UPDATED EVALUATION FOR THE EAST TEXAS PRIORITY GROUNDWATER MANAGEMENT STUDY AREA

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Priority Groundwater Management Area File Report

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EXECUTIVE SUMMARY

This study is an update to the Texas Water Commission (predecessor agency to the Texas Commission on Environmental Quality) critical area study, *Ground Water Protection and Management Strategies for East Texas* by Mark A. Weegar, completed in March 1990. The original study area included all or portions of Angelina, Cherokee, Gregg, Nacogdoches, Rusk, and Smith counties. The 1990 study concluded that sufficient groundwater and surface water supplies existed so that critical groundwater problems in the next 20 years were not likely, and that the East Texas study area should not be designated a Critical Area. However, the study also concluded that the study area should be monitored and reevaluated at a later date. The purpose of this evaluation is to determine if the study area is experiencing, or is likely to experience in the next 25 years, critical groundwater problems and whether a groundwater conservation district should be created in order to address such problems. Since the original study, three groundwater conservation districts have been formed in Angelina, Cherokee, Nacogdoches, and Rusk counties. Because these groundwater conservation districts have the authority to manage groundwater resources, Angelina, Cherokee, and Nacogdoches counties have been excluded from this update study. The groundwater conservation district in Rusk County was not confirmed by the voters until after much of this study had been completed, therefore the evaluation of Rusk County is included.

For this report, TCEQ staff considered comments, data, and information provided by a number of different sources. These sources included water stakeholders from within the study area, the Texas Water Development Board (TWDB), the Texas Parks and Wildlife Department, Regions D and I Water Planning Groups, the TWDB groundwater availability model for the Carrizo-Wilcox (northern part) aquifer, and independent research by the staff. The report discusses the available authority and management practices of existing groundwater management entities within and adjacent to the study area, and makes recommendations on appropriate strategies needed to conserve and protect groundwater resources in the study area.

The Carrizo-Wilcox aquifer is the primary source of groundwater within the study area. Lesser amounts of groundwater are available from the Queen City aquifer and the Sparta Formation. The municipal water user group has been historically the largest user of groundwater. The total annual water requirement for the study area is expected to increase by more than 26 percent by 2030. Surface water resources include tributaries and reservoirs of the Sabine River, Neches River, and Cypress Creek. The 2001 estimated population for the study area is over 338,600 and is projected to increase to almost 460,500 by 2030.

The report concludes that the East Texas Study Area should not be designated as a priority groundwater management area at this time. Evaluation of available data indicates that the problems identified in the report are not critical problems nor region-wide in nature. Based on currently available information, the study area has adequate water resources of sufficient quality to meet water demands for the next 25-year period.

However, parts of the study area do have water supply problems such as natural and man-induced, poor-quality groundwater zones. A small number of wells, most of which are completed in the Carrizo-Wilcox aquifer, produce water with elevated iron concentrations. There are also a number of wells that produce water with elevated TDS levels with one of those wells exhibiting concentrations higher than 3,000 mg/L. In addition to water quality problems, there are parts of the study area that have had significant water declines, particularly in the vicinity of the City of Tyler. However, most problems identified in this report can be addressed by water suppliers and water users through conservation, well and well field siting considerations, and development of alternative supplies, or through local initiative to establish a groundwater conservation district.

INTRODUCTION

To enable effective management of the state's groundwater resources in areas where critical groundwater problems exist or may exist in the future, the Legislature has authorized the Texas Commission on Environmental Quality (TCEQ), with assistance from other agencies, to study, identify, and delineate priority groundwater management areas (PGMAs), and to initiate the creation of groundwater conservation districts (GCDs) within those areas, if necessary.

In 1990 and 1991, the Texas Water Commission (TCEQ predecessor agency) completed 14 "Critical Area" studies (now PGMA studies) in various parts of the state to determine if these areas were experiencing critical water problems, or were expected to experience such problems in the next two decades. The Commission determined four of these study areas had or were expected to have critical groundwater problems and designated them as such, and five of the study areas did not have and were not expected to have critical groundwater problems and no further evaluation or action was needed.

The Commission determined the other five study areas did not meet the criteria to be designated as having critical groundwater problems; however, the Commission requested these five areas be reinvestigated at a later date when more data became available. The East Texas area, overlying the Queen City and Carrizo-Wilcox aquifers, was one of these five study areas. Appendix 1 includes a reproduction of the technical summary for the East Texas 1990 study and recommendations.

Purpose and Scope

This area was initially studied by the Texas Water Commission (TWC) in a report released in March 1990. The study was conducted under the Critical Area Program in response to House Bill 2 passed by the 69th Texas Legislature in 1985. The purpose of the investigation was to determine if the area was experiencing, or was likely to experience in the next 20 years, critical groundwater problems and whether a groundwater conservation district should be created in order to address such problems. This study recommended the East Texas study area not be designated as a Critical Area (now referred to as Priority Groundwater Management Area). From available data and projections of water availability versus demand, the study concluded critical groundwater problems existed within the study area.

The present report is an update of the original TWC report developed with input from the Texas Parks and Wildlife Department (TPWD) and Texas Water Development Board (TWDB). Information from the Region D (Northeast Texas) and Region I (East Texas) Water Plans was also included in this report. This updated report serves as the basis of the Executive Director's recommendations to the Commission for action regarding designation of a Priority Groundwater Management Area (PGMA), necessary management activities, and the need to create a groundwater conservation district.

Methodology and Acknowledgments

This report summarizes and evaluates data and information developed for the East Texas area over the past thirteen years to determine if the area is experiencing or is expected to experience, within the next 25-year period, critical groundwater problems. By statutory definition, these critical groundwater problems can include shortages of surface water or groundwater, land subsidence resulting from groundwater withdrawal, and contamination of groundwater supplies.

Further, since the end-purpose of PGMA designation is to ensure GCDs are created in areas of the state with critical groundwater problems, PGMA evaluation has not been initiated for areas presently within the jurisdiction of an existing GCD. The existing GCDs are authorized to adopt policies, plans, and rules to address critical groundwater problems.

The present report has been prepared using information contained in the following reports: Weegar, 1990; Preston and Moore, 1991; Culhane, 1998; and El-Hage and Moulton, 1998. Information was also taken from the North East Texas (Region D) and East Texas (Region I) Regional Water Plans and the Carrizo-Wilcox (northern part) Groundwater Availability Model. Additionally, information provided by some of the major water-stakeholders in the area (through questionnaires) has also been used in the report. Although several aquifers exist in the study area, the report focuses primarily on the Carrizo-Wilcox aquifer not only because it is the largest aquifer in the area, but also because it has experienced the greatest water-level declines.

Location, Topography, and Surface Water Resources

The East Texas update study area is located in Gregg, Rusk, and Smith counties in northeast Texas (Figure 1). The original study also included Angelina, Cherokee, and Nacogdoches counties. Angelina and Nacogdoches counties now make up the Pineywoods Groundwater Conservation District, and Cherokee along with Henderson and most of Anderson counties make up the Neches and Trinity Valleys Groundwater Conservation District (Figure 2). Due to Angelina, Cherokee, and Nacogdoches counties establishing GCDs, they will not be considered in the update study. The Rusk County Groundwater Conservation District, created by an Act of the 78th Legislature, was confirmed by the voters of Rusk County on June 5, 2004 by election. Since the Rusk County Groundwater Conservation District had not been confirmed by the voters until the near completion of this writing, this county was included.

The study area is located within the East Texas Basin and on the western flank of the Sabine Uplift. The study area covers parts of the Neches River, Sabine River, and Cypress Creek Basins. The major population centers for the study area are the Cities of Tyler (Smith County) and Longview (Gregg County) with 2000 populations of 86,694 and 76,438, respectively. The 2001 population of the study area was estimated to be 338,636 including the Cities of Tyler and Longview.

Little information related to historical development of the Carrizo-Wilcox aquifer in the study area was found during a literature review conducted for the Groundwater Availability Model study for the Carrizo-Wilcox (northern part). Little development of the waters in the Carrizo-Wilcox aquifer occurred in Gregg and Rusk counties until the discovery of the East Texas Oilfield in 1930-1931. This discovery caused an immediate demand for water for industrial uses and for oil production. As a result of the discovery of oil, the area population increased dramatically and created additional demands for municipal water.

The water needs were met by completing wells to the Carrizo-Wilcox aquifer. In Gregg County, by the mid-1950s, the City of Kilgore began obtaining its water from a Carrizo-Wilcox field in Smith County and the City of Gladewater switched to surface water (Broom, 1969). The data on the TWDB web site and in the county report by Broom indicate the first wells drilled to the Carrizo-Wilcox aquifer were completed in 1931 and the first water-level measurements were also taken in 1931 (Broom, 1969; TWDB, 2003).

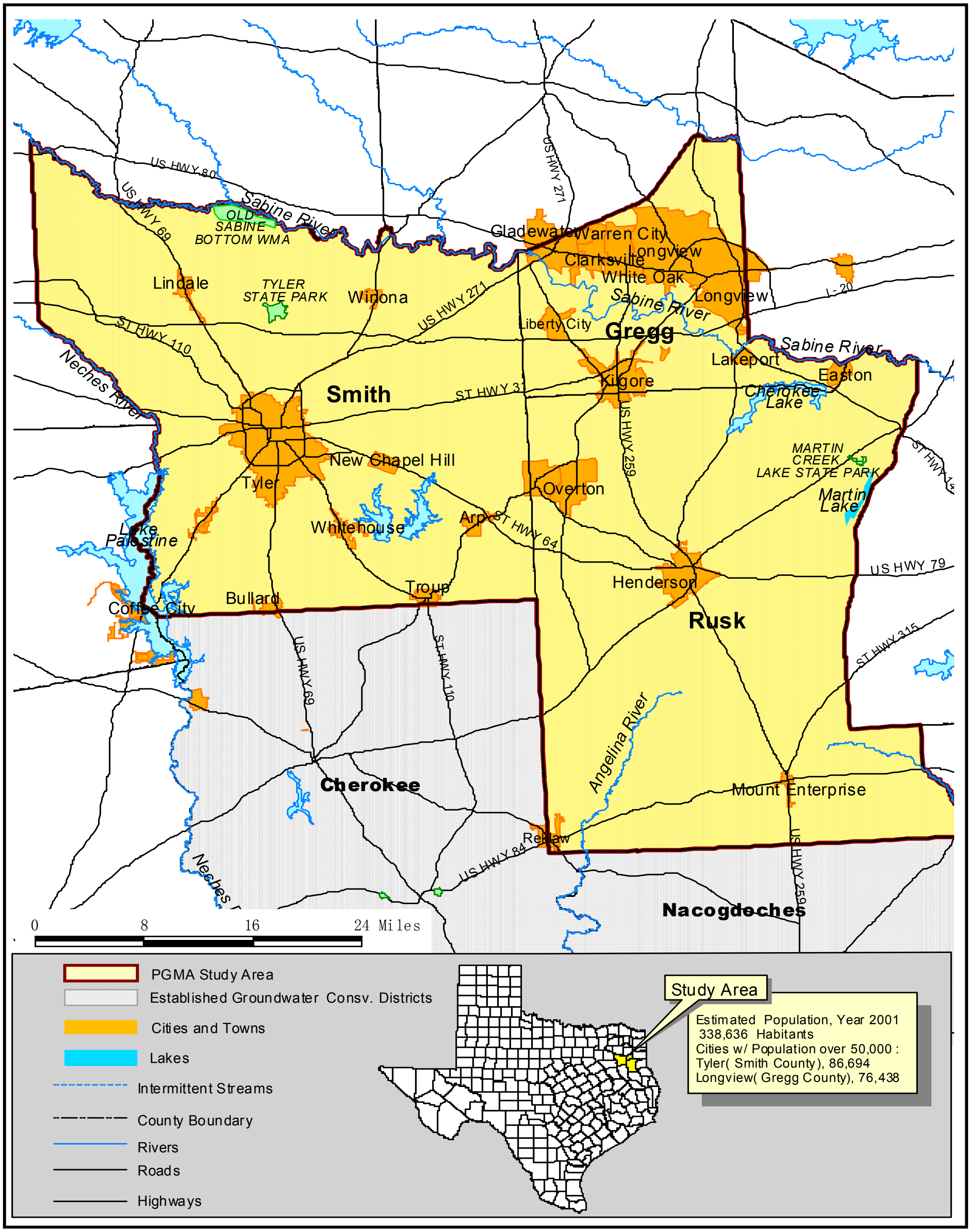

Figure 1. Location of the Study Area

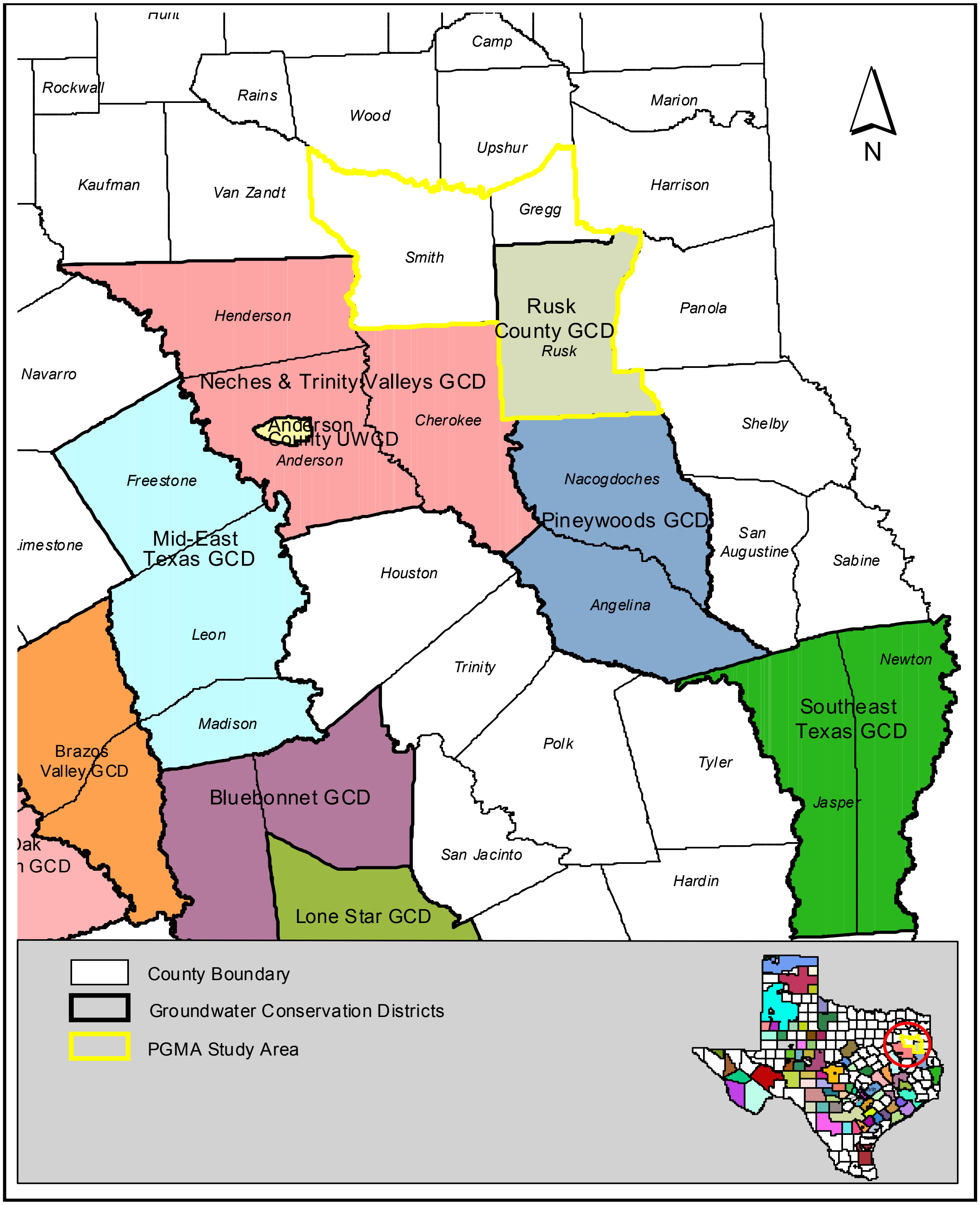

Figure 2. Map Showing the Location of Groundwater Conservation Districts.

Prior to 1920, nearly all the water used in Rusk County came from shallow wells dug into the Carrizo-Wilcox aquifer. The earliest date given on the TWDB web site for a well completed to the Carrizo-Wilcox aquifer in Rusk County is in the 1860s (TWDB, 2003). Almost all of the withdrawal of groundwater associated with the discovery of the East Texas Oilfield was from the Carrizo-Wilcox aquifer. Shallow wells continued to be used extensively into the 1960s and 1970s. At that time, the Farmers Home Administration organized a number of rural water supply corporations (WSCs). By 1981, there were 24 WSCs serving Rusk County. The WSCs, along with the cities of Henderson, Overton, New London, and Tatum, supplied about 90 percent of the water used for domestic and livestock purposes. By 1980, the use of groundwater by industries had significantly decreased, but the use by municipalities had significantly increased. In addition, the use of groundwater for mining purposes began in the 1970s. The largest municipal user is the city of Henderson (Sandeen, 1987).

Groundwater from the Carrizo-Wilcox aquifer in Smith County is used for municipal, industrial, domestic, and agricultural purposes. The first wells completed to the Carrizo-Wilcox aquifer in Smith County, recorded in the TWDB's groundwater database, were drilled in 1930s (TWDB, 2003). In 1961, the municipalities were the largest users of groundwater, followed by industries and domestic supplies. Pumping of Carrizo-Wilcox waters for agricultural purposes in 1961 was negligible (Dillard, 1963).

The study area comprises 2,137 square miles. Topographically, the area is characterized by north-south trending relatively flat valleys formed by the major streams with rolling to hilly terrain between these valleys. There is a general slope of the land surface from north to south and elevations range from about 600 feet above mean sea level in the north to about 200 feet in the south. Local relief may be as much as 150 to 200 feet. Among the major physiographic features of the study area are the flood plains of the Neches and Sabine Rivers.

The climate is characterized by a warm, sub-humid climate, with long hot summers and short mild winters. The average annual rainfall ranges between 43 inches per year at Lufkin to over 47 inches per year east of Kilgore. Much of the rainfall occurs in May-June and September-October. Annual average lake surface evaporation is about 60 inches. The mean temperature ranges from of 37° to 39° F in January and the July mean temperature ranges from 94° to 96° F.

Several man-made reservoirs are located within or just outside of the study area. These reservoirs include: Lake Palestine on the Neches River between Smith, Henderson, Anderson, and Cherokee counties; and, Tyler East and West Lakes on two branches of Mud Creek in southeast Smith County. Lake Cherokee is located along the Gregg-Rusk county line, a few miles east of Kilgore and southeast of Longview (Preston and Moore, 1991). Lake Striker is located on Striker Creek on the border between Rusk and Cherokee counties. Martin Lake is located on Martin Creek in northeastern Rusk County. Lake Gladewater is located on Glade Creek in Upshur County, north of the City of Gladewater. The City of Longview receives water from Lake O' the Pines located on Big Cypress Creek, approximately 25 miles northeast of Longview in Marion, Morris, Upshur, and Camp counties. The City of Longview receives water from Lake Fork located on Lake Fork Creek, Birch Creek and Big Caney Creek in Wood, Rains, and Hopkins counties.

There are also proposed and potential sites for man-made reservoirs in the study area. A damsite located 11 miles west of Longview in Gregg and Smith counties on Prairie Creek has been proposed in the *City of Longview Preliminary Engineering Report for Prairie Creek*. The potential reservoirs to be built in or near the area include: Big Sandy on Big Sandy Creek in Wood and Upshur counties; Carthage on the Sabine River within Panola, Harrison, Rusk, and Gregg counties; Kilgore on the upper Wilds Creek within Rusk, Gregg, and Smith counties; and, Waters Bluff on the Sabine River within Wood, Upshur, and Smith counties (Bucher, Willis & Ratliff Corporation et al, 2001).

Precipitation

Area aquifers, including the Carrizo-Wilcox, are recharged by precipitation and by streams flowing across aquifer outcrop areas. Most of the Carrizo-Wilcox outcrop, and thus recharge, occur outside the study area, both to the east and west. However, recharge does occur within the study area, mainly in Rusk County, due to a large outcrop area, with small areas of outcrop also occurring in Smith and Gregg counties. Culhane (1998) evaluated the records of a precipitation gauge from near the City of Henderson. This gauge was chosen mainly due to the completeness of the records, but also due to the location over the outcrop of the Carrizo-Wilcox aquifer.

Figure 3 from Culhane's study presents City of Henderson gauge precipitation data from 1970 through 1997 with a moving three-year average in order to help discern trends. From 1908, since data was first collected, to 1997, the average annual precipitation at the Henderson gauge has been approximately 45 inches with a minimum of 23.2 inches (1963) and a maximum of 68.8 inches (1991). Figure 3 indicates precipitation has primarily been above the average since 1988 with a peak occurring in 1990, followed by a decline through 1995 based on a comparison between long-term precipitation and the location of the three-year moving average.

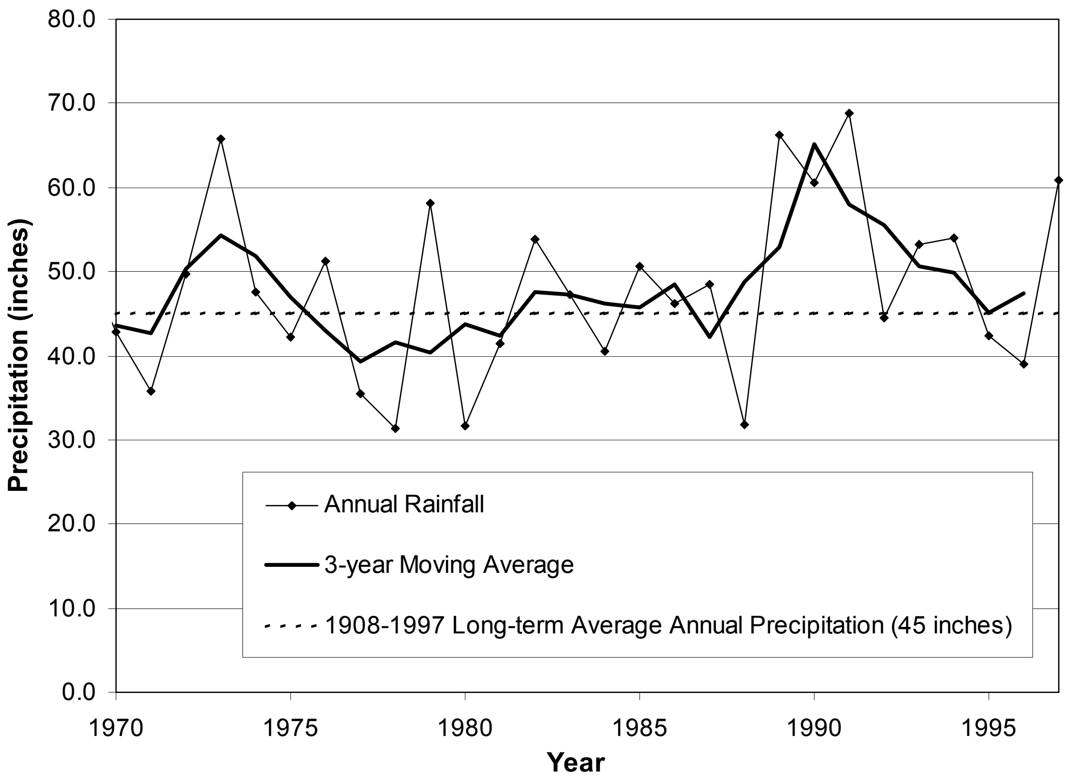

Figure 3. Precipitation at Henderson, Rusk County (Culhane, 1998).

Geology and Groundwater Resources

The major structural features which modify regional dip and modify groundwater flow within the aquifers of the study area include the East Texas Basin, the Sabine Uplift, and the Mount Enterprise Fault Zone (Figure 4). The trend of the axis of the East Texas Basin runs in a north-south direction through the western part of Smith County. The formations dip toward the axis of the basin in most of the study area; however in the southern part of Rusk County, the rock units dip in a southerly direction. The Sabine Uplift is a structural high centered in Panola County to the east of the study area. The Mount Enterprise Fault Zone strikes in an east-west direction across southern Rusk County. The full effect of the Mount Enterprise Fault Zone on groundwater flow is not fully known, but there is some reduction of flow in parts of this area (Preston and Moore, 1991).

The stratigraphy of the geologic units affecting groundwater supply in the study area are, from oldest to youngest, the Wilcox Group, Carrizo Formation, Reklaw Formation, Queen City Formation, Weches Formation, and Sparta Formation, all of Eocene age. These formations were deposited by regressive fluvial-deltaic and transgressive marine environments. Sandy fluvial and fluvial deltaic sediments of the Wilcox Group, Carrizo Formation, Queen City Formation, and Sparta Formation are the principal aquifers. Marine sediments of the Reklaw and Weches Formations are relatively muddy (silt or clay rich) and constitute intervening aquitards (Figure 4 and Table 1).

The Eocene formations are underlain by the Midway and Navarro Groups (Paleocene and Upper Cretaceous units, respectively). The Midway-Navarro Groups compose one low-permeability hydrologic unit from approximately 700 to 1,100 feet thick. This section is an aquiclude, isolating the Eocene aquifers from deeper flow systems, except, potentially, in areas adjacent to salt domes and in the fault zone (Fogg and Kreitler, 1982).

The Wilcox Group is mostly silty and sandy clay with local beds of clay, lignite, silt, and quartz sand. The Wilcox ranges in thickness from 500 to 1,000 feet. The Wilcox is overlain by the Carrizo Formation. The Carrizo, in the upper part, consists of very fine sand, silt, clayey silt, and silty clay. The lower part contains fine to medium grained quartz sand. The Carrizo ranges from 20 to 100 feet in thickness (Bureau of Economic Geology, 1975). Due to the hydrological interconnectiveness of Carrizo Formation with the Wilcox Group, the two units are considered as one aquifer, the Carrizo-Wilcox aquifer. The TWDB has classified the Carrizo-Wilcox aquifer as a major aquifer (Ashworth and Hopkins, 1995). The Carrizo-Wilcox aquifer extends from the Rio Grande in south Texas northeast into Arkansas and Louisiana, providing water to all or parts of sixty counties in Texas (Bucher, Willis & Ratliff Corporation et al, 2001). The aquifer ranges in thickness from approximately 700 feet in northeast Rusk County to over 1,600 feet in the southwest corner of Rusk County (Preston and Moore, 1991). The Carrizo-Wilcox aquifer commonly has well yields of 500 gal/min and may reach 3,000 gal/min downdip from the outcrop where the aquifer is under confined conditions. The aquifer yields fresh to slightly saline water. In the outcrop area, the aquifer contains hard water yet is usually low in dissolved solids. Downdip, the water is softer, has a higher temperature, and contains more dissolved solids. Hydrogen sulfide and methane gas may occur locally. Excessively corrosive water with a high iron content is common in much of the northeastern part of the aquifer (Muller and Price, 1979).

The Reklaw Formation overlies the Carrizo Formation and acts as an aquitard. The upper 100± feet of the formation is composed of clay with the lower 15± feet composed of fine to very fine grained, quartz sand. Above the Reklaw, The Queen City Formation has a maximum thickness of 700 feet in central Smith County. Fine grained to medium grained, quartz sand constitutes 50 to 80 percent of the Queen City (Fogg and Kreitler, 1982). The Queen City has been classified as a minor aquifer by the TWDB

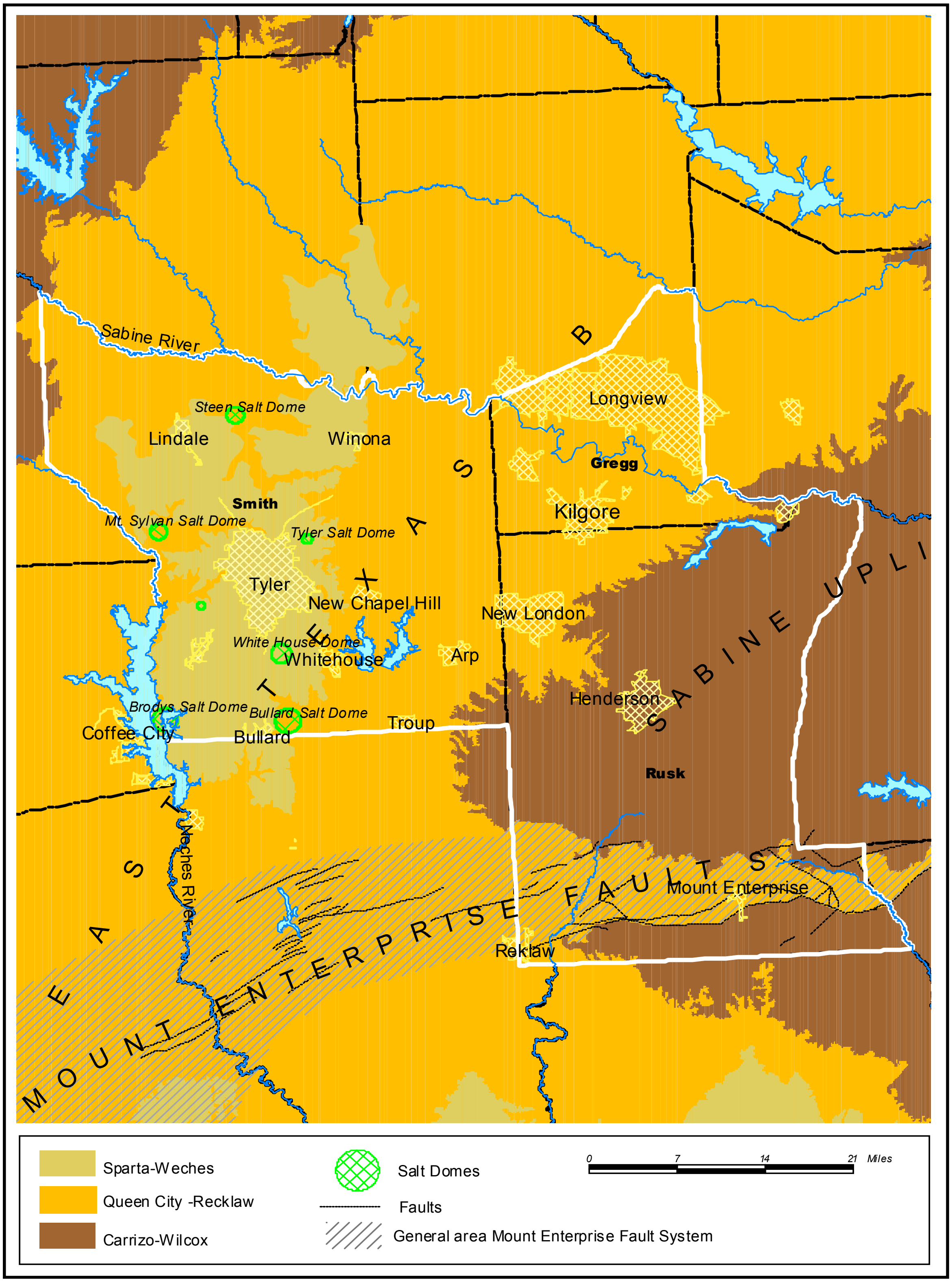

Figure 4. Generalized Geologic Map of the Study Area.

SYSTEM	SERIES	GROUP	FORMATION	HYDROLOGIC	WATER-BEARING PROPERTIES
TERTIARY	EOCENE	CLAIBORNE	COOK MOUNTAIN		Not present within the study area.
			YEGUA		
			SPARTA	Sparta Aquifer (minor)	Yields small to moderate amounts of useable-quality water over much of the study area.
			WECHES		May yield small amounts of useable-quality
			QUEEN CITY	Queen City Aquifer (minor)	Yields moderate amounts of useable-quality
			REKLAW		May yield small amounts of useable-quality
			CARRIZO	Carrizo-Wilcox Aquifer (major)	Yields large amounts of useable-quality water throughout the study area.
		WILCOX	UNDIFFERENTIATED		
	PALEOCENE	MIDWAY	UNDIFFERENTIATED		Not known to yield useable-quality water within the study area.
CRETACEOUS	UPPER CRETACEOUS	UNDIFFERENTIATED	UNDIFFERENTIATED		Not known to yield useable-quality water within the study area.

Table 1. Geologic Units and Their Water-Bearing Properties (After Preston and Moore, 1991 and Jackson, M.P.A., 1982).

(Ashworth and Hopkins, 1995). Well yields from the Queen City aquifer are generally low with only a few exceeding 400 gal/min. The aquifer yields groundwater generally low in dissolved solids concentrations. The Queen City does, however, contain high acidity and, locally, excessive iron concentrations. Hydrogen sulfide is also encountered in wells in some areas (Muller and Price, 1979).

The Weches Formation, overlying the Queen City Formation, is composed of glauconite and quartz sand. The formation is 35± feet thick with limonitic and sideritic iron ore and clay ironstone concretions forming locally. An outlier of the Sparta Formation, overlying the Weches, is located in central and western Smith County. The Sparta is composed of fine to medium grained, quartz sand cohesive from silt and clay matrix and at the base a hard ferruginous sandstone. In the vicinity of the City of Tyler, the Sparta includes the Tyler Greensand member, composed of quartz-glauconite sand with abundant ironstone concretions. The Sparta has a maximum thickness of approximately 170 feet (Bureau of Economic Geology, 1975). The Sparta has been classified as a minor aquifer by the TWDB (Ashworth and Hopkins, 1995). Well yields from the Sparta aquifer are generally 400 to 500 gal/min. The Sparta yields groundwater that is generally low in dissolved solids concentrations, however, in many areas the aquifer contains high iron concentrations.

BACKGROUND

This section includes descriptions of local and state agency actions which have affected data acquisition and groundwater management in the East Texas study area since the Commission's 1990 decision regarding the area. The purpose of the section is to describes data collection efforts, statutory changes regarding priority groundwater management areas and water planning, interim agency studies and activities, and creation of groundwater conservation districts leading up to the writing of this report.

Data Collection

As part of its ongoing water monitoring program, the TWDB continued to collect groundwater elevation and groundwater quality data in the East Texas area. Many other wells in the study area have also been measured by the TWDB and its contributors numerous times over the past decade. These measurements allow for the development of well hydrographs and yield information regarding water-level trends over the past decade. Also, as part of its ambient water quality monitoring program, the TWDB has collected water quality samples from the study area in 1992, 1993, and 1998 (TGPC, 1993; TGPC, 1994; and TGPC, 1999).

Statutory Changes - Senate Bill 1

In 1997, the Texas Legislature made significant changes to the laws governing groundwater management and water planning. Senate Bill 1 (SB 1), the omnibus water bill passed by the 75th Legislature, renamed "Critical Areas" as PGMAs, significantly amended the PGMA process, and placed a renewed emphasis on the PGMA program. SB 1 also directed the TWDB to coordinate a regional water planning process and to develop a state water plan incorporating regional water plans, resolves interregional conflicts, provides additional analyses, and makes policy recommendations.

SB 1 extended the PGMA planning horizon from 20 to 25 years, formally included the involvement of area water stakeholders and the Texas Parks and Wildlife Department in the PGMA study process, and directed the Texas Cooperative Extension Service to develop and implement a water education program. In addition, SB 1 changed the PGMA designation process from an agency rulemaking procedure to a

TCEQ order and mandated previously initiated PGMA studies be completed. Two pending studies were completed by TCEQ in 1998. Of these two study areas, one area was determined not to be a PGMA and one area was designated as a PGMA. Also during this implementation period, the TCEQ's Executive Director requested updated studies from the TWDB and new studies from the TPWD for the five study areas which required further evaluation, and distributed water-issue questionnaires to statutorily-identified stakeholders in two of the five areas.

SB 1 established a new approach to water management and planning in Texas by creating a long-range, bottom-up, water supply planning process in which regional water planning groups (RWPGs) were responsible for assessing the needs for water in their regions during drought-of-record conditions and developing conservation and management plans to meet those needs. The TWDB established 16 regional water planning areas covering the entire state, and a RWPG for each of theses areas. Each regional water planning area, through its RWPG, is responsible for obtaining local input and developing a regional water plan. The East Texas study area is included in the Regions D and I planning areas.

SB 1 also charged the TWDB with guiding the development of a statewide water resources data collection and dissemination network to insure water data is effectively and efficiently collected, maintained, and made available for all users. To accomplish this, the TWDB initiated the Texas Water Information Network. The primary objective of this network is to identify potential program cooperators presently involved in data collection and dissemination activities throughout Texas and build and maintain partnerships with the cooperators for the data network (TNRCC and TWDB, 2001).

Study Update Actions

At an April 1998 annual TCEQ/TWDB meeting, the agency executives recognized the groundwater needs and availability information developed in the regional water planning process would be a valuable asset for the PGMA program assessments. At this meeting, the agency executives made completing update studies as a Fiscal Year 1999 work effort a priority. Subsequently, in December 1998, TCEQ's Executive Director requested updated water planning information for the East Texas study area from the Executive Administrator of the TWDB, and natural resource information from the Executive Director of the TPWD. The TWDB update study was provided by the Executive Administrator on January 21, 1999, (Culhane, 1998) and the TPWD study was provided by the Executive Director on December 30, 1998, (El-Hage and Moulton, 1998). Results of these two studies are discussed in detail in subsequent sections of this report.

Groundwater Availability Models

In 1999, the 76th Legislature approved TWDB funding for the Groundwater Availability Modeling (GAM) program. The purpose of GAM is to provide reliable and timely information on groundwater availability to the citizens of Texas to ensure adequate supplies or recognize inadequate supplies over a 50-year planning period. Numerical groundwater flow models of the major aquifers in Texas will be used to make this assessment. GAMs with stakeholder input will result in a standardized, thoroughly-documented, and publicly available numerical groundwater flow model with support data. The model provides predictions of groundwater availability through 2050 based on current projections of groundwater usage and future demands during normal and drought-of-record conditions.

Regional Water Plan

The first RWPG task was to review and adopt population growth and water demand projections, using the TWDB's extensive population growth and demand estimates. All 16 RWPGs submitted requests for revisions to population and water demand projections for some of the water users within their region, and the TWDB formally approved the requests for revisions which met the criteria established for this process. Water demand was calculated for all cities with a population of 500 or greater and aggregated by county for water user groups, such as manufacturing. A water user group could be a small, rural community or all of the manufacturers in a county. Each RWPG was responsible for identifying all water user groups in the regional planning area.

The next RWPG step was to determine what water supplies were available during a drought-of-record. Planning for a drought-of-record was required by SB 1 and is important because it helps communities prepare for drought. The RWPGs used groundwater and surface water availability data developed for the 1997 Consensus State Water Plan (TWDB, 1997). In some cases, the RWPGs undertook new studies to update existing TWDB data. After collecting this information, the RWPGs analyzed it to determine when and where there was a water surplus or a need for additional water supplies for each identified water user group.

If current supplies did not meet demand, the RWPGs recommended specific water management strategies to meet near-term (less than 30 years) needs and either strategies or options to meet long-term (30-50 years) needs. The RWPGs also determined the social and economic impact of not meeting those needs. If it was not feasible to meet a need, the regions noted and explained the conditions which led to the inability to meet the need. The RWPGs considered a variety of issues when they determined the feasibility of water management strategies, such as conservation, reuse of wastewater, and development of new supplies. They also evaluated the cost, reliability, and environmental factors of selected strategies, their affect on other water resources, and the potential impact to agricultural and natural resources. All 16 of the regional water plans were formally adopted and submitted to the TWDB prior to the statutory deadline of January 5, 2001 (TWDB, 2001). The East Texas Priority Groundwater Management study area is included in the 19-county Region D and 20-county I Regional Water Planning Areas (Figure 5). Smith County is located in both regional water planning areas with the divide occurring along the southern edge of the Sabine River Basin (Bucher, Willis & Ratliff Corporation et al, 2001) (Schaumburg & Polk, Inc. et al, 2001).

State Water Plan

The 2002 State Water Plan was the culmination of a three-year effort by local, regional, and state representatives. Clearly, the most significant difference in this planning effort, as compared with previous efforts, was the broad level of public involvement throughout the process. Nearly 900 public meetings and hearings, along with technical assistance and support from the state's natural resource agencies, demonstrate the broad commitment of Texas to ensuring adequate water supplies to meet future needs. To ensure as many individuals and organizations as possible would have an opportunity to provide comments on the draft 2002 State Water Plan, during the month of October 2001, 26 public meetings were held by the TWDB in 16 cities. In addition, for the first time, video conferences were held in 10 cities to receive comments on the draft 2002 State Water Plan. Finally, in November 2001, two public hearings were held in Austin. Throughout this effort, more than 600 individuals attended to provide comments on the draft 2002 State Water Plan.

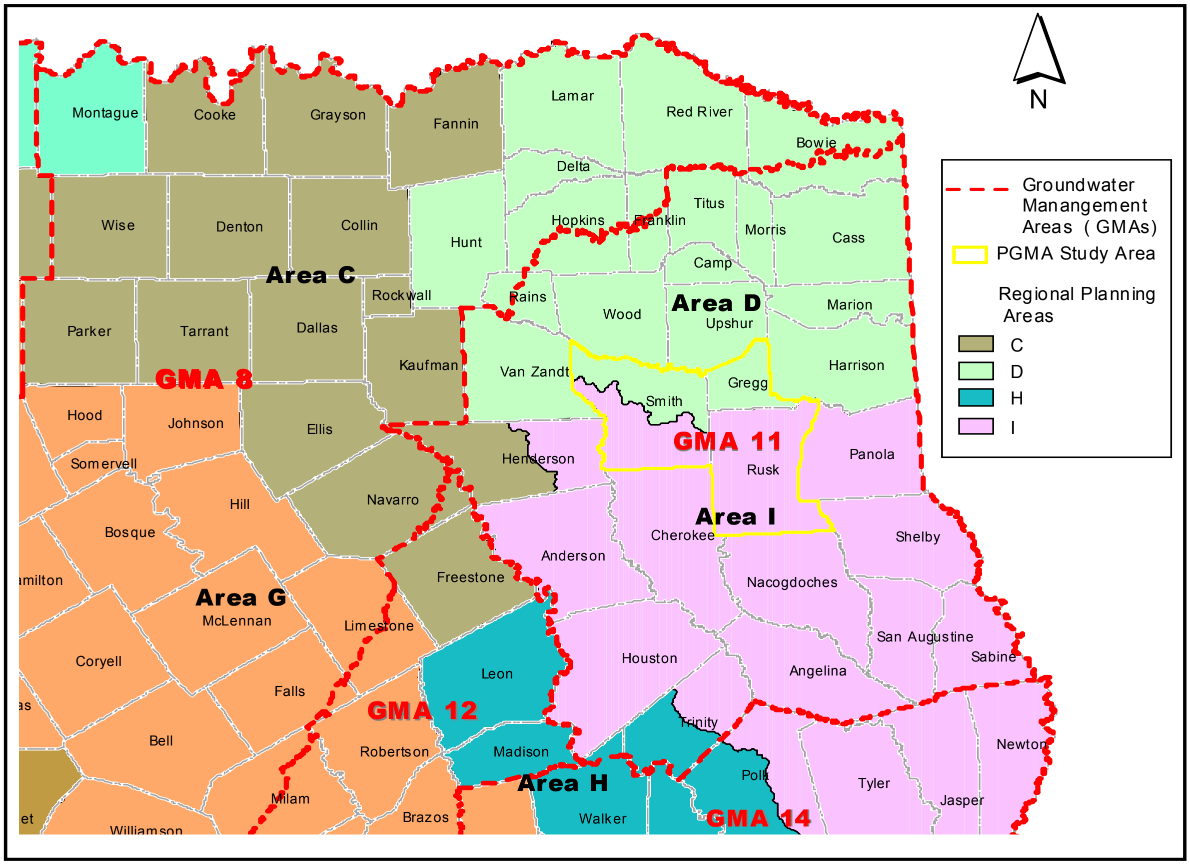

Figure 5. Map Showing Groundwater Management Area and Regional Water Planning Group Boundaries.

The 2002 State Water Plan, providing detailed water management for the next 50 years, identifies all water user groups in the state, including cities having populations of 500 or more, and aggregate demands according to county for other water use sectors, such as manufacturing. It also records the projected water demand for each water user group over the 50-year planning period, indicates whether the water user group has a need for additional water in the future, and provides water management strategies to meet the projected need. The 2002 State Water Plan was adopted unanimously by the TWDB on December 12, 2001 (TWDB, 2002).

Statutory Charge - Senate Bill 2

Senate Bill 2, passed by the 77th Legislature in 2001, was a second omnibus water bill relating to the development and management of the water resources of the state. SB 2 set a September 1, 2005, deadline for the TCEQ to complete the initial designation of PGMAs across all major and minor aquifers of the state for all areas meeting the criteria for that designation. Other statutory changes by SB 2 streamlined the PGMA designation process and the process for the creation of GCDs in designated PGMAs. The streamlined PGMA designation process incorporates considerations for district creation in addition to the determination of critical groundwater problems in a PGMA designation hearing. The law now requires specific GCD recommendations be considered in a TCEQ's PGMA evidentiary hearing and PGMA designation order. SB 2 also provided the TCEQ greater flexibility to make legislative recommendations if GCD creation in a designated PGMA would not be appropriate for, or capable of, protection of groundwater resources.

Creation of Groundwater Conservation Districts

The number of groundwater conservation districts (GCDs) in the state has more than doubled since 1990. During the original East Texas PGMA study, the only GCD present in what is now the Region D and Region I Water Planning Areas was the Anderson County Underground Water Conservation District. No GCDs were present in the six-county study area (Angelina, Cherokee, Gregg, Nacogdoches, Rusk, and Smith counties). Since the time of the publication of the original East Texas PGMA study, new GCDs have been established in the Region D and Region I Water Planning Areas in Anderson (the area outside the boundaries of the Anderson County UWCD), Angelina, Cherokee, Henderson, Nacogdoches, and Rusk counties (Figure 2).

In the study area, the Neches and Trinity Valleys GCD was created by Chapter 1387, Acts of the 77th Legislature, Regular Session, 2001 (SB 1821). Also in 2001, the Pineywoods GCD was created by Chapter 1330, Acts of the 77th Legislature, Regular Session, 2001 (HB 2572). The voters of Anderson, Cherokee, and Henderson counties confirmed the creation of the Neches and Trinity Valleys GCD by election on November 6, 2001. On the same day, the voters of Angelina and Nacogdoches counties confirmed the creation of the Pineywoods GCD by election. These districts are authorized to adopt policies, plans, and rules to address groundwater management within Angelina, Cherokee, and Nacogdoches counties; therefore, further PGMA evaluation for these counties will not be undertaken in this report. In addition to the aforementioned districts, the Rusk County GCD has been created by an Act of the 78th Legislature, Regular Session, 2003 (House Bill 3569). The voters of Rusk County confirmed the creation of the creation of the district on June 5, 2004. Since the Rusk County GCD had not been confirmed by election until after the East Texas PGMA study was well underway, it was included in this evaluation.

Present Status (2003 Request)

On April 23, 2003, the TCEQ requested TWDB to provide summarized information from the state and regional water plans for the East Texas study area. The TWDB, on May 29, 2003, provided population, water use and demand, water supply and availability, and water management strategy information for Angelina, Cherokee, Gregg, Nacogdoches, Rusk, and Smith counties from the 2002 water planning cycle (TWDB, 2003).

PUBLIC PARTICIPATION

Questionnaires & Comments

As part of the effort to solicit information from stakeholders in the study area, a questionnaire on water issues was sent to approximately 43 individuals or entities representing a broad range of interests in the original six county study area in June 1999. Sixteen stakeholders from the original study area responded to the mailing by completing and returning the questionnaire. Of those sixteen, nine of those were from the present three-county study area.

The respondents reported, since 1990, groundwater declines were significant in some parts of Smith County where well pumps have had to be lowered almost 95 feet to maintain production. Two of the respondents, water supply corporations, report water-levels dropping 100 to 150 feet. In other areas of Smith County, such as in the City of Troup (located along the Smith-Cherokee county line), the decline was smaller (four to six feet), and the City of Kilgore (located in Gregg County with water supply wells located in southeastern Smith County) reported decreases of only 2 feet and increases of up to 4 feet in some wells. Moderate declines (up to 30 feet) were reported from Gregg and Rusk counties.

Respondents noted that groundwater quality problems appeared to be widespread across the study area, but generally were not a deterrent to usage of the aquifers. High concentrations of iron and sulfur in Carrizo and Wilcox aquifer waters were reported from Smith County, and high concentrations of iron and total dissolved solids and corrosive water was reported from Gregg County. Conjunctive use of surface and groundwater was evidently being practiced in all counties of the study area.

Most respondents did not consider the groundwater problems in the area to be critical. Six thought the problems were not critical whereas two did. Of the eight who responded to the question about the formation of a groundwater conservation district in the area, two favored forming one in the study area, two did not support formation, four were undecided, and two had not heard about such an entity. Interestingly, not all respondents who thought the area faced critical water problems necessarily supported the formation of a groundwater conservation district in the area, and vice versa.

On May 4, 2004, TCEQ solicited additional stakeholder input by making a draft study area report available and requesting feedback on the draft report. A copy of this report was sent to the county judges, groundwater conservation districts, regional water planning groups, and river authorities in and adjacent to the study area. In addition, the draft report was posted on the TCEQ website and stakeholders could request a copy of the report. Area stakeholders were given until June 4, 2004 to comment the report, however, no stakeholder comments were received.

Regional Water Plan Input

Gregg County and the Sabine River Basin portion of Smith County lie within the North East Texas Regional Water Planning Area; Rusk County and the Neches River Basin portion of Smith County are within the East Texas Regional Water Planning Area. The Region D and I Water Planning Groups are composed of voting and non-voting members who represent the general public, counties, municipalities, industrial, agricultural, environmental, small business, electric generating utilities, river authorities, water districts, and water utilities. The Region D and I Water Planning Groups made special efforts to contact water providers in the region to review population and water demand data provided by the TWDB, especially relating to the "County Other" category. These RWPGs also sought to gather a large volume of information about current water supplies, current and projected water demands, and the management and policy problems encountered by these organizations. In Region D, many members of the RWPG, including several members of the consultant team, made presentations to business clubs, membership organizations, professional associations, county commissioners courts, and other groups. Issues and concerns raised by the public at these sessions were forwarded to the consultant team for inclusion in their research (Bucher, Willis & Ratliff Corporation et al, 2001). In Region I, questionnaires were sent to counties, cities with populations greater than 1,000, regional water suppliers, retail water suppliers supplying over 0.2 million gallons per day, and large industries. The questionnaires sought information on population and water use projections and other water supply issues (Schaumburg & Polk, Inc. et al, 2001).

Initially, the Region D Water Planning Group held a public hearing in June 1998 to gather comment and ideas from the public before submitting a proposed scope of work and budget for the regional planning process. The Region D Water Planning Group made efforts to emphasize the importance of public outreach and education by 1) making presentations to community groups by RWPG members, using slides prepared by the public involvement specialist; 2) distributing press releases prepared by the consultant on the day following each monthly meeting to all daily and weekly papers in the region; and 3) conducting outreach interviews with members of the RWPG and key stakeholders to identify issues of special importance. The consultant team contacted reporters and editors at major papers in the region to generate stories to help educate the public about the regional planning process. The Region D Water Planning Group approved the release of the *Initially Prepared Region D Water Plan* to the public on August 25, 2000. The Region D Water Planning Group made copies of the report available for public inspection in the county clerk's office of each county in the region and in at least one public library of each county. In September 2000, the Region D Water Planning Group conducted a series of five public meetings and one public hearing to gather public input on the *Initially Prepared Regional Water Plan*. During theses sessions, oral and written comments were recorded and were considered by the RWPG in the *Adopted Regional Water Plan* (Bucher, Willis & Ratliff Corporation et al, 2001).

The initial public meeting for the Region I Water Plan occurred on March 25, 1998 to discuss the planning process and the scope of work for the region. The RWPG conducted a series of public awareness presentations from May 1999 to October 2000 at various locations within the region. The RWPG also published newsletters and sent them to water right holders, county judges, mayors and officials of cities in the region, other water planning regions, Texas Water Development Board staff, and approximately 75 media contacts. Copies of the draft plan were also posted on the Region I website, maintained by the TWDB. In September of 2000, the RWPG held a set of public meetings to discuss the East Texas (Region I) Regional Water Plan including the planning effort, present population and water use projections, possible water management strategies for each county, and to encourage public feedback. These meetings were held throughout the region. Media outreach during development of the Region I plan included using a number of communications vehicles (e.g., newsletters, public meetings, and ongoing media relations) to keep the media, and hence the public, informed of the progress and activities of the Region I Water Planning Group (Schaumburg & Polk, Inc. et al, 2001).

On September 12, 14, and 21, 2000, the Region D Water Planning Group held public meetings in Paris, Longview, Texarkana, Greenville, and Canton to present the *Initially Prepared Region I Water Plan* and seek public input (Bucher, Willis & Ratliff Corporation et al, 2001). On September 25, 26, and 27, 2000, the Region I Water Planning Group also held public meetings to present the *Initially Prepared Region I Water Plan* and seek public input. The meetings were located in Tyler, Nacogdoches, and Beaumont. Oral comments were received following the presentation and written comments were accepted through October 3, 2000. Where appropriate, modifications to the plan were made and incorporated into the adopted Regional Water Plans (Schaumburg & Polk, Inc. et al, 2001).

Implementation issues identified for the Region D *Regional Water Plan* include: 1) Marvin Nichols I Reservoir and related issues; 2) other reservoir sites; 3) water policy, including interbasin transfers; 4) condemnation and property rights; 5) groundwater, including shallow groundwater protection, groundwater conservation districts, and sustainable use; 6) ecologically unique stream segments and environmental protection; 7) conservation and alternative technologies; 8) regional water planning process, strategies, terminology; and, 9) public participation process (Bucher, Willis & Ratliff Corporation et al, 2001). The Region I Water Planning Group responded to public comments related to: 1) hydroelectric plants on Sam Rayburn and Toledo Bend Reservoirs and their impact on water availability; 2) evaluation of environmental impacts for the various water management strategies; 3) utilization of advanced water conservation measures; 4) recreational considerations regarding reservoir construction; and, 5) reservoir sites (Schaumburg & Polk, Inc. et al, 2001).

NATURAL RESOURCES

At the request of the TCEQ, an evaluation of selected natural resources in the study area was conducted by the Texas Parks and Wildlife Department (TPWD) in 1998. Most information presented in this section was obtained from TPWD's 1998 report prepared by El-Hage and Moulton (1998). The remaining information has been obtained from the Region D and I Regional Water Plans (Bucher, Willis & Ratliff Corporation et al, 2001; Schaumburg & Polk, Inc. et al, 2001).

Texas Parks and Wildlife Department Regional Facilities

Within the study area, TPWD operates two state parks. Tyler State Park (SP) and Martin Creek Lake SP. Tyler SP (Figure 1) is a 983 acre park in northern Smith County. The park is a transition ecotone of the Piney Woods and Post Oak Savanna vegetation areas. The park is located at the headwaters of a spring-fed stream which flows into Hitt Creek, a tributary of the Sabine River. A dam on this creek has formed the 65 acre lake in the center of the park. Martin Creek Lake SP is a 286.9 acre park located in northeastern Rusk County and is situated on the edge of a 5,000 acre lake. It was constructed to provide cooling water for a lignite-fired, electric power generation plant.

In addition to the state parks, TPWD operates a Wildlife Management Area (WMA) on the northern edge of Smith County. The Old Sabine Bottom WMA covers 5,121 acres and is one of 14 bottomland hardwood preservation sites rated "Priority One" in Texas by the U.S. Fish and Wildlife Service. These sites are considered the most threatened wetland type in the United States. The area is located in the Middle Sabine Bottom contiguous to the Little Sandy National Wildlife Refuge, which many consider as the number one bottomland forest in the state. The two areas preserve one of the largest, intact bottomland hardwood forests remaining in Texas (LeBeau 1997).

Springs

Due to the hilly topography and the number of sandy formations, an abundance of springs occur in the study area. Brune (1981) lists forty springs and three seeps in the study area, nine in Gregg County, nineteen in Rusk County, and twelve springs and three seeps in Smith County. Brune also reports one former spring that at one time existed in Smith County. Most of the springs in the study area emanate from Tertiary Eocene sands, primarily Carrizo, Reklaw, and Queen City. These units dip mainly toward the west into the embayment at about three meters per kilometer. There are some springs issuing from Quaternary terrace sand and gravel, especially along the Sabine River. Vegetation associated with the springs include ferns, mosses, cattails, dogwood, sumac, black gum, redbud, willow sweetgum, maple, sycamore, birch, and wild plum (El-Hage and Moulton, 1998).

As of 1980, according to Brune, the groundwater table had not been severely affected by man's activities, except in areas of heavy pumpage. El-Hage and Moulton state the creation of a PGMA in this region could prevent the lowering of groundwater tables in these areas to the point where more springs go dry.

Wetlands

Some important wetlands of the study area are the forested wetlands on the floodplains of the region's rivers. These wetlands are generally called bottomland hardwood forests. The most extensive type is the water oak-willow oak-black gum association found along the Neches, Angelina, and Sabine Rivers, and along Attoyac Bayou. The water oak-elm-hackberry association is found primarily along the Sabine River in the northwest corner of the area. There is also a significant bald cypress-water tupelo swamp along the Neches River on the southern edge of the area. These wetlands, in conjunction with the large reservoirs in the study area, support a diverse flora and fauna consisting of wetland dependent, aquatic, semi-aquatic, and riparian species.

Fishes and Stream Segments with Significant Natural Resources

The study area rivers and streams have a variety of fish species. Two of the species are listed on the Texas Biological and Conservation Database special species list because they are threatened, the paddlefish and the creek chubsucker. The paddlefish, in Texas, once occurred in every major river from the Trinity River Basin eastward. Its numbers and range have been substantially reduced (Hubbs et al, 1991). The creek chubsucker occurs in eastern Texas streams. It prefers headwaters, but seldom occurs in springs.

During 1978 and 1979, a series of fish kill in three East Texas reservoirs were investigated by TPWD biologists and personnel from other agencies. One of the reservoirs is located within the study area, Martin Creek Lake. The fish kill in this lake was attributed to elevated selenium body burdens within the fish, which apparently accumulated after discharges from power plant ash settling ponds to the reservoir.

The study area has a number of large reservoirs and impoundments which support game fish and other fish not as typical of rivers and streams. These lakes provide recreational fishing opportunities, as do the rivers and streams. They also provide habitat for birds and other wildlife. There are at least 64 species of wetland-dependent mammals, reptiles, and aquatic/semi-aquatic amphibians present in the study area (El-Hage and Moulton, 1998).

According to state law, a RWPG may recommend legislative designation of river or stream segments within the region as ecologically unique. The criteria applied in the evaluation of potential ecologically unique river or stream segments are: 1) stream segments display significant overall habitat value; 2) stream segments fringed by habitats which perform valuable hydrologic functions; 3) stream segments fringed by significant areas in public ownership; 4) stream segments and spring resources with unique or critical habitats and exceptional aquatic life uses dependent on or associated with high water quality; and, 5) sites along streams where water development projects would have significant detrimental effects on state- or federally- listed threatened and endangered species, and sites along segments with unique, exemplary , or unusually extensive natural communities. The Region D Water Planning Group have submitted a list of potential ecologically unique river or stream segments in that region (Bucher, Willis & Ratliff Corporation et al, 2001). The segments located within the study area are:

River Basin/Segment -	Sabine River/0505
Location -	From US 59 in south Harrison County upstream to Easton along the Rusk/Harrison County line.
Justification -	Texas Natural River System nominee; diverse riparian assemblage including hardwood forest and wetlands; natural areas; exceptional aesthetic value; priority bottomland hardwood habitat; and paddlefish.

River Basin/Segment -	Sabine River/Gladewater Creek
Location -	From the confluence with Sabine River in the northwestern corner of Gregg County near Gladewater upstream to its headwaters located about five miles southwest of Gilmer in Upshur County.
Justification -	Significant bio-diversity; unique habitat-swamp/bog area.

River Basin/Segment - Sabine/0506
Location - From FM 14 in Wood/Smith County upstream to FM 1804 in Wood/Smith County.
Justification - Priority bottomland hardwood habitat; paddlefish.

The Region I Water Planning Group listed the Sabine River from the Rusk/Panola County line to the Louisiana state line as having significant natural resources due to having priority bottomland habitat (Schaumburg & Polk, Inc. et al, 2001).

Issues of Concern

The construction of reservoirs within the study area has resulted in the loss of significant amounts of valuable forested wetlands. Mitigating the negative impacts of past and current activities, such as grazing, forestry, agriculture, industrialization, urbanization, and reservoir construction will improve the chances of natural resources recovery. In addition, fundamental changes in natural resources management strategies and valuation are needed to protect the biological systems and natural resources in the study area (El-Hage and Moulton, 1998).

WATER SUPPLY DEMANDS AND AVAILABILITY

Population

Current and projected population estimates, presented in Table 2, were obtained from the TWDB (2003b). Overall, between 1990 and 1995 the population in the study area increased by 16,449 inhabitants, or 5.5 percent, and from 1995 to 2000, the study area experienced a growth of 5.8 percent (19,475 inhabitants). Smith County experienced the largest growth in the 1990-1995 period (6.7 percent or 10,128 inhabitants) and in the 1995-2000 period (7.6 percent or 13,296 inhabitants). The smallest

Gregg County

	Table 2. Current and Projected Population Estimates					
City	1990	1995	2000	2010	2020	2030
Longview			76,438	82,596	89,188	95,336
Liberty City			1,834	2,012	2,190	2,367
Lakeport			945	1,036	1,128	1,219
Kilgore			9,276	10,174	11,073	11,971
Gladewater			4,126	4,525	4,925	5,325
Clarksville City			964	1,057	1,151	1,244
White Oak			6,056	6,643	7,230	7,817
County-Other			14,350	16,989	19,190	21,840
County Total	104,948	109,664	113,989	125,032	136,075	147,119

Rusk County

	Table 2. Current and Projected Population Estimates					
City	1990	1995	2000	2010	2020	2030
Tatum			1,063	1,077	1,053	1,031
Overton			2,069	2,102	2,062	2,018
New London			1,039	1,069	1,079	1,127
Mount Enterprise			519	513	496	488
Kilgore			3,207	3,408	3,519	3,616
Henderson			12,006	12,161	11,866	11,584
County-Other			27,291	29,609	34,210	38,858
County Total	43,735	45,340	47,194	49,939	54,285	58,722

Smith County

	Table 2. Current and Projected Population Estimates					
City	1990	1995	2000	2010	2020	2030
Whitehouse			7,230	9,535	11,289	11,724
Tyler			86,702	98,656	111,156	124,006
Troup			1,887	2,050	2,153	2,236
Overton			136	151	164	178
Lindale			2,749	3,046	3,300	3,538
Bullard			331	368	438	471
Arp			942	1,020	1,072	1,116
County-Other			74,756	86,202	98,359	111,373
County Total	151,309	161,437	174,733	201,028	227,931	254,642

Study Area

	Table 2. Current and Projected Population Estimates					
County	1990	1995	2000	2010	2020	2030
Gregg	104,948	109,664	113,989	125,032	136,075	147,119
Rusk	43,735	45,340	47,194	49,939	54,285	58,722
Smith	151,309	161,437	174,733	201,028	227,931	254,642
Study Area Total	299,992	316,441	335,916	375,999	418,291	460,483

growth 3.7 percent (1,605 inhabitants) in the 1990-1995 period occurred in Rusk County and in Gregg County 3.9 percent (4,325 inhabitants) in the 1995-2000 period.

Population projections suggest a 37.1 percent (124,567 inhabitants) population increase between the years 2000 and 2030. The largest increase is expected to occur in Smith County with a gain of 45.7 percent (79,909 inhabitants), whereas the smallest increase is expected to occur in Rusk County with a gain of 24.4 percent (11,525 inhabitants).

Historical Water Use

Historical water usage in the study area is presented in Appendix B. Total water use in the study area for all purposes (municipal and non-municipal) increased by 7.6 percent (7,308 acre feet) between 1995 and 2000, with Gregg County experiencing the largest increase (37.2 percent or 7,957 acre-feet). During this time period, total water use for all purposes in Smith County increased by 17.7 percent (6,912 acre-feet). However, in Rusk County, total water use decreased by 26.4 percent (7,561 acre-feet). During that same time period, area-wide, municipal demand accounted for 59.2 (in 1995) to 70.7 (in 2000) percent of total water usage with groundwater contributing about 52.50 to 42.5 percent, respectively, of that total. Water for non-municipal purposes was obtained primarily from surface water sources (86.9 percent in 2000). From 1995 to 2000, the amount of groundwater and surface water used for municipal purposes in the study area increased whereas the amount of groundwater used for non-municipal purposes decreased by 3.8 percent and decreased by 33.3 percent for surface water.

Groundwater: In 2000, the total amount of groundwater used in the study area for both municipal and non-municipal purposes was 31,204 acre-feet (30.1 percent of total water use). During that year, the biggest user of groundwater in the study area was Smith County (63.0 percent of total groundwater used in the study area) followed by Rusk County with 25.6 percent. Gregg County was the smallest user in 2000 accounting for only 11.3 percent of total groundwater used. Of the total amount of groundwater used in the study area in 2000, use for municipal purposes was greater than use for non-municipal purposes in all three counties of the study area. The amount of surface water used for both municipal and non-municipal purposes exceeded the amount of groundwater used for the same purposes in all three counties.

Historically, between 1995 and 2000, the total amount of groundwater used in the study area increased 4.1 percent (from 29,969 acre-feet in 1995 to 31,204 acre-feet in 2000). Gregg and Smith counties had groundwater use increases of approximately 5.7 and 7.8 percent, respectively, while Rusk County had a decrease of 4.6 percent. In the 1995-2000 time period, groundwater use for municipal purposes increased in Gregg and Smith counties, while decreasing in Rusk County. The biggest increases occurred in Gregg County (8.0 percent) followed by Smith County (7.5 percent); whereas, the decrease recorded in Rusk County was 1.1 percent. In the same time period, total groundwater usage for non-municipal purposes decreased in Gregg and Rusk counties (14.0 and 20.3 percent) and increased in Smith County (11.0 percent).

Surface Water: The total amount of surface water used in the study area in 2000 for both municipal and non-municipal uses was 72,515 acre-feet (or 69.9 percent of total water use). Furthermore, usage for municipal purposes exceeded usage for non-municipal purposes in two counties (Gregg and Smith). From 1995 to 2000, total surface water usage (municipal and non-municipal) in the study area decreased in Rusk County by 35.2 percent, respectively, and increased in Gregg and Smith counties (43.0 and 26.3 percent). Surface water usage for municipal purposes increased in Gregg and Smith counties (66.6 and 34.7 percent) and decreased in Rusk County by 12.0 percent. Surface water usage for non-municipal purposes decreased in all three counties (Gregg County, 36.7 percent; Rusk County, 35.8 percent; and Smith County, 14.5 percent)(TWDB, 2003).

Projected Water Demand

Projected water demands in the study area are presented in Appendix C, which lists water demands by area (city or county), river basin (Cypress Creek, Neches, or Sabine), regional water planning group (Region D or I), and user category (municipal, manufacturing, mining, livestock, irrigation, or power). The Region D Water Planning Group generated municipal water demand projections by starting with the state default projections and making updates on the basis of better, more current data. Municipal water demand was determined by multiplying the projected per capita municipal use by the projected population. The TWDB data from “Population and Water Use Projections-Region D from TWDB” was used for the projected year 2000 daily per capita water use rate. The State Data Center populations and the populations generated by the “FORECAST” method were multiplied times the TWDB calculated water use rates. In the case of the survey data, the total community water use divided by the calculated population determined the proposed per capita daily water use rate. The Region D Water Planning Group proposed a minimum per capita water use rate of 115 gal/cap/day.

Manufacturing water demand was predicted based on the information provided by the major manufacturing industries. Surveys were conducted and revisions made to the TWDB manufacturing water demand projections. The water use projections for irrigation, steam electric, mining, and livestock developed by the TWDB and used in the 1997 State Water Plan were used as the default projections except where better, more current information was submitted (Bucher, Willis & Ratliff Corporation et al, 2001).

Under projected conditions, the total annual water demand for the study area is expected to increase by more than 26 percent between the years 2000 and 2030. In 2030, the water demand is projected to be about 150,235 acre-feet per year, an increase of 31,224 acre-feet per year from 2000. The greatest increase in water demand, over the study period, is projected to occur in Rusk County with an increase of 34 percent. Gregg County and Smith County are expected to have water demand increases of 25 and 19 percent, respectively. The higher increase in water demand in Rusk County is the result of a steam electric power water use increase of 15,000 acre-feet per year, an increase of 50 percent. The greatest demand increase in Gregg County is projected to be in manufacturing demand with an increase of 42 percent. In Smith County, the greatest demand increase is projected to be in municipal water demand with an increase of almost 22 percent.

In the study area, municipal water demand is expected to increase 17 percent, over the 2000-2030 period, from 59,941 to 69,703 acre-feet per year. Power water demand is expected to increase by 48 percent from 31,251 to 46,251 acre-feet per year. Manufacturing water demand is expected to increase from 21,500 to 29,533 acre-feet per year (37 percent), over the 2000-2030 period. There is only a slight increase in irrigation and livestock water demand (4.9 and 2.1 percent, respectively) from 1,427 to 1,497 acre-feet per year for irrigation and from 2,608 to 2,663 acre-feet per year for livestock. Mining water demand is projected to decrease in the three-county area by 26 percent from 2,284 to 588 acre-feet per year.

Water Supplies

Gregg County

Projected water supply data, by county and category for the study area are presented in Appendix D. The study area is projected to have a water supply of 154,224 acre-feet per year in 2000 decreasing to 142,717 acre-feet per year in 2030. Of the 154,224 acre-feet per year water supply, 76 percent (117,025 acre-feet per year) comes from surface water. The major surface water supply source in Gregg County is the Sabine River, which flows through the southern portion of the county and provides water for the cities of Kilgore, White Oak, and Longview. The City of Gladewater owns and is supplied by Lake Gladewater. Lake Gladewater also provides supply for Clarksville City, Warren City, and a portion of Starrville-Friendship Water Supply Corporation (WSC). The water supply for the other major municipal water users is from the Sabine River Authority, Cherokee Water Company, City of Longview, Northeast Texas Municipal Water District; run-of-the-river permits on Big Sandy Creek and the Sabine River; and from the Carrizo-Wilcox aquifer. Water supplies for manufacturing comes from the Carrizo-Wilcox aquifer, local supply sources, the City of Longview, and direct reuse. Mining and livestock supplies come the Carrizo-Wilcox aquifer. Steam electric power water supply comes from direct reuse and from the Cherokee Water Company (Bucher, Willis & Ratliff Corporation et al, 2001). Gregg County is projected to have the greatest decrease in water supplies during this time period with a reduction of 20 percent from 68,777 to 57,334 acre-feet per year. Much of the reduction is due to a number of water supply contracts expiring. In Gregg County, 96 percent of water supplies are projected to be from surface water in 2000. The municipal water user group is the largest user of water in Gregg County at 84% of the water supplies.

Rusk County

Other than power usage which receives most of its water supply from Lake Martin, the single largest source of water supply is the Carrizo-Wilcox. Future development of the Carrizo-Wilcox is favorable except in areas where existing well field development appears to be at a maximum, such as around the Henderson, New London, and Mount Enterprise areas. The Region I Water Planning Group recommends entities near the Henderson, New London, and Mount Enterprise areas should look to obtain surface water sources either through contracts with Henderson and Kilgore or with participation in the Lake Columbia project (previously the Lake Eastex project). Alternatively, The Region I Water Planning Group recommends entities near the Henderson, New London, and Mount Enterprise areas could construct well fields at further distances (3-10 miles) from these developed areas. Construction on surface water treatment plants in the cities of Henderson and Kilgore have recently been completed. The City of New London is currently involved in the Lake Columbia project. Current power demands are provided through Martin Lake. A power plant is currently under construction in southern Rusk County with water demand to be met with the construction of a raw water line from Toledo Bend Reservoir (Schaumburg & Polk, Inc. et al, 2001). Water supplies in Rusk County are projected to be reduced by 17 acre-feet per year (0.045 percent) from 2000 to 2030. Surface water is projected to comprise 70 percent of water supplies throughout the study period. Most surface water supplies (95 percent) are used for steam electric power. Aside from steam electric power supplies, surface water makes up 3.6 percent of total county water supplies. All municipal water supplies in Rusk County come from groundwater.

Smith County
With the exception of the City of Tyler, Resort Water Service, Inc., and local sources for mining and livestock, Smith County is almost solely supplied by the Carrizo-Wilcox aquifer. The City of Tyler currently utilizes groundwater to fulfill 15 percent of its needs (Schaumburg & Polk, Inc. et al, 2001). The City of Tyler also provides approximately 75 percent of the manufacturing demands. At present, There are 12 water wells providing groundwater supplies of approximately nine million gallons per day to the City of Tyler. The wells, completed from the late 1930s to 1996 to supplement surface water supply, produce from the Carrizo-Wilcox aquifer at depths ranging from 600 feet to 1,100 feet (City of Tyler, Texas, 2003).

The City of Tyler currently has a project underway to supply treated water from Lake Palestine. The initial phase of construction will add approximately 30 mgd capacity. There are four entities in Smith County currently participating in the Lake Eastex project: the City of Arp; Jackson WSC; City of Tyler; and, City of Whitehouse. The Region I Water Planning Group states, where feasible, surface water supplies from the City of Tyler are designated to be the selected strategy. Smaller communities are expected to continue to utilize the Carrizo-Wilcox (Schaumburg & Polk, Inc. et al, 2001).

The Region D Water Planning Group recommends projected water shortages in the Neches River Basin part of Smith County be met by the construction of more water wells (Bucher, Willis & Ratliff Corporation et al, 2001). Smith County water supplies are projected to increase during the study period by 943 acre-feet per year (2.0 percent) from 46,410 to 47,353 acre-feet per year. Surface water is projected to comprise almost 52 percent of water supplies throughout the study period. Aside from the surface water supplies for the City of Tyler, surface water makes up less than 13 percent of total county water supplies.

Groundwater Availability

Groundwater availability has been estimated differently for different aquifers in the Region D and I Water Planning Areas. The availability estimates for the Carrizo-Wilcox aquifer were determined by the TWDB through the utilization of a groundwater flow model. In using the model, the TWDB first estimated groundwater demand to the year 2050. The model was then used to evaluate whether demand could be met during the planning period. If the model indicated the groundwater demand could be met, the groundwater availability was set equal to the groundwater demand. If the model indicated that the groundwater demand could not be met, the model was used to estimate the maximum groundwater availability over the planning period. Therefore, the Carrizo-Wilcox groundwater availability estimates in Appendix E provide a relatively conservative estimate of long-term availability. In some counties where historical use has been low due to small demand, the actual groundwater availability may be larger than given in Appendix E. In other counties, where the demand has been higher, the groundwater availability estimates may approximate actual long-term supply for the county. The details of the TWDB modeling assessment have not been documented (Bucher, Willis & Ratliff Corporation et al, 2001; Schaumburg & Polk, Inc. et al, 2001).

For the other aquifers in Regions D and I, groundwater availability was estimated by calculating the long-term sustainable annual recharge to the aquifer. For these aquifers, the table in Appendix E provides a reasonable estimate of long-term groundwater availability not dependent on historical or projected groundwater demand (Bucher, Willis & Ratliff Corporation et al, 2001; Schaumburg & Polk, Inc. et al, 2001). The groundwater availability estimates for the Queen City aquifer in Region D assume, on average, approximately 3.5 percent of the total precipitation recharges the aquifer (Bucher, Willis & Ratliff Corporation et al, 2001). The availability projection of groundwater from the Queen City aquifer in Region I assumes an estimated 5 percent of the average annual precipitation recharges the aquifer

(Schaumburg & Polk, Inc. et al, 2001). Due to shallowness of the aquifer, some of this water discharges to streams. According to the Region D Water Plan, based on 1996 groundwater usage statistics, only about two percent of the available groundwater from the Queen City aquifer is pumped (Bucher, Willis & Ratliff Corporation et al, 2001).

The total annual groundwater available in the study area is 174,165 acre-feet per year in the year 2000 with a projected increase to 174,273 acre-feet per year in 2030. Smith County has the largest groundwater availability at 122,076 acre-feet per year followed by Gregg County with 35,936 acre-feet per year. Rusk County has the least amount of groundwater available at 16,153 acre-feet per year increasing to 16,261 in 2030. Based on availability, the largest source of groundwater in Smith County is the Queen City aquifer making up 71 percent of the groundwater available. The Carrizo-Wilcox aquifer provides the greatest source of available groundwater for Gregg and Rusk counties at 60 and 71 percent, respectively, of total groundwater availability.

Surface Water Availability

Preston and Moore (1991) previously described the availability of surface water within the study area, and concluded that adequate quantities were available to supplement groundwater supplies. At present, there are eight surface reservoirs that are major suppliers of water to the study area, three of which lie outside of the study area (Figure 6).

- Lake Tyler and Lake Tyler East, interconnected by a channel so as to function as one lake, supply water to the City of Tyler, and can provide about 37,250 acre-feet per year under drought of record conditions. The lakes have a total water supply capacity of 73,700 acre-feet.

- The City of Tyler has a contract to receive approximately 67,200 acre-feet per year (60 million gallons per day) from Lake Palestine. Tyler completed its Lake Palestine Water Treatment Plant in October, 2003. Initially, Tyler Water Utilities will draw up to 30 million gallons of water daily from Lake Palestine and treat it at the new plant.

- Lake Cherokee, located east of Kilgore, supplies 5,600 acre-feet water to Longview, which in turn sells water to Kilgore. The total storage of the lake is 46,700 acre-feet with a supply of 22,500 acre-feet.

- Martin Creek Lake is a steam-electric power generation reservoir owned by Texas Utilities Generating Company. The conservation storage for Martin Creek Lake is 75,116 acre-feet with a firm yield of 25,000 acre-feet.

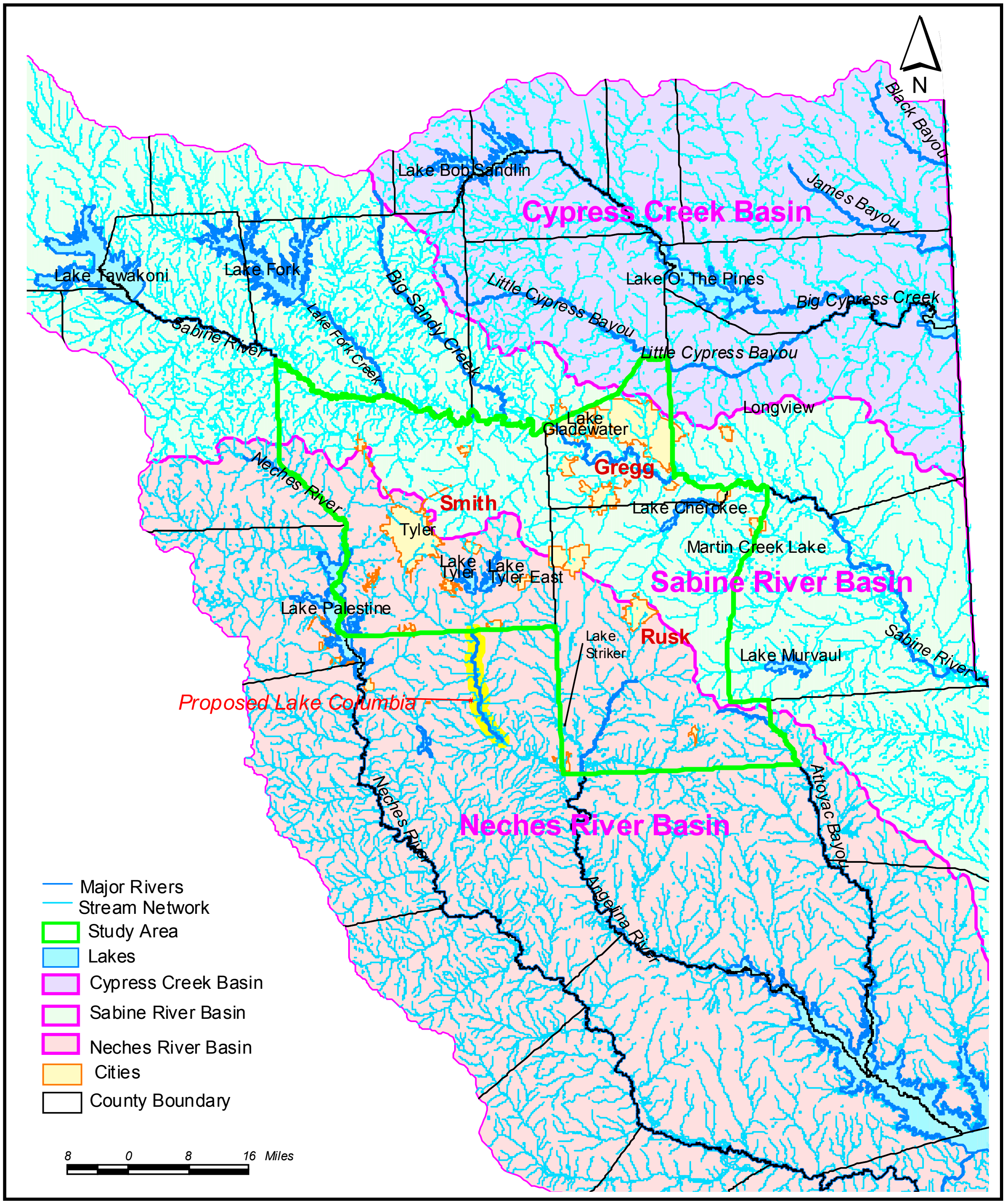

Figure 6. Surface Water Supplies Map

- Lake Gladewater is located on Glade Creek in Upshur County, outside of the study area, north of the City of Gladewater and serves as water supply for the Cities of Gladewater and Clarksville City. The lake currently provides 499 acre-feet per year increasing to 796 acre-feet per year by 2010 to the City of Gladewater. The lake currently provides 322 acre-feet per year to the City of Clarksville City, however the contract is set to expire by 2010. The conservation storage for Lake Gladewater is 4,738 acre-feet with a firm yield of 2,125 acre-feet. The supply for Lake Gladewater is 1,679 acre-feet.

- Lake O' the Pines serves as water supply for the City of Longview. Lake O' the Pines is located on Big Cypress Creek, outside of the study area, approximately 25 miles northeast of Longview in Marion, Morris, Upshur, and Camp counties. Longview as rights to 15,000 acre-feet per year from this reservoir. The conservation storage for Lake O' the Pines is 241,081 acre-feet with a firm yield of 153,670 acre-feet. The supply from Lake O' the Pines is 130,600 acre-feet.

- The City of Longview also receives water from Lake Fork located on Lake Fork Creek, Birch Creek and Big Caney Creek, outside of the study area, in Wood, Rains, and Hopkins counties. Longview as rights to 15,000 and 14,502 acre-feet per year from this reservoir. The contract for 15,000 acre-feet per year will expire in 2006 unless renewed at that time (City of Longview, 2004). The conservation storage for Lake Fork is 636,133 acre-feet with a firm yield of 176,800 acre-feet. The supply for Lake Fork is 188,660 acre-feet.

- Striker Creek Reservoir is located on the border of Rusk and Cherokee county. However, the reservoir only supplies water for industrial and power uses in Cherokee County, outside of the study area, at a rate of up to 10,000 acre-feet per year. The lake can supply 20,600 acre-feet of water under drought conditions.

There are a number of entities in the study area involved with the Lake Columbia project. The Lake Columbia project, previously called the Lake Eastex project, had its name changed by an Act of the 78th Legislature, 2003 (Senate Bill 1362). Participants in this project from the study area include Jackson WSC and the cities of New London (Rusk County), Troup, Tyler, and Whitehouse (Smith County). The lake will be located in the Mud Creek floodplain, approximately 10 miles northeast of Jacksonville, Texas, primarily in Cherokee County, with the northern limits of the lake extending into Smith County. The Lake will contain 187,839 acre-feet of water; and provide 85,507 acre-feet of water per year to water supply customers. The current phase for the project is the US Army Corps of Engineers 404 permitting process. This process will address a number of environmental issues. It will allow for input from state and federal agencies as well as the public. The 404 permit application was filed in the fall of 2000 (ANRA, 2003). The expected completion date for the date is 2011.

Aside from the reservoirs, a number of entities in Gregg County receive water from area rivers with run-of-the-river permits on Big Sandy Creek and the Sabine River amounting to 2,428 acre-feet per year from 2000 to 2030. Smith County has 2,100 acre-feet of river water available throughout the study period. There are also other surface water supplies listed under Livestock Local, Irrigation Local, or Other Local supply. Total local supply available in the study area is projected to equal 5,692 acre-feet per year in 2000 increasing to 5,779 in 2030. The county with the most local supply available is Gregg at 2,500 acre-feet per year throughout the study period. Gregg County has entities with direct reuse of water available to them. In 2000, direct reuse is projected to make 727 acre-feet per year available increasing to 4,622 by 2030.

GROUNDWATER AND WATER SUPPLY CONCERNS

This section summarizes data and information to evaluate whether the three-county study area is experiencing, or is expected to experience, critical groundwater problems within the next 25 years. Discussions in this section regard groundwater level declines which may be indicative of aquifer-overdrafting, water quality conditions which may limit usability, and water supply concerns. This discussion relies primarily upon Preston and Moore (1991), Culhane (1998), Intera, Inc. (2003), *the Region D Regional Water Plan* (Bucher, Willis & Ratliff Corporation et al, 2001), and the *Region I Regional Water Plan* (Schaumburg & Polk, Inc. et al, 2001).

Groundwater Level Declines

Water declines have occurred in most water wells completed in the Carrizo-Wilcox aquifer throughout the study area. The major areas of water-level decline are all within the downdip artesian portion of the Carrizo-Wilcox aquifer. Due to high rates of pumpage, the aquifer responds by establishing a steeper hydraulic gradient in order to move adequate amounts of water from areas of recharge to the points of heavy pumpage (Preston and Moore, 1991). Large head changes over extensive areas are required to produce substantial water yields from confined aquifers (Freeze and Cherry, 1979). Hydrographs for select wells in the study area are presented in Appendix F. Three wells used in the previous East Texas PGMA study (Weegar, 1990) were used as part of this study, wells 34-38-805, 34-40-102, and 34-45-803, all located within Smith County.

The most significant declines in the study area have occurred in Smith County. Since the 1940s, water-level declines up to 500 feet have been recorded in the vicinity of the City of Tyler. Water-level difference maps from the Fall of 1988 to the Fall of 1997 (Culhane, 1998) indicate water-levels have lowered in the vicinity of Tyler by more than 80 feet in the Carrizo Formation (Figure 7) and by more than 100 feet in the Wilcox Group (Figure 8). Much of this pumpage has been to fulfill municipal and industrial needs. The City of Tyler has been practicing conjunctive use of groundwater and surface water for many years, and has reduced groundwater use to about 15 percent of its total supply (Culhane, 1998). Water-levels measured over the past few years in Tyler's wells, completed in the Carrizo-Wilcox aquifer, have shown erratic rises and falls, perhaps due more to changes in recharge rates than to pumpage (Preston and Moore, 1991) . Two public-use wells (34-38-805 and 34-46-511) from the area around the City of Tyler do demonstrate erratic fluctuations; however, they exhibit net losses of 255 and 287 feet, respectively. From the first measurement in 1964 until 1996, the wate-level in well 34-38-805 dropped 318 feet, since then the water-level has rebounded 63 feet. The largest water-level decline occurred in a public supply well, owned by Walnut Grove WSC, in south central Smith County, southwest of the City of Whitehouse (34-54-602). This well, completed in the Wilcox Group, has experienced a water-level decline of 300 feet since 1966, and over 90 feet since 1988. Six of the seven wells with water-level declines of greater than 100 feet, included in this study, are public supply wells. The other well is a domestic well.

There are five water wells listed in the TWDB's groundwater database for Gregg County with long-term water-level measurements. Water well 35-33-501, an irrigation well located in the City of Liberty City, has recorded the greatest water-level declines in Gregg County. The water-level in this well has dropped 59 feet since the first measurement taken in 1961, but from 1988 to 2001 the water-level only dropped 6.5 feet. Three of the other wells show little fluctuation with water-level drops over a 10-year period (1992-2002) of 16.5 feet or less. However, over the whole monitoring period of these wells, two of them

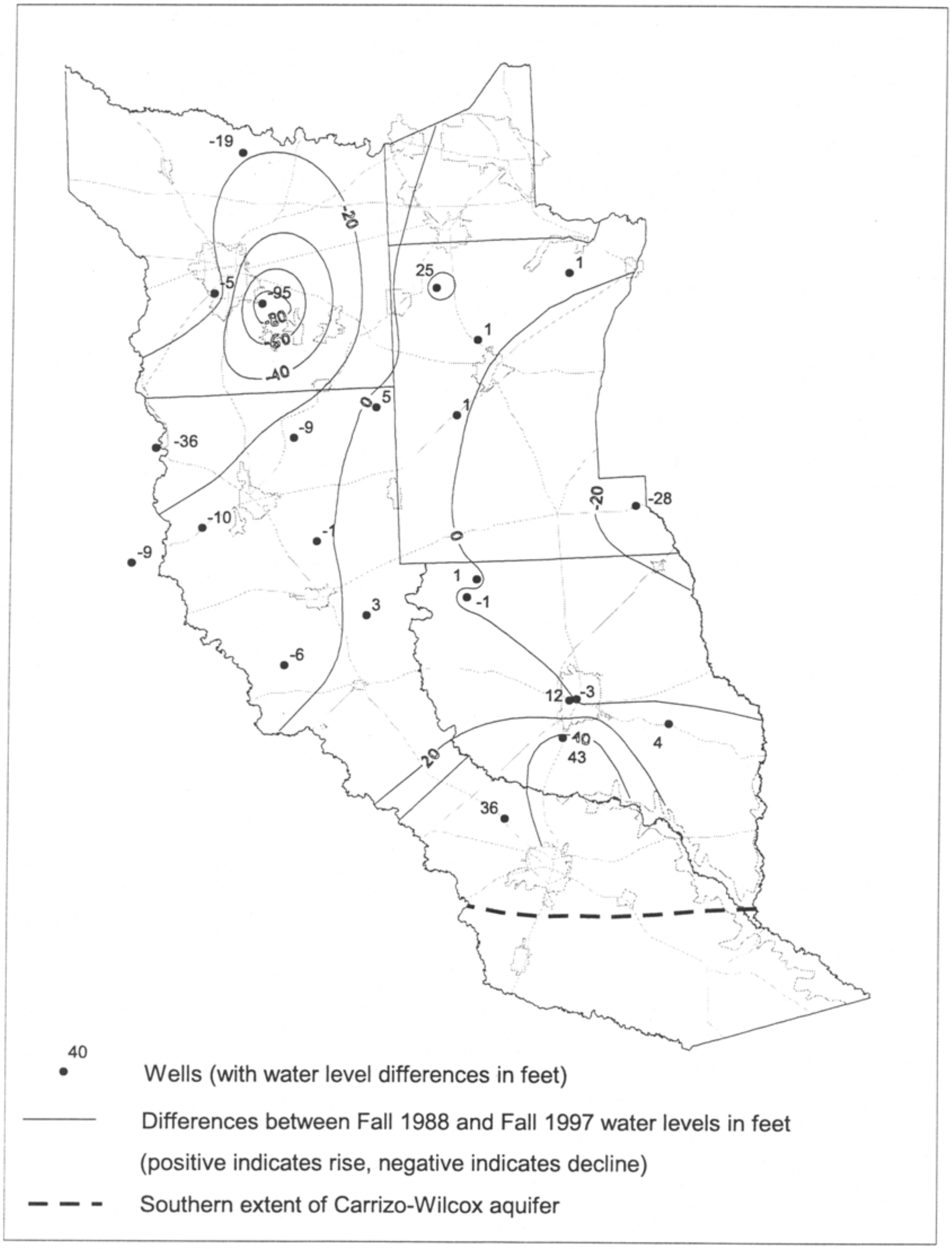

Figure 7. Carrizo aquifer water-level difference map (11/88 - 12/88 through 10/97 - 11/97) (Culhane, 1998).

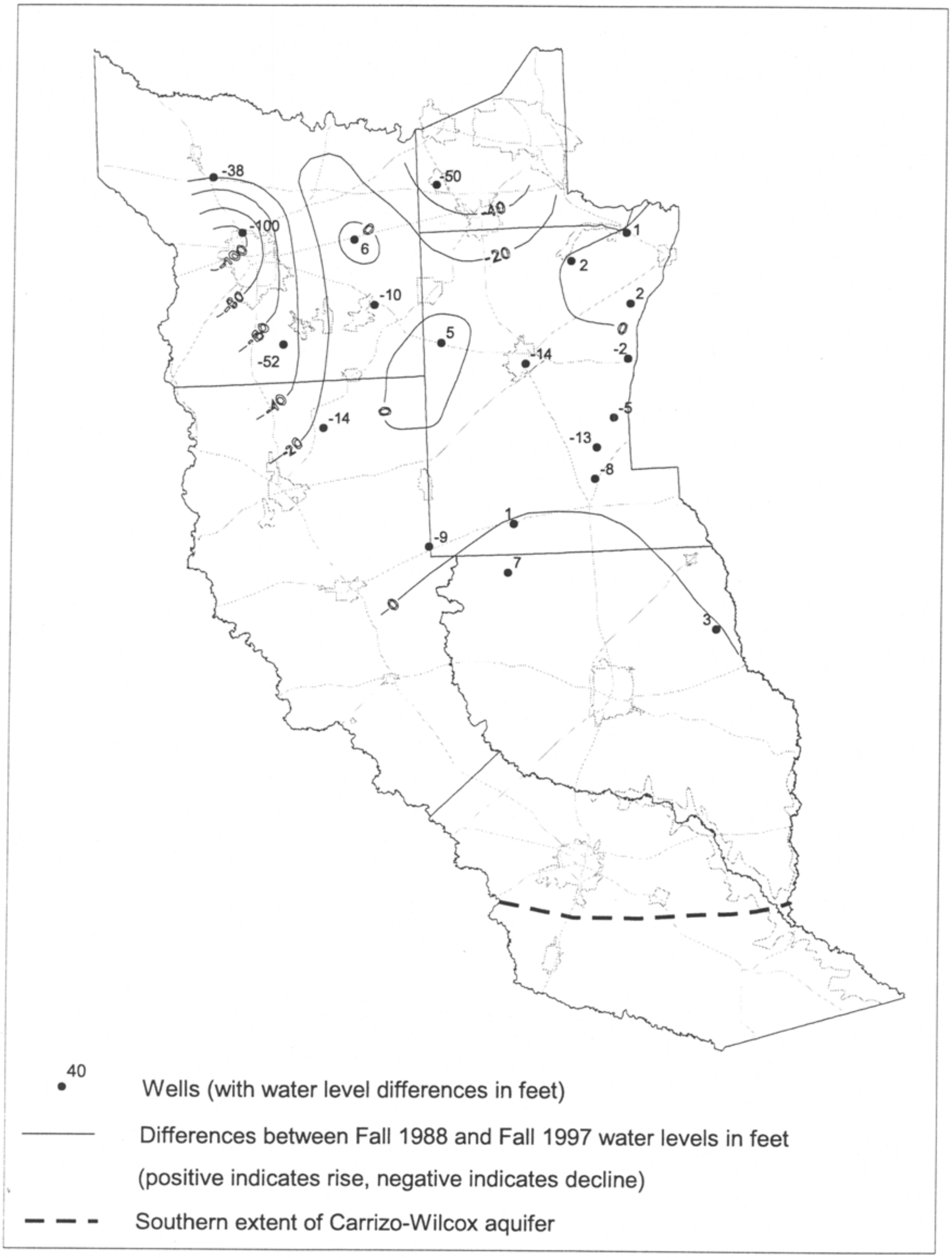

Figure 8. Wilcox aquifer water-level difference map (11/88 -12/88 through 10/97 - 11/97) (Culhane, 1998).

have had net gains of 8 and 35 feet and third well has had a net loss of almost three feet. The final long-term monitoring well in the database has greatly fluctuating water-levels, but with a net loss of less than three feet.

In Rusk County, the well recording the greatest water-level drop is a public supply well for the Crossroads WSC (35-42-202) located southeast of the City of Kilgore. This well has exhibited wide fluctuations in water-level. The water-level in 2002 was more than 155 feet lower than in 1976 and has dropped more than 79 feet since 1988. Most of the hydrographs for public supply wells in Rusk County exhibit water fluctuations. Two of those wells have had large declines in water-levels. The Mount Enterprise WSC well 37-03-201 had water-levels drop over 97 feet from 1979 to 2002 with over 33 feet since 1988; and well 35-51-502, for the Church Hill WSC, has had its water-level lowered almost 79 feet from 1971 to 2002, and over 21 feet since 1988. A public supply well for the City of Tatum had water-levels drop over 60 feet from 1972 to 1982, however the water-levels since have rebounded about 24 feet. There is little fluctuation in water-levels for private wells. Among the wells indicating a lowering of water-levels since the 1960s and 1970s, the average water-level drop was 17.6 feet and ranged from just over 5 feet to almost 27 feet. Among wells showing a loss of water-level since 1988, the average water-level decline was 5.1 feet ranging from 7.5 to less than 2 feet. Some wells indicate a rise in water-levels since the 1960s and 1970s ranging from less than a quarter foot to over 16 feet.

Preston and Moore (1991) state, while there is some general water-level decline in the Carrizo-Wilcox aquifer throughout much of the study area, declines are significant only in the immediate vicinity of some isolated municipal well or small well fields. They attributed much of this water-level decline to the fact that many of the relatively high capacity city or water supply corporation wells have been located too close to each other.

Carrizo-Wilcox (northern part) GAM Predictive Simulation Results

The purpose of the Carrizo-Wilcox (northern part) GAM is to assess groundwater availability within the modeled northern Carrizo-Wilcox region over a 50-year planning period (2000-2050) using Regional Water Planning Group water-demand projections under drought-of-record conditions. The GAM will be used to predict changes in regional groundwater levels and fluctuations related to baseflow to major streams and rivers, springs, and cross-formational flow. The two most important stresses to be considered in the future predictive modeling period are the same two stresses imposed during the calibration and verification periods; recharge and pumping.

Predictive pumping demands from the RWPGs are used in the predictive mode simulations assuming the pumping distribution for 1999 applies in the future (2000-2050). Predictive simulations assume average recharge conditions for the duration of the prediction ending with drought-of-record conditions. For purposes of the GAM report, average recharge was defined as the average recharge rate applied in the transiently calibrated model from 1975 through 1999.

The Carrizo-Wilcox (northern part) GAM is divided into six layers, the Queen City Sand (Layer 1), Reklaw Formation, Carrizo Sand, upper Wilcox, middle Wilcox, and lower Wilcox (Layer 6). Figure 9 shows the simulated water-level difference from 1999 to 2030 for the Carrizo (Layer 3). This figure shows a significant water-level rebound in Smith County with an orientation roughly corresponding to the overlying Sparta Formation. In the southern part of this depression, south and southeast of the City

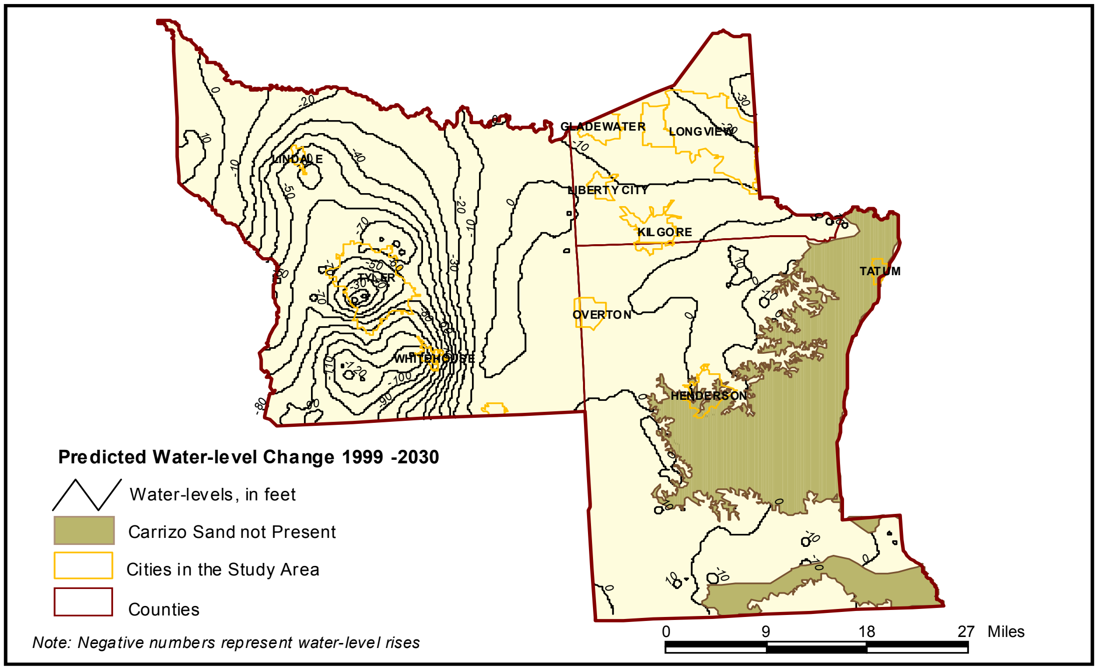

Figure 9. Projected Water-Level Changes in the Carrizo Layer of the GAM Model from 1999 to 2030 (based on TWDB run of the groundwater availability model).

of Tyler, the amount of rebound is over 110 feet and over 120 feet in places. However, in the vicinity of Tyler, the amount of water-level rise is less ranging from approximately 20 to 60 feet.

Figure 10 presents the simulated water-level difference in the upper Wilcox (Layer 4) from 1999 to 2030. Figure 10 indicates that water-levels decrease in the vicinity of the City of Tyler by approximately 5 to 80 feet by 2030, and in the vicinity of Sand Flat (north central Smith County) are predicted to decrease by over 40 feet. However, in the vicinity of Lindale water-levels are projected to increase by more than 50 feet, and in the vicinity of the City of Henderson (Rusk County) water-levels are expected to increase by as much 10 to 20 feet.

The simulated water-level difference from 1999 to 2030 in the middle Wilcox (Layer 5) is shown in Figure 11. For the middle Wilcox, water-levels drop significantly in the vicinity of Tyler, by over 100 feet by 2030, creating a large cone of depression projected to extend westward into Henderson and Van Zandt counties. While water-levels are lowering for the middle Wilcox around Tyler, water-levels are projected to increase around the cities of Henderson and Tatum in Rusk County. By 2030, water-levels are expected to rise 20 to 30 feet around Henderson and 30 to 40 feet around Tatum.

Figure 12 presents the water-level difference from 1999 to 2030 in Layer 6 (lower Wilcox) of the model. The lower Wilcox is not present in most of Gregg County nor in parts of northern Rusk and Smith counties. There is projected to be a small decrease in water-levels in the vicinity of Tyler of 10 feet with water-levels projected to increase in Rusk County by 10 feet, locally increasing to over 20 feet by 2030.

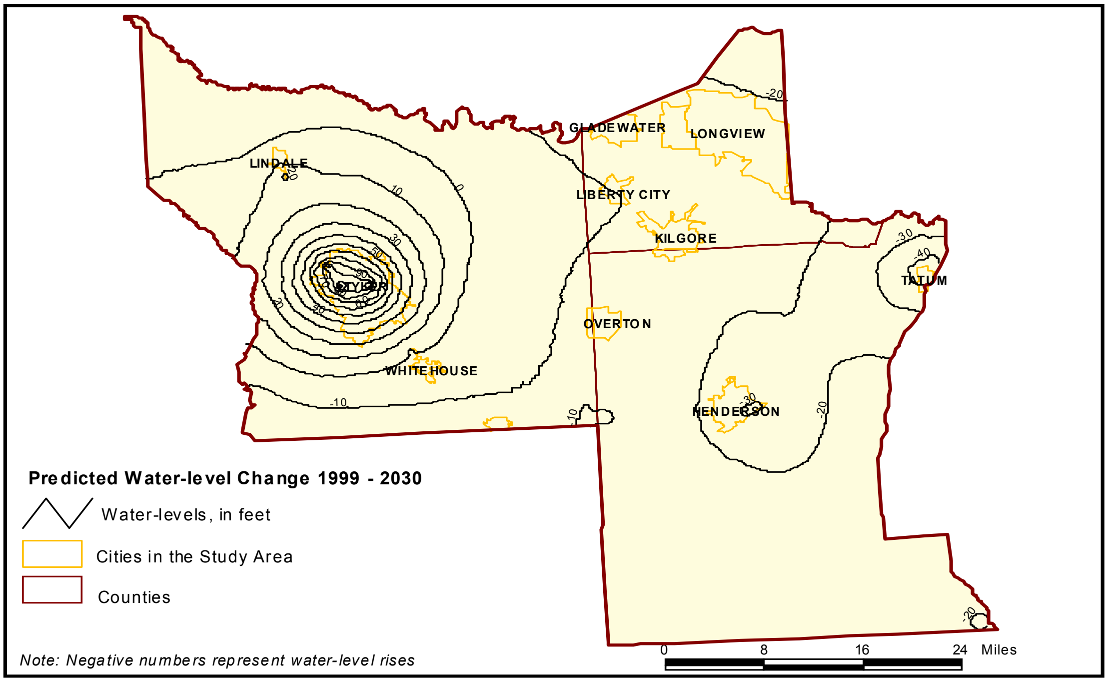

Figure 10. Projected Water-Level Changes in the Upper Wilcox Layer of the GAM Model from 1999 to 2030 (based on TWDB run of the groundwater availability model).

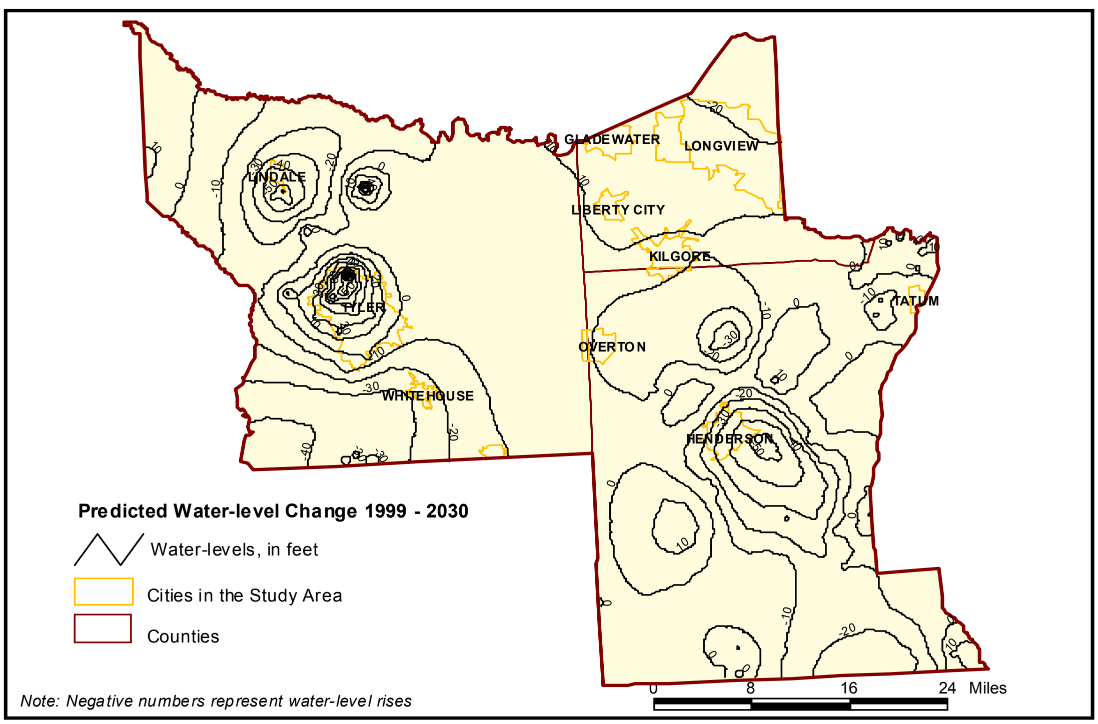

Figure 11. Projected Water-Level Changes in the Middle Wilcox Layer of the GAM Model from 1999 to 2030 (based on TWDB run of the groundwater availability model).

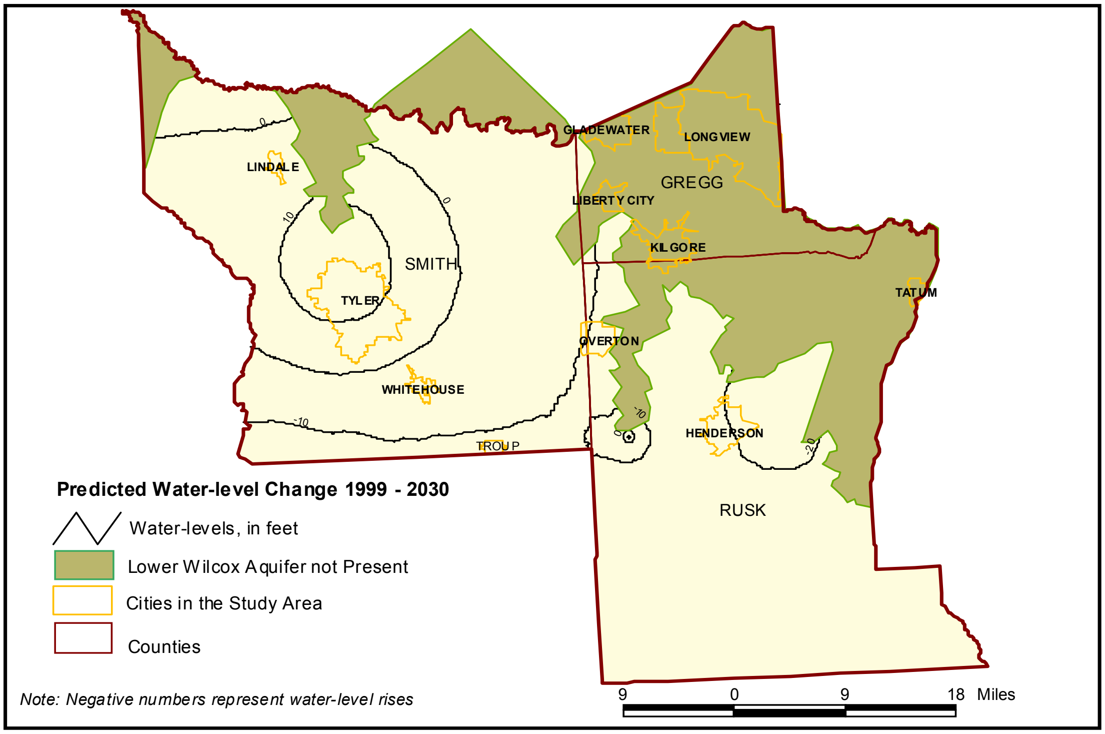

Figure 12. Projected Water-Level Changes in the Lower Wilcox Layer of the GAM Model from 1999 to 2030 (based on TWDB run of the groundwater availability model).

Groundwater Quality Conditions

Preston and Moore (1991) report, in general, the Carrizo-Wilcox, Queen City, and Sparta aquifers contain relatively good quality water throughout most of the study area. In isolated areas, water within some sand intervals in the three aquifers may contain concentrations of dissolved iron in excess of the state drinking water secondary constituent level of 0.3 mg/L (30 Texas Administrative Code, Chapter 290, Subchapter F). Within each aquifer, water quality deteriorates with increasing depth. The Sparta and Queen City aquifers rarely have fresh water (total dissolved solids of less than 1,000 mg/L) below depths of 600 to 700 feet. Although, fresh water may occur at depths of up to 2,500 to 3,000 feet in some areas.

Culhane (1998) reports sixteen wells, located in the original six-county study area, completed within the Carrizo-Wilcox aquifer and three wells within "Other aquifers" have produced water with iron concentrations exceeding 0.3 mg/L since 1988 (Figure 13). Only six of those wells completed in the Carrizo-Wilcox are located within the present three-county study area, all within Smith County. Two of the three wells completed in "Other aquifers" are located in Smith County with one located in Gregg County. State drinking water secondary standards set the level for total dissolved solids (TDS) at 1,000 mg/L (30 Texas Administrative Code, Chapter 290, Subchapter F). In well analyses reporting TDS from 1970 to 1997, seven wells completed in the Carrizo-Wilcox report concentrations between 1,000 and 3,000 mg/L with one of those having concentrations higher than 3,000 mg/L (Figure 14). One well completed in "Other aquifers" had a TDS concentration between 1,000 and 3,000 mg/L.

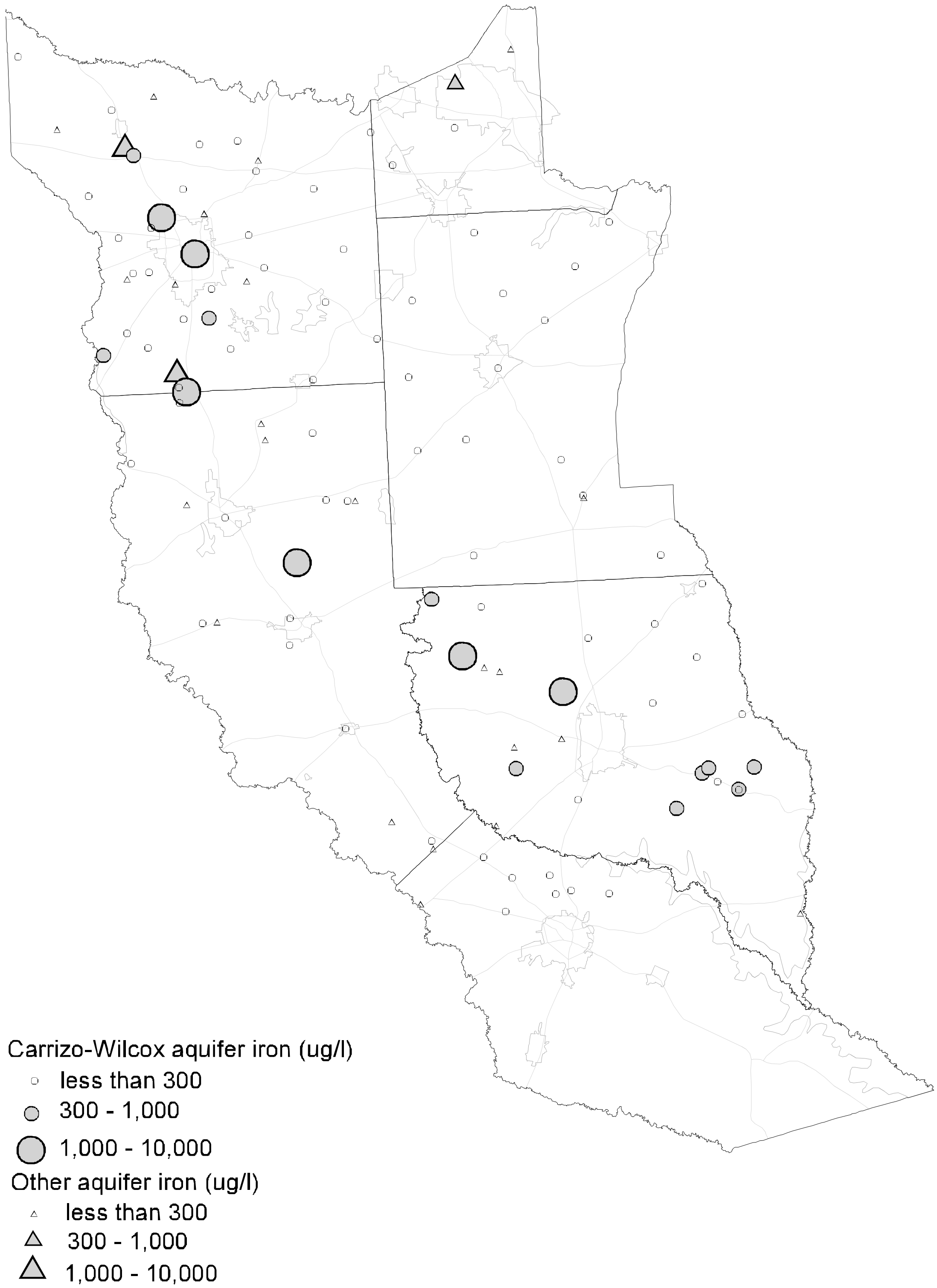

Figure 13. Iron Concentrations in Wells (1988-1997) (Culhane, 1998).

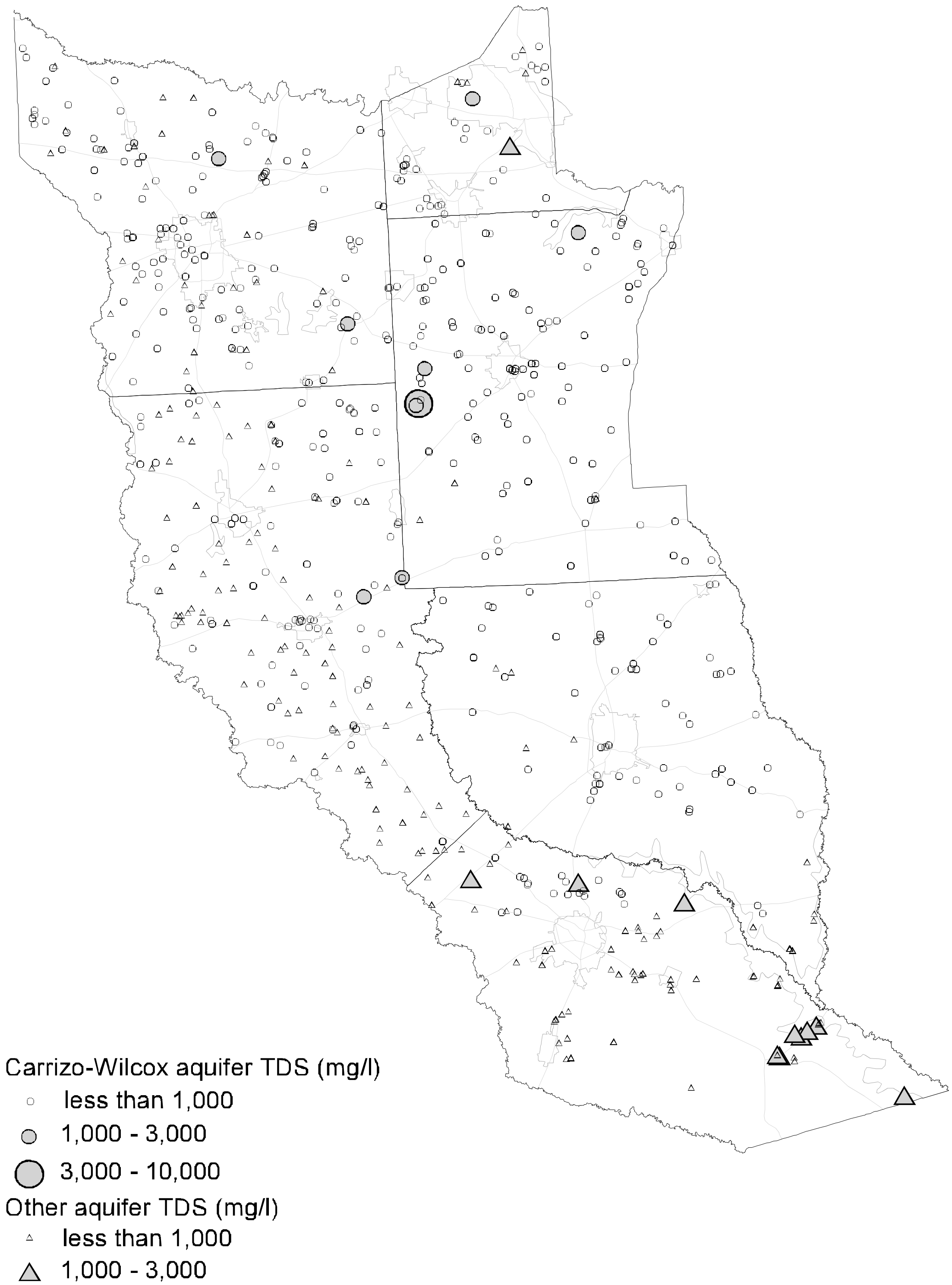

Figure 14. Total Dissolved Solids in Wells (1970-1997) (Culhane, 1998).

Poor-quality groundwater with relatively high concentrations of dissolved solids, sulfate, and chloride have been documented in isolated wells. Some of these shallow sites are located adjacent to areas where lignite is known to occur. The lignite may be the source for the high sulfate. The high total dissolved solids may have been introduced by past oil field practices such as storing oil field brines in unlined surface storage pits.

Annually, the Texas Groundwater Protection Committee (TGPC) publishes a report, Joint Groundwater Monitoring and Contamination Report, describing the current status of groundwater monitoring activities conducted by or required by each member agency of the committee. The member agencies include the Texas Commission on Environmental Quality, Texas Water Development Board, Railroad Commission of Texas, Texas Department of Health, Texas Department of Agriculture, Texas State Soil and Water Conservation Board, Texas Alliance of Groundwater Districts, Texas Agriculture Experiment Station, Bureau of Economic Geology of the University of Texas at Austin, and Texas Department of licensing and Regulation.

The 2002 Joint Groundwater Monitoring and Contamination Report lists 113 point source industrial contamination sites in Gregg County. Most of these sites (70) are contaminated with gasoline, diesel, or waste oil. Other point source contaminants listed in the area include metals, chlorinated solvents, VOC, PAH, Benzene, BTEX, creosote, PCP, and Nitrate. Rusk County had 23 point source industrial contamination sites listed in the 2002 report. Of these sites, seventeen were contaminated with gasoline, diesel, or waste oil. The only other contaminant listed was organic chemicals. There were 93 point source industrial contamination sites in Smith County. Of those 93, 70 were contaminated by gasoline, diesel, or waste oil. Other point source contaminants listed in the 2002 report include BTEX, chlorinated solvents, TPH, VOC, metals, chloride, fluoride, and sodium sulfate (TGPC, 2003).

Water Supply Concerns

The Region I Water Plan discusses threats and constraints to that region's water supply. The Sabine River forms the boundary line between Texas and Louisiana for the downstream half of its length. Almost all of the basin upstream, from the state line, is in Texas, forming the northern border of Smith County, flowing through Gregg County, and forming the northeastern boundary of Rusk County. However, Texas does not have unrestricted access to water in the Sabine River. According to the Sabine River Compact between the states of Texas and Louisiana, executed in 1953, Texas may have unrestricted access to the water in the upper reach of the river as long as the river maintains a minimum flow of 36 cubic feet per second at the junction between the river and the state line. In addition to the commitments to the state of Louisiana, a large portion of the Sabine River Basin lies upstream of the study area. The basin contains many medium-sized cities as well as smaller communities. Large amounts of surface water are already being used by the upstream communities, and this usage can be expected to increase dramatically in the future along with population growth. The Sabine River Authority has contracts to provide over 300,000 acre-feet of water per year to the Dallas area from reservoirs in the upper Sabine Basin (Schaumburg & Polk, Inc. et al, 2001). A number of entities in Gregg County receive water from the Sabine River including the City of Kilgore. Any activity upstream from Gregg County to intercept water from the Sabine River could affect surface water supplies in Gregg County.

Another potential water supply concern for the study area is the City of Dallas' contractual rights to 114,337 acre-feet of water from Lake Palestine. The city does not currently have the facilities to transport and treat the water, but anticipates the required construction by 2015 (Schaumburg & Polk, Inc. et al, 2001).

IDENTIFIED WATER MANAGEMENT STRATEGIES

Each regional water planning group is responsible for identifying all water user groups (WUGs) in the regional water planning area. The categories of WUGs include municipal (municipalities and County-Other), manufacturing, mining, irrigation, livestock, and steam electric power. After evaluating water supplies and availability, and present use and future demand, the regional water planning groups are required to identify WUGs which have, or will have, unmet water needs and develop strategies to address the unmet needs in the future. This section describes the identified water management strategies for WUGs in Gregg, Rusk, Smith counties.

Water User Groups and Groundwater Management Approaches

Gregg County

According to the Region D Water Plan, surface water is the primary water source for the North East Texas Region. Two of the 19 manufacturing WUGs in the North East Texas Region (one of which is in Gregg County) show shortages within the 50-year planning period. No water shortages are expected for this region in the irrigation, mining, and livestock WUGs. The Region D Water Planning Group identifies four categories of options for meeting the needs of these water users. These four categories are advanced water conservation, water reuse, groundwater, and surface water. The Region D RWPG does not recommend any major water supply development projects to meet needs within the region. In summary, four Gregg County WUGs will experience shortages within the next thirty years, two municipalities, a water supply corporation, and manufacturing. The recommendation for two of these entities is to increase groundwater supplies and the recommended strategies for the other two entities is to increase surface water supplies.

Clarksville, Lakeport, White Oak, and County-Other are expected to have water supply deficits due to contractual expirations over the study period. The City of Clarksville is expected to have a water supply shortfall of 131 acre-feet per year by 2010 increasing to 144 acre-feet per year in 2030. The City of Lakeport is projected to have a water supply deficit of 107 acre-feet per year starting in 2010 increasing to 119 in 2030. The City of White Oak is expected to have a deficit of 870 acre-feet per year by 2010 increasing to 928 in 2030. The County-Other water user group (WUG) within the Sabine River Basin is expected to have deficits due to contractual expirations by 990 acre-feet per year in 2010 increasing to 1,412 in 2030. The County-Other WUG within the Cypress Creek Basin is expected to have deficits due to contractual expirations by 92 acre-feet per year in 2010 increasing to 142 in 2030. The recommended water management strategy for these WUGs is to renew their contract with the respective reservoirs.

The City of Gladewater, located on the Gregg/Upshur county line, was projected to have a water deficit of 157 acre-feet per year, beginning in 2000, increasing to 429 acre-feet per year in 2050. At the time of the writing of the Region D Water Plan, the City of Gladewater had requested a water permit amendment from the TCEQ to expand the withdrawal amount from 1,679 to 3,358 acre-feet per year from Lake Gladewater. The Region D Water Plan recommends the City of Gladewater continue the permit amendment process and upgrade their water treatment facilities as necessary to expand their treatment capabilities to meet demands. Updated information submitted by the RWPG for the 2002 State Water Plan indicates, for the part of the City of Gladewater that lies only within Gregg County, there is a water deficit of 222 acre-feet per year in 2000. By 2010, however, Gladewater is projected to have a surplus through 2020. After 2020, Gladewater is again projected to have a deficit at 15 acre-feet per year in 2030, increasing into the future. The recommended management strategy is still to expand use of Lake Gladewater. Lake Gladewater, with a firm yield 6,900 acre-feet per year, has ample supply to provide for the further needs of the City of Gladewater.

According to the Region D Water Plan, the Liberty City WSC provides water service to rural southern Gregg County including the City of Liberty City. The Liberty City WSC was projected to have a water deficit of 134 acre-feet per year, beginning in 2000, increasing to 461 acre-feet per year in 2050. The Region D Water Plan noted the Liberty City WSC was constructing a new well to be completed in June, 2000. The Region D Water Planning Group, at that time, recommended four more wells be constructed and completed in the Carrizo-Wilcox aquifer.

According to the Region D Water Plan, the West Gregg WSC, located adjacent to the Liberty City WSC, provides water service in rural southwestern Gregg County, a portion of eastern Smith County, and a small portion of Rusk County. West Gregg WSC was projected to have a water deficit of 0.2 acre-feet per year beginning in 2000, increasing to 385 acre-feet per year in 2050. The RWPG recommended that West Gregg WSC construct five water wells completed in the Carrizo-Wilcox aquifer.

The manufacturing WUG is expected to have a water deficit of 10,717 acre-feet per year beginning in 2000 increasing to a deficit of 12,671 in 2030. The North East Texas Regional Water Plan recommended strategy is to purchase raw or treated water from the City of Longview. The City of Longview has an sufficient supply of water to meet the needs of manufacturing in Gregg County (Bucher, Willis & Ratliff Corporation et al, 2001).

Rusk County

According to the Region I Water Plan, within the next thirty years, there are seven Rusk County WUGs expected to experience shortages, two municipalities, County-Other, livestock, steam electric, and irrigation. In summary, the recommended strategies for three of the WUGs is to create or increase surface water supplies. Increasing groundwater supplies is recommended for three WUGs. The Region I Water Plan recommends the County-Other WUG increases groundwater supplies and pursues surface water supplies from either the cities of Henderson or Kilgore, if available.

The City of Henderson is expected to have water supply shortages of 212 acre-feet per year starting in 2000 decreasing to 65 in 2030. This WUG is expected to have a water supply surplus of 9 acre-feet per year in 2030. Henderson is presently constructing a 3 million gallon per day water treatment plant to treat water taken from the Sabine River near the City of Longview. A portion of the supply line will be shared with the City of Kilgore. Henderson has a contract with the Sabine River Authority for 4.5 million gallons of water per day (5,040 acre-feet per year). This project will meet the demands of the City in the planning period.

The City of Tatum is expected to have water supply shortages in 2000 of 13 acre-feet per year decreasing to 6 in 2010. In 2020, Tatum will have a surplus of 5 acre-feet per year increasing to 11 in 2030. The recommended strategy for this WUG is to increase supply from the Carrizo-Wilcox aquifer.

Water supply shortages are projected to begin in the County-Other WUG in 2000 at 143 acre-feet per year increasing to 724 in 2030. The recommended strategies to fulfill the demands are to increase water supplies from groundwater and to expand service from the cities of Kilgore and Henderson. The current supply for the County-Other WUG is from the Carrizo-Wilcox aquifer with the exception of surface water from Upper Neches Municipal Water Authority provided to New Salem WSC and sales to Cross Roads WSC from the City of Kilgore. Development of groundwater from Carrizo-Wilcox is favorable except in areas of existing well field development such as around the Henderson, New London, and Mount Enterprise areas. Well fields could be built away from these areas. The surface water the cities of Henderson and Kilgore receive from the Sabine River could be a source of new water for parts of the County-Other WUG.

The livestock WUG is projected to have water supply shortages 16 acre-feet per year by 2030 increasing into the future. The recommended water management strategy is to increase supply from the Carrizo-Wilcox aquifer. The Steam Electric WUG is also expected to have shortages due to the construction of the Tanaska/Coral plant in southern Rusk County. The shortages begin at 4,821 acre-feet per year in 2000 and increase to and level off at 19,821 acre-feet per year in 2030. The demand will be met with construction of a raw water line from Toledo Bend Reservoir. The manufacturing WUG had a deficit of 47 acre-feet per year in 2000 increasing to 64 in 2030. The recommended strategy is to increase groundwater supply. Water from the Neches River Basin portion of Rusk County has been used to meet the irrigation needs in the Sabine River Basin portion of the County. The irrigation shortages in the Sabine River Basin can be adequately supplied by the Neches River Basin (Schaumburg & Polk, Inc. et al, 2001).

Smith County

In the Region D part of Smith County (Sabine River Basin), there are three entities within the County-Other WUG projected to have shortages within the next thirty years. The recommendation for these three entities is to increase groundwater supplies. Within the Region I part of Smith County (Neches River Basin), water shortages are expected to occur in two municipalities and in the County-Other WUG. For one of the municipalities and for part of the shortages in the County-Other WUG, the RWPG recommends production from the Carrizo-Wilcox aquifer be increased. For the other municipality and the remaining part of the County-Other WUG, the RWPG recommends renewing and expanding contracts with the City of Tyler.

The Enchanted Lakes Water Company, included in the County-Other WUG, is expected to have water supply deficit of 4 acre-feet per year in 2000 and increasing to a deficit of 48 acre-feet per year in 2050. The recommended strategy is to construct another well and complete the well in the Carrizo-Wilcox aquifer.

The Lindale Rural WSC, included in the County-Other WUG, is projected to have a water supply deficit of 147 acre-feet per year in 2020 and increasing to a deficit of 819 acre-feet per year in 2050. The recommended strategy is to drill one well by 2020 completed in the Carrizo-Wilcox, then by 2050 drill another well also completed in the Carrizo-Wilcox aquifer.

The Star Mountain WSC, included in the County-Other WUG, is expected to have water supply deficit of 78 acre-feet per year in 2000 and increasing to a deficit of 342 acre-feet per year in 2050. The recommended strategy is to construct three wells completed in the Carrizo-Wilcox aquifer with the first well constructed in 2000, the second in 2010, and the third in 2030 (Bucher, Willis & Ratliff Corporation et al, 2001).

The City of Lindale is projected to have water supply shortages starting by 2010 at 3 acre-feet per acre per year increasing to 7 in 2030. The recommended strategy is to increase supply from the Carrizo-Wilcox aquifer.

The City of Whitehouse receives approximately 95 percent of its water supplies through the City of Tyler. The City of Whitehouse has water supply deficits beginning in 2000 of 22 acre-feet per year. The water deficits are expected to increase 403 acre-feet per year by 2030. The water management strategy recommended by the RWPG is renew and expand the contract with the City of Tyler.

The County-Other WUG for Region I receives most of its water supply from the Carrizo-Wilcox aquifer with the exception of surface water provided to Resort Water Services by the Upper Neches Municipal Water Authority and some sales by the City of Tyler. The demands could be provided by increasing production from the Carrizo-Wilcox or through water contracts with the City of Tyler. The Region I County-Other WUG is expected to have water shortages starting in 2020 of 901 acre-feet per year increasing to 1,996 in 2030 (Schaumburg & Polk, Inc. et al, 2001).

In general, the identified strategies to meet 2030 WUG deficits in Gregg, Rusk, and Smith counties include new groundwater production from the Carrizo-Wilcox aquifer and new surface water supplies from existing sources through new or amended permits or contract extensions. This increased groundwater production has been factored into the Carrizo-Wilcox (northern part) GAM, and no adverse effects are projected by 2030 due to the increased pumpage. Present surface water sources are available to meet these strategies.

EXISTING WATER PLANNING, REGULATORY AND MANAGEMENT ENTITIES

In evaluating the need for groundwater management, it is important to examine the efficiency of existing institutions in managing, planning, and regulating groundwater use. If existing entities can effectively develop and implement groundwater management and protection strategies, new entities may neither be necessary nor desirable. However, if such entities do not exist, if an existing entity does not implement its programs consistently, or does not have sufficient authority, then alternatives may need to be considered.

Several major groups of entities can be considered in the evaluation of groundwater management. These include government entities, authorities and planning groups, water suppliers and water users. Entities which may be involved with groundwater regulatory or management activities include: local municipalities; counties; state and federal government; regional planning authorities and commissions; regional surface water and groundwater management authorities; regional, municipal, and private water suppliers; and, major agricultural, industrial and commercial water users.

Federal and Interstate Programs

The U.S. Environmental Protection Agency (USEPA), U.S. Department of Agriculture (USDA), and U.S. Nuclear Regulatory Commission are federal agencies responsible for enforcing numerous federal laws for protecting groundwater quality. Generally, these agencies have delegated the administration of federal regulatory programs to individual states, or occasionally to local authorities. For example, the USEPA which has authority over the federal Resource Conservation and Recovery Act; the Comprehensive Environmental Response, Compensation and Liability Act; the Clean Water Act; the Safe Drinking Water Act; and the Federal Insecticide, Fungicide and Rodenticide Act has delegated administration of these programs in Texas to the TCEQ.

The USDA administers numerous programs at the local level to protect and conserve water resources. The USDA Farm Service Agency's Conservation Reserve Program (CRP) undertakes to reduce soil erosion and sedimentation in streams and lakes, improve water quality, establish wildlife habitats, and enhance wetland resources. The CRP encourages farmers to convert highly erodible cropland or other environmentally sensitive areas to vegetative cover such as native grasses. The USDA Natural Resource Conservation Service (NRCS) provides technical assistance to landowners, communities, and local governments in planning and implementing conservation programs. The USDA/NRCS's national Farm*A*Syst and Home*A*Syst programs promote voluntary assessments to prevent pollution. Step-by-step worksheets allow individuals to apply site-specific management practices to their property.

State Water Planning and Regulatory Programs

Water planning efforts at the state level are the responsibility of the TWDB which prepares a statewide water plan using plans developed by regional stakeholders and other state water agencies. State law requiring the TWDB to develop a statewide water plan was significantly modified by Senate Bill 1, Acts of the 75th Legislature, 1997, which established a TWDB-coordinated regional water planning process. The TWDB established 16 regional water planning areas covering the entire state, and a region water planning group (RWPG) in each of these areas. Each regional water planning area , through its RWPG, is responsible for obtaining local input and developing a regional water plan. The East Texas PGMA study area straddles the border between the Region D Water Planning Area and the Region I Water Planning Area. The Region D Regional Water Plan (Bucher, Willis & Ratliff Corporation et al, 2001) and the Region I Regional Water Plan (Schaumburg & Polk, Inc. et al, 2001) were adopted and submitted to the TWDB prior to January 5, 2001, and incorporated into the 2002 State Water Plan, adopted by the TWDB on December 12, 2001 (TWDB, 2002).

In addition to its water planning responsibilities, the TWDB collects and analyzes data to its planning functions, and administers water development funds under state and federal programs. Water development funds generally are available as low interest loans and some as grants to local and regional governments for water supply and wastewater planning, feasibility, and infrastructure development. However, TWDB financial assistance may be provided only to water supply projects which meet needs in a manner consistent with an approved regional water plan. In addition, the TCEQ cannot issue a water right for municipal purposes unless it is consistent with an approved regional water plan.

Other state agencies such as the TCEQ, the Railroad Commission of Texas, Texas Department of Health, Texas Department of Agriculture, Texas Department of Licencing and Regulation, and the Texas State Soil and Water Conservation Board have management or regulatory responsibilities for activities related to environmental protection (TGPC, 2001). The TCEQ is the state's primary environmental regulatory agency. Among its regulatory authorities are water rights permitting; creation and supervision of water districts; industrial, municipal and waste management; and water quality protection. State law, however, does not provide the TCEQ or any other state agency the authority to manage or control groundwater pumpage and use.

State agencies do not have authority to manage or regulate groundwater resources. The roles of state agencies in addressing the problems and concerns identified in the study area are limited to water quality protection primarily through the regulation of waste management, water resource planning and project funding, and facilitation of groundwater management activities through the creation and limited oversight of groundwater conservation districts.

Regional Institutions

Regional planning and water supply authorities to be considered in evaluating groundwater management activity include some water districts, river authorities, and surface water management authorities. Other regional planning institutions include councils of governments and regional water planning groups.

The Sabine River Authority (SRA) of Texas was created by the Legislature in 1949 as an official agency of the State of Texas. The Authority was created as a conservation and reclamation district with responsibilities to control, store, preserve, and distribute the waters of the Sabine River and its tributary system for useful purposes. The boundaries established for the SRA by the Act of the Legislature comprise all of the area lying within the watershed of the Sabine River and its tributary streams within the

State of Texas. The watershed area in Texas includes all or parts of twenty-one counties, including parts of all three of the counties in the study area. The State of Texas has jurisdiction to the midstream boundary for the stateline reach of the Sabine River (Sabine River Authority, 2003).

The Angelina and Neches River Authority (ANRA) is a government agency created by the state legislature under the state constitution. It is recognized as an independent governmental agency authorized to construct, maintain, and operate any and all works necessary for the purpose of controlling, storing, and preserving water resources in its 17-county jurisdiction, including parts of Rusk and Smith counties, in the Neches River Basin. The ANRA receives no tax revenues from the state nor can it levy any taxes. ANRA revenues are derived solely from services provided. It is authorized to issue revenue bonds for the purpose of financing projects to be paid by and through customer contracts which obligate the customer to pay its share of the debt obligation. The major functions of the ANRA are water quality management, water resource development, and conservation of water resources. The ANRA administers several water quality related environmental programs including the Upper Neches basin surface water quality monitoring programs, permit compliance monitoring programs, industrial pre-treatment program, and a water/wastewater sample collection and testing program (Angelina & Neches River Authority, 2003).

The Northeast Texas Municipal Water District (NETMWD) is charged with the orderly development and conservation of the water resources in the Cypress Creek Basin. The mission of NETMWD is to protect the water quality in the Cypress Creek Basin and to provide a sufficient supply of water to Northeast Texas. The major objectives of this district are to assure delivery of a sufficient supply of water to communities in northeast Texas, to be actively involved in water quality issues, to continue as a contractor for the Clean Rivers Program for the TCEQ, and to be actively involved in regional water planning issues. NETMWD serves as the administrative agency for the North East Texas Regional Planning Group (Northeast Texas Municipal Water District, 2003).

Upper Neches River Municipal Water Authority (UNRMWA) is the owner and operator for Lake Palestine. UNRMWA holds rights to approximately 238,000 acre-feet per year in Lake Palestine, from which it distributes raw water to municipalities and other contract buyers in the region (Schaumburg & Polk, Inc. et al, 2001). In 1965, the lake became part of the water supply for the City of Tyler, when the city entered into a contract with the Upper Neches River Muncipal Water Authority for the purchase of 67,200 acre-feet of water per year. Tyler Water Utilities completed construction on the Lake Palestine Water Treatment Plant on October 9, 2003. Initially, the Tyler Water Utilities is expected to draw up to 30 million gallons of water daily from Lake Palestine and treat it at the new plant. Tyler indicates it has the rights to 60 million gallons per day from the lake (City of Tyler, Texas, 2003).

Other water districts in the study area identified in the TCEQ Water Utilities Database are Smith County Water Control and Improvement District Number 1 - Owentown, Chalk Hill Special Utility District, Liberty-Danville Fresh Water Supply District Number 2, and Emerald Bay Municipal Utility District.

The Texas State Soil and Water Conservation Board (TSSWCB) was established by the Texas Legislature to administer the Texas Soil Conservation Law. The TSSWCB offers a technical assistance program to the state's 216 soil and water conservation districts (SWCDs). The TSSWCB is the lead agency for the planning, management and abatement of agricultural and silvicultural nonpoint source pollution. The TSSWCB maintains regional offices in strategic locations in the state to help carry out the agency's water quality responsibilities. There are three SWCDs located in the study area, Upshur-Gregg SWCD #417, Smith County SWCD #426, and Rusk SWCD #447. Senate Bill 503, an Act of the 73rd Legislature, 1993, created the Water Quality Management Plan Program to provide agricultural and silvicultural (forestry) producers with an opportunity to comply with state water quality laws through traditional, voluntary, incentive-based programs. Landowners and operators may request the development of a site-specific water quality management plan through local SWCDs. Plans include appropriate land treatment practices, production practices, and management and technology measures to achieve a level of pollution prevention or abatement consistent with state water quality standards (Texas State Soil and Water Conservation Board, 2003).

The study area is located within the 14-county East Texas Council of Governments (ETCOG). Established in 1970, the ETCOG is a voluntary association open to all local governments in the East Texas region, including counties, cities, school districts, river authorities, soil and water conservation districts, and special purpose districts. ETCOG has 139 current members and is the fifth largest such organization in the state. Councils of governments (COGs) are political subdivisions of the state and are basically planning and funding distribution agencies with no independent regulatory authority. Among numerous other responsibilities, COGs may make recommendations concerning recreational sites, public utilities, and water supplies. State law assigns COGs the primary responsibility for the development of regional municipal solid waste plans Regional municipal solid waste plans must conform with the state plan and are adopted by TCEQ rule.

The study area is located both in the North East Texas Region Water Planning Area, Region D and in the East Texas Region Water Planning Area, Region I, two of the 16 regional water planning areas. Gregg County and the Sabine River Basin portion of Smith County are located in Region D, and Rusk County and the Neches River Basin portion of Smith County are located in Region I. North East Texas Region Water Planning Area covers all or part of 19 counties. The East Texas Region Water Planning Area covers all or part of 20 counties.

The North East Texas and East Texas Regional Water Planning Groups (NETRWPG and ETRWPG, respectively) consist of members representing the public, counties, municipalities, industry, agriculture, environmental groups, small business, electric generating utilities, river authorities, water districts, and water utilities. The NETRWPG and ETRWPG are required to develop a regional water plan, establish policies, make decisions, and consider interest groups in the development of the plans as required by Senate Bill 1 (75^{th} Legislature, 1997). The development of a regional water plan includes studies, decisions, and recommendations on water supply needs. The purpose of the plan is to identify and recommend methods or strategies to conserve water supplies, meet future water supply needs, and respond to future droughts in the region.

Both the NETRWPG and ETRWPG have identified a number of water supply options in the development of their regional water plans. These water supply options include local water conservation options, existing and new reservoir options, Carrizo-Wilcox and other aquifer options, and river diversion options. The regional water plans were completed before January 2001, and the TWDB has incorporated the plans into the 2002 state water plan.

Local Government and Water Purveyors

Counties and municipalities typically carry out public health programs such as disposal of municipal solid waste; production, distribution, and protection of public drinking water supplies; and treatment and discharge of municipal wastewater. Local water suppliers include municipalities, water supply corporations, water supply districts, and water conservation and irrigation districts. Wholesale and retail water suppliers are required to prepare and adopt drought contingency plans under TCEQ rules (Title 30, Texas Administrative Code, Chapter 288). These plans are to be implemented during times of water shortage or drought and usually address a variety of measures to reduce peak demands and to extend water supplies. The TCEQ public water system database lists 89 public water supply systems in the study area.

The Local Government Code, §§212.0101 and 232.0032 provide groundwater availability certification authority to all municipal and county platting authorities in the state. Under this statute, a municipal platting authority or county commissioners court may require a person submitting a plat for the subdivision of a tract of land for which the intended source of water supply is groundwater under that land to demonstrate adequate groundwater is available for the proposed subdivision. If groundwater availability certification is required by the local platting authority under the Local Government Code, the plat applicant must evaluate groundwater resources and prepare the availability certification pursuant to TCEQ rules. The rules establish the appropriate form and content of a groundwater availability certification and have been adopted as Title 30, Texas Administrative Code, Chapter 230.

Municipalities have authorities for the protection of public health but are not directly authorized to manage or regulate groundwater withdrawals. Municipalities and other water suppliers can indirectly limit groundwater withdrawals by implementing and enforcing water conservation programs and securing and developing alternative supplies. Municipal and county groundwater availability authority under the Local Government Code can be an effective groundwater management tool and can address certain wells outside of a groundwater conservation district's management jurisdiction. However, this management tool is limited because it only addresses areas being subdivided and does not allow for aquifer-wide or regional assessments.

Groundwater Conservation Districts

Groundwater conservation districts are charged to manage groundwater by providing for the conservation, preservation, protection, recharging, and prevention of waste of the groundwater resources within their jurisdictions. Groundwater conservation districts have required duties which must be performed, as well as a number of authorized powers which may be invoked. The required duties include:

- developing and adopting a comprehensive management plan and coordinating planning with regional planning groups, state agencies, and other groundwater conservation districts located within the same groundwater management area;
- adopting necessary rules to implement the management plan;
- requiring permits for drilling, equipping, or completing wells producing more than 25,000 gallons per day;
- requiring records to be kept of the drilling, equipping, and completion of water wells, as well as on the production and use of groundwater, and make information on groundwater resources available to the TCEQ and the TWDB upon request; and,
- adopting rules for governance and to establish administrative and financial procedures, such as preparing and approving an annual budget, having an annual audit, holding regular board meetings, and submitting records to the appropriate state agency.

To manage groundwater resources, groundwater conservation districts are also authorized to adopt rules to conserve, preserve, protect, recharge, and control land subsidence. Districts are authorized to make rules regarding:

- the spacing of water wells and regulating the production of wells;
- carry out research projects and collect information regarding the use of groundwater;
- require abandoned wells permanently closed or capped;
- aquifer recharge projects;
- the levying of taxes and setting fees; and
- the acquisition of land by use of eminent domain.

The study area lies wholly within Groundwater Management Area 11 as designated by the TWDB (Figure 5). This management area includes all or part of Anderson, Angelina, Bowie, Camp, Cass, Cherokee, Franklin, Gregg, Harrison, Henderson, Hopkins, Houston, Marion, Morris, Nacogdoches, Panola, Rains, Rusk, Sabine, San Augustine, Shelby, Smith, Titus, Trinity, Upshur, Van Zandt, Walker, and Wood. All or part of five groundwater conservation districts have been created within this groundwater management area (Figure 2). All five of these GCDs have been confirmed by election including: Anderson County UWCD, roughly located over the Keechi Salt Dome in Anderson County southwest of the study area; Bluebonnet GCD, located in Austin, Grimes, and Walker counties with only the northernmost part of Walker County actually located within GMA 11; Neches & Trinity Valleys GCD, located in Anderson (outside of Anderson County UWCD), Cherokee, and Henderson counties bordering on the south and southwest parts of the study area; Pineywoods GCD, located in Angelina and Nacogdoches counties bordering on south side of the study area; and, Rusk County GCD, located within the study area. A GCD, located in Wood County (Lake Country GCD) and created in 2002 by petition, failed its confirmation election; and, a GCD in Upshur County (Upshur County GCD) failed its confirmation electon in June 5, 2004.

Anderson County GCD is the only district in this area of the state which was in existence during the previous East Texas PGMA study. Anderson County UWCD was created in 1987 as an Act of the 70th Legislature, Regular Session (Chapter 992). Bluebonnet GCD, Neches & Trinity Valleys GCD, and Pineywoods GCD were created by Acts of the 77th Legislature in 2001. Rusk County GCD was created by an Act of the 78th Legislature in 2003.

In summary, five groundwater conservation districts have been established within Groundwater Management Area 11 to manage the Carrizo-Wilcox, Queen City, and Sparta aquifers and these districts have sufficient authority to conserve, preserve, and protect groundwater resources. One of the groundwater conservation districts, Rusk County GCD, is located within the study area. This district has the authority to manage groundwater resources. However, in the rest of the study area, there are no existing groundwater management authorities that can effectively manage the Carrizo-Wilcox or Queen City aquifers.

ADMINISTRATIVE FEASIBILITY OF GROUNDWATER MANAGEMENT

At present, no confirmed groundwater conservation districts exist in the three-county study area. The study area originally included Angelina, Cherokee, and Nacogdoches counties in addition to Gregg, Rusk, and Smith counties. Groundwater conservation districts were formed in Angelina, Cherokee, and Nacogdoches counties, and thus, are not included in the current study. The feasibility of managing groundwater resources within the study area is presented within this section. Groundwater management approaches which can be utilized by groundwater conservation districts are evaluated. Area-specific groundwater management strategies, economic and financial considerations, and available district-creation options are discussed below.

Groundwater Management Approaches

Various mechanisms are available for protecting groundwater resources in an area. They range from imposing restrictions on groundwater withdrawals to developing alternate supplies, to conjunctively using both surface water and groundwater. Regulating groundwater withdrawal can prolong the life of an aquifer and increase land value by assuring a reliable supply of water for future use and economic development.

Local or regional groundwater conservation districts (GCDs) are the state's preferred method of managing groundwater resources, and are the only entities in Texas explicitly granted the power to regulate groundwater withdrawals. These districts are charged with managing groundwater by conserving, preserving, protecting, recharging, and preventing wastage of the groundwater resources within their jurisdiction. The approaches or techniques for managing groundwater through a groundwater conservation district include:

- water resource planning;
- groundwater resource assessment and research;
- monitoring of water-levels, water quality and land subsidence;
- well permitting and registration;
- limiting withdrawals through well spacing or setback requirements;
- well pumpage or use limitations; and,
- use of engineered structures or injection wells to enhance natural recharge or artificially recharge groundwater aquifers.

Through groundwater monitoring (both quantity and quality) and assessment functions, a GCD can quantify groundwater resources, study and investigate aquifer characteristics, and identify groundwater problems which need to be addressed. Planning functions outline appropriate management objectives and goals for the district to preserve and protect groundwater resources and GCD rules are adopted to achieve the management planning objectives and goals.

GCDs are required to establish water well permitting and registration programs and through these programs, can quantify aquifer impacts from pumpage. An efficient water well inventory, permitting, and registration program allows a groundwater conservation district to establish an overall understanding of groundwater use and production within the district. Permits must be obtained from the district to drill, equip or complete wells, or to substantially alter the size of wells or well pumps. Certain types of water wells are exempted from GCD permitting. These exempted wells generally include wells incapable of producing 25,000 gallons per day on tracts of land larger than 10 acres and wells supplying water for exploration, production, and other activities permitted by the Railroad Commission of Texas. Wells exempted from regulation by a district must, however, be completed and maintained in accordance with the district's rules regarding prevention of waste and pollution of the groundwater, and must be registered with the district before being installed.

GCDs may also adopt rules to regulate the spacing and production of water wells. Spacing regulations are generally adopted by a district to minimize drawdown of water-levels (both water table and artesian pressure), control subsidence, prevent waste, and prevent interference from other nearby wells. Spacing and production regulations are commonly based on minimum distances from other wells or property lines, a maximum number of wells in a specified area of land (e.g., ¼-section, ½-section, or full-section), or a maximum allowable production per a given unit of land (e.g., 5 gallons per minute per acre or 1 acre-foot of production per year per acre of land).

Groundwater conservation district management activities can include protecting water quality by regulating water well construction and ensuring proper well closure and actively identifying and closing abandoned wells. Districts may also administer activities such as weather modification or recharge enhancement projects to enhance natural recharge and increase groundwater supplies. Other important GCD management programs include water conservation, public education efforts, and providing conservation assistance through loan and grant programs.

The NETRWPG and the ETRWPG are required to consider current water availability and use, existing water supply plans, and drought contingency plans during the development of their regional water plans. The regional water planning groups are charged to include potentially feasible water management strategies, including groundwater strategies, within their regional water plans. The regional water planning groups are designed to involve the stakeholders and the public in water issues both at a local and regional level. Such local participation should improve the development of management, conservation, and reclamation practices for those whose lives and livelihoods depend on protection their common water resources.

Identified Groundwater Management Strategies

The water supply problems identified in the study area include naturally occurring poor-quality groundwater zones, water-level declines in some areas of continued municipal and industrial overdraft, and potential groundwater impacts from new well field development. Opportunities for the study area include participation in regional water planning and cooperation with local water supply, conservation, and education entities. The following management strategies are recommended for the area to address identified problems and issues:

- quantify groundwater availability and quality, understand aquifer characteristics, and identify groundwater problems which should be addressed (both quantity and quality) through aquifer- and area-specific research, monitoring, data collection, and assessment programs;
- quantify aquifer impacts from pumpage and establish an overall understanding of groundwater use through a comprehensive water well inventory, registration, and permitting program;
- establish programs encouraging conservation of fresh groundwater and the use of poorer-quality groundwater when feasible and practicable, and facilitate such transitions;
- evaluate and understand aquifers sufficiently to establish spacing regulations to minimize drawdown of water levels and to prevent interference from neighboring wells;
- establish educational programs, for school children and for the general public, to make them aware of actions which can be taken to conserve water resources;
- protect water quality by requiring water well construction to be protective of fresh-water zones and by administering a program to locate and plug abandoned water wells; and,
- actively participate in the regional water planning process, groundwater availability model refinements, and regional groundwater management and protection programs with other east Texas groundwater conservation districts and entities.

Implementation of any or all of the above management programs would be a benefit to the study area by protecting groundwater resources. These programs could best be implemented by a GCD. A GCD could benefit the study area by implementing groundwater management strategies as authorized under Texas Water Code, Chapter 36 such as monitoring, assessment, planning, and permitting programs as well as water well spacing and water-quality protection rules for the Queen City and Carrizo-Wilcox aquifers.

Economic Considerations and Impacts

Obtaining alternative sources of water for an area is often cost prohibitive because either new or additional surface water rights must be acquired or infrastructure constructed to deliver surface water or groundwater from outside sources. The economic impacts of managing groundwater resources through a groundwater conservation district are both positive and negative. For example, managing an area's groundwater resources can increase the value of land in the area by extending the economic life of the aquifer(s), limiting the possible encroachment of salt-water, and reducing other water quality impacts. Indeed, one of the benefits of a GCD is the district's proactive approach through its assessment and monitoring, planning, permitting, and other conservation programs to equitably extend groundwater supplies for future use and economic development. GCDs also benefit the area by developing and implementing regulations for adequate well spacing, water well construction, pollution prevention through the plugging of abandoned wells, and also by providing public education outreach programs.

While a district may provide many benefits to those living within its boundaries, there is a cost for the groundwater management services and activities provided. To finance its operations, a GCD must generate revenue which is generally done either through property taxes collected from all residents within the district or from well production fees collected from major water users. Collection of tax to operate a district places an additional financial burden on all individuals within the district, and the collection of well production fees adds a financial burden to the users of water with permitted wells. The scale of cost for residents is dependent upon many factors including the size and total tax base of the district or the quantity of water subject to production fees, and the scale and scope of the programs undertaken by the district. Additionally, because a GCD is a political subdivision, it is an additional layer of local government which may not be welcomed by all residents.

Financing Groundwater Management Activities

Groundwater conservation districts are required to operate from an annual budget with spending limited to budgeted items. Present budgets for existing, operational GCDs range from slightly over $100,000 for some single-county districts with limited permitting and monitoring programs to over several million dollars for special-law type, multi-county districts with specific statutory groundwater management responsibilities such as restricting production to protect spring-flow or to cease subsidence cause by groundwater withdrawal. Present budgets for three- to four-county GCDs range from about $150,000 to about $425,000 (TCEQ personnel communication, August 27, 2003).

Under Texas Water Code, Chapter 36, a GCD may levy an *ad valorem* tax at a rate not to exceed 50 cents per $100 assessed valuation to pay for maintenance and operating expenses. In fact, most GCDs have lower *ad valorem* tax caps established either by their enabling legislation or by voters. Existing groundwater conservation districts currently have tax rates ranging from $0.004 to $0.0775 per $100 assessed valuation (or, $4.00 to $77.50 annual tax paid on property valued at $100,000) (Texas Alliance of Groundwater Districts, 2003). Single-county districts generally tend to have higher tax rates than multi-county districts which typically have tax rates averaging around $0.01 per $100 assessed valuation.

The total appraised value for county taxation in each of the three counties in the study area is as follows: Gregg - $5,063,828,476, Rusk - $2,532,513,050, and Smith - $8,101,054,805 (Texas Association of Counties, 2003). For the three-county study area, the total appraised value is approximately $15,697,396,331. Assuming a GCD was created to cover all three counties, a tax rate of $0.005 (one-half cent) per $100 value would generate approximately $784,870 annually. If three single-county GCDs were created, and each assessed a tax at the same rate ($0.005 per $100), the following approximate revenue would be generated for each: Gregg - $253,191, Rusk - $126,625, and Smith - $405,052.

GCDs may also generate revenue through the assessment and collection of well production fees on permitted wells. Unless otherwise addressed by a district's enabling legislation, the production fees are capped by state law at $1 per acre-foot/year for agricultural use, and $10 per acre-foot/year for other uses. Based on year 2000 supply data provided in Appendix 2, and assuming county-other, livestock, and mining uses would be exempt from potential regulation and fees, about 169 acre-feet of water was produced for irrigation and about 16,206 acre-feet of water was produced for other purposes (municipal, manufacturing, steam electric) in the three-county study area. Based on the creation of a three-county GCD and utilizing the maximum statutory well production fee rates ($1 per acre-foot/year for agricultural use and $10 per acre-foot/year for other uses), about $162,229 of revenue could be generated through this method to finance district operation and maintenance.

To a lesser extent, GCDs may also generate revenue by assessing fees for administrative services such as processing permit or groundwater transport applications, performing water quality analysis, providing services outside of the district, and capping or plugging abandoned wells. These fees must not unreasonably exceed the cost of providing these services. GCDs can also impose export fees (see below) and apply for and receive grants, loans and donations from governmental agencies, individuals, companies or corporations for specific conservation projects or research.

In addition, GCDs can issue and sell tax bonds for capital improvements such as building dams, draining lakes and depressions, installing pumps and equipment, and providing facilities for the recharge of aquifers. Such tax bonds are subject to voter authorization, TCEQ review, and the State Attorney General's approval. The taxing rate is not capped for the repayment of bond indebtedness.

GCDs may impose an export fee on water transferred out of the district, unless otherwise addressed by a district's enabling legislation. The export fee is based on the district's existing tax or production fee rates or is negotiated with the transporter. GCDs are allowed to charge a 50 percent export surcharge in addition to the production fee charged for in-district use. Conversely, a few groundwater conservation districts have been created without the authority to impose *ad valorem* taxes or water use fees. These districts have generally been funded by county government and are limited in the scope of programs they can implement by the amount of funding received.

Management Options

Water management planning can be carried out at various scales of oversight and authority. On a state-wide scale, no single entity has authority to manage all the groundwater resources of the state. However, state-level water planning responsibilities and GCD management plan oversight responsibilities are well defined, as previously discussed. Assessment and planning by the regional water planning groups can identify areas with groundwater problems and appropriate management options for use by regional and local entities. However, the regional water planning groups do not have authority to manage groundwater or other water resources.

Historically, single-county GCDs have been the predominant choice of Texas citizens. However, multi-county GCDs covering larger portions of aquifers have become more prevalent over the past half-dozen years. Such districts can exercise management and planning authority on a local scale and can affect groundwater management on a regional scale. Generally, multiple single-county GCDs or a few multi-county GCDs are created within the same groundwater management area and each district operates under its own rules and regulations to manage the groundwater resource. However, because these GCDs share common groundwater resources, it is imperative their efforts to manage the resource be coordinated.

Under §36.108 of the Texas Water Code, GCDs within a common groundwater management area are required to share their certified groundwater management plans with the other districts present within the management area. These GCDs are encouraged, under §36.108, to conduct joint public meetings to review management plans and plan-accomplishments for the management area. The districts are further advised under §36.108 to consider the goals and effectiveness of each management plan and the impact each management plan will have on planning throughout the management area. Through these cooperative efforts, local GCDs can effectively provide coordinated regional management of a shared groundwater resource.

Several groundwater management options are available for the study area. In one scenario, citizens can opt not to take any action and allow existing groundwater problems to persist or worsen. Limited groundwater management can be accomplished if the local platting authorities adopt groundwater availability requirements under §§212.0101 or 232.0031 of the Local Government Code. However, this level of groundwater management would only address specific land areas proposed for platting for the subdivision of land. This groundwater management tool is suitable for addressing small capacity wells but inadequate for resource assessment or regional coordination.

A GCD created within the study area would have the necessary authority to accomplish groundwater management objectives identified in the preceding text. Such a district working in coordination with local platting authorities would have the best available regulatory authority to manage groundwater resources in the area. If true groundwater management is desired, the citizen must consider several methods for the creation of a groundwater conservation district. Most GCDs are created by special Acts of the Texas Legislature. In other general law procedures, statute allows landowners to petition the TCEQ for the creation of a GCD, or allows landowners to petition another district to be added into that district. Lastly, if an area is designated as a PGMA, landowners are provided a two-year period to accomplish one of the above district creation actions. If they do not, TCEQ is required to create a GCD or recommend the area be added to an existing GCD. (Methods of, and procedures for GCD creation are discussed in significant detail in TCE, 2002a and 2002b.) Since this report concludes this three-county area is not a PGMA, only the first three GCD creation methods are evaluated here.

Multi-County Groundwater Conservation District

Besides considering the different groundwater conservation district creation methods, citizens must also consider several different GCD creation options and the implication for each. The most economical option would be a multi-county GCD consisting of all three counties in the study area. Because of the broader tax base this option provides, sufficient revenue could be generated to finance district operation and maintenance at a very low tax rate. As discussed above, a tax rate of $0.005 (one cent) per $100 assessed valuation would generate about $784,870 annually. These revenue estimates are far above the amount on which existing GCDs of the same size operate. A tax rate of one-half to one cent per $100 would be enough to finance groundwater management activity through a GCD.

Alternatively, a three-county GCD could finance operations and maintenance through the assessment of well production fees, and it is estimated (see above) about $162,229 could be generated annually at the maximum fee rates authorized by Texas Water Code, Chapter 36. Although Chapter 36 authorizes GCDs to generate revenue through the levy of taxes and the assessment of well production fees, the TCEQ is unaware of any districts doing both simultaneously. Frequently, the authority for special-law created GCDs requires the generation of revenue through either taxes or fees, but not both.

Furthermore, since the three-county GCD creation option would include the greatest areal extent of the Carrizo-Wilcox and Queen City aquifers, a single GCD management program for the aquifers would also represent the most optimal groundwater management option.

Single-County Groundwater Conservation Districts

Citizens could also consider a district configuration of either all single-county GCDs or one bi-county GCD and a single-county GCD. The generation of revenue to finance meaningful groundwater management programs would be the limiting factor for the consideration of these GCD creation options. TCEQ staff estimate approximately $150,000 in revenue must be generated to operate a district and fund groundwater management programs. All of the counties are capable of generating sufficient revenue to operate a GCD alone through an *ad valorem* tax of less than $0.01 per $100 valuation. For example, at a tax rate of $0.01 per $100 valuation, about $253,251 could be generated annually in Rusk County, while in the other two counties the amount would be significantly more.

Rusk County GCD, created under HB 3569, Act of the 78th Legislature, Regular Session may impose an *ad valorem* tax at a rate not to exceed one-half cent on each $100 of assessed valuation of taxable property in the district. This would generate approximately $126,625 in revenue. The board may also, by rule, impose reasonable fees on each well may not exceed: (A) $0.25 per acre-foot for water used for agricultural irrigation; or (B) $0.0425 per thousand gallons for water used for any other purpose. This rate may be increased at a cumulative rate not to exceed three percent per year. These production fees would generate approximately $19 from irrigation and $78,715 for water used for any other purpose, a total of $78,734 annually. The District is also authorized to assess an export fee on groundwater from a well produced for transport outside the district (Texas Legislature, 2003).

Having two or three GCDs would require a like number of individual groundwater management programs. These options provide for the most local control because each director represents a smaller area. However, these options would also require largely duplicative administrative and management programs be implemented. For example, each GCD would be required to:

- establish and maintain an office;
- establish procedures to address open meetings and open records and records retention;
- annually address financial budgeting and auditing requirements;
- develop and adopt a management plan;
- develop and adopt administrative, well permitting and other regulatory rules;
- meet and uphold other statutory requirement relating to policies and district operation; and,
- jointly plan with other GCDs located within the same groundwater management area.

The creation of single-county districts in the study area is feasible. Nevertheless, better economic and administrative options do exist. The only apparent trade-off would be the most-localized form of groundwater management would be forfeited if something other than single-county GCDs were created. However, the creation of GCDs by special law, and Texas Water Code, Chapter 36, allow sufficient flexibility to assure the number and representation by district directors alleviate this misconception. Under either method, district directors must be accountable to, and responsive to, the electorate.

Addition to Existing Groundwater Conservation District

Alternatively, the landowners in Gregg and/or Smith County could join the Rusk County GCD or the study area could opt to join another existing groundwater conservation district through the petition and annexation procedures outlined in Texas Water Code, Chapter 36, Subchapter J. Under such circumstances, and assuming a petition to add territory is accepted by the receiving district, landowners in the study area would agree to assume the financial obligations of the district they would join and be provided equitable representation on the receiving district's board of directors. The advantage of joining an existing district include having established regulations, programs, and infrastructure in place, and an increased tax base which may be less burdensome on the taxpayers in the study area.

Presently, the only GCDs that landowners in the study area could join are the Neches and Trinity Valleys GCD, Pineywoods GCD, or Rusk County GCD. The residents of Anderson, Cherokee, and Henderson counties confirmed creation of the Neches and Trinity Valleys GCD by election, and the residents of Angelina and Henderson counties confirmed creation of the Pineywoods GCD by election, both on November 6, 2001. Both of these districts generate revenue by assessing well production and permit fees. The residents of Rusk County confirmed creation of the Rusk County GCD by election on June 5, 2004. This district is to be funded by an *ad valorem* tax with a rate of $0.005 (one-half cent) per $100 valuation. Since these are recently formed GCDs, groundwater management regulations and programs may not be well established.

If any of these GCDs were agreeable to an inclusion-petition from two or three counties in the study area, the resultant GCD would have the benefit of a larger revenue base, would include a larger areal extent of area aquifers, and would be able to develop uniform management programs for the area aquifers. However, the enabling legislation for the Neches and Trinity Valleys GCD, Pineywoods GCD, and Rusk County GCD would need to be amended to allow flexibility for board member representation.

Under any of the groundwater conservation district creation scenarios outlined above, it will be imperative for a district to understand the water supply options and strategies that have been identified in the North East Texas and East Texas Regional Water Plans (Bucher, Willis & Ratliff Corporation et al, 2001 and Schaumburg & Polk, Inc. et al, 2001), the groundwater data that is built into the State Water Plan (TWDB, 2002) and TWDB's groundwater availability model for the area. These data and water supply strategies will serve as guides for water planning in the study area, and in the region for the next 50 years. Further, a district should also intimately understand and recognize the drought contingency plans of the wholesale and retail water suppliers in the area and the water demands of areas proposed for platting. Through monitoring programs, assessment, research, and cooperation, a district in the study area should be able to institute successful groundwater management programs for the Carrizo-Wilcox and other aquifers and provide better information and input about the groundwater resources for consideration in future updates to the regional and state water plans.

CONCLUSIONS AND RECOMMENDATIONS

Section 35.007 of the Texas Water Code requires the TCEQ's Priority Groundwater Management Area (PGMA) Report to include the following information:

- an examination of the reasons along with supporting information for or against designating the area as a PGMA;
- delineation of the boundaries of any proposed PGMA;
- recommendations on either creating a groundwater conservation district in the PGMA or adding the PGMA to an existing adjoining district;
- recommendation on the actions necessary to conserve the natural resources of the study area; and,
- an evaluation of information or studies submitted to the TCEQ by the area's stakeholders.

The Water Code requires the report to identify current critical groundwater problems, or those projected to occur within the next 25 years. Critical problems which warrant PGMA designation include shortages of surface water or groundwater, land subsidence resulting from groundwater withdrawal, and contamination of groundwater supplies. This report evaluates authorities and management practices of existing entities and makes recommendations on groundwater management strategies for the study area.

The purpose of a PGMA study is to ascertain if any critical groundwater supply or groundwater quality issues are occurring or will occur within the next 25 years within the study area. If there are critical groundwater issues, the study area is designated as a PGMA and a GCD(s) must be formed in the area to manage these issues. When the East Texas PGMA study was originally conducted in 1990, the study area included Angelina, Cherokee, Gregg, Nacogdoches, Rusk, and Smith counties. Angelina and Nacogdoches formed into the Pineywoods GCD and Cherokee along with Anderson and Henderson counties formed into the Neches and Trinity Valleys GCD both in 2001. Since these counties have formed into GCDs, they are not included in the current study.

TCEQ staff has considered data and information provided by the Texas Water Development Board, Texas Parks and Wildlife Department, Regional Water Planning Groups, stakeholders in the study area, and other information collected through our own research to support the following conclusions and recommendations regarding the East Texas PGMA study area.

Water Supply Conclusions

In 2000, approximately 103,719 acre-feet of water was used to supply the study area's needs. Groundwater made up 30 percent of the area water supply; however, in Smith County, over 42 percent of water usage came from groundwater (less than 12 percent for Gregg County). The main aquifer used in the study area is the Carrizo-Wilcox aquifer. The Queen City and other (not Carrizo-Wilcox) aquifers were predicted, in 2000, to make up only about three percent of all groundwater supplies. Water supplied by the Queen City and other aquifers is used primarily for mining and livestock, but is also used for irrigation, manufacturing, and rural domestic supplies. These minor aquifers are not used for water supply in Gregg County.

In 2000, groundwater produced for municipal use made up 87 percent of total groundwater usages followed by 4 percent for both manufacturing and mining usages, individually. Most of the groundwater produced for municipal usage, almost 65 percent, occurs in Smith County. All of the cities in Rusk County (six) and most of the cities in Smith County (five of seven) rely solely on groundwater, while most cities (four of seven) in Gregg County rely solely on surface water. Only one city in Gregg County depends totally on groundwater.

The total study area water demand is expected to increase by more than 26 percent from the year 2000 to 2030. The projected water demand is expected to increase to 150,235 acre-feet by 2030. The Regional Water Planning Groups estimate there was a total water supply of 154,224 acre-feet in 2000. Only Rusk County has less water supply than demand. The Regional Water Plans for the study area identify the water shortages as being either contractual or actual. For the entities with contractual shortages, the Regional Water Plans recommend renewing, and in some cases expanding contracts with the water supplier. For entities with actual water shortages, the regional water plans recommend increasing groundwater supplies and securing additional surface water supplies.

Surface water is supplied by eight reservoirs, the Sabine River, and Big Sandy Creek. The Regional Water Plans for this area estimate surface water supplies for the study area amount to 110,991 acre-feet in 2000. This amount does not include local supply sources for irrigation, livestock, manufacturing, and mining, which comes to 5,307 acre-feet of water. The City of Tyler recently completed the construction of a water treatment plant that will be able draw and treat up to 33,600 acre-feet of water per year. This amount is half of the amount that the City of Tyler is contractually able to draw from Palestine Lake. In addition to these surface water supplies, a number of entities in the study area are involved in the Lake Columbia project, expected to be completed in 2011, and have reserved a total of 23,130 acre-feet of water.

Groundwater Level Conclusions

In 1991, a report by Preston and Moore concluded water-levels in most wells completed in the Carrizo-Wilcox aquifer have declined over most of the study area, but declines are only significant proximate to solitary municipal wells or small well fields. The reason for much of the water-level declines is many of the municipalities and water supply corporations have located their relatively high capacity wells close to each other. The most significant declines have occurred in areas of heavy industrial and municipal pumping such as in the area around Tyler. However lesser depressions have occurred northwest of the City of Kilgore and around the City of Henderson. The groundwater availability model for the Carrizo-Wilcox (northern part) projects water-levels will continue to decline under Tyler in the upper, middle, and lower layers of the Wilcox Group, while the model predicts water-levels will rebound in the vicinity of Henderson. The areas of major water-level declines are located in the confined part of the aquifer and may be the result of the aquifer responding to high pumpage rates by creating a higher gradient to adequately move water from areas of recharge.

Groundwater Quality Conclusions

In general, groundwater quality in the study area is good. Evaluated TWDB water quality data from the study area indicates there are a small number of wells, most of which are completed in the Carrizo-Wilcox aquifer, which have produced water with iron concentrations in excess of the 0.3 mg/L secondary drinking water standard since 1988. There are also a small number of wells producing water with elevated TDS levels with one of those wells exhibiting concentrations higher than 3,000 mg/L. Almost all of the wells which exhibit elevated concentrations of iron are located in Smith County; and, most of the wells with elevated concentrations of total dissolved solids are located in Rusk County. There are a number of reports of point source contamination, most of which are related leaking petroleum storage tanks. However, in general, groundwater quality is not a significant problem, but the potential for pollution, especially in shallow sands remains high.

Natural Resources Considerations and Recommendations

Stresses on study area ecosystems are due to population growth and location and types of activities carried on by the populace. The Census Bureau estimates that the population of the study area in 2001 was 338,636 and is expected to grow to 460,483 by 2030. Some of the activities carried out in the study area have caused a negative impact to local ecosystems include grazing, forestry, agriculture, industrialization, urbanization, and reservoir construction.

There are 40 springs and 3 seeps in the study area, 9 in Gregg County,19 in Rusk County, and 12 springs and 3 seeps in Smith County. Overpumping of water wells can cause springs to stop flowing destroying habitat essential to certain wildlife. One spring, in Smith County, has stopped flowing. The staff recommend care be taken in locating water wells so as not to interfere with spring flow.

There are at least 64 species of wetland-dependent animals located within the study area. There are also many species of waterfowl, migrating birds, wintering shorebirds, and neotropical songbirds which stop in the study area to feed and rest in the riparian habitat along water bodies. Two fish species located within the study area are threatened: the paddlefish; and, the creek chubsucker. The construction of reservoirs in and around the study area, with proposals to build more, have resulted in the loss of forested wetland habitat. TPWD staff conclude that careful consideration wil be necessary in the placement of any new reservoirs to protect against the loss of anymore forested wetland habitat.

Public Participation Evaluation

Nine comments were received by the TCEQ in response to questionnaires mailed on June 30, 1999. The respondents included the Gregg County and Rusk County Texas Agricultural Extension Offices, Lindale Rural WSC, Walnut Grove WSC, and the cities of Henderson, Kilgore, Lindale, and Troup. As required by statute, all relevant information submitted by the stakeholders has been evaluated and considered in the preparation of this report.

The respondents reported groundwater declines of as much as 100 to 150 feet have occurred since 1990 in Smith County. While others reported declines as small as two to six feet with some wells with water-level well rises of as much as four feet. Respondents reported more moderate declines (from 10 to 30 feet) in Gregg and Rusk Counties. Respondents noted groundwater quality problems appeared to be widespread across the study area with wells, some of which completed in the Carrizo-Wilcox aquifer, having high concentrations of iron and sulfur in Smith County, and high concentrations of iron, total dissolved solids, and corrosive water in Gregg County. In general, these water quality problems were not a deterrent to usage of the aquifers.

Most respondents did not consider the groundwater problems in the area to be critical. Only two of the respondents favored forming a groundwater conservation district in the study area, four were undecided, and two had not heard of such an entity. Not all of the respondents who thought the area faced critical water problems necessarily supported the formation of a groundwater conservation district in the area, and vice versa.

From May 4, 2004 to June 4, 2004, area stakeholders were afforded an opportunity to provide comment on a draft version of this report. No comments on the draft were received from area stakeholders during this time period.

Designation Recommendation

There are naturally occurring and man-induced, poor-quality groundwater zones in the study area. However, the poor-quality groundwater zones are localized and not region-wide. Continued municipal and industrial overdraft have caused water-level declines in the study area, mainly in the vicinity of the larger population centers. The groundwater availability model for the Carrizo-Wilcox in this region projects future water-level declines will mainly be in the vicinity of the City of Tyler. The water-level declines, however, are neither region-wide nor are the declines critical within the 25-year time frame. Regarding water supplies, the regional water plans suggest strategies to fulfill identified unmet needs. Strategies include constructing new wells, expanding existing or locating new sources of surface water supplies, and renewing water supply contracts with reservoirs. Data indicate that the study area has adequate water resources to meet water demands for the next 25-year period and that water supplies are of useable quality.

The East Texas Study Area is not projected to have a water supply shortage for the next 25 years and should not experience critical, region-wide water-level declines based on current available information and groundwater availability model projections. Gregg, Rusk, and Smith counties should not be designated as a PGMA at this time.

Groundwater Conservation District Considerations and Recommendations

While area water problems are not critical, problems exist and are a concern to water stakeholders. Weegar (1990), Preston, Moore (1991), and Culhane (1998) indicated much of the significant water declines have occurred due to high capacity, municipal water wells located too close together. The confined nature of the Carrizo-Wilcox aquifer in the Tyler area coupled with the distance to areas of recharge may lead to greater cones of depression for areas under significant pumping stress. In addition, many of the strategies identified by the Regional Water Planning Groups to meet future water needs involve increasing groundwater production.

Many of the groundwater problems identified in this report can be addressed locally, and the need for groundwater management has been identified by landowners in the east Texas region. Strategies to be utilized by water users and suppliers include; increased conservation; well field impact considerations prior to installations; and, heightened efforts to secure additional surface water supplies. Local management could also include a locally initiated creation of a GCD. Within the 29-county Groundwater Management Area 11 for the northern part of the Carrizo-Wilcox, Sparta, Queen City, Yegua-Jackson, and Gulf Coast aquifers, five GCDs have been created through local initiative and confirmed by the citizens. Two additional GCDs, in Upshur and Wood counties, were defeated by the voters.

Rusk County GCD was confirmed by the voters in June, 2004, and is now starting its efforts to become fully functional to manage groundwater resources. However, in Smith County and Gregg counties, there are no existing entities with the full statutory authority to manage groundwater. A groundwater conservation district can enact rules and groundwater management programs to protect groundwater quantity and quality. Such rules or programs could include the regulation of water well spacing, the regulation of groundwater production, the requirement of permits for drilling, equipping and completing wells, and for alterations to well size or well pumps.

These programs could include:

- quantifying aquifer impacts from pumpage and establishing an overall understanding of groundwater use through a comprehensive water well inventory, registration, and permitting program;
- encouraging conservation of fresh groundwater and the use of poorer-quality groundwater when feasible and practicable, and facilitate such transitions;
- evaluating and understanding aquifers sufficiently to establish spacing regulations; establishing educational programs, for school children and for the general public, to make them aware of actions which can be taken to conserve water resources;
- protecting water quality by requiring water well construction to be protective of fresh-water zones and by administering a program to locate and plug abandoned water wells; and,
- actively participating in the regional water planning process, groundwater availability model refinements, and regional groundwater management and protection programs with other east Texas groundwater conservation districts and entities.

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APPENDIX A

1990 CRITICAL AREA REPORT SUMMARY FOR TEXAS WATER COMMISSION

CRITICAL AREA GROUND WATER STUDY
EAST TEXAS AREA
(Subchapter C, Chapter 52, Texas Water Code)

TECHNICAL SUMMARY

The East Texas study area, comprised of all or portions of Angelina, Cherokee, Gregg, Nacogdoches, Rusk, and Smith counties was identified as a potential critical area and nominated for detailed study by the Commission and the Water Development Board in a joint press release dated January 13, 1987. A study of the area was requested by the Executive Director in a letter to the Executive Administrator of the Water Development Board dated September 1, 1989. A draft report of the study area conducted by the Water Development Board was received from the Executive Administrator in November 1989. A Critical Area Report has been prepared by Commission staff recommending that the East Texas study area not be designated as a Critical Area. Information supporting this recommendation is contained within the report.

This report describes hydrogeologic conditions in the East Texas study area. The report also contains a discussion of issues affecting ground water in the study area. The area was chosen as a potential critical area jointly by the Texas Water Commission and Texas Water Development Board in 1987. The Texas Water Development Board's report, Evaluation of the Ground-Water Resources of the Cities of Henderson, Jacksonville, Kilgore, Lufkin, Nacogdoches, Rusk, and Tyler in East Texas is currently in press, however, a draft report accompanies this study.

A public meeting was held in Tyler, Texas on September 11, 1986 to solicit comments regarding critical area designation for the study area. In 1989, a Critical Area Advisory Committee, consisting of nine members, was formed to assist TWC staff in assessing local ground water conditions and management issues, and to gain increased public participation at the local level. The Committee concurs with the conclusions and recommendations of the Critical Area Report.

The primary hydrologic problem facing the study area has been declining water-levels in the Carrizo-Wilcox aquifer. While these declines have generally occurred throughout the study area, the most significant declines have come in areas of concentrated municipal and industrial pumpage located in the vicinity of the cities of Lufkin, Nacogdoches, and Tyler. Historically, water-level declines in many wells in these areas have exceeded 300-400 feet, and in a few wells as much as 500 feet. Recent data indicate, however, that a number of areas of past decline are now experiencing a reduction in annual decline rates and in some cases a rise in water-levels. This is particularly true of the Lufkin-Nacogdoches area which has experienced a rise in water-levels. This reversal of water-level decline trends has been primarily attributed to reductions in ground water pumpage by municipal and industrial users through conservation and conjunctive use strategies. The Tyler/Smith County area continues to experience water-level declines at a rate that warrants concern and continued monitoring. The City of Tyler is keenly aware of decline problems and is in the planning stages of expanding conservation and conjunctive use strategies.

Historically, the water demands of the study area have been supplied from both surface and ground water sources. Available surface water supplies (more than 160,000 acre-feet annually) and ground water supplies from the Carrizo-Wilcox aquifer (105,000 acre-feet annually effective recharge) are estimated to exceed future maximum demand (135,425 acre-feet) through 2010. In addition, significant amounts of ground water exist in the Sparta and Queen City aquifers, however this water may not be economical for development other than for rural domestic and stock water purposes. Texas Water Development Board projections also suggest that additional ground water, exceeding the 105,000 acre-feet annual effective recharge rate of the Carrizo-Wilcox aquifer, can be safely developed from ground water in storage in the aquifer; provided that careful planning of well locations and design are considered in future development programs.

Recent data indicate that reductions in ground-water pumpage by municipal and industrial users through conservation and conjunctive use practices have resulted in a reversal of water-level decline trends throughout the majority of the study area. This is particularly true of the Lufkin-Nacogdoches area which has experienced water-level rises. Water-levels in the Tyler/Smith County area have continued to decline and are a source of concern. If present decline rates continue it is projected that a large number of Tyler's city wells will need to have some form of remedial work done in order to maintain present well-field pumpage capacity. The City of Tyler which currently obtains only about 13 percent of its total water from ground water, is well aware of the problems that continued water-level declines represent. The City is in the process of formulating more aggressive ground water conservation and conjunctive use strategies. Tyler's long-range goals are to utilize ground water only in periods peak demand and eventually to rely solely on surface water.

Total water demand in the study area is projected to increase by slightly more than 17 percent from 115,347 acre-feet annually in 1990 to 135,425 acre-feet annually by the year 2010. Nearly 95 percent of the water used in the study area was for industrial and municipal purposes. This trend in water use is expected to continue. Available surface water (more than 160,000 acre-feet/year) are adequate to meet projected water demands through the year 2010. Increases in future water demand should be primarily met from surface water sources. Additional ground water development from the Carrizo-Wilcox aquifer should be carefully planned to avoid overdraft of the aquifer.

It is recommended that the East Texas study area not be designated as a Critical Area. Available data and projections of water availability versus demand do not indicate that a critical ground water problem exists in the study area. It is recommended however, that water-level declines in the Tyler/Smith County area and the effects of voluntary ground water conservation and conjunctive use strategies on these declines be monitored for an additional five years. In 1995, at the end of the five-year monitoring period, the effectiveness of these strategies and the status of ground water management programs in Smith County should be reevaluated.

Prepared by: Mark A. Weegar, Geologist — March 29, 1990
Ground Water Conservation Section
Texas Water Commission

Approved by: Bill Klempt, Chief — March 29, 1990
Ground Water Conservation Section
Texas Water Commission

APPENDIX B

Historical Water Usage, East Texas PGMA Study Area

Gregg County

Year	Population	gw mun	sw mun	gw mfg	sw mfg	gw power	sw power	gw irrig	sw irrig	gw mining	sw mining	gw stock	sw stock
1974	84596	3258	7165	396	5971	0	3544	0	0	502	0	38	330
1977	91739	2638	9977	470	6822	1	2581	0	0	309	16	123	185
1980	99487	3465	11431	414	6367	1	2562	0	0	305	0	109	164
1984	111816	3002	16949	385	5301	1	1440	0	0	3984	24	102	154
1985	112251	3214	17088	416	2926	2	2498	0	66	129	79	82	124
1986	110600	3024	16136	377	3023	1	695	0	67	156	25	82	124
1987	109100	2732	15911	342	2942	1	505	0	67	66	90	75	113
1988	109100	2228	16108	675	5513	1	424	0	100	61	99	87	131
1989	104390	2117	17448	609	13925	1	255	0	0	29	95	93	140
1990	104948	2064	15602	289	14345	1	464	0	0	29	95	92	138
1991	106873	1874	16197	262	14439	1	444	0	0	11	92	94	141
1992	108116	2059	16076	283	14422	1	430	0	0	0	87	106	159
1993	108172	2151	12388	282	3229	1	841	20	0	0	126	99	148
1994	109502	2669	12630	319	3117	1	1439	25	0	0	126	86	129
1995	109664	2960	13506	252	3205	19	1102	25	0	0	129	86	129
1996	111509	3015	13481	321	3505	64	1659	25	0	0	129	86	129
1997	112399	2952	15489	323	3919	113	986	25	0	0	116	92	139
1998	113556	2685	16427	207	425	131	1142	25	0	0	42	83	124
1999	113685	3009	21253	131	409	128	1131	25	0	0	42	101	152
2000	111379	3198	22498	100	1818	140	1335	0	0	0	42	95	144

Rusk County

Year	Population	gw mun	sw mun	gw mfg	sw mfg	gw power	sw power	gw irrig	sw irrig	gw mining	sw mining	gw stock	sw stock
1974	36846	4682	0	478	46	0	0	0	1	593	0	226	1836
1977	39048	5820	0	384	0	3	16045	0	0	605	200	690	974
1980	41382	6216	33	113	16	0	14515	0	0	634	200	621	862
1984	43159	4958	418	168	15	125	27493	33	54	1690	6	566	849
1985	43168	5953	310	198	15	11	28101	38	62	2492	6	507	762
1986	42400	5563	233	207	15	20	24850	19	31	2584	6	477	716
1987	42400	5539	248	190	15	24	20803	19	31	2111	221	455	684
1988	42200	5940	357	183	224	16	30478	19	31	2020	672	473	709
1989	43494	5740	276	175	192	17	23539	32	57	1855	436	482	725
1990	43735	5861	458	152	153	17	28303	27	48	1855	436	507	762
1991	44539	5603	550	122	139	18	18510	27	48	1241	436	515	772
1992	44777	5663	594	103	5	24	19070	27	48	1232	436	495	742
1993	44685	5902	609	85	0	23	20835	149	330	1202	436	507	761
1994	44496	5805	462	82	0	18	18329	38	341	1173	436	467	701
1995	45340	6529	617	80	0	20	25557	151	336	1189	436	414	622
1996	45572	6671	431	94	0	179	24698	149	330	1189	436	353	529
1997	45568	6337	460	92	37	14	16898	149	330	1201	197	367	550
1998	46107	6631	571	74	0	18	18855	149	330	1201	197	426	640
1999	45913	6076	554	77	0	19	18865	149	330	1201	197	460	689
2000	47372	6455	551	69	0	18	18787	18	75	974	287	462	694

Smith County

Year	Population	gw mun	sw mun	gw mfg	sw mfg	gw power	sw power	gw irrig	sw irrig	gw mining	sw mining	gw stock	sw stock
1974	108567	5353	9554	2202	3789	0	0	50	217	894	4	186	1352
1977	118052	7575	11880	1311	4614	0	0	100	250	654	0	472	675
1980	128366	10481	12859	1630	3529	0	0	50	371	689	0	423	583
1984	146108	13096	13244	1901	2904	0	0	0	1959	505	8	511	767
1985	150105	13525	14330	1774	2607	0	0	0	1000	815	8	429	644
1986	152100	12715	13546	1615	2742	0	0	0	583	772	8	464	697
1987	152600	13148	14194	1501	2340	0	0	228	531	722	6	429	643
1988	152600	19695	14823	1856	1825	0	0	183	732	739	9	454	683
1989	148841	13331	14570	1364	2341	0	0	39	137	689	7	470	705
1990	151309	12046	15219	1008	2333	0	0	9	171	689	7	483	725
1991	155906	12456	12727	957	2386	0	0	9	171	680	170	491	737
1992	157766	13742	13671	1102	2062	0	0	9	171	680	170	442	664
1993	159652	14681	15408	974	2291	0	0	112	476	660	170	413	620
1994	159434	14555	15664	1073	2320	0	0	112	416	660	170	451	675
1995	161437	16340	17134	1132	2443	0	0	100	428	251	166	421	632
1996	164547	16083	16862	1181	2257	0	0	112	476	259	166	374	561
1997	165705	15713	16808	1037	2052	0	0	112	476	259	111	374	561
1998	167801	17033	20137	1095	1964	0	0	112	476	255	90	427	642
1999	168744	17533	21961	889	1633	0	0	112	476	255	90	471	705
2000	174706	17562	23080	1203	1877	0	0	208	566	255	90	447	671

APPENDIX C

Total Water Demand Projections, East Texas PGMA Study Area

GREGG

WUG NAME	CATEGORY	WUG BASIN	RWPG	YR2000	YR2010	YR2020	YR2030
LAKEPORT	MUN	SABINE	D	122	129	135	141
LONGVIEW	MUN	SABINE	D	15,498	15,913	16,484	17,193
LIBERTY CITY	MUN	SABINE	D	345	356	368	390
LIVESTOCK	STK	SABINE	D	230	230	230	230
MANUFACTURING	MFG	SABINE	D	16,538	18,576	20,934	23,507
KILGORE	MUN	SABINE	D	1,984	2,074	2,158	2,280
LIVESTOCK	STK	CYPRESS	D	35	35	35	35
STEAM ELECTRIC POWER	PWR	SABINE	D	1,251	1,251	1,251	1,251
GLADEWATER	MUN	SABINE	D	721	745	767	811
WHITE OAK	MUN	SABINE	D	848	870	890	928
COUNTY-OTHER	MUN	SABINE	D	1,839	2,044	2,139	2,466
CLARKSVILLE CITY	MUN	SABINE	D	124	131	138	144
COUNTY-OTHER	MUN	CYPRESS	D	201	225	236	275
MINING	MIN	SABINE	D	96	67	46	37
				39,832	**42,646**	**45,811**	**49,688**

RUSK

WUG NAME	CATEGORY	WUG BASIN	RWPG	YR2000	YR2010	YR2020	YR2030
IRRIGATION	IRR	SABINE	I	479	479	479	479
HENDERSON	MUN	SABINE	I	246	239	224	212
KILGORE	MUN	SABINE	I	686	695	686	689
HENDERSON	MUN	NECHES	I	2,215	2,145	2,009	1,903
MINING	MIN	SABINE	I	563	314	104	89
TATUM	MUN	SABINE	I	141	134	123	117
STEAM ELECTRIC POWER	PWR	SABINE	I	30,000	35,000	40,000	45,000
OVERTON	MUN	SABINE	I	407	396	368	352
OVERTON	MUN	NECHES	I	22	21	20	19
MANUFACTURING	MFG	NECHES	I	290	323	360	398
MOUNT ENTERPRISE	MUN	NECHES	I	53	49	44	42
MINING	MIN	NECHES	I	935	587	295	149
COUNTY-OTHER	MUN	NECHES	I	1,718	1,739	1,863	2,015
LIVESTOCK	STK	SABINE	I	549	556	565	573
MANUFACTURING	MFG	SABINE	I	54	59	65	71
COUNTY-OTHER	MUN	SABINE	I	1,644	1,664	1,783	1,928
LIVESTOCK	STK	NECHES	I	688	697	706	719
NEW LONDON	MUN	SABINE	I	233	230	221	227
				40,923	**45,327**	**49,915**	**54,982**

SMITH

WUG NAME	CATEGORY	WUG BASIN	RWPG	YR2000	YR2010	YR2020	YR2030
COUNTY-OTHER	MUN	NECHES	I	7,757	8,645	9,624	10,719
COUNTY-OTHER	MUN	SABINE	D	3,479	3,693	3,890	4,148
BULLARD	MUN	NECHES	I	70	72	80	81
ARP	MUN	NECHES	I	180	185	185	185
MINING	MIN	NECHES	I	265	270	276	281
WHITEHOUSE	MUN	NECHES	I	972	1,186	1,328	1,353
TYLER	MUN	SABINE	D	2	2	2	2
TYLER	MUN	NECHES	I	17,577	19,006	20,418	20,139
TROUP	MUN	NECHES	I	306	324	323	321
OVERTON	MUN	SABINE	D	16	18	19	20
LIVESTOCK	STK	NECHES	I	653	653	653	653
MINING	MIN	SABINE	D	425	178	91	32
IRRIGATION	IRR	NECHES	I	502	502	502	502
MANUFACTURING	MFG	SABINE	D	262	298	325	346
MANUFACTURING	MFG	NECHES	I	4,356	4,722	4,972	5,211
LIVESTOCK	STK	SABINE	D	453	453	453	453
LINDALE	MUN	SABINE	D	262	279	295	319
LINDALE	MUN	NECHES	I	261	267	266	271
IRRIGATION	IRR	SABINE	D	446	468	491	516
OVERTON	MUN	NECHES	I	12	12	12	13
				38,256	**41,233**	**44,205**	**45,565**

APPENDIX D
Total Water Supply Projections, East Texas PGMA Study Area

GREGG COUNTY

WUG NAME	RWPG	BASIN	SOURCE TYPE	SOURCE NAME	YR2000	YR2010	YR2020	YR2030
LAKEPORT	D	05	00	CHEROKEE LAKE/RESERVOIR	112	0	0	0
LAKEPORT	D	05	01	CARRIZO-WILCOX AQUIFER	22	22	22	22
LIBERTY CITY	D	05	01	CARRIZO-WILCOX AQUIFER	356	356	356	356
CLARKSVILLE CITY	D	05	00	GLADEWATER LAKE/RESERVOIR	322	0	0	0
KILGORE	D	05	00	SABINE RIVER COMBINED RUN-OF-RIVER	2,241	2,241	2,241	2,241
KILGORE	D	05	01	CARRIZO-WILCOX AQUIFER	490	490	490	490
GLADEWATER	D	05	00	GLADEWATER LAKE/RESERVOIR	499	796	796	796
LONGVIEW	D	05	00	BIG SANDY CREEK RUN-OF-RIVER	0	840	840	840
LONGVIEW	D	05	00	O' THE PINES LAKE/RESERVOIR	15,000	15,000	15,000	15,000
LONGVIEW	D	05	00	FORK LAKE/RESERVOIR	15,000	0	0	0
LONGVIEW	D	05	00	FORK LAKE/RESERVOIR	14,502	14,502	14,502	14,504
LONGVIEW	D	05	00	CHEROKEE LAKE/RESERVOIR	5,600	5,600	5,600	5,600
WHITE OAK	D	05	00	BIG SANDY LAKE/RESERVOIR	1,035	0	0	0
COUNTY-OTHER	D	04	01	CARRIZO-WILCOX AQUIFER	40	40	40	40
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	80	80	80	80
COUNTY-OTHER	D	05	00	CHEROKEE LAKE/RESERVOIR	18	18	18	18
COUNTY-OTHER	D	05	00	GLADEWATER LAKE/RESERVOIR	21	33	33	33
COUNTY-OTHER	D	04	01	CARRIZO-WILCOX AQUIFER	74	74	74	74
COUNTY-OTHER	D	05	00	GLADEWATER LAKE/RESERVOIR	12	0	0	0
COUNTY-OTHER	D	04	01	CARRIZO-WILCOX AQUIFER	19	19	19	19
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	106	106	106	106
COUNTY-OTHER	D	04	00	CHEROKEE LAKE/RESERVOIR	516	0	0	0
COUNTY-OTHER	D	05	00	BIG SANDY CREEK RUN-OF-RIVER	12	0	0	0
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	59	59	59	59
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	43	43	43	43
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	18	18	18	18
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	16	16	16	16
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	65	65	65	65
COUNTY-OTHER	D	05	00	SABINE RIVER COMBINED RUN-OF-RIVER	110	110	110	110
COUNTY-OTHER	D	05	00	CHEROKEE LAKE/RESERVOIR	404	0	0	0
COUNTY-OTHER	D	05	00	GLADEWATER LAKE/RESERVOIR	215	0	0	0
COUNTY-OTHER	D	05	00	CHEROKEE LAKE/RESERVOIR	412	0	0	0
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	244	244	244	244
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	75	75	75	75
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	76	76	76	76
COUNTY-OTHER	D	05	00	GLADEWATER LAKE/RESERVOIR	18	18	18	18
COUNTY-OTHER	D	05	00	SABINE RIVER COMBINED RUN-OF-RIVER	77	77	77	77
MANUFACTURING	D	05	01	CARRIZO-WILCOX AQUIFER	200	200	200	200
MANUFACTURING	D	05	00	OTHER LOCAL SUPPLY	2,500	2,500	2,500	2,500

GREGG COUNTY (cont.)

WUG NAME	RWPG	BASIN	SOURCE TYPE	SOURCE NAME	YR2000	YR2010	YR2020	YR2030
MANUFACTURING	D	05	00	DIRECT REUSE	100	3,395	3,842	3,842
MANUFACTURING	D	05	00	CHEROKEE LAKE/RESERVOIR	3,021	3,393	3,824	4,294
MINING	D	05	01	CARRIZO-WILCOX AQUIFER	96	67	46	37
STEAM ELECTRIC POWER	D	05	00	CHEROKEE LAKE/RESERVOIR	1,873	2,330	2,280	2,220
STEAM ELECTRIC POWER	D	05	01	CARRIZO-WILCOX AQUIFER	186	186	186	186
STEAM ELECTRIC POWER	D	05	00	DIRECT REUSE	627	670	720	780
STEAM ELECTRIC POWER	D	05	00	CHEROKEE LAKE/RESERVOIR	2,000	2,000	2,000	2,000
LIVESTOCK	D	04	01	CARRIZO-WILCOX AQUIFER	35	35	35	35
LIVESTOCK	D	05	01	CARRIZO-WILCOX AQUIFER	230	230	230	230
					68,777	**56,024**	**56,881**	**57,344**

Basin: 04 = Cypress; 05 = Sabine; 06 = Neches Source: TWDB, 2003
Source Type: 00 = Surface Water; 01 = Groundwater

RUSK COUNTY

WUG NAME	RWPG	BASIN	SOURCE TYPE	SOURCE NAME	YR2000	YR2010	YR2020	YR2030
OVERTON	I	06	01	CARRIZO-WILCOX AQUIFER	34	34	34	34
OVERTON	I	05	01	CARRIZO-WILCOX AQUIFER	649	649	649	649
NEW LONDON	I	05	01	CARRIZO-WILCOX AQUIFER	242	242	242	242
MOUNT ENTERPRISE	I	06	01	CARRIZO-WILCOX AQUIFER	59	59	59	59
KILGORE	I	05	01	CARRIZO-WILCOX AQUIFER	2,098	2,098	2,098	2,098
HENDERSON	I	06	01	CARRIZO-WILCOX AQUIFER	2,054	2,021	1,984	1,946
HENDERSON	I	05	01	CARRIZO-WILCOX AQUIFER	195	190	184	178
TATUM	I	05	01	CARRIZO-WILCOX AQUIFER	128	128	128	128
COUNTY-OTHER	I	06	01	QUEEN CITY AQUIFER	12	12	12	12
COUNTY-OTHER	I	05	01	QUEEN CITY AQUIFER	13	13	13	13
COUNTY-OTHER	I	06	01	CARRIZO-WILCOX AQUIFER	1,507	1,507	1,507	1,507
COUNTY-OTHER	I	05	01	CARRIZO-WILCOX AQUIFER	1,687	1,687	1,687	1,687
MANUFACTURING	I	05	00	OTHER LOCAL SUPPLY	7	7	7	7
MANUFACTURING	I	05	01	CARRIZO-WILCOX AQUIFER	41	41	41	41
MANUFACTURING	I	06	00	OTHER LOCAL SUPPLY	146	146	146	146
MANUFACTURING	I	06	01	CARRIZO-WILCOX AQUIFER	144	177	214	252
MINING	I	05	01	CARRIZO-WILCOX AQUIFER	378	378	378	378
MINING	I	05	01	QUEEN CITY AQUIFER	92	92	92	92
MINING	I	06	01	CARRIZO-WILCOX AQUIFER	1,324	1,324	1,324	1,324
MINING	I	06	01	QUEEN CITY AQUIFER	61	61	61	61
MINING	I	05	00	OTHER LOCAL SUPPLY	433	433	433	433
IRRIGATION	I	05	00	IRRIGATION LOCAL SUPPLY	341	341	341	341
IRRIGATION	I	05	01	CARRIZO-WILCOX AQUIFER	76	76	76	76
STEAM ELECTRIC POWER	I	05	00	MARTIN LAKE/RESERVOIR	25,000	25,000	25,000	25,000
STEAM ELECTRIC POWER	I	05	01	CARRIZO-WILCOX AQUIFER	40	40	40	40

RUSK COUNTY (cont.)

WUG NAME	RWPG	BASIN	SOURCE TYPE	SOURCE NAME	YR2000	YR2010	YR2020	YR2030
LIVESTOCK	I	05	00	LIVESTOCK LOCAL SUPPLY	338	338	338	338
LIVESTOCK	I	06	01	CARRIZO-WILCOX AQUIFER	275	275	275	275
LIVESTOCK	I	06	01	QUEEN CITY AQUIFER	11	11	11	11
LIVESTOCK	I	05	01	CARRIZO-WILCOX AQUIFER	212	212	212	212
LIVESTOCK	I	05	01	QUEEN CITY AQUIFER	17	17	17	17
LIVESTOCK	I	06	00	LIVESTOCK LOCAL SUPPLY	423	423	423	423
					38,037	**38,032**	**38,026**	**38,020**

Basin: 04 = Cypress; 05 = Sabine; 06 = Neches — Source: TWDB, 2003
Source Type: 00 = Surface Water; 01 = Groundwater

SMITH COUNTY

WUG NAME	RWPG	BASIN	SOURCE TYPE	SOURCE NAME	YR2000	YR2010	YR2020	YR2030
WHITEHOUSE	I	06	00	TYLER LAKE/RESERVOIR	880	880	880	880
WHITEHOUSE	I	06	01	CARRIZO-WILCOX AQUIFER	70	70	70	70
OVERTON	I	06	01	CARRIZO-WILCOX AQUIFER	20	20	20	20
OVERTON	D	05	01	CARRIZO-WILCOX AQUIFER	16	18	19	20
BULLARD	I	06	01	CARRIZO-WILCOX AQUIFER	209	209	209	209
TROUP	I	06	01	CARRIZO-WILCOX AQUIFER	374	374	374	374
TYLER	D	05	00	TYLER LAKE/RESERVOIR	2	2	2	2
TYLER	I	06	01	CARRIZO-WILCOX AQUIFER	5,810	5,810	5,810	5,810
TYLER	I	06	00	TYLER LAKE/RESERVOIR	18,475	18,109	17,859	17,620
TYLER	I	06	00	PALESTINE LAKE/RESERVOIR	0	0	0	0
ARP	I	06	01	CARRIZO-WILCOX AQUIFER	199	199	199	199
LINDALE	D	05	01	CARRIZO-WILCOX AQUIFER	1,253	1,207	1,166	1,123
LINDALE	I	06	01	CARRIZO-WILCOX AQUIFER	264	264	264	264
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	2	2	2	2
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	0	56	105	156
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	0	0	0	0
COUNTY-OTHER	D	05	00	TYLER LAKE/RESERVOIR	21	28	34	43
COUNTY-OTHER	D	05	00	GLADEWATER LAKE/RESERVOIR	28	28	28	28
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	575	575	575	575
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	5	5	5	5
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	195	195	195	195
COUNTY-OTHER	I	06	01	CARRIZO-WILCOX AQUIFER	8,710	8,710	8,710	8,710
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	183	183	183	183
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	35	81	122	165
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	59	59	59	59
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	62	62	62	62
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	90	90	90	90
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	108	108	108	108
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	115	115	115	115
COUNTY-OTHER	I	06	01	QUEEN CITY AQUIFER	13	13	13	13

SMITH COUNTY (Cont.)

WUG NAME	RWPG	BASIN	SOURCE TYPE	SOURCE NAME	YR2000	YR2010	YR2020	YR2030
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	161	161	161	161
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	12	12	12	12
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	258	258	258	258
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	729	729	729	729
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	887	887	887	887
COUNTY-OTHER	D	05	01	CARRIZO-WILCOX AQUIFER	118	118	118	118
MANUFACTURIN G	I	06	01	CARRIZO-WILCOX AQUIFER	356	356	356	356
MANUFACTURIN G	I	06	01	OTHER AQUIFER	45	45	45	45
MANUFACTURIN G	I	06	00	TYLER LAKE/RESERVOIR	2,065	2,431	2,681	2,920
MANUFACTURIN G	I	06	00	NECHES RIVER RUN-OF-RIVER	1,500	1,500	1,500	1,500
MANUFACTURIN G	D	05	01	CARRIZO-WILCOX AQUIFER	262	298	325	346
MANUFACTURIN G	I	06	01	CARRIZO-WILCOX AQUIFER	390	390	390	390
MINING	I	06	01	CARRIZO-WILCOX AQUIFER	124	124	124	124
MINING	I	06	01	QUEEN CITY AQUIFER	12	12	12	12
MINING	D	05	01	CARRIZO-WILCOX AQUIFER	176	176	91	32
MINING	I	06	00	OTHER LOCAL SUPPLY	167	167	167	167
MINING	D	05	01	QUEEN CITY AQUIFER	249	2	0	0
IRRIGATION	D	05	00	IRRIGATION LOCAL SUPPLY	446	468	491	516
IRRIGATION	I	06	00	IRRIGATION LOCAL SUPPLY	409	409	409	409
IRRIGATION	I	06	01	CARRIZO-WILCOX AQUIFER	71	71	71	71
IRRIGATION	I	06	01	QUEEN CITY AQUIFER	22	22	22	22
LIVESTOCK	I	06	01	QUEEN CITY AQUIFER	262	262	262	262
LIVESTOCK	D	05	01	QUEEN CITY AQUIFER	242	242	242	242
LIVESTOCK	D	05	01	CARRIZO-WILCOX AQUIFER	211	211	211	211
LIVESTOCK	I	06	01	CARRIZO-WILCOX AQUIFER	28	28	28	28
LIVESTOCK	I	06	00	LIVESTOCK LOCAL SUPPLY	435	435	435	435
					47,410	**47,286**	**47,305**	**47,353**

Basin: 04 = Cypress; 05 = Sabine; 06 = Neches
Source Type: 00 = Surface Water; 01 = Groundwater

Source: TWDB, 2003

APPENDIX E
Total Water Availability Projections, East Texas PGMA Study Area

GREGG

NAME OF SOURCE	SOURCE TYPE	RWPG	YR2000	YR2010	YR2020	YR2030
CARRIZO-WILCOX AQUIFER	01	D	1,333	1,333	1,333	1,333
QUEEN CITY AQUIFER	01	D	9,646	9,646	9,646	9,646
QUEEN CITY AQUIFER	01	D	4,690	4,690	4,690	4,690
CARRIZO-WILCOX AQUIFER	01	D	20,267	20,267	20,267	20,267
OTHER LOCAL SUPPLY	00	D	2,500	2,500	2,500	2,500
DIRECT REUSE	02	D	727	4,065	4,562	4,622
			39,163	**42,501**	**42,998**	**43,058**

RUSK

NAME OF SOURCE	SOURCE TYPE	RWPG	YR2000	YR2010	YR2020	YR2030
QUEEN CITY AQUIFER	01	I	1,890	1,890	1,890	1,890
LIVESTOCK LOCAL SUPPLY	00	I	423	423	423	423
LIVESTOCK LOCAL SUPPLY	00	I	338	338	338	338
QUEEN CITY AQUIFER	01	I	2,756	2,756	2,756	2,756
CARRIZO-WILCOX AQUIFER	01	I	5,752	5,752	5,752	5,752
IRRIGATION LOCAL SUPPLY	00	I	341	341	341	341
OTHER LOCAL SUPPLY	00	I	146	146	146	146
OTHER LOCAL SUPPLY	00	I	487	492	498	504
CARRIZO-WILCOX AQUIFER	01	I	5,755	5,788	5,825	5,863
			17,888	**17,926**	**17,969**	**18,013**

SMITH

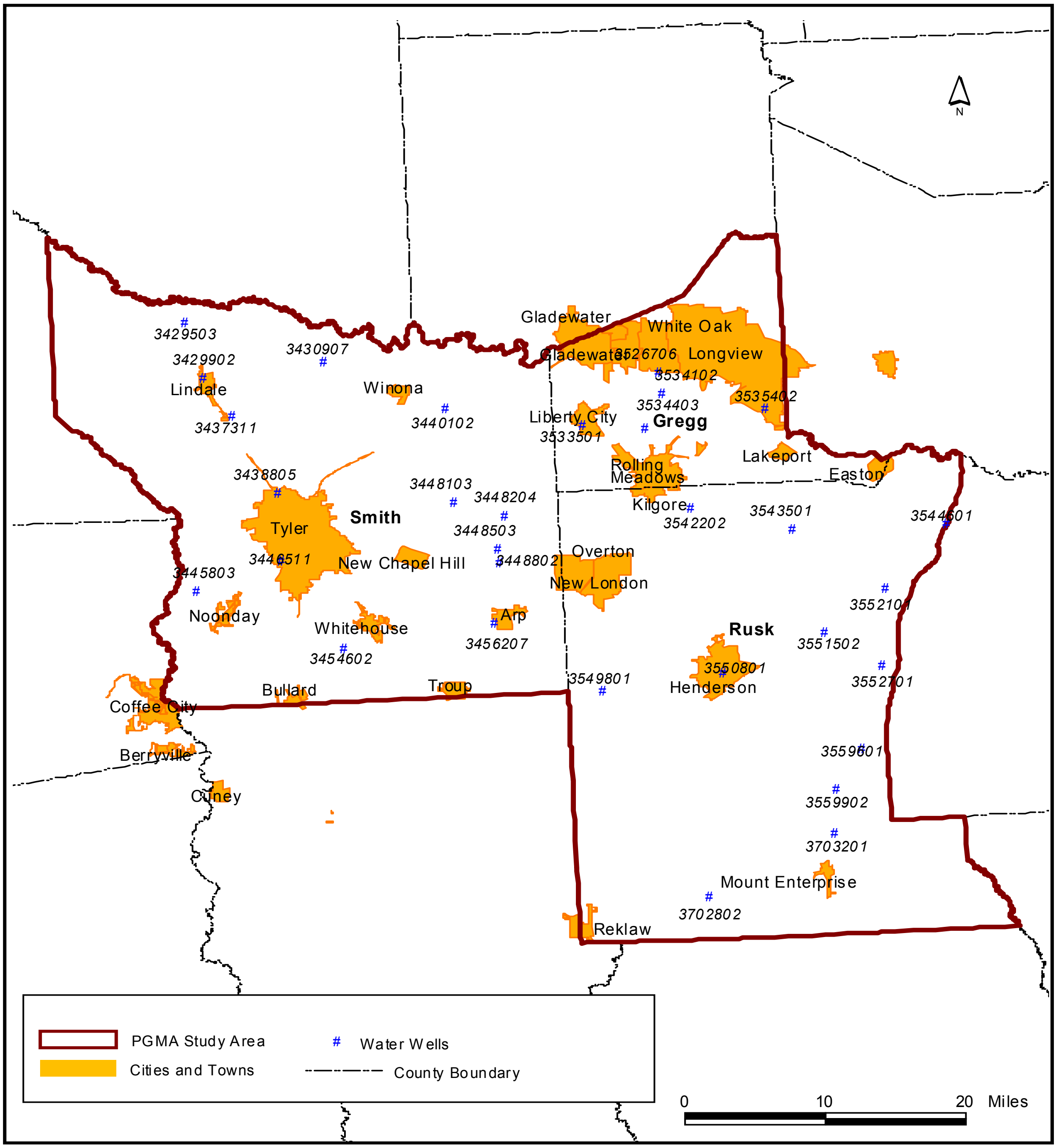
NAME OF SOURCE	SOURCE TYPE	RWPG	YR2000	YR2010	YR2020	YR2030
CARRIZO-WILCOX AQUIFER	01	D	8,194	8,194	8,194	8,194
CARRIZO-WILCOX AQUIFER	01	I	27,006	27,006	27,006	27,006
IRRIGATION LOCAL SUPPLY	00	D	446	468	491	516
IRRIGATION LOCAL SUPPLY	00	I	409	409	409	409
NECHES RIVER RUN-OF-RIVER	00	I	2,100	2,100	2,100	2,100
OTHER AQUIFER	01	I	45	45	45	45
OTHER LOCAL SUPPLY	00	I	167	167	167	167
QUEEN CITY AQUIFER	01	D	46,852	46,852	46,852	46,852
QUEEN CITY AQUIFER	01	I	39,979	39,979	39,979	39,979
LIVESTOCK LOCAL SUPPLY	00	I	435	435	435	435
			125,633	**125,655**	**125,678**	**125,703**

Source Type: 00 = Surface Water;
01 = Groundwater

Source: TWDB, 2003

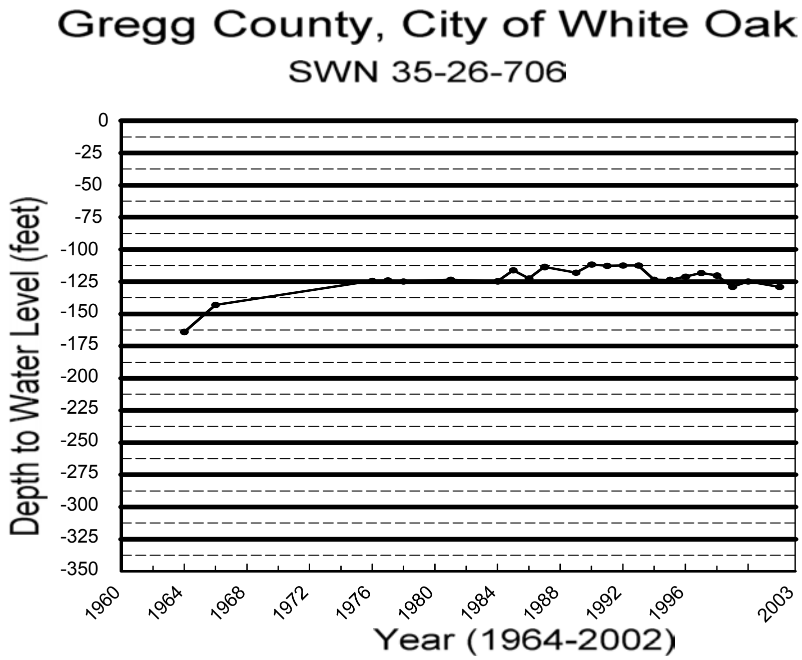
APPENDIX F

Selected Hydrographs

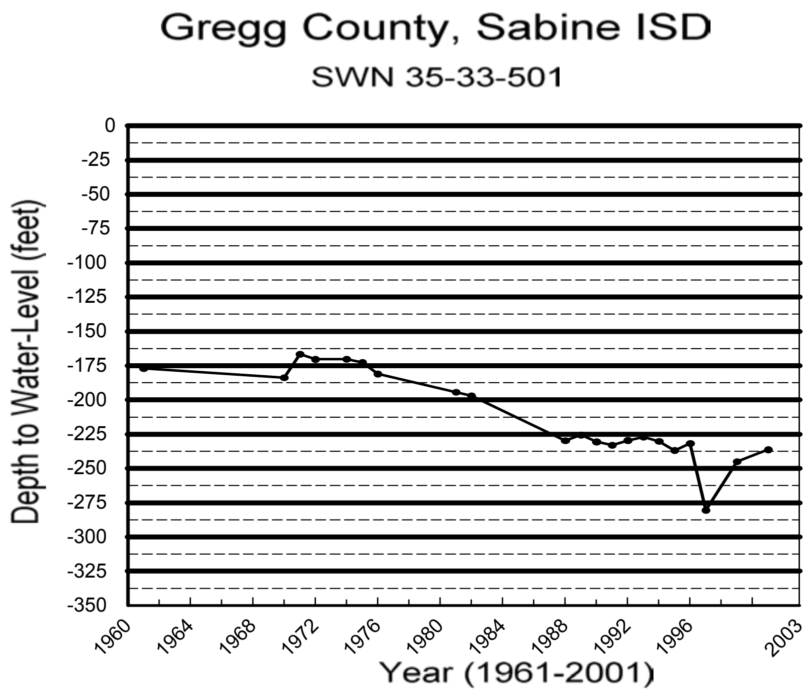


Location of Water Wells (The Wells are Identified by State Well Number).

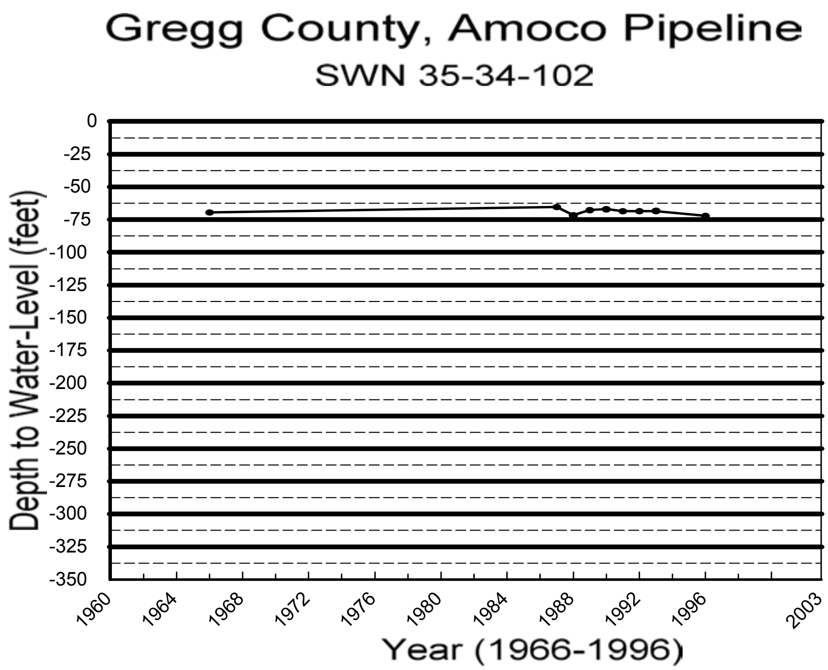
3526706 Year	Carrizo-Wilcox Water-Level
1964	-164
1965	
1966	-143.01
1967	
1968	
1969	
1970	
1971	
1972	
1973	
1974	
1975	
1976	-124.21
1977	-124
1978	-124.74
1979	
1980	
1981	-123.46
1982	
1983	
1984	-124.66
1985	-116.08
1986	-122.35
1987	-113.54
1988	
1989	-117.98
1990	-111.56
1991	-112.72
1992	-112.38
1993	-112.38
1994	-123.5
1995	-123.6
1996	-121.09
1997	-118.17
1998	-120.15
1999	-128.9
2000	-124.8
2001	
2002	-128.92
2003	



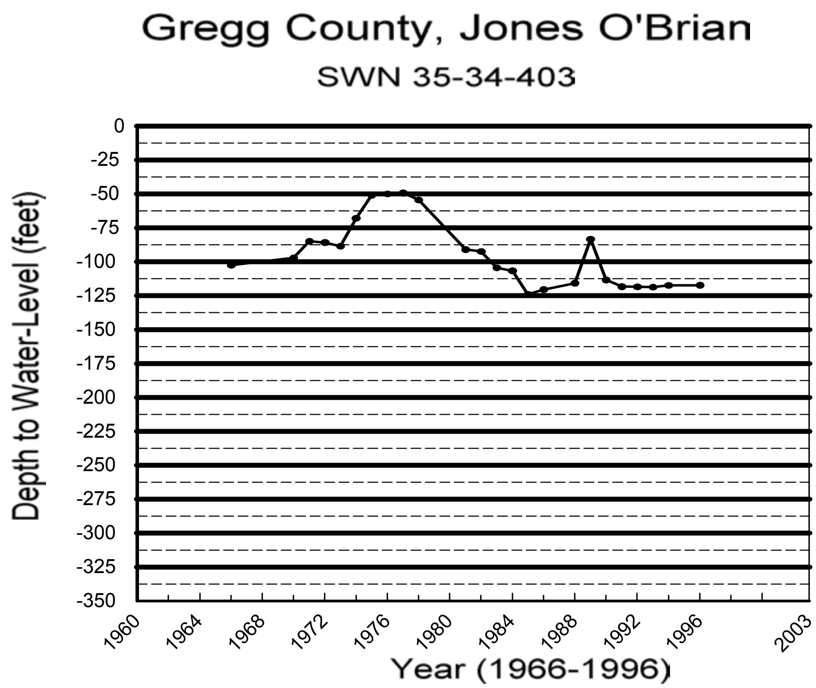
3533501	Wilcox
Year	Water-Level
1961	-177
1970	-183.9
1971	-166.75
1972	-170.44
1973	
1974	-170.33
1975	-172.69
1976	-181.1
1977	
1978	
1979	
1980	
1981	-194.53
1982	-197.11
1983	
1984	
1985	
1986	
1987	
1988	-229.76
1989	-225.68
1990	-230.6
1991	-233.1
1992	-229.6
1993	-227.1
1994	-230.28
1995	-236.85
1996	-231.74
1997	-280.48
1998	
1999	-245.05
2000	
2001	-236.3
2002	
2003	



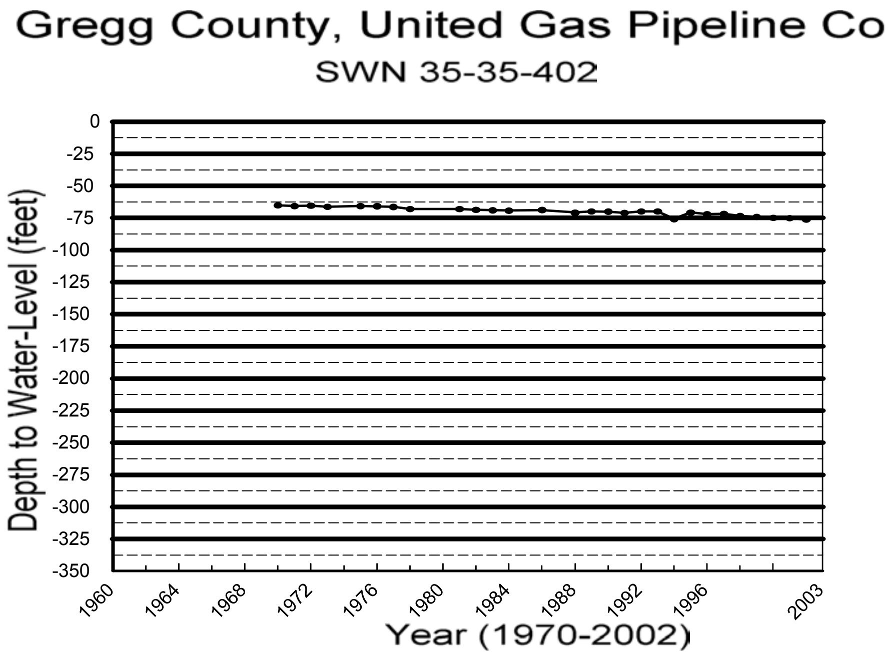
3534102	Carrizo-Wilcox
Year	Water-Level
1966	-69.5
1967	
1968	
1969	
1970	
1971	
1972	
1973	
1974	
1975	
1976	
1977	
1978	
1979	
1980	
1981	
1982	
1983	
1984	
1985	
1986	
1987	-65.27
1988	-71.7
1989	-67.69
1990	-67.04
1991	-68.4
1992	-68.4
1993	-68.37
1994	
1995	
1996	-72.24
1997	
1998	
1999	
2000	
2001	
2002	
2003	



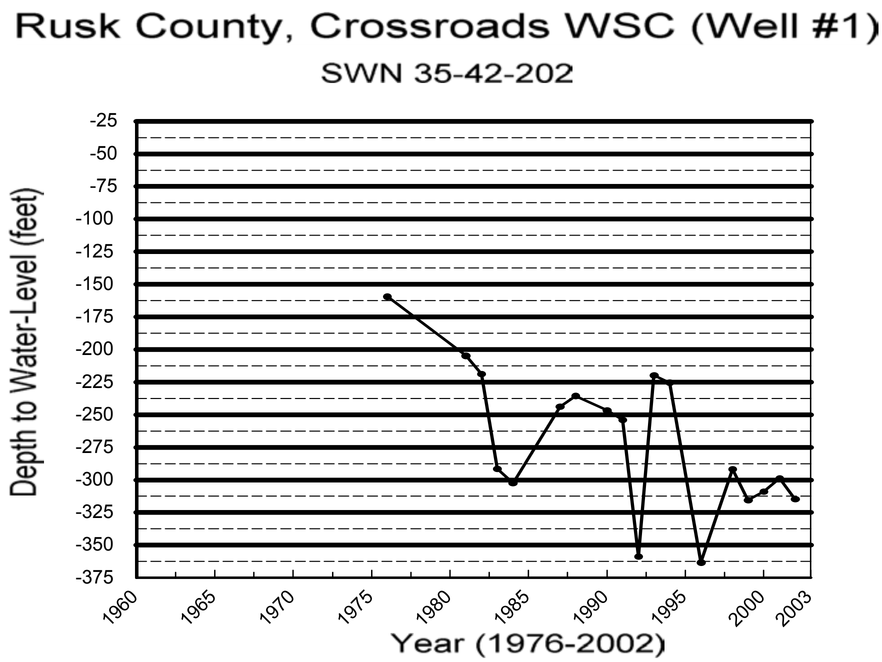
3534403	Carrizo-Wilcox
Year	Water-Level
1941	-114.5
1966	-102.8
1970	-97.3
1971	-85
1972	-85.95
1973	-88.73
1974	-68.04
1975	-51.02
1976	-50.02
1977	-49.44
1978	-54.5
1979	
1980	
1981	-91.09
1982	-92.6
1983	-104.56
1984	-106.78
1985	-123.99
1986	-120.56
1987	
1988	-115.89
1989	-83.44
1990	-113.5
1991	-118.47
1992	-118.67
1993	-118.95
1994	-117.6
1995	
1996	-117.43
1997	
1998	
1999	
2000	
2001	
2002	
2003	



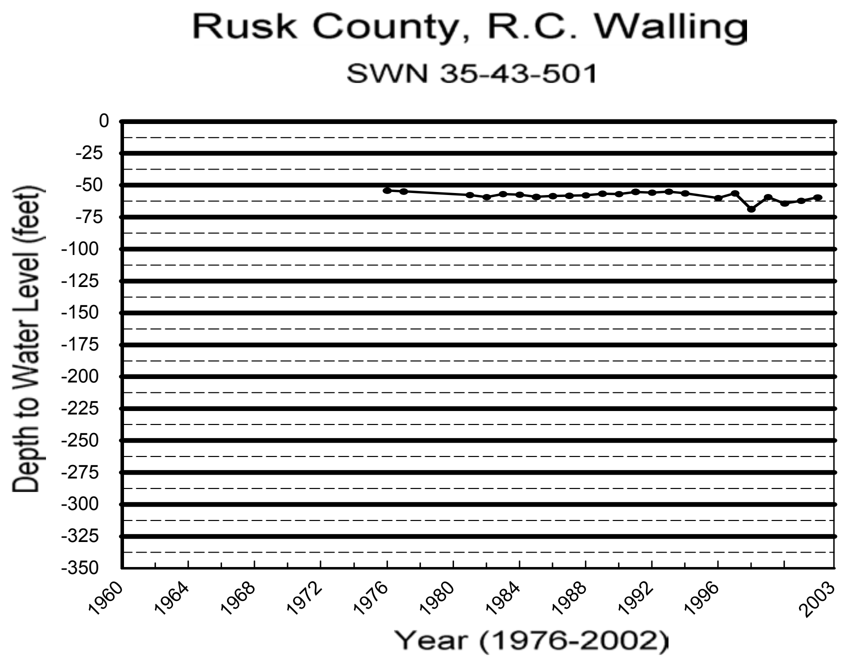
3535402	Carrizo-Wilcox
Year	Water-Level
1955	-84
1970	-65.2
1971	-65.7
1972	-65.44
1973	-66.19
1974	
1975	-65.7
1976	-65.87
1977	-66.35
1978	-68.04
1979	
1980	
1981	-68.12
1982	-68.62
1983	-68.99
1984	-69.24
1985	
1986	-68.73
1987	
1988	-70.8
1989	-69.87
1990	-70.06
1991	-70.95
1992	-69.9
1993	-70
1994	-75.78
1995	-70.75
1996	-71.97
1997	-71.7
1998	-73.3
1999	-74.2
2000	-74.88
2001	-75.1
2002	-76.08
2003	



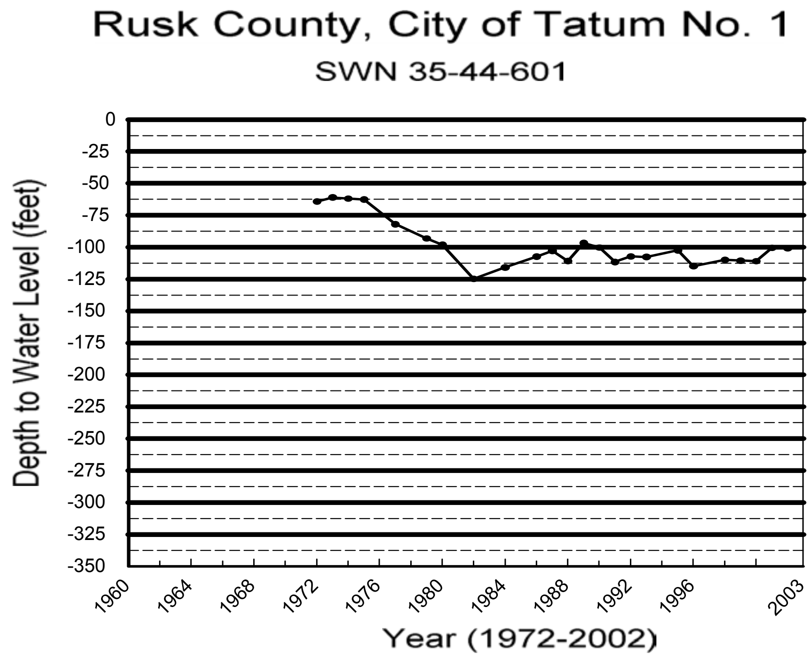
3542202	Wilcox
Year	Water-Level
1976	-159.48
1977	
1978	
1979	
1980	
1981	-204.8
1982	-218.86
1983	-291.44
1984	-302.44
1985	
1986	
1987	-243.82
1988	-235.64
1989	
1990	-246.7
1991	-254
1992	-358.85
1993	-219.9
1994	-225.45
1995	
1996	-363.33
1997	
1998	-291.79
1999	-315.5
2000	-308.95
2001	-298.85
2002	-314.8
2003	



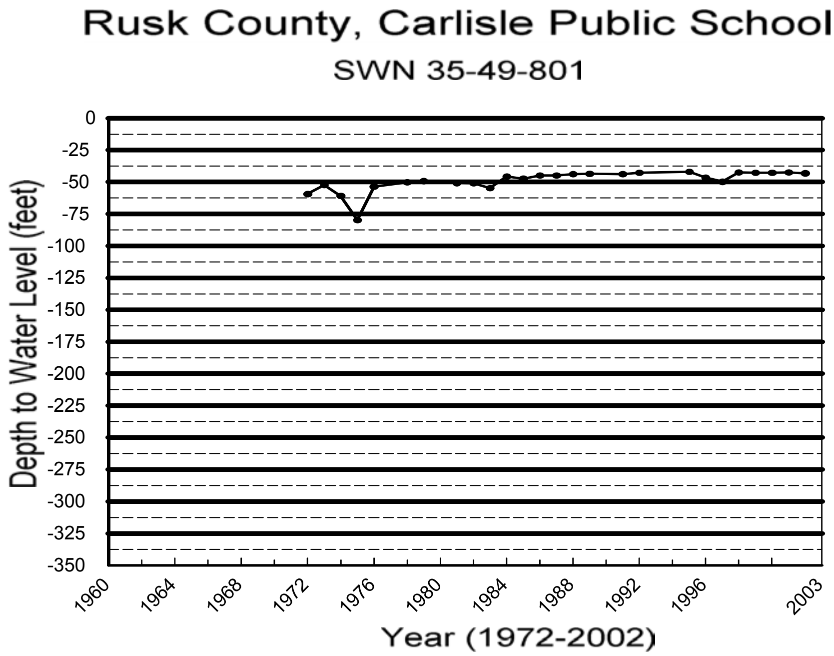
3543501	Wilcox
Year	Water-Level
1976	-54.2
1977	-54.83
1978	
1979	
1980	
1981	-57.56
1982	-59.2
1983	-56.76
1984	-57.44
1985	-59.08
1986	-58.41
1987	-58.2
1988	-57.9
1989	-56.5
1990	-56.84
1991	-55.11
1992	-55.7
1993	-54.95
1994	-56.3
1995	
1996	-60.05
1997	-56.23
1998	-68.72
1999	-59.25
2000	-64.31
2001	-62.2
2002	-59.54
2003	



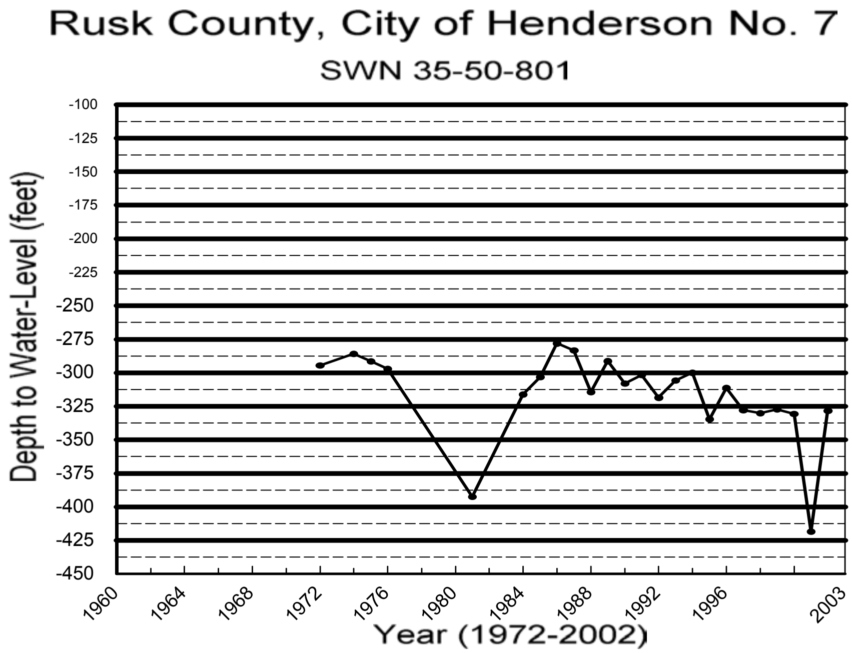
3544601	Wilcox
Year	Water-Level
1972	-64.18
1973	-61
1974	-61.86
1975	-62.58
1976	
1977	-81.98
1978	
1979	-93
1980	-98
1981	
1982	-124.81
1983	
1984	-115.8
1985	
1986	-107.35
1987	-102.8
1988	-110.8
1989	-96.67
1990	-100.22
1991	-111.55
1992	-107.1
1993	-107.6
1994	
1995	-102.5
1996	-114.78
1997	
1998	-109.85
1999	-110.5
2000	-110.82
2001	-100.6
2002	-100.82
2003	



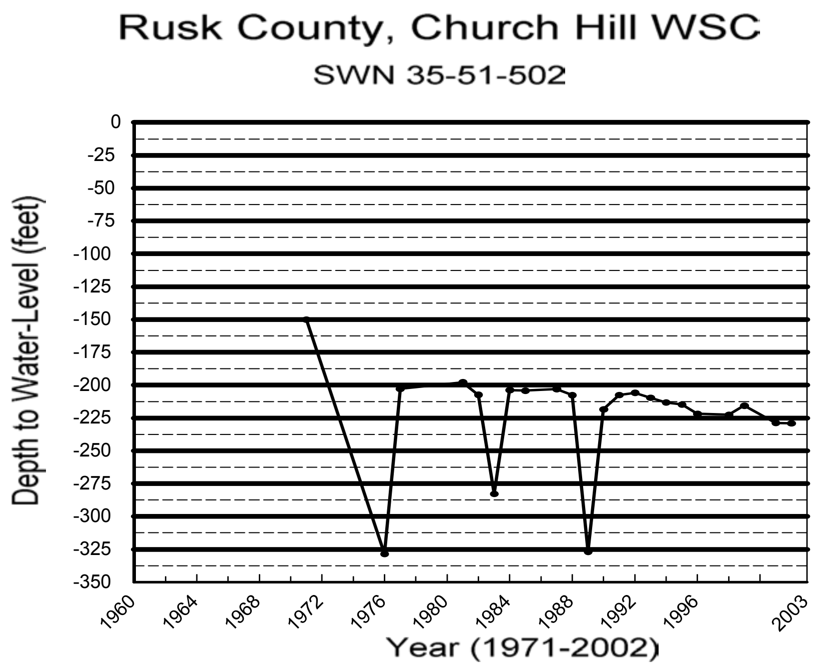
3549801	Carrizo-Wilcox
Year	Water-Level
1972	-59.34
1973	-52.26
1974	-60.87
1975	-79.8
1976	-53.51
1977	
1978	-50.27
1979	-49.2
1980	
1981	-50.8
1982	-51.04
1983	-54.74
1984	-45.61
1985	-47.42
1986	-44.83
1987	-44.9
1988	-43.75
1989	-43.55
1990	
1991	-43.7
1992	-42.7
1993	
1994	
1995	-41.92
1996	-46.58
1997	-49.75
1998	-42.45
1999	-42.8
2000	-42.65
2001	-42.5
2002	-43.12
2003	



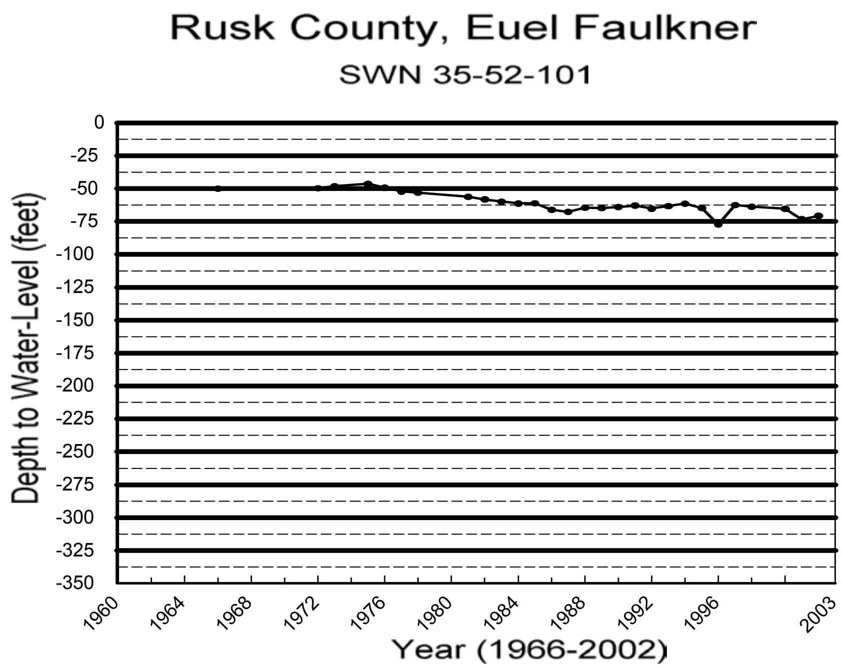
3550801	Wilcox
Year	Water-Level
1972	-294.4
1973	
1974	-285.85
1975	-291.37
1976	-296.95
1977	
1978	
1979	
1980	
1981	-392.48
1982	
1983	
1984	-316.1
1985	-303.05
1986	-278.01
1987	-283.24
1988	-314.35
1989	-291.24
1990	-308
1991	-301.61
1992	-318.48
1993	-305.66
1994	-299.9
1995	-334.54
1996	-311.18
1997	-327.73
1998	-330
1999	-327.2
2000	-330.6
2001	-418.3
2002	-328.23
2003	



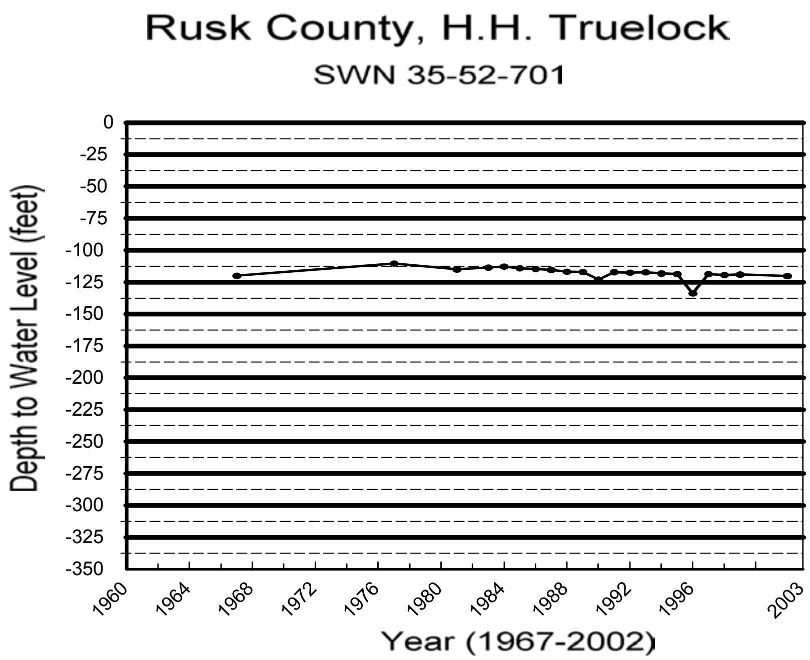
3551502	Wilcox
Year	Water-Level
1971	-150
1972	
1973	
1974	
1975	
1976	-328.53
1977	-202.7
1978	
1979	
1980	
1981	-197.71
1982	-207.33
1983	-282.73
1984	-203.67
1985	-204.17
1986	
1987	-202.9
1988	-207.54
1989	-326.75
1990	-218.25
1991	-207.4
1992	-205.77
1993	-209.45
1994	-213.22
1995	-214.66
1996	-221.82
1997	
1998	-222.49
1999	-215.6
2000	
2001	-228.75
2002	-228.95
2003	



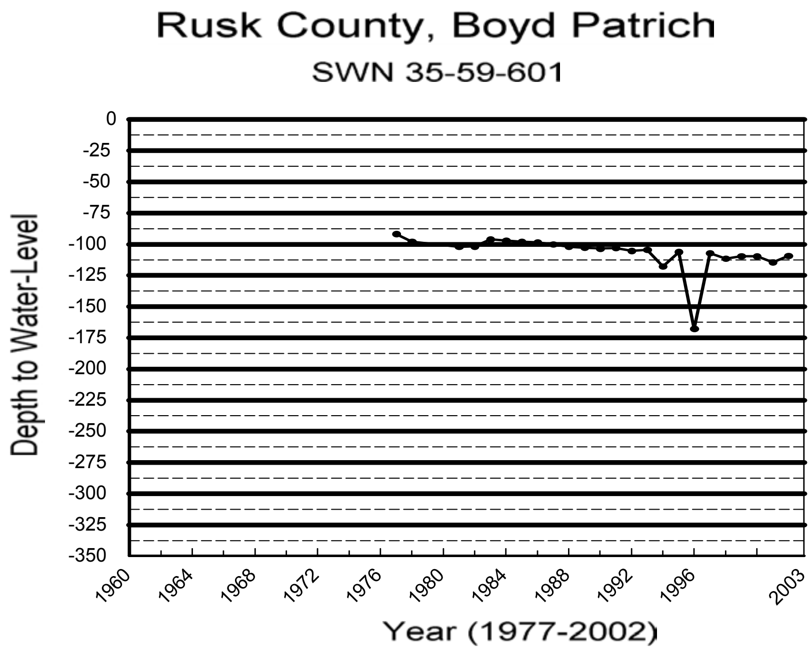
3552101	Wilcox
Year	Water-Level
1966	-50
1967	
1968	
1969	
1970	
1971	
1972	-49.7
1973	-48.27
1974	
1975	-46.47
1976	-49.33
1977	-52.2
1978	-53.15
1979	
1980	
1981	-56.15
1982	-58.2
1983	-59.89
1984	-61.27
1985	-61.13
1986	-66.08
1987	-67.6
1988	-64.64
1989	-64.81
1990	-64.05
1991	-62.9
1992	-65.2
1993	-63.3
1994	-61.38
1995	-64.75
1996	-77.2
1997	-62.55
1998	-63.71
1999	
2000	-65.3
2001	-73.3
2002	-70.7
2003	



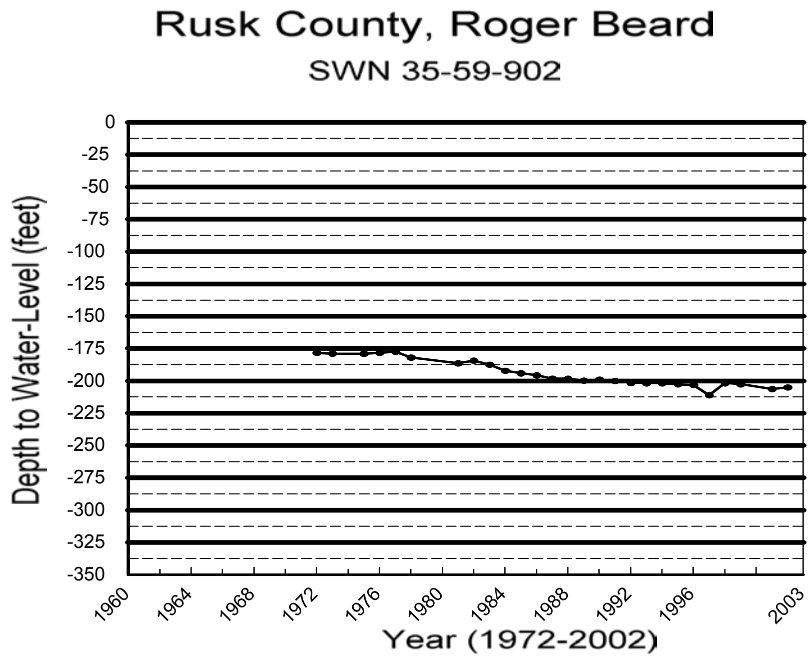
3552701	Wilcox
Year	Water-Level
1967	-120
1968	
1969	
1970	
1971	
1972	
1973	
1974	
1975	
1976	
1977	-110.45
1978	
1979	
1980	
1981	-115.03
1982	
1983	-113.59
1984	-112.72
1985	-114.05
1986	-114.68
1987	-115.48
1988	-116.83
1989	-116.98
1990	-122.92
1991	-117.2
1992	-117.5
1993	-117.35
1994	-118.22
1995	-118.66
1996	-133.75
1997	-118.65
1998	-119.42
1999	-119.02
2000	
2001	
2002	-120.22
2003	



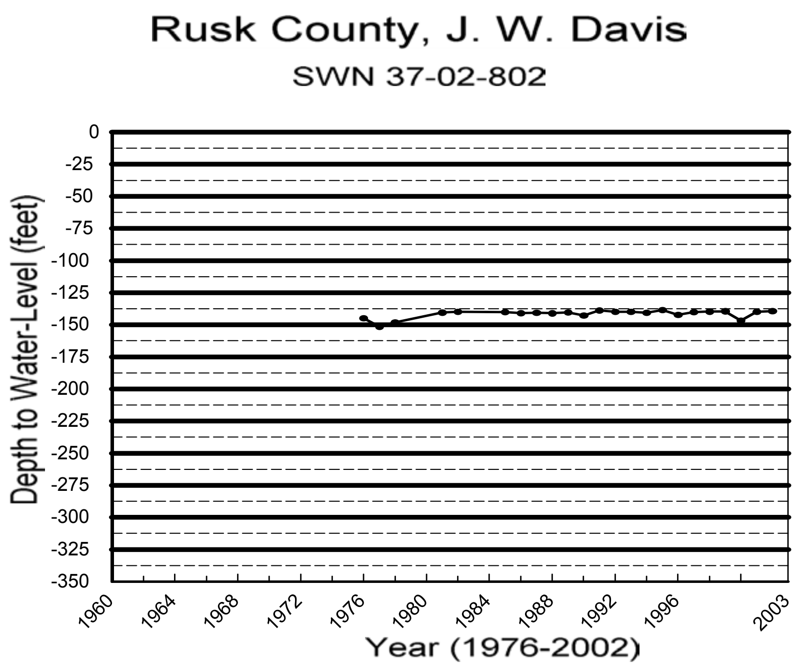
3559601	Wilcox
Year	Water-Level
1977	-91.8
1978	-97.98
1979	
1980	
1981	-102.09
1982	-101.84
1983	-96.11
1984	-97.16
1985	-98
1986	-98.45
1987	-100
1988	-101.93
1989	-102.75
1990	-103.47
1991	-103.1
1992	-105.4
1993	-104.48
1994	-117.82
1995	-106.26
1996	-167.8
1997	-107.15
1998	-111.59
1999	-109.7
2000	-109.77
2001	-114.6
2002	-109.45
2003	



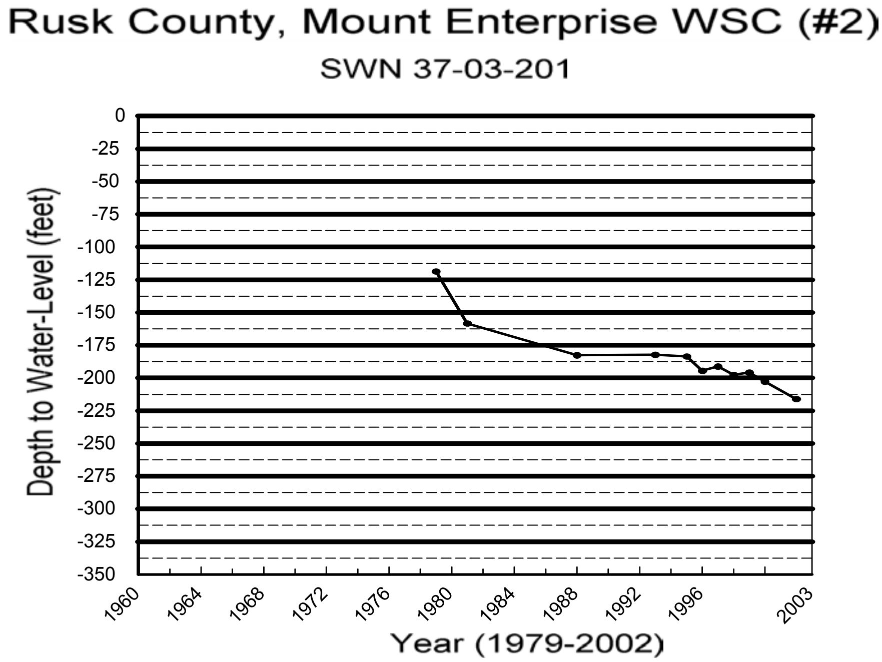
3559902	Wilcox
Year	Water-Level
1972	-178.28
1973	-179
1974	
1975	-179
1976	-178.32
1977	-177.44
1978	-182.07
1979	
1980	
1981	-186.48
1982	-184.43
1983	-187.5
1984	-192.19
1985	-194.17
1986	-195.76
1987	-198.24
1988	-198.34
1989	-199.77
1990	-199.22
1991	-200.1
1992	-201.52
1993	-201.8
1994	-201.88
1995	-202.78
1996	-203.17
1997	-211.15
1998	-201.78
1999	-202.6
2000	
2001	-206.4
2002	-205.18
2003	



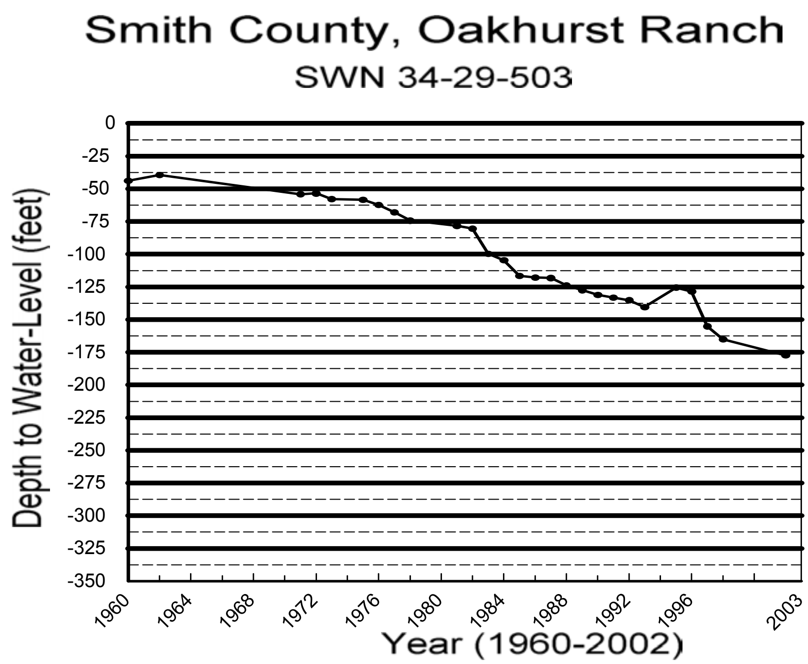
3702802	Wilcox
Year	Water-Level
1976	-144.93
1977	-151.5
1978	-148.07
1979	
1980	
1981	-140.5
1982	-139.84
1983	
1984	
1985	-140.15
1986	-141
1987	-140.71
1988	-141.05
1989	-140.38
1990	-142.75
1991	-138.82
1992	-139.82
1993	-139.78
1994	-140.68
1995	-138.64
1996	-142.24
1997	-140.17
1998	-139.71
1999	-139.5
2000	-146.7
2001	-139.8
2002	-139.28
2003	



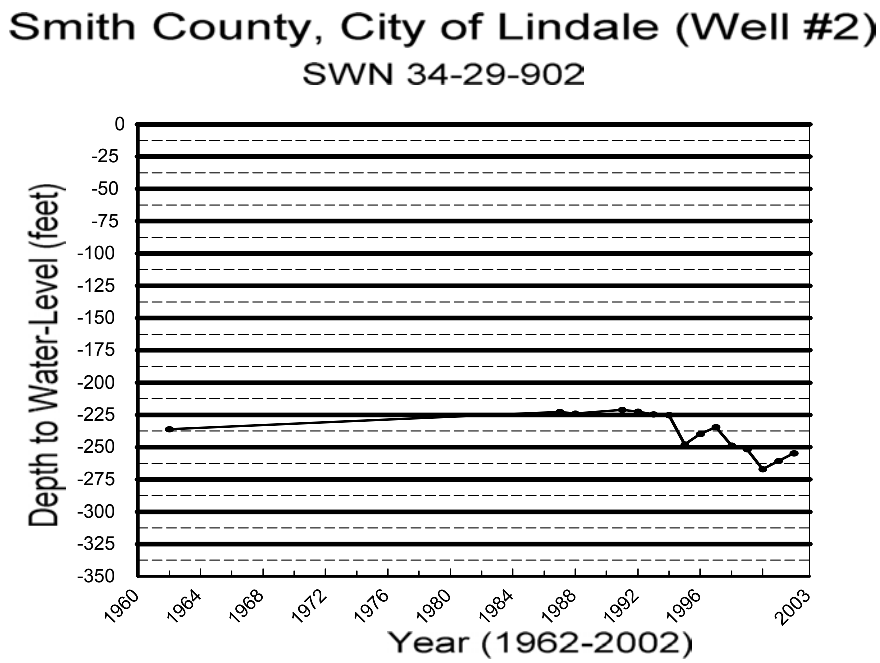
3703201	Wilcox
Year	Water-Level
1979	-118.6
1980	
1981	-158.4
1982	
1983	
1984	
1985	
1986	
1987	
1988	-182.6
1989	
1990	
1991	
1992	
1993	-182.16
1994	
1995	-183.56
1996	-194.43
1997	-191.19
1998	-197.53
1999	-195.85
2000	-202.8
2001	
2002	-216.03
2003	



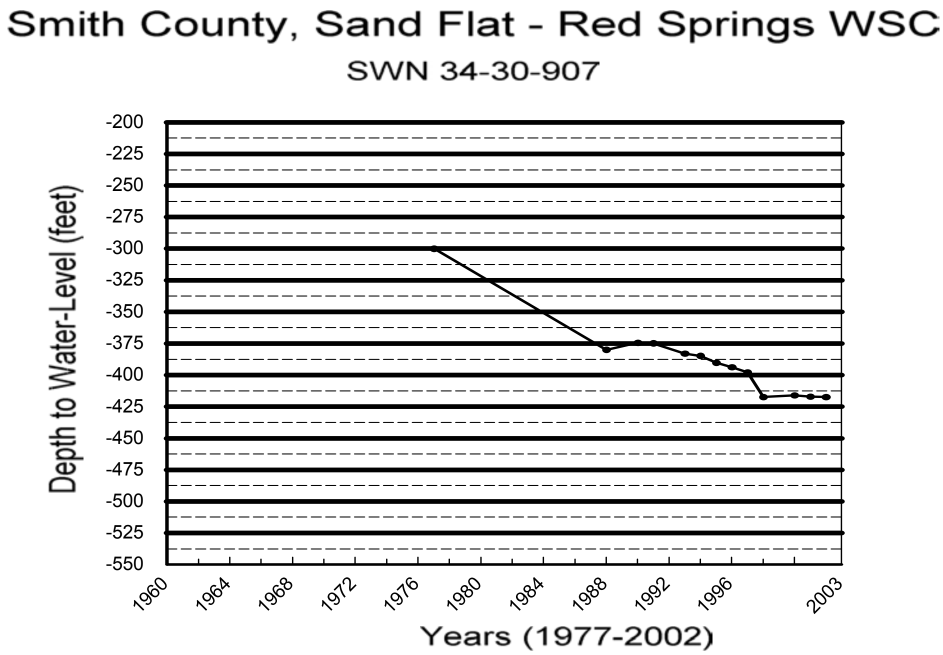
3429503	Carrizo-Wilcox
Year	Water-Level
1960	-43.8
1961	
1962	-39.42
1963	
1964	
1965	
1966	
1967	
1968	
1969	
1970	
1971	-54.06
1972	-53.5
1973	-57.84
1974	
1975	-58.4
1976	-62.18
1977	-68.03
1978	-74.3
1979	
1980	
1981	-78.32
1982	-80.47
1983	-99.7
1984	-104.59
1985	-116.52
1986	-117.8
1987	-118.2
1988	-123.9
1989	-127.54
1990	-131
1991	-133.06
1992	-135.1
1993	-140.35
1994	
1995	-125.5
1996	-128.55
1997	-155.1
1998	-165
1999	
2000	
2001	
2002	-177.3
2003	



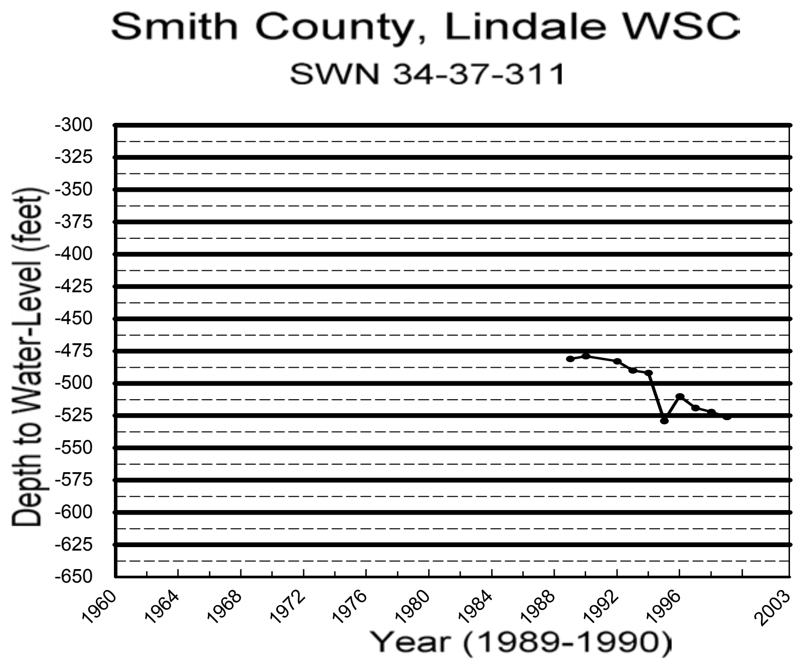
3429902	Carrizo-Wilcox
Year	Water-Level
1962	-236
1963	
1964	
1965	
1966	
1967	
1968	
1969	
1970	
1971	
1972	
1973	
1974	
1975	
1976	
1977	
1978	
1979	
1980	
1981	
1982	
1983	
1984	
1985	
1986	
1987	-222.72
1988	-224
1989	
1990	
1991	-221.14
1992	-222.45
1993	-224.57
1994	-225.22
1995	-248
1996	-239.67
1997	-234.46
1998	-248.67
1999	-251.6
2000	-267
2001	-260.8
2002	-254.7
2003	



3430907	Carrizo
Year	Water-Level
1977	-300
1978	
1979	
1980	
1981	
1982	
1983	
1984	
1985	
1986	
1987	
1988	-380
1989	
1990	-374.53
1991	-374.88
1992	
1993	-383.1
1994	-384.82
1995	-390.26
1996	-393.82
1997	-397.72
1998	-417.3
1999	
2000	-416.12
2001	-417.13
2002	-417.33
2003	

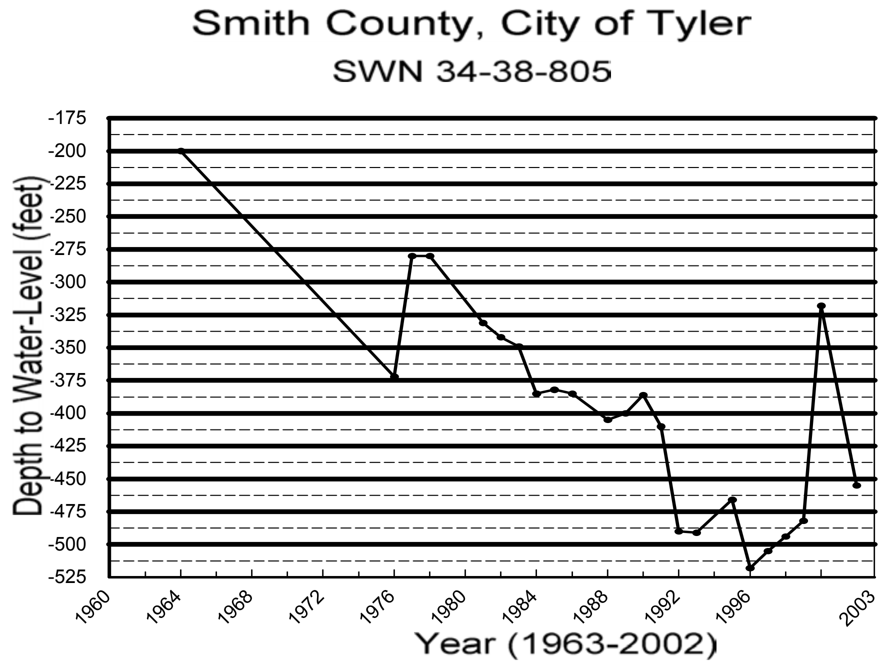


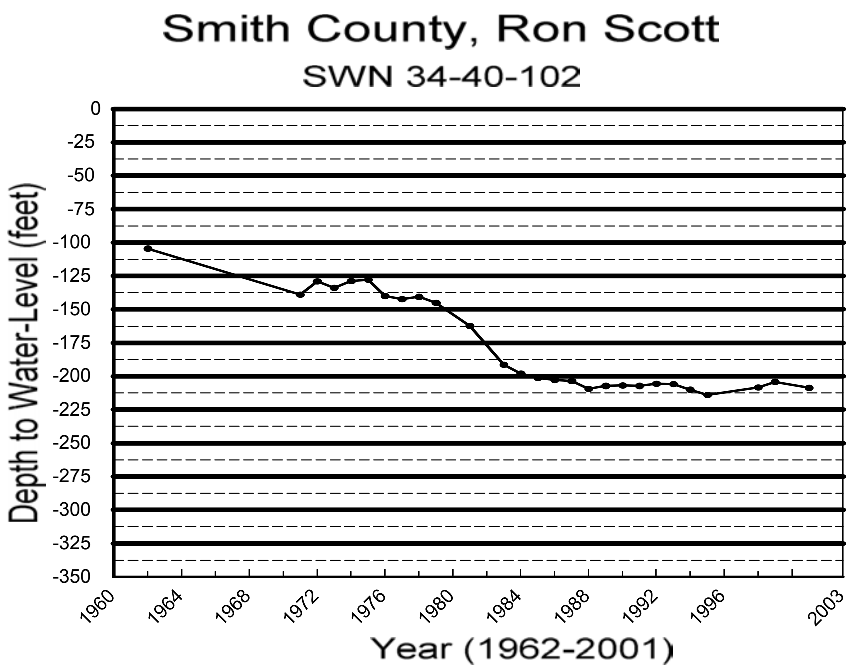
3437311	Wilcox
Year	Water-Level
1989	-481
1990	-478.87
1991	
1992	-482.85
1993	-490
1994	-491.8
1995	-529
1996	-510
1997	-519
1998	-522
1999	-526
2000	
2001	
2002	
2003	



3438805 Wilcox

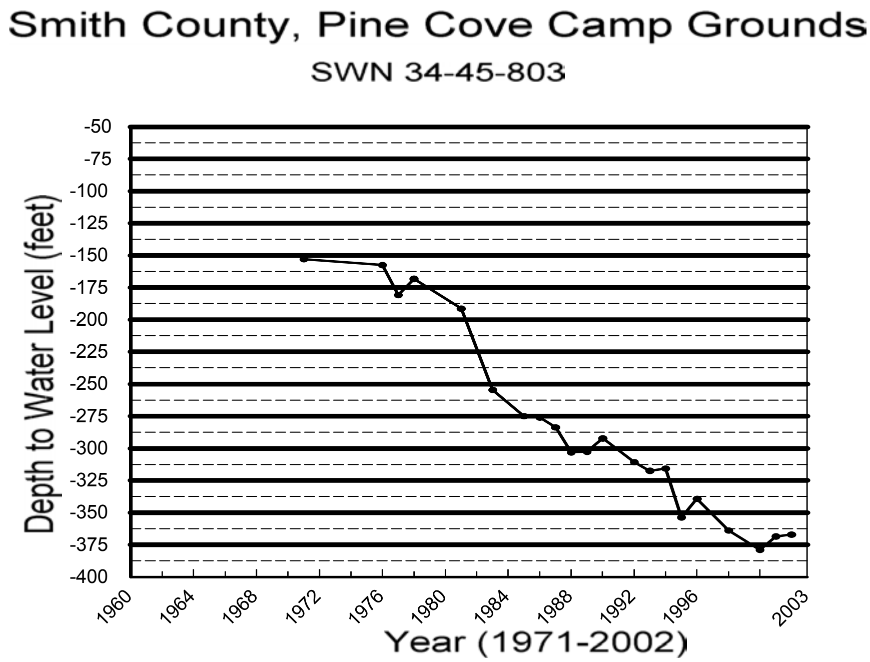
Year	Water-Level
1964	-200
1965	
1966	
1967	
1968	
1969	
1970	
1971	
1972	
1973	
1974	
1975	
1976	-372
1977	-280
1978	-280
1979	
1980	
1981	-331
1982	-342
1983	-349
1984	-385
1985	-382
1986	-385
1987	
1988	-405
1989	-400
1990	-386
1991	-410
1992	-490
1993	-491
1994	
1995	-466
1996	-518
1997	-505
1998	-494
1999	-482
2000	-318
2001	
2002	-455
2003	



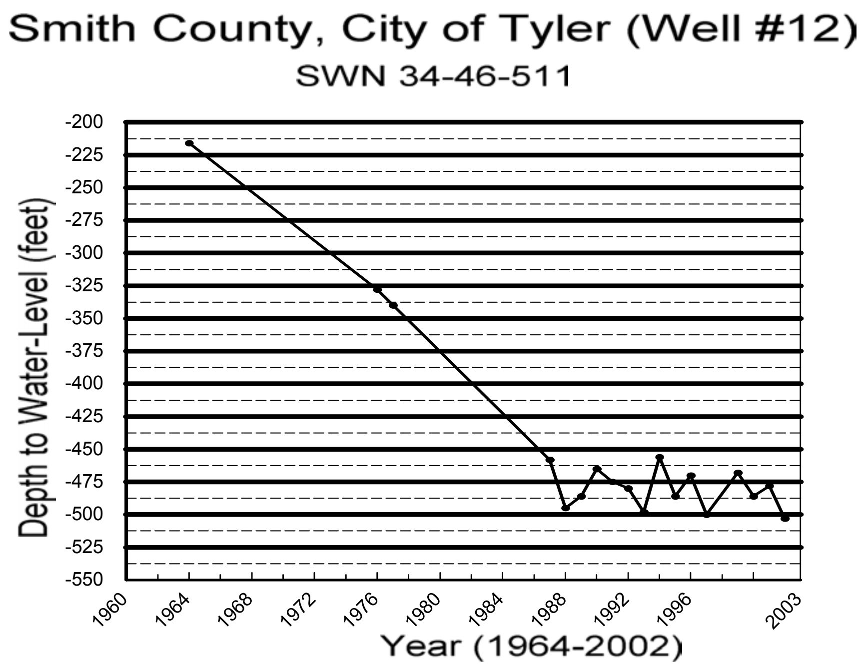


3440102	Carrizo-Wilcox
Year	Water-Level
1962	-104.52
1963	
1964	
1965	
1966	
1967	
1968	
1969	
1970	
1971	-139.05
1972	-129.1
1973	-133.9
1974	-128.8
1975	-127.75
1976	-139.9
1977	-142.29
1978	-140.6
1979	-145.13
1980	
1981	-162.34
1982	
1983	-191.35
1984	-198.05
1985	-201.19
1986	-202.7
1987	-203.6
1988	-209.42
1989	-207.25
1990	-206.95
1991	-207.21
1992	-205.61
1993	-205.9
1994	-210.05
1995	-214
1996	
1997	
1998	-208.34
1999	-204.2
2000	
2001	-208.6
2002	
2003	

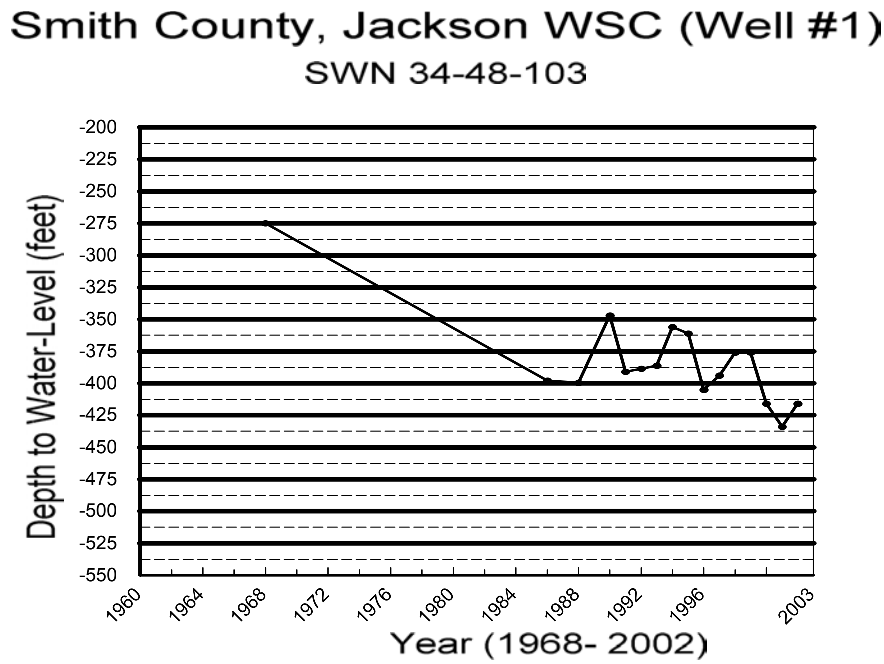
3445803	Carrizo-Wilcox
Year	Water-Level
1971	-153
1972	
1973	
1974	
1975	
1976	-157.49
1977	-180.87
1978	-168.26
1979	
1980	
1981	-191.32
1982	
1983	-254.52
1984	
1985	-274.88
1986	-276.1
1987	-283.7
1988	-303.1
1989	-302.6
1990	-292.28
1991	
1992	-310.7
1993	-317.46
1994	-315.7
1995	-353.7
1996	-339.28
1997	
1998	-363.9
1999	
2000	-379
2001	-368.5
2002	-367.02
2003	



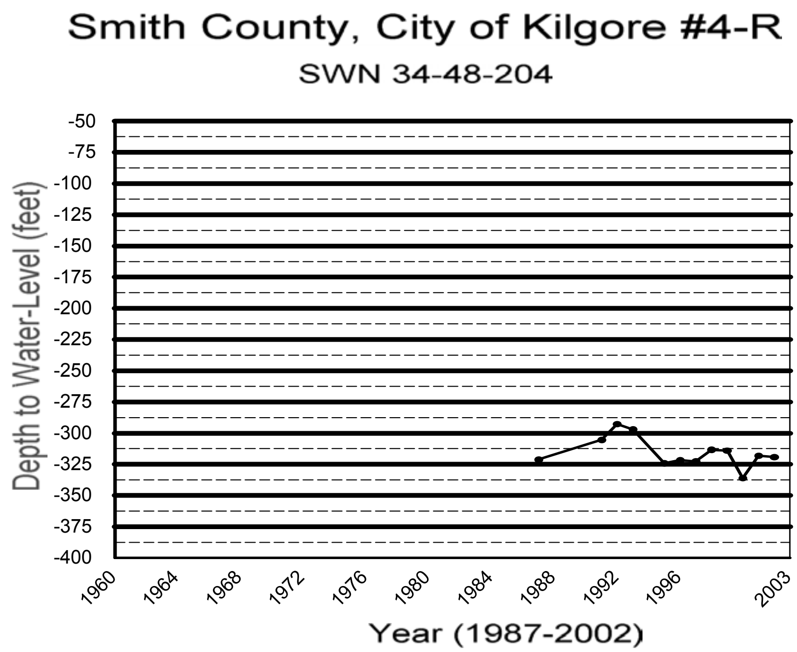
3446511	Carrizo
Year	Water-Level
1964	-216
1965	
1966	
1967	
1968	
1969	
1970	
1971	
1972	
1973	
1974	
1975	
1976	-328
1977	-340
1978	
1979	
1980	
1981	
1982	
1983	
1984	
1985	
1986	
1987	-458
1988	-495
1989	-486
1990	-465
1991	-475
1992	-480
1993	-498
1994	-456
1995	-486
1996	-470
1997	-500
1998	
1999	-468
2000	-486
2001	-478
2002	-503
2003	



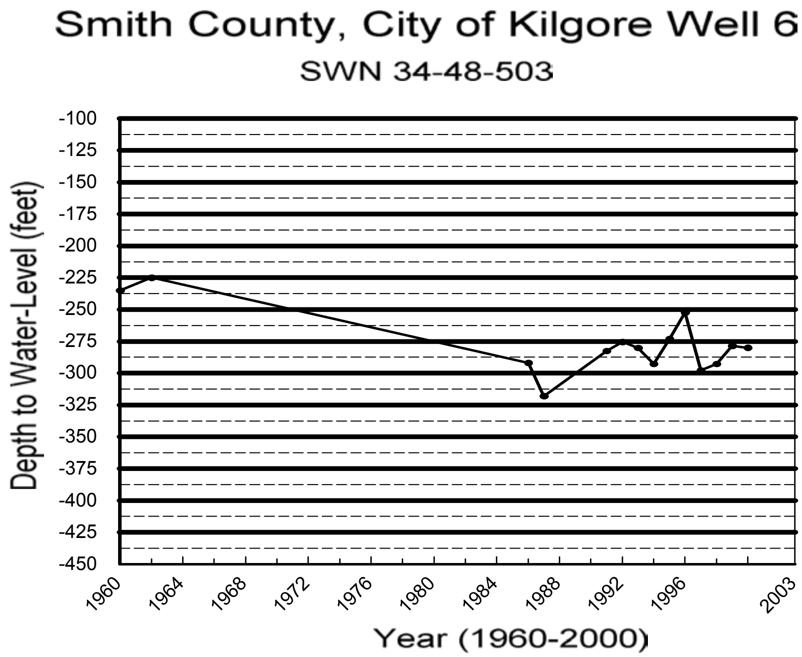
3448103	Wilcox
Year	Water-Level
1968	-275
1969	
1970	
1971	
1972	
1973	
1974	
1975	
1976	
1977	
1978	
1979	
1980	
1981	
1982	
1983	
1984	
1985	
1986	-398
1987	
1988	-399.59
1989	
1990	-347
1991	-391
1992	-388.58
1993	-386.3
1994	-356
1995	-361
1996	-405
1997	-394
1998	-376
1999	-376
2000	-416
2001	-434
2002	-416
2003	



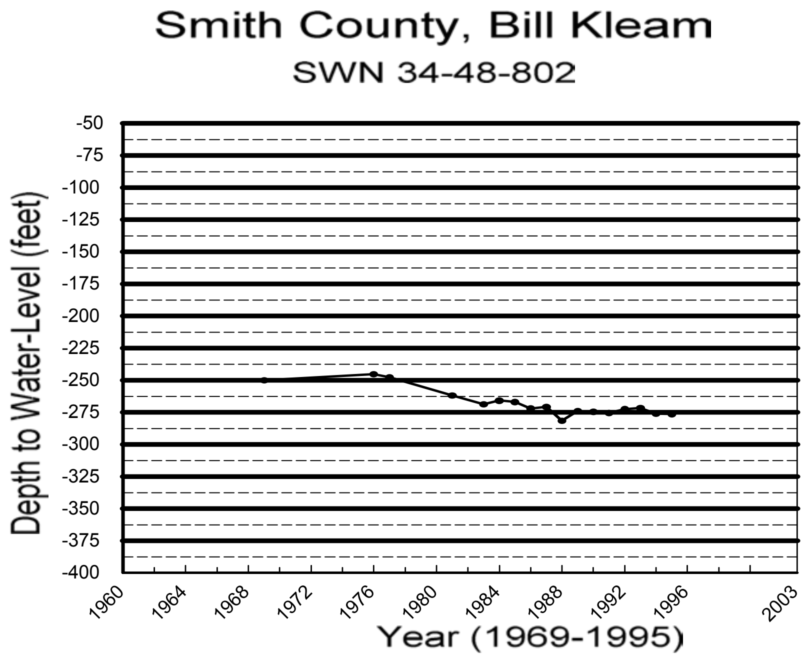
3448204	Carrizo-Wilcox
Year	Water-Level
1987	-321.2
1988	
1989	
1990	
1991	-305.4
1992	-292.8
1993	-297
1994	
1995	-324.2
1996	-321.69
1997	-322.6
1998	-313.34
1999	-314
2000	-336.05
2001	-318.18
2002	-319.25
2003	



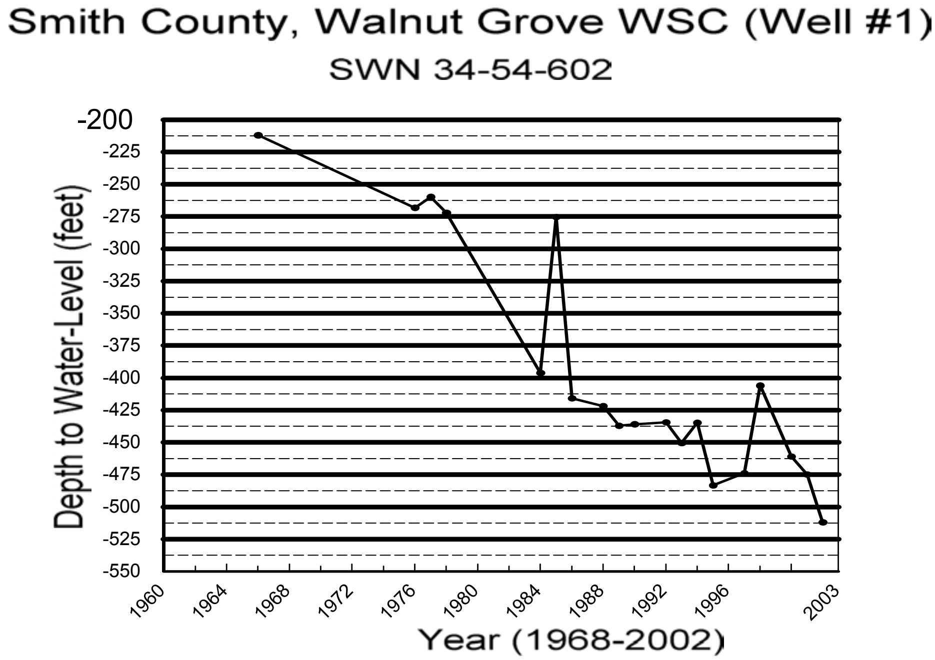
3448503	Carrizo
Year	Water-Level
1960	-235
1961	
1962	-225
1963	
1964	
1965	
1966	
1967	
1968	
1969	
1970	
1971	
1972	
1973	
1974	
1975	
1976	
1977	
1978	
1979	
1980	
1981	
1982	
1983	
1984	
1985	
1986	-292
1987	-318
1988	
1989	
1990	
1991	-282.65
1992	-275.5
1993	-280.22
1994	-292.7
1995	-273
1996	-252.46
1997	-297.9
1998	-292.81
1999	-278.65
2000	-280.1
2001	
2002	
2003	



3448802	Carrizo-Wilcox
Year	Water-Level
1969	-250
1970	
1971	
1972	
1973	
1974	
1975	
1976	-245.15
1977	-247.5
1978	
1979	
1980	
1981	-261.74
1982	
1983	-268.62
1984	-265.84
1985	-266.91
1986	-271.95
1987	-270.7
1988	-281.59
1989	-273.93
1990	-274.55
1991	-275.43
1992	-272.45
1993	-271.5
1994	-275.98
1995	-276.4
1996	
1997	
1998	
1999	
2000	
2001	
2002	
2003	



3454602	Wilcox
Year	Water-Level
1966	-212
1967	
1968	
1969	
1970	
1971	
1972	
1973	
1974	
1975	
1976	-268.2
1977	-259.82
1978	-271.97
1979	
1980	
1981	
1982	
1983	
1984	-396.16
1985	-275.47
1986	-415.85
1987	
1988	-421.83
1989	-437.14
1990	-435.95
1991	
1992	-434.55
1993	-450.45
1994	-434.67
1995	-483.35
1996	
1997	-474
1998	-406
1999	
2000	-461
2001	-475
2002	-512
2003	



3456207	Carrizo-Wilcox
Year	Water-Level
1965	-200
1966	
1967	
1968	
1969	
1970	
1971	
1972	
1973	
1974	
1975	
1976	-243.59
1977	
1978	
1979	
1980	
1981	
1982	
1983	
1984	-247.56
1985	
1986	-224
1987	-225.63
1988	-224.85
1989	-234.57
1990	-224.68
1991	-225.63
1992	-227.69
1993	-246.15
1994	-228.87
1995	-246.2
1996	-228.94
1997	-248.58
1998	-236.6
1999	
2000	-273
2001	
2002	
2003