliminary design of the water line layout would have brought a transmission main up the Missouri Pacific Railroad easement from the San Marcos treatment plant to the Creedmoor-Maha well fields in the northernmost demand center near San Leanna, approximately 20 miles, as displayed in Figure 5.1.

The original cost projections (as much as $4.00/1000 gallons wholesale), made participation unlikely for the three PWS's in the District. The District began negotiations with GBRA to consider the possible advantages of the District acting as a regional wholesaler of surface water. Several benefits became apparent. First, financing rates may be lower than the rates available for profit-oriented entities. Local and regional governments like the District qualify for lower rates and by participating in a regional project like this, the financing of the total project is reduced. Second, if the District can represent a core group of permittees, the wholesale water rate may be more attractive, rather than if individual PWS's were to negotiate the rates separately. Third, the District would potentially represent enough total volume to make the project feasible. Any combination of these factors would possibly make it realistic for individual District permittees to tie onto a regional system, when it would not be possible to do so independently. The cost analysis completed by GBRA in September, 1996, estimates treated water rates for the City of Kyle at $2.03/1000 gallons wholesale.

The GBRA is looking for potential participants to step forward and make a formal commitment to participate in the project. If the District is unable to make the commitment for actual water delivery at this time, the possibility exists in this stage of planning to build the diversion system from Lake Dunlap to San Marcos to accommodate for the expansion of the treatment plant. By oversizing the initial facilities during the first phase of construction, future water distribution to other entities is feasible without having to improve the intake structure and the transmission line from the lake to the plant. If the District reserved 1,378 acre-feet capacity, the treatment plant would be rated for 6.9 MGD. Given that the treatment plant remains in the general vicinity as currently proposed, the District's proportional share in laying a 30" water line from Lake Dunlap to the treatment plant would be approximately $143,915 per year. A Canyon Lake contract for 1,378 acre-feet / year at the present rate of $53.03 acre-feet / year would amount to $73,075. The total yearly District obligation would amount to about $216,950.

The actual cost of water from the system is dependent upon the number and location of entities that ultimately participate in the system. The first step is for interested entities to sign a "letter of intent." This letter of intent would outline major elements of the project along with the responsibility of each entity participating in the implementation of the plan. The second step would be for participating entities to execute a water purchase agreement with GBRA. Once those agreements are executed, the implementation of the project could begin.

LCRA - "Northern Hays County and Southwest Travis County Regional Surface Water System Feasibility Study" - March 1996

The purpose of this study is to determine the economic feasibility of a regional surface water supply system to serve areas of northern Hays County and southwest Travis County. The LCRA plan has been developed to address water supply needs inside its jurisdiction that includes areas immediately west of the District. This proposal would bring Lake Travis water from the Uplands Water Treatment Plant south in a loop system extending as far south as Dripping Springs (Figure 5.2). The southeastern leg of this loop system would run along US 290 approximately 3.5 miles from and paralleling FM 1826, the approximate western edge of the District. This plan would bring the infrastructure improvement from the western edge of the recharge zone across to the demand centers located on the artesian zone approximately 6 miles to the east, near I-35 and the Missouri Pacific Railway.

The District has served on the advisory committee in this planning effort since the first public input and coordination meeting on May 23,1995 in Dripping Springs, where about 60 people attended. On August 8, 1995, the firm of Espey, Huston & Associates, Inc. (EH&A) was retained to undertake the study on behalf of the LCRA. The feasibility of a regional system appears to be justified through several emerging trends. First, the Lower Colorado River Authority is taking a more active role in the operation or ownership of water supply facilities in its service area. The LCRA is now operating and expanding the West Travis County Regional Water System (WTCRWS) near the Village of Bee Cave. Second, development pressures are once again accelerating in the Austin area and transportation improvements on West Ben White, U.S. 290/ State Highway 71 and Mopac are expected to make northern Hays and southwest Travis counties even more attractive to residential development. Home building activity in subdivisions along Hamilton Pool Road, Fitzhugh Road, and R.R. 12 has been steadily increasing in the last 3 to 4 years, including building on acreage tracts. Third, the establishment of water utilities, such as Hill Country Water Supply Corporation, provides the retail entities that are essential to the economic viability of a wholesale regional system.

As mentioned earlier, the northwesternmost section of the loop system is currently under construction to extend service to the Village of Bee Cave. Completion of subsequent phases of this design is contingent upon the identification of a customer-support base sufficient to meet the fiscal requirements of the project. Retail water use rates in areas around south Lake Travis range from $2.50/1000 gallons (up to 30,000 gallons) for the Uplands Development to $3.50/1000 gallons for the Hill Country Water Supply Corporation (HCWSC). HCWSC customers pay a base rate of $103.00 per month in addition to their water use fees. New customers in the Uplands Development pay a residential tap fee of $600 to tie onto the water supply system with a $20 monthly meter fee in addition to their monthly water use fees. While other tap fees can range up to several thousand dollars, capital costs to implement this Stage I loop regional system by the year 2000 would run between $8,474 and $10,597 per typical household, depending on the percent participation.

Compared with on-site water supply alternatives (individual water wells), a regional system is an attractive option for new homes built in the area served by the Stage I loop. Nevertheless, for those who have already invested in on-site water systems, the additional cost to connect to a regional water system is significant. Concerns about water quality and reliability may entice many residents to seek service from a regional system. Residents with aging well systems that will need rehabilitation may also be wish to connect to the regional system.

The Stage I loop system could provide reasonably priced water service if enough current and future customers agree to participate in the system. While the LCRA and other retail purveyors, like HCWSC, can provide some leadership in the implementation of a regional system, the District as wholesale provider could possibly develop the customer base necessary to bring Lake Travis water into our service area. To do so, potential water use customers will need to be informed of the costs of regional alternatives presented in this plan and a level of commitment will need to be obtained before the LCRA can move forward with the project.

City of Austin - "Water Distribution System Long-Range Planning Guide" - February 1994

The COA Water Long-Range Planning Guide outlines the limits to the City's ability and willingness to extend services during the next 40 to 50 years. The boundaries were established based on City Planning and Development Department allocations of growth, topographic and jurisdictional barriers, proximity of other service providers, and the professional judgment of the planning team, which are aimed at minimizing urban sprawl (Figure 5.3). Annexation and the provision of water and wastewater utilities must work hand-in-hand to integrate developing suburban areas into the Austin community. Under Texas law, the ability to provide water and wastewater services has been closely linked to the ability of cities to annex.

Other cities' ETJs provide the "natural" limits of the planning area. With the exception of several small communities already encompassed by Austin's ETJ, the planning team's assumption was that the service area and the city boundaries will one day be identical. The COA 5-mile ETJ extends southward to just north of the City of Kyle. The ETJs of the cities of Buda, Hays, San Leanna, Creedmoor, Niederwald, and Mustang Ridge are enveloped by or adjacent to the COA 2-or 5-mile ETJ. Although The City of Austin's immediate water supply improvements focus on the rapidly expanding northern edge of their service area through Cedar Park, Pflugerville and Round Rock into Williamson County, long-range water plans are scheduled to address the water needs for the potential customers within its ETJ, primarily southward to the Travis-Hays county line. As was discussed at the BS/EACD Board of Directors meeting on September 12, 1996, the COA would consider extending service to customers south of their existing water distribution system if they were approached to do so. The COA primary focus is on areas needing service that could potentially be annexed.

Many entities other than the City of Austin provide water service within or adjacent to the COA service area. As the City has grown, it has typically absorbed most of the entities operating near major utility facilities. Several water supply corporations with certificates of convenience and necessity are not considered long-term limiting factors to the City's ability to provide service to new customers, including Creedmoor-Maha WSC. These entities have not demonstrated an ability to provide urban levels of service, including fire flow for multi-family, commercial, industrial and institutional/educational uses. In the past, the service boundaries of such entities have tended to shrink whenever urban/suburban levels of development occur. As development intensifies over time, a suburban or urban level of service is required. Traditionally, the increased level of service is provided by the COA after negotiation with the initial service provider.

COA infrastructure is nearing its capacity to treat and distribute water to its entire service area. There are scheduled facility improvements between now and the year 2001, but until some of these improvements are completed, they are pushing the existing treatment plant capacities to supply peak demand water needs. Another issue to consider is the fact that at the current COA growth rate, Austin could exhaust its Colorado River firm water rights as early as the year 2015, a relatively short-term problem when put in the context of water resource or financial planning.

All things considered, the COA is willing to negotiate with any entity inside its service area wishing to connect to its water system. Austin can also provide water outside of its service area by entering into a wholesale water contract with interested parties. To extend service further south than the city is currently serving will require an upgrade of existing, facilities, along with the construction of additional infrastructure facilities.

"Trans-Texas" - A Cooperative State-wide Effort

The District has attended numerous meetings on the Trans-Texas West Central and South Central Phase I projects. The District serves on the Technical Advisory Committee and participates to the extent possible under the programs as established by the lead agencies and participating organizations. We have participated to a limited extent on Phase II of the North Central Study, which includes Austin, with implications on water availability in northern Hays County. We have inquired about being a full partner on the Study Area Policy Management Committee of the Trans-Texas programs, but in general have been steered away by the Texas Water Development Board from an active or key participatory role. The TWDB has been very supportive of our efforts to plan for and develop a more local solution to our current needs and future demands. It is clear from our research that wherever our future alternatives come from, Trans-Texas issues will likely arise and it will be in our interest to maintain whatever level of participation is necessary to be sure our issues, concerns and needs are adequately addressed. This is especially true where it may impact, infringe upon, or provide an opportunity to participate in portions of the Trans-Texas Projects that may be of benefit to our District's residents in providing alternative, affordable water supplies wherever possible. We have been encouraged by the TWDB to continue to inform and coordinate our efforts with both of the current ongoing Trans-Texas studies in our region -- *North Central and South Central Study Areas.*

5.1 Preliminary Engineering and Cost Evaluation of Supplemental Water Supply Alternatives

5.1.1 Background

An objective of this study was to evaluate the potential of developing a District-wide water supply system capable of providing supplemental water to existing private and public purveyors to augment their Edwards Aquifer resources, especially during drought conditions.

As discussed in Section 2.2.3, "Demand Centers, " the District's 31 major permitted water users were grouped, based on their locale and points of use, into 3 water demand centers as shown in Table 2.2 and in Figure 2.2 (see Section 2 of this report). The historic and projected total water requirements for each demand center are shown in Table 2.10.

By the year 2000, it is projected that the total water use for all three demand centers will reach approximately 4,550 acre-feet per year (4.1 mgd). Water requirements for the three centers are estimated to reach about 5.5 mgd or 6,157 acre-feet per year by the year 2016 (total pumpage from all sources is estimated to be 6,900 acre-feet per year). These projections reflect water use within 31 existing public and private water systems and do not include supply to new water systems that may develop within the study area (i.e. the District's geographic boundaries) in the foreseeable future[1].

Water supply options for the three demand centers include purchasing treated water from the Guadalupe-Blanco River Authority, the Lower Colorado River Authority, and the City of Austin. An additional alternative for future supply involves the District developing an Edwards Aquifer well field in an area remote to current public and private District permitted wells and pumping water to the demand centers. In order to evaluate these four options, the following assumptions were used:

1. All major District well permittees (i.e. private or public water purveyors) would obtain supplemental water from the regional system;

2. The regional system would be initially sized to provide at least 30 percent of the projected year 2000 water demands for major Edwards Aquifer well permittees;

3. The District's regional system would include all necessary improvements to transport potable water from supply sources to centrally located water demand centers;

4. The District's regional system would deliver water to the demand centers under sufficient pressure for subsequent transfer to each permittee's points of use;

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1 Water use projections and needed infrastructure requirements for "new" water systems are outside the scope of this study.

5. Each water purveyor would bear the cost of any infrastructure improvements needed to deliver water from the District's regional system to their individual point of use;

6. A 12-inch water transmission main would be utilized to supply water from the supply source to a central location within each demand center;

7. Flow velocity in the 12-inch water transmission main is limited to 4.5 feet per second for preliminary design purposes[2];

8. All District owned water transmission and storage facilities will be located in private easements or land owned by the District;

9. Capital and operation and maintenance costs would be estimated based on 1996 dollars; and

10. For cost purposes the following water supply alternatives serving all three water demand centers were evaluated:

    A. GBRA Treated Water Supply Option;
    B. LCRA Treated Water Supply Option;
    C. COA Treated Water Supply Option; and
    D. District Well Field Option, located near Manchaca Road and Slaughter Lane.

5.1.2 Guadalupe-Blanco River Authority Alternative

Under this alternative, the District would enter into a wholesale treated water agreement with the GBRA. The District would purchase Canyon Lake contract water from the GBRA and participate in a raw water intake structure, located on the Guadalupe River at Lake Dunlap, and a 30-inch diameter, 19-mile pipeline to the San Marcos water treatment plant, as illustrated in Figure 5.1. The cost of GBRA contract water is estimated at $53.03 per acre-foot per year. The District would need to purchase a minimum of 1,378 acre-feet (i.e. 30 percent of year 2000 demands for the three water demand centers) of contract water at an annual cost of $73,075. The District's proportionate share of debt service on the 19-mile transmission main from Lake Dunlap to the San Marcos WTP is estimated at $143,915 per year[3]. This amount, which is included in the final cost analysis, pays for the District's capacity in the Lake Dunlap to San Marcos water treatment plant pipeline. This yields a total annual cost (excluding operation and maintenance costs associated with the 30-inch diameter, 19-mile raw water pipeline) of $216,950 per year.

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[2] A 12-inch water transmission main can deliver approximately 2.3 mgd (2,600 acre-feet) per year at a pipe flow velocity of 4.5 feet per second (fps).

[3] Information provided by Thomas D. Hill, P.E., Chief Engineer, GBRA, fax dated April 18, 1997.

The District would enter into a contract with the City of San Marcos to treat and pump District-purchased GBRA water from the GBRA WTP to a District point of delivery, which is anticipated to be located along Interstate Highway 35 near the CFAN Corporation Manufacturing Plant (approximately 2-miles north of the Blanco River, as shown on Figure 5.1). The unit cost of the District's treated water contract with San Marcos is estimated at $0.75 per 1,000 gallons of treated water[4].

For purposes of evaluating this alternative, it is assumed that the City of Kyle will cost participate with the District to construct a 24-inch diameter treated water transmission main from the District's San Marcos point of delivery (i.e. along I.H. 35 near CFAN Corporation) to Kyle. From Kyle, the District would construct a 12-inch diameter water transmission main, with appurtenances (including an elevated storage facility) to Buda for supplying the three water demand centers.

The total projected capital cost for all required water improvements to supply Kyle and the District initial water needs for this alternative is $7.3 million, as shown in Table 5.1. The District's portion of this capital cost is for improvements extending from the San Marcos point of delivery to the three water demand centers and is estimated at $5.6 million (see Table 5.1).

The annual cost of service for this alternative is shown in Table 5.2. The assumptions used in developing an annual cost of service are presented in Table 5.3. The annual revenue requirement for this alternative is projected at $1,325,996 (see Table 5.2). The largest annual cost of service items are for water treatment services[5] ($553,703) and for debt service[6] ($491,808).

5.1.3 Lower Colorado River Authority Alternative

The LCRA is planning to construct Phase II of their treated water regional supply system, originating from its Uplands Water Treatment Plant. This plant is located near the intersection of FM 2244 and State Highway 71, in the Village of Bee Cave. LCRA's water system will extend from its WTP eastward along State Highway 71 and thence westward along U.S. Highway 290 to Dripping Springs. The Phase II system should be completed around the year 2000, if wholesale water supply contracts with area purveyors are secured.

The LCRA alternative entails the District constructing a 12-inch diameter water main from LCRA's Phase II system. The District's point of delivery will be near the intersection of U.S. Highway 290 and Nutty Brown Road (see Figure 5.2). The District's line will extend along Nutty Brown Road (with a ground storage tank that will serve as an elevated storage),

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[4] The treated unit cost of $0.75 per 1,000 gallons represents a conservative state wide average (current market) for water treatment and pressurization costs (operation, maintenance and debt service) and includes the cost for delivering the District's water to the CFAN point of delivery.

[5] Water treatment services are estimated at $0.75 per 1,000 gallons, based on 1.23 mgd (30 percent of all water demand centers' year 2000 needs), plus raw water cost from GBRA ($216,950 per year).

[6] Annual debt service is based on financing $5.6 million at 6 percent for 20 years.

thence along FM 1826 and thence eastward along the proposed alignment of Bliss Spillar Road to FM 1626. From this point, the District will construct a 12-inch diameter water transmission main westward towards the City of Hays to serve Water Demand Center No. 2 and eastward to the Village of San Leanna to serve Water Demand Center No. 3. Another 12-inch diameter main would extend from the FM 1626 line southward to Buda to serve Water Demand Center No. 1 wholesale customers.

The District would enter into a wholesale treated water supply contract with LCRA and must purchase contract water from the authority. LCRA's treated water cost is estimated at $1.60 per 1,000 gallons[7], with contract water costing about $105 per acre-foot per year or $144,648 per year for 1,378 acre-feet per year[8].

The projected capital cost for this alternative, shown in Table 5.4, is $5.7 million. The annual cost of service, based on 30 percent of Water Demand Centers Nos. 2 and 3 year 2000 water need, is estimated at $1.5 million as shown in Table 5.5. Of this amount, approximately $500,595 is for debt service and $1.0 million is for annual operation and maintenance costs (as shown in Table 5.6).

5.1.4 City of Austin Alternative

Under the COA alternative, the District may be able to connect directly to an existing Austin water main located near the intersection of Manchaca Road and Slaughter Lane. Austin would provide water and the District would boost or repressurize the water in the District's distribution network. The District would construct a 12-inch diameter transmission main from the point of delivery to supply water to all water demand centers (see Figure 5.3). The District would enter into a wholesale treated water contract with Austin. Currently, Austin provides water to its wholesale treated water customers at about $1.90 per 1,000 gallons[9].

The capital cost for this alternative, presented in Table 5.7, is estimated at $4.7 million. The projected annual cost of service and assumptions for the cost of service analysis are presented in Tables 5.8 and 5.9, respectively. Annualized cost of service for this alternative is estimated at $1.5 million based on satisfying 30 percent of the year 2000 demands for all water demand centers. As in the other alternatives, wholesale water purchases (estimated at $853,005) and debt service (approximately $405,004) represent the largest annual cost of service items.

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[7] Currently, LCRA charges a water impact fee of approximately $1,900 per residential connection. This fee may decrease as the LCRA regional water system expands. In any event, this fee, to be paid by District customers, is not included in the financial analyses presented in this study.

[8] Personal communication between Steve Parks, P.E., Project Engineer, LCRA, and Donald Rauschuber, P.E., on October 21, 1996.

[9] **The COA charges a customer water impact fee of about $1,308 per residential connection. This impact fee, to be paid by District wholesale water customers, is not included in the financial analysis presented in this report.**

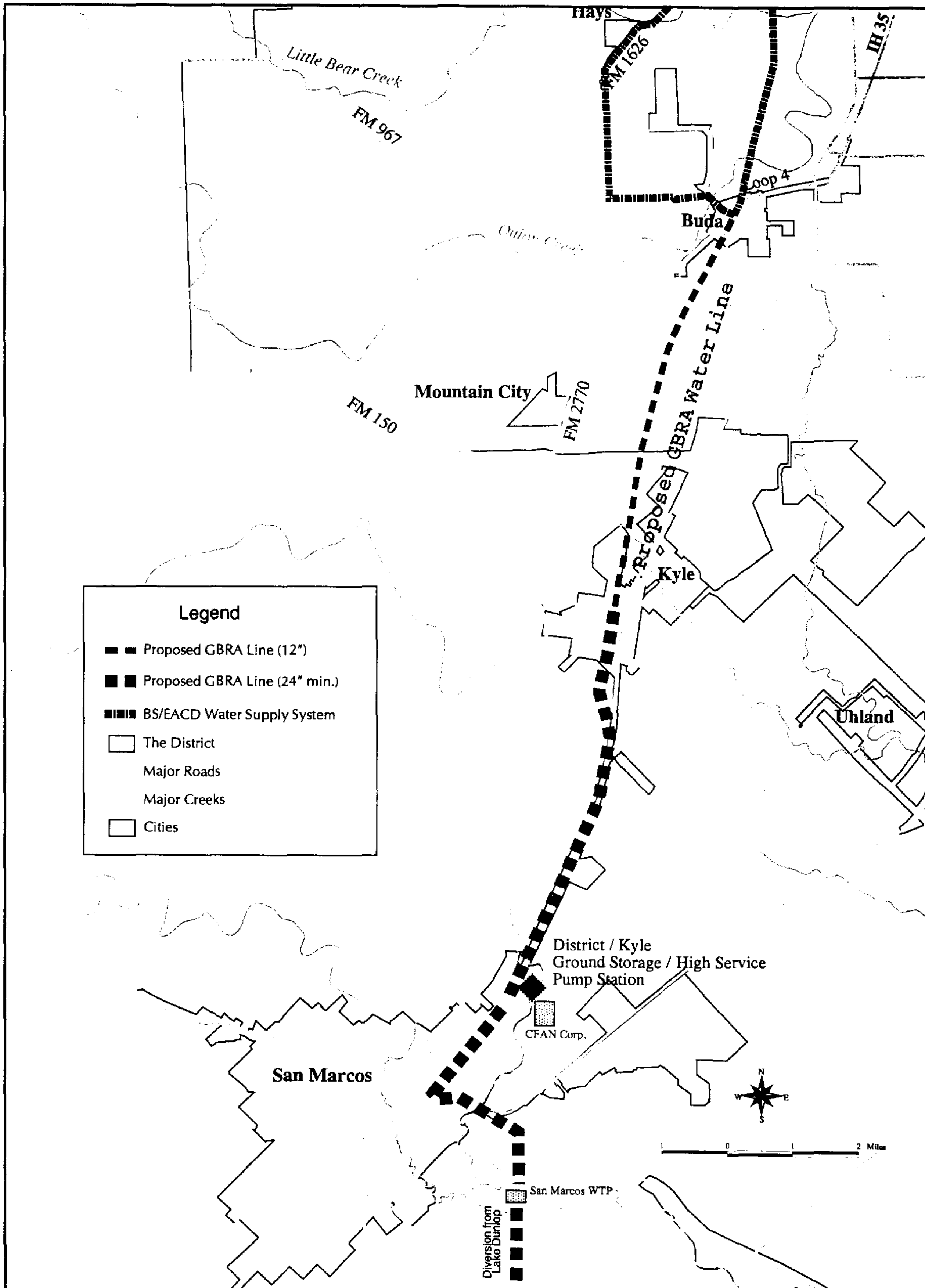

Figure 5.1

Date: 2/4/97
Created By: Shu Liang
File Name: wsfig54.eps
Location:
/home4/maps/prj.rws
Source:
TxDoT Data – Roads, Creeks
CAPCO Data – Cities
District Data – Internal District Transmission Main, Proposed GBRA Line, District Area

Proposed GBRA Water Line

TABLE 5.1

CAPITAL COST PROJECTIONS FOR GBRA TREATED WATER SUPPLY OPTION FROM SAN MARCOS

ITEM NO.	DESCRIPTION	QUANTITY	UNITS	UNIT COST	UNITS	ESTIMATED COST	BS/EACD'S SHARE 50% OF COMMON ELEMENTS PLUS NON-COMMON ELEMENTS	KYLE SHARE 50% FOR COMMON ELEMENTS
1.	C-FAN Ground Storage Facility	200000	GALS.	$1	PER GAL.	$100,000	$50,000	$50,000
2.	C-FAN High Service Pump Station	1	EA.	$100,000	EA.	$100,000	$50,000	$50,000
3.	24-Inch Diameter Concrete Pressure Pipe From C-FAN Pump Station to Limekiln Rd./Kyle	25900	L.F.	$75	PER L.F.	$1,942,500	$971,250	$971,250
4.	12-Inch Diameter C-900 P.V.C. Pipe From Limekiln Rd./Kyle through District w/Valves & Fittings	53550	L.F.	$32	PER L.F.	$1,713,600	$1,713,600	$0
5.	12-Inch Diameter C-900 P.V.C. Pipe From Transmission Main to Elevated Storage	1500	L.F.	$32	PER L.F.	$48,000	$48,000	$0
6.	30-Inch Bore and Case For 24-Inch C.P. From C-FAN to Limekiln Rd./Kyle	820	L.F.	$250	PER L.F.	$205,000	$102,500	$102,500
7.	Creek Crossings For 24-Inch C.P. From C-FAN to Limekiln Rd./Kyle	50	L.F.	$100	PER L.F.	$5,000	$2,500	$2,500
8.	16-Inch Bore and Case For 12-Inch C-900 Pipe From Limekiln Rd./Kyle through District	2160	L.F.	$150	PER L.F.	$324,000	$324,000	$0
9.	Creek Crossings For 12-Inch C-900 Pipe From Limekiln Rd./Kyle through District	900	L.F.	$75	PER L.F.	$67,500	$67,500	$0
10.	Fence and Structure Repairs For 24-Inch C.P. From C-FAN to Limekiln Rd./Kyle	1	L.S.	$75,000	L.S.	$75,000	$37,500	$37,500
11.	Fence and Structure Repairs For 12-Inch C-900 P.V.C. From Limekiln Rd./Kyle Through District	1	L.S.	$60,000	L.S.	$60,000	$60,000	$0
12.	Elevated Storage (880 msl Overflow) on Hill 780 Between Kyle and Buda	300000	GAL.	$2	PER GAL.	$600,000	$600,000	$0
13.	Air Relief Valves C-FAN to Kyle	2	EA.	$1,200	EA.	$2,400	$1,200	$1,200
14.	Air Relief Valves Kyle through District	12	EA.	$800	EA.	$9,600	$9,600	$0
15.	Telemetry and Remote Controls/Sensors	1	L.S.	$60,000	L.S.	$60,000	$30,000	$30,000
16.	Flow Meter w/Vault @ C-FAN	1	L.S.	$50,000	L.S.	$50,000	$25,000	$25,000
17.	Flow Meter w/Vault @ Limekiln Rd./Kyle	1	L.S.	$15,000	L.S.	$15,000	$15,000	$0
18.	All Weather Road to Hill 780	2000	L.F.	$20	PER L.F.	$40,000	$40,000	$0
19.	Fence Around Required Public Water Facilities	600	L.F.	$18	PER L.F.	$10,800	$8,100	$2,700
SUBTOTAL PROJECTED CONSTRUCTION						$5,428,400	$4,155,750	$1,272,650
CONTINGENCIES (15% OF CONSTRUCTION)						$736,560	$584,513	$152,048
EASEMENTS AND RIGHT-OF-WAY C-FAN TO LIMEKILN RD./KYLE		17.83746556	ACS.	$5,000	PER AC.	$89,187	$44,594	$44,594
EASEMENTS AND RIGHT-OF-WAY LIMEKILN RD./DISTRICT		37.91322314	ACS.	$5,000	PER AC.	$189,566	$189,566	$0
LAND ACQUISITION C-FAN TO LIMEKILN RD./KYLE		2	ACS.	$15,000	PER AC.	$30,000	$15,000	$15,000
LAND ACQUISITION LIMEKILN RD./KYLE TO DISTRICT		2	ACS.	$15,000	PER AC.	$30,000	$30,000	$0
ENGINEERING DESIGN (8% OF CONSTRUCTION)						$392,832	$311,740	$81,092
DESIGN SURVEY C-FAN TO LIMEKILN RD./KYLE		25900	L.F.	$1	PER L.F.	$25,900	$12,950	$12,950
DESIGN SURVEY LIMEKILN RD./KYLE TO DISTRICT		55050	L.F.	$1	PER L.F.	$55,050	$55,050	$0
CONSTRUCTION SURVEY C-FAN TO LIMEKILN RD./KYLE		25900	L.F.	$1	PER L.F.	$32,375	$16,188	$16,188
CONSTRUCTION SURVEY LIMEKILN RD./KYLE TO DISTRICT		55050	L.F.	$1	PER L.F.	$68,813	$68,813	$0
GEOTECHNICAL AND TESTING (0.5% OF CONSTRUCTION)						$24,552	$19,484	$5,068
LEGAL (1% OF CONSTRUCTION)						$49,104	$38,968	$10,137
FINANCING AND BOND COUNSEL (.6% OF CONSTRUCTION)						$29,462	$23,381	$6,082
PERMITTING (LOCAL, STATE AND FEDERAL)						$20,000	$10,000	$10,000
PROJECTED TOTAL PROJECT COST						$7,331,819	$5,641,003	$1,690,816

5.1.5 District Well Field Alternative

Under this alternative, the District will construct a well field, located on Slaughter Lane approximately 0.5 miles west of Manchaca Road (see Figure 5.4). The District's well field would consist of two municipal water supply wells capable of producing approximately 1,000 gpm each. The wells would pump water to a ground storage tank. High service pumps, located at the well field, would pump water to an elevated storage tank located on the east side of FM 1626, approximately 2,500 feet southeast of the City of Hays. The District would construct a 12-inch diameter water transmission main from the high service pump station along Slaughter Lane and Manchaca Road. The main would extend along FM 1626 eastward to the San Leanna area (for Water Demand Center No. 3 wholesale customers) and westward to the City of Hays region (for Water Demand Center No. 2 customers). Another 12-inch diameter main would extend from the FM 1626 line southward along the MOPAC Railroad right-of-way to Buda to serve Water Demand Center No. 1 wholesale customers. The cost analysis for this alternative includes the construction of all necessary improvements to provide 30 percent of the water needs to Water Demand Center Nos. 1, 2 and 3. The capital cost for this alternative is estimated at $5.0 million dollars, as shown in Table 5.10. The annual cost of service (O&M and debt service), is estimated at $773,000 (Table 5.11), based on year 2000 demands (30 percent) for the three water demand centers. The assumptions used to develop the annual cost of service for this alternative are presented in Table 5.12.

5.1.6 District Infrastructure Capital Cost for Water System Improvements

Another objective of this project was to project capital costs associated with District "internal" water system improvements, regardless of wholesale water supply source. To assess this objective, the capital cost for the following internal system improvements (as depicted on Figure Nos. 5.1 through 5.4) were evaluated:

1. Demand Center 1: 12-inch diameter water transmission main extending from FM 1626 to Buda along the MOPAC Railroad right-of-way (Table 5.13);
2. Demand Center 2: 12-inch diameter water transmission main extending westward from the intersection of Manchaca Road and FM 1626 to the City of Hays (Table 5.14);
3. Demand Center 1&2: 12-inch diameter water transmission main extending westward along FM 1626 to CR 147, thence southward along FM 967 to Buda (Table 5.16);
4. Demand Center 3: 12-inch diameter water transmission main extending eastward from the intersection of Manchaca Road and FM 1620 to the Village of San Leanna (Table 5.15); and
5. The Entire System: The 12-inch diameter water transmission system inclusive of Nos. 1 through 4 above (Table 5.17).

The projected cost (1996 dollars) for each of these segments are illustrated in Figure 5.5.

TABLE 5.2

ANNUAL COST OF SERVICE ANALYSIS FOR GBRA TREATED
WATER SUPPLY OPTION FROM SAN MARCOS

ITEM NO.	COST OF SERVICE ITEM	PROJECTED COST
	OPERATION AND MAINTENANCE EXPENSE	
1.	Salaries and Wages	$42,120
2.	Contract Labor for Reoccurring O&M not a Function of Water Pumped	$10,000
3.	Contract Labor for Reoccurring O&M that is a Function of Water Pumped	$10,000
4.	Chemicals and Treatment	$0
5.	Plant Site Utilities	$2,400
6.	Utilities For High Service Pumps	$134,685
7.	Repairs and Maintenance for Reoccurring O&M Not a Function of Water Pumped	$10,000
8.	Repairs and Maintenance for Reoccurring O&M that is a Function of Water Pumped	$10,000
9.	Office Supplies	$600
10.	Repair and Maintainence on Vehicles and Small Equip.	$3,000
11.	Small Tools and Equipment	$600
12.	Professional Services	$15,000
13.	Administration	$33,750
14.	Water Purchases	$553,703
15.	Insurance	$4,000
16.	Regulatory Expense	$3,000
17.	Miscellaneous	$1,300
18.	TOTAL O&M EXPENSES	$756,589
	OTHER EXPENSES:	
19.	Debt Service on Capital Improvements for This Alternative (6% For 20-Yrs)	$491,808
TOTAL ANNUAL REVENUE REQUIREMENT FOR CAPITAL AND O&M EXPENSES.................		$1,325,966

TABLE 5.3

ASSUMPTIONS FOR ANNUAL O&M COST OF SERVICE FOR GBRA TREATED WATER SUPPLY OPTION FROM SAN MARCOS

No. 1 - Salary and Wages 1-Full Time @ $15/Hr. W/1.35 Benefits Multiplier		$42,120
No. 2 - Contract Labor not a Func. of Water Pumped Plant Upkeep, Etc. - Assumed		$10,000
No. 3 - Contract Labor as a Func. of Water Pumped Minor Repairs and Maintenance - Assumed		$10,000
No. 4 - Chemicals and Treatment (Clorination) None for this alternative		$0
No. 5 - Plant Site Utilities Assumed $200/month		$2,400
No. 6 - Utilities for High Service Pumps $0.20/1,000 Gallons Pumped for 1.23 mgd Treated Water Plus $0.10/1,000 Gallons Pumped for 1.23 mgd Raw Water	$89,790 $44,895	$134,685
No. 7 - Repairs and Maint. Not a Func. of Water Pumped Assumed		$10,000
No. 8 - Repairs and Main. a Func. of Water Pumped Assumed		$10,000
No. 9 - Office Supplies Assumed $50/Month		$600
No. 10 - Repairs and Main. on Vehicles, etc. Assumed $250/Month		$3,000
No. 11 - Small Tools and Equip. Assumed $50/Month		$600
No. 12 - Professional Services (Annual) Accounting and Audits ($5,000/yr)	$5,000	
Legal (Reoccurring $5,000/yr)	$5,000	
Engineering (Reoccurring $5,000/yr)	$5,000	
TOTAL		$15,000
No. 13 - Administration Assumed: 20% of $50,000/yr employee and 50% of $30,000/yr employee w/1.35 benefits		$33,750
No. 14 - Water Treatement/Purchase Assumed 1.23 mgd @ $0.75/1,000 gals. Plus $216,990/yr Raw Water Charge		$553,703
No. 15 - Insurance Assumed: $4,000/yr		$4,000
No. 16 - Regulatory Expense Assumed: $3,000/yr		$3,000
No. 17 - Miscellaneous Postage	$100	
Supplies Other Than Office	$1,000	
Forms/Flyers	$200	
TOTAL		$1,300
TOTAL		$834,158

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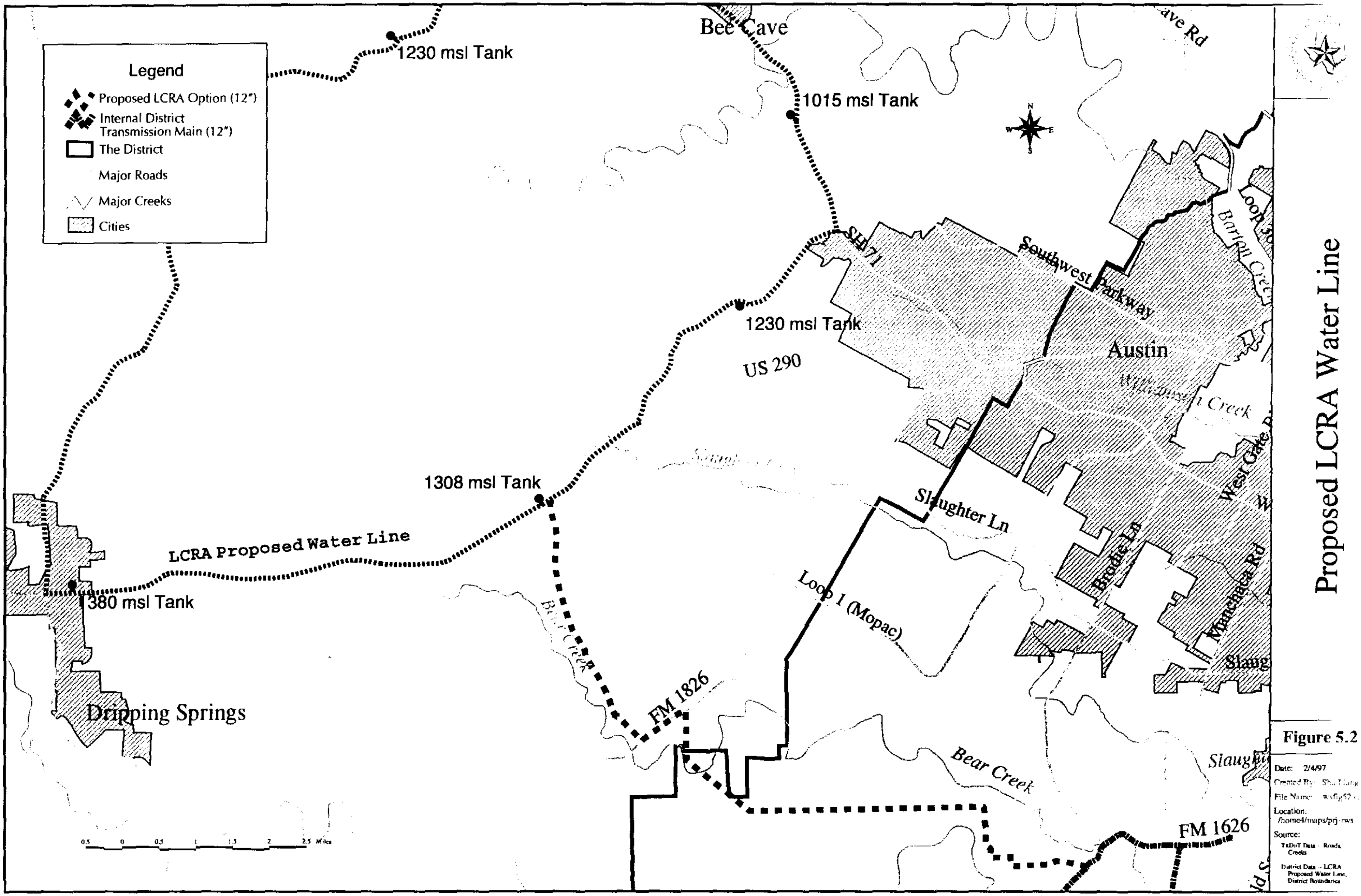


Figure 5.2

Proposed LCRA Water Line

TABLE 5.4

CAPITAL COST PROJECTIONS FOR LCRA TREATED WATER
SUPPLY OPTION FROM U.S. HIGHWAY 290 AT NUTTY BROWN ROAD

ITEM NO.	DESCRIPTION	QUANTITY	UNITS	UNIT COST	UNITS	PROJECTED COST
1.	12-Inch Diameter C-900 P.V.C. Pipe From U.S. Highway 290 to Hill 1000 G.S. Reservoir w/Valves and Fittings	27,750	L.F.	$32.00	PER L.F.	$888,000
2.	12-Inch Diameter C-900 P.V.C. Pipe From Hill 1000 G.S. Reservoir to FM 1626 Via Bliss Spiller w/Valves and Fittings	30,900	L.F.	$32.00	PER L.F.	$988,800
3.	12-Inch Diameter C-900 P.V.C. Pipe From Bliss Spiller to San Leanna Via FM 1626 w/Valves and Fittings	12,850	L.F.	$32.00	PER L.F.	$411,200
4.	12-Inch Diameter C-900 P.V.C. Pipe From Bliss Spiller to Hays Via FM 1626 w/Valves and Fittings	8,000	L.F.	$32.00	PER L.F.	$256,000
5.	12-Inch Diameter C-900 P.V.C. Pipe From Intersection of MOPAC R.R. and FM 1626 to Buda Via R.R. R.O.W. w/Valves and Fittings	21,900	L.F.	$32.00	PER L.F.	$700,800
6.	Hill 1000 Ground Storage Reservoir	200,000	GALS.	$0.50	PER GAL.	$100,000
7.	16-Inch Bore and Case For 12-Inch C-900 Pipe	3,300	L.F.	$150.00	PER L.F.	$495,000
8.	Creek Crossings For 12-Inch C-900 Pipe	870	L.F.	$75.00	PER L.F.	$65,250
9.	Fence and Structure Repairs For 12-Inch C-900 P.V.C.	1	L.S.	$75,000.00	L.S.	$75,000
10.	Air Relief Valves	13	EA.	$800.00	EA.	$10,400
11.	Flow Meter w/Vault @ U.S. Highway 290	1	L.S.	$15,000.00	L.S.	$15,000
12.	All Weather Road to Hill 1000	4,000	L.F.	$20.00	PER L.F.	$80,000
13.	Fence Around Required Public Water Facilities	380	L.F.	$18.00	PER L.F.	$6,840
SUBTOTAL PROJECTED CONSTRUCTION						$4,092,290
CONTINGENCIES (15% OF CONSTRUCTION)						$613,844
EASEMENTS AND RIGHT-OF-WAY		70	ACS.	$5,000.00	PER AC.	$349,174
LAND ACQUISITION		2	ACS.	$15,000.00	PER AC.	$30,000
ENGINEERING DESIGN (8% OF CONSTRUCTION)						$327,383
DESIGN SURVEY		101,400	L.F.	$1.00	PER L.F.	$101,400
CONSTRUCTION SURVEY		101,400	L.F.	$1.25	PER L.F.	$126,750
GEOTECHNICAL AND TESTING (0.5% OF CONSTRUCTION)						$20,461
LEGAL (1% OF CONSTRUCTION)						$40,923
FINANCING AND BOND COUNSEL (0.6% OF CONSTRUCTION)						$24,554
PERMITTING (LOCAL, STATE AND FEDERAL)						$10,000
PROJECTED TOTAL PROJECT COST						$5,736,778

TABLE 5.5

ANNUAL COST OF SERVICE ANALYSIS FOR LCRA TREATED WATER SUPPLY OPTION FROM U.S. HIGHWAY 290 AT NUTTY BROWN ROAD

ITEM NO.	COST OF SERVICE ITEM	PROJECTED COST
	OPERATION AND MAINTENANCE EXPENSE	
1.	Salaries and Wages	$42,120
2.	Contract Labor for Reoccurring O&M not a Function of Water Pumped	$10,000
3.	Contract Labor for Reoccurring O&M that is a Function of Water Pumped	$10,000
4.	Chemicals and Treatment	$0
5.	Plant Site Utilities	$1,200
6.	Utilities For High Service Pumps	$0
7.	Repairs and Maintenance for Reoccurring O&M Not a Function of Water Pumped	$10,000
8.	Repairs and Maintenance for Reoccurring O&M that is a Function of Water Pumped	$10,000
9.	Office Supplies	$600
10.	Repair and Maintainence on Vehicles and Small Equip.	$3,000
11.	Small Tools and Equipment	$600
12.	Professional Services	$15,000
13.	Administration	$33,750
14.	Water Purchases	$862,968
15.	Insurance	$4,000
16.	Regulatory Expense	$3,000
17.	Miscellaneous	$1,300
18.	TOTAL O&M EXPENSES	$1,007,538
	OTHER EXPENSES:	
19.	Debt Service on Capital Improvements for This Alternative (6% For 20-Yrs)	$500,158
TOTAL ANNUAL REVENUE REQUIREMENT FOR CAPITAL AND O&M EXPENSES..................		$1,507,696

TABLE 5.6

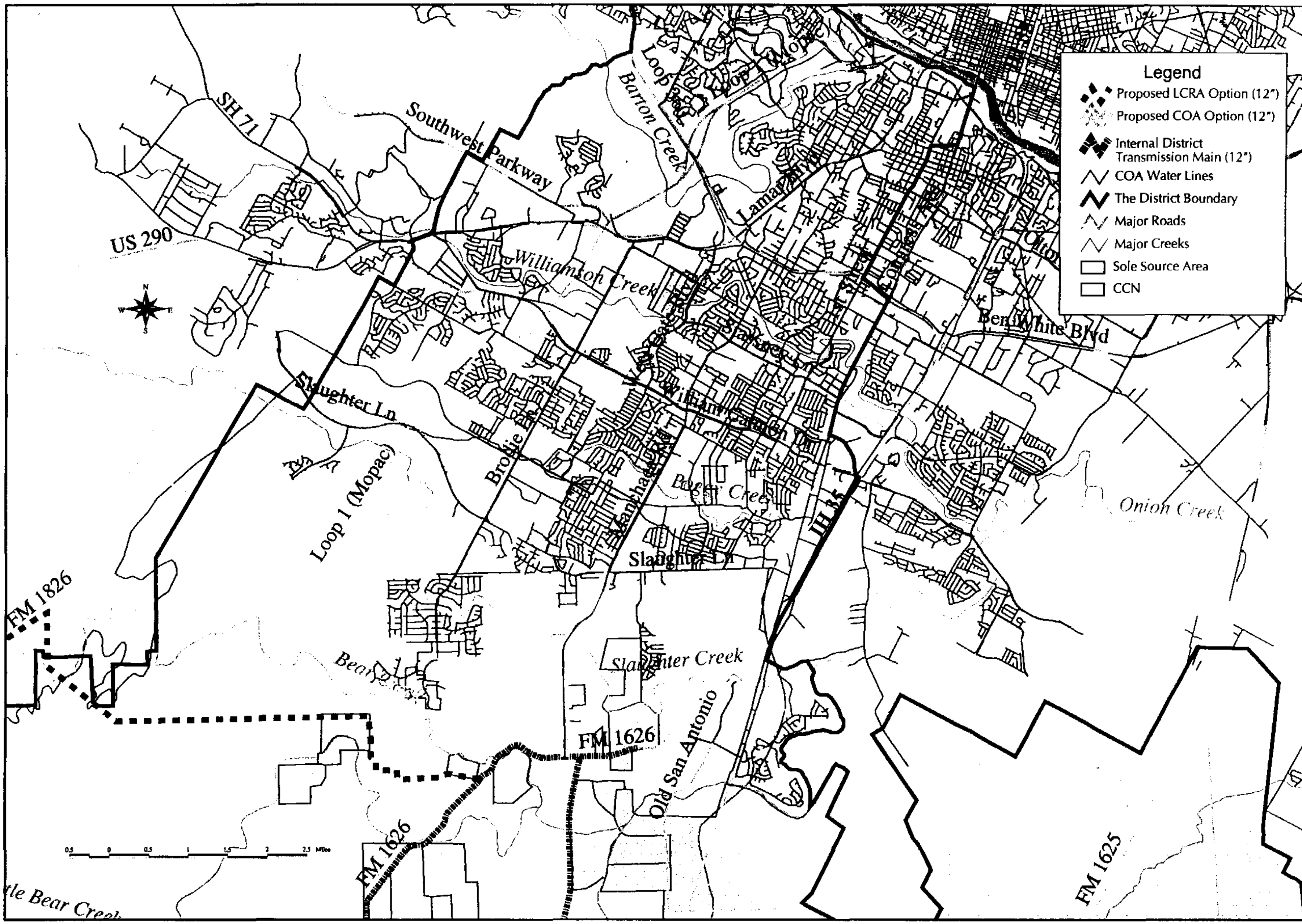
ASSUMPTIONS FOR ANNUAL O&M COST OF SERVICE FOR LCRA TREATED WATER OPTION FROM U.S HIGHWAY 290 AT NUTTY BROWN ROAD

No. 1 - Salary and Wages 1-Full Time @ $15/Hr. W/1.35 Benefits Multiplier		$42,120
No. 2 - Contract Labor not a Func. of Water Pumped Plant Upkeep, Etc. - Assumed		$10,000
No. 3 - Contract Labor as a Func. of Water Pumped Minor Repairs and Maintenance - Assumed		$10,000
No. 4 - Chemicals and Treatment (Clorination) None for this alternative		$0
No. 5 - Plant Site Utilities Assumed $100/month		$1,200
No. 6 - Utilities for High Service Pumps None for this alternative		$0
No. 7 - Repairs and Maint. Not a Func. of Water Pumped Assumed		$10,000
No. 8 - Repairs and Main. a Func. of Water Pumped Assumed		$10,000
No. 9 - Office Supplies Assumed $50/Month		$600
No. 10 - Repairs and Main. on Vehicles, etc. Assumed $250/Month		$3,000
No. 11 - Small Tools and Equip. Assumed $50/Month		$600
No. 12 - Professional Services (Annual) Accounting and Audits ($5,000/yr)	$5,000	
Legal (Reoccurring $5,000/yr)	$5,000	
Engineering (Reoccurring $5,000/yr)	$5,000	
TOTAL		$15,000
No. 13 - Administration Assumed: 20% of $50,000/yr employee and 50% of $30,000/yr employee w/1.35 benefits		$33,750
No. 14 - Water Treatement/Purchase Assumed 1.23 mgd @ $1.60/1,000 gals. Plus $144,648/yr Raw Water Charge		$862,968
No. 15 - Insurance Assumed: $4,000/yr		$4,000
No. 16 - Regulatory Expense Assumed: $3,000/yr		$3,000
No. 17 - Miscellaneous Postage	$100	
Supplies Other Than Office	$1,000	
Forms/Flyers	$200	
TOTAL		$1,300
TOTAL		$1,007,538

TABLE 5.9

ASSUMPTIONS FOR ANNUAL O&M COST OF SERVICE FOR CITY OF AUSTIN TREATED WATER SUPPLY OPTION FROM MANCHACA ROAD AT SLAUGHTER LANE

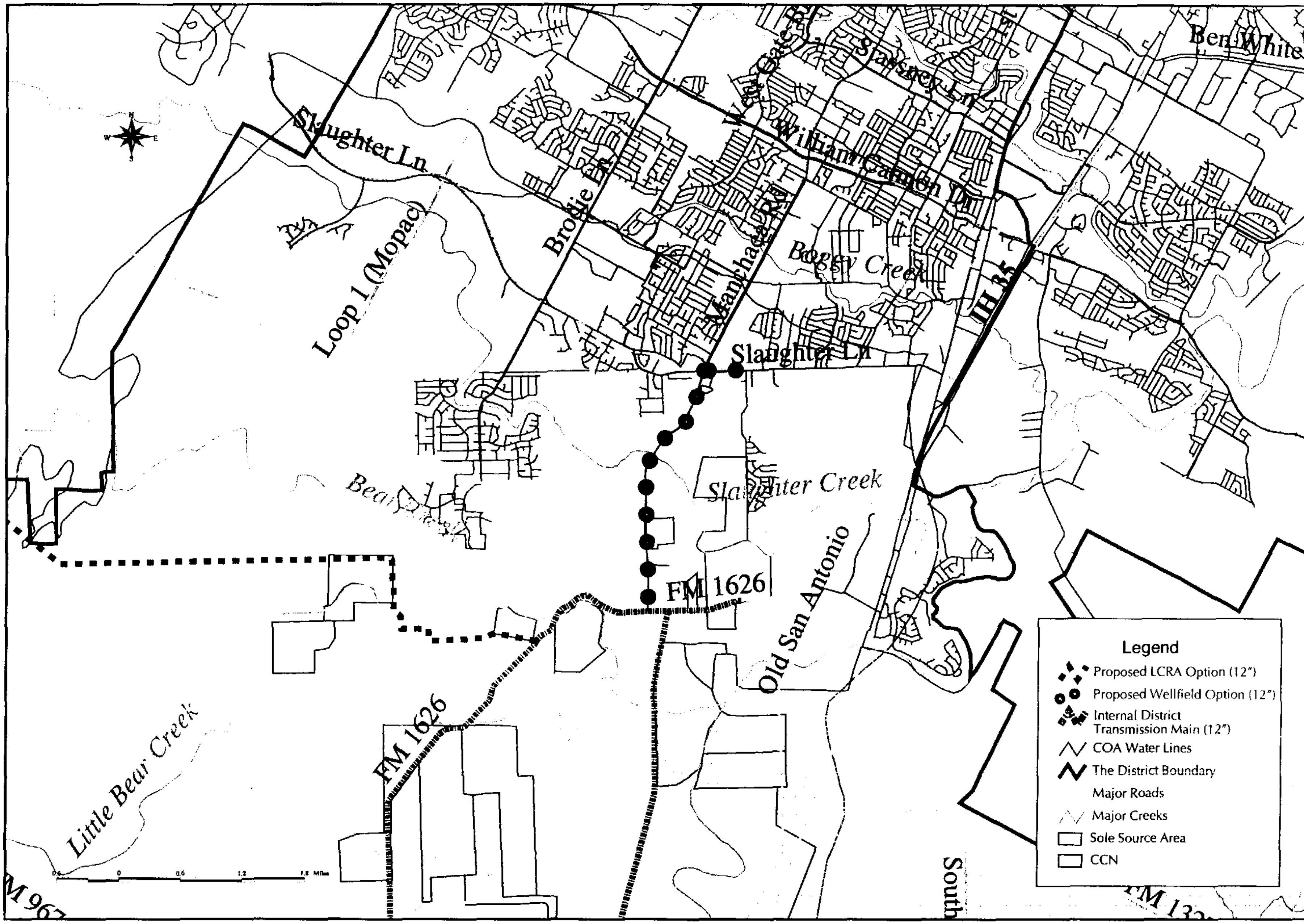
No. 1 - Salary and Wages 1-Full Time @ $15/Hr. W/1.35 Benefits Multiplier		$42,120
No. 2 - Contract Labor not a Func. of Water Pumped Plant Upkeep, Etc. - Assumed		$10,000
No. 3 - Contract Labor as a Func. of Water Pumped Minor Repairs and Maintenance - Assumed		$10,000
No. 4 - Chemicals and Treatment (Clorination) None for this alternative		$0
No. 5 - Plant Site Utilities Assumed $200/month		$2,400
No. 6 - Utilities for High Service Pumps $0.20/1,000 Gallons Pumped for 1.23 mgd Treated Water		$89,790
No. 7 - Repairs and Maint. Not a Func. of Water Pumped Assumed		$10,000
No. 8 - Repairs and Main. a Func. of Water Pumped Assumed		$10,000
No. 9 - Office Supplies Assumed $50/Month		$600
No. 10 - Repairs and Main. on Vehicles, etc. Assumed $250/Month		$3,000
No. 11 - Small Tools and Equip. Assumed $50/Month		$600
No. 12 - Professional Services (Annual) Accounting and Audits ($5,000/yr)	$5,000	
Legal (Reoccurring $5,000/yr)	$5,000	
Engineering (Reoccurring $5,000/yr)	$5,000	
TOTAL		$15,000
No. 13 - Administration Assumed: 20% of $50,000/yr employee and 50% of $30,000/yr employee w/1.35 benefits		$33,750
No. 14 - Water Treatement/Purchase Assumed 1.23 mgd @ $1.90/1,000 gals.		$853,005
No. 15 - Insurance Assumed: $4,000/yr		$4,000
No. 16 - Regulatory Expense Assumed: $3,000/yr		$3,000
No. 17 - Miscellaneous Postage	$100	
Supplies Other Than Office	$1,000	
Forms/Flyers	$200	
TOTAL		$1,300
TOTAL		$1,088,565



Proposed City of Austin Water Line

Figure 5.3

Date: 2/4/97
Created By: Shu Liang
File Name: wsfig53.eps
Location: /home4/maps/prj-rws
Source:
TxDoT Data -- Roads and Creeks
COA Data -- Water Lines
TWDB Data -- CCN's
District Data -- Sole Source Area, LCRA Water Line and District Boundaries



Proposed District Well Field Alternative

Figure 5.4

Date: 2/497
Created By: Shu Liang
File Name wsfig54.eps
Location: /home4/maps/prj-rws
Source:
TxDoT Data – Roads and Creeks
COA Data – Water Lines
TWDB Data – CCN's
District Data – Sole Source Area and District Boundaries

TABLE 5.10

CAPITAL COST PROJECTIONS FOR BS/EACD EDWARDS AQUIFER WELL FIELD AND WATER SUPPLY SYSTEM

ITEM NO.	DESCRIPTION	QUANTITY	UNITS	UNIT COST	UNITS	ESTIMATED COST
1.	12-Inch Diameter C-900 P.V.C. Pipe Along Manchaca Road and FM 1626 w/Valves & Fittings	32,500	L.F.	$32.00	PER L.F.	$1,040,000
2.	12-Inch Diameter C-900 P.V.C. Pipe From Slaughter Lane Well Field to Manchaca Road w/Valves & Fittings	1,500	L.F.	$32.00	PER L.F.	$48,000
3.	12-Inch Diameter C-900 P.V.C. Pipe From FM 1626 to Buda w/Valves and Fittings	21,900	L.F.	$32.00	PER L.F.	$700,800
4.	12-Inch Diameter C-900 P.V.C. Pipe From FM 1626 Near Hays to Elevated Storage Tank on Hill 824	2,500	L.F.	$32.00	PER L.F.	$80,000
5.	Edwards Aquifer Water Supply Well 400-Feet Total Depth	2	EA.	$125,000.00	EA.	$250,000
6.	Ground Storage Reservoir @ Well Field	200,000	GALS.	$0.50	PER GAL.	$100,000
7.	High Service Pump Station @ Well Field	1	EA.	$100,000.00	EA.	$100,000
8.	Chlorination Facilities @ Well Field	1	EA.	$20,000.00	EA.	$20,000
9.	Yard Piping and Controls @ Well Field	1	L.S.	$15,000.00	L.S.	$15,000
10.	Electric Power Supply @ Well Field	1	L.S.	$25,000.00	L.S.	$25,000
11.	Elevated Storage (924 msl Overflow) on Hill 824 Southeast of Hays near Leisurewoods	300,000	GAL.	$2.00	PER GAL	$600,000
12.	16-Inch Bore and Case For 12-Inch C-900 Pipe	1,900	L.F.	$150.00	PER L.F.	$285,000
13.	Creek Crossings For 12-Inch C-900 Pipe	800	L.F.	$75.00	PER L.F.	$60,000
14.	Fence and Structure Repairs For 12-Inch C-900 P.V.C.	1	L.S.	$75,000.00	L.S.	$75,000
15.	Air Relief Valves	12	EA.	$800.00	EA.	$9,600
16.	Flow Meter and Vault	1	L.S.	$15,000.00	L.S.	$15,000
17.	Telemetry and Remote Controls/Sensors	1	L.S.	$60,000.00	L.S.	$60,000
18.	All Weather Road at Well Field	1,000	L.F.	$20.00	PER L.F.	$20,000
19.	All Weather Road to Hill 824	2,500	L.F.	$20.00	L.F.	$50,000
20.	Fence Around Required Public Water Facilities	600	L.F.	$18.00	L.F.	$10,800
SUBTOTAL PROJECTED CONSTRUCTION						$3,564,200
CONTINGENCIES (15% OF CONSTRUCTION)						$534,630
EASEMENTS AND RIGHT-OF-WAY		38	ACS.	$10,000.00	PER AC.	$384,986
ENGINEERING DESIGN (8% OF CONSTRUCTION)						$285,136
LAND ACQUISITION FOR WELL FIELD/PUMPING PLANT		4	ACS.	$20,000.00	PER AC.	$80,000
DESIGN SURVEY		55,900	L.F.	$1.00	PER L.F.	$55,900
CONSTRUCTION SURVEY		55,900	L.F.	$1.25	PER L.F.	$69,875
GEOTECHNICAL AND TESTING (0.5% OF CONSTRUCTION)						$17,821
LEGAL (2% OF CONSTRUCTION)						$71,284
FINANCING AND BOND COUNSEL (1% OF CONSTRUCTION)						$35,642
PERMITTING (LOCAL, STATE AND FEDERAL)						$5,000
PROJECTED TOTAL PROJECT COST						$5,104,474

TABLE 5.11

ANNUAL COST OF SERVICE ANALYSIS FOR BS/EACD EDWARDS AQUIFER
WELL FIELD AND WATER SUPPLY SYSTEM

ITEM NO.	COST OF SERVICE ITEM	PROJECTED COST
	OPERATION AND MAINTENANCE EXPENSE	
1.	Salaries and Wages	$42,120
2.	Contract Labor for Reoccurring O&M not a Function of Water Pumped	$15,000
3.	Contract Labor for Reoccurring O&M that is a Function of Water Pumped	$15,000
4.	Chemicals and Treatment	$1,200
5.	Plant Site Utilities	$2,400
6.	Utilities For High Service Pumps	$179,580
7.	Repairs and Maintenance for Reoccurring O&M Not a Function of Water Pumped	$10,000
8.	Repairs and Maintenance for Reoccurring O&M that is a Function of Water Pumped	$10,000
9.	Office Supplies	$600
10.	Repair and Maintainence on Vehicles and Small Equip.	$3,000
11.	Small Tools and Equipment	$600
12.	Professional Services	$15,000
13.	Administration	$33,750
14.	Water Purchases	$0
15.	Insurance	$4,000
16.	Regulatory Expense	$3,000
17.	Miscellaneous	$1,300
18.	TOTAL O&M EXPENSES	$336,550
	OTHER EXPENSES:	
19.	Debt Service on Capital Improvements for This Alternative (6% For 20-Yrs)	$445,031
TOTAL ANNUAL REVENUE REQUIREMENT FOR CAPITAL AND O&M EXPENSES..................		$781,581

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TABLE 5.12

ASSUMPTIONS FOR ANNUAL O&M COST OF SERVICE FOR BS/EACD EDWARDS AQUIFER WELL FIELD AND WATER SUPPLY SYSTEM

No. 1 - Salary and Wages 1-Full Time @ $15/Hr. W/1.35 Benefits Multiplier		$42,120
No. 2 - Contract Labor not a Func. of Water Pumped Plant Upkeep, Etc. - Assumed		$15,000
No. 3 - Contract Labor as a Func. of Water Pumped Minor Repairs and Maintenance - Assumed		$15,000
No. 4 - Chemicals and Treatment (Clorination) Assumed $100/month		$1,200
No. 5 - Plant Site Utilities Assumed $200/month		$2,400
No. 6 - Utilities for High Service Pumps $0.20/1,000 Gallons Pumped for 1.23 mgd times 2		$179,580
No. 7 - Repairs and Maint. Not a Func. of Water Pumped Assumed		$10,000
No. 8 - Repairs and Main. a Func. of Water Pumped Assumed		$10,000
No. 9 - Office Supplies Assumed $50/Month		$600
No. 10 - Repairs and Main. on Vehicles, etc. Assumed $250/Month		$3,000
No. 11 - Small Tools and Equip. Assumed $50/Month		$600
No. 12 - Professional Services (Annual) Accounting and Audits ($5,000/yr)	$5,000	
Legal (Reoccurring $5,000/yr)	$5,000	
Engineering (Reoccurring $5,000/yr)	$5,000	
TOTAL		$15,000
No. 13 - Administration Assumed: 20% of $50,000/yr employee and 50% of $30,000/yr employee w/1.35 benefits		$33,750
No. 14 - Water Treatement/Purchase None		$0
No. 15 - Insurance Assumed: $4,000/yr		$4,000
No. 16 - Regulatory Expense Assumed: $3,000/yr		$3,000
No. 17 - Miscellaneous Postage	$100	
Supplies Other Than Office	$1,000	
Forms/Flyers	$200	
TOTAL		$1,300
TOTAL		$336,550

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TABLE 5.13

INTERNAL TRANSMISSION MAIN SYSTEM CAPITAL COST PROJECTIONS FOR DEMAND CENTER 1

ITEM NO.	DESCRIPTION	QUANTITY	UNITS	UNIT COST	UNITS	ESTIMATED COST
1.	12-Inch Diameter C-900 P.V.C. Pipe From FM 1626 to Buda					
	Along MOPAC R.R. w/Valves & Fittings	21900	L.F.	32	PER L.F.	$700,800
2.	16-Inch Bore and Case For 12-Inch C-900 Pipe	240	L.F.	150	PER L.F.	$36,000
3.	Creek Crossings For 12-Inch C-900 Pipe	300	L.F.	75	PER L.F.	$22,500
4.	Structure Repairs For 12-Inch C-900 P.V.C.	1	L.S.	5000	L.S.	$5,000
5.	Air Relief Valves	5	EA.	800	EA.	$4,000

SUBTOTAL PROJECTED CONSTRUCTION						$768,300
CONTINGENCIES (15% OF CONSTRUCTION)						$115,245
EASEMENTS AND RIGHT-OF-WAY		15.08264463	ACS.	10000	PER AC.	$150,826
ENGINEERING DESIGN (8% OF CONSTRUCTION)						$61,464
DESIGN SURVEY		21900	L.F.	1	PER L.F.	$21,900
CONSTRUCTION SURVEY		21900	L.F.	1.25	PER L.F.	$27,375
GEOTECHNICAL AND TESTING (0.5% OF CONSTRUCTION)						$3,842
LEGAL (2% OF CONSTRUCTION)						$15,366
FINANCING AND BOND COUNSEL (1% OF CONSTRUCTION)						$7,683
PERMITTING (LOCAL, STATE AND FEDERAL)						$5,000

PROJECTED TOTAL PROJECT COST						$1,177,001

TABLE 5.14

INTERNAL TRANSMISSION MAIN SYSTEM CAPITAL COST PROJECTIONS FOR DEMAND CENTER 2

ITEM NO.	DESCRIPTION	QUANTITY	UNITS	UNIT COST	UNITS	ESTIMATED COST
1.	12-Inch Diameter C-900 P.V.C. Pipe From Manchaca Road					
	To Hays Along FM 1626 w/Valves & Fittings	14850	L.F.	32	PER L.F.	$475,200
2.	16-Inch Bore and Case For 12-Inch C-900 Pipe	600	L.F.	150	PER L.F.	$90,000
3.	Creek Crossings For 12-Inch C-900 Pipe	300	L.F.	75	PER L.F.	$22,500
4.	Air Relief Valves	4	EA.	800	EA.	$3,200
SUBTOTAL PROJECTED CONSTRUCTION						$590,900
CONTINGENCIES (15% OF CONSTRUCTION)						$88,635
EASEMENTS AND RIGHT-OF-WAY		10.22727273	ACS.	10000	PER AC.	$102,273
ENGINEERING DESIGN (8% OF CONSTRUCTION)						$47,272
DESIGN SURVEY		14850	L.F.	1	PER L.F.	$14,850
CONSTRUCTION SURVEY		14850	L.F.	1.25	PER L.F.	$18,563
GEOTECHNICAL AND TESTING (0.5% OF CONSTRUCTION)						$2,955
LEGAL (2% OF CONSTRUCTION)						$11,818
FINANCING AND BOND COUNSEL (1% OF CONSTRUCTION)						$5,909
PERMITTING (LOCAL, STATE AND FEDERAL)						$5,000
PROJECTED TOTAL PROJECT COST						$888,174

TABLE 5.15

INTERNAL TRANSMISSION MAIN SYSTEM CAPITAL COST PROJECTIONS FOR DEMAND CENTER 3

ITEM NO.	DESCRIPTION	QUANTITY	UNITS	UNIT COST	UNITS	ESTIMATED COST
1.	12-Inch Diameter C-900 P.V.C. Pipe From Manchaca Road					
	To San Leanna Along FM 1626 w/Valves & Fittings	5000	L.F.	32	PER L.F.	$160,000
2.	16-Inch Bore and Case For 12-Inch C-900 Pipe	560	L.F.	150	PER L.F.	$84,000
3.	Air Relief Valves	1	EA.	800	EA.	$800
SUBTOTAL PROJECTED CONSTRUCTION						$244,800
CONTINGENCIES (15% OF CONSTRUCTION)						$36,720
EASEMENTS AND RIGHT-OF-WAY		3.44352617	ACS.	10000	PER AC.	$34,435
ENGINEERING DESIGN (8% OF CONSTRUCTION)						$19,584
DESIGN SURVEY		5000	L.F.	1	PER L.F.	$5,000
CONSTRUCTION SURVEY		5000	L.F.	1.25	PER L.F.	$6,250
GEOTECHNICAL AND TESTING (0.5% OF CONSTRUCTION)						$1,224
LEGAL (2% OF CONSTRUCTION)						$4,896
FINANCING AND BOND COUNSEL (1% OF CONSTRUCTION)						$2,448
PERMITTING (LOCAL, STATE AND FEDERAL)						$5,000
PROJECTED TOTAL PROJECT COST						$360,357

TABLE 5.16

INTERNAL TRANSMISSION MAIN SYSTEM CAPITAL COST PROJECTIONS FOR DEMAND CENTERS 1 & 2

ITEM NO.	DESCRIPTION	QUANTITY	UNITS	UNIT COST	UNITS	ESTIMATED COST
1.	12-Inch Diameter C-900 P.V.C. Pipe From Hays to Buda Via					
	FM 1626 and Old Black Colony Rd. w/Valves & Fittings	24100	L.F.	32	PER L.F.	$771,200
2.	16-Inch Bore and Case For 12-Inch C-900 Pipe	620	L.F.	150	PER L.F.	$93,000
3.	Creek Crossings For 12-Inch C-900 Pipe	250	L.F.	75	PER L.F.	$18,750
4.	Structure Repairs For 12-Inch C-900 P.V.C.	1	L.S.	5000	L.S.	$5,000
5.	Air Relief Valves	4	EA.	800	EA.	$3,200

SUBTOTAL PROJECTED CONSTRUCTION						$891,150
CONTINGENCIES (15% OF CONSTRUCTION)						$133,673
EASEMENTS AND RIGHT-OF-WAY		16.59779614	ACS.	10000	PER AC.	$165,978
ENGINEERING DESIGN (8% OF CONSTRUCTION)						$71,292
DESIGN SURVEY		24100	L.F.	1	PER L.F.	$24,100
CONSTRUCTION SURVEY		24100	L.F.	1.25	PER L.F.	$30,125
GEOTECHNICAL AND TESTING (0.5% OF CONSTRUCTION)						$4,456
LEGAL (2% OF CONSTRUCTION)						$17,823
FINANCING AND BOND COUNSEL (1% OF CONSTRUCTION)						$8,912
PERMITTING (LOCAL, STATE AND FEDERAL)						$5,000

PROJECTED TOTAL PROJECT COST						$1,352,508

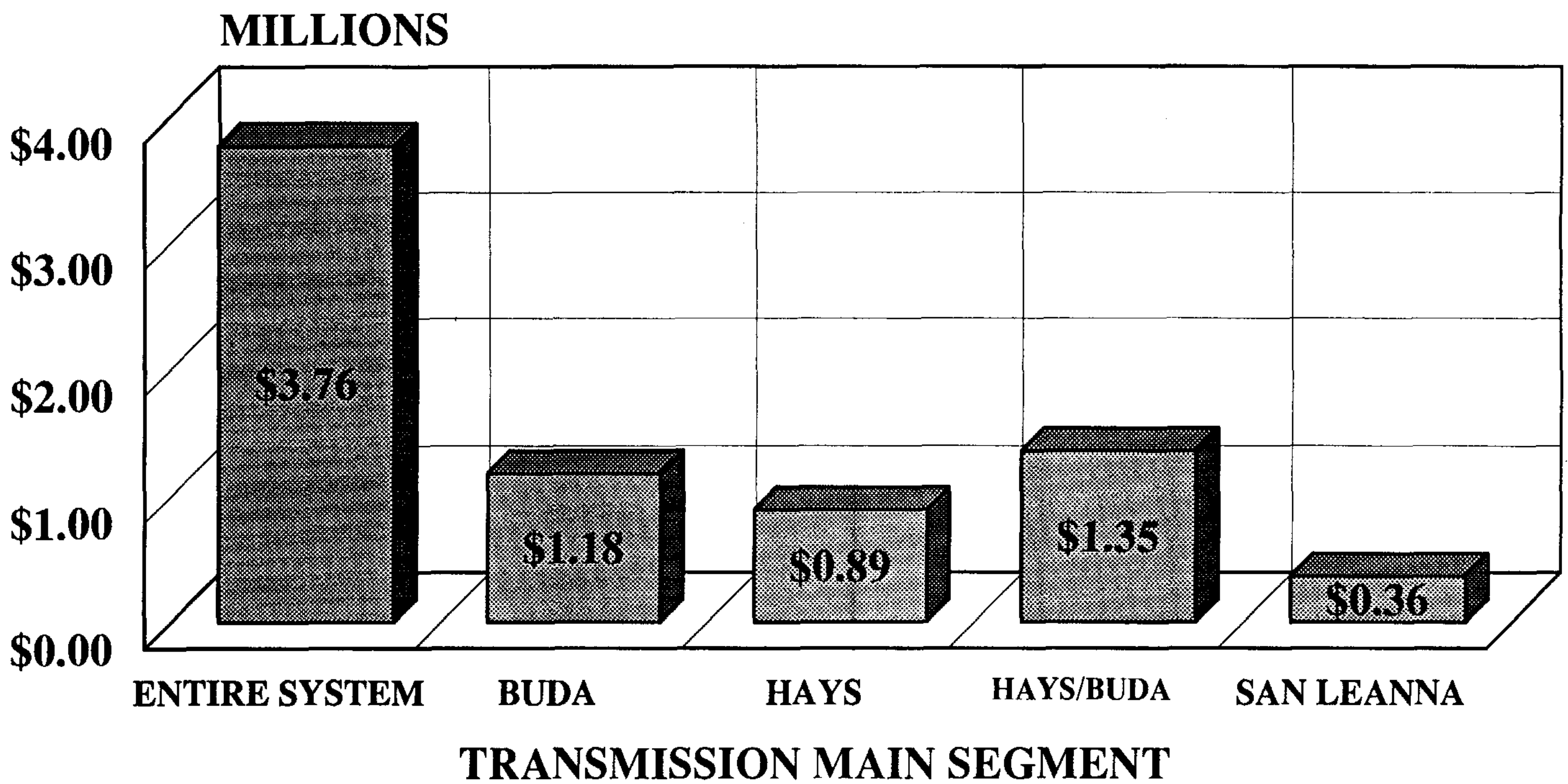
TABLE 5.17

INTERNAL TRANSMISSION MAIN SYSTEM CAPITAL COST PROJECTIONS FOR ENTIRE DISTRICT SYSTEM

ITEM NO.	DESCRIPTION	QUANTITY	UNITS	UNIT COST	UNITS	ESTIMATED COST
1.	12-Inch Diameter C-900 P.V.C. Pipe					
	w/Valves & Fittings	65850	L.F.	32	PER L.F.	$2,107,200
2.	16-Inch Bore and Case For 12-Inch C-900 Pipe	2020	L.F.	150	PER L.F.	$303,000
3.	Creek Crossings For 12-Inch C-900 Pipe	850	L.F.	75	PER L.F.	$63,750
4.	Fence and Structure Repairs For 12-Inch C-900 P.V.C.	2	L.S.	5000	L.S.	$10,000
5.	Air Relief Valves	14	EA.	800	EA.	$11,200
SUBTOTAL PROJECTED CONSTRUCTION						$2,495,150
CONTINGENCIES (15% OF CONSTRUCTION)						$374,273
EASEMENTS AND RIGHT-OF-WAY		45.35123967	ACS.	10000	PER AC.	$453,512
ENGINEERING DESIGN (8% OF CONSTRUCTION)						$199,612
DESIGN SURVEY		65850	L.F.	1	PER L.F.	$65,850
CONSTRUCTION SURVEY		65850	L.F.	1.25	PER L.F.	$82,313
GEOTECHNICAL AND TESTING (0.5% OF CONSTRUCTION)						$12,476
LEGAL (2% OF CONSTRUCTION)						$49,903
FINANCING AND BOND COUNSEL (1% OF CONSTRUCTION)						$24,952
PERMITTING (LOCAL, STATE AND FEDERAL)						$5,000
PROJECTED TOTAL PROJECT COST						$3,763,040

FIGURE 5.5
Barton Springs/Edwards Aquifer Conservation District

CAPITAL COST FOR THE INTERNAL SYSTEM



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5.1.7 Projected Unit Cost for Water

The projected capital cost and annual cost of service for each of the District's water supply alternatives (i.e. GBRA, LCRA, COA, and Well Field) are shown in Figure 5.6 and Figure 5.7, respectively. The COA option has the lowest capital cost at approximately $4.7 million, followed by the District Well Field option at an estimated $5.0 million. The GBRA option has the third highest capital cost at approximately $5.3 million. The highest capital cost alternative is the LCRA option at an estimated $5.74 million.

However, on an annual cost basis (i.e. annual debt service plus annual O&M cost), the lowest cost alternative is the District Well field option at $0.77 million, followed by the GBRA option (at $1.22 million), the COA option (at $1.49 million) and LCRA option (at $1.64 million). Annual cost of service for each water supply alternative is shown in Figure 5.7. The District's Well Field option has the lowest annual cost since it does not include the purchase of treated surface water from a regional purveyor.

The unit cost (i.e. annual cost of service divided by water sold: 1.23 mgd or 30 percent of year 2000 projected demands) of water for each option follows the same trend as annual cost, as shown in Figure 5.8. Unit costs range from $1.72 per 1,000 gallons for the District Well Field option to $3.66 per 1,000 gallons for the LCRA option. Unit costs for the GBRA option and the COA option are estimated at $2.71 per 1,000 gallons and $3.33 per 1,000 gallons, respectively.

5.1.8 Cost Assessment

The unit cost for each water supply option for delivering treated water to the demand centers represents the annual revenue requirement (annual debt service plus annual O&M costs) divided by 30 percent of the year 2000 aggregate demands (i.e. 1.2 mgd or 438 million gallons per year). Table 5.18 presents a summary of each option's annual debt requirement and O&M costs. Also presented in Table 5.18 is the projected unit cost associated with each option's annual revenue requirement and O&M expenses. As can be seen in this table, the annual debt requirement for each water supply option falls within a range of approximately $400,000 per year to $500,000 per year. Projected annual O&M cost for the options ranges from about $337,000 to $1.0 million.

The District has several potential revenue generating alternatives available to pay for annual cost of service. These alternatives include, but are not limited to, the following:

1. Water Sales Revenues: The District could charge a water sales rate or gallonage charge to the 31 permittees or wholesale water customers who would receive water. This is normally accomplished through "take or pay" contracts, whereby each wholesale customer would pay for a base volume of water (e.g., 30 percent of demands) whether it is used or not. Under this alternative, the gallonage charge for water would range from $1.74 per 1,000 gallons to $3.36 per 1,000 gallons (see Figure 5.8), depending on the water supply option selected, as shown in Table 5.19.

2. Ad Valorem Tax: The District could ask the legislature to amend the enabling Texas statute to provide for the levying of an ad valorem tax against all real and personal property located within the District boundary. This would require a District-wide voter referendum for levying a tax. Revenues collected from the ad valorem tax could repay the District's annual debt service requirement for the selected water supply option, while water revenues would be used to pay annual O&M costs. The estimated 1996 District valuation (i.e. the portion of the District located within Travis and Hays counties) is $577 million (see Appendix IV). At this valuation, each $0.01 per $100 valuation tax would raise approximately $58,000. As such, a tax of between $0.07 per $100 valuation (raising $407,166 per year) and $0.09 per $100 valuation (generating $500,158 per year) would raise sufficient revenues to retire the debt service component of each option (see Table 5.19). Under this scenario, the District could enter into "take or pay" contracts with the 31 wholesale customers, whereby wholesale customer would pay for a base volume of water (e.g., 30 percent of demands) at a rate that would offset annual O&M expenses. As shown in Table 5.19, the required "take or pay" water rate would range from $0.75 per 1,000 to $2.24 per 1,000, depending on the selected water supply option. This payment alternative (i.e. using taxes to retire annual debt service and water revenues to offset annual O&M expenses) has the advantage of having District-wide water users and residents pay for reducing the demands on the Edwards Aquifer, in regards to the GBRA, LCRA and COA options.

3. Pumpage Fee Surcharge: The District could assess a pumpage fee surcharge on all District permittees[10]. As in the case of the ad valorem tax alternative, revenues collected from the pumpage fee surcharge could repay the District's annual debt service requirement for the selected water supply option, while water revenues would be used to pay annual O&M costs. At an estimated District permitted pumpage quantity of 1.4 billion gallons, a surcharge of $0.29 per 1,000 gallons per year to $0.36 per 1,000 gallons per year, as shown in Table 5.19, would be required to retire the debt service for the water supply option presented in Table 5.18. Likewise, the "take or pay" water rate required to pay for annual O&M expenses would range from $0.75 per 1,000 to $2.24 per 1,000, depending on the selected water supply option[11].

4. Impact Fees or Capital Recovery Fees[12]: The District could assess a water impact fee or capital recovery fee on a per meter basis based on new water connections (i.e. water connections that occur after wholesale water contracts are executed between the District and the 31 wholesale water customers. Assuming the year 2000 as the base year, projected growth in water meters (Figure 5.9) between the year 2000 and year 2010 would approximately 2,470 meters. If an impact fee or capital recovery fee of $2,025 per new connection were charged, as shown in Table 5.19, the District could raise about $5.0 million over a 10 year period, which would be sufficient for interest and principal payments (for a 10 year

[10] Also, the District could place a surcharge on all well registrations to raise additional capital for debt service and O&M requirements. This would provide a mechanism to assess a charge on all users of the Edwards Aquifer that would directly or indirectly benefit from a regional system.

[11] Under the alternatives, all District Permittees would be assessed a surcharge fee of $0.29 to $0.36 per 1,000 gallons. The take or pay rate of $0.75 to $2.24 per 1,000 gallons would be paid solely by the entities purchasing surface water.

[12] A formal study would have to be performed and adopted by the District in order to assess an impact fee or capital recovery fee.

FIGURE 5.6
Barton Springs/Edwards Aquifer Conservation District

PROJECTED CAPITAL COST FOR EACH WHOLESALE WATER SUPPLY ALTERNATIVE

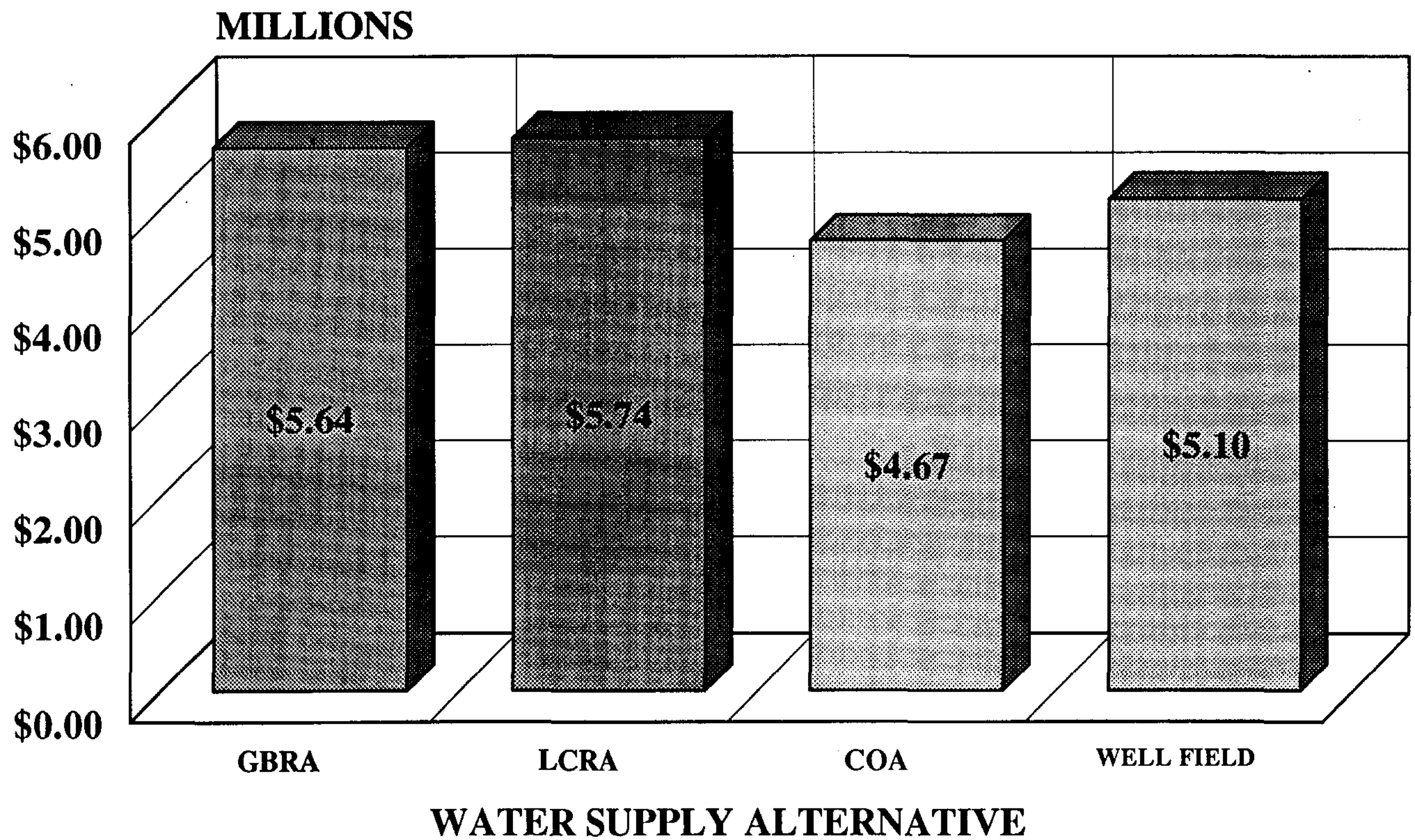

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FIGURE 5.7

Barton Springs/Edwards Aquifer Conservation District

PROJECTED ANNUAL COST OF SERVICE FOR EACH WHOLESALE WATER SUPPLY ALTERNATIVE

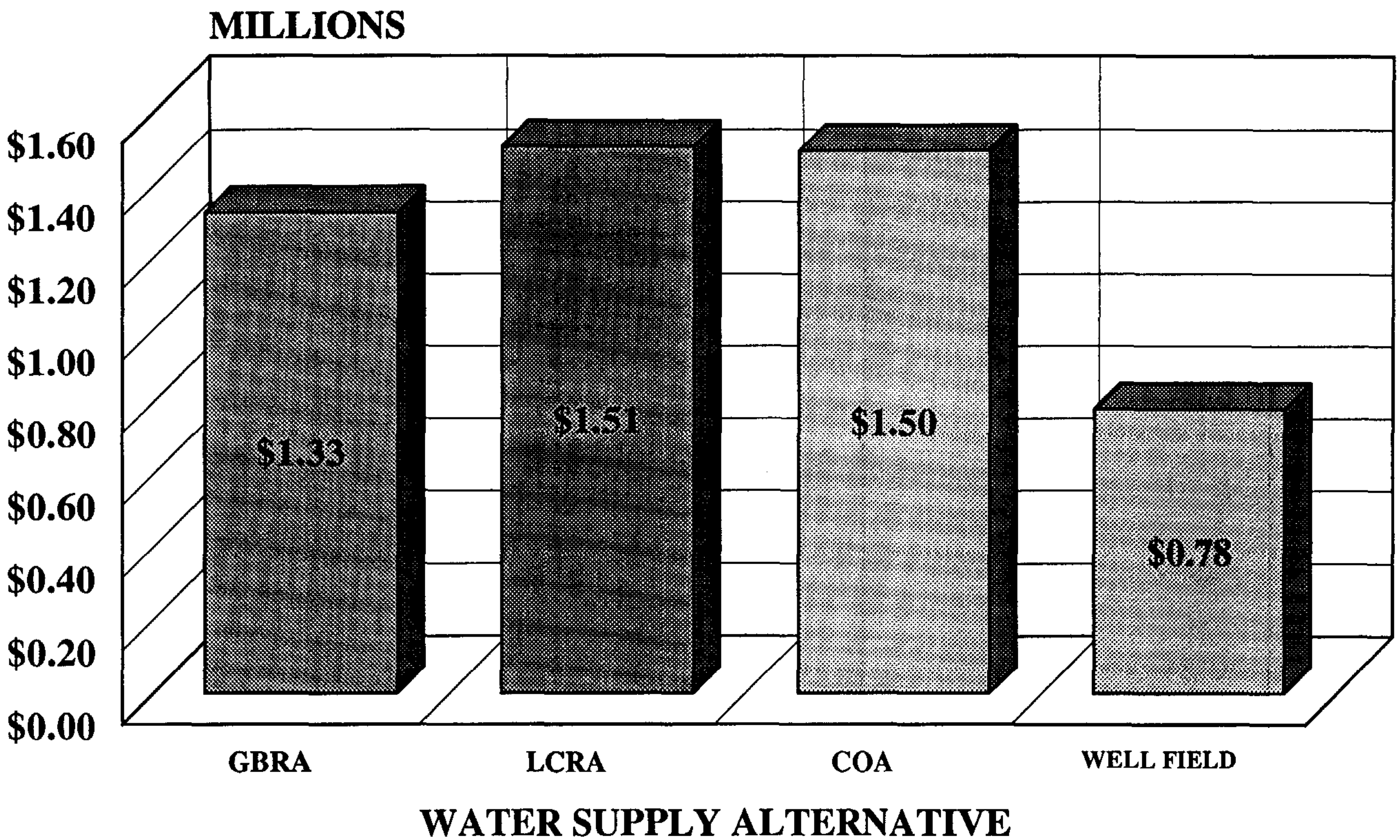

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FIGURE 5.8

Barton Springs/Edwards Aquifer Conservation District

PROJECTED UNIT COST FOR EACH WHOLESALE WATER SUPPLY ALTERNATIVE

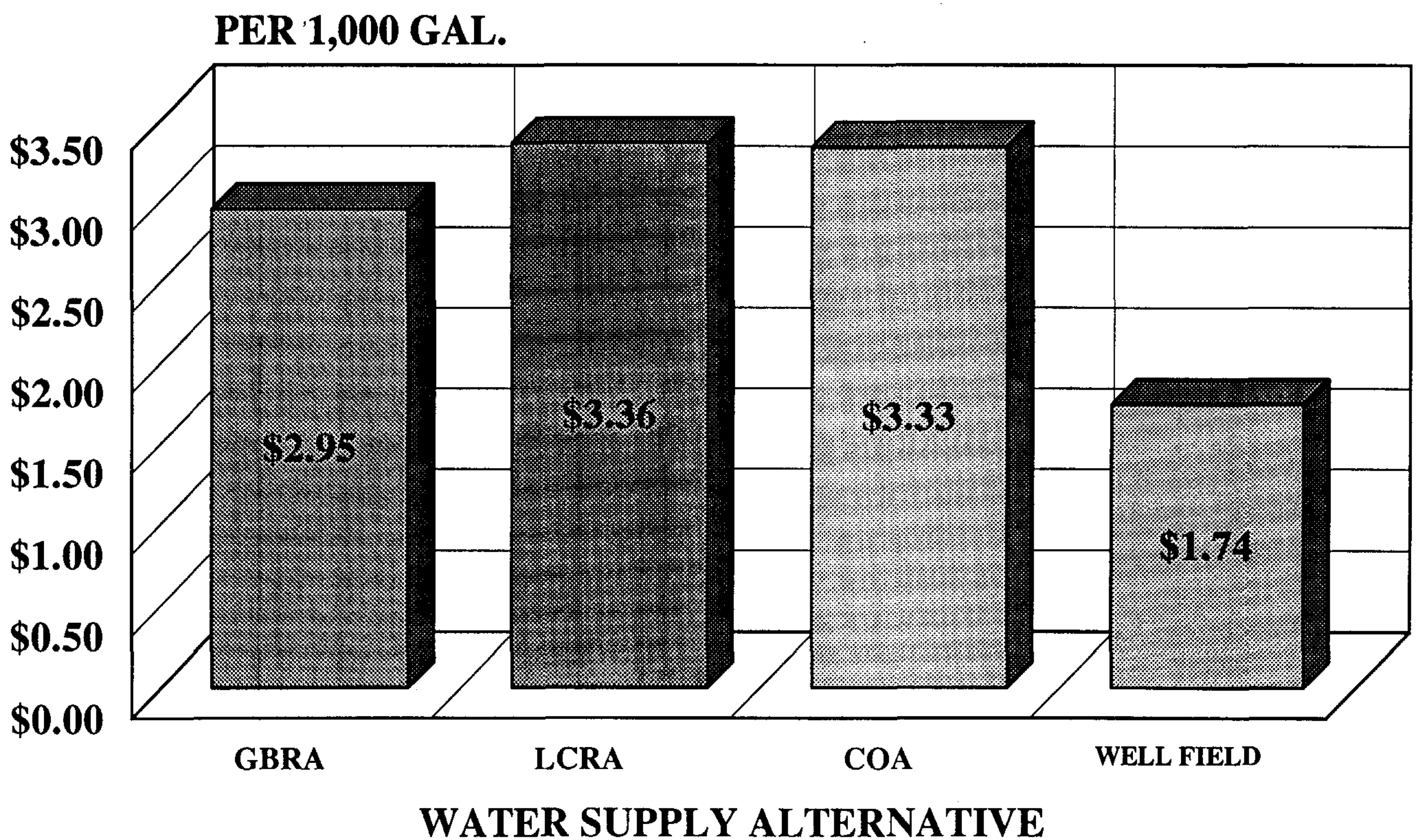

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TABLE 5.18

ANNUAL REVENUE REQUIREMENT AND O&M COST ASSOCIATED WITH EACH WATER SUPPLY OPTION

WATER SUPPLY OPTION	PROJECTED ANNUAL REVENUE REQUIREMENT FOR DEBT SERVICE	UNIT COST BASED ON ANNUAL REVENUE REQUIREMENT (Dollars/1,000 Gals.)	PROJECTED ANNUAL O&M COST	UNIT COST BASED ON ANNUAL O&M COST (Dollars/1,000 Gals.)	TOTAL UNIT COST (Dollars/1,000 Gals.)
GBRA	$491,808	$1.10	$834,158	$1.86	$2.95
LCRA	$500,158	$1.11	$1,007,538	$2.24	$3.36
COA	$407,166	$0.91	$1,088,565	$2.42	$3.33
DISTRICT WELLFIELD	$445,031	$0.99	$336,550	$0.75	$1.74

[File: c:\grants\rws\report\tables\5-18.xls] period) for the most costly annual debt service requirement water supply option (i.e. LCRA as shown in Table 5.18). Similarly, an impact fee or capital recovery fee of about $1,648 per new connection would retire the principal and interest debt service requirement (for a 10 year period) for the least costly annual debt service requirement water supply option (i.e. City of Austin).

5. Combination Alternative: The District could use a combination of the above described revenue generating models to repay projected annual debt service and O&M costs for the selected water supply option.

5.2 Institutional Considerations

Groundwater districts have broad regulatory authority in terms of the ability to manage groundwater resources. Few groundwater districts to date have pursued or acquired surface water alternatives to serve as conjunctive or supplemental sources of water for groundwater. No groundwater districts have pursued authority to own or operate wastewater treatment facilities to protect the groundwater resources from potential pollution. Some districts are the designated agents for onsite wastewater treatment (septic tank permits) within their jurisdiction. In an area such as the Barton Springs Edwards Aquifer, the ability to construct, own, and operate a local or regional wastewater treatment facility may provide the opportunity to not only protect the aquifer from potential pollution from failing or substandard onsite septic systems, but also provide a significant alternative water source for a number of permittees, which could utilize treated wastewater and treatment facilities. Having wastewater treatment facilities would address some of the problems created from the growth that would be generated from additional water supplies. It would also provide the opportunity to implement a conjunctive use at another level by allowing the District to develop an alternative source of water (treated wastewater) for industries or businesses that could use a water source that may be of lesser quality than the Edwards, but of a high enough quality to satisfy their needs, thereby reducing additional demands on the Edwards.

5.2.1 Required Legislative Changes

Legislative changes would not be required for the District to have the authority to acquire and provide surface water to its permittees. However, in order to pay for the acquisition of surface water or the construction of transmission facilities, additional revenues would be required. Also, the statutory limitation on the District's ability to borrow funds for more than one year poses some limitations on type of debt that can be incurred and under what conditions and circumstances bonded debt can be incurred. Clear authority for the criteria for the issuance of debt may need to be established through legislative change. The District's user fee mechanism and general fee authority may provide the basis for paying for these facilities, but with the current cap placed on the District's water use fee, other sources of revenue would have to be developed. The District does not currently have the authority to assess taxes, a funding option that will need to be considered.

In order for a groundwater district to own or operate a wastewater treatment facility, statutory authority would have to be acquired from the Legislature or an interlocal agreement adopted with another organization or local government that currently has that authority. Chapter 36 of the Texas Water Code could be amended to provide general wastewater

FIGURE 5.9

Barton Springs/Edwards Aquifer Conservation District

HISTORICAL AND PROJECTED WATER CONNECTIONS FOR THE THREE WATER DEMAND CENTERS

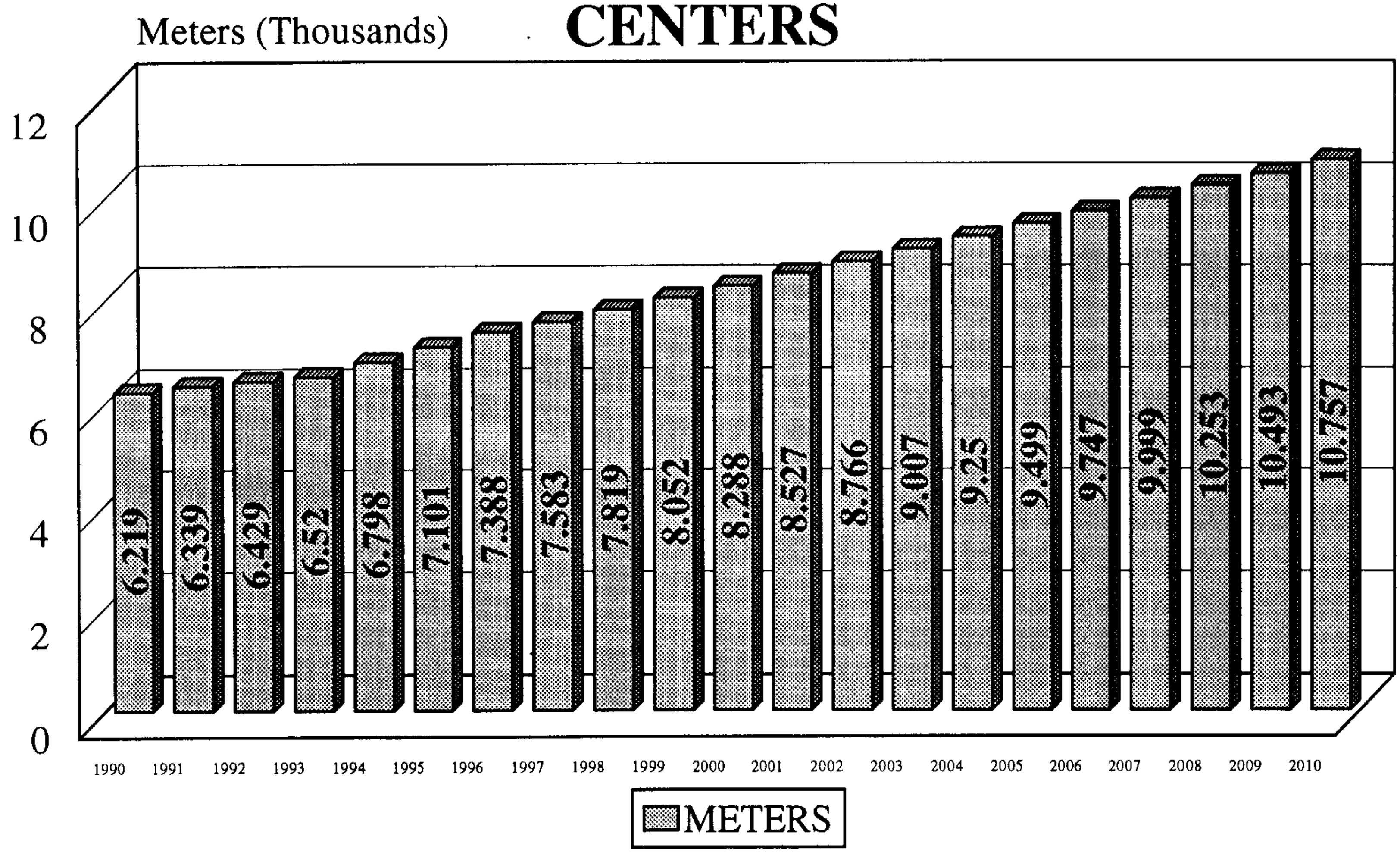

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TABLE 5.19

ANALYSIS OF ALTERNATIVE DISTRICT REVENUE GENERATING MODELS TO RAISE REQUIRED REVENUES FOR WATER SUPPLY OPTIONS

WATER SUPPLY OPTION	WATER REVENUE GENERATING ALTERNATIVE	AD VALOREM TAX AND GALLONAGE CHARGE METHOD		PUMPAGE FEE SURCHARGE AND GALLONAGE CHARGE METHOD		CAPITAL RECOVERY FEE AND GALLONAGE CHARGE METHOD	
		REQUIRED TAX PER $100 VALUATION	REQUIRED GALLONAGE CHARGE PER 1,000 GAL.	REQUIRED SURCHARGE PER 1,000 GAL.	REQUIRED GALLONAGE CHARGE PER 1,000 GAL.	REQUIRED CAPITAL RECOVERY FEE PER CONN.	REQUIRED GALLONAGE CHARGE PER 1,000 GAL.
GBRA	2.95	0.08	1.86	0.35	1.86	1991.13	1.86
LCRA	3.36	0.09	2.24	0.36	2.24	2024.93	2.24
COA	3.33	0.07	2.42	0.29	2.42	1648.45	2.42
DISTRICT WELLFIELD	1.74	0.08	0.75	0.32	0.75	1801.74	0.75

authority to all groundwater districts, or SB 988, the BS/EACD's enabling legislation, could be amended to provide specific authority to the District.

5.2.2 Permitting Issues

5.2.2.1 Interbasin Transfers

Because the District straddles the surface water divide between the Lower Colorado River and the Guadalupe-Blanco River Basins, an interbasin transfer permit would almost certainly be necessary. The areas currently experiencing extensive growth pressures and which are also the existing large volume users, are situated in the heart of the surface basin divide. Although interbasin transfers are an issue, more than 80 interbasin transfers currently exist for municipalities in many areas of the state. The same kinds of transfer between basins occur on a regular basis in these areas, and any interbasin transfer issues should be able to be addressed similarly in a groundwater district.

5.2.2.2 Other Required Permits

Implementation of any water supply option evaluated in this study will require the acquisition of local, state and federal permits. A summary of the potential regulatory authorizations required for each option is presented below:

GBRA ALTERNATIVE:

Local Permits

Hays County and Travis County Permits to Utilize County Right-of-Way for Utility Improvements

Union Pacific/Missouri Pacific Railroad Permit/Authorization to Utilize Private Railroad Right-of-Way for Utility Improvements

Land Development/Improvement Permits from the Cities of San Marcos (possibly), Kyle, Buda, Hays, San Leanna, and Austin (for ETJ only)

State of Texas Permits

TNRCC Water Rights Permit for the Interwatershed Transfers as Set Forth Under the Texas Administrative Code Section 297.18 - To transfer water from the Guadalupe River Basin to the Colorado River Basin

Texas Department of Transportation Permit to Utilize State Right-of-Way for Utility Improvements

Federal Permit

Possible U.S. Army Corps of Engineers Section 10-404 Permit for Dredge and Fill Activities in Navigable Waters of the United States (Onion Creek and Bear Creek)

LCRA ALTERNATIVE:

Local Permits

Hays County and Travis County Permits to Utilize County Right-of-Way for Utility Improvements

Union Pacific/Missouri Pacific Railroad Permit/Authorization to Utilize Private Railroad Right-of-Way for Utility Improvements

Land Development/Improvement Permits from the Cities of Buda, Hays, San Leanna, and City of Austin (possible for ETJ only)

State of Texas Permits

TNRCC Water Rights Permit for the Interwatershed Transfers as Set Forth Under the Texas Administrative Code Section 297.18 - To transfer water from the Colorado River Basin to the Guadalupe River Basin

Texas Department of Transportation Permit to Utilize State Right-of-Way for Utility Improvements

Federal Permit

Possible U.S. Army Corps of Engineers Section 10-404 Permit for Dredge and Fill Activities in Navigable Waters of the United States (Onion Creek and Bear Creek)

COA ALTERNATIVE:

Local Permits

Hays County and Travis County Permits to Utilize County Right-of-Way for Utility Improvements

Union Pacific/Missouri Pacific Railroad Permit/Authorization to Utilize Private Railroad Right-of-Way for Utility Improvements

Land Development/Improvement Permits from the Cities of Buda, Hays, San Leanna, and City of Austin (possibly for ETJ only)

State of Texas Permits

TNRCC Water Rights Permit for the Interwatershed Transfers as Set Forth Under the Texas Administrative Code Section 297.18 - To transfer water from the Colorado River Basing to the Guadalupe River Basin

Texas Department of Transportation Permit to Utilize State Right-of-Way for Utility Improvements

Federal Permit

Possible U.S. Army Corps of Engineers Section 10-404 Permit for Dredge and Fill Activities in Navigable Waters of the United States (Onion Creek and Bear Creek)

DISTRICT WELL FIELD ALTERNATIVE:

Local Permits

Hays County and Travis County Permits to Utilize County Right-of-Way for Utility Improvements

Union Pacific/Missouri Pacific Railroad Permit/Authorization to Utilize Private Railroad Right-of-Way for Utility Improvements

Land Development/Improvement Permits from the Cities of Buda, Hays, San Leanna, and City of Austin (possible for ETJ only)

Barton Springs/Edwards Aquifer Conservation District Water Well Permits

State of Texas Permits

Texas Department of Transportation Permit to Utilize State Right-of-Way for Utility Improvements

Federal Permit

Possible U.S. Army Corps of Engineers Section 10-404 Permit for Dredge and Fill Activities in Navigable Waters of the United States (Onion Creek and Bear Creek)

5.3 Environmental Concerns

There are a number of environmental issues of concern relative to alternative water supplies. They basically can be separated into two principal categories: the environmental impacts of doing nothing and the impacts of bringing in an alternative water supply. Growth is occurring and it is expected that it will continue to occur in the Barton Springs segment of the Edwards Aquifer. By planning for it, and by trying to address critical issues associated with growth, the demands placed on the natural and built environments along with impacts and potential problems associated with them can be addressed. One method to address these issues is by providing infrastructure in preferred growth areas. If growth is ignored, the consequences and fallout from not having done anything to prepare for shortages in the groundwater supply associated with growth or a drought include: diminished water quality, reduced water table and spring flows and localized water supply outages/shortages. If the demand issue is addressed by bringing in additional surface water resources, then the issues become those of impacts on the recharge zone, the artesian zone, and spring flow. If new wells are located in areas where groundwater is under-utilized, then all the issues previously identified must be addressed. It also must be realized that the negative impacts on spring flow may potentially be more immediate and more extreme during drought conditions because of the proximity of the proposed District well fields to Barton Springs and the existing demand centers.

Each alternative has an environmental impact on the area of origin for the surface water. Demand for surface water supplies continues to grow and the basins where water is available are rapidly approaching their carrying capacity. Recently, water available in the Colorado River is being sought by Corpus Christi and San Antonio. Interbasin transfers are major topics of discussion. Lawmakers and agency personnel are working to address the myriad of environmental, water rights, social and economic issues associated with moving water across basins. The limited availability of existing water, the fact that few good sites exist for new surface water reservoirs, and the environmental impacts associated with constructing new reservoirs continues to increase the cost of existing and new sources of surface water. Also, infrastructure costs continue to increase, as do land prices for right-of-way, treatment and distribution facilities.

If any of the proposed alternatives are pursued, then a detailed environmental analysis will need to be prepared before selecting the final alternative, or alternatives. In general, all of the proposed alternatives would have construction-related environmental impacts very similar to any other water line construction project. Only those that actually cross over the recharge zone would require any special consideration beyond the typical right-of-way assessment and installation of temporary structural controls.

5.4 Role of BS/EACD as Regional Surface Water Wholesale Provider

The District, as manager and steward of the groundwater resources, must evaluate the options available to extend the useful life and sustain the yield of the groundwater resources in our area. As growth in the area continues to increase, demands on the groundwater resources will increase, as will the potential for contamination. This is a result of increased development activities as the area transforms from rural ranch and farm land uses to more suburban, urban, industrial and commercial uses. Changes in the demands for increased quantities of water from the Edwards Aquifer will also cause water quality variations resulting from intrusion of lower quality waters -- leakage from the Trinity and Glen Rose aquifers because of reduced head pressure on the Edwards, and the potential for migration of bad water from the east. Also, as water within the aquifer is pumped out and is replaced with more recently recharged waters, the quality of Edwards water may decline as a result of increased sediments and other pollutants entering the aquifer.

The role of the District is also dependent upon the growth the area experiences and what role the permittees and residents want the District to serve. As a regional surface water wholesale provider, the District could identify available sources, acquire surface water, construct transmission lines, storage facilities and establish the distribution system. There are many public and private water supply companies to provide retail-level service in most areas. In growing areas, developers should strongly consider public water systems, particularly as surface water alternatives are developed, as a more dependable alternative, rather than individual private wells dependent solely on groundwater. By placing distribution infrastructure in the ground today, a development would be capable of utilizing surface water or other alternatives through the storage and distribution system in the future.

The economies of scale gained by the District in organizing all interested permittees, and the rates for bonds used to finance the facilities are benefits the District can provide as a local government. These are benefits not generally available to existing investor-owned and nonprofit Public Water Supply systems. It is doubtful that any of the existing public water supply systems alone could fund an alternative water supply sized to serve the needs of the residents in their service areas.

5.4.1 Conjunctive Use of Surface and Groundwater

By identifying and developing an alternative surface water supply, the District's permittees and residents can begin to take advantage of the conjunctive use of surface water and groundwater. As proposed under the three surface water alternatives (GBRA, LCRA, and COA) considered in this report, the District would propose to provide surface water to satisfy 30 percent of the region's groundwater demand from existing permitted users through the year 2016. This does not take into account growth in groundwater demand from new permittees in the area, or the ever-increasing demand from exempt private wells. Groundwater may not be available, depending on aquifer conditions, demand, or any limitation the District may put on permittees to reduce impacts on the groundwater resources overall; therefore, by having a surface water supply available some future, potential permittees may choose surface water over groundwater for a more dependable and consistent quantity and quality of water.

If surface water is available in the existing high demand areas, most of which are in the deeper artesian portion of the aquifer, it may be possible to manage the groundwater resource, reducing negative consequences by providing an alternative source in these high demand areas. By reducing the demand on the aquifer in these areas, groundwater will remain available to those dependent upon it in the western portion of the District and in the more shallow recharge zone areas.

The major inequity that has to be addressed is the fact that the major permitted pumpers in the artesian portions of the aquifer (the Haves) will be expending funds for improvements and paying for the surface water that will ultimately help sustain the availability of groundwater in the recharge zone where there are few permitted District wells (the Have Nots) to share the cost. By allowing the District to assess fees to a broader range of users, or by establishing a fee or taxing mechanism to allow all beneficiaries to contribute to the establishment of an alternative water source in the region, would be of benefit to all users and to the economic viability of the area. It would allow for ongoing improvements and expansions of selected surface water alternatives designed to reduce the negative impacts on groundwater demand from future growth.

5.5 Future Studies

This report begins to identify options for future water supplies and has examined a number of issues that will require further evaluation in order to make a more informed decision about available groundwater supplies, and alternatives water supplies currently available or under study for near-term implementation. It also leaves a number of questions unanswered that are environmental, social, economic, and financial in nature--considerations that are well beyond the scope of this planning effort.

Several issues clearly need further study. We propose for future study:

(1) More specifics on the environmental impact of the proposed alternatives presented in this report. Issues such as the impact on spring flow from the construction of additional water supply wells, both within the existing pumping centers, and the alternative proposed in this study that calls for a new well field outside of the existing demand centers;

(2) Refinement and development of additional data to build on the framework introduced in this report for identifying safe yield based on the geology, porosity and transmissivity of the aquifer is necessary. Volumetric values established in this report based on recent studies and field investigations of geology, well log evaluations and pump test information should be augmented with data from additional pump tests and well logs, particularly in the recharge zone. This new information would help refine the existing data, more thoroughly test and evaluate the methodology utilized in this report, and potentially help affirm the value of this type of information. There is potential utility for this type of data for establishing well spacing or production limitations for future well development and water supply planning and management purposes. The City of Austin, the TWDB, the Center for Research in Water Resources (CRWR), the District, and other agencies have information that could be utilized, if combined, to better refine existing groundwater availability models;

(3) Other research efforts conducted by the Bureau of Economic Geology and the Edwards Underground Water District have established a framework for research that could be extended into the Barton Springs segment and would build upon and enhance the quality of the information developed within the context of this study;

(4) As current water supply options become clearer, more detailed studies of the cost-benefit analysis of the alternatives needs to be conducted prior to final consideration of any specific alternative. Public hearings and public input are essential and must be obtained to determine the best solution for our regional water problems;

(5) This study only addressed growth and demand from existing permittees. New areas are being developed over the recharge and artesian zones and indications are that development will continue. As an increase in demand for smaller, more affordable lots becomes an issue in northern Hays County, there will be increasing pressure from more single family wells on the aquifer. Also, developers will begin to establish public water systems in areas where none currently exist, which will also increase demand on the aquifer. These new developments are not currently included in any of the water demand analysis presented in this report. The pattern and timing of development in the District has not been evaluated and the impacts of this future development have just recently been considered when planning for future water supplies. Current and future major subdivision development projects include the Ruby Ranch, Hays County Ranch, Negley Ranch (Plum Creek Development), the Heep and Rutherford Ranches, along with many other projects including the many smaller but important parcels that are currently being planned;

(6) As has been discussed in the series of public hearings held for this report, the District should expand the research on conservation and drought management practices that were included in the original Regional Water Plan compiled in 1990.

With on-going studies, research and implementation of various alternatives underway by GBRA, LCRA, the City of Austin, Trans -Texas, the legislature and others, it is difficult to determine which avenue will provide the best solution for our current and future needs. The District is responsible for preserving, protecting and enhancing groundwater resources in the Barton Springs segment of the Edwards Aquifer. Depending on the decisions and outcomes of the activities of the entities identified above, coupled with the will of the people, the water laws currently in effect, and the financial resources at our disposal, the ability of our agency to implement any of the proposed alternatives presented in this study will vary substantially.

VI. APPENDICES

APPENDIX I - SURVEY RESULTS

27 Surveys **1,180,328,250 Total Permitted Volume (TPV)**
17 Responses **1,085,272,000 (92%) Permitted Volume Accounted for in Survey**
63% Response Rate
NR: # No Responses
Analysis: # Responses / % Total Responses

PUBLIC WATER SUPPLY WATER USE SURVEY

NAME ____
ORGANIZATION ______________________________________

This survey has been written to determine the projected water demands for the immediate future and to assess the current status of the aquifer. Your input is very important in this effort and we ask that you answer each question as completely as possible. Please try to project your future needs based on whatever data sources or methods you may use to determine water demand. Please provide any additional comments you may feel relevant in a planning effort of this scope. Thank you in advance for your cooperation. Please return this to the District by July 15 -- a self addressed metered envelope has been included for your convenience.

Section 1: General Questions

1. The rate of growth, and the corresponding number of new well drillings, we are currently experiencing over the Barton Springs segment of the Edwards Aquifer will lead to a reduced **quantity** of water available at my location. **(NR 1)**

   I ☐ agree **14 Responses / 82%** or ☐ disagree **2 Responses / 12%**

2. The rate of growth, and the corresponding number of new well drillings, we are currently experiencing over the Barton Springs segment of the Edwards Aquifer will lead to a reduced **quality** of water available at my location. **(NR 0)**

   I ☐ agree **13 Responses / 76%** or ☐ disagree **4 Responses / 24%**

3. It is important to develop an alternate source of water to ensure that the quality and quantity of Edwards water available at my location is preserved. **(NR 0)**

   I ☐ agree **16 Responses / 94%** or ☐ disagree **1 Response / 6%**

4. It is the responsibility of all of the users of Edwards water to protect the resource.**(NR 0)**

   I ☐ agree **17 Responses / 100%** or ☐ disagree **0 Responses / 0%**

5. I ☐ have **1 Response / 6%** (have had to choke back on the pumps due to low water levels) or ☐ have not **16 Responses / 94%** experienced problems with the **quantity** of the Edwards aquifer groundwater at my location. If you have, please explain: **(NR 0)**

6. I ❑ have **1 Response / 6%** (no explanation) or ❑ have not **16 Responses / 94%** experienced problems with the **quality** of the Edwards aquifer groundwater at my location. If you have, please explain: **(NR 0)**

7. As the demand for Edwards aquifer groundwater increases, which of the following statements best represents your view. **(NR 0)**

8 Responses / 47% ❑ Existing users should be allowed to continue to use the same volume of Edwards water as they are currently permitted for and the remainder of the Edwards water should be distributed on a first come, first serve basis;
0 Responses / 0% ❑ Existing users should reduce their current permitted volume by some percentage to accommodate the water demands of new users;
1 Response / 6% ❑ Edwards water should be distributed equally, with each user receiving their equal share;
3 Responses / 18% ❑ New users should be required to meet their water demands with alternative sources of water.
6 Responses / 35% ❑ All users should be reducing their water demands on the Edwards aquifer.

8. Which of the following would you consider as to be a viable source of alternative water for your location. Indicate if it is currently available and the source (or supplier) of the water. **(NR 1)**

2 Responses / 12% ❑ Trinity aquifer groundwater;
❑ Supplier: ____________________
1 Response / 6% ❑ Reclaimed and treated wastewater;
❑ Supplier: ____________________
0 Responses / 0% ❑ Rainwater collection;
❑ Supplier: ____________________
❑ Surface water;
❑ Supplier: ____________________
3 Responses / 18% GBRA
1 Response / 6% Guadalupe Regional Water Supply
6 Responses / 35% LCRA
7 Responses / 41% COA
4 Responses / 24% BSEACD

0 Responses / 0% ❑ Other: please identify. ____________________

9. What are your primary concerns with connecting to an alternative source of water other than the Edwards (check all that apply)? **(NR 0)**

16 Responses / 94% ❑ Cost of the infrastructure or facilities;
16 Responses / 94% ❑ Cost of the water;
17 Responses / 100% ❑ Cost of the water and of the infrastructure or facilities;
10 Responses / 59% ❑ Quality of the water;
10 Responses / 59% ❑ Quantity of the water;
10 Responses / 59% ❑ Dependability of the water source.

10. If the District initiates a partnership to provide a surface water alternative, what level of participation would you consider in this project (check all that apply): **(NR 0)**

1 Response / 6% ❑ I do not need an alternative source of water, but consider surface water as a viable alternative for other users;
0 Responses / 0% ❑ I do not need an alternative source of water and do not consider surface water to be a viable alternative for other users;
15 Responses / 88% ❑ I realize the need for an alternative source of water and consider surface water as a viable alternative for myself;
1 Response / 6% ❑ I realize the need for an alternative source of water, but do not consider surface water to be a viable alternative for myself.

11. Which statement concerning the economics of surface water would you agree with? **(NR 1)** ***or other 1*** (Depends on where the connection is and the cost)

9 Responses / 53% ❑ I would consider paying for alternative surface water if it does not cost me any more than I am currently paying for Edwards water;
6 Responses / 35% ❑ I would consider paying for alternative surface water at a comparable cost for surface water resources provided to similar areas.

12. What are the potential benefits for the use of alternative surface water at your location (check all that apply)? **(NR 0)**

9 Responses / 53% ❑ I could use surface water to help make up for losses in supply or revenues I will experience because of required groundwater pumping reductions during drought conditions;
12 Responses / 71% ❑ Service to my customers, or the delivery of my goods and services would continue independent of the demand on the Edwards aquifer;
1 Response / 6% ❑ Other: please identify.
Conservation of the aquifer only lets more water out at the springs.

13. What are the overall benefits for developing an alternative source of water to supply the additional demand being placed on the Barton Springs segment of the Edwards aquifer? **(NR 3)**

1 Response / 6%	A - Quality
3 Responses / 18%	B - Quantity
1 Response / 6%	C - Water Cost
9 Responses / 53%	D - Meet customer demands
10 Responses / 59%	E - Reduce demand during drought
2 Responses / 12%	F - Alternative must be at a reasonable cost
1 Response / 6%	G - Ensure future growth and development of the area

14. What is the greatest restriction to growth in your industry in this area (check all that apply)? **(NR 0)**

9 Responses / 53% ❑ Availability of dependable and safe drinking water;
4 Responses / 24% ❑ Lack of wastewater treatment facilities;
7 Responses / 41% ❑ Availability of alternative sources of water;
❑ Other: please identify.

2 Responses / 12%	No room for expansion;
1 Response / 6%	COA ETJ;
1 Response / 6%	None;
1 Response / 6%	Current and proposed regulations.

Section 2: Public Water Supplies

1. Number of existing connections?	**n=15; Sum = 7,310; Avg. = 487 / PWS**
2. Total number of possible connections?	**n=15; Sum = 9,176; Avg. = 612 / PWS (+20%)**
3. Existing permitted volume?	**n=17; 1,085,272,000 / 1,180,328,250 TPV (92%)**
4. Existing growth rate?	**n=15; Avg. = 8%; Range = 0% - 39%**
5. Average water consumption (connection/day) ?	**n=15; 375 GPD / Connection**
6. Peak water consumption (MGD/day) ?	**n=12; 578 GPD / Connection** **5,057,815 MGD Est. Peak Consumption**
7. Projected growth rate for the year 2000?	**n=15; Avg. = 9%; Range = 0% - 30%**
8. Projected permitted volume for the year 2000?	**n=31; Est. V = 1,310,454,118**
9. Projected growth rate for the year 2010?	**n=15; Avg. = 5%; Range = 0% - 30%**
10. Projected permitted volume for the year 2010?	**n=31; Est. V = 1,713,520,136**
11. Projected growth rate for the year 2020?	**n=15; Avg. = 5%; Range = 0% - 30%**
12. Projected permitted volume for the year 2020?	**n=31; Est. V = 2,315,770,886**

Section 3: Additional Comments (NR 6)

2 Responses / 12%	A - BS/EACD to play active role to bring in reasonably priced surface water.
2 Responses / 12%	B - Cover cost of infrastructure with revenue bonds.
1 Response / 6%	C - Pursuing interconnect with COA.
1 Response / 6%	D - Regulate the flows at Barton Springs.
1 Response / 6%	E - LCRA could be the source for both surface water and for wastewater needs.
1 Response / 6%	F - Need to see costs and engineering proposals.
1 Response / 6%	G - Survey respondent has not done any growth projections.
1 Response / 6%	H - Should build recharge dams on Onion Creek.
1 Response / 6%	I - Survey respondent supplies water to their subdivision only.

51 Surveys **284,843,927 Total Permitted Volume (TPV)**
26 Responses **181,210,000 (64%) Permitted Volume Accounted for in Survey**
51% Response Rate
NR: # No Responses
Analysis: # Responses / % Total Responses

PERMITTED USERS WATER USE SURVEY

NAME ____

ORGANIZATION ______________________________________

This survey has been written to determine the projected water demands for the immediate future and to assess the current status of the aquifer. Your input is very important in this effort and we ask that you answer each question as completely as possible. Please try to project your future needs based on whatever data sources or methods you may use to determine water demand. Please provide any additional comments you may feel relevant in a planning effort of this scope. Thank you in advance for your cooperation. Please return this to the District by July 15 -- a self addressed metered envelope has been included for your convenience.

Section 1: General Questions

1. The rate of growth, and the corresponding number of new well drillings, we are currently experiencing over the Barton Springs segment of the Edwards Aquifer will lead to a reduced **quantity** of water available at my location. **(NR 2)**

   I ❑ agree **14 Responses / 54%** or ❑ disagree **10 Responses / 38%**

2. The rate of growth, and the corresponding number of new well drillings, we are currently experiencing over the Barton Springs segment of the Edwards Aquifer will lead to a reduced **quality** of water available at my location. **(NR 0)**

   I ❑ agree **10 Responses / 38%** or ❑ disagree **13 Responses / 50%** ***or other 3*** (unknown)

3. It is important to develop an alternate source of water to ensure that the quality and quantity of Edwards water available at my location is preserved. **(NR 1)**

   I ❑ agree **19 Responses / 73%** or ❑ disagree **6 Responses / 23%**

4. It is the responsibility of all of the users of Edwards water to protect the resource. **(NR 4)**

   I ❑ agree **22 Responses / 85%** or ❑ disagree **0 Responses / 0%**

5. I ❑ have **2 Responses / 8%** (Not Edwards Water) or ❑ have not **23 Responses / 88%** experienced problems with the **quantity** of the Edwards aquifer groundwater at my location. If you have, please explain: **(NR 1)**

6. I ❑ have **4 Responses / 15%** ((2) East of I35; (1) Odor - Use bottled water to drink; (1) Public Water Supply pipeline system problem) or ❑ have not **21 Responses / 78%** experienced problems with the **quality** of the

Edwards aquifer groundwater at my location. If you have, please explain: **(NR 1)**

7. As the demand for Edwards aquifer groundwater increases, which of the following statements best represents your view. **(NR 1)** ***or other 1*** (Disagree with all of the above)

15 Responses / 58% ❑ Existing users should be allowed to continue to use the same volume of Edwards water as they are currently permitted for and the remainder of the Edwards water should be distributed on a first come, first serve basis;
2 Responses / 8% ❑ Existing users should reduce their current permitted volume by some percentage to accommodate the water demands of new users;
1 Response / 4% ❑ Edwards water should be distributed equally, with each user receiving their equal share;
3 Responses / 12% ❑ New users should be required to meet their water demands with alternative sources of water.
5 Responses / 19% ❑ All users should be reducing their water demands on the Edwards aquifer.

8. Which of the following would you consider as to be a viable source of alternative water for your location. Indicate if it is currently available and the source (or supplier) of the water. **(NR 9)**

4 Responses / 15% ❑ Trinity aquifer groundwater;
❑ Supplier: ____________________
4 Responses / 15% ❑ Reclaimed and treated wastewater;
❑ Supplier: ____________________
4 Responses / 15% ❑ Rainwater collection;
❑ Supplier: ____________________
8 Responses / 31% ❑ Surface water;
❑ Supplier: ____________________
(6) COA
(2) LCRA
3 Responses / 12% ❑ Other: please identify. ____________________
Get Buda Water;
Must determine sustainable yield 1st;
Use Colorado River water to inject into the aquifer.

9. What are your primary concerns with connecting to an alternative source of water other than the Edwards (check all that apply)? **(NR 4)**

20 Responses / 77% ❑ Cost of the infrastructure or facilities;
15 Responses / 58% ❑ Cost of the water;
13 Responses / 50% ❑ Cost of the water and of the infrastructure or facilities;
8 Responses / 31% ❑ Quality of the water;
7 Responses / 27% ❑ Quantity of the water;
10 Responses / 38% ❑ Dependability of the water source.

10. If the District initiates a partnership to provide a surface water alternative, what level of participation would you consider in this project (check all that apply): **(NR 3)** ***or other 1*** (need to determine the total volume of the aquifer before making any decisions)

10 Responses / 38% ☐ I do not need an alternative source of water, but consider surface water as a viable alternative for other users;
2 Responses / 8% ☐ I do not need an alternative source of water and do not consider surface water to be a viable alternative for other users;
7 Responses / 27% ☐ I realize the need for an alternative source of water and consider surface water as a viable alternative for myself;
4 Responses / 15% ☐ I realize the need for an alternative source of water, but do not consider surface water to be a viable alternative for myself.

11. Which statement concerning the economics of surface water would you agree with? **(NR 1)** ***or other 3*** ((3) Neither)

15 Responses / 58% ☐ I would consider paying for alternative surface water if it does not cost me any more than I am currently paying for Edwards water;
6 Responses / 23% ☐ I would consider paying for alternative surface water at a comparable cost for surface water resources provided to similar areas.

12. What are the potential benefits for the use of alternative surface water at your location (check all that apply)? **(NR 8)**

8 Responses / 31% ☐ I could use surface water to help make up for losses in supply or revenues I will experience because of required groundwater pumping reductions during drought conditions;
5 Responses / 19% ☐ Service to my customers, or the delivery of my goods and services would continue independent of the demand on the Edwards aquifer;
6 Responses / 23% ☐ Other: please identify.
N/A - None
Stewardship of aquifer

13. What are the overall benefits for developing an alternative source of water to supply the additional demand being placed on the Barton Springs segment of the Edwards aquifer? **(NR 14)**

6 Responses / 23% A - Accommodate Future Growth
3 Responses / 12% B - Aquifer Protection
6 Responses / 23% C - Dependable Supply of Water
3 Responses / 12% D - Better Quality
1 Response / 4% E - Affordable Source

14. What is the greatest restriction to growth in your industry in this area (check all that apply)? **(NR 5)**

10 Responses / 38% ☐ Availability of dependable and safe drinking water;
8 Responses / 31% ☐ Lack of wastewater treatment facilities;
5 Responses / 19% ☐ Availability of alternative sources of water;
5 Responses / 19% ☐ Other: please identify:
A - N/A;
B- Lack of more permitted volume;
C - Cost of complying with City of Hays Runoff Ordinance;
D - Home Sales

Section 2: Specific Use Questions

1. Existing permitted volume? **n=26/51; 181,210,000 / 284,843,927 TPV (64%)**
2. Projected plans for expansion or growth? **(NR 5)**

10 Responses / 38%	A - No
1 Response / 4%	B - Until year 2000
1 Response / 4%	C - Calculated Volume
4 Responses / 15%	D - Percentage
14 Responses / 54%	E - Additional Facilities

3. Factors affecting the growth rate of your business? **(NR 6)**

1 Response / 4%	A - International growth
5 Responses / 19%	B - Economy
13 Responses / 50%	C - Available Land
7 Responses / 27%	D- N/A
7 Responses / 27%	E - Natural Disasters - Floods, Drought, Hurricanes, Etc...
4 Responses / 15%	F - Construction in Area
3 Responses / 12%	G - Growth of Customer Base

4. Anticipated changes in your current businesses delivery of goods or services? **(NR 7)**

13 Responses / 50%	A - No / Few
1 Response / 4%	B - Water use is not correlated with business growth
2 Responses / 8%	C - Until Reach Land Constraints
10 Responses / 38%	D - Percentage
1 Response / 4%	E - Membership and Attendance

5. Anticipated water demand for the year 2000? **n= 51; 298,818,927 (105%)**

6. Anticipated water demand for the year 2010? **n= 51; 309,696,927 (109%)**

7. Anticipated water demand for the year 2020? **n= 51; 330,689,427 (116%)**

Section 3: Additional Comments (NR 13)

2 Responses / 8%	A - BS/EACD to bring surface water into the District.
1 Response / 4%	B - All Edwards water users should bear cost of surface water system.
1 Response / 4%	C - Water reclamation should be utilized.
1 Response / 4%	D - Although inside BS/EACD jurisdiction, does not pump Edwards water and therefore feels BS/EACD is exceeding authority.
1 Response / 4%	E - Hasn't owned property long enough to answer most questions on survey.
1 Response / 4%	F - Something must be done to protect our water supply.
1 Response / 4%	G - Those in charge must do the best thing for the region.
1 Response / 4%	H - Thanks.

1 Response / 4% I - LCRA water should be injected into the aquifer, small users can't afford large distribution systems.

1 Response / 4% J - Plans to be on COA water by 1997.

1 Response / 4% K - BS/EACD must be sure the Edwards is in danger before getting into the surface water business.

1 Response / 4% L - Can harvest runoff from intermittent rains, extended dry spells cause harvesting problems.

APPENDIX II - PUBLIC MEETING OUTLINE

Permittee Meeting -- Surface Water Plans for the District
Outline -- June 27, 1996

A. Current Plans
1. GBRA - Principally serving areas east of IH-35 and Kyle South
2. LCRA - Hill Country - west of District
3. COA - ? - No plans to serve within sole source area particularly into Hays County
4. TRANS TEXAS - TWDB (COA, BRA, LCRA, GBRA, EUWD) Regional plans currently no services planned for this area, but we have initiated a dialogue.
5. BS/EACD - Looking at all options including those above and others.

B. Unknowns
1. Rate of growth.
2. Long term impacts of continued increased demands, changes in rate and quality of recharge waters.
3. Safe yield - Aquifer-wide and at levels impacting availability in Recharge Zone.
4. Changes in SDWA requirements relative to systems dependent on groundwater.
5. Impacts of Endangered Species Act (if any) on future pumpage, growth, and land use patterns.
6. Groundwater regulations at State or Federal level regarding "Right of Capture".

C. Options for Water in the Area
1. Do nothing.
2. Build to meet maximum demand.
3. Build to reduce impact of droughts on existing systems.
4. Build to reduce impacts of demand on recharge zone wells by supplying water for growth and droughts.

D. District Role
1. Facilitator of progress to reduce impacts of increased demand on groundwater.
2. Serve as Regional Sponsor to develop plans, funding, financing, construction of distribution water mains and storage facilities.
3. Manage groundwater supplies through conjunctive use with surface water supplies.
4. Act as regional wholesaler of treated surface water to "willing participants".

E. Wastewater Issues and Technologies
1. Increased growth means increased wastewater - currently mostly dependent on septic.
2. Continued reliance on past and current practices increases pollution potential.
3. Options:
   a. "Localized" treatment systems using existing and advancing technologies (clustering).
   b. Large regional systems.
   c. Split black/greywater systems on-site.
   d. Treat, reuse, and recycle wastewater for various industrial, irrigation, and commercial uses.

F. Options
1. Do nothing.
2. Consider available options - (few currently exist).
3. Seek solutions by beginning to assess options and developing public/public partnerships (e.g. district/river authority) and public/private partnerships (e.g. district/developer).
4. Seek authorization to pursue wastewater treatment authority through Texas Legislature.
5. Encourage other local governments to pursue expanded treatment facilities or develop alternative wastewater treatment facilities.

APPENDIX III - REGIONAL WATER SUPPLY STUDY CHRONOLOGY

1994

September 14	Final draft TWDB grant application
December 22	DGRA prepared Expense Budget
	TWDB Contract #95-483-079 for BSEACD review
	$65,523 total; $32,761.50 50% match; $25,778.50 in-kind $6,983.00 cash

1995 - Report Review/GIS, Hardcopy Data Acquisition/Participation in Other Efforts

January 12	Final execution of Contract
February 6	Meeting to introduce planning effort to local elected officials
	Order 2.1 GB Harddrive, 32 MB RAM
on-going efforts	

1996 - Report Review/GIS, Hardcopy Data Acquisition/Participation in Other Efforts

February 22	Order 1990 Census CDs
	Acquire COA Water/Wastewater GIS Coverages
	Request for hardcopy/electronic maps of PWS mains/primary distribution systems
April 4	HDR - Herb Grubb @ BSEACD Meeting
	LCRA Steve Parks @ BSEACD Meeting
April 15	LCRA Meeting with Joe Beal There
May 30	Meeting @ HDR - with DGR
June 14	DGRA projection of groundwater availability for HDR & Trans-Texas
June 24	GBRA Meeting in Seguin
June 27	RWS Meeting @ BSEACD - permittees, COA, GBRA, LCRA, HDR, EH&A
July 8	BS/EACD letter to request contract extension
July 16	TWDB letter granting contract extension
July 31	DGR Meeting @ BSEACD
July 1	Permittee Questionnaire Distributed
July 11	Clay Hodges is first questionnaire respondent representing Goforth Water Supply Corporation
August 14	GBRA - Tommy Hill, Fred Blumberg Meeting @ BSEACD
August 19	GBRA Meeting @ Kyle City Hall
August 27	DGR Meeting @ BSEACD
August 31	Compile questionnaire responses
September 12	Public Hearing - Presentations by the District, GBRA, LCRA, and COA -- all local legislative and elected officials invited -- representatives from Senator Ken Armbrister, Representative Dawnna Dukes, City of Sunset Valley, City of Hays, Hays Consolidated ISD, Hays County Environmental Health, City of Austin, and 14 permittees were present.
September 14-30	Follow-up phone calls to permittees requesting survey completion
October	Final analysis of questionnaire responses

1997 - Report Review/Presentations/Participation in Other Efforts

January 9	Board Approval to Submit Draft Regional Water Supply Plan
January 10	Draft Report and Executive Summary Available for Public Review and Comment - Mailed to Permittees, Local and State Elected Officials
January 17	Deliver Draft Report to TWDB
February 10	Media Coverage in the Austin-American Statesman (Several to Follow)
February 13	1st Public Hearing on the Plan @ District Offices
February 17-28	Solicit Input From Interested Parties - Presentations at Hays County Citizens for Responsible Planning, Hays County Commissioners Court, the City of Hays, the Village of San Leanna
March 3	Presentation to Goforth Water Supply Corporation Board of Directors
March 10	2nd Public Hearing on the Plan @ Buda Elementary
March 12	3rd Public Hearing on the Plan @ Manchaca Library
April 10	District Board Approval to Submit Final Report
April 14-30	Technical and Public Review Comments Incorporated Into Final Report
April 30	Final Report Due to the TWDB

Participation in the Trans-Texas Study on the Advisory Committee

LCRA/HDR Regional Water Supply Plan

October 24, 1995	First Draft circulated to Advisory Committee for comment	Dripping Springs HS
November 7, 1995	Travis County Extension	First Task finished
March 1996	Second Submittal to Advisory Committee	
April 25, 1996	Meeting @ Dripping Springs Elementary	

LCRA Water Management Plan Revision Advisory Committee

GBRA/EH&A Regional Water Supply Plan

October 11, 1995	First Meeting/First Draft	City of Kyle - City Hall
November 6, 1995	Tommy Hill	BSEACD Office - Private Meeting
November 28, 1995	Second Meeting	Hays County Extension Service Office San Marcos
December 1995	Final Draft	

APPENDIX IV - DISTRICT ESTIMATED PROPERTY VALUATION

The estimation of the tax base value of the District was performed by two different methods for Travis and Hays County respectively. Property in Bastrop and Caldwell Counties was not included in this report since it is believed that it would not greatly effect the total of the valuation. Both methods are explained below:

Travis County

The valuation of Travis County was based on the summation of the value all the property located within county index maps from the Appraisal District. The tax maps are based on these index maps and a request was placed with the county to provide BS/EACD with a list of all property and its market and appraised values along with other information. The selection of which index maps to include in the query was based on the evaluation of district boundaries and the map of Travis County. However, a physical overlay of the two boundaries was not feasible at the time, therefore, a very broad interpretation of the was needed to be inclusive of all property. Thus, the estimated value of the appraised land is believed to be an over-estimate of the actual net worth or District valuation.

Hays County

The valuation of Hays County was based on a listing of average household values of all the subdivisions in the county found in an article of the *Free Press.* The source is the *Austin American-Statesman* computer analysis of data from the Hays County Appraisal District. Each subdivision has an average '96 appraisal along with the number of homes located in it. For all subdivisions located within the District, the average value was multiplied by the number of homes, then added together to provide the total valuation of residential property in the county. This is used as the estimate since most residential property in Hays County is located within a given subdivision. The majority of the valuation of commercial property in Hays County is centered around Texas Lehigh Cement and Centex Materials. Other commercial property valuations were researched to get an idea of how much more the total valuation would increase with all commercial property included.

The total valuation for the District is a sufficient estimate since the value for Travis County is considered an over-estimate and the value for Hays County is an under-estimate. Some balance between the two can produce a number that has been determined by the District as an acceptable best-guess for all the appraised land in the District.

APPENDIX V - EXCERPT OF DISTRICT RULES AND BY-LAWS

RULE 3-6 CONSERVATION

3-6.1 CONSERVATION - ORIENTED RATE STRUCTURE: All water suppliers within the District shall be required to adopt and institute a conservation-oriented rate structure in the sales of water to their customers. The conservation-oriented rate structure shall be adopted and put into effect prior to renewal of the permit in calender year 1989, or prior to amendment of the permit which would increase the amount of permitted pumpage volume.

Extensions or exceptions for adoption of conservation-oriented rates may be granted by the Board in consideration of postponing implementation of a conservation-oriented rate structure until the next water utility rate change, provided a conservation-oriented rate structure is proposed for that rate hearing. The Board may grant such exceptions when requested by the permittee of a water supply company.

3-6.2 CONTRACT AGREEMENT FOR NEW CONNECTIONS: All Water Supply Companies (WSC) within the District shall be encouraged to enter into contracts with builders and developers which use water produced from within the District. The agreement should require the use of ultra low flow plumbing fixtures and other water saving devices and methods (i.e.: Xeriscape) in the construction of new homes or buildings and their landscaping. The water suppliers should require all new connections to provide proof of the inclusion of said devices to the WSC prior to the issuance of a meter or certificate of occupancy.

3-6.3 ULTRA LOW FLOW PLUMBING FIXTURES IN NEW CONSTRUCTION: Ultra low flow plumbing fixtures should be required in all new construction after January 1, 1992 by contract with all entities who issue building permits or water taps for new construction. Such ultra low flow fixtures should include: flow restricters on faucets, restricted flow shower heads and ultra low volume flush toilets. Other water saving devices such as grey water irrigation systems, rain water collection tanks and water recycling systems shall be encouraged. The District shall work with the builder to encourage installation of alternative water conservation devices and systems.

3-6.4 LANDSCAPE IRRIGATION: The District will work with owners, builders, and developers of new construction to encourage the use of water efficient landscape practices (i.e., Xeriscape, a planned, low water usage landscaping) in the landscaping of homes or buildings. The use of water intensive plants or turf, such as St. Augustine grass, is discouraged. The District will use all means at its disposal to discourage the implementation of landscaping which is water intensive, including potentially limiting the size, source, and type of irrigation sprinkler systems permitted.

3-6.5 LOW FLOW SERVICES IN HOMES FOR RESALE: The District will develop, in conjunction with the counties, cities and other entities within the District, Rules and incentives for minimal water conservation devices installed in a home prior to resale of that home. Such minimal water conservation devices may include: flow restricted shower heads, flow restricted water faucets and ultra low flow toilets.

3-6.6 CONSERVATION POLICY: The District may implement conservation policies through incentive fee structures and amendments to water use fees.

3-6.7 USER CONSERVATION PLANS: Each permittee is required to prepare, adopt and implement User Conservation Plans (UCP) consistent with these Rules.

A. Contents of UCP: UCPs shall consider, as a minimum, the following:

(1) implementation of a conservation-oriented rate structure;

(2) promotion and encouragement of voluntary conservation measures;

(3) promotion and encouragement, installation, and use of water saving devices;

(4) promotion and encouragement of water efficient landscape practices;

(5) financial measures which encourage conservation;

(6) distribution of conservation information and other educational efforts, and

(7) provision for ordinances, regulations or contractual requirements necessary for the permittee to enforce the UCP.

B. Compliance: The District shall approve UCPs, if they satisfy the objectives of this Rule. The permittee may revise or amend the UCP, as necessary, with approval by the District. UCPs shall be prepared and presented for District approval by April 1, 1992. After April 1, 1992, permittees must have a District approved UCP prior to receiving a permit amendment. For users obtaining permits after the effective date of this Rule, UCPs shall be prepared and presented for District approval within ninety (90) days of obtaining a permit.

RULE 3-7 DROUGHT

3-7.1 PURPOSE: The purpose of these Rules is to provide guidelines and procedures for the District to implement and administer a Drought Contingency Plan (DCP) (also known as a Demand Management Plan). Drought, or other uncontrollable circumstances, can disrupt the normal availability of groundwater supplies, causing localized and/or regional water availability and water quality emergencies. This Rule establishes procedures intended to preserve the availability and quality of water during such conditions. The implementation of drought severity stages, aquifer warning conditions, and other procedures shall be at the direction of the District.

3-7.2 APPLICABILITY: These Rules apply to all well permittees within the District. In addition, the District shall utilize public education and assistance programs to encourage compliance with this Rule by owners of wells exempt from permitting and all other water users located within the District's jurisdictional area.

These Rules are directly applicable to water users of the Barton Springs segment of the Edwards Aquifer. The District may apply these Rules to other groundwater aquifers and water-bearing formations located within its jurisdictional boundaries.

3-7.3 DROUGHT STAGES AND TRIGGERS: Drought severity stages are triggered by hydrologic and water level parameters existing in selected wells monitored by the District. Table 1 contains a listing of the location of monitor wells and the parameters triggering drought severity stages. There is one "No-Drought" stage and three drought severity stages: Alert Status, Alarm Status, and Critical Status. The implementation of demand reduction measures will begin with the requirements of the Alert Status. Each subsequent drought management stage will be declared in progression.

A. No-Drought Status: The Barton Springs segment of the Edwards Aquifer will be in a "No-Drought" condition when the groundwater or potentiometric water level elevations for selected monitor wells are above Alert Status trigger level elevations. During this condition, the District will maintain and conduct a routine aquifer monitoring program. This stage shall be determined and administered at the discretion of the District's General Manager.

TABLE 1. WATER LEVEL ELEVATION MONITOR WELLS AND DROUGHT SEVERITY STAGE PARAMETERS

WELL NAME/NO.	NO-DROUGHT CONDITION WATER LEVEL ELEVATION ABOVE (FT. MSL)	ALERT STATUS WATER LEVEL ELEVATION BETWEEN (FT. MSL)	ALARM STATUS WATER LEVEL ELEVATION BETWEEN (FT. MSL)	CRITICAL STATUS WATER LEVEL ELEVATION BELOW (FT. MSL)
MOUNTAIN CITY AREA: LR 58-57-9A	596.8	596.8 - 584.4	584.4 - 554.0	554.0
BUDA AREA LR 58-58-101	599.8	599.8 - 580.2	580.2 - 550.7	550.7
SAN LEANNA AREA YD 58-50-801	564.6	564.6 - 541.2	541.2 - 505.9	505.9
SOUTH AUSTIN AREA YD 58-50-301	463.4	463.4 - 452.8	452.8 - 431.0	431.0
BARTON CREEK / BARTON SPRINGS AREA YD 58-42-903	431.9	431.9 - 430.0	430.0 - 426.7	426.7

B. Alert Status: An Alert Status signifies that the District is in a local or regional drought. A local drought Alert Status commences when the water level elevation in one or more of the District's monitor wells declines below a historical median level elevation for fourteen (14) consecutive days and the District's General Manager determines that conditions warrant the execution of this stage. A regional drought Alert Status commences when the water level elevation in two or more of the District's monitor wells declines below a historical median level elevation for fourteen (14) consecutive days and the District's General Manager determines that conditions warrant the execution of this stage.

C. Alarm Status: An Alarm Status signifies that the District is in a local or regional drought. This stage commences when the water level elevation in two or more of the District's monitor wells declines below the historical lower quartile level elevation for 14 (fourteen) consecutive days and the District's Board of Directors determines that conditions warrant the execution of this stage.

D. Critical Status: A Critical Status signifies that the District is in a local or regional drought. This stage commences when the water level elevation in two or more of the District's monitor wells declines below the lowest historical observed / established level for 14 (fourteen) consecutive days and the District's Board of Directors determines that conditions warrant the execution of this stage.

E. Discontinuance of Drought Stages and Triggers: Each drought management stage will be discontinued in progression when water level elevations in the monitor wells rise above the trigger conditions associated with each stage for more than 14 (fourteen) consecutive days or when in the judgment of the District's General Manager or Board of Directors a drought situation no longer exists.

3-7.4 WATER QUALITY: As aquifer level elevations approach historical lows, the District may monitor the water quality of public water supply wells along or near the bad water line, in the water table zone, and/or in the artesian zone.

3-7.5 AQUIFER EMERGENCY WARNING FOR WATER QUALITY AND WATER QUANTITY: When the concentration of Total Dissolved Solids (TDS) increases above Safe Drinking Water Standards in any water well(s) and/or other contamination or hazardous conditions affecting water quality or water quantity exist, an Aquifer Emergency Warning may be declared by the Board of Directors. During an Aquifer Emergency Warning the District may:

A. initiate further detailed analysis to determine whether significant changes have occurred in the water quality;

B. identify additional measures that may include a maximum per capita allotment for permitted water suppliers and reduction or cessation of industrial output and agricultural irrigation; or

C. encourage the interconnection of public and private water systems to prevent health hazards and localized water shortages or depletions.

3-7.6 USER DROUGHT CONTINGENCY PLANS: Each permittee is required to prepare, adopt and implement User Drought Contingency Plans (UDCP) consistent with these Rules.

A. Contents of UDCP: UDCPs shall consider, as a minimum, the following:

(1) establishment of a permittee historical baseline pumpage volume and target pumpage volume in accordance with reduction goal percentages of the three drought management stages;

(2) voluntary compliance restrictions to achieve a 10% reduction goal;

(3) demand reduction measures which may include prohibition of water waste, alternative and/or supplemental water supply sources, adjustment to water rates and use of water saving devices;

(4) additional demand reduction measures developed by the permittee which achieve reduction goal percentages associated with each drought management stage;

(5) financial measures which encourage compliance with the UDCP and DCP while maintaining financial stability of the permittee during drought stages;

Goforth Water Supply Company Board Meeting March 5, 1997

- How can residents (customers) pay for this plan when they can barely afford their current water bill
- If we take 30%, will we get conservation credits for pumping less than our permitted volume
- What happens if we choose (GBRA for ex.) and someone else (COA for ex.)extends service into our area at a later date
- Can we be assured that the water contract price (53$/acre foot) won't change in the future
- If Austin grows, how can we be sure we will still get COA water in 2015
- Why don't we determine how much the internal system would cost per system and prorate that share instead of everyone paying for the part of the system they aren't using
- If one of these options is available, can we take 100% of our permitted volume from the other source and stop pumping altogether
- How much water is in the Aquifer
- When will it go dry
- When will the springs stop flowing
- Expressed concern from past experiences dealing with GBRA (i.e. having to pay for costs associated with Victoria and other projects)
- Spread the cost to all permittees, not just PWS
- Discussion on treating bad water
    - -Unlikely discharge permit
    - -Partial treatment and mix with Edwards
- Our users consume 82 gpd, why do we have to spend as much as Shady Hollow, COA...
- How much is this (each) project going to cost each PWS - break out costs per PWS so they can see how much and individual customers bill will go up/month

Notes from Public Meeting March 7, 1997 (District Office)

- Legal costs aren't considered
- Conjunctive use
    - -conservation
    - -recharge enhancement
- Demand Management
- If user makes deal with supplier what are the limitations
    - -Golf course irrigation
    - -filling up swimming pools

-we need water for essentials first

-throw away society

-gray water use

- District not in business for land use/growth management
- Not happy about tax or raising tax
- Emphasize "supplemental" not "alternative"
- Seek grants from federal government
- If you have a good well then there is no problem
- Tap fees are unacceptable
- Creedmoor-Maha will help others if asked
- PWS corporations have caused the problems
- Law of Indies is still the prevailing law
- Water must be shared, if others are aggrieved they must be compensated
- Work with Hays County Commissioners to work within existing legal framework
- Who's enforcing user drought and conservation measures
- Schedule meetings in the evening and in a larger room
- Moratorium/equity
- Message didn't get to the people; you need their input

Notes from Public Meeting March 10, 1997 (Buda Elementary)

(McCormick)

- Recharge as option

    -Robin Hood plan to take water from those who can't afford it

- Who asked the District to provide water
- What services

    -can't regulate water when water's available

    -District becoming monster

        -just for research

    -What is the Buda's proportional share

    -District should work on existing 17 cent budget

(Laycock) -Must visit conservation efforts

    -Demand is not addressed

        -precipitation 600,000 acre foot/year

        -groundwater discharge 7.5%

- From 10% - 30% rural to urban
- Quantity is not problem in next 20 years quality is

(Ragland) -Meetings not publicized to limit input

-160,000 people and only 75 surveys sent

-3 days notice

-Board trying to railroad through

-Probably won't ever need this system

-Buying something that will never be used

(Howze) -Primary interest is on recharge

-dam the creeks

-we will have a problem

(Johnson) -Why is the District involved

-each entity could do the same thing individually

(Draper) -Are you doing the best job possible

"Turner - District large dollars on studies, survey, " more money on monitor wells could have been done

-Don't drive thoughts down rural minds

-Take majority of comments and implement

(Poer) -Reinforced 8.5 years to go dry

-Spend, spend, spend and you still need more money

(Tiller) -Rise and fall has always occurred in Mystic Oaks

-Board is not equal rural/urban

-7.5 million dollars, not a drop in the aquifer

-Concerned about District expenditures

-Raising the cap

-First it's 30 cents, then 50 and then a 1.00

-The only thing the Board protects is its own pocketbook

-Austin Board members out vote rural members

(Porter) -Trust must be earned

-we're all good people

-Problem of information

-District is trying to educate public

(Savoy) Not in the plan

-COA service north

-impervious cover increasing equals recharge goes up

-density equals increased sewer/water services

-Colorado River water @ Circle C increase recharge

-Buda survived because of low density approach

-17% development impervious cover on recharge zone up to 40%

-lawsuits to determine land use - 25 % prediction

-Water/wastewater concerns

-District shouldn't put plant on recharge zone

-we should tie onto COA lines

-desirable to develop well field

-aquifer is OK, no real problem

(West) -Problem is "people" have gotten away from American life

-ancestors hauled water

-when population increases someone brought in water

-private sector will do anything for the profit

-treated water can be reused

-probable for government to get involved in everything

(Conneley) -Buda is going to loose their water supply

-advocate of conservation

-increased population means more straws in the bowl

-empirical data is important

-water problem with increased population

-communication/public/animosity

-developers will use your water

-water issue in state, especially in county

(West) -environmentalists keep San Antonio from their water

- Legal costs not included
-

34.5" ten year average precipitation

32" 30 year average potential evapotranspiration 44"

31" long term average

(all in an 18" - 56" range)

In 1990,10 % urban but 30% by 2016 - more runoff than recharge (183,000 vs. 123,000)

35% ranch

35% farm

- Potential for recharge enhancement
- Smaller storms contribute more
- Construction controls = land use regulation
- Curb vs. ribbons - street runoff can water landscape/wildflowers
- Conjunctive use of GW/SW
- Conservation/recharge/reuse
- Education

- Rainwater pH slightly acid for plants
- Incentives

- **Notes from Public Meeting March 12, 1997 (Public Library)**

- Will customers be charged in addition to their usual water bill
- Could the loop later be used by the COA if they were to come in
- Would the District ever take over all area PWS and thereby distribute the cost of these alternatives to all in the District
- Even though these are supplemental alternatives, if necessary(i.e. wells go dry) could we buy more than 30%
- Will the District supply 30% if the PWS cut back 30% during drought stage III
- Has the District considered drilling wells and pumping water
- Will these new systems allow for future area development
- How much will the land acquisition or right of way cost and how long will it take
- Mystic Oaks is going to get water from COA in the future
- When will the Board select a plan
- How is this going to help those of us in the SW sector
- If we bring water in we are speeding development up
- Why can't the developers pay for it
- Why can't the Board just protect the aquifer and concentrate on getting more recharge so more water flows into the aquifer
- There needs to be more input from the public, and notification
- How will the Board select a plan, will there be a vote by the public, that seems fair
- COA is considering serving San Leanna anyway
- Doesn't the District need a CCN to sell water, does the District have dominion over the aquifer
- Why not capture the water flowing out of Barton Springs
- How much has the water dropped in the last 10 years
- What causes bad water and could it be pumped into the Colorado River
- Couldn't the District store water somewhere, how much more expensive is recharge enhancement compared to these plans
- Why does the District do these studies, are we the middleman for someone else, who doe s the staff report to
- The public doesn't like any of these plans, what is the value of these plans and study-spend more time and money on recharge, conservation and public education
- How many people will be affected
- Can't these scenarios be simplified so everyone can understand what you are saying

ATTACHMENT 1

Texas Water Development Board

Review Comments for Barton Springs/Edwards Aquifer Conservation District Study
Contract No. 95-483-079

1) Population : The procedures used to estimate population within the service area of the District appear reasonable and applicable. In order to project the population for the sole source area of the study area, a weighted average growth rate (1985-1990) was used for the communities of Buda, Hays, and Mountain City as well as the unincorporated portions of Hays County. The result of this assumption is an annual growth rate of 7.45 percent. Attaining an annual growth rate of this magnitude over a 15 to 20 year period is a major assumption which could be difficult to attain; however, the TWDB does not have sufficient data to disagree with this assumption.

2) Water Demands: The procedures used to project future water requirements for the study area appear reasonable for long-range water supply planning. However, the scope of work calls for the determination of the effects of existing water conservation and drought management plans. Those issues were not addressed. In order to comply with the terms of the District's contract with the Board, the effect of existing water conservation and drought management plans must be addressed. The report indicates that water conservation practices and programs for reducing daily water use were not incorporated into the projection process. As a potential water short area, a water use management program such as water conservation is an effective means for extending the useful life of the existing water supply and should be considered as part of the water use projection process.

3) Barton Springs/Edwards Aquifer Yield Analysis: This evaluation is consistent with other similar geohydrologic work that has been performed on the aquifer.

4) Section V. of the draft plan includes capital cost projections for each option which appear adequate for this stage of planning.

5) In the analysis of the GBRA alternative, a detailed estimate is not provided for costs associated with the District's portion of the raw water pipeline. It is unclear if the cost of the District's portion of this line would be included in the construction of the project or included in the cost of the treated water. Please clarify.

6) Section V. includes capitol cost projections for the internal transmission main systems for each demand center. These cost projections appear adequate for this stage of project planning.

7) The draft plan probably could not be used to support an application for financal assistance from the Board; however it could be used as the basis for an engineering report which may accompany an application.

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