

# **THE EDWARDS AQUIFER: CONFLICTS SURROUNDING USE OF A REGIONAL WATER RESOURCE**

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## **INTRODUCTION**

Integrated management of surface and groundwater has special relevance to the area surrounding San Antonio, Texas. San Antonio is the largest city in the United States entirely dependent upon a single source of underground water, the Edwards Aquifer. Since prehistoric times, the Edwards Aquifer and its associated system of springs provided dependable supplies of high-quality water for residents of the region. The continued viability of the aquifer as a dependable water supply and as an important biological resource is now threatened by overpumpage caused by population and economic growth. Public calls for action to plan and manage future surface water development and withdrawals from the aquifer have not gone unheeded by both judiciary and legislative arms of local, state, and federal governments.

This paper provides an introduction to the large region of southwest Texas dependent upon and impacted by the Edwards Aquifer. The overview includes descriptions of the population and economy of the region, the surface and groundwater resources of the region, including the Edwards Aquifer, and legal statutes governing surface and ground water rights under which ownership and use of water is administered.

## **THE REGION**

The Edwards Aquifer and associated area has a semi-arid to arid climate, with precipitation in the east of approximately 36 inches annually, and precipitation at the western boundaries of approximately 22 inches annually. The region includes three river basins -Nueces, San Antonio, and Guadalupe. The rivers flow in a southeasterly direction from elevations of approximately 2,000 to 2,400 feet msl to the Gulf of Mexico (Figure 1).

The Nueces River discharges into Nueces Bay at Corpus Christi, Texas, the San Antonio River discharges into the Guadalupe River about 28 miles south of Victoria, Texas, and the combined flows of the Guadalupe and San Antonio Rivers discharge into San Antonio Bay.

The region has a highly developed economy which includes dryland and irrigated agriculture, cattle, sheep, and goat ranching, food processing, textiles, high tech industries, petroleum production and refining, petrochemicals, metals, stone and masonry, aircraft, transportation, communication, finance, insurance, real estate, tourism and recreation, research and development, military services for the nation, wholesale and retail trade, and professional and personal services. In 1990, the population of the three-basin area was approximately 2.2 million, with 1.4 million (64 percent) in the Edwards Aquifer area, and is projected to be 5.3 million in 2050. Water use in the area in 1990 was 1.32 million acre-feet per year, with projections to 2050 of demands of 1.93 million acre-feet per year. Projections include the future needs of adjacent areas at the mouths of the Nueces and Guadalupe Basins that presently hold surface water permits to use water from these basins. Notable in these projections are a decline in irrigation water use from 700 thousand acre-feet per year in 1990 to 516 thousand acre-feet per year in 2050, and all projections include potential effects of water conservation programs.

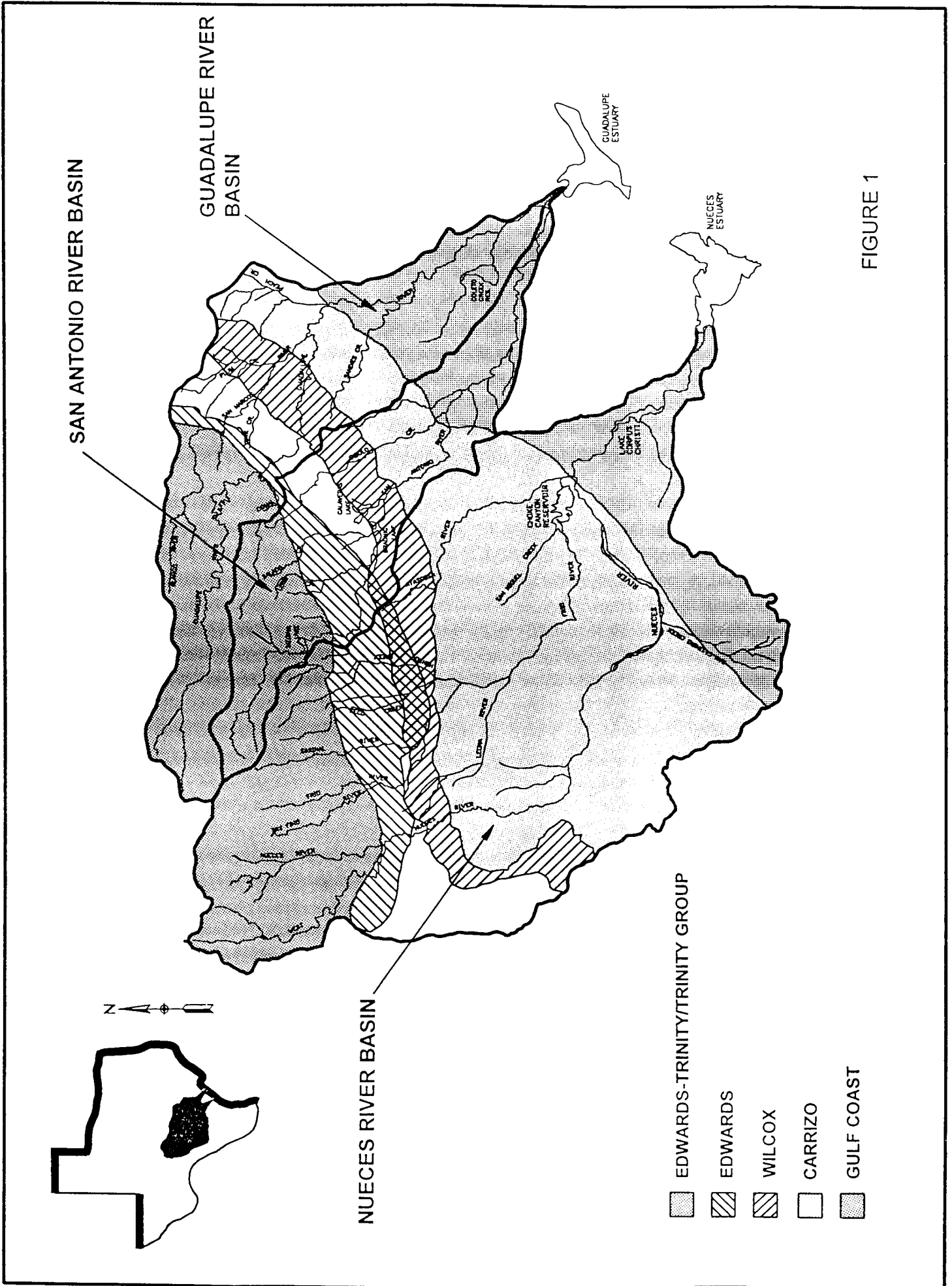


FIGURE 1

## **WATER RESOURCES**

The Nueces (16,950 mi<sup>2</sup>), San Antonio (4,180 mi<sup>2</sup>), and Guadalupe (6,070 mi<sup>2</sup>) River Basins are underlain by four major aquifers (Trinity Group, Edwards, Carrizo-Wilcox, and Gulf Coast), and several minor aquifers of local importance. Water supply for the region is from both surface sources and aquifers. The State of Texas follows the "rule-of-capture" on ownership of groundwater, with surface water rights being appropriative. However, on June 28, 1996, the Texas Supreme Court declared the Edwards Aquifer Authority that was created by the Texas Legislature in 1993 to be constitutional, and thereby changed the rules for Edwards Aquifer use to a system of permits to be awarded and managed by the Authority (1). The objective of the legislation creating the Authority is to limit pumpage to a level sufficient to maintain spring flows at Comal and San Marcos Springs for the purpose of protecting endangered species (2).

Within the three-basin area, the hydrology from which water supplies are obtained, is quite complicated. The Edwards-Trinity and Trinity Group Aquifers of the Edwards Plateau underlie the headwaters areas of the three basins and supply water locally for municipal and livestock purposes. The Edwards (Balcones Fault Zone) Aquifer spans six counties and the three river basins, whose upstream watersheds contribute recharge to the aquifer in the west and north, and receive spring flows in the east. In the mid sections of the three-basin area, the CarrizoWilcox aquifer is an important source of supply which is recharged from precipitation on the recharge zones and from streams which cross the recharge zones, a part of whose flow may have originated upstream of the Edwards recharge zone. In the downstream reaches of the three-basin area, the Gulf Coast Aquifer supplies water locally and is recharged in a fashion similar to that of the Carrizo-Wilcox, i.e., from local precipitation and stream flow across the recharge zones.

### Surface Water

With respect to surface water, permits have been issued throughout the three basins for both run-of-river rights and reservoir storage rights. In the Nueces Basin, permits have been awarded for diversion rights of 530,046 acre-feet per year, of which 42 percent is for municipal purposes, 43 percent is for industrial purposes, 14.5 percent is for irrigation, and the remaining one-half percent is for mining, recharge, and other uses. The basin is fully appropriated. In the Guadalupe-San Antonio Basins, there are about 580 individual water rights for consumptive uses, with the vast majority of these being individual irrigation water rights with authorized annual diversion of less than 100 acre-feet. In these basins, there are 39 owners of storage or annual diversion rights which are in excess of 2,000 acre-feet. Total authorized diversions are 578,446 acre-feet per year in the Guadalupe-San Antonio Basins, with municipal purposes being 30.7 percent, industrial and steam-electric power generation purposes at 34.4 percent, and irrigation purposes at 34.7 percent (3).

In addition to consumptive rights referenced above, there are nonconsumptive rights for hydroelectric power generation in the Guadalupe Basin in the amount of 1,300 cfs at Lake Dunlap in the mid-basin area. In the San Antonio Basin, the permit for use of wastewater return flows for electric power generation provides for a minimum flow at Elmendorf, about 8 miles downstream of San Antonio as the crow flies, of 50 cfs during the three summer months, and 10 cfs for the remainder of the year. In addition to these permit conditions, there is an informal agreement for a minimum flow of 55,000 acre-feet per year at Falls City, which is approximately 36 miles downstream of San Antonio, as the crow flies. This quantity is composed largely of treated wastewater return flows from the San Antonio area Edwards Aquifer water users, and is a surrogate for stream flows that would occur in the San Antonio River if pumpage for municipal purposes had not resulted in a lowering of the Edwards Aquifer at San Antonio Springs such that San Antonio Springs cannot flow except at times when the Edwards Aquifer is full to overflowing.

### Edwards-Trinity and Trinity Group Aquifers

The Edwards-Trinity and Trinity Group Aquifers are composed of the Comanche Peak, Edwards, and Georgetown Limestones, Hosston and Hensel sands, and the Glen Rose Limestone. The surface is severely eroded, with deep canyons. The aquifers consist of interbedded sand and clay and various types of limestone with fracture and solution porosity. Well yields are generally low (100gpm and less), and water quality ranges from fresh to slightly saline.

Historically, the areas underlain by the Edwards-Trinity and Trinity Group Aquifers have been sparsely populated, and the economy has been predominantly ranching (sheep, goats, and cattle). In recent years, there has been significant residential development for professionals who commute to San Antonio and other nearby cities, retirement homes, weekend residences, and recreation enterprises, placing a significant strain upon the available ground and surface water resources. Precipitation on the Edwards Plateau is the source of runoff, which forms the Nueces, San Antonio, and Guadalupe Rivers and recharges the aquifers.

### Edwards Aquifer

The Edwards (Balcones Fault Zone) Aquifer spans six counties (Kinney, Uvalde, Medina, Bexar, Comal, and Hays) and three river basins (Nueces, San Antonio, and Guadalupe) in South Central Texas. This fractured limestone aquifer is highly transmissive, accepting an average of about 642,000 acre-feet of recharge annually, and discharging an equivalent quantity through springs and wells. Recharge to the aquifer originates from surface sources which enter the unconfined portions of the aquifer in identified reaches of streams to the west and north of San Antonio. The flow path within the aquifer is toward the east and northeast where part is captured by wells and part is discharged via springs in the San Antonio and Guadalupe Basins.

The Edwards Aquifer extends 175 miles from Brackettville in Kinney County to a point north of Kyle in Hays County, and ranges in width from 5 to 30 miles. The Aquifer has a shallow outcrop area where recharge occurs, and a deeper (800-1200 feet) confined or artesian area through which most of the flow moves in an east, northeast direction toward the cities of San Antonio, New Braunfels, and San Marcos. The lower boundary is the underlying Glen Rose Formation. The southern limits of the aquifer are defined by a "badwater" line, where saline water with TDS greater than 1,000 mg/l occurs.

The Edwards Aquifer has developed within the Balcones Fault Zone through limestone dissolution and channeling along a series of steep-angled step faults which occur in a narrow band along the Balcones Escarpment (4). The faults form a framework in which hairline cracks, open fractures, honey combed zones, and large caverns have been dissolved by moving underground waters (5). These large and numerous voids allow development of wells having very large yields, i.e., 6,000 to 7,000 gpm are common, and yields of as much as 19,000 gpm have been recorded. The freshwater portion of the aquifer contains excellent quality water, however, since recharge is through streambeds, cracks, fissures, and caves, without much filtration, there is a continuous threat of pollution and contamination. Development is regulated by local, state, and federal agencies in the urbanizing parts of the recharge zone.

Much of the area overlying the Edwards Aquifer is highly developed, with the aquifer being the sole source of municipal water supply (246,000 acre-feet annually) for more than 1.4 million people in parts of 8 counties (Uvalde, Medina,

Bexar, Atascosa, Comal, Hays, Caldwell, and Guadalupe). In addition, the aquifer is the source of 246,000 acre-feet of irrigation water for approximately 83,000 acres in three of these counties (Uvalde, Medina, and Bexar), 19,000 acrefeet annually of industrial water, and 9,000 acre-feet annually of water for other purposes.

On an annual basis, total withdrawal from the aquifer through wells is approximately 520 thousand acre-feet per year, or 80 percent of the aquifer area's water supply. In addition, springflows from the aquifer at Comal Springs in Comal County (New Braunfels) and San Marcos Springs in Hays County (San Marcos) support several endangered species (Texas Blind Salamander, Fountain Darter, Ssn Marcos Gambusia and Texas Wild Rice), and contribute to stream flows of the Guadalupe and San Antonio rivers, which supply surface water for municipal, industrial, irrigation, and fish and wildlife of both basins in the areas downstream of the springs.

### Carrizo-Wilcox Aquifer

To the south and southeast of the Edwards Aquifer lies the Carrizo-Wilcox Aquifer which underlies all or parts of 15 counties of the three river basins in which the Edwards Aquifer is located. This aquifer supplies water to the area in which it is located, is a potential source of water to supplement supplies for the Edwards area, and to a degree its recharge may be affected by use from and recharge to the Edwards Aquifer.

Potentiometric-surface maps of the Carrizo-Wilcox in the Nueces River Basin show that the aquifer has undergone extensive development over the last 70 years. At the turn of the century, the aquifer was full and a significant local component of groundwater flow did not migrate down dip but discharged to the major streams and rivers in the basin. Later, the large irrigation withdrawals of groundwater from aquifer storage (130 thousand acres irrigated with about 250 thousand acre-feet per year of water from the Carrizo-Wilcox Aquifer) caused regional declines in Carrizo-Wilcox water levels, which directly affected the cost of pumping water and which are also potentially related to reduced stream flows. Many of the groundwater studies conducted by the Texas Water Development Board (TWDB) and U.S. Geological Survey document the irrigation development and provide useful data regarding the interaction of groundwater and surface water flow in the basin.

Significant water level declines have occurred in the outcrop of the Carrizo-Wilcox Aquifer in the Atascosa River Watershed over the 1930-1990 period. For example, water level data contained in TWDB Report 210 shows that average water level declines of about 0.5 feet per year occurred since 1930. Large-scale groundwater production from this aquifer may be resulting in decreased stream flows, thereby affecting water availability to downstream water rights, in-stream flows and fresh water flows to estuaries.

### Gulf Coast Aquifer

To the southeast of the Carrizo-Wilcox Aquifer lies the Gulf Coast Aquifer, which underlies all or parts of 10 counties in the coastal area of the three river basins. Although the coastal area obtains water from the Gulf Coast Aquifer, it is very important to note that the coastal area relies upon the Guadalupe and San Antonio Rivers for a large part of its present water supply. In fact, nearly 80 percent of surface water rights of the Guadalupe Basin are permitted for municipal, industrial, and irrigation use in this coastal area. In addition, in the Guadalupe and San Antonio Basin areas, the Gulf Coast aquifer is being overdrafted locally, resulting in water level declines, saline water encroachment, and increased pump lifts. Thus, local users now on Gulf Coast Aquifer supplies are being forced to turn to the Guadalupe and San Antonio Rivers for surface water.

In the Nueces and adjoining coastal basins, the Gulf Coast Aquifer supplies water locally to the smaller cities and communities, however, water level declines and salinity encroachment is affecting these areas in the same manner as was

described above for the Guadalupe Basin coastal areas and new supplies from surface sources are being sought.

## MANAGING WITHDRAWALS FROM THE EDWARDS AQUIFER

Within the three river basin area where the Edwards Aquifer is located, growing demands are increasing the competition for scarce water resources. As the description of the area has shown, aquifer recharge affects stream flows in some areas, aquifer pumpage and use affects spring flows, which in turn affect endangered species and stream flows for downstream water rights holders, instream supplies for fish and wildlife, and ultimately freshwater flows to two of Texas' seven major estuaries -- Nueces and San Antonio Bays.

Lawsuits under the Federal Endangered Species Act have resulted in Court Orders to reduce pumping from the Edwards Aquifer in order to protect spring flows at Comal and San Marcos Springs to levels needed for species survival (6). In 1993, the Texas Legislature enacted legislation which created the Edwards Aquifer Authority (7). The Act was amended in 1995, and tested in 1996 all the way through the Texas Supreme Court. The Authority is governed by 15 directors elected from single member districts of the 8 county (all of 3 counties and parts of 5 counties) aquifer area for staggered terms of 4 years. The Authority has powers to issue pen-nits to Edwards Aquifer users who can demonstrate a history of water use from the Edwards Aquifer during the period June 1, 1972, through May 31, 1993. Total annual permitted Aquifer usage is set at 450,000 acre-feet through 2007, reduced to 400,000 acre-feet from 2008 through 2011, and by December 31, 2012, must be at a level to ensure flows of Comal and San Marcos Springs. Under the Act, the Authority must implement a water management plan, and has powers to develop aquifer recharge and other water supply projects.

The Act provides that water permitted for use from the Edwards Aquifer must be used within the boundaries of the Edwards Aquifer Authority, and irrigators may lease up to one-half of their respective permitted right, with the other half remaining with the land to which it is assigned. The Authority will assess user fees, but may not levy taxes, and will be advised by a 20 member South Central Texas Water Advisory Committee regarding downstream water rights and issues.

## CONCLUDING COMMENTS

Economic development and water use have occurred within the area of the Edwards Aquifer under conditions of Texas water law, in which the right of capture applied to groundwater and appropriative rights based upon the principal of first-in-time first-in right applied to surface water. As growth has occurred, the demand for water has increased to a point at which competition for limited supplies has resulted in major conflicts between users and environmental needs, and among users. For example, stream flows of the three rivers spanned by the Edwards Aquifer are affected by recharge to the aquifer and spring flows from the aquifer affect stream flows of the Guadalupe River, a factor which affects endangered species and the downstream area's water supplies. Reference is made to the areas of the Guadalupe and San Antonio Basins mentioned in the Gulf Coast Aquifer discussion, where spring flows affect supplies for endangered species and downstream water rights holders.

In the Nueces Basin, a case in point is the 10-county Corpus Christi regional service area, whose water supply is the Choke Canyon/Lake Corpus Christi Reservoir System in the Nueces Basin. The yield of this system is determined by Nueces and Nueces Tributary flows. To the extent that recharge to the Edwards and Carrizo-Wilcox Aquifers and/or channel losses between the downstream boundaries of the Edwards Aquifer recharge zone reduces inflows to these reservoirs, this 10-county area's water supply is adversely affected, and becomes a consideration in management and administration of the Edwards Aquifer. Added to the other demands are the needs for instream flows for fish and wildlife and freshwater flows for bays and estuaries, and one begins to see the level of competition and conflict for scarce water resources. In fact, the degree of competition has led to legislation which changes the right to use of water from the Edwards Aquifer from that of right of capture to one of permits, with controls upon total withdrawals. Implementation of

this new legislation is just beginning, and the expected results are improvements in water use efficiency, a market in water rights, and development of supplemental supplies, both within the region and in the longer term, development of supplies for importation from neighboring basins.

## REFERENCES

(1) Barshop, Phil, Ralph Zendeias, Mike Beldon, Rosa Maria Gonzalez, John Sanders, Sylvia Ruiz Mendelsohn, Joe Bernal, Rogetio Mimos, Mack Martinez, Jane Hughson, Doug Miller, Paul DiFonzo, and the State of Texas v. Medina County Underground Water Conservation District, et al, appellees, on direct appeal from the 38th District Court of Medina County, Texas, in the Supreme Court of Texas, No. 95-0881, Austin, Texas, June 28, 1996.

(2) Barshop, Phil, Ralph Zendeias, Mike Beldon, Rosa Maria Gonzalez, John Sanders, Sylvia Ruiz Mendelsohn, Joe Bernal, Rogetio Mimos, Mack Martinez, Jane Hughson, Doug Miller, Paul DiFonzo, and the State of Texas v. Medina County Underground Water Conservation District, et al, appellees, on direct appeal from the 38th District Court of Medina County, Texas, in the Supreme Court of Texas, No. 95-0881, Austin, Texas, June 28, 1996.

(3) Of the 61,400 acre-feet of steam-electric power generation rights, approximately 48,900 acre-feet or 80 percent is for diversion and use of this quantity of San Antonio's treated municipal wastewater which originates from municipal water that is obtained from the Edwards Aquifer.

(4) Harden, Rollin, "Proceedings, San Marcos and Comal Springs Symposium," Southwest Texas State University, San Marcos, Texas, December, 1988.

(5) Harden, Rollin, "Proceedings, San Marcos and Comal Springs Symposium," Southwest Texas State University, San Marcos, Texas, December, 1988.

(6) Sierra Club v Babbitt, Cause No. MO-9 I -CA-069 in the United States District Court for the Western District of Texas, Midland/Odessa Diversion, February 1, 1993, and subsequent findings and conclusions.

(7) Senate Bill 1477, as amended in 1995, Texas Legislature, Austin, Texas, 1993.

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