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CHAPTER 1.0: INTRODUCTION AND DESCRIPTION OF THE LOWER COLORADO REGIONAL WATER PLANNING AREA

1.1 INTRODUCTION TO THE PLANNING PROCESS

Sections 16.051 and *16.055* of the Texas Water Code direct the Executive Administrator of the Texas Water Development Board (TWDB) to prepare and maintain a comprehensive State Water Plan. The overall goal of the State Water Plan is to address water supply needs at the local level with the consideration of balancing affordable water supply availability and conserving the State's natural resources and serves as a flexible guide for the development and management of all water resources in Texas.

In February 1998, the TWDB adopted rules establishing 16 regional water planning areas. Each planning area is responsible for preparing a consensus-based Regional Water Plan that will provide for the water needs of its region for the next 50 years. The TWDB incorporates the resulting Regional Water Plans into the State Water Plan, which is updated in 5-year cycles. Three previous Region K Water Plans have been completed (in years 2001, 2006, 2011) and were subsequently incorporated into the 2002, 2007, and 2012 State Water Plans. It is anticipated that the current cycle of Regional Water Plans will be finalized and adopted by January 5, 2016. Subsequently, by January 5, 2017, the TWDB will prepare a new State Water Plan.

The Lower Colorado Regional Water Planning Area, initially designated by the TWDB as "Region K," encompasses all or part of 14 counties mostly within the Lower Colorado River Basin from the Hill Country to the Gulf of Mexico (*Figure 1.2*). The Lower Colorado Regional Water Planning Group (LCRWPG), representing the 11 TWDB-required interest groups, Groundwater Management Area representatives, and one additional regional interest group, is responsible for the development of the Lower Colorado Regional Water Plan (*Table 1.1*). The TWDB's guidelines require that each regional water plan include the following sections:

- Description of the region (Chapter 1)
- Population and water demand projections (Chapter 2)
- Estimates of currently available water supplies (Chapter 3)
- Identification of Water Needs (Chapter 4)
- Evaluation and selection of water management strategies, including a subsection on water conservation (Chapter 5)
- Impacts of selected water management strategies on key parameters of water quality and impacts of moving water from rural and agricultural areas (Chapter 6)
- Drought response information, activities, and recommendations (Chapter 7)
- Unique stream segments/reservoir sites and Legislative recommendations (Chapter 8)
- Report to Legislature on water infrastructure funding (Chapter 9)
- Public participation and education/input (Chapter 10)
- Report on implementation and comparison of the previous regional water plan (Chapter 11)

Figure 1.1: TWDB Designated Regional Water Planning Areas

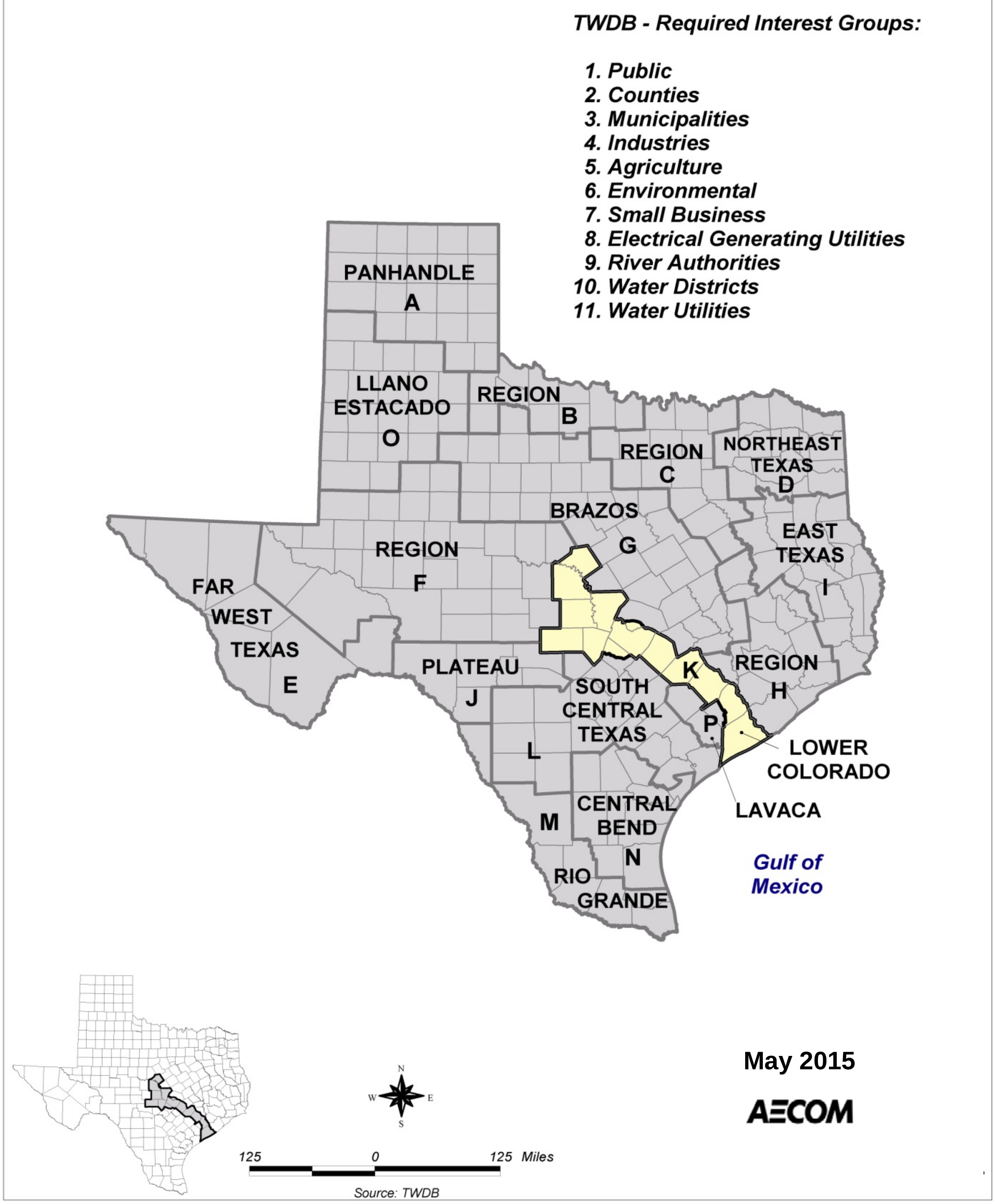


Figure 1.2: Lower Colorado Regional Water Planning Area (Region K)

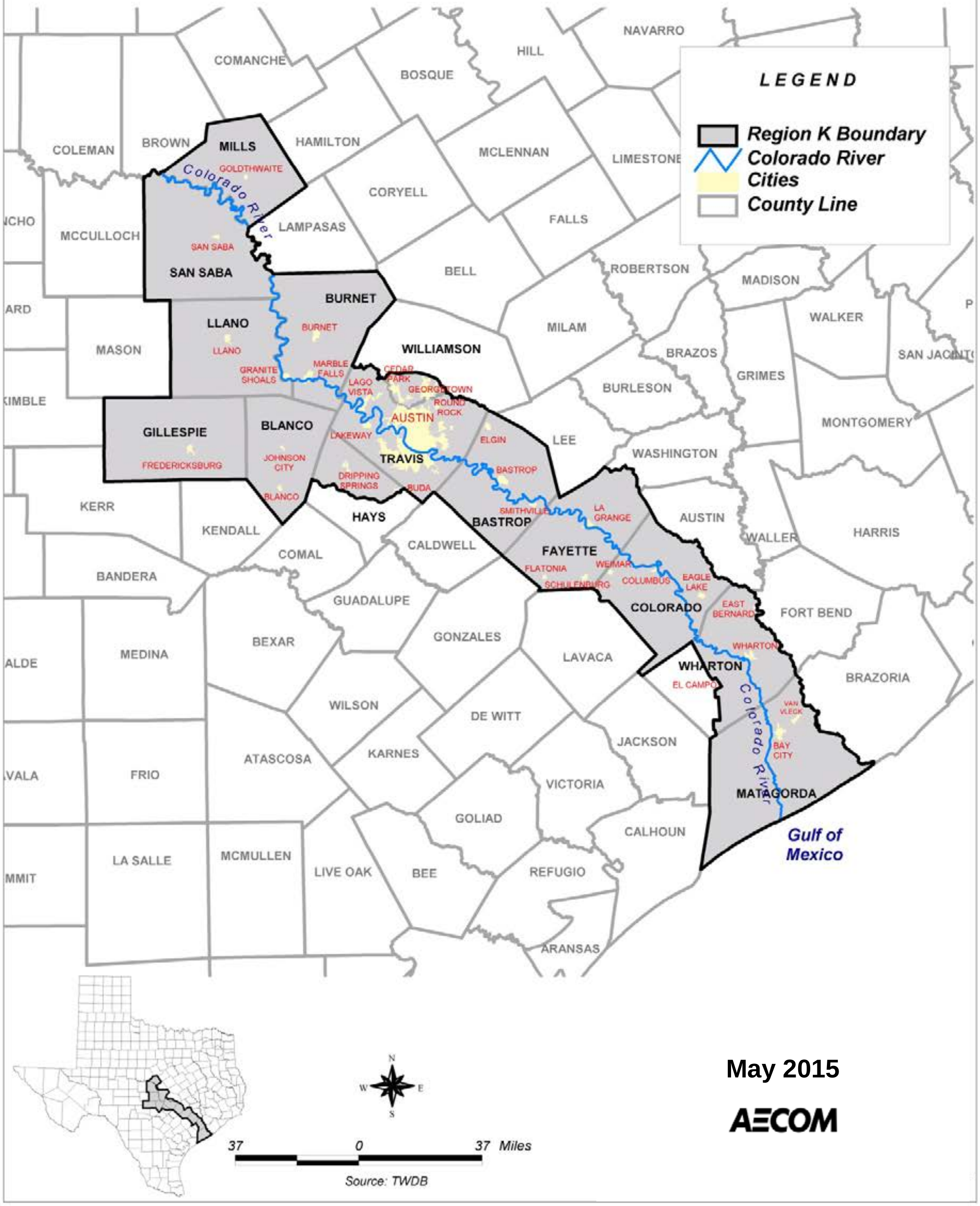


Table 1.1a The Lower Colorado Regional Water Planning Group Voting Board Members (as of November 12, 2015)

Interest	Name	Entity	County (Location of Interest)
Public	Karen Haschke	League of Women Voters	Travis
Counties	Donna Klaeger	Former Burnet County Judge	Burnet
	Byron Theodosis	San Saba County Judge	San Saba
	James Sultemeier	Blanco County Commissioners Court	Blanco
Municipalities	Mike Reagor	City of Llano	Llano
	Lauri Gillam	Pflugerville	Williamson
	Teresa Lutes	City of Austin	Travis
Industries	Barbara Johnson	Austin Area Research Organization, Inc.	Travis
Agricultural	Billy Roeder		Gillespie
	Haskell Simon	Rice Industry Rep. and Farmer	Matagorda
Environmental	Jim Barho	Protect Lakes Inks, Buchanan	Burnet
	Jennifer Walker	Sierra Club, Lone Star Chapter	Travis
Small Businesses	Ronald Gertson		Wharton
	Rob Ruggiero		Travis
Electric Generating Utilities	John Hoffman	STP Nuclear Operating Company	Matagorda
River Authorities	David Wheelock	Lower Colorado River Authority	Travis
Water Districts	David Van Dresar	Fayette County Groundwater Conservation District	Fayette
Water Utilities	John Burke		Bastrop
Recreation	Doug Powell	Emerald Point Marina	Travis
GMA 7	Paul Tybor	Hill Country Underground Conservation District	Gillespie
GMA 8	Charles Shell	Central Texas GCD	Burnet
GMA 9	Ronald G. Fieseler	Blanco-Pedernales GCD	Blanco
GMA 10	John Dupnik	Barton Springs/Edwards Aquifer Conservation District	Travis
GMA 12	Jim Totten	Lost Pines GCD	Bastrop
GMA 15	Jim Brasher	Colorado County GCD	Colorado

Table 1.1b The Lower Colorado Regional Water Planning Group Nonvoting Members

David Bradsby	Texas Parks & Wildlife Department
David T. Villareal	Texas Department of Agriculture
Temple McKinnon	Texas Water Development Board

Table 1.1c The Lower Colorado Regional Water Planning Group Alternate Members

Voy Althaus	Charlie Flatten	Dave Lindsay
Paul Babb	Jeff Fox	Peggy Matli
Brent Batchelor	Robin Gary	Cindy Smiley
Patricia Bennett	Neil Hudgins	Mitchell Sodek
Karen Bondy	Joe King	Brandon Wade
Terry Bray	Chris Liesmann	

Texas is an extremely diverse state, both in climate and economics. This diversity requires the use of a variety of water management strategies, the combination of which will be unique for each of the 16 regions. The types of strategies that may be considered include, but are not limited to:

- expected/advanced water conservation
- drought management
- water reuse
- expanded use of existing supplies
- reallocation of reservoir storage
- water marketing and inter-basin transfers
- subordination of water rights
- yield enhancement measures
- new supply development
- chloride control measures

Water availability, economics, environmental concerns, and public acceptance were considered during the process of developing water management strategies within each region. The final Regional Water Plan must comply with all existing state and federal regulations regarding existing water rights, instream flows, bay/estuary freshwater inflows, water quality, threatened/endangered species, critical habitats, and sites of historical importance.

The overall goal of the State Water Plan is to address water supply needs at the local level with the consideration of balancing affordable water supply availability and conserving the State's natural resources.

1.2 DESCRIPTION OF THE LOWER COLORADO REGIONAL WATER PLANNING AREA

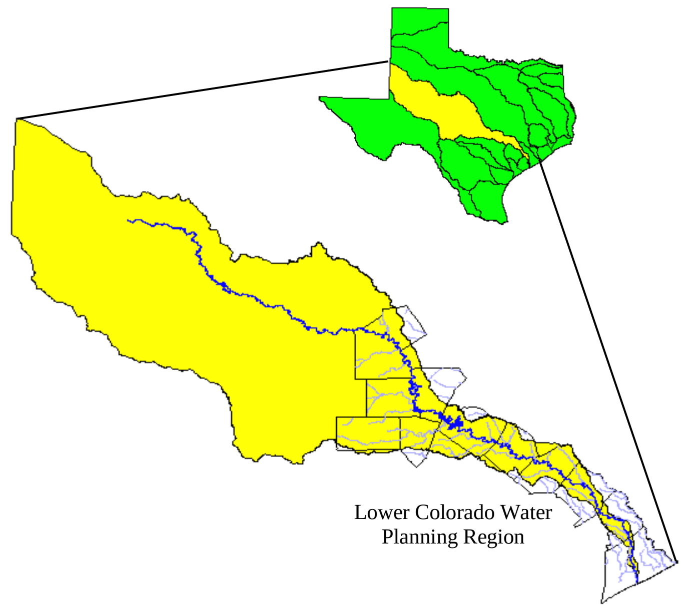
The Lower Colorado Regional Water Planning Area encompasses all or part of the following counties:

- Bastrop
- Blanco
- Burnet
- Colorado
- Fayette
- Gillespie
- Hays (partial)
- Llano
- Matagorda
- Mills
- San Saba
- Travis
- Wharton (partial)
- Williamson (partial)

Most of the Lower Colorado Region lies within the Colorado River Basin and crosses the Great Plains and the Coastal Plains physiographic provinces. The following sections provide a general description of the area's physical and socioeconomic characteristics, as well as water quality and natural resource issues of importance to the region.

1.2.1 Physical Characteristics of the Lower Colorado Regional Water Planning Area[1]

Figure 1.3: The Colorado River Basin



The headwaters of the Colorado River Basin are located in eastern New Mexico, and the basin extends approximately 900 miles to the Texas Gulf Coast, ending at Matagorda Bay as shown in *Figure 1.3*. The full extent of the basin exceeds the boundaries of the Lower Colorado Regional Planning Area. The Colorado River Basin is bordered by the Brazos River Basin to the north and east, and by the Guadalupe River and Lavaca River Basins to the south and west. The total drainage area of the Colorado River is 42,318 sq mi, 11,403 sq mi of which is considered non-contributory to the river's water supply. There are six major tributaries with drainage areas greater than 1,000 sq mi that contribute to the Colorado River: Beall's Creek and the Concho River, above the Region K boundary; and the San Saba, Llano, and Pedernales Rivers as well as Pecan Bayou. All of these major tributaries and approximately 90 percent of the entire contributing drainage for the river occur upstream of Mansfield Dam near Austin. This dam is the primary regulator of water flow from its location south to the Gulf of Mexico. Downstream of Austin, there are only two tributaries with drainage areas greater than 300 sq mi, Onion Creek in Travis County and Cummins Creek in Colorado County.

1.2.1.1 Geology of the Lower Colorado River Basin[2, 3]

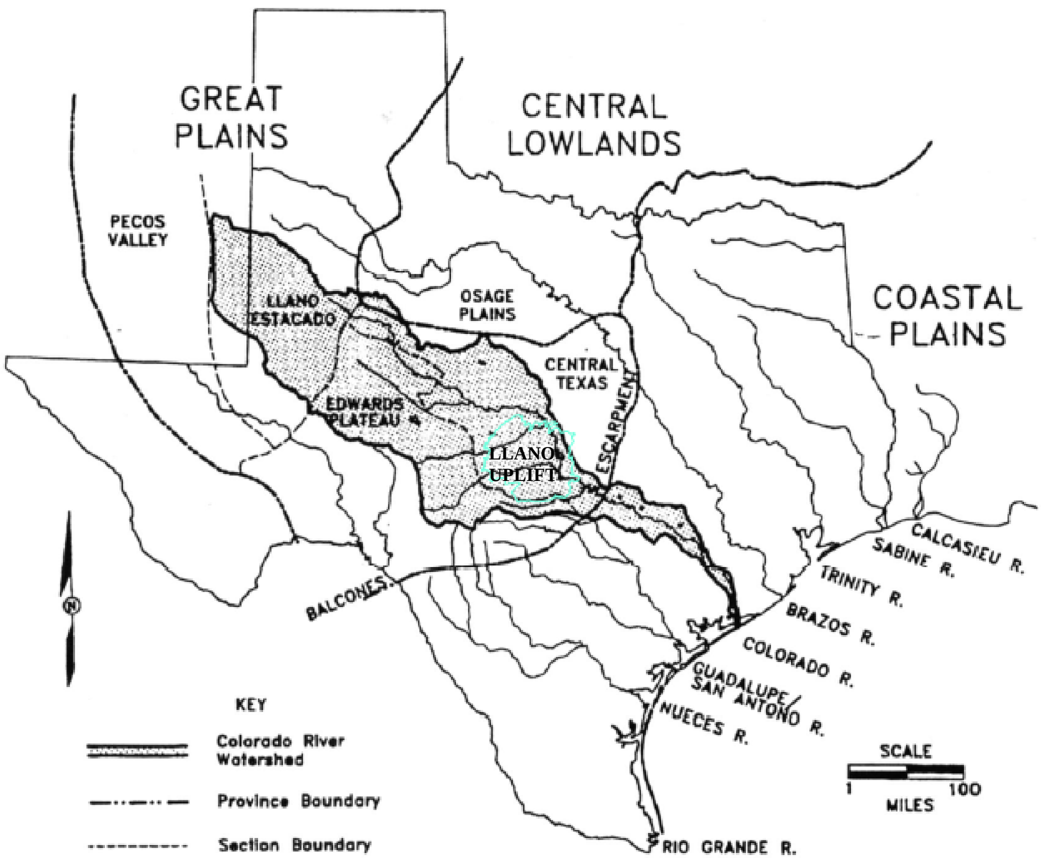
The northernmost boundary of the Lower Colorado Regional Planning Area lies in the Central Texas section of the Great Plains physiographic province (*Figure 1.4*). It is here that the Colorado River intersects the Llano Uplift; a broad, low relief but highly structured area exposing early Paleozoic and Precambrian igneous and metamorphic formations. In the northwestern portion of the region, the major southern tributaries and the Colorado River drain the Edwards Plateau section of the Great Plains province, which is characterized by Cretaceous- aged limestone formations overlain by Tertiary-aged sediments. The Colorado River meanders through these limestone deposits in relatively steep narrow

[1] Lower Colorado River Authority (LCRA), June 1992. *Instream Flows for the Lower Colorado River*, Final Report.
[2] LCRA, Op. Cit., June 1992.
[3] Texas Water Development Board (TWDB), May 1977. *Continuing Water Resource Planning and Development for Texas, Volume II*.

canyons in this area; however, there are also flat-topped remnants of the once more extensive Edwards Plateau. At the eastern edge of the Edwards Plateau, the Edwards aquifer outcrops at several locations along the Balcones Fault Zone (shown as the Balcones Escarpment on *Figure 1.4*), creating aquifer recharge zones and associated natural discharge points or springs, such as Barton Springs in Travis County. Typical soils (*Figure 1.5*) of the Llano Uplift are reddish-brown to brown, neutral to slightly acidic, calcareous, sandy loams. Soils mapped on the Edwards Plateau section typically consist of dark, deep to shallow, stony, calcareous clays.

Figure 1.4: Physiographic Provinces and Major Drainage Basins of the Western Gulf Slope

(Modified from Conner and Suttkus, 1977)

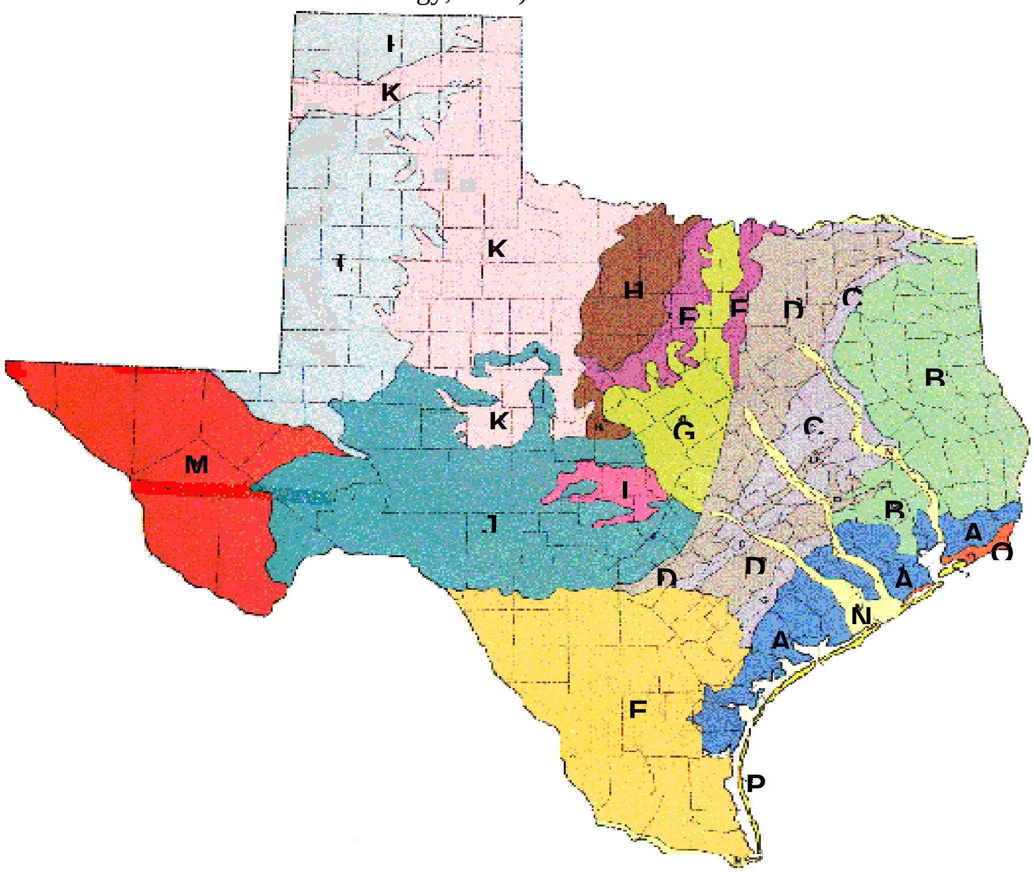


The Western Gulf Coast section of the Coastal Plains province contains the remaining 300 miles of the Colorado River south of the Balcones Fault Zone in Travis County to the Gulf of Mexico. The Western Gulf Coast section is characterized as an elevated sea bottom with low topographic relief ranging from low hills in the west to coastal flats. Surface geologic units mapped along this portion of the Colorado

River include a relatively narrow band of Upper Cretaceous formations just southeast of the Balcones Fault Zone, followed by a belt of Tertiary deposits that outcrop from Bastrop County southeast to Colorado County. The remaining geologic units, from Colorado County to the Gulf of Mexico, are mapped as Quaternary-aged deposits. Sediments in the Western Gulf Coast section are composed

Figure 1.5: Soils of Texas

(Source: Bureau of Economic Geology, 1977)



- **A** Dark-colored, neutral to slightly acid clay loams & clays; some lighter colored sandy loams; acid soils mostly east of Trinity River.
- **B** Light-colored, acid sandy loams, clay loams, & sands; some red soils & clays.
- **C** Light-brown to dark-gray, acid sandy loams, clay loams, & clays.
- **D** Dark-colored calcareous clays; some grayish-brown, acid sandy loams & clay loams along eastern edge of the major prairie & interspersed in minor prairies.
- **E** Dark calcareous to neutral clays & clay loams; reddish-brown, neutral to slightly acid sandy loams; grayish-brown, neutral sandy loams & clay loams; some saline soils near coast.
- **F** Light-colored, acid loamy sands & sandy loams.
- **G** Dark-colored, deep to shallow clay loams, clays, & stony calcareous clays over limestone.
- **H** Reddish-brown to grayish-brown, neutral to slightly acid sandy loams & clay loams; some stony soils.
- **I** Reddish-brown to brown, neutral to slightly acid, gravelly & stony sandy loams.
- **J** Dark, calcareous stony clays & clay loams.
- **K** Dark-brown to reddish-brown, neutral to slightly calcareous sandy loams, clay loams, & clays.
- **L** Dark-brown to reddish-brown neutral sands, sandy loams, & clay loams; some very shallow calcareous clay loams.
- **M** Light reddish-brown to brown sands; clay loams & clays (mostly calcareous, some saline) & rough stony lands.
- **N** Light-brown to reddish-brown, acid sandy loams; acid & calcareous clay loams & clays.
- **O** Light- & dark-colored, acid sands, sandy loams, & clays.
- **P** Tan, loose sand & shell material.

primarily of marine deposits such as limestones, marls, and shales; however, the river valley also contains significant fluvial (river) terrace deposits of granitic assemblage, quartz and quartzite, chert, limestone, sandstone, siltstone, hornblende schist, silicified wood, and rip-up clasts. Colorado Basin soils in the Western Gulf Coast section are typically dark, neutral to slightly acidic, clay loams, and clays. Near the coast, soils become light, acidic sands, and darker, loamy to clayey soils.

1.2.1.2 Climate[4, 5, 6]

The climate across the State of Texas varies considerably; however, there are no natural boundaries, and changes occur gradually from east to west. In general, average temperatures, rainfall, and the length of the growing season decrease from the east to the north and west. The upper atmospheric winds, or jetstreams, affect the large-scale weather patterns in the state. The polar jetstream affects the movement of cold arctic air masses from December through February. The moist warm air masses are brought to Texas from the Pacific Ocean by the subtropical jetstream, whose influence is most prevalent during the spring and fall.

Region K lies entirely within the warm-temperate/subtropical zone. The constant flow of warm tropical maritime air from the Gulf of Mexico produces a humid subtropical climate with hot summers across the lower third of the region. This maritime air combines with cooler and drier continental air further inland, which results in a subtropical climate with dry winters and humid summers in the remainder of the region. Winters in Region K typically are mild with frequent, short duration surges of colder continental air masses and strong northerly winds. Average annual net evaporation in Region K varies from 20 to 24 inches at the coast to approximately 44 inches in the uppermost portion of the region (*Figure 1.6*).

The amount of rainfall varies across the Lower Colorado Planning Region from an average of 48 inches at the coast to 24 inches in the northwestern portion of the region (*Figure 1.7*). The rainfall distribution pattern in this region has two peaks: spring is typically the wettest season with a peak in May, and a second peak usually occurs in September and October, coinciding with the tropical cyclone season in the late summer/early fall. The spring rains are typified by convective thunderstorms that produce high intensity, short duration precipitation events with rapid runoff. These thunderstorms are generally caused by successive frontal systems that move through the state. These weak cold air masses are overrun by warm Gulf moisture, and the line of instability that develops where the two air masses collide produces thunderstorms. The fall seasonal rains are primarily governed by tropical storms and hurricanes that originate in the Caribbean Sea or the Gulf of Mexico and make landfall on the coast from Louisiana to Mexico. As the storm moves inland, the coverage area for a single tropical cyclone event can be quite large and the storm severe, with wind and flood damage common. Fall cold fronts can also bring widespread, heavy rain events.

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[4] TWDB, Op. Cit., May 1977.

[5] Hatch, S. L., et al. July 1990. *Checklist of the Vascular Plants of Texas*. Texas Agricultural Experiment Station, College Station, Texas.

[6] Jones, B. D., 1990. *Texas Floods and Droughts. In National Water Summary 1988–1989*. U.S. Geological Survey, pp. 513–520.

Figure 1.6: Lower Colorado Regional Water Planning Area (Region K) Average Annual Net Evaporation

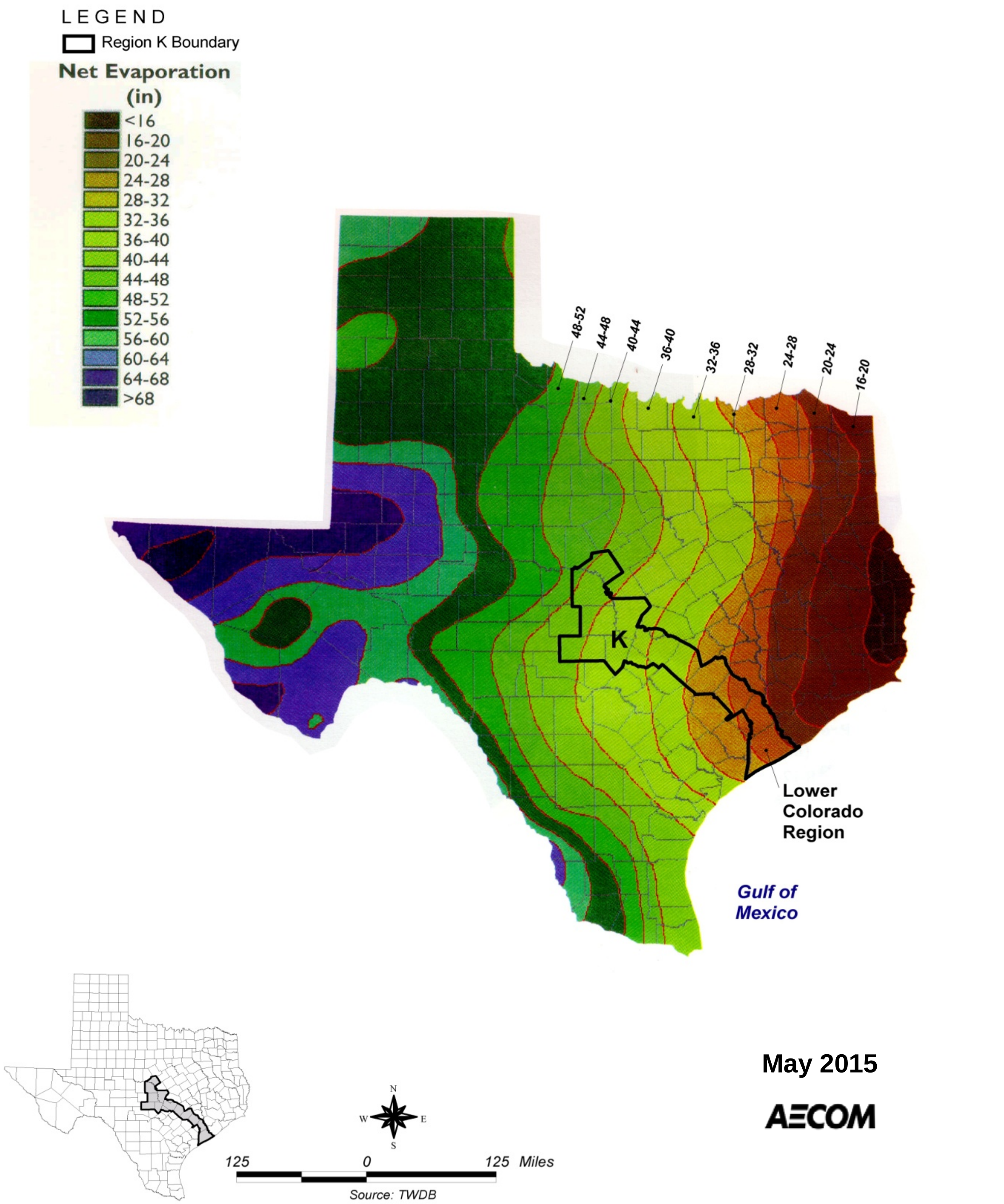
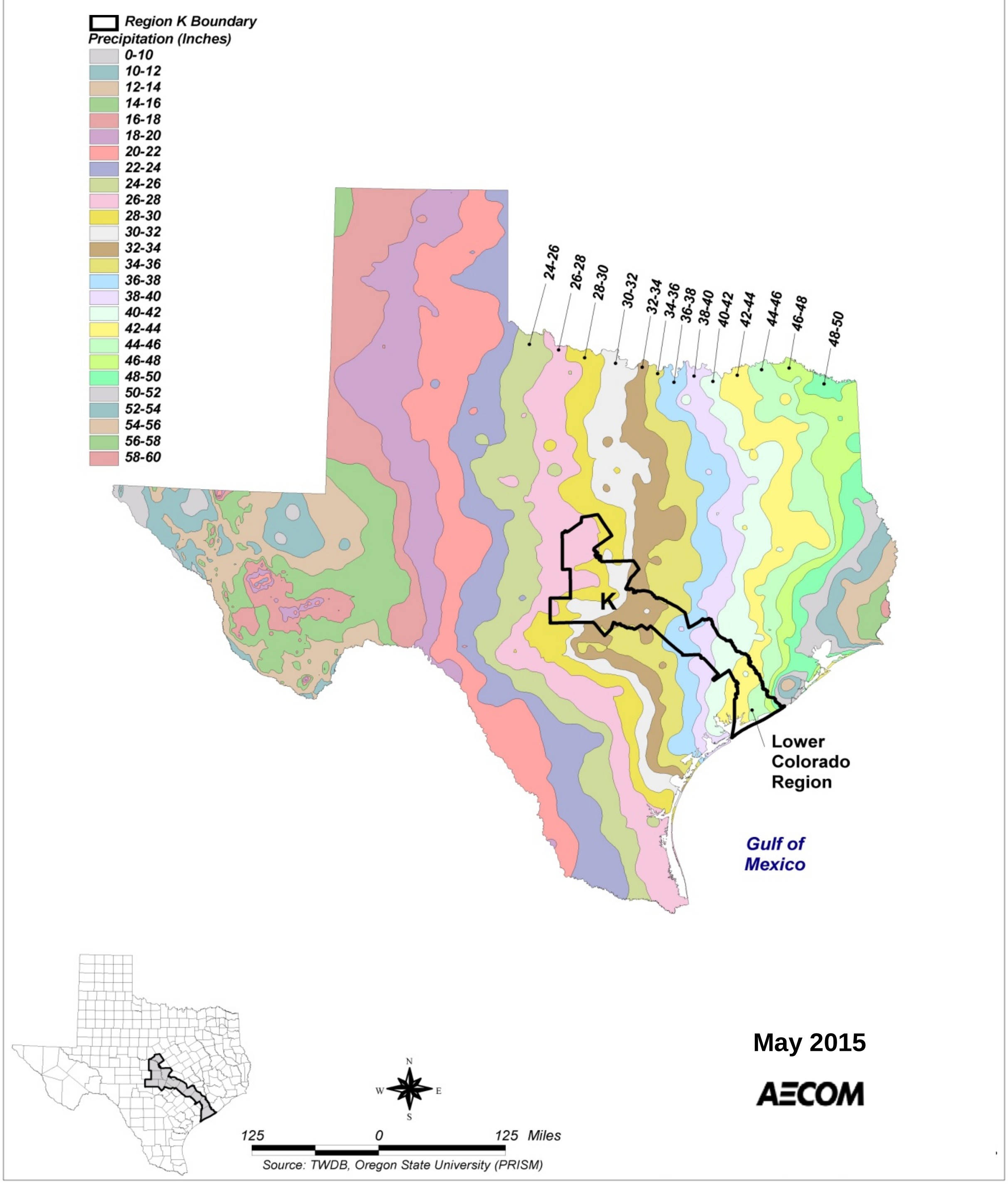


Figure 1.7: Lower Colorado Regional Water Planning Area (Region K) Average Annual Precipitation



The hydrologic characteristics of the Colorado River are closely linked to the precipitation patterns that occur in the river basin, especially the cycles of floods and droughts, which are common in Texas. Major flood and drought events are those with statistical recurrence intervals greater than 25 years and 10 years, respectively. Streamflow gaging data collection began in the early 1900s, and the data show that there has been a major drought in almost every decade of this century. Droughts in Texas are primarily the result of the presence of a strong subtropical high-pressure cell, called a Bermuda High, which becomes stationary over the state and prevents low-pressure fronts from passing through the state. Major droughts can cause stock ponds and small reservoirs to go dry and large reservoirs, such as Lake Travis, can drop their storage levels to less than one-third their capacity. The average annual runoff during the period from 1941 to 1970 ranged from 350 ac-ft/sq mi near the mouth of the Colorado River to less than 50 ac-ft/sq mi in the westernmost portion of the basin's contributing zone, which translates to an overall basin average of 81 ac-ft/sq mi. During this 30-year time period there were three major statewide droughts: 1947 to 1948, 1950 to 1957, and 1960 to 1967. These periods of drought saw average annual runoff values decrease 72 to 80 percent, to 16 to 23 ac-ft/sq mi, which resulted in record low flows in the Colorado River. The most severe of these droughts occurred from 1950 to 1957, in which 94 percent of the counties in the state were declared disaster areas. Considering the 1940 to 2013 time period, the drought of record for Region K is the period 1947 to 1957, and this drought-of-record period was used in this regional water planning effort for estimating reservoir firm yields. In some, if not all cases, the lowest single year flows in the period of record occurred in 2011 and this critical year period defines the availability of water from run-of-river water rights. The drought currently affecting Central Texas has the potential to be a new drought-of-record, and is discussed in more detail in Chapter 7 of this Plan.

The end of a drought cycle is often marked by one or more flooding events, allowing aquifers and man-made water storage facilities to recharge. The floodplains of the upper Colorado River and its tributaries are typically steep, narrow channels with rocky soils and sparse vegetative cover. During intense rain events this allows for rapid runoff, resulting in sharp-crested floods with high peak discharges and velocities. Downstream, the floodplains become wider with denser vegetation, which decreases these streamflow velocities; however, the massive volumes of water moving down the river basin can still cause a great deal of flood damage. Areas expected to be most prone to flood damage in the Lower Colorado Planning Region are along Lake Travis and Lake Austin, and the Cities of Austin, La Grange, Columbus, Wharton, and Matagorda. Historically, the coastal portion of the river basin is affected by hurricanes two of every five years. The Hill Country in Central Texas has experienced more severe flood events than any other region of the country. In fact, the continental United States record for the most intense 18-hour rainfall occurred in Williamson County in the Brazos River Basin in 1921, with 36 inches of rain. From 1843 to 1938, there were 22 major floods along the Colorado River. The most intense localized flash flood in the Lower Colorado Planning Region in recent history occurred 24 May 1981 in Austin. This storm produced a flood with a recurrence level greater than 100 years, caused $40 million in damages, and was responsible for 13 deaths. Another intense event occurred on 27 June, 2007 in Marble Falls. This storm produced a flood with a recurrence level of greater than 500 years. Most recently, the Onion Creek Watershed in Travis County experience a flood with a recurrence level greater than 100 years on October 31, 2013. The flood caused millions of dollars in damage and was responsible for several deaths.

1.2.1.3 Vegetational Areas[7]

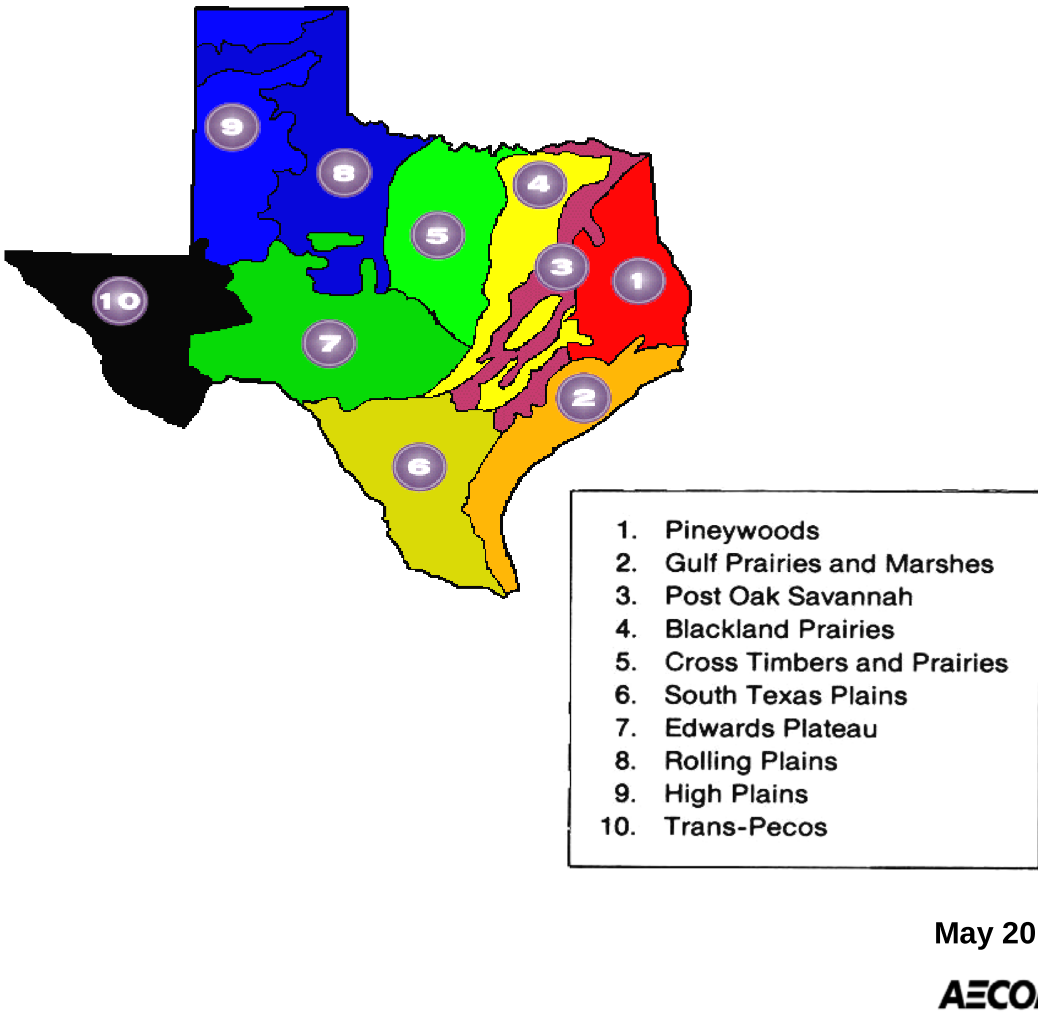
Natural regions, or vegetation areas, are based on the interaction of geology, soils, physiography, and climate. There are ten vegetational areas that cross the State of Texas and five of these intersect Region K

[7] Hatch, et al., Op. Cit., July 1990.

(*Figure 1.8*). These are the Cross Timbers and Prairies, the Edwards Plateau, the Blackland Prairies, the Post Oak Savannah, and the Gulf Prairies and Marshes. Each of these vegetation areas is described below. *Figure 1.9* shows the dominant plant species that occur in Region K.

Figure 1.8: Vegetational Areas of Texas

(Source: Dr. Stephen L. Hatch, Texas Agricultural Experiment Station)



The **Cross Timbers and Prairies** vegetational area includes all of Mills County, most of Burnet County, the north portions of San Saba and Travis Counties, and the section of Williamson County within the Lower Colorado Planning Region. This region falls within the southern extension of the Central Lowlands and the western edge of the Coastal Plains physiographic provinces. There are sharp contrasts in topography, soils, and vegetation in this region due to the wide variety of geologic formations in the area. Elevations range from 500 feet to 1,500 feet above mean sea level. Cross Timber soils are typically of the orders Mollisol and Alfisol. In the East and West Cross Timbers subregions, soils range from light, slightly acid loamy sands and sandy loams with yellowish-brown to red clayey subsoils in the upland areas to dark, neutral to calcareous clayey bottomland soils, and loamy alluvial soils along minor streambeds. The North Central Prairies subregion is interspersed with sandstone and shaley ridges and hills. Uplands are brown sandy loam to silt loam, slightly acid soils that overlay red to gray, neutral to alkaline clayey subsoils. The bottomlands have brown to dark gray, loamy, and clayey, neutral to calcareous, and alluvial soils.

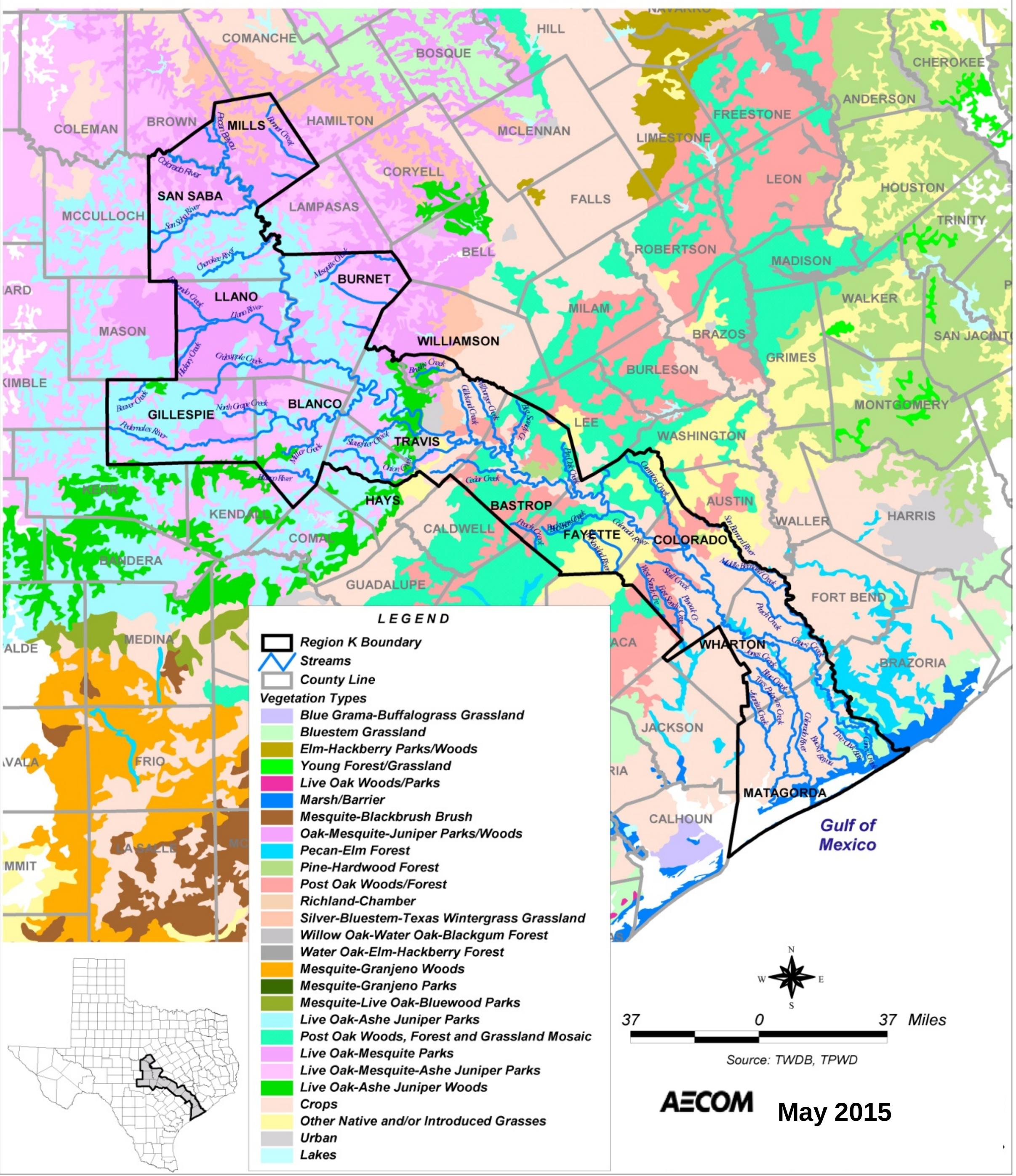
The Cross Timbers and Prairies support tallgrasses such as big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and Canada wildrye (*Elymus canadensis*), with minor populations of midgrasses and shortgrasses such as sideoats grama (*Bouteloua curtipendula*), blue grama (*B. gracilis*), hairy grama (*B. hirsuta*), Texas wintergrass (*Stipa leucotricha*), and buffalograss (*Buchloe dactyloides*). Overgrazing has allowed the midgrasses and shortgrasses to increase their range and has allowed the invasion of scrub oak (*Quercus turbinella*), honey mesquite (*Prosopis glandulosa*), and Ashe juniper (*Juniperus ashei*) in upland areas, as well as hairy tridens (*Erioneuron pilosum*), Texas grama (*Bouteloua rigidiseta*), red lovegrass (*Eragrostis secundiflora*), wild barleys (*Hordeum*), threeawns (*Aristida*), fringed-leaf paspalum (*Paspalum setaceum*), and tumble windmillgrass (*Chloris verticillata*). Bottomland trees include pecan (*Carya illinoensis*), oak (*Quercus*), and elm (*Ulmus*), with invasion of mesquite. Typical shrubs and vines include skunkbush (*Rhus aromatica*), saw greenbriar (*Smilax bona-nox*), bumelia (*Bumelia lanuginosa*), and poison ivy (*Rhus toxicodendron*).

Today, approximately 75 percent of the Cross Timbers and Prairies natural region is rangeland and pastureland. White-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), squirrel (*Sciurus spp*.), bob white quail (*Colinus virginianus*), and mourning dove (*Zenaida macroura*) are plentiful.

The **Edwards Plateau** vegetational area consists of an area of West Central Texas commonly known as the “Hill Country” and includes the entire portion of Hays County within the Lower Colorado Planning Region; all of Llano, Gillespie, and Blanco Counties; most of San Saba County; southern Burnet County; and western Travis County. The geologic formation known as the Balcones Escarpment forms the eastern and southern boundary of this region. Elevations range from 1,200 feet to over 3,000 feet above mean sea level, and the landscape is deeply dissected, hilly, rough, and well drained. Edwards Plateau soils are typically shallow Entisols, Mollisols, or Alfisols that have a variety of surface textures and are underlain by limestone.

Historically, the natural vegetation of the Edwards Plateau was grassland or open savannah-type plains with trees or brush along rocky slopes and streambeds. Tallgrasses such as cane bluestem (*Bothriochloa barbinodis*), big bluestem, little bluestem, Indiangrass, and switchgrass, are still common today along rocky outcrops and protected areas with good soil moisture. In areas with more shallow soils, tallgrasses have been replaced by midgrasses and shortgrasses such as sideoats grama, Texas grama, and buffalograss. Typical wildflowers are Engelmann daisy (*Engelmannia pinnatifida*), orange zexmania (*Wedelia hispida*), western ragweed (*Ambrosia psilostachya*), and sneezeweed (*Helenium quadridentatum*). Areas disturbed by over-grazing have been invaded by pricklypear (*Opuntia*), bitterweed (*Hymenoxys odorata*), broadleaf milkweed (*Asclepias latifolia*), smallhead sneezeweed (*H. microcephalum*), broomweeds (*Amphiachyris* and *Gutierrezia*), prairie coneflower (*Ratibida columnifera*), mealycup sage (*Salvia farinacea*), and tasajillo (*Opuntia leptocaulis*). Common woody species are live oak (*Quercus virginiana*), sand shin oak (*Quercus havardii*), post oak (*Quercus stellata*), mesquite, and juniper.

Figure 1.9: Lower Colorado Regional Water Planning Area (Region K) Vegetation Distribution



Land suitable for cultivation occurs only along narrow streams and divides within the Edwards Plateau region and in these areas tree orchards are common. The majority of the region is utilized as rangeland for the production of livestock and wildlife. This area was once one of the major wool and mohair producers in the country, providing up to 98 percent of the nation's mohair. Over the last three decades, however, many factors have contributed to the decline of the fiber industry including labor/shearer shortages, prices, changing land use, increase of predators (coyotes), and the loss of federal subsidies which had been paid by tariffs and opened foreign markets. The Edwards Plateau also supports the largest deer population in North America, and exotic big game ranches are increasing across the region.

Within Region K, the **Blackland Prairies** vegetational area occurs in eastern Travis County, several small sections of Bastrop County, western and eastern portions of Fayette County, and a minor portion of Colorado County. The characteristic topography is gently rolling hills to nearly level with well-defined contours for rapid surface drainage. Elevation varies from 250 to 700 feet above mean sea level. Major soil orders include Vertisols and Alfisols, which are naturally very productive and fertile. Upland soils are dark, calcareous, and clayey. Bottomland soils are typically reddish-brown to dark gray, slightly acid to calcareous, loamy to clayey to alluvial.

The Blackland Prairie once supported a tallgrass prairie dominated by big bluestem, little bluestem, Indiangrass, tall dropseed (*Sporobolus asper*), and Silveus dropseed (*S. silveanus*). Minor species including sideoats grama, hairy grama, Mead's sedge (*Carex meadii*), Texas wintergrass, and buffalograss have increased due to grazing pressure. Erosion and agricultural activities have decreased the productivity of these soils. Common wildflowers include asters (*Aster*), prairie bluet (*Hedyotis nigricans*), prairie-clover (*Petalostemon*), and late coneflower (*Rudbeckia serotina*). Typical legumes are snoutbeans (*Rhynchosia*), and vetch (*Vicia*). Areas disturbed by grazing and agriculture have been invaded by mesquite, huisache (*Acacia smallii*), oak, and elm trees. Oak, elm, cottonwood (*Populus deltoides*), and native pecan can be found in moist drainage areas. Isolated areas of Blackland Prairies are intermingled within the Post Oak Savannah vegetation area.

In the latter 19th and early 20th centuries, approximately 98 percent of the Blackland Prairies vegetational area had been converted to cropland. Pastureland and livestock forage cropland began to increase in the 1950s, and today only 50 percent of the area is used for cropland. Cultivated pastures make up 25 percent of the land area, and the rest is used as rangeland. Significant game species include dove, bobwhite quail, and squirrel.

The **Post Oak Savannah** vegetational area within Region K occurs in most of Bastrop and Colorado Counties and central Fayette County. The region is characterized by gently rolling, moderately dissected wooded plains with elevations between 300 feet and 800 feet above mean sea level. There are several areas of Blackland Prairie intermingled in the southern portion of the Post Oak Savannah. Typically shallow upland soils are gray, slightly acid sandy loams that overlay gray, mottled, or red, firm clayey subsoils. Infiltration-resistant claypan layers occur at varying soil depths, which impedes the percolation of moisture. Bottomland soils are reddish-brown to dark gray, slightly acid to calcareous, loamy to clayey alluvial.

Typically, short oak trees, such as post oak and blackjack oak (*Q. marilandica*), are interspersed among the tallgrass species of little bluestem, silver bluestem (*Bothriochloa saccharoides*), Indiangrass, switchgrass, and midgrass and shortgrass species of Texas wintergrass (*Stipa leucotricha*), purpletop (*Tridens flavus*), narrowleaf woodoats (*Chasmanthium sessiliflorum*), and beaked panicum (*Panicum anceps*). Elms, junipers, hickories (*Carya*), and hackberries (*Celtis*) are also common trees here. Shrubs and vines such as yaupon (*Ilex vomitoria*), American beautyberry (*Callicarpa americana*), coralberry (*Symphoricarpos orbiculatus*), greenbriar (*Smilax*), and grapes (*Vitis*) are typical. Historically, periodic wildfires have suppressed the overgrowth of brush and trees, and in their absence thickets tend to form. Wildflowers characteristic of the true prairie species include wild indigo (*Babtisia*), indigobush (*Amorpha fruticosa*), senna (*Cassia*), tickleclover (*Desmodium*), lespedezas (*Lespedeza*), prairie-clovers, western ragweed, crotons (*Croton*), and sneezeweeds.

The post oak savannah was extensively cultivated through the 1940s; however, today many acres have been returned to native habitat or tame pastureland, which have been seeded with nonnative species such as bermudagrass, bahiagrass, weeping lovegrass, and clover. The region supports game species such as deer, squirrel, and quail.

The Bastrop County Complex fire which ignited on September 4, 2011 struck Bastrop County, destroying over 1,600 residential structures and impacting 32,000 acres of land and habitat. According to Texas Parks and Wildlife officials, only 50-100 acres of the Bastrop State Park's 6,565acre premises remained undamaged following the wildfire. The endangered Houston toad was believed to have lost the vast majority of its habitat in the fire. The Lost Pines Forest, a disjunct population of loblolly pine trees thought to have originated in or before the Pleistocene era, was heavily affected by the fire.

The **Gulf Prairies and Marshes** vegetational area encompasses all of Matagorda County, the entire portion of Wharton County within Region K, and the eastern tip of Colorado County. This is a 30- to 80-mile-wide strip of lowlands adjacent to the Texas coast from the Louisiana border to the Mexico border. The landscape consists of low, wet coastal marshes, and nearly flat, undissected plains with elevations from sea level to 250 feet. Marsh soils are typically dark, poorly drained, saline and sodic, sandy loams, and clays, and light neutral sands. Prairie soils are characterized by dark, neutral to slightly acid clay loams, and clays, with a narrow belt of light acid sands and darker loamy to clayey soils along the coast. Bottomland and delta soils are typically reddish-brown to dark gray, slightly acid to calcareous, loamy to clayey alluvial.

Original Gulf Prairie vegetation consisted of tallgrasses and post oak savannah. Today, however, trees and shrubs such as honey mesquite, oaks, acacia, and bushy sea-ox-eye (*Borrichia frutescens*) have formed thickets in many areas. Characteristic tallgrasses include gulf cordgrass (*Spartina spartinae*), big bluestem, little bluestem, Indiangrass, eastern gamagrass (*Tripsacum dactyloides*), gulf muhly (*Muhlenbergia capillaris*), tanglehead (*Heteropogon contortus*), as well as *Panicum* and *Paspalum* species. Typical wildflowers include asters, Indian paintbrush (*Castilleja indivisa*), poppy mallows (*Callirhoe*), phloxs (*Phlox*), bluebonnets (*Lupinus*), and evening primroses (*Oenothera*). Common invaders such as yankeeweed (*Eupatorium compositifolium*), broomsedge bluestem (*Andropogon virginicus*), smutgrass (*Sporobolus indicus*), western ragweed, tumblegrass (*Schedonnardus paniculatus*), threeawns (*Aristida*), pricklypear, and many annual wildflowers and grasses have increased their ranges. Saline Gulf Marsh areas support species of sedges (*Carex* and *Cyperus*), rushes (*Juncus*), bulrushes (*Scirpus*), cordgrasses (*Spartina*), seashore saltgrass (*Distichlis spicata*), common reed (*Phragmites australis*), marshmillet (*Zizaniopsis miliacea*), longtom (*Paspalum lividum*), seashore dropseed (*Sporobolus virginicus*), and knotroot bristlegrass (*Setaria geniculata*). Marshmillet and maidencane (*Panicum hemitomon*) are two important freshwater grass species found in the upper coast. Typical aquatic forbs include pepperweeds (*Lepidium*), smartweeds (*Polygonum*), docks (*Rumex*), bushy seedbox (*Ludwigia alternifolia*), green parrotfeather (*Myriophyllum pinnatum*), pennyworts (*Hydrocotyle*), water lilies (*Nymphaea*), narrowleaf cattail (*Typha domingensis*), spiderworts (*Tradescantia*), and duckweeds (*Lemna*). Common halophytic herbs and shrubs found on the salty sands of the coast include spikesedges (*Eleocharis*), fimbries (*Fimbrystalis*), glassworts (*Salicornia*), sea-rockets (*Cakile*), maritime saltwort (*Batis maritima*), morning glories (*Ipomoea*), and bushy sea-ox-eye.

The low coastal marshes of the Gulf Prairies and Marshes vegetational area provide excellent habitat for upland game and waterfowl. Higher elevations of the marshes are used for livestock and wildlife production. These coastal marshes and barrier islands contain most of the State's National Seashore parks. Urban, industrial, and recreational developments have been increasing in this region and cultivation has never been of much importance due to the saline soils and recurrent flooding of the area. However, approximately one-third of the inland prairies region is cultivated. This is also the major area of irrigated crop production, consisting primarily of rice cultivation, for the entire Lower Colorado Region. Bermudagrass and several bluestem species are common in tamed pasturelands. The Gulf Prairies and Marshes region has seen more industrialization than anywhere in Texas since World War II.

1.2.1.4 Water Resources[8, 9]

The primary surface water feature of Region K is the Colorado River. *Figure 1.10* displays the surface water hydrology characteristics of the region. The major sources of dependable surface water supplies in the region are the Highland Lakes reservoir system and the run-of-the-river (ROR) water from the Colorado River. ROR water rights allow permit holders to divert water directly from a watercourse up to their permitted amounts if the water is present in the river and after downstream senior priority rights are satisfied. Tributary ROR water rights and off-channel storage are also utilized by several water user groups (WUGs). In addition, a small portion of the planning region's surface water supply comes from local supplies within adjacent river basins. There are 16 water supply reservoirs within the Region K boundaries: Goldthwaite, Blanco, Llano (2), Lometa, STP, and Cedar Creek reservoirs, Lake Bastrop, Lady Bird Lake, Lake Walter E. Long, and the Highland Lakes System (Lakes Buchanan, Inks, LBJ, Marble Falls, Travis, and Austin). The major Colorado River ROR water rights holders (based on firm yield) in Region K are the Lower Colorado River Authority (LCRA), City of Austin (COA), and STP Nuclear Operating Company. The City of Corpus Christi, located in Region N, and the Colorado River Municipal Water District, located in Region F immediately upstream of Region K, are also major water right holders on the Colorado River. Region K also has many springs, which are the transition from groundwater to surface water. Overall, there are approximately 43 major and significant springs in Region K, with 19 of those in San Saba County. Other counties with significant springs include Bastrop, Blanco, Burnet, Fayette, Gillespie, Hays, Llano, and Travis. For more information on the springs within Region K, please refer to *Texas Water Development Board Report 189: Major and Historical Springs of Texas, by Gunnar Brune, March 1975*.

Large quantities of fresh to slightly saline groundwater underlie more than 81 percent of the land in Texas. There are nine "major" aquifers that can produce large quantities of water over a large area, and 21 "minor" aquifers that yield smaller amounts of water over smaller geographic areas. At present, 56 percent of the State's annual water consumption is derived from the State's major and minor aquifers, 75 percent of which is used for agriculture. Of these 30 aquifers, five major and six minor aquifers occur within Region K. The five major aquifers are the Carrizo-Wilcox, Edwards (Balcones Fault Zone [BFZ]), Edwards-Trinity (Plateau), Gulf Coast, and Trinity (*Figure 1.11*). These aquifers tend to run in curved belts northeast to southwest across the state.

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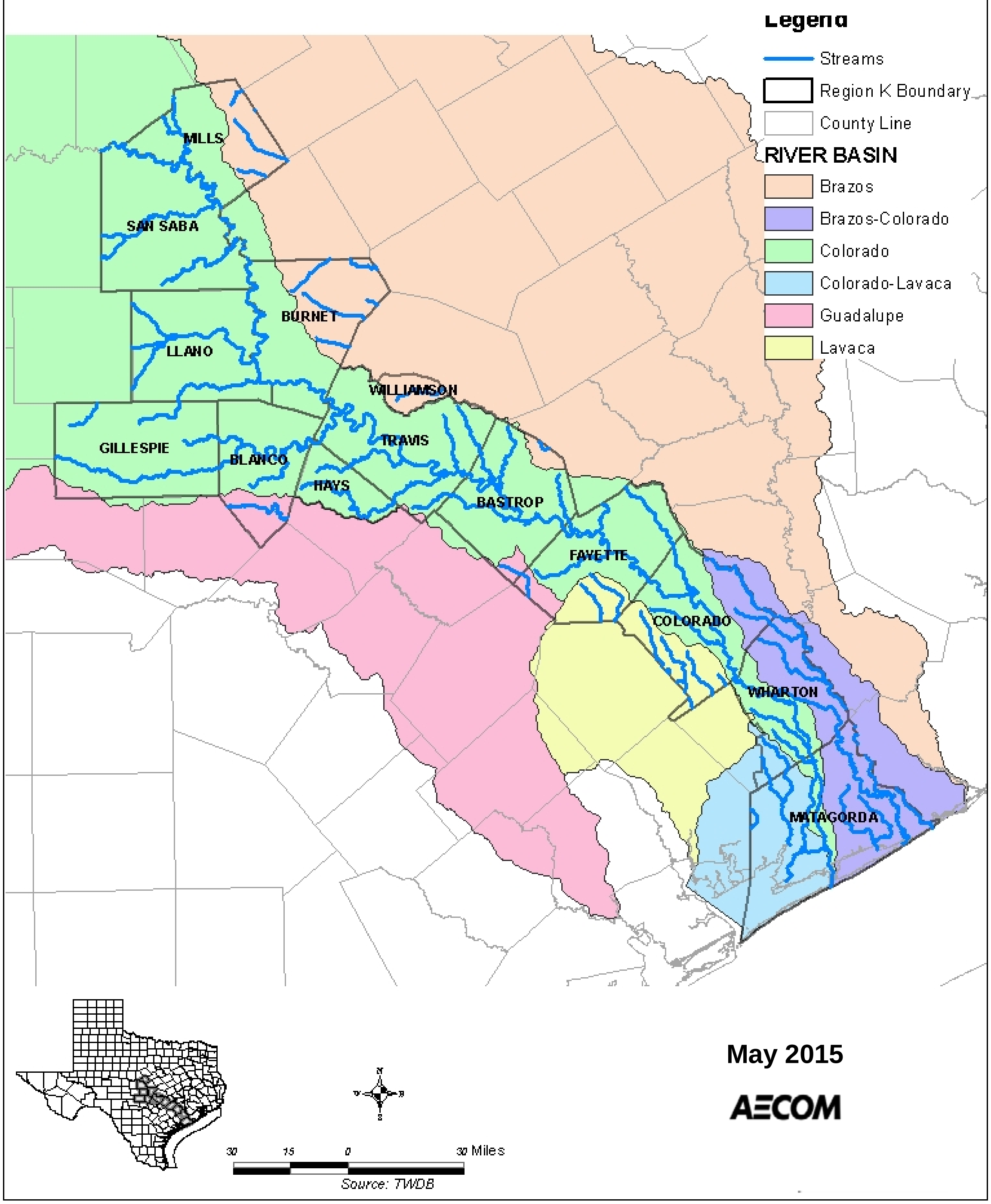
[8] Dallas Morning News, 1999. *Texas Almanac 2000-2001, 60th Edition*, Texas A&M Press.
[9] Texas Water Development Board (TWDB), November 1995. *Aquifers of Texas, Report 345*.

Figure 1.10: Lower Colorado Regional Water Planning Area (Region K) Surface Water Hydrology



The northern most major aquifer in Region K is the Trinity, which has both unconfined water-table and pressurized artesian zones, and covers portions of Mills, Burnet, Gillespie, Blanco, Travis, Hays, and Bastrop Counties. Within the region, the Trinity aquifer contains two major early Cretaceous age formations: the Antlers formation, which consists of a maximum of 900 feet of sand and gravel, with clay beds in the middle section; and the Travis Peak formation, which contains calcareous sands and silts, conglomerates, and limestones. West of the Trinity aquifer in Gillespie County is a small eastern water-table portion of the Edwards-Trinity (Plateau) aquifer. Within the planning region, the Edwards-Trinity (Plateau) aquifer contains saturated sediments of lower Cretaceous age formations and overlying limestones and dolomites. Maximum saturated thickness of the aquifer is 800 feet; however, the eastern portion of the aquifer in Gillespie County is thinner. Overlying a portion of the Trinity artesian zone is the Edwards (BFZ) aquifer, which covers portions of Hays, Travis, and Williamson Counties within Region K. In this area, the aquifer contains both unconfined and artesian zones and feeds the well-known recreational Barton Springs, which contributes an estimated average of 50 cubic feet per second (cfs) of flow to the Colorado River. The Edwards BFZ is primarily composed of early Cretaceous age limestone deposits that have a thickness ranging between 200 feet and 600 feet. This aquifer has a high permeability and transmissivity, making it heavily dependent on consistent recharge and extremely sensitive to environmental stresses. Southeast of the Trinity is the Carrizo-Wilcox aquifer in portions of Bastrop and Fayette Counties. This aquifer contains both water-table and artesian zones and consists of two hydrologically connected formations, the Wilcox Group and the overlying Carrizo formation, which are predominantly composed of Tertiary age sand that is imbedded with gravel, silt, clay, and lignite. The thickness of the artesian zone ranges from 200 feet to 3,000 feet. The southernmost and largest major aquifer within Region K is the Gulf Coast aquifer, which stretches continuously from southeastern Fayette County through Matagorda County. This portion of the aquifer is described as a leaky artesian system, which is composed of Cenozoic age complex interbedded clays, silts, sands, and gravel. In some areas near the Gulf Coast, heavy pumping has caused the intrusion of saltwater into aquifer layers that previously had good water quality. The physical characteristics of this aquifer make it susceptible to dewatering, or a permanent compaction of the clay layer and loss of water storage capacity, as a result of overuse of the aquifer. This compaction can also cause subsidence of surface land overlying the aquifer, which can contribute to flood and structural damage in the area.

The minor aquifers occurring within Region K are the Ellenburger-San Saba, Hickory, Marble Falls, Queen City, Sparta, and Yegua-Jackson (*Figure 1.12*). All six of these aquifers contain unconfined zones and pressurized artesian zones. The Ellenburger-San Saba, Hickory, and Marble Falls aquifers occur in the northwestern portion of the planning region, have discontinuous circular coverage areas, and overlap one another. The Hickory aquifer is composed of the Hickory Sandstone Member of the Cambrian Riley formation, which contains some of the oldest sedimentary rocks found in Texas. This aquifer has a maximum thickness of 480 feet. The Ellenburger-San Saba aquifer has the same general shape as the Hickory and is composed of late Cambrian age limestone and dolomite. San Saba Springs is thought to be supplied primarily by the Ellenburger-San Saba and Marble Falls aquifers, which may be hydrologically connected in some areas. The Marble Falls aquifer occurs in several disconnected outcrops of Pennsylvanian age limestone that form fractures, solution cavities, and channels. The maximum thickness of this aquifer is 600 feet. Numerous large springs are fed by the Marble Falls aquifer, which provide a substantial portion of baseflow to the San Saba and Colorado Rivers in San Saba County. The Queen City, Sparta, and Yegua-Jackson aquifers overlap one another across southeastern Bastrop and northwestern Fayette Counties. The Queen City aquifer is composed of Tertiary age sand, loosely cemented sandstone, and interbedded clay. The maximum thickness of this aquifer is less than 500 feet. The Sparta aquifer overlies the downdip portion of the Queen City aquifer and consists of

Tertiary age sand and interbedded clay. The Yegua-Jackson aquifer consists of interbedded sands, silts, and clays.

Figure 1.11: Lower Colorado Regional Water Planning Area (Region K) Major Aquifers

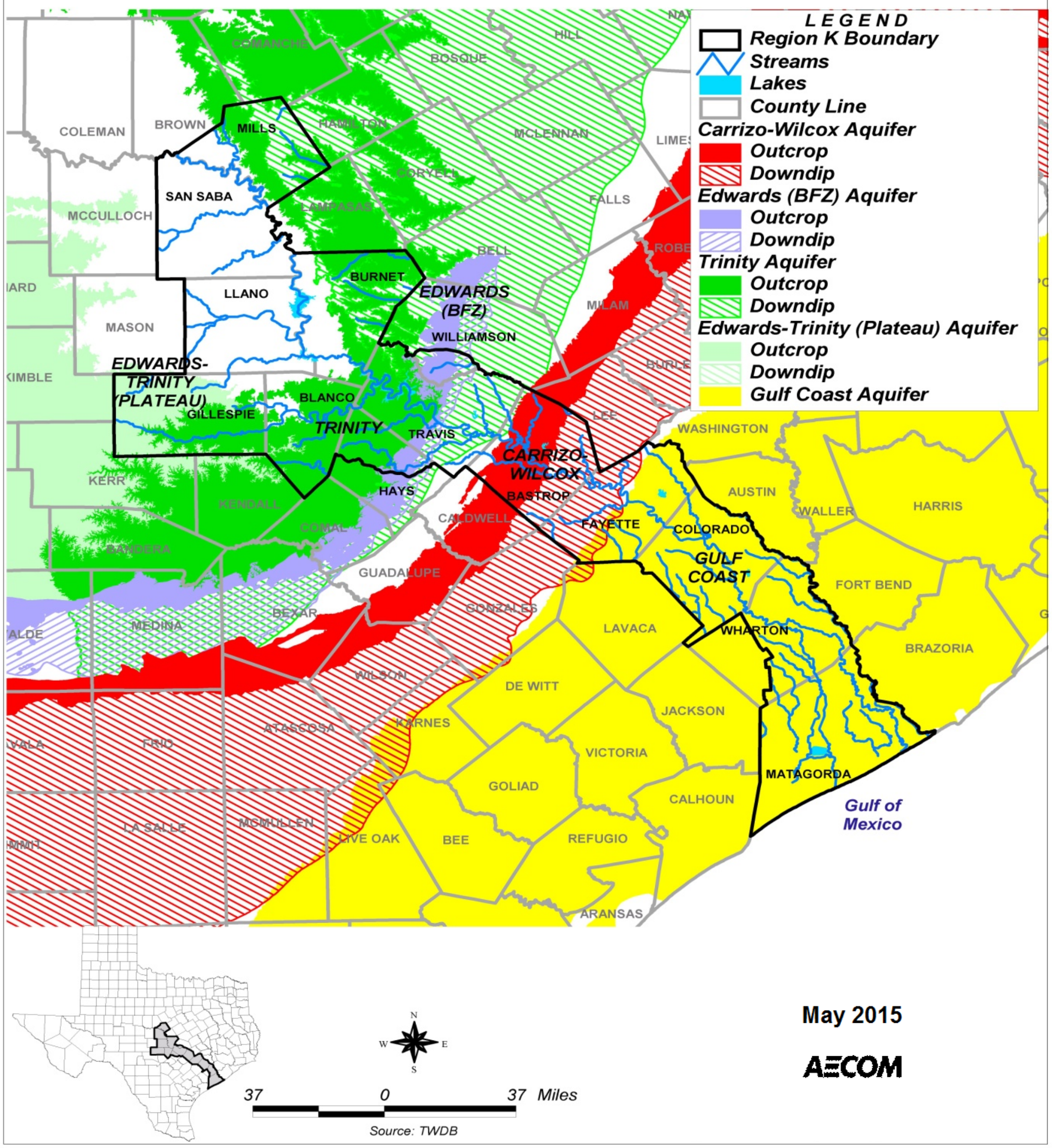
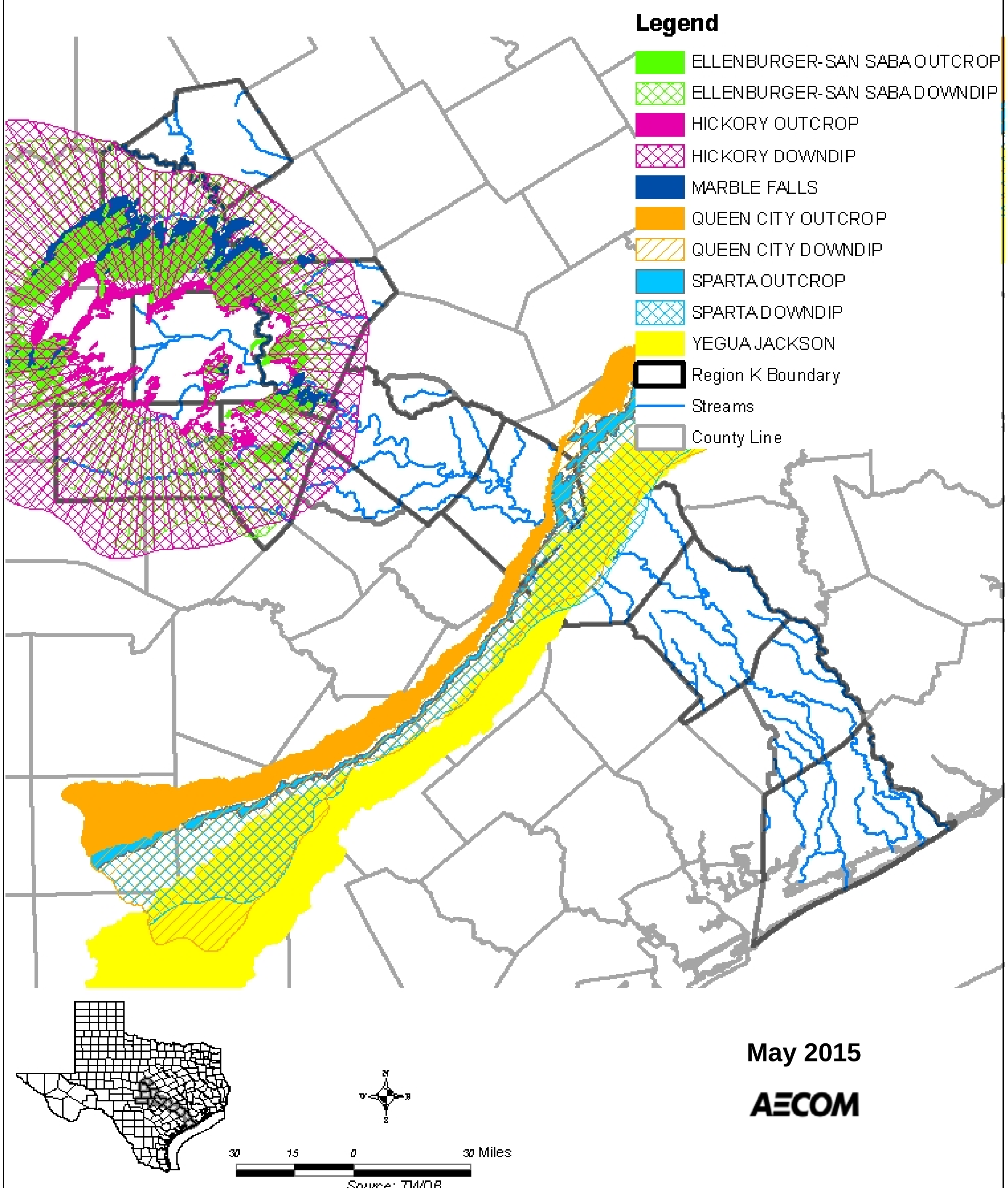


Figure 1.12: Lower Colorado Regional Water Planning Area (Region K) Minor Aquifers



Surface water and groundwater supply availabilities for Region K are discussed in Chapter 3 of this report.

1.2.1.5 Land Resources[10]

The majority of Region K falls within the Colorado River Basin and 92 percent of the region's population resides in this portion of the basin. Land use (*Figure 1.13*) in Region K consists primarily of agricultural land in Matagorda, Wharton, Colorado, Fayette, and eastern Travis Counties. Forestland runs through the middle of Colorado and Fayette Counties; western Travis and Burnet Counties; southeastern Llano County; and a significant portion of Gillespie and Hays Counties. Rangeland predominates in Mills, San Saba, northwestern Llano, and eastern Burnet Counties. Blanco County is primarily a mixture of forestland and rangeland. Bastrop County is a mixture of forestland, agricultural land, and rangeland. A significant concentration of urban land only occurs in the Austin metropolitan area.

The State of Texas has 123 state parks and 14 of these, with a total of 28,316 acres, occur within the counties of Region K (*Table 1.2*). The Texas State Park System offers a variety of recreational and educational opportunities, including camping, hiking, fishing, boating, water skiing, swimming, wildlife viewing, picnicking, and tours of nature exhibits and historical sites.

1.2.1.6 Wildlife Resources[11]

There are 17 national wildlife refuges in Texas, comprising over 470,000 acres, and four of these occur within Region K (67,468 acres). Refuges function to preserve and protect critical wildlife habitat for unique, rare, threatened, and/or endangered species. Many refuges allow bird and wildlife viewing, hunting, and fishing during specific times of the year. In addition, the Texas Parks & Wildlife Department (TPWD) currently manages 51 Wildlife Management Areas (WMAs) in the state with a total of 756,464 acres. Two WMAs lie within Region K and encompass approximately 7,500 acres. These areas preserve and manage quality wildlife habitat and can allow compatible activities such as research, hunting, fishing, hiking, camping, bicycling, and horseback riding. *Table 1.3* lists the wildlife refuges and management areas within Region K.

Region K hosts a diversity of plant and animal wildlife species. In addition to the more commonly found species, each county within Region K provides habitat for several threatened or endangered animal and plant species. Endangered species are those at risk of extinction. Threatened species are those likely to become endangered in the future. These designations are made at the state and federal level by the TPWD and the U.S. Fish and Wildlife Service (USFWS). State and federal threatened and endangered species listings for each county in Region K are presented in *Appendix 1A*. Rare species that are not listed as threatened or endangered are also included.

[10] Dallas Morning News (Texas Almanac 2004–2005).
[11] Dallas Morning News (Texas Almanac 2004–2005).

Table 1.2 State Parks Located Within the Lower Colorado Region

Name	County	Acreage	Description
Admiral Nimitz Museum and Historical Center	Gillespie	7	Established in 1969 and contains special exhibits from World War II.
Bastrop State Park	Bastrop	6,565	Established between 1933 and 1935 and contains the "Lost Pines" isolated region of loblolly pine and hardwoods. The Bastrop County Complex fire in September 2011 affected 96 percent of the park, including significant impact to the Lost Pines ecosystem and the loblolly pines.
Blanco State Park	Blanco	105	Established in 1933 along the Blanco River and has fishing for winter rainbow trout, perch, catfish, and bass.
Buescher State Park	Bastrop	1,017	Established between 1933 and 1936 and was part of Stephen F. Austin's colonial grant; an estimated 250 species of birds can be found in the park.
Colorado Bend State Park	San Saba	5,328	Established in 1984 and part is in Lampasas Co.; contains scenic Gorman Falls and is home to rare and endangered species including the bald eagle, golden-cheeked warbler, and black-capped vireo.
Enchanted Rock State Park	Gillespie and Llano	1,644	Established in 1978 along Big Sandy Creek and contains a large granite outcrop that is the second largest batholith in the U.S. Enchanted Rock is also a national natural landmark and a national historic site.
Inks Lake State Park	Burnet	1,202	Established in 1940 along Inks Lake.
Lake Bastrop S. Shore Park	Bastrop	773	Established in 1989.
Longhorn Cavern State Park	Burnet	646	Established between 1932 and 1937 and was dedicated as a natural landmark in 1971. The cave has been used as a shelter since prehistoric times.
LBJ State Historical Park	Gillespie	733	Established in 1965 along the banks of the Pedernales River; contains LBJ's home and a portion of the official Texas Longhorn herd, as well as bison, deer, and wild turkey; living-history demonstrations at the restored Sauer-Beckmann house.
Matagorda Island State Park	Matagorda	7,325	A natural accreting barrier island located offshore between Port O'Conner and Fulton and is home to a variety of migratory and resident wildlife, including 18 state or federally listed endangered species.
McKinney Falls State Park	Travis	744	Established in 1970.
Monument Hill State Historical Park/Kreische Brewery State Historical Park	Fayette	40/36	Established in 1907/1977. Memorial to the Salado Creek Battle in 1842 and the "black bean lottery" of the Mier Expedition; and one of the first breweries in the state.
Pedernales Falls State Park	Blanco	5,212	Established in 1970 and has typical Edwards Plateau terrain with live oaks, deer, turkey, and stone hills.

Figure 1.13: Lower Colorado Regional Water Planning Area (Region K) Land Use Distribution

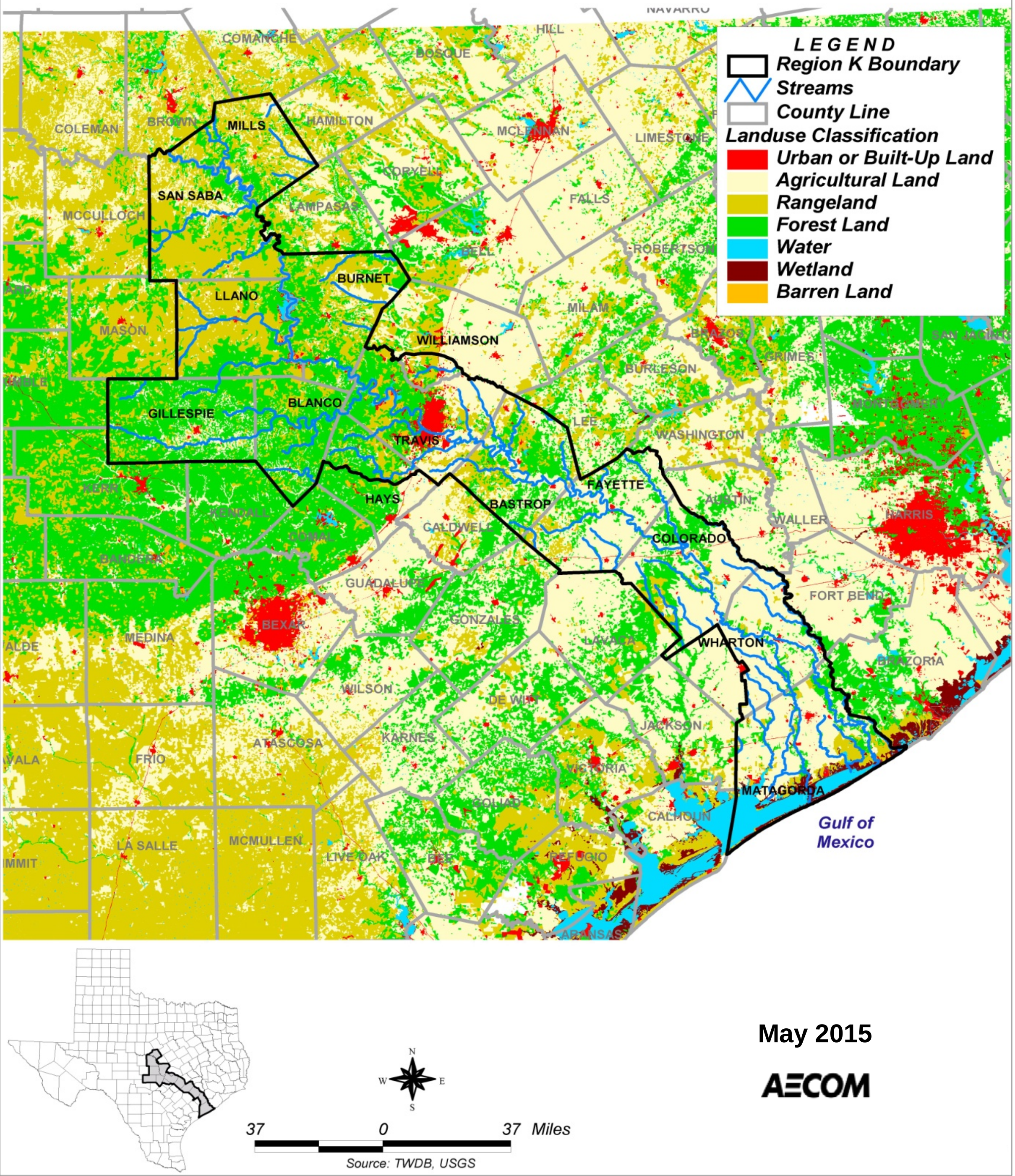


Table 1.3 Wildlife Refuges/Management Areas Located Within the Lower Colorado Region

Name	County	Acreage	Description
National Wildlife Refuges			
Attwater Prairie Chicken[1]	Colorado	10,528	Established in 1972 to preserve habitat for the endangered Attwater Prairie Chicken, which includes native tallgrass prairie, potholes, sandy knolls, marshes, and some wooded areas.
Balcones Canyonlands[2]	Travis	45,958	Established in 1992 northwest of Austin to protect the nesting habitat of two endangered bird species: golden-cheeked warbler and the black-capped vireo. The refuge will eventually encompass 46,000 acres of oak-juniper woodlands and other habitats.
Big Boggy[3]	Matagorda	5,000	Established in 1983 along the coast of Texas in southeastern Matagorda County to conserve key coastal wetlands for Neotropical migratory birds and shorebirds in spring and fall, as well as for winteringfowl and year-round wildlife.
San Bernard[4]	Matagorda	54,000	Established in 1968 near Freeport which attracts white-fronted and Canada geese and several species of duck
Wildlife Management Areas			
Mad Island[5]	Matagorda	7,281	This area allows hunting and wildlife viewing.
D. R. Wintermann WMA[6]	Wharton	246	This area has restricted access.

[1] U.S. Fish & Wildlife Service (URL: http://www.fws.gov/refuge/attwater_prairie_chicken/faqs.html)
[2] Balcones Canyonlands National Wildlife Refuge (URL: http://www.wikipedia.org)
[3] Big Boggy National Wildlife Refuge (URL: http://wikipedia.org)
[4] U.S. Fish & Wildlife Service (URL: http://www.fws.gov/refuge/San_Bernard/faqs.html)
[5] Texas Parks & Wildlife (URL: http://www.tpwd.state.tx.us/huntwild/hunt/public/lands/table_contents/media/729.pdf)
[6] Texas Parks & Wildlife (URL: http://www.tpwd.state.tx.us/huntwild/hunt/wma/find_a_wma/list/?id=44)

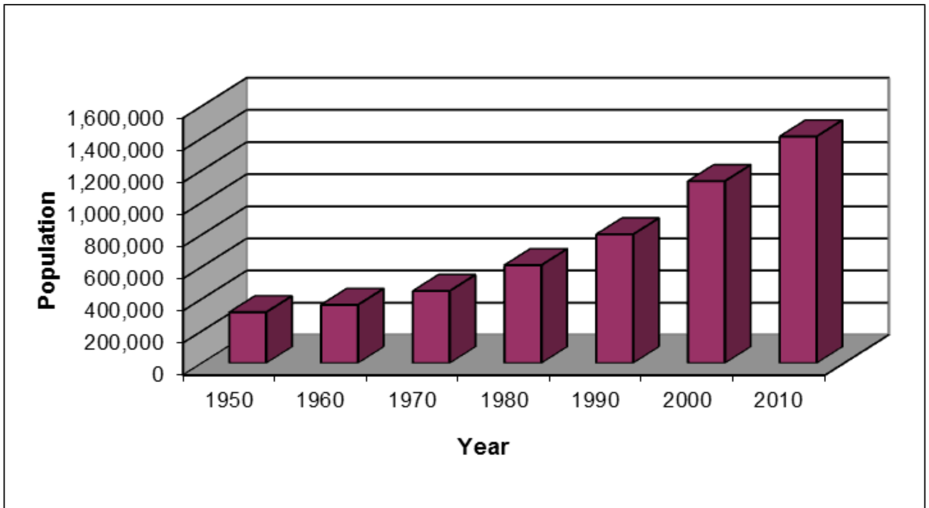
1.2.2 Socioeconomic Characteristics of the Lower Colorado Regional Water Planning Area

1.2.2.1 Historic and Current Population Trends[12]

Region K has had a steady increase in population from 1950 to the present. As *Figure 1.14* shows, in 1950 there were approximately 316,573 people, which has increased to an estimated 1,410,328 people in 2010. This corresponds to an overall 345 percent increase in the number of people living in the region during that time period. The period from 1990 to 2000 had the largest percent increase of almost 41 percent, or an addition of 331,199 people. The time period of smallest population growth occurred between 1950 and 1960, with an increase of 45,830 persons (14.5 percent). As discussed in Chapter 2, this growth trend is expected to continue for the entire State of Texas, as well as Region K. For the period 2020 to 2070, a compound annual growth rate of 1.26 percent is projected, resulting in a total regional population of 3,243,127 in 2070.

[12] Bureau of the Census, Decadal Censuses of 1950, 1960, 1970, 1980, 1990 and 2000; and Region K historic population data supplied by the Texas Water Development Board for 1980–2010. The Region K 2020 Population projections were developed utilizing year 2010 census data as a starting point with adjustments made by the LCRWPG as necessary. Populations for the Partial Region K counties of Hays, Williamson, and Wharton were estimated by determining the percent decreases observed in projections from the U.S. Census and the TWDB for 1980 and 1990; these percent decreases were then averaged and applied to the 1950, 1960, and 1970 U.S. Census partial-county populations.

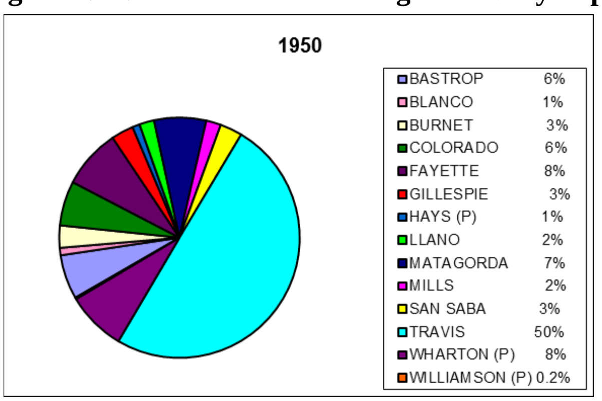
Figure 1.14: Historic Lower Colorado Regional Water Planning Area Population[1]

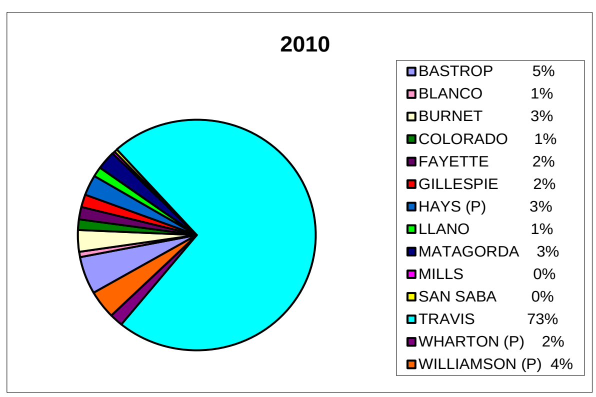


[1] Texas Water Development Board (URL: http://www.twdb.texas.gov/waterplanning/waterusesurvey/estimates/index.asp)
(Water Planning. County Summary, 2000 and Later)

Comparison of the region's county population distribution between 1950 and 2010 (*Figure 1.15*) shows that Travis County contains the majority of the region's population. Travis County's proportion of population compared to the region has increased from 50 percent in 1950 to 73 percent in 2010 due to the rapid growth of the Austin area. Travis County's population has increased more than 500 percent between 1950 and 2010, with the addition of over 800,000 people. Hays County has also seen a large population increase with over twelve times as many people living in the county in 2010 as in 1950. The Region K portion of Williamson County has shown an even larger percent increase in population as well, with a 2010 population 85 times the size of the 1950 population. Other counties in the region have experienced much smaller growth rates, historically.

Figure 1.15: Lower Colorado Region County Population Distribution[1]





[1] Texas Water Development Board (URL: http://www.twdb.texas.gov/waterplanning/waterusesurvey/estimates/index.asp)
(Water Planning. County Summary, 2000 and Later)

Recent population growth, since the year 2000, of the Austin metropolitan area has expanded from Travis County into Bastrop County, Hays County, and Williamson County. With the recent construction of the SH 130 and SH 45 corridors in Travis County, travel between counties has become easier and thus is facilitating increased population growth within a larger radius of the City of Austin. Increased development surrounding the corridors should continue for the next several decades. Areas surrounding the Highland Lakes are also seeing larger increases in population growth, specifically Burnet County and Llano County.

1.2.2.2 Primary Economic Activities[13, 14]

Economic activities in Region K include agriculture, government/services, manufacturing, mining, tourism, and trades. *Table 1.4* lists the primary economic base of each county as well as the breakdown of mining and agricultural activities.

Table 1.4 Lower Colorado Region Primary Economic Activities by County

County	Primary Economic Base	Mineral Deposits	Agriculture
Bastrop	government/services, tourism, agribusiness, bio-technology research, computer equipment	clay, oil, gas, lignite	hay, beef cattle, horses, goats, pecans, pine, oak
Blanco	tourism, agribusiness, ranch supplies and equipment manufacturing, hunting/fishing	insignificant	cattle, sheep, goats, hay, vegetables, wheat, peaches, pecans, greenhouse nurseries
Burnet	stone processing, manufacturing, tourism, hunting	granite, limestone, graphite	cattle, goats, hay, hunting,
Colorado	agribusiness, oilfield services/ equipment, manufacturing, mineral processing	gas, oil	rice, cattle, nursery, corn, poultry, hay, sorghum,
Fayette	agribusiness, tourism, electrical power generation, mineral production, small manufacturing, government/services	oil, gas, sand, gravel, bentonite, clay	beef cattle, corn, sorghum, peanuts, hay, pecans
Gillespie	agribusiness, tourism, government/ services, food processing, hunting, small manufacturing, granite processing	sand, gravel, gypsum, limestone	beef cattle, turkeys, sheep, goats, peaches, hay, sorghum, oats, wheat, grapes
Hays (p)	tourism, retirement, some manufacturing	sand, gravel, cement	beef cattle, goats, exotic wildlife, greenhouse nurseries, hay, corn, sorghum, wheat, cotton
Llano	tourism, retirement, ranch commerce center, vineyards, granite mining	granite, vermiculite, llanite	beef cattle, sheep, goats
Matagorda	petroleum operations, petrochemicals, agribusiness, varied manufacturing, significant tourism, electrical power generation	gas, oil, salt	major rice-growing area, cotton, turfgrass, grains, corn, cattle, catfish
Mills	agribusiness, hunting	insignificant	beef cattle, sheep, goats, pecans
San Saba	retail pecan industry, tourism, hunting, government/ services	Limestone, rock, quarry	cattle, sheep, goats, pecans, wheat, hay
Travis	education, state government, tourism, research, industries, conventions	Lime, stone, sand, gravel, oil, gas	cattle, nursery crops, hogs, sorghum, corn, cotton, small grains, pecans
Wharton (p)	oil, agribusiness, hunting, varied manufacturing, government/services	oil, gas	leading rice producing county, cotton, milo, corn, sorghum, soybeans, turfgrass, eggs, beef cattle, rice, aquaculture
Williamson (p)	agribusiness, varied manufacturing, government/services, education	stone, sand, gravel	beef cattle, sorghum, cotton, corn, wheat

(p) - a portion of the county lies within the REGION K boundaries

[13] Dallas Morning News (Texas Almanac 2004–2005),.
[14] Texas Comptroller of Public Accounts, Texas Economy, www.window.state.tx.us/ecodata/regional/.

Agriculture plays a major role in most of the counties in Region K. Livestock accounts for more than 60 percent of the planning region's agricultural cash receipts and important crops include rice, hay, wheat, and cotton. The counties located in the northwestern portion of the planning region depend heavily on livestock production. Rice is the major crop produced in the southernmost counties of Colorado, Wharton, and Matagorda.

The manufacturing sector consists primarily of the technology and semiconductor industries, in the mid-region counties of Bastrop, Travis, and Williamson. The largest single manufacturing industry in the coastal counties is petroleum refining and petrochemicals. Electrical generation is a notable industry in Matagorda County. The South Texas Project Electric Generating Station provides generation capacity to serve more than 2 million homes as well as being the largest employer and source of revenue for the county. At the same time, there has been significant economic growth in food processing, lumber, wood products, and construction supplies for the coastal counties. The tourism industry represents an important economic sector that is heavily dependent on water resources in Llano, Burnet, and Travis Counties. *Appendix 1B* includes background information on the history and social and economic importance of the Highland Lakes, as provided by a stakeholder interest group within Region K.

Population and economic estimates are presented in *Table 1.5* for the Lower Colorado Region by county.

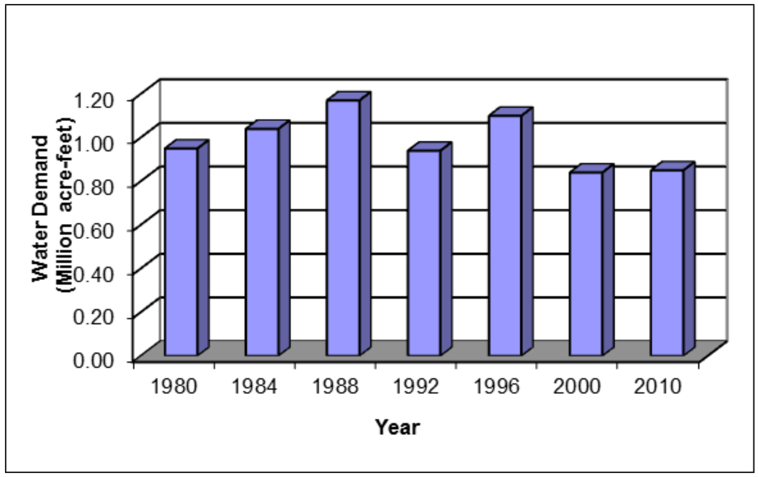
Table 1.5 Lower Colorado Region County Population and Economic Estimates

County Name	2010 Resident Population [1]	Per Capita (2012 dollars) 2008-2012 Personal Income [1]		CY 2008-2012	CY 2008-2012 Poverty [2]	Average Labor Force Employment and Unemployment [3]			
		Per Capita ($)	Total (millions $)	Median Household Income ($)[2]	Poverty Rate (%)	Labor Force	Persons Employed	Persons Un-employed	Unemploy-ment Rate (%)
Bastrop	74,171	$23,940	$1,776	$ 52,516	*14.1*	35,166	32,244	2,922	8.3
Blanco	10,497	$27,014	$284	*$46,881*	*9.3*	5,205	4,880	325	6.2
Burnet	42,750	$24,991	$1,068	$49,047	15.6	22,766	21,367	1,399	6.1
Colorado	20,874	$24,706	$516	$43,273	16.8	10,826	10,038	788	7.3
Fayette	24,554	$27,520	$676	$45,478	14.5	12,385	11,645	740	6.0
Gillespie	24,837	$29,178	$725	$55,017	9.3	13,962	13,291	671	4.8
Hays	157,107	$26,662	$4,189	$57,834	16.8	82,604	76,891	5,713	6.9
Llano	19,301	$33,905	$654	*$45,533*	*14.1*	8,512	7,863	649	7.6
Matagorda	36,702	$23,079	$847	$43,146	19.2	18,468	16,393	2,075	11.2
Mills	4,936	$19,556	$97	*$34,984*	*16.4*	2,392	2,252	140	5.9
San Saba	6,131	$18,316	$112	*$37,230*	*19.1*	2,369	2,196	173	7.3
Travis	1,024,266	$32,777	$33,572	$56,403	17.4	565,502	526,300	39,202	6.9
Wharton	41,280	$21,353	$881	$40,988	18.5	21,519	19,684	1,835	8.5
Williamson	422,679	$30,540	$12,909	$70,849	6.8	222,793	206,678	16,115	7.2
Region K [4]	1,910,085	$30525	$58,305	-	-	1,024,469	951,722	72,747	7.1
Texas	25,145,561	$25,809	$648,982	$51,563	17.4	12,287,566	11,280,558	1,007,008	8.2

[1] U.S. Bureau of the Census (URL: http://factfinder2.census.gov) (Fact Sheet for community profiles.)
[2] U.S. Bureau of the Census (URL: http://quickfacts.census.gov) (State & County QuickFacts profiles.)
[3] Texas Workforce Commission (URL: http://www.tracer2.com/)
[4] Includes all of Hays, Wharton, and Williamson Counties.

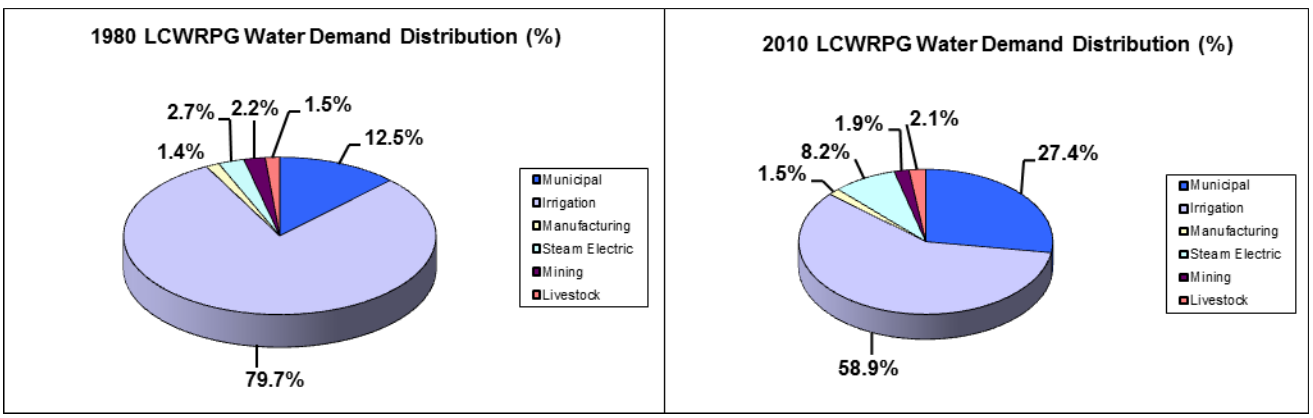
1.2.2.3 Historical Water Uses[15, 16]

Figure 1.16: Lower Colorado Regional Water Planning Area Historical Water Demand[15]



Total annual water use in the Lower Colorado Regional Planning Area has decreased approximately 10 percent from 1980 to 2010 (*Figure 1.16*). A peak water use of 1.17 million ac-ft occurred in 1988. Water demand in each year is impacted by many factors, including rainfall and can show fluctuation from year to year. Recent years have demonstrated that, as 2011 water use neared the 1988 level at 1.15 million ac-ft, due to drought conditions with corresponding high municipal and agricultural irrigation use. In 2012 water use saw a low of 0.65 million ac-ft due mostly to emergency curtailment of agricultural irrigation and implementation of municipal drought contingency plans. Relative water use distribution, by water use category, has remained relatively similar between 1980 and 2010 (*Figure 1.17*). Irrigation is the largest water use in Region K, which accounted for almost 80 percent of water use in 1980 and 59 percent in 2010. Municipal has consistently been the second largest water use since 1980, followed by steam-electric power, mining, manufacturing, and livestock water uses.

Figure 1.17: Lower Colorado Region User Group Water Demand Distribution[15, 16]



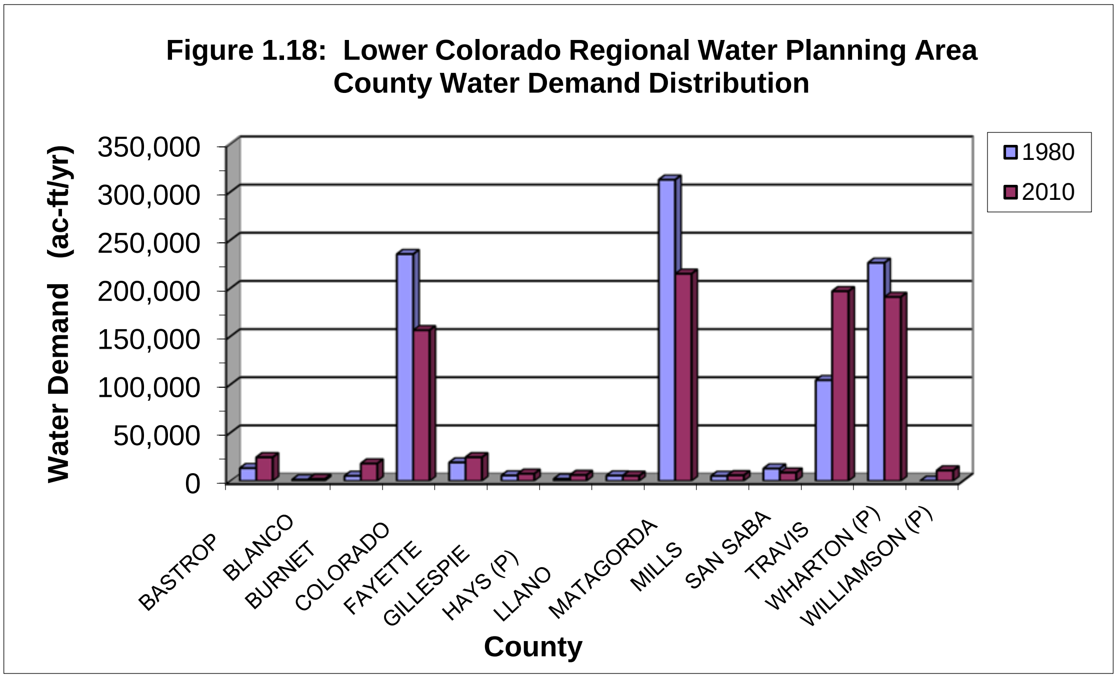
When comparing 1980 demands to 2010 demands, irrigation water demands show a 34 percent decrease, municipal demands show a 97 percent increase, livestock demands show 27 percent increase, mining demands show a 23 percent decrease, and manufacturing demands show a 6 percent decrease. Steam-electric power generation shows the largest water demand increase of 171 percent.

[15] Texas Water Development Board (URL: http://www.twdb.texas.gov/waterplanning/waterusessurvey/estimates/index.asp) (Water Planning. State/Planning Region (map))

[16] Texas Water Development Board (URL: http://www.twdb.texas.gov/waterplanning/waterusessurvey/estimates/index.asp) (Water Planning. County Summary, 2000 and Later)

The water demand distribution between the 14 counties in Region K shows that when comparing water demands for 1980 and 2010, demand was consistently the greatest in Matagorda County, which accounted for approximately 33 percent of the region's total water demand in 1980 and 25 percent in 2010 (*Figure 1.18*). The major water use in Matagorda County is rice irrigation. Colorado and Wharton Counties are among the largest water users in the region, which is also attributed to the extensive rice irrigation in these counties. Travis County contains the region's only major demand center, and its water use ranked fourth overall in 1980 and second overall in 2010. Overall, these four counties account for approximately 93 and 87 percent of the region's total water demand, respectively, for 1980 and 2010. Details of Region K's projected future water demands are presented in Chapter 2.

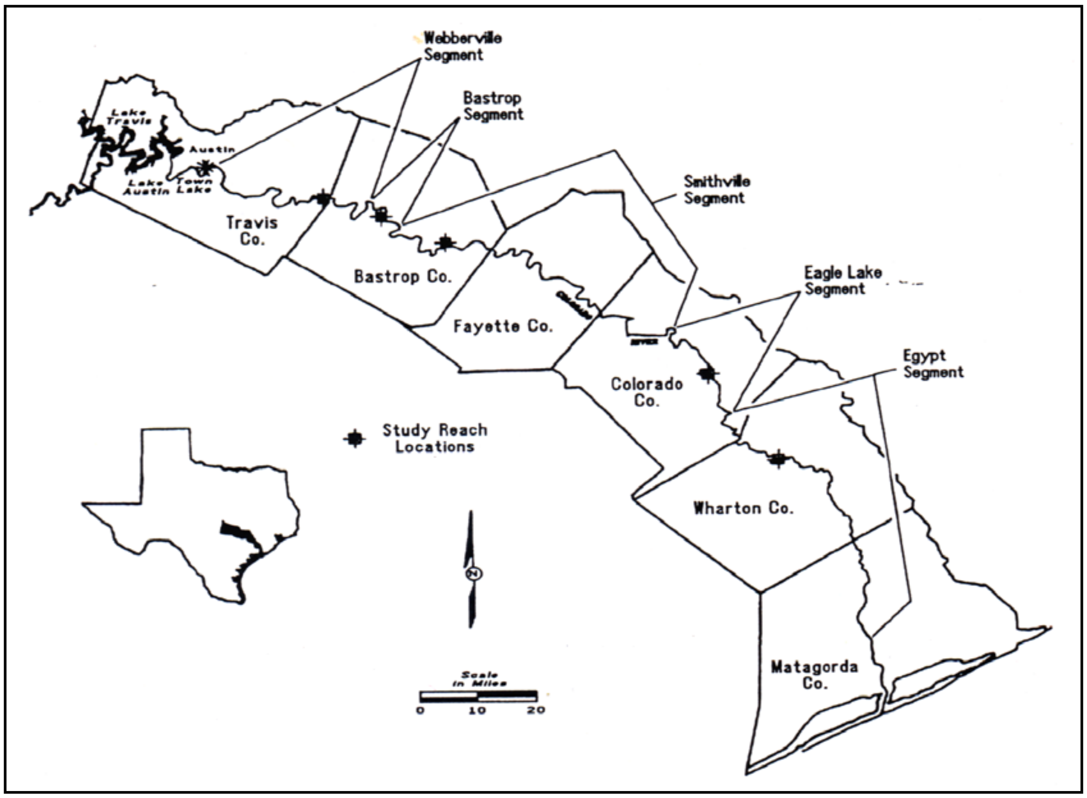
Figure 1.18: Lower Colorado Regional Water Planning Area County Water Demand Distribution[16]



Flows for the maintenance of important environmental resources are also a significant water use within the free-flowing reaches of streams in Region K. Free-flowing reaches above the Highland Lakes in San Saba and Mills Counties are dependent on rainfall, springflow and water releases from Stacy Dam at O.H. Ivie Reservoir, which is outside Region K and is under the control of the Colorado River Municipal Water District within Region F. A management plan was implemented in this area, between O. H. Ivie Reservoir and Lake Buchanan, to protect the federally endangered Concho Water Snake. Minimum continuous instream flow releases from Stacy Dam were required by the USFWS as a mitigation component to obtain a Section 404 permit from the U.S. Army Corps of Engineers (USACE) in order to build Stacy Dam. The management plan also specified that once every 2 years Stacy Dam will release a 2-day 2,500 cfs instream flow to provide channel maintenance for the water snake habitat. The Concho Water Snake has recovered under this plan and was delisted in 2011. The District agrees to maintain the above-mentioned flows, to the extent that inflows are available to the reservoir.

A 1992 instream flow study was performed by the LCRA for five contiguous reaches, which start downstream of Austin at river mile 290 (from the mouth of the Colorado River) to river mile 34 near Bay City (*Figure 1.19*). The results of the 1992 study were subsequently incorporated into the TCEQ approved LCRA Water Management Plan (WMP). The LCRA Water Management Plan is updated infrequently on an as-needed basis to reflect changing conditions in the basin. The current version of the LCRA WMP was approved by the TCEQ in January 2010. Although the latest update to the LCRA WMP was approved by the LCRA Board and submitted for approval to the TCEQ in 2014,when work began on the 2016 Region K update, the 2014 update was not approved by the TCEQ. Therefore, the information used for the 2016 Region K update is from the 2010 LCRA WMP. More details on the LCRA WMP are provided in Chapter 2.

Figure 1.19: Lower Colorado River Instream Study Reaches (Source: LCRA)



Subsistence or critical instream flows are classified as a firm demand on water resources, and instream flows have been maintained by LCRA at or above the minimum critical flow in accordance with the current WMP. Target instream flows are designed to provide an optimal range of habitat complexity to support a well-balanced, native aquatic community within a stream reach. Chapter 2 provides extensive details on critical and target instream flow recommendations for the Lower Colorado River in *Section 2.4*.

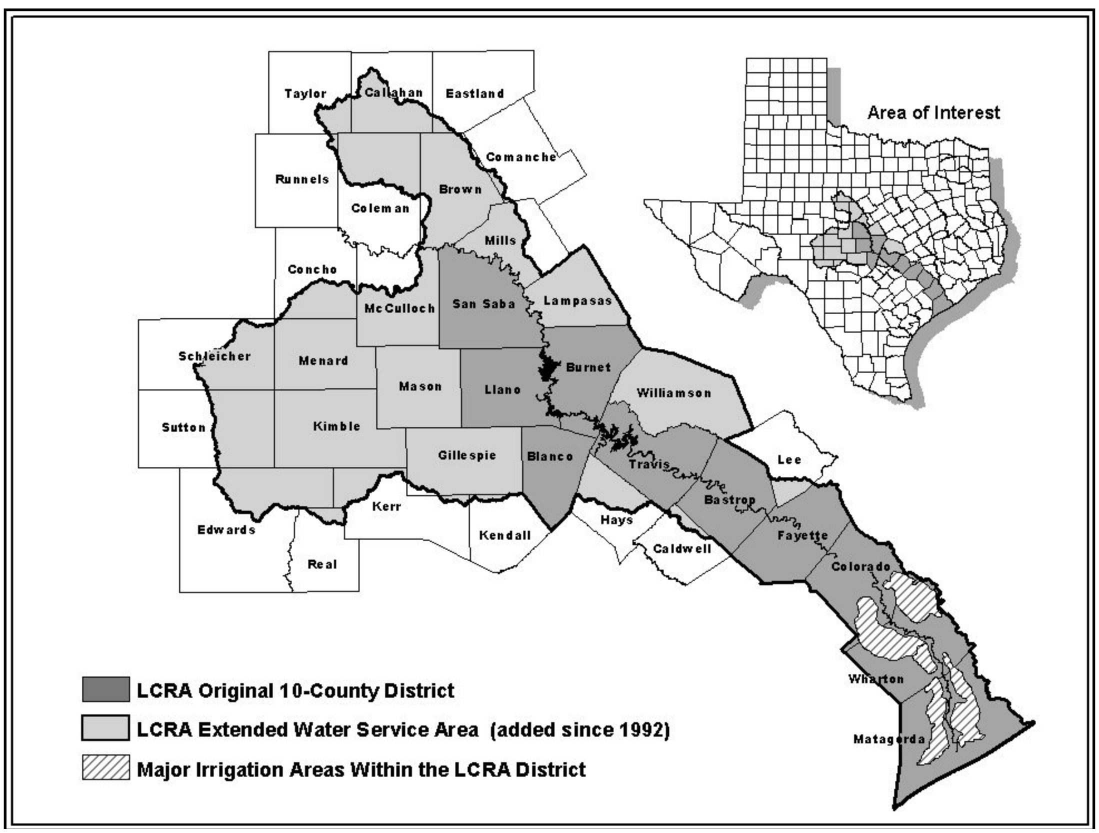
Freshwater inflow is also essential for healthy coastal estuarine ecosystems along the Texas Coast. Ninety-seven percent of the fishery species (shellfish and finfish) in the Gulf of Mexico spend all or a portion of their life cycle in estuaries. The life cycles of estuarine-dependent species vary seasonally and have different migratory patterns between the estuary and the Gulf. The Matagorda Bay system is the second largest estuary in the state, and this system receives freshwater inflow from the Colorado River, the Lavaca River, and surface runoff from the contributing drainage basin areas. On average, Matagorda Bay annually receives approximately 560 billion gallons (more than 1.7 million ac-ft) of freshwater from the Colorado River and basin. This corresponds to about 69 percent of the river's available water supply from surface runoff inflow. Chapter 2 provides extensive details on Bay and Estuary freshwater inflows for Matagorda Bay in *Section 2.4*.

1.2.2.4 Wholesale Water Providers

The TWDB guidelines allow each RWPG to identify and designate "wholesale water provider(s)" for each region. These guidelines define a wholesale water provider as an entity ". . . which delivers and sells a significant amount of raw or treated water for municipal and/or manufacturing use on a wholesale basis." The intent of these TWDB guidelines is to ensure that there is an adequate future supply of water for each entity that receives all or a significant portion of its current water supply from another entity.

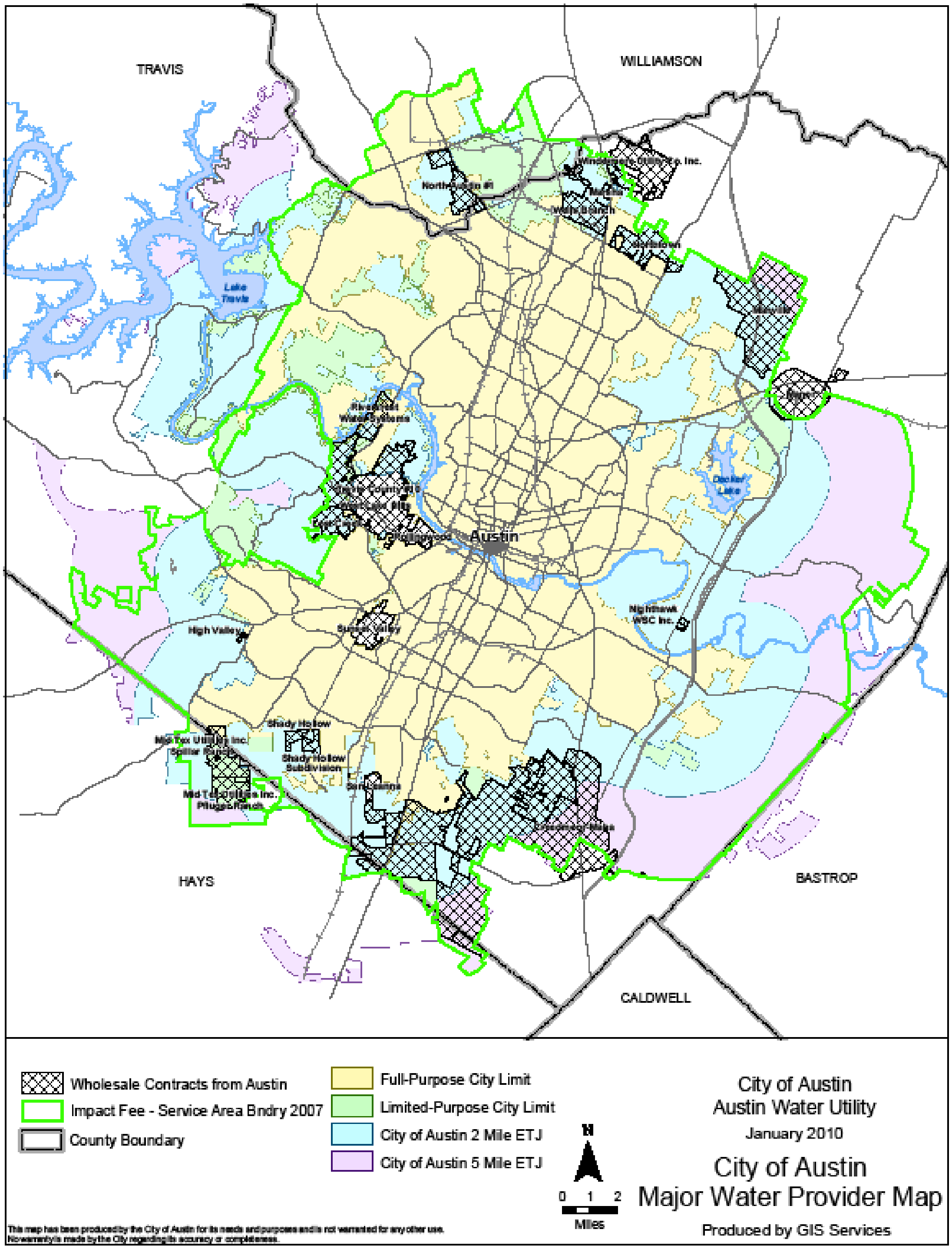
As discussed in Chapter 2, the LCRWPG has officially designated the LCRA and the City of Austin (COA) as wholesale water providers. The LCRA provides water for municipal, agricultural (irrigation), manufacturing, steam-electric, mining and other uses within all or part of a 36-county service area. LCRA's current service area allows it to provide water to entities in each of the 14 counties within the Lower Colorado Regional Planning Area (*Figure 1.20*). The COA supplies water for municipal, manufacturing, and steam-electric uses. The City's water planning area encompasses portions of Travis, Williamson, and Hays Counties (*Figure 1.21*).

Figure 1.20: Lower Colorado River Authority Water Supply Service Area



Source: The Lower Colorado River Authority (March 2000)

Figure 1.21: City of Austin Water Supply Service Area



1.2.3 Water Quality in the Colorado River Basin[17, 18, 19]

The chemical characteristics of and the State Water Quality Criteria assigned to the Colorado River vary along its length (900 river miles) from the upper basin that is mainly within the West Texas Regional Water Planning Area (Region F) to the mouth of the river at Matagorda Bay in the Lower Colorado Regional Planning Area (Region K) (*Table 1.6*). The water quality differences of the various stream segments of the Colorado River are due to variations in both natural and man-made influences affecting each segment's drainage area. In addition, water flowing from upstream segments of the Colorado River and its tributaries also contribute to each downstream segment's water quality characteristics.

The Colorado River is divided into 18 mainstream classified stream segments, which are defined by the Texas Commission on Environmental Quality (TCEQ), which was formerly the Texas Natural Resource Conservation Commission (TNRCC), as:

> Surface waters of an approved planning area exhibiting common biological, chemical, hydrological, natural, and physical characteristics and processes. Segments will normally exhibit common reactions to external stresses (e.g., discharge or pollutants). Segmented waters include most rivers and their major tributaries, major reservoirs and lakes, and marine waters, which have designated physical boundaries, specific uses, and specific numerical physicochemical criteria. Segments are classified in the water identification system utilized by the TNRCC Office of Water Resources Management (OWRM) and are the management unit to which water quality standards and regulations are applicable under the Clean Water Act.

Approximately 70 percent of the Colorado River mainstream segments are located within Region K. There are also 16 classified stream segments that are tributaries of the Colorado River, and almost 40 percent of these are within Region K.

The TNRCC initiated the Texas Clean Rivers Program (CRP) in 1991 to address the Texas Clean Rivers Act. The State Legislature passed this act in response to concerns within the state that water quality issues were being addressed in an uncoordinated fashion. The CRP established a watershed management approach to identify and evaluate water quality issues, as well as to set priorities for the improvement of water quality throughout the state. The CRP set up a partnership in each river basin that consisted of the TNRCC, other state agencies, river authorities, local governments, and private citizens. Each river basin is to provide the TNRCC with updated regional water quality data, and the TNRCC is required to summarize these basin-wide assessments into a statewide report every 2 years.

In 1996, the TNRCC published two reports that updated water quality information for each river basin and stream segment in the state: *The State of Texas Water Quality Inventory* and *Texas Water Quality: A Summary of River Basin Assessments*. The CRP's Colorado River Basin regional assessment technical report defines the "Upper Basin" of the Colorado River as the classified mainstream segments 1411–1413 and 1426 and classified tributary segments 1421–1425. These segments fall within the SB 1 Regions F and G. The "Middle Basin" contains mainstream segments 1403–1410, 1429, and 1433 and tributary segments 1414–1417, 1427, 1431, and 1432. These segments fall within SB 1 Region F and the Lower

[17] TWDB, Op. Cit., May 1977.
[18] TNRCC, December 1996. *Texas Water Quality: A Summary of River Basin Assessments*, Texas Clean Rivers Program Report SFR-46.
[19] TNRCC, October 1996. *Regional Assessment of Water Quality: Colorado River Basin & Colorado/Lavaca Coastal Basin*, Texas Clean Rivers Program Technical Report.

Table 1.6 Classified Stream Segment Uses and Water Quality Criteria in the Colorado River Basin 2014

COLORADO RIVER BASIN			USES [*]			STATE STREAM STANDARDS CRITERIA [**]						
Stream Segment #	**Stream Segment Name**	**SB 1 Planning Region**	**Recreation**	**Aquatic Life**	**Water Supply**	**Chloride Annual Avg. (mg/L)**	**Sulfate Annual Avg (mg/L)**	**TDS Annual Avg (mg/L)**	**D.O. (mg/L)**	**pH Range**	**Fecal Coliform[1] (30-day geometric mean, CFU/100ml)**	**Temp (*F)**
1401	Colorado River Tidal	K	PCR1	H					4.0	6.5–9.0	35	95
1402	Colorado River Below La Grange	K	PCR1	H	PS	100	100	500	5.0	6.5–9.0	126	95
1403	Lake Austin	K	PCR1	H	PS	100	75	400	5.0	6.5–9.0	126	90
1404	Lake Travis	K	PCR1	E	PS	100	75	400	6.0	6.5–9.0	126	90
1405	Marble Falls Lake	K	PCR1	H	PS	125	75	500	5.0	6.5–9.0	126	94
1406	Lake Lyndon B. Johnson	K	PCR1	H	PS	125	75	500	5.0	6.5–9.0	126	94
1407	Inks Lake	K	PCR1	H	PS	150	100	600	5.0	6.5–9.0	126	90
1408	Lake Buchanan	K	PCR1	H	PS	150	100	600	5.0	6.5–9.0	126	90
1409	Colorado River Above Lake Buchanan	K	PCR1	H	PS	200	200	900	5.0	6.5–9.0	126	91
1410	Colorado River Below O.H. Ivie Reservoir	K	PCR1	H	PS	500	455	1,475	5.0	6.5–9.0	126	91
1411	E. V. Spence Reservoir	F	PCR1	H	PS	440	360	1,630	5.0	6.5–9.0	126	93
1412	Colorado River Below Lake J. B. Thomas	F	PCR1	H		4,740	1,570	9,210	5.0	6.5–9.0	33	93
1413	Lake J. B. Thomas	F	PCR1	H	PS	140	250	520	5.0	6.5–9.0	126	90
1414	Pedernales River	K	PCR1	H	PS	125	75	525	5.0	6.5–9.0	126	91
1415	Llano River[2]	K	PCR1	H	PS	50	50	350	5.0	6.5–9.0	126	91
1416	San Saba River	K/G	PCR1	H	PS	50	50	425	5.0	6.5–9.0	126	90
1417	Lower Pecan Bayou	K	PCR1	H		310	120	1,025	5.0	6.5–9.0	126	90
1418	Lake Brownwood	F	PCR1	H	PS	150	100	500	5.0	6.5–9.0	126	90
1419	Lake Coleman	F	PCR1	H	PS	150	100	500	5.0	6.5–9.0	126	93
1420	Pecan Bayou Above Lake Brownwood	F	PCR1	H	PS	500	500	1,500	5.0	6.5–9.0	126	90
1421	Concho River	F	PCR1	H	PS	610	420	1,730	5.0	6.5–9.0	126	90
1422	Lake Nasworthy	F	PCR1	H	PS	450	400	1,500	5.0	6.5–9.0	126	93
1423	Twin Buttes Reservoir	F	PCR1	H	PS	200	100	700	5.0	6.5–9.0	126	90
1424	Middle Concho/SouthConcho River[3]	F	PCR1	H	PS	150	150	700	5.0	6.5–9.0	126	90
1425	O. C. Fisher Lake	F	PCR1	H	PS	150	150	700	5.0	6.5–9.0	126	90

Source: TCEQ (formerly TNRCC), 2014. URL: http://www.tceq.state.tx.us/assets/public/legal/rules/rules/pdflib/307%60.pdf (pg 80, 81)

[*] Uses: PCR1 =Primary Contact Recreation 1; H = High Aquatic Life; E = Exceptional Aquatic Life; PS = Public Water Supply; AP = Aquifer Protection

[**] Criteria: Standards set by the TCEQ (formerly TNRCC) do not guarantee the water to be usable for municipal, domestic, irrigation, livestock, &/or industrial uses, such as segment #1412 & others; this causes the above screening process to be misleading for certain segments, especially for salinity.

[1] The indicator bacteria for freshwater is *E. coli* and for saltwater is Enterococci. The indicator bacteria for Segment 1412 is Enterococci.

[2] The critical low-flow for the South Llano River portion of Segment 1415 is calculated according to §307.8(a)(2)(B) of the Texas Administrative Code, Title 30.

[3] The critical low-flow for the South Concho River portion of Segment 1424 is calculated according to §307.8(a)(2)(B) of the Texas Administrative Code, Title 30.

Table 1.6 (Continued) Classified Stream Segment Uses and Water Quality Criteria in the Colorado River Basin 2014

COLORADO RIVER BASIN			USES *			STATE STREAM STANDARDS CRITERIA **						
Stream Segment #	**Stream Segment Name**	**SB 1 Planning Region**	**Recreation**	**Aquatic Life**	**Water Supply**	**Chloride Annual Avg. (mg/L)**	**Sulfate Annual Avg (mg/L)**	**TDS Annual Avg (mg/L)**	**D.O. (mg/L)**	**pH Range**	**Fecal Coliform[1] (30-day geometric mean, CFU/100ml)**	**Temp (*F)**
1426	Colorado River Below E. V. Spence Reservoir	F	PCR1	H	PS	1000	1,100	1,770	5.0	6.5–9.0	126	91
1427	Onion Creek	K	PCR1	H	PS/AP[4]	100[5]	100[5]	500[5]	5.0	6.5–9.0	126	90
1428	Colorado River Below Lady Bird Lake/Town Lake[7]	K	PCR1	E	PS	100	100	500	6.0[6]	6.5–9.0	126	95
1429	Lady Bird Lake/Town Lake[7]	K	PCR1	H	PS	75	75	400	5.0	6.5–9.0	126	90
1430	Barton Creek[8]	K	PCR1	H	AP[4]	50	50	500	5.0	6.5–9.0	126	90
1431	Mid Pecan Bayou	F	PCR1			410	120	1,100	2.0	6.5–9.0	126	90
1432	Upper Pecan Bayou	F	PCR1	H	PS	200	150	800	5.0	6.5–9.0	126	90
1433	O. H. Ivie Reservoir	F	PCR1	H	PS	430	330	1520	5.0	6.5–9.0	126	93
1434	Colorado River above La Grange	K	PCR1	E	PS	100	100	500	6.0	6.5–9.0	126	95

Source: TCEQ (formerly TNRCC), 2014. URL: http://www.tceq.state.tx.us/assets/public/legal/rules/rules/pdflib/307%60.pdf (pg 80, 81)

* Uses: PCR1 =Primary Contact Recreation 1; H = High Aquatic Life; E = Exceptional Aquatic Life; PS = Public Water Supply; AP = Aquifer Protection

** Criteria: Standards set by the TCEQ (formerly TNRCC) do not guarantee the water to be usable for municipal, domestic, irrigation, livestock, &/or industrial uses, such as segment #1412 & others; this causes the above screening process to be misleading for certain segments, especially for salinity.

[4] The aquifer protection use applies to the contributing, recharge, and transiton zones of the Edwards Aquifer.

[5] The aquifer protection reach of Segment 1427 is assigned the following criteria: 50 mg/L for Cl^{-1}, 50 mg/L for $SO4^{-2}$, and 400 mg/L for TDS.

[6] Dissolved oxygen criterion of 6.0 mg/L only applies at stream flows greater than or equal to 150 cfs as measured at USGS Gauging Station 08158000 located in Travis County upstream from U.S. Highway

183. A dissolved oxygen criteria of 5.0 mg/L will applies to stream flows less than 150 cfs and greater than or equal to the 7Q2 for the segment.

[7] While Segment 1429 exhibits quality characteristics that would make it suitable for primary recreation, the use is prohibited by local regulation for reasons unrelated to water quality.

[8] The critical low-flow for Segment 1430 is calculated according to §307.8(a)(2)(A) of the Texas Administrative Code, Title 30.

Colorado Regional Water Planning Area. The Colorado River's "Lower Basin" lies wholly within Region K and includes the mainstream segments 1401, 1402, 1428, and 1434 as well as several unclassified tributary segments.

Upstream of Region K, high salinity concentrations are the primary concern in the CRP's "Upper Basin" stream segments. This is caused both by the natural characteristics of the geologic formations in the watershed as well as pollution from oil and gas activities. As *Table 1.6* shows, some of these stream segments have very high water quality criteria for salinity, or total dissolved solids (TDS), which is an aggregate measurement of various mineral concentrations including chlorides, carbonates, and sulfates. The designated uses of a stream segment, such as recreation, aquatic life, and water supply, are based on the Texas Surface Water Quality Standards, which are criteria with the force of law. Potential uses for water in segments with very high salinity criteria, such as segment 1412 below Lake J. B. Thomas, are limited by the high TDS concentrations that exist, despite the fact that the criteria are rarely exceeded. For example, the secondary drinking water standard for TDS is 1,000 milligrams per liter (mg/l).

The water quality of the "Middle Basin" and "Lower Basin" improves significantly due largely to the dilution of the upstream base flow by inflow of higher quality tributary waters. Major tributaries from the headwaters of O. H. Ivie Reservoir down through the Highland Lakes System, namely the Llano River and the San Saba River, have TDS concentrations that are generally less than 500 mg/l at their confluence with the Colorado River. Water quality of the "Lower Basin" is subject to poor quality at low flow conditions due to salt water intrusion (i.e., tidal influence).

1.2.4 Agricultural and Natural Resources Issues Within the Lower Colorado Region[20, 21, 22, 23, 24]

The primary agricultural issue in the Lower Colorado Regional Water Planning Area is the availability of sufficient quantities of irrigation water for agricultural irrigation under dry year conditions. Natural resources, on the other hand, have impacts from both water quantity and water quality issues. Classified stream segments in the Colorado River Basin are shown in *Figure 1.22* and those with water quality concerns are listed. The stream segments that have water quality concerns within the region are discussed below in *Section 1.2.4.1*. *Section 1.2.4.2* discusses threats due to water quantity issues.

1.2.4.1 Threats Within the Lower Colorado Region Due to Water Quality Issues

The primary water quality issue for all of the surface water stream segments and the major groundwater aquifers in the Lower Colorado Region is the increasing potential for water contamination due to nonpoint source pollution. Nonpoint source pollution is precipitation runoff that, as it flows over the land, picks up various pollutants that adhere to plants, soils, and man-made objects and which eventually infiltrates into the groundwater table or flows into a surface water stream. As additional land in the Colorado River watershed and aquifer recharge zones is developed, the runoff from precipitation events will pick up increasing amounts of pollution. Another nonpoint source of pollution is the accidental spill

[20] TCEQ (formerly TNRCC), Op. Cit., December 1996.
[21] TCEQ (formerly TNRCC), Op. Cit., October 1996.
[22] LCRA, March 1999, *Water Management Plan*.
[23] Texas Water Development Board (TWDB), February 2000. *A Numerical Groundwater Flow Model of the Upper and Middle Trinity aquifer*, *Hill Country Area*, Open-file report 00–02.
[24] TWDB, et al., April 1999. *Assessment of Groundwater Availability in the Carrizo-Wilcox aquifer in Central Texas – Results of Numerical Simulations of Six Groundwater-Withdrawal Projections (2000–2050),* Draft Final Contract Report.

of toxic chemicals near streams or over recharge zones that will send a concentrated pulse of contaminated water through stream segments and/or aquifers. Public water supply groundwater wells that currently use only chlorination for water treatment, and domestic groundwater wells that may not treat the water before consumption, may be especially vulnerable to nonpoint source pollution, depending on how directly influenced they are by surface or near surface contamination. Habitats of threatened and endangered species that live in and near springs and certain stream segments may be vulnerable as well. Nonpoint sources of pollution are difficult to control and there has been increased awareness and research of this issue as well as interest in the initiation of abatement programs. The water management strategies recommended in this plan won't necessarily impact the water quality levels in the region, but as population growth and development occurs, more opportunities for nonpoint source pollution may exist.

The TCEQ categorizes the physical use of a stream into various defined uses such as "general use", "aquatic life use", "recreational contact use", and "public water supply use". Assessments of the basin conducted by TCEQ determine whether or not a stream segment will support its use. Segments which do not support its designated or assumed use are classified as impaired. Additionally, these assessments will identify segments which are of concern for not meeting the use, but are not at the time of the assessment considered impaired. There are 22 stream segments in Region K considered impaired as published in the 2012 303(d) List. Additionally, 44 stream segments are listed as "of concern" for exceeding the State Water Quality Criteria in Region K (*Table 1.6, Table 1.7, and Table 1.8*).

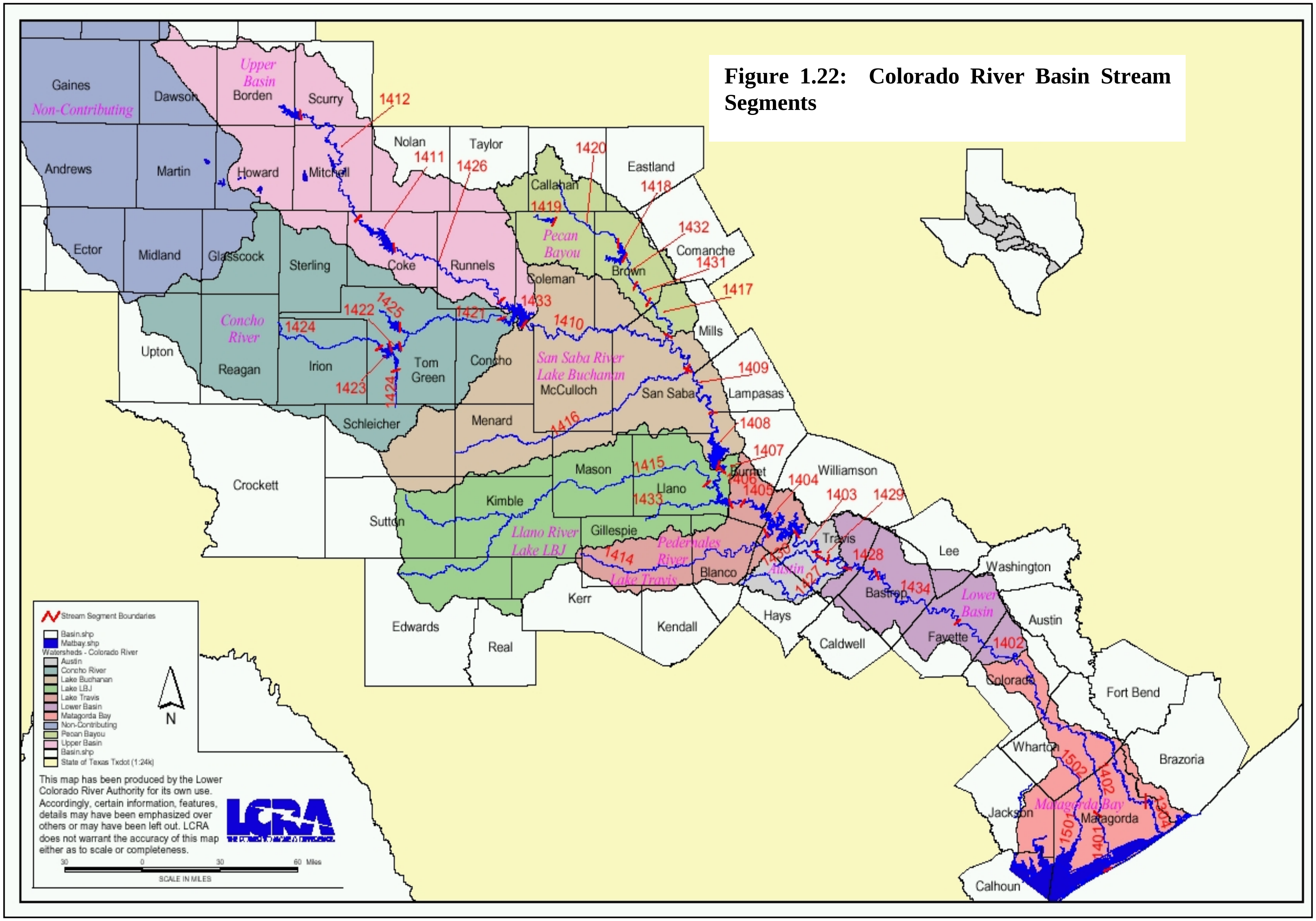


Figure 1.22: Colorado River Basin Stream Segments

Table 1.7 Stream Segment Water Quality Impairments in the Lower Colorado Region[1,2]

Segment ID #	Segment Name	Stream Use	Impairment
1217D	North Rocky Creek (unclassified water body)	Aquatic Life	Depressed dissolved oxygen
1302	San Bernard River Above Tidal	Recreation Use	Bacteria
1302A	Gum Tree Branch (unclassified water body)	Recreation Use	Bacteria
1302B	West Bernard Creek (unclassified water body)	Aquatic Life and Recreation Use	Depressed dissolved oxygen and Bacteria
1304	Caney Creek Tidal	Recreation Use	Bacteria
1304A	Linnville Bayou (unclassified water body)	Recreation Use	Bacteria
1305	Caney Creek Above Tidal	Aquatic Life and Recreation Use	Depressed dissolved oxygen and Bacteria
1401	Colorado River Tidal	Recreation Use	Bacteria
1402C	Buckners Creek	Aquatic Life	Depressed Dissolved Oxygen
1402H	Skull Creek (unclassified water body)	Aquatic Life Use	Depressed dissolved oxygen
1403	Lake Austin	Aquatic Life Use	Depressed dissolved oxygen
1403A	Bull Creek (unclassified water body)	Aquatic Life Use	Depressed dissolved oxygen
1403J	Spicewood Tributary to Shoal Creek (unclassified water body)	Recreation Use	Bacteria
1403K	Taylor Slough South (unclassified water body)	Recreation Use	Bacteria
1407A	Clear Creek (unclassified water body)	General Use	Aluminum in water, pH, Sulfate, and Total Dissolved Solids
1416	San Saba River	Recreation Use	Bacteria
1416A	Brady Creek (unclassified water body)	Aquatic Life Use	Depressed dissolved oxygen
1427A	Slaughter Creek (unclassified water body)	General Use	Impaired Macrobenthic Community
1428B	Walnut Creek (unclassified water body)	Recreation Use	Bacteria
1429C	Waller Creek (unclassified water body)	Recreation Use	Bacteria
1501	Tres Palacios Creek Tidal	Aquatic Life and Recreation Use	Depressed dissolved oxygen and Bacteria
2441OW	East Matagorda Bay (Oyster Waters)	Recreation Use	Bacteria (oyster waters)

[1] Texas Commission on Environmental Quality (URL: http://www.tceq.state.tx.us/waterquality.assessment/305_303.html) (2012 Texas 303 (d) List).
[2] Texas Commission on Environmental Quality (URL: http://www.tceq.texas.gov/gis/segments-viewer)

Table 1.8 Stream Segment Water Quality Concerns in the Lower Colorado Region[1]

Segment ID #	Segment Name	Stream Use	Concern
1401	Colorado River Tidal	General Use	Nutrient
1402A	Cummins Creek (unclassified water body)	Aquatic Life Use	Impaired habitat and impaired macrobenthic community
1402C	Buckners Creek (unclassified water body)	General and Aquatic Life Use	Nutrient and depressed dissolved oxygen
1402G	Fayette Reservoir (unclassified water body)	General Use	Nutrient
1402H	Skull Creek (unclassified water body)	General Use	chlorophyll-a
1403	Lake Austin	General Use	Manganese in sediment
1403A	Bull Creek (unclassified water body)	Aquatic Life Use	Impaired macrobenthos community
1403D	Barrow Preserve Tributary (unclassified water body)	General Use	Nitrate
1403E	Stillhouse Hollow (unclassified water body)	General Use	Nitrate
1403J	Spicewood Tributary to Shoal Creek (unclassified water body)	Recreation Use	Bacteria
1403K	Taylor Slough South (unclassified water body)	General Use	Nitrate
1404	Lake Travis	Aquatic Life Use	Depressed dissolved oxygen
1406	Lake Lyndon B. Johnson	Aquatic Life Use	Depressed dissolved oxygen
1407	Inks Lake	Aquatic Life Use	Depressed dissolved oxygen and manganese in sediment
1407A	Clear Creek	General Use	Cadium in water
1408	Lake Buchanan	General Use	Chlorophyll-a
1411	E. V. Spence Reservoir	General Use	Chlorophyll-a and harmful algal bloom/golden alga
1412	Colorado River Below Lake J. B. Thomas	General and Aquatic Life Use	Chlorophyll-a and depressed dissolved oxygen
1412A	Lake Colorado City (unclassified water body)	General Use	Chlorophyll-a and harmful algal bloom/golden alga
1412B	Beals Creek (unclassified water body)	General and Recreation Use	Ammonia, chlorophyll-a, nitrate, orthophosphorus, selenium in water, and total phosphorus
1416A	Brady Creek (unclassified water body)	General and Aquatic Life Use	Nitrate, total phosphorus, chlorophyll-a, and orthophosphorus
1417	Lower Pecan Bayou	GeneralUse	Chlorophyll-a

Segment ID #	Segment Name	Stream Use	Concern
1418	Lake Brownwood	Aquatic Life Use	Manganese in sediment
1420	Pecan Bayou Above Lake Brownwood	General Use	Chlorophyll-a
1421	Concho River	General and Aquatic Life Use	Chlorophyll-a, Nitrate, and orthophosphorus
1421A	Dry Hollow Creek (unclassified water body)	General Use	Nitrate
1425	O. C. Fisher Lake	General Use	Ammonia, chlorophyll-a, and depressed dissolved oxygen
1425A	North Concho River (unclassified water body)	Recreation , Aquatic Life Use, and General Use	Bacteria, depressed dissolved oxygen, and chlorophyll-a
1426	Colorado River Below E. V. Spence Reservoir	General and Aquatic Life Use	Chlorophyll-a, and harmful algal bloom/golden alga
1426C	Bluff Creek (unclassified water body)	General Use	Nitrate
1426D	Coyote Creek (unclassified water body)	General Use	Nitrate
1427G	Granada Hills Tributary to Slaughter Creek (unclassified water body)	General Use	Nitrate
1428	Colorado River Below Town Lake	Recreation and Aquatic Life Use	Impaired fish, nitrate, orthophosphorus, and total phosphorus
1428B	Walnut Creek (unclassified water body)	Recreation and Aquatic Life Use	Bacteria, impaired macrobenthos community, and impaired habitat
1428C	Gilleland Creek (unclassified water body)	General Use	Nitrate, and orthophosphorus
1429	Town Lake	General Use	dibenz(a,h) anthracene in sediment
1429C	Waller Creek (unclassified water body)	General Use	Benz(a)antracene in sediment, benzo(a)pyrene in sediment, chrysene in sediment, dibenz(a,h)anthracene in sediment, fluoranthene in sediment, lead in sediment, phenanthrene in sediment, and pyrene in sediment
1429D	East Bouldin Creek (unclassified water body)	Aquatic Life Use	benz(a)antracene in sediment, cadmium in sediment, chrysene in sediment,

Segment ID #	Segment Name	Stream Use	Concern
			dibenz(a,h)anthracene in sediment, fluoranthene in sediment, lead in sediment, phenanthrene in sediment, and pyrene in sediment
1430	Barton Creek	Aquatic Life Use	Toxicity in sediment
1430A	Barton Springs (unclassified water body)	Aquatic Life Use	Depressed dissolved oxygen, and toxicity in sediment
1430B	Tributaries to Barton Creek (unclassified water bodies)	General Use	Nitrate
1431	Mid Pecan Bayou	General Use	Chlorophyll-a, nitrate, orthophosphorus, and total phosphorus
1434	Colorado River above La Grange	General Use	Orthophosphorus, and Nitrate
1434B	Cedar Creek (unclassified water body)	Aquatic Life Use	Depressed dissolved oxygen

[1] Texas Commission on Environmental Quality
(URL: https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/12twqi/2012_concerns.pdf)

A major surface water quality indicator for protection of aquatic life is dissolved oxygen (DO) and the associated biochemical oxygen demand (BOD). DO is a measure of the amount of oxygen that is available in the water for metabolism by microbes, fish, and other aquatic organisms. BOD is a measure of the amount of organic material, containing carbon and/or nitrogen, in a body of water that is available as a food source to microbial and other aquatic organisms, which require the consumption of dissolved oxygen from the water to metabolize the organic material. The basin-wide concentrations of DO that have existed in the past were indicative of relatively unpolluted waters; however, these have been changing and have become a concern in some segments of the Colorado River and its tributaries, as populations and urban development continue to increase. The primary manmade sources of BOD in bodies of water are the discharge of municipal and industrial waste, as well as nonpoint source pollution from urban and agricultural runoff. Thus, the presence of excess amounts of BOD allows increased rates of microbial and algal metabolism, which in turn depletes the dissolved oxygen concentrations in the water. Without sufficient levels of DO in the water, other aquatic organisms such as fish cannot survive. Data from 2012 indicates that there are ten classified stream segments with a concern for DO, based on the State Water Quality Criteria in the Lower Colorado Regional Water Planning Area (*Tables 1.6, 1.7,* and *1.8*).

Another set of surface water quality indicators that can deplete DO levels in surface water bodies are termed "nutrients" and includes nitrogen (Kjeldahl nitrogen, nitrite+nitrate, and ammonia nitrogen), phosphorus (phosphates, orthophosphates, and total phosphorus), sulfur, potassium, calcium, magnesium, iron, and sodium. Nutrients are monitored by the TCEQ as a part of the Texas Clean Rivers Program; however, there are no state or federal standards for screening nutrients. Currently, naturally occurring background levels reported by the U.S. Geological Survey (USGS) or historical data collected by the

TCEQ are used to determine the level of concern for nutrients. Nutrients have the same primary man-made sources as the BOD sources described above. Based on 2012 data, there are three classified stream segments with a concern in the Lower Colorado Regional Water Planning Area (*Tables 1.6, 1.7,* and *1.8*).

Fecal indicator organisms E. coli and Enterococcus are harmless bacteria that are present in human and/or animal waste. However, the presence of these organisms is an indicator for the presence of disease-causing bacteria, protozoa and viruses that are also found in human/animal wastes. Municipal waste is treated to remove most of the bacterial, protozoan and viral contaminants so that safe levels will exist in the surface water body upon discharge from the point source. Therefore, when fecal indicators are detected, the most likely source of contamination should be nonpoint source pollution, which can include agricultural runoff as well as runoff from failed septic systems. A wastewater treatment plant point source could also be the source of contamination if the system is not functioning properly. Data reported for 2012 indicate that there are a number of classified stream segments with impairments for E. coli and the tidal portion is impaired for the presence of Enterococcus, based on the State Water Quality Criteria in Region K (*Tables 1.6, 1.7,* and *1.8*).

The presence of toxic dissolved metals, such as aluminum, barium, arsenic, chromium, cadmium, copper, lead, nickel, mercury, selenium, silver, and zinc, in surface water are a concern in three classified stream segments in the Lower Colorado Regional Water Planning Area (*Tables 1.6, 1.7,* and *1.8*).

1.2.4.2 Threats Due to Water Quantity Issues

Threats are present in Region K from both too much water and from too little water. Too much water can be an issue during high river flows and during flooding episodes. The Highland Lakes provide the primary surface water storage and flood control capabilities for Region K.

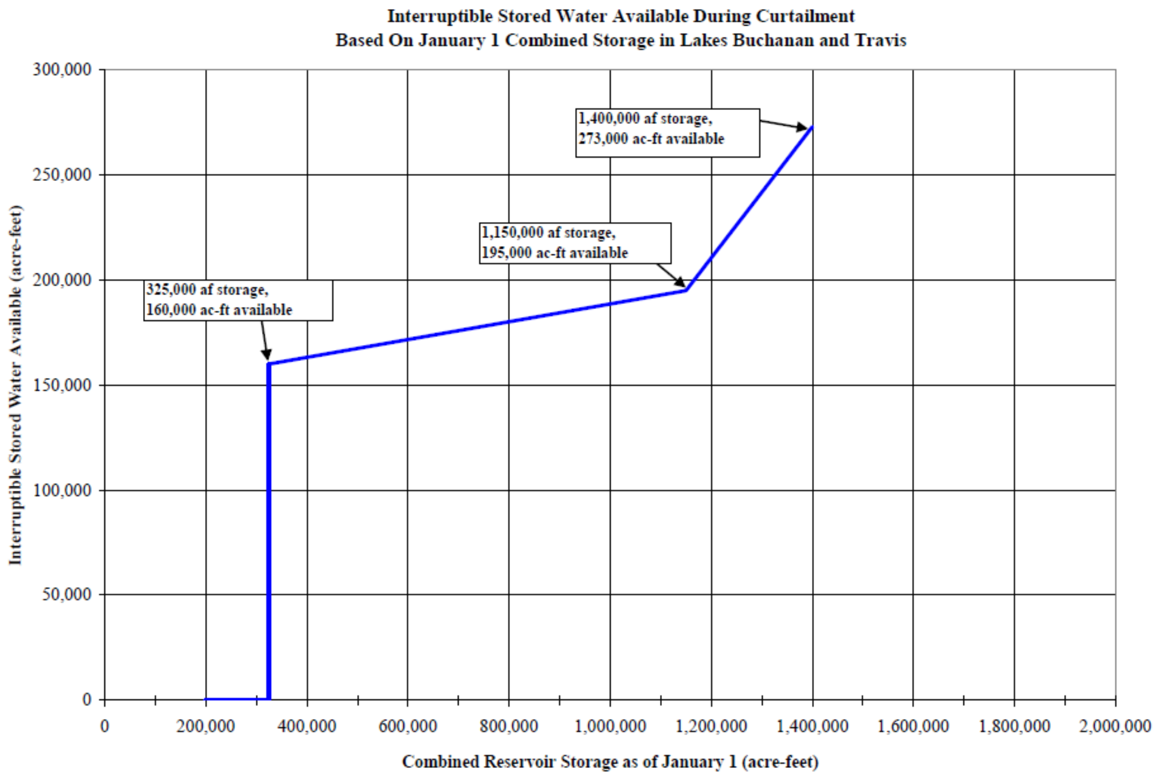
With regard to flood control, Lake Travis is the only reservoir in the Highland Lakes System with flood control storage. Currently, the LCRA must regulate the release of flood flows from Mansfield Dam so as to minimize and balance the impacts of floodwaters upstream and downstream of the dam without compromising the safety of the dam. Because development continues to encroach upon and alter the floodplain of the Lower Colorado River, the LCRA, in cooperation with the USACE, is currently studying alternative flood control measures, such as modifying current flood control operations and the possible addition of new off-channel flood control structures.

As mentioned previously, the primary threat to agriculture in Region K is water shortages for irrigation that are anticipated to occur in Matagorda, Wharton, and Colorado Counties during a repeat of the drought of record or a drought worse than the drought of record. The water supply available for irrigation is from three sources: ROR supplies, stored water from the Highland Lakes, and groundwater. When the Colorado River's natural flows are insufficient to meet irrigation demands, allocations of stored water from the Highland Lakes under the LCRA Water Management Plan can be made by to supplement the available downstream ROR supplies. The water supplied from the Highland Lakes storage is an interruptible supply and is subject to curtailment in accordance with policies and procedures specified in LCRA's Water Management Plan. Under drought conditions, there are substantial shortages of water for irrigation in Matagorda, Wharton, and Colorado Counties. The shortages will be addressed through water management strategies such as conservation, discussed in Chapter 5 of this Plan.

Water quantity is also a concern during drought conditions in terms of instream flows and freshwater inflows to Matagorda Bay. As discussed in *Section 1.2.2.3,* the reaches below the Highland Lakes downstream to the mouth of the Colorado River have been studied by the LCRA, and critical instream flows have been determined as firm demands on water resources. Instream flows have been maintained by LCRA at or above the minimum critical flow in accordance with the current WMP. Target instream flows, also determined by the LCRA study, provide flows to support an optimal range of habitat complexity for a well-balanced, native aquatic community within a stream reach. LCRA has maintained these flow regimes whenever water resources are adequate, but target flows are classified as interruptible demands that have been reduced during drought conditions. For further details, please refer to LCRA's WMP at http://www.lcra.org/water/water-supply/water-management-plan-for-lower-colorado-river-basin/Documents/lcra_wmp_june2010.pdf.

The following figure is from page 4-26 of the LCRA's 2010 Water Management Plan and summarizes the trigger levels for the allocation of interruptible supplies.

Figure 1.23: LCRA 2010 WMP Trigger Levels for Interruptible Supplies



The Highland Lakes provide the primary surface water storage and flood control capabilities for Region K. The issue of providing maintenance of these reservoirs to retain the maximum water storage capacity may become important as natural sedimentation processes decrease the volume of water each reservoir can hold.

With regard to flood control, Lake Travis is the only reservoir in the Highland Lakes with flood control storage. Releases by LCRA from the flood pool of Lake Travis are governed by rules of the U.S. Corps of Engineers (USACE). Under the rules, flood releases are determined by: specified ranges of observed or forecasted reservoir levels; the pool condition (i.e. rising or falling); the month of the year; and stage and flow criteria at three designated downstream locations. The amount of release increases with higher ranges of reservoir level and as long as downstream stage and flow limitations are not exceeded. The rules also provide that the U.S. Bureau of Reclamation will schedule flood releases as required for the safety of the dam when the reservoir level is forecast to exceed 722 feet above mean sea level. Because development continues to encroach upon and alter the floodplain of the Lower Colorado River, the LCRA, in cooperation with the USACE, the Federal Emergency Management Agency (FEMA) and over 60 local cities and counties in the Texas Colorado River Floodplain Coalition are currently studying flood damage reduction alternatives, such as modifying current flood control operations, updating floodplain maps, and the addition of new levees and off-channel flood control structures.

One of the major groundwater quantity concerns involves the Barton Springs segments of the Edwards aquifer (BFZ), which is a karst formation that responds quickly to changes in the environment due to its highly permeable and transmissive characteristics. South of the artesian zone of the Edwards aquifer there exists an interface, or “bad water line,” that separates the good quality groundwater from a layer of water that is not usable for human consumption, without further treatment, due to the high TDS content. This line, which is also referred to as the saline-water line or freshwater/saline-water interface, marks the interface where the groundwater reaches a TDS concentration of 1,000 mg/l. Research is currently being conducted to determine the effects that pumping large quantities of aquifer water will have on its location. Water management strategies recommended in Chapter 5 discuss Aquifer Storage and Recovery (ASR) opportunities in this aquifer, as well as desalination of the Saline Zone.

The second major issue in the Barton Springs segments of the Edwards aquifer (BFZ) is the minimum required environmental flows discharged from the artesian zone through Barton Springs. Increased groundwater pumping from the aquifer during drought conditions decreases all spring discharges, which can potentially impact the state- and federally-listed threatened and endangered species that depend on the springs for habitat, such as the Barton Springs salamander, and can potentially affect water supply availability downstream. Recommended water management strategies stay within the Modeled Available Groundwater (MAG) volume, so impacts to the minimum springflows should be negligible.

The primary water quantity issue in the Gulf Coast aquifer is subsidence, which is the dewatering of the interlayers of clay within the aquifer as a result of continued or long-term over-pumping. The resultant compaction of the clay causes a loss of water storage capacity in the aquifer, which in turn causes the land surface to sink, or subside. Once the ability of the clay to store water is gone, it can never be restored. The implementation of water conservation practices and conversion to other sources are currently the only remedies for this situation. Saltwater intrusion from the Gulf of Mexico into the Gulf Coast aquifer is also a potential concern due to groundwater pumping rates that are greater than the recharge rates of the aquifer. Recommended water management strategies stay within the Modeled Available Groundwater (MAG) volume, and overpumping is not encouraged.

The primary water quantity concern with the Trinity aquifer is the anticipated water-level decline during drought conditions due to increased demand that will be placed on the aquifer’s resources. A computer model was developed to simulate the flow of groundwater within the Trinity aquifer. The results for the portion of the aquifer that lies within Region K suggest that water levels in the Dripping Springs area of Hays County could decline more than 100 feet by the year 2040. Other portions of Hays County as well as Blanco and Travis Counties, may experience moderate water-level declines between 50 to 100 feet by the year 2020. Most of the streams gain water as they pass over the Trinity aquifer and in consequence may be affected by the declining water levels in the underlying aquifer. In addition, drought conditions may further decrease the base flow of the streams. Recommended water management strategies stay within the Modeled Available Groundwater (MAG) volume, and include an importation to the western Hays County area of groundwater from Gonzales County.

The primary water quantity concern with the Carrizo-Wilcox aquifer is the water-level decline anticipated through the year 2060 due to increased pumping. Groundwater withdrawals increased an estimated 270 percent between 1988 and 1996, from 10,100 to 37,200 ac-ft/yr, from the mostly porous and permeable sandstone aquifer. The area in and around the Carrizo-Wilcox aquifer is expected to see continued population growth and increases in water demand. The TWDB co-sponsored a study of the Central Texas portion of the Carrizo-Wilcox aquifer using a computer model to assess the availability of groundwater in the area. Six water demand scenarios were simulated in the model, which ranged from considering only the current 1999 demand to analyzing all projected future water demands through the year 2050. On the basis of the calibrated model, all withdrawal scenario water demands appear to be met by groundwater from the Carrizo-Wilcox aquifer through the year 2050. The simulations indicate that the aquifer units remain fully saturated over most of the study area. The simulated water-level declines in the Carrizo-Wilcox aquifer mainly reflect a pressure reduction within the aquifer's artesian zone. Some dewatering takes place in the center of certain pumping areas. In addition, simulations indicate that drawdown within the confined portion of the aquifer will significantly increase the movement of groundwater out of the shallow, unconfined portions to the deeper artesian portions of the aquifer. Both a pressure reduction within the artesian zone and the migration of groundwater from the unconfined portions of the aquifer may impact historical access to groundwater in the region. The relationships that currently exist between surface and groundwater may also change. Simulations indicate that the Colorado River, which currently gains water from the Carrizo-Wilcox aquifer, may begin to lose water to the aquifer by the year 2050. Recommended water management strategies stay within the Modeled Available Groundwater (MAG) volume.

The LCRWPG passed a resolution regarding the "mining of groundwater" on February 9, 2000, which strongly opposes the over-utilization of groundwater, including the mining of groundwater, within its region at rates that could lead to eventual harm to the groundwater resources, except during limited periods of extreme drought. The LCRWPG defines groundwater mining as "the withdrawal of groundwater from an aquifer at an annualized rate, which exceeds the average annualized recharge rate to an aquifer where the recharge rate can be scientifically derived with reasonable accuracy." This resolution addresses the concerns listed above for the Barton Springs segments of the Edwards (BFZ), Gulf Coast, Trinity, and Carrizo-Wilcox aquifers that are located within Region K.

1.2.5 Existing Water Planning in the Lower Colorado Regional Water Planning Area

As charged by Senate Bill 1, enacted in 1997, the LCRWPG prepared, adopted, and submitted the *2000 Region "K" Water Supply Plan* to the TWDB, which described how local entities may address future water supply needs for the next 50 years. Subsequently, a State Water Plan, Water for Texas-2002, was delivered by the TWDB to the Texas Legislature in January 2002, and incorporated the approved 2001 Regional Water Plan and contained legislative recommendations for future water policies. This cycle of planning is repeated every five years and thus far has resulted in the 2006 and 2011 *Region K Water Plans* being submitted to the TWDB by the Lower Colorado Regional Water Planning Group. These regional plan updates assisted in the creation of the 2007 and 2012 State Water Plans by the TWDB. The current cycle of regional water planning will culminate in the 2016 Lower Colorado Regional Water Plan, which the TWDB will utilize in developing the 2017 State Water Plan.

Because regional water planning is intended to be a bottom-up process, the Region K planning group used knowledge from its own members as well as publicly available local plans to develop the details of the 2016 Region K Water Plan. Documents from local planning efforts, including the *Water and Wastewater Facilities Plan for the portion of Hays County*, *Texas West of the I-35 Corridor*, the *Bastrop Regional Water Supply Facilities Planning Study*, and the *Burnet-Llano County Regional Water Facility Study*, helped shape the water management strategies that were recommended by the Region K planning group. These local plans also provided regionalization concepts for water and wastewater services that the Region K planning group considered during the planning process. The LCRA Water Management Plan was referenced for several chapters in the 2016 Region K Plan. Additional publicly available local plans that were referenced for the planning process are discussed below in the next few sections.

SB 1 legislation also amended Chapter 36 of the Texas Water Code to require certain water supply entities to develop water management plans (WMPs), water conservation plans (WCPs), and/or drought contingency plans (DCPs). WCPs and DCPs must be submitted to TCEQ for review and certification. TCEQ received the plans, reviewed them for minimum criteria according to TCEQ's Chapter 288 Rules that reflect SB 1 requirements. Finally, TCEQ sent the water supply entity a letter of certification that its plan contains the necessary minimum criteria components. It should be noted that TCEQ has not subjectively critiqued the quality of the water management, water conservation, or drought contingency plans; it only determined whether or not minimum criteria have been met. Each water supply entity is required to update their respective plan every five years, so that the plan will improve as the water supply entity gains experience in managing its water resources. TWDB also receives copies of each certified WCP and DCP for review with respect to TWDB's water planning efforts. However, there are no rules requiring action by TWDB.

1.2.5.1 Groundwater Conservation District Management Plans (MP)

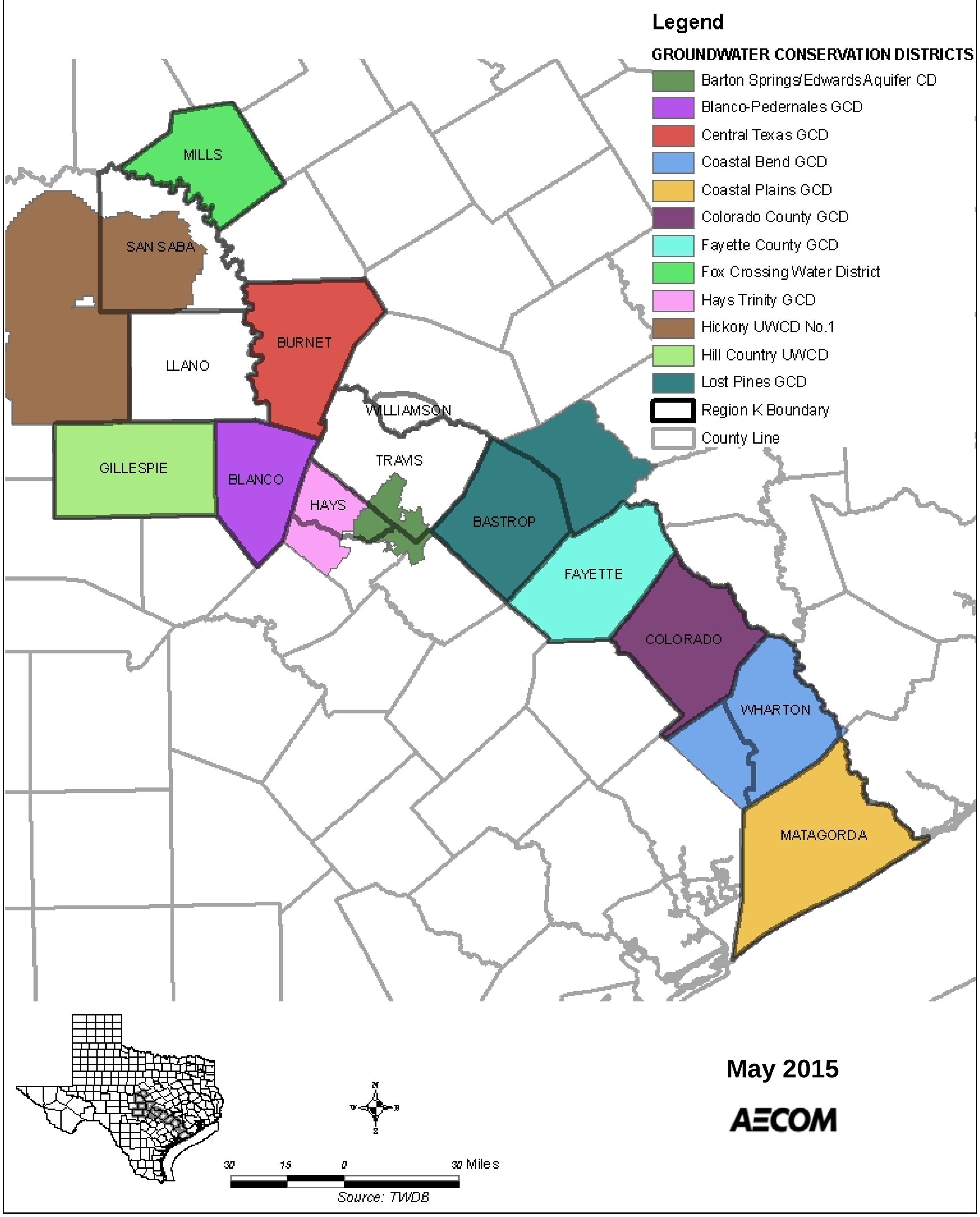
One category of the SB 1 required plan is the Management Plan (MP), which must be developed by each Groundwater Conservation District (GCD) and surface water conservation district in the state. The intent of a MP is to conserve, preserve, prevent waste, protect, and recharge water supplies within the water conservation district. These MPs are required to be submitted to TWDB for review and administrative certification. Surface water conservation districts, primarily river authorities, are also required to submit MPs as a provision of the final adjudication of the river authority's water rights and receive administrative certification from TCEQ. *Table 1.9* shows each district in Region K and the aquifers they manage. MPs are also submitted to RWPGs for inclusion in the Regional Water Plan and to allow the regional planning groups to focus on strategies for current and future shortages that do not conflict with the management plans. *Figure 1.24* shows the groundwater conservation districts located in Region K.

Table 1.9 Groundwater Conservation Districts in Lower Colorado Region

Groundwater Conservation District [1]	Lower Colorado Region County	Aquifers Managed [2]
Barton Springs/Edwards Aquifer Conservation District (BSEACD)	Hays, Travis	Edwards (BFZ) & Trinity Aquifers, & Alluvial Deposits
Blanco-Pedernales GCD	Blanco	Trinity, Edwards-Trinity, Ellenburger, Hickory and Marble Falls Aquifers
Central Texas GCD	Burnet	Trinity, Marble Falls, Ellenburger-San Saba, Hickory
Coastal Bend GCD	Wharton	Gulf Coast Aquifer
Coastal Plains GCD	Matagorda	Gulf Coast Aquifer
Colorado County GCD	Colorado	Gulf Coast Aquifer
Fayette County GCD	Fayette	Gulf Coast, Carrizo-Wilcox, Queen City, Sparta Aquifer, Yegua- Jackson and Colorado River Alluvium
Fox Crossing UWCD	Mills	Trinity Aquifer
Hays-Trinity GCD	Hays	Trinity Aquifer
Hickory UWCD #1	San Saba	Hickory Aquifer, Ellenberger-San Saba, & Marble Falls Aquifers
Hill Country UWCD	Gillespie	Edwards-Trinity, Ellenberger-San Saba, & Hickory Aquifers
Lost Pines GCD	Bastrop	Carrizo-Wilcox Aquifer

Source: TWDB
[1] UWCD = Underground Water Conservation District; GCD = Groundwater Conservation District.
[2] Water systems managed: Only portions of the indicated aquifer systems are located within a GCD's jurisdiction.

Figure 1.24: Lower Colorado Regional Water Planning Area (Region K) Groundwater Conservation Districts



1.2.5.2 Groundwater Management Areas (GMA)

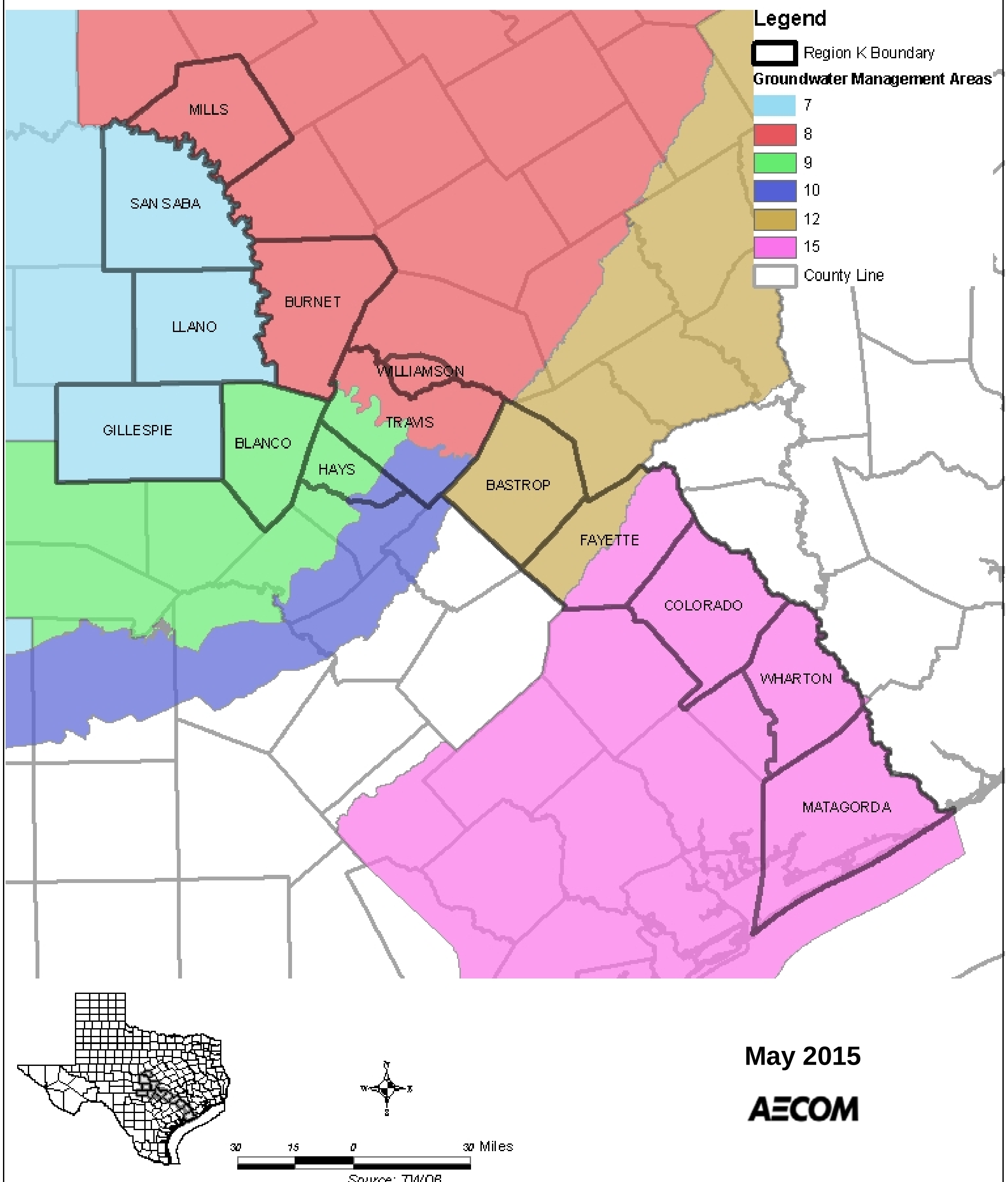
In response to legislation passed in 2001, in December 2002 the TWDB designated 16 GMAs covering the entire state. In 2005, the legislature required all GCDs located within a GMA to conduct joint planning. The new requirements indicated that.

"Not later than September 1, 2010, and every five years thereafter, the districts shall consider groundwater availability models and other data or information for the management area and shall establish desired future conditions for the relevant aquifers within the management area." .

Groundwater districts are required to meet at least annually to decide on "desired future conditions" for the aquifers within their GMA. A desired future condition is a quantifiable future groundwater condition. These conditions, called metrics, can be a particular groundwater level, level of water quality, volume of spring flow, etc. Based on the adopted desired future condition, the TWDB is responsible for providing each groundwater conservation district and regional water planning group, located wholly or partly in the management area, with a modeled available groundwater volume (MAG) that will be used for planning and groundwater management purposes. Groundwater availability models and other data or information help in establishing modeled available groundwater for the relevant aquifers within the management area.

In Region K, there are six groundwater management areas (GMAs). They include GMA-7, GMA-8, GMA-9, GMA-10, GMA-12, and GMA-15. *Figure 1.25* shows the delineation of these groundwater management areas.

Figure 1.25: Lower Colorado Regional Water Planning Area (Region K) Groundwater Management Areas



1.2.5.3 Water Conservation Plans (WCP) and Drought Contingency Plans (DCP)

SB 1 also required each entity that possesses major surface water and/or groundwater rights to develop a Water Conservation Plan (WCP). These plans are required by irrigation water rights of at least 10,000 ac-ft/yr, non-irrigation (municipal, industrial, mining, recreational) water rights of at least 1,000 ac-ft/yr, and retail public water suppliers which serve 3,300 connections or more. The intent of the WCP is to develop and implement programs that will reduce water use within each of the major WUGs listed below, primarily through utilizing advances in technology, reducing distribution system water losses, and educating customers and encouraging voluntary participation in water use efficiency efforts. Approximately 90 percent of Region K's water use occurs in the agricultural irrigation and municipal sectors, and the majority of the WCPs have targeted these two water use groups. The remainder of entities holding water rights in Region K are not required to develop or submit a WCP unless they petition TCEQ for an amendment to their water right or apply for a capital improvement loan with TWDB. In addition, Chapter 288 of the TCEQ Rules requires wholesale water supply purchasers to submit water conservation plans to their wholesale supplier. More details on Water Conservation Plans are provided in Chapter 5 of this Plan.

The third category of water resource planning effort required by SB 1 is the Drought Contingency Plan (DCP). The intent of the DCP is to specify how a water supply entity will contract and supply dependable stored water supplies to its customers during a repeat of the drought of record, which is the period 1947–1957 for Region K. Triggering conditions for water shortages during a drought must be defined, and the actions that will be taken by the water supplier to mitigate the adverse effects of these water shortages must be specified. The DCP's major goals are extending the supplies of dependable water, preserving essential water uses, protecting public health and safety, and establishing equitable distributions of water among the water supplier's customers.

The amended Title 30, Texas Administrative Code, Chapter 288 became effective on December 6, 2012. The next revision of the drought contingency plans for retail public water suppliers serving 3,300 or more connections, wholesale public water suppliers, and irrigation districts were to be submitted no later than May 1, 2014, and every five years thereafter to coincide with the regional water planning group process. Any new or revised plans must be submitted to the TCEQ within 90 days of adoption by the governing body of the entity. Drought contingency plans are to be provided to the local regional water planning group as well; however, the RWPGs do not review or certify drought contingency plans. More details on Drought Contingency Plans are provided in Chapter 7 of this Plan.

For all retail public water suppliers serving less than 3,300 connections, the drought contingency plans were to be prepared and adopted no later than May 1, 2014, and shall be available for inspection upon request.

The definition of a WUG for municipal purposes has been expanded to include entities that provide retail water service in excess of 280 ac-ft/yr, or approximately 250,000 gallons per day (gpd). Systems which serve 3,300 connections, assuming 3.2 persons per connection and 130 gallons per person per day, would be serving approximately 1.4 million gallons per day (mgd). As a result, the WUGs covered in the category of less than 3,300 connections will have water usage ranging from 250,000 gpd to 1.3 mgd, or 280 to 1,540 ac-ft/yr. Entities with less than 280 ac-ft/yr of usage are included in the County-Other Municipal WUG.

1.2.5.4 Water Audits

House Bill 3338, passed by the 78th Texas Legislature (2003), requires public utilities providing potable water to file water audits with the TWDB once every five years giving the most recent year's water loss. TWDB subsequently commissioned a study of available loss data. The results of this statewide data gathering was compiled into the "Analysis of Water Loss as Reported by Public Water Suppliers in Texas", TWDB, 24 January 2007. For the first phase of water auditing, a number of issues were identified with the data provided, and work to correct inconsistencies is ongoing. Year 2010-2013 water loss audit information was provided to the LCRWPG by TWDB.

One hundred and thirteen (113) public utilities in Region K submitted water loss audit data as part of the required 2010 submittal to TWDB. Limited data was submitted in 2011-2013, so the 2010 data is used for this report. Total loss rates for the utilities within Region K were found to vary widely, with an average total loss percentage rate of 12.3%. Losses may vary annually and could currently be higher or lower.

Total losses are not limited to loss from known leaks, although for some utilities leakage is responsible for a majority of lost water. Total loss also includes meter inaccuracy, unmetered or unauthorized water use, unidentified line leaks, and storage overflows. Real loss accounts for reported breaks and leaks, and unreported loss. Real loss rates for the utilities within Region K were also found to vary widely, with an average real loss percentage rate of 9.8%.

Figure 1.26 below summarizes the water loss audit data provided by TWDB to Region K.

Figure 1.26: Water Loss Audit Summary for Region K

<table>
<tr><td rowspan="8">Region K
113 Audits Submitted</td><td rowspan="8">System Input Volume
66,719,840,013</td><td rowspan="4">Authorized Consumption
58,543,433,092
87.7%</td><td rowspan="2">Billed Consumption
57,831,743,895
86.7%</td><td>Billed Metered
57,510,510,563
86.2%</td><td rowspan="2">Revenue Water
57,831,743,895
86.7%</td></tr>
<tr><td>Billed Unmetered
321,233,332
0.5%</td></tr>
<tr><td rowspan="2">Unbilled Consumption
711,689,197
1.1%</td><td>Unbilled Metered
285,879,389
0.4%</td><td rowspan="6">Non-revenue Water
8,903,987,628
13.3%</td></tr>
<tr><td>Unbilled Unmetered
425,809,808
0.6%</td></tr>
<tr><td rowspan="4">Water Loss
8,197,494,676
12.3%</td><td rowspan="3">Apparent Loss
1,682,786,409
2.5%</td><td>Unauthorized Consumption
169,661,891
0.3%</td></tr>
<tr><td>Customer Meter Accuracy Loss
1,435,555,946
2.2%</td></tr>
<tr><td>Systematic Data Handling Discrepency
77,568,572
0.1%</td></tr>
<tr><td>Real Loss
6,520,618,737
9.8%</td><td>Reported Breaks and Leaks
435,448,567
0.7%
Unreported Loss
6,086,474,612
9.1%</td></tr>
</table>

Source: 2010 Summary of Water Loss Audit Data by Gallons and Percentage by Region with Statewide Totals

APPENDIX 1A

THREATENED AND ENDANGERED SPECIES IN THE LOWER COLORADO REGIONAL WATER PLANNING AREA
(Texas Parks & Wildlife Department Special Species Lists and Annotated County Lists of Rare Species)

APPENDIX 1B

THE HIGHLAND LAKES: HISTORY AND SOCIAL AND ECONOMIC IMPORTANCE

This Appendix was developed by the Central Texas Water Coalition, Inc. using the following reference materials: "Lake Travis Economic Impact Report" prepared by Robert Charles Lesser & Co. for Travis County and the Lake Travis Economic Stakeholders Committee (Sept. 2011); "The Economic Impact of the Upper Highland Lakes of the Colorado River" prepared by TXP, Inc., Concept Development & Planning, LLC, and Diverse Planning and Development for Burnet and Llano Counties (Fall 2012); Multiple Listing Service reports on property sales; and County Appraisal District data on property valuations.

APPENDIX 1C

TWDB DB17 REPORTS