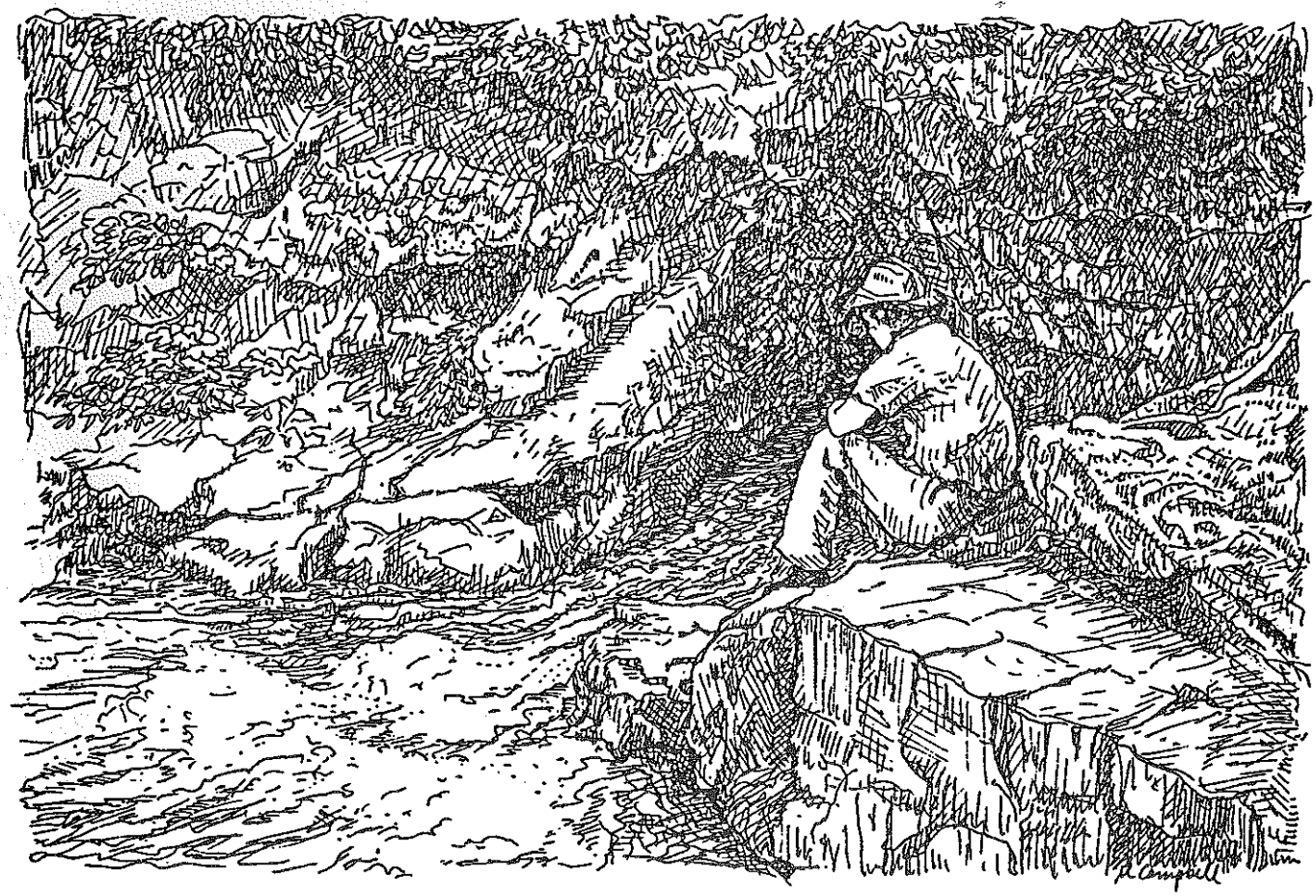
Tony

Proceedings

San Marcos & Comal Springs Symposium



December 2 - 3, 1988

Southwest Texas State University

SYMPOSIUM - SAN MARCOS & COMAL SPRINGS
December 2-3, 1988

STATEMENT OF ISSUES

1. Within the Edwards Balcones Faults Zone - BFZ Aquifer (herein after called the Edwards or the Aquifer) area, population and economic growth have reached a point at which present levels of water use for people and the economy are straining the capacity of the Aquifer to support the water needs of the people, the economy, San Marcos and Comal Springs, the ecology within the formation, and downstream rights to stream flows from these springs (downstream rights include rights to water supplies for both instream and out-of-stream uses).
2. The growth of water using activities -- people, the economy, and outdoor water oriented recreation - is projected to continue, thereby placing additional strain upon the Aquifer and threatening to reduce and/or stop the flows at San Marcos and Comal Springs. The interruption of spring flows is expected to increase in the future, as larger quantities of water are pumped from the Aquifer for other uses.
3. There is a widespread lack of awareness and understanding that San Marcos and Comal Spring flows are threatened by the growth of water use in the Edwards (Balcones Fault Zone - BFZ) Aquifer area.
4. Some of those who are aware and understand the nature and implications of the threats to spring flows are apathetic and are taking no actions to solve the problem.
5. Controversy has grown as to the economic and social value of spring flow.
6. There is controversy about the effects of drawing water levels of the Edwards Aquifer below historic lows; i.e., below elevation 612 feet mean sea level which occurred in 1956. Note: Comal Springs did not flow for a period of five months during the summer of 1956 at the end of the drought of record for the area. The hypothesized effects include:
   (a) "bad" water intrusion from formations adjacent to the southern or down slope boundaries of the Edwards (BFZ);
   (b) adverse, and perhaps devastating effects upon aquatic organisms of the aquifer and of the streams that are supplied with water from the springs, including stream reaches that extend into San Antonio Bay and Estuary;
   (c) elimination of stream flows in the Comal, San Marcos, and

Guadalupe rivers to which water rights have been permitted by the Texas Water Commission for beneficial uses; and

(d) the adverse effects upon those who obtain water from the Edwards Aquifer through wells, from "bad"water intrusion, increased pump lifts, and reduced supplies of water during times of drought.

7. There is controversy about how to meet the future water supply needs of the area which now depends upon the Edwards Aquifer, including:

(a) conservation programs;

(b) Aquifer recharge methods and extent of recharge projects;

(c) reuse of treated wastewater effluent;

(d) regulation of withdrawals from the Aquifer and allocation of withdrawals among established water uses in areas that overlie the Aquifer as well as in some areas adjacent to the Aquifer;

(e) the role and extent of surface water development to supplement supplies from the Edwards Aquifer;

(f) who or what water using entities should develop surface water to supplement supplies from the Aquifer, how water from the Aquifer and surface water should be allocated and integrated into a management system, and how the costs of developing and distributing surface water should be allocated among water users served by the Aquifer and interdependent surface streams.

8. Whether the Edwards Aquifer should be classified under the Texas Water Code as an underground stream, and as such be regulated by the Texas Water Commission in the same manner as rights to withdraw and use water from surface streams is done. Thus, the question would be whether the Texas Water Commission would assume jurisdiction over the Edwards underground stream (if it is so classified) and should adjudicate, establish, recognize, and award water use permits to those who can demonstrate and prove a history of withdrawal and beneficial use of water from this underground stream.

9. Whether water quality of the Edwards Aquifer should be protected through regulation of uses of land in the recharge zones, and through collection, treatment, and safe disposal of wastewater effluent that might otherwise reach the Aquifer.

10. Whether local planning and management is preferable to that imposed from outside by the State or Federal governmental authority.

11. Means by which local area objectives should be stated, described, fully evaluated, and used as the basis to manage and finance water use and water quality protection of the Edwards Aquifer area.

SYMPOSIUM PURPOSE

The Symposium was planned by its Sponsors because they were concerned for the future of the springs and the potential for loss of the contribution the springs make to the State of Texas, Central Texas, and downstream interests dependent on flows of the Guadalupe-Blanco River system below San Marcos to the coastal bays and estuaries.

Sponsors identified the symposiums objectives as follows:

> To begin formulation of an orderly assessment of the several values and costs of maintaining and protecting natural flows at San Marcos and Comal Springs - to assess effects locally and downstream of changes on streamflows, water rights, fish and wildlife, ecology within spring sites; to identify the expertise required to make these assessments; to begin an active and detailed public information program to make certain all interests are properly represented in the assessment process and that policy decisions are reached appropriately.

A Technical Panel was formed by the Sponsors including representatives of statewide and spring interests and nationally known experts. The Panel provided a broad overview of Symposium results through these Proceedings. Based on its collective experience and knowledge, the Panel identified the issues involving the springs under present and projected patterns of water use in the Edwards Aquifer and in consideration of the delicately balanced environment and ecology of the springs issuing from the Edwards.

SUMMARY OF PHYSICAL CONDITIONS IN THE EDWARDS AQUIFER (From Symposium Papers)

Water flowing through the Edwards Aquifer originates from its tributary surface streams. The major tributary streams include the West Nueces, Nueces, Dry Frio, Frio, Sabinal, Seco, Hondo, Medina, Helotes, Salado, Cibolo, Dry Comal, and the Blanco. Typically, most of the base flow and a large portion of the flood flows of these streams feed the Edwards and through it the Guadalupe River. Increased use of water from the Edwards Aquifer has been substantial, as regional populations have grown, particularly around the city of San Antonio. Irrigation has increased in Uvalde, Medina and Kinney Counties.

Based upon hydrologic records the springs comprise the base flow of the Guadalupe River. Over the 1940 - 1985 period, flows from the Comal and San Marcos springs comprised 30.6% of the total flow of the Guadalupe River on an average annual basis at the confluence of the Guadalupe and San Marcos River. In the lower Guadalupe Basin near Victoria, spring flows comprise 25% of the total average annual flow of the river. Over the nine year drought of record in the basin from 1948 to 1956, spring flows were 48% of the average annual flow of the Guadalupe-San Marcos confluence. More significantly, spring flows comprised 76% of the total river flow at the Guadalupe-San Marcos confluence in one of the nine years, that was 1954. It was over 70% in three of the nine years and over 60% in five of the nine years. In 1988, spring flow at Victoria was 84% of the total river flow.

Rights to use of surface water from the Guadalupe River have been adjudicated by State courts and are administered by the Texas Water Commission. In excess of a quarter of a million people living in the Guadalupe Basin and adjacent coastal basins depend upon the waters of the Guadalupe for their water needs. Approximately 320 permits and certified filings have been established to surface water rights in the Guadalupe River. Water used under these permits and certified filings include for consumptive use: municipalities using 70,024 acre feet; industrial 142,866; irrigation 119,029; mining 313; other 961; a subtotal of 333,193 acre-feet. Non-consumptive uses include hydroelectric 5,671,249 acre-feet, recreation 11,412, industrial 354,419, other 1,624 for a subtotal of 6,038,704; for a total of 6,371,897 acre-feet of water used in the river basin.

LEGAL ACTIONS - JANUARY, 1989 THROUGH JANUARY, 1990

JANUARY 21, 1989

An election was held in Medina and Uvalde counties on the proposition to withdraw from the Edwards Underground Water Conservation District. The result in Medina County was 2241 to 846 in favor of withdrawing. In Uvalde county, the result was 3120 to 305 to withdraw. Thus, the Edwards District includes the areas of only three counties - Bexar, Comals and Hays.

June 15, 1989

Notice of Endangered Species Act Violations

To: Manuel Lujan, Jr.
Secretary, Department of Interior

By: Guadalupe-Blanco River Authority

The Notice details violations of the Act and regulations adopted to implement the Act by actions. Taken with respect to the Edwards Aquifer (Balcones Fault Zone - San Antonio Region). The Notice identifies alleged violations in its Exhibit "R" (federal agencies) and Exhibit "B" (water well owners or pumpers). Actions by listed alleged violators are described as imperiling three endangered species and one threatened species by "destroying or adversely modifying those protected species critical habitat".

June 15, 1989

Original Petition filed in the District Court of Hays County, 22nd Judicial District;

In Re: The Adjudication of Rights to Water in the Edwards Aquifer No. 89-0381.

Action filed by the Guadalupe-Blanco River Authority alleging that "Massive, unregulated pumping from the Edwards Aquifer (the "Edwards") is threatening to cause severe and irreparable harm to the Comal and San Marcos Springs. the Guadalupe River Basin, the San Antonio Bay and Estuary and the Edwards itself. The petition further declares "The Edwards is an underground river. It is the major tributary of the Guadalupe River".

August 17, 1989

Notice of Removal filed by the Army/Air Force removing the GBRA suit to the United States District Court for the Western District of Texas, Austin

Division. The case was styled Guadalupe Blanco River Authority vs. City of Lytle, et al., and was assigned Civil Cause No, 89-CA-771 in the federal court.

In subsequent legal actions, the case has been remanded to the state court where it has not been heard.

TABLE OF CONTENTS

TABLE OF CONTENTS - CONTINUED

PROCEEDINGS

Walter Cardwell III - Chairman, Governors Committee on Water Resources Management

This symposium has two purposes as I understand it. One is education and the second is an explanation of the planning process and the proposals for gaining the assistance of the legislature in implementing the regional water plan that has been put together. The biggest enemy to that plan and to this process is ignorance. We held hearings on groundwater matters and it is no surprise, I know, to anybody here, that Texans are very interested in propositions to regulate groundwater. Let me speak to the task in front of this group when it comes to propositions to regulate groundwater or manage groundwater in the Edwards Aquifer. I give you my humble and not too tentative opinion that there is very little if no chance of persuading the State of Texas that statewide groundwater needs to be regulated at this time. But I don't consider that to be a problem; I don't consider that to be an impediment, because the Edwards Aquifer is a very unique structure. It's a different situation than we find anywhere else in the state. It has a problem, it deserves special attention. And, Texas does have a history of local control, local solutions for local problems.

Don Rains - County Judge Hays County - December 2, Afternoon Session A

I have the pleasure of moderating the first afternoon session. Subject for our first Panel -<u>What are the Issues?</u>

Eddie Gumbert - Chairman, Guadalupe-Blanco River Authority

The origin of the water flowing through the Edwards Aquifer is its tributary surface streams. The major tributary streams include the West Nueces, Nueces, Dry Frio, Frio, Sabinal, Seco, Hondo, Medina, Helotes, Salado, Cibolo, Dry Comal, and the Blanco. Typically, all to nearly, all of the base flow and a large portion of the flood flows of these streams feed the Edwards and through it the Guadalupe River. Increased use of water from the Edwards Aquifer has been substantial, as regional populations have grown, particularly around the city of San Antonio, and irrigation has increased in Uvalde, Medina and Kinney Counties. In 1934 the total diversion from the Edwards was 102,000 acre-feet. In 1985, 522,500 acre feet were diverted. Based on 1982 data, water from the Edwards for municipal use was 59%, industrial use 3%, irrigation 29%, and other use 9%. Current levels of diversion from the Edwards cannot be sustained if another drought occurs equal to or greater in severity than the drought of record. Inflows to the Edwards during the drought of record in the Guadalupe Basin from

1948 to 1956 averaged 212,800 acre-feet per year compared to the historical annual average recharge of(608,000) acre-feet.

As a result of the population growth and rise in economic activity, the average water requirements in the region served by the Edwards are projected to increase to approximately 600,000 acre feet in the year 2010 and approximately 900,000 acre-feet in the year 2040. In 1956, the Comal Springs ceased to flow for a period of five months, and the San Marcos Springs were reduced to a minimum flow of 46 cubic feet per second during that time. Because of the increased diversion from the Edwards since 1956, springs flows now fluctuate dramatically during less severe droughts. It is projected that if diversions from the Edwards are allowed to increase, the springs will become intermittent and will finally cease to flow except during periods of high rainfall.

Based upon hydrologic records, it is obvious that the springs comprise the base flow of the Guadalupe River. Over the 1940 - 1985 period, flows from the Comal and San Marcos springs comprised 30.6% of the total flow of the Guadalupe River on an average annual basis at the confluence of the Guadalupe and San Marcos River. In the lower Guadalupe Basin near Victoria, spring flows comprise 25% of the total average annual flow of the river. Over the nine year drought of record in the basin from 1948 to 1956, spring flows were 48% of the average annual flow of the Guadalupe San Marcos confluence. More significantly,spring flows comprised 76% of the total river flow at the Guadalupe San Marcos confluence in one of the nine years, that was 1954. It was over 70% in three of the nine years and over 60% in five of the nine years. Today (December 2, 1988),the spring flow at Victoria is 84% of the total river flow.

Rights to the use of the surface water of the Guadalupe River have been adjudicated by the state courts and are administered by the Texas Water Commission. In excess of a quarter of a million people living in the Guadalupe Basin and adjacent coastal basins depend upon the waters of this river for their daily needs and economic well being. There are approximately 320 permits and certified filings to surface water rights for the Guadalupe River. Water used under these permits and certified filings include for consumptive use: municipalities using 70,024 acre feet; industrial 142,866; irrigation 119,029; mining 313; other 961; a subtotal of 333,193 acre-feet. Non-consumptive uses are hydroelectric, 5,671,249 acre feet; recreation 11,412; industrial 354,419; other 1,624; for a subtotal of 6,038,704; for a total of 6,371,897 acre-feet of water used in the river basin. Flows of fresh water in the San Antonio Bay system necessary to maintain the salinity gradient for the continuance of the population of many endemic estuarine species and many other marine species. If diversions from the Edwards are allowed to increase, flows from the Comal and San Marcos

Springs will decrease even further and flows from the Guadalupe River south of the Balcones Escarpment will cease for brief periods of time and will result in severe economic and environmental damage to the Guadalupe River Basin, adjacent coastal basins, and the San Antonio Bay and Estuary.

Harry Bishop - Director, Edwards Underground Water District, Hays County

In dealing with the questions of issues facing the springs, the obvious temptation is to make a laundry list. I have a list to present to you of those that seem most critical. I am not sure they are the most important, but they are ones that came to mind and fit the alphabet game that I chose to play. Begin with the "A" word and that is apathy. It is really one of the most frustrating problems I have faced in trying to talk to people, trying to stimulate interest in the Aquifer, the spring flow situation, and downstream water rights and uses.

"B" is the bad water zone or the bad water line.

"C" is conservation, one of the major components of the regional water plan. Another "C"are the competitive interest groups from where the Aquifer begins in the west, moving to the east and downstream from San Marcos. They are legitimate interests; they have legitimate priorities; and they have legitimate needs: agricultural interests in the west, and downstream on the Guadalupe, municipal and industrial interests in San Antonio and the other cities in the district and certainly all the other people in the region. To take a moment to clarify the regional concept, as it is used in this Symposium it includes the area along the Nueces River, the San Antonio River, and the Guadalupe Blanco River systems that feed to and are fed by the Edwards Aquifer, extending all the way to the coastal bays and estuaries.

The region includes the water needs of all the downstream people, which leads to "D" the downstream interests, and to "E" the estuaries. Water that flows out of these springs in Hays County and Comal County ends up at Lavaca Bay. The San Antonio River goes into the estuaries as does the Nueces River at Corpus Christi. The marine life in those estuarine areas cannot reproduce and survive if salinities get too high. They need dilution and therefore they require base flow into the estuaries.

"F" is financing. There is a regional water plan proposed. If implemented, it will cost a lot of money.

"G" is groundwater regulation, "P" "Q" we might call protection of water quality.

I skipped a number of letters, but I think you could go through the alphabet and come up with four issues per letter. We go on to "R" words-rainfall and recharge. Another issue is withdrawal from the aquifer and that has two facets - withdrawal as the amount of water withdrawn from the aquifer through wells, and also the two counties considering withdrawing from the district. That would have far reaching and potentially devastating effects on what we are doing. The all important issue, the overriding issue, the issue that all of these things are associated with in one way or another is management of the resource, management of the Aquifer. That's the key issue. We need to manage the resource because we are running out of water. We are bringing more people into the region; we are developing industry; we are developing irrigated agriculture in the west. The demands are ever increasing and we are dealing with a fairly finite amount of water. That amount fluctuates but the annual withdrawals have now exceeded the average recharge. The idea is to develop a comprehensive management plan. Such a plan has been developed. It is going to take legislative action and legislative approval.

This comprehensive regional management plan has four major components. One is conservation of water. Reuse is another part of the comprehensive plan. The City of San Antonio calls these re-use treatment plants water factories. The third facet of the regional management plan is surface water development. Equitable distribution of water and costs are the fourth major factors of the plan.

Dr. Kenneth Ikels - Director, Edwards Underground Water District, Comal County

We have a unique Aquifer; unique in the sense that there is none other like it. You can drain it, and it refills as soon as it rains. But the minute it starts raining again we get apathetic, and we lose sight of what we need to do. If we are going to go ahead on this idea of a regional waterplan, to help get this regional water plan into the legislature, we're going to have to convince a lot of people that this is a unique Aquifer. There is not another one like it in the State of Texas.

There are groundwater management organizations in Texas that have specific responsibilities, such as the Harris- Galveston Subsidence District. When you take water out of the Gulf Coast aquifer what happens? The ground sinks down. That doesn't happen to our particular Aquifer.

The Texas Water Development Board in publication #189 in 1975 mentioned that there were 281 historic and significant springs in the state of Texas. In 1975,there were four large springs of which two of them had already disappeared, leaving Comal and San Marcos Springs. These springs have historical significance and environmental significance and should not be allowed to dry up and be forgotten.

One of the important things that has come out of the Edwards Underground Water District in recent times is the drought management plan. This was the first management tool that we have put into existence. This drought management plan is a special plan for specific times. The goals of the plan are to protect health and safety; to protect the quality of the Edwards water; to share some of the impacts or hardships caused by the drought; to minimize disruption of the economy; to lengthen the time before the Comal Springs go dry, and to prevent the San Marcos Springs from going dry. This is a very important piece of legislation passed by the last session of the legislature in House Bill 1942. There are those who say that this plan is too restrictive, that the levels for trigger conditions are too high. But our goals are that we are not going to overdraft the Aquifer. If you overdraft the Aquifer and pull the level down below the lip of the springs, then this plan is not working. But, if you've established that you're not going to overdraft the Aquifer, then this is an excellent management tool. With rainfall as it is at the present time, we have cause to use this plan very quickly. But this plan could be in jeopardy. If counties to the west vote to withdraw from the district then this plan would only apply to the remaining counties within the district. It would not apply to those counties that have withdrawn. Sometime in the future we may want to address the issue of what we would do in the event that some of the western counties or one of the western counties withdraws. Then we lose that effort of concentration on restrictions caused by drought conditions.

I think that having this seminar and getting together and talking about it, learning about it, asking questions and getting information is probably one of the finest things that we should do. And I think that we should do this, not just once in awhile, but every year because we are growing, the numbers of people are growing, conditions are changing and we need to bring these to the forefront. Thank you.

Questions

Q. Has there been any work done as far as dealing with population growth? The general approach has been a kind of acceptance that the area is going to grow. The demographics of course have changed in the last two or three

years. Before that it was a rapidly growing area and probably will be again. It is slow right now but it's continuing to grow. There is concern that if we become known as a water scarce area, industries are going to stop coming in. So, it's a bit self-limiting, and interest groups and factions are concerned with that image, but the general approach has been to prepare for more people, more users.

A. In general none of the plans are predicated on the notion that population growth will decline, but suggest that it will continue to increase. The issue has arisen more and more times than you can imagine, because people are beginning to ask that question. The fundamental problem may be increased population, but what people have to recognize and understand is whether we have the mechanisms to do anything about it. We know that since 1973, we have known that energy is reasonably finite. I think the number of cars on the highway has increased since that time. The idea is that somehow it just keeps on happening and there's not a whole lot that we can do about it. But the point is that people are asking that question.

Q. Are there regional differences among Edwards water users?

A. In the past several years, the Edwards Board has been very actively looking at the agricultural, the municipal San Antonio area, and of course the spring area. So we have three distinct areas that we're trying to meld together into this regional water plan. Certainly there are going to be differences of opinion. Each one has a different priority. And as a result of that, we're going to have a lot of discussion and a lot of weeping and wailing and gnashing of teeth.

Q. What about use of reclaimed water?

A. I think it's a matter of location. The concept is a little difficult to sell. So we're looking for markets. If there are existing markets, we could care for those needs while other needs are developing. It's a matter of locating the plants in the right place and transporting the water to them. If we can designate a site for industrial, high water use industries then we can try to put a wastewater treatment plant there.

Panel A Surface and Groundwater in the Region

Surface Water - Dr. William Espey, Espey, Huston and Associates

The Guadalupe River Watershed

The Guadalupe River Watershed consists of two component watersheds which are referred to herein as the "contributory watershed" and the "traditional watershed." The following discussion describes these component watersheds and their relationship. Figure 1 shows the Guadalupe River Watershed and its component parts.

The Contributory Watershed

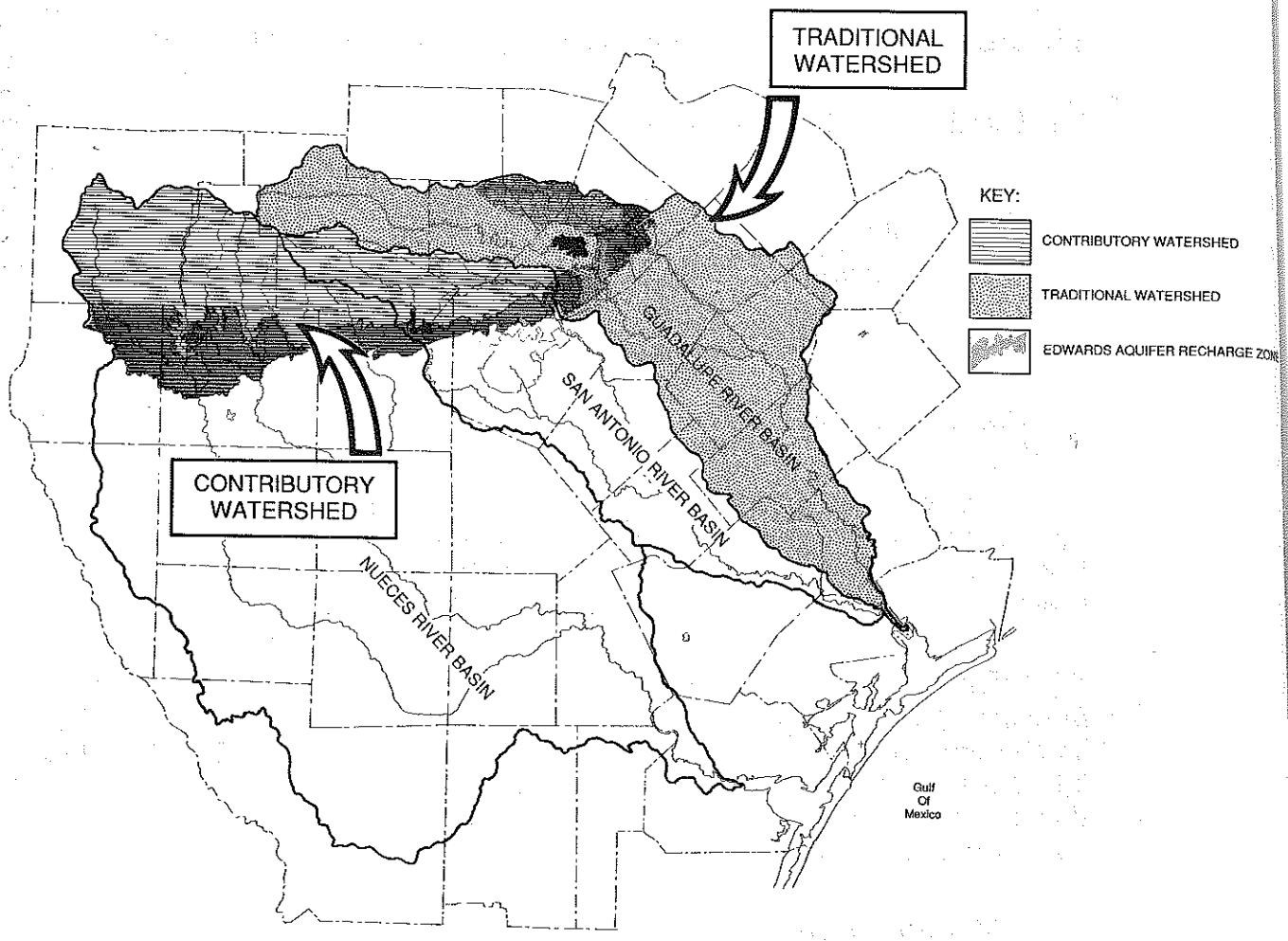
The contributory watershed of the Guadalupe River consists of numerous surface drainage basins which contribute to the Guadalupe River via the Edwards Aquifer. This area is also sometimes referred to as the catchment area and recharge zone of the Edwards Aquifer.

The contributory watershed consists of approximately 4,647 square miles,composed of approximately 3,546 square miles of non-recharging catchment area and 1,101 square miles of recharge zone. Approximately 1,812 square miles of drainage area upstream and within the recharge zone do not contribute significantly to Edwards Aquifer recharge and are not part of the contributory watershed.

Within the Nueces River Basin boundaries, the contributory watershed contains portions of Edwards, Real, Bandera, Kinney, Uvalde, and Medina counties. Major surface streams which collect surface runoff within this portion of the contributory watershed include the West Nueces River, the Nueces River, the Dry Frio River, the Frio River, the Sabinal River, Seco Creek, and Hondo Creek.

Within the San Antonio River Basin boundaries, the contributory watershed contains portions of Kerr, Bandera, Kendall, Comal, Medina, and Bexar counties.
Major surface streams which collect surface runoff within this portion of the contributory watershed include the Medina River, Helotes Creek, Salado Creek, and Cibolo Creek.

Within the Guadalupe River Basin boundaries, the contributory watershed contains portions of Blanco, Hays, and Comal counties. Major



THE GUADALUPE RIVER WATERSHED

(FIGURE 1)

surface streams which collect surface water runoff within this portion of the contributory watershed include Dry Comal Creek and the Blanco River. The main stem of the Guadalupe River itself contributes little recharge; therefore the contributory watershed does not include the Guadalupe River surface drainage upstream of the point where the Guadalupe River crosses the southern boundary of the recharge zone.

Table 1 provides a summary of the recharge of water to the Edwards Aquifer which occurs from the contributory watershed. Total average annual recharge to the Edwards Aquifer has historically averaged 604,600 acre-feet per year(1934-1985). Of this, 342,100 acre-feet per year (or 56.6 percent) is from the Nueces River Basin, 205,300 acre-feet per year (or 34.0 percent) is from the San Antonio River Basin, and 57,200 acre-feet per year (or 9.4 percent) is from the Guadalupe River Basin.

The range of recharge is dramatic. The higher annual range of recharge varies from 200 percent to 700 percent of the average annual values, while the lower annual range of recharge is less than 11 percent (averaging 6.5 percent) of the average annual recharge values.

TABLE 1

CONTRIBUTORY WATERSHED

	Drainage Area Upstream of the Recharge Zone[1] (sq mi)	Drainage Area within the Recharge Zone[1] (sq mi)	Total Drainage Area[1] (sq mi)	Average[2] Annual Recharge (1934-85) (ac-ft/yr)	Recharge Extremes[2] (ac-ft/yr) High		Low	
Nueces River Basin								
Nueces/West Nueces River	1,233	481	1,714	100,900				
Interfluve: Nueces/Dry Frio	0	100	100	Insig	411,300	(1935)	8,600	(1934)
Frio/Dry Frio Rivers	443	168	611	110,400				
Interfluve: Frio/Sabinal	0	53	53	Insig	365,200	(1981)	4,200	(1956)
Sabinal River	215	6	221	37,900				
Interfluve: Sabinal/Medina	253	180	433	92,900	223,800	(1958)	600	(1955)
Subtotal	2,144	988	3,132	342,100	294,900	(1958)	3,600	(1956)
San Antonio River Basin								
Medina River	631	27	658	60,000				
Interfluve: Medina/Cibolo	147	129	276	65,000	104,000	(1960)	6,300	(1956)
Cibolo Creek	245	21	266	80,300[3]	237,200	(1973)	2,000	(1956)
Subtotal	1,023	177	1,200	203,200	316,900	(1957)[3]	1,800	(1956)[3]
Guadalupe River Basin								
Dry Comal Creek	7	61	68	20,500[3]				
Guadalupe River	1,482	177	1,659	Insig	81,000	(1957)[3]	400	(1955)[3]
Blanco River	372	28	400	36,700				
Subtotal	1,861	266	2,127	57,200	85,900	(1975)	8,200	(1956)
Total	5,028	1,431	6,459	604,600				
TOTAL CONTRIBUTORY WATERSHED[4]:	3,546[4]	1,101[4]	4,647[4]	604,600				

1/ Planimetered from USGS 1:250,000 topographic maps.
2/ Ozuna, et al, 1987 Edwards Underground Water District, Bulletin 45.
3/ Total average annual recharge for Cibol/Dry Comal Creek Basin split by drainage area ratio.
4/ Excludes drainage areas which do not contribute to Edwards Aquifer recharge.

Insig = "Insignificant"

The Traditional Watershed

The traditional watershed of the Guadalupe River consists of the entire surface drainage basin within the topographic confines of the Guadalupe River Basin.

The total drainage area of the Guadalupe River at its confluence with the San Antonio River is 5,963 square miles (EH&A, 1986). Of this, 2,127 square miles are upstream of the southern boundary of the recharge zone of the Edwards Aquifer, and 3,836 square miles are below the southern boundary of the recharge zone. Of the 2,127 square miles upstream of the southern boundary of there charge zone, 1,659 square miles are non-contributing to the recharge of the Edwards Aquifer (due to the fact that the main stem of the Guadalupe River itself plus the Guadalupe River drainage area within the recharge zone contribute an insignificant amount to recharge). The remaining 468 square miles contribute to recharge through Dry Comal Creek and the Blanco River, and are, therefore, a part of the contributory watershed. The situation is further complicated by the fact that all surface runoff which originates within the 468 square mile drainage area of Dry Comal Creek and the Blanco River, which is not recharged, eventually flows downstream and enters the Guadalupe River. Thus, these 468 square miles contribute to the Guadalupe River both as a portion of the contributory watershed and of the traditional watershed.

The traditional watershed thus consists of the entire surface drainage basin within the topographic confines of the Guadalupe River Basin. Of this area, 468 square miles also are part of the contributory watershed due to recharge to the Edwards which occurs in the Dry Comal Creek and Blanco River watersheds.

Stream flows within the traditional watershed are made up of surface runoff from within the traditional watershed and spring flows conveyed from the contributory watershed. Table 2 provides some basic data regarding the average annual flows and high and low flows for the period of record. Spring flow provides an average of 346,800 acre-feet per year, with a range of 75,600 to 557,600 acre-feet per year.

TABLE 2 TRADITIONAL WATERSHED

	Drainage Area (sq mi)	Average Annual Discharge (ac-ft/yr)		Discharge Extremes (ac-ft/yr) High		Low	
Springs							
Comal Springs	—	208,500	(1940-85)	295,400	(1975)	28,000	(1956)
Hueco Springs[1/]	—	26,500	(1944-74)	94,800	(1968)	—[2/]	
San Marcos Springs	—	111,800	(1940-85)	167,400	(1975)	47,600	(1956)
Subtotal		346,800		557,600[3/]		75,600	
Stream flow							
Above the Lower Edge of Edwards Recharge Zone (excl. spring flow)	2,127	351,500		706,600		14,700	(1956)
At Lower Edge of Recharge Zone (inc. spring flow)	2,127	698,312	(1940-85)	1,264,200	(1973)	90,300	(1956)
From Lower Edge of Edwards Recharge Zone to Victoria	3,071	582,088	(1940-85)	1,487,800	(1973)	25,300	(1956)
Guadalupe River at Victoria	5,198	1,280,400	(1940-85)	2,752,200	(1973)	115,300	(1956)

1/ Woodruff and Abbott, 1986, "Stream Piracy and Evolution of the Edwards Aquifer Along the Balcones Escarpment, Central Texas".
2/ Numerous periods of no flow.
3/ Summed for illustration purposes since Hueco Springs flow unavailable for 1975.

Surface stream flow from the traditional watershed above the southern boundary of the Edwards Aquifer recharge zone contributes an annual average of 351,500 acre-feet, with a range of 14,700 to 706,600 acre-feet per year.

Surface stream flow from the traditional watershed downstream of the southern boundary of the Edwards Aquifer recharge zone to the USGS gaging station on the Guadalupe River at Victoria amounts to an annual average of 582,088 acre-feet, with a range of 25,300 to 1,487,800 acre-feet per year.

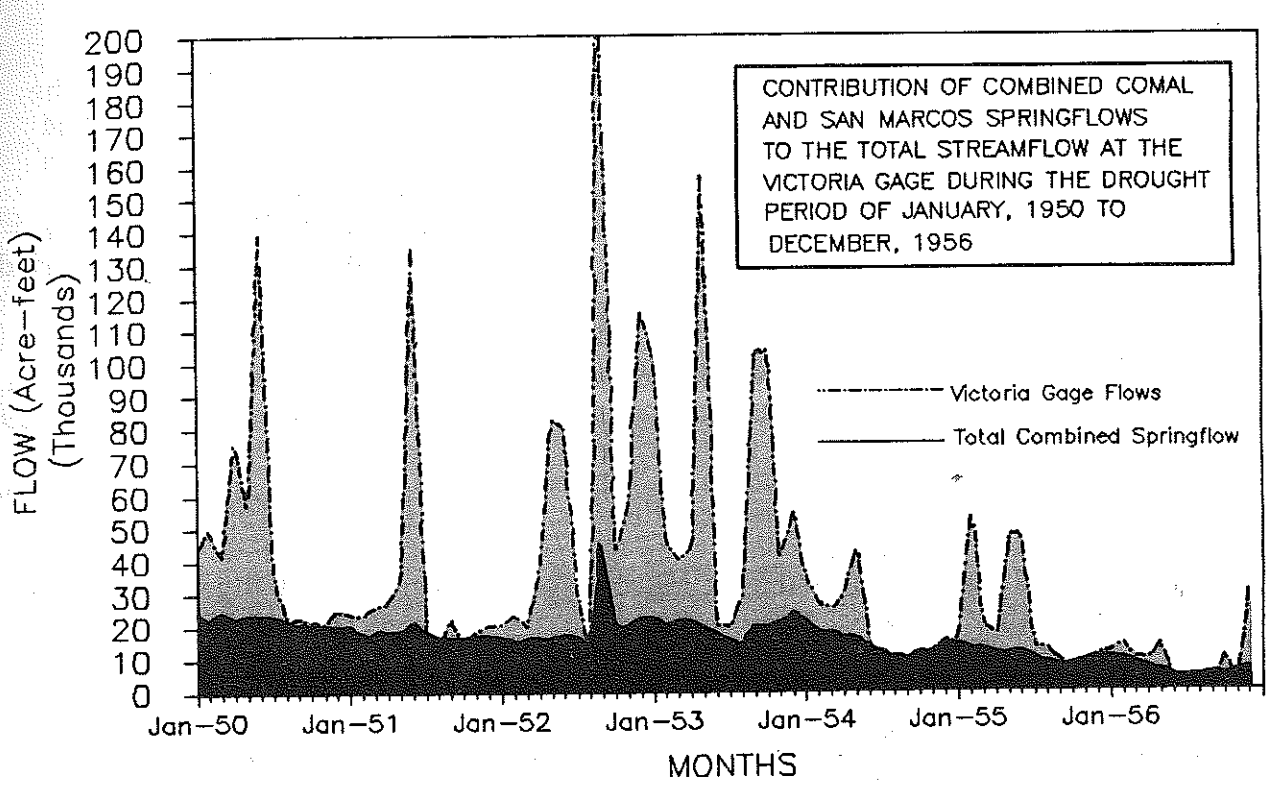
Contribution of Spring Flows to Total Flow in the Guadalupe River

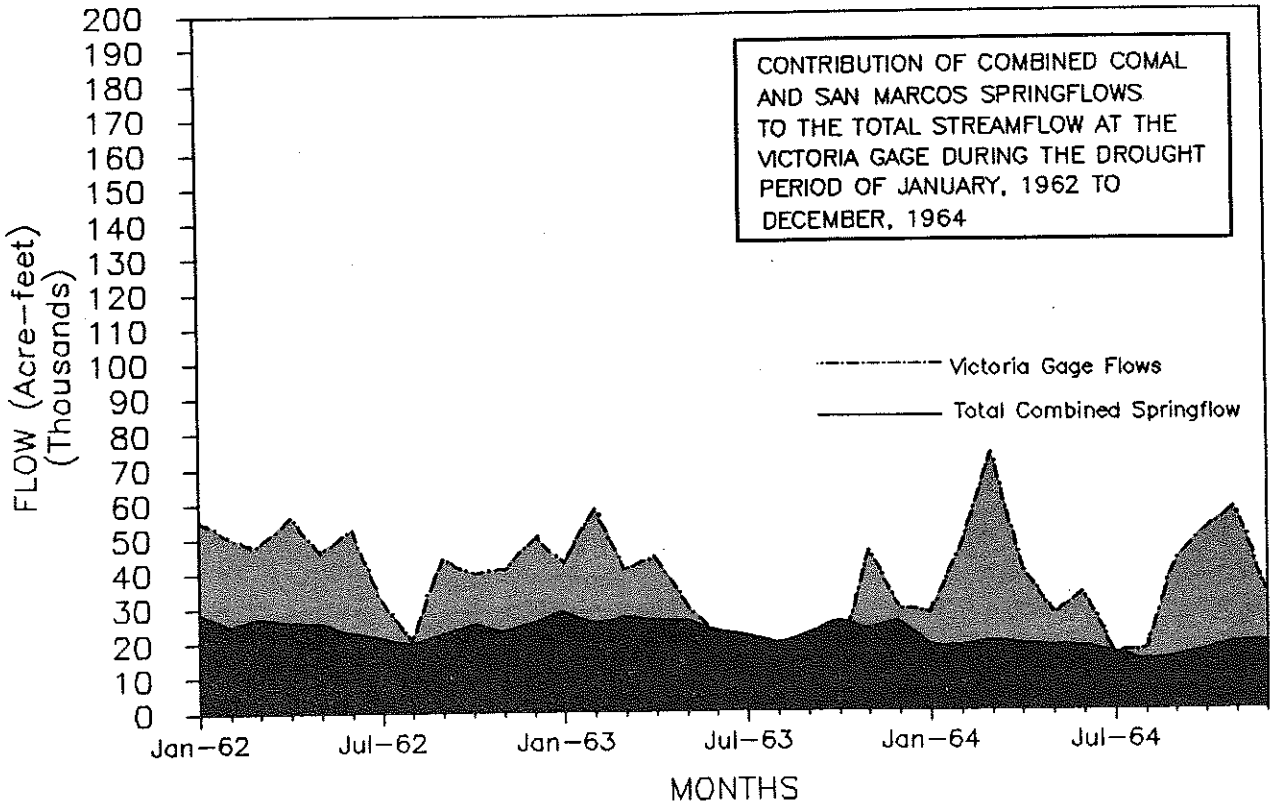
Figure 2 provides a comparison of monthly flow during the 1950-1956 and 1962-1964 time periods from the San Marcos and Comal springs to total flow in the Guadalupe River at Victoria (near the downstream end of the basin). Springflows, which are fed by the surface flows of the contributory watershed, comprise a significant and extremely important portion of the river flows.

On an average annual basis (1940-1985), spring flows comprise 49.7 percent of the total flow in the Guadalupe River Basin just downstream of the lower edge of the recharge zone (Table 2). Further downstream, at the confluence of the Guadalupe and San Marcos rivers, spring flows comprise 30.6 percent of the total flow in the Guadalupe River. At Victoria, near the lower end of the Guadalupe River Basin, spring flows comprise 25.0 percent of the total flow of the Guadalupe River.

During the drought of record, which lasted for approximately nine years from 1948 through 1956, spring flows averaged 212,800 acre-feet per year, or 48.0 percent of the total annual average flow of 444,600 acre-feet per year in the Guadalupe River just below the confluence of the Guadalupe and San Marcos rivers. On an annual basis during this period, spring flows comprised 76.2 percent of the total flow at the Guadalupe-San Marcos confluence in 1954; over 70 percent in three of the nine years; and over 60 percent of the total in five of the nine years.

COMPARISON OF SPRINGFLOW TO STREAMFLOW



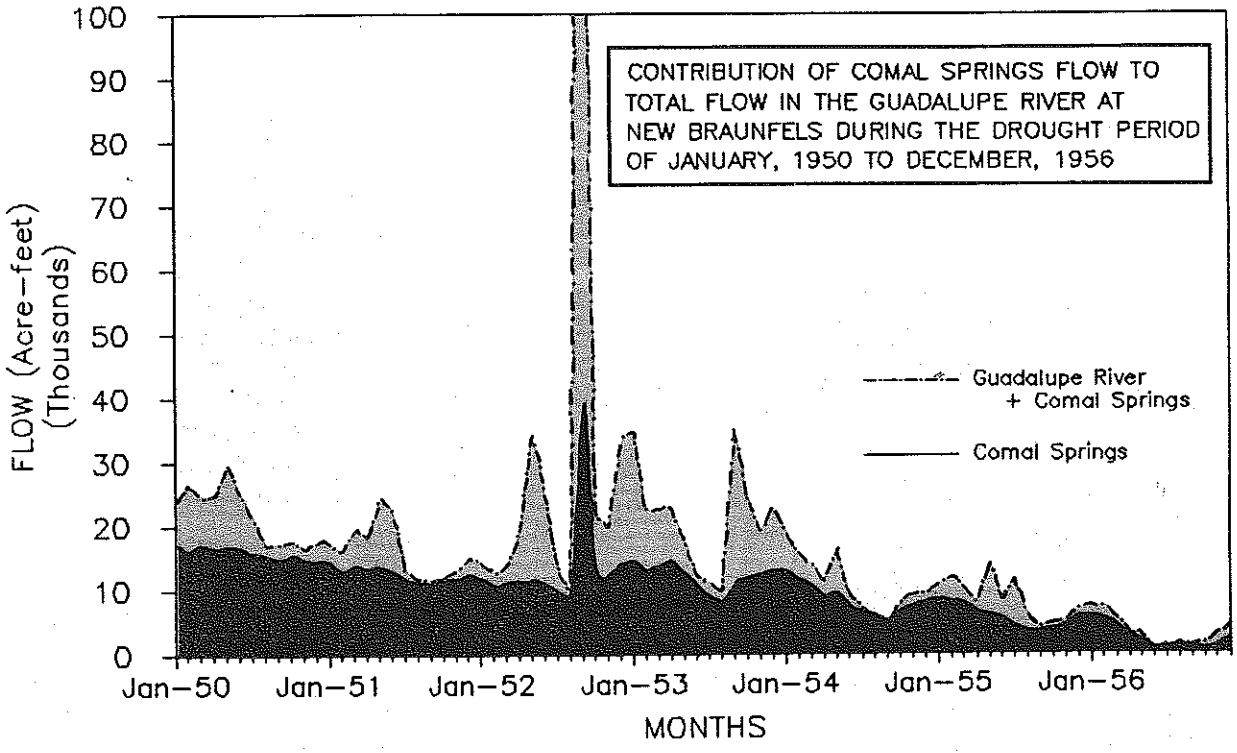


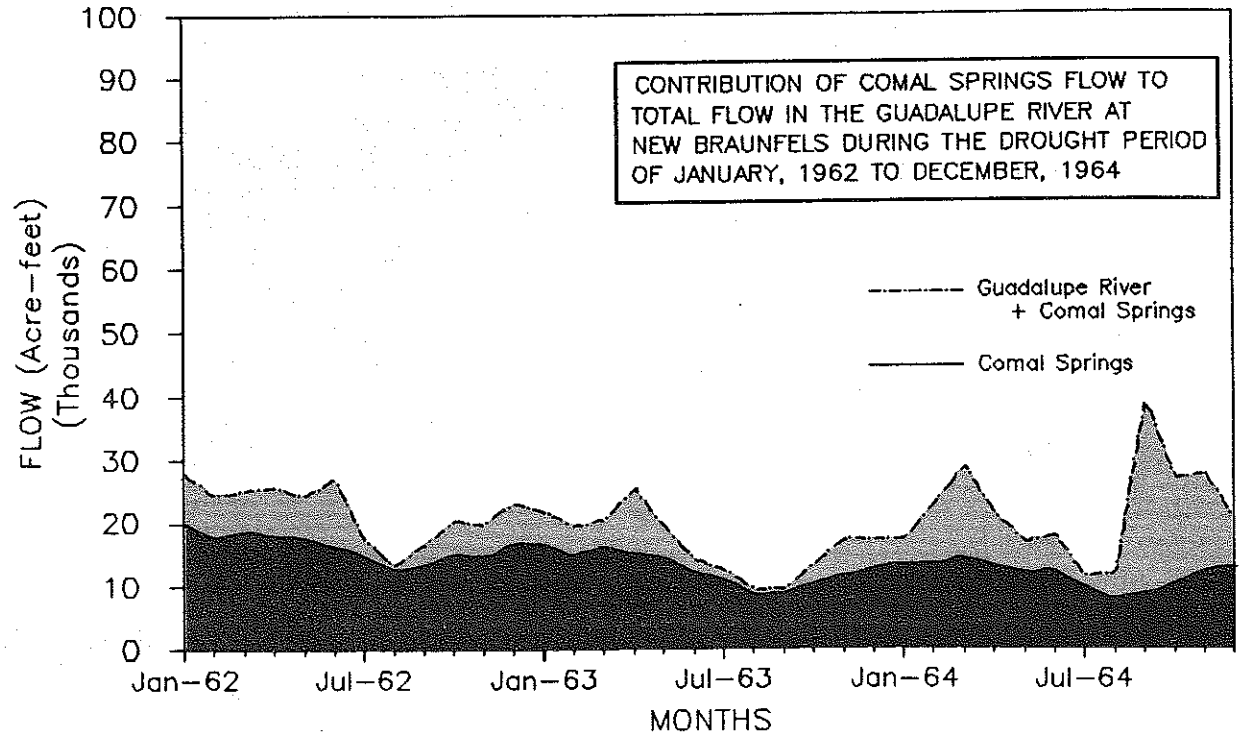
(FIGURE 2)

Figure 3 compares Comal Springs spring flow to total flow in the Guadalupe River at New Braunfels during the 1950-1956 and 1962-1964 drought periods. Over the 1940-1985 period, Comal Springs flows have averaged 25.0 percent of the total flow in the Guadalupe River at the confluence of the Comal and Guadalupe rivers. For the 1950-1956 time period, the percentage was 59.2 percent, and for the 1962-1964 time period, the percentage was 65.3 percent.

Figure 4 compares San Marcos Springs spring flow to total flow in the San Marcos River and Blanco River at their confluence for the 1950-1956 and 1962-1964 drought periods. Over the 1940-1985 period, San Marcos spring flows have averaged 48.3 percent of the total flow in the San Marcos and Blanco rivers at their confluence. During the 1950-1956 time period, San Marcos spring flows were 74.4 percent of the total flow. During the 1962-1964 time period, San Marcos spring flows were 86.9 percent of the total flow in the San Marcos and Blanco rivers at their confluence.

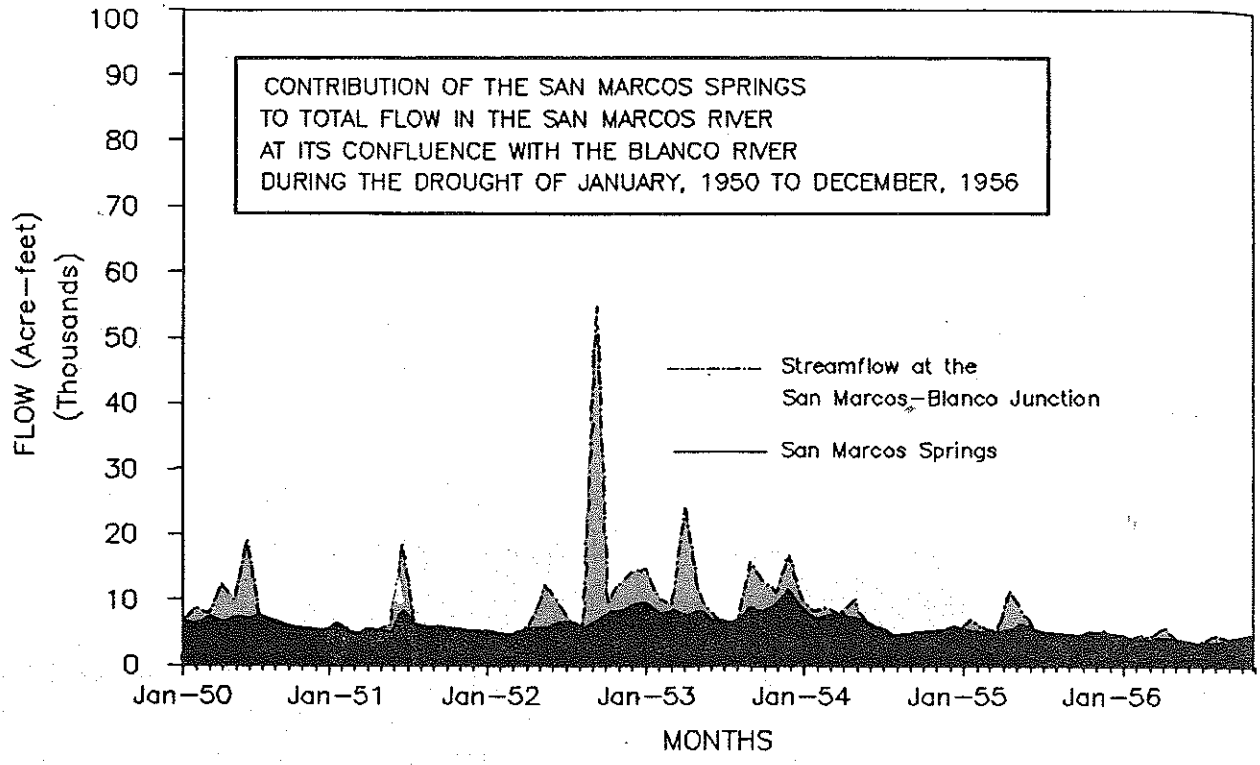
COMPARISON OF SPRINGFLOW TO STREAMFLOW

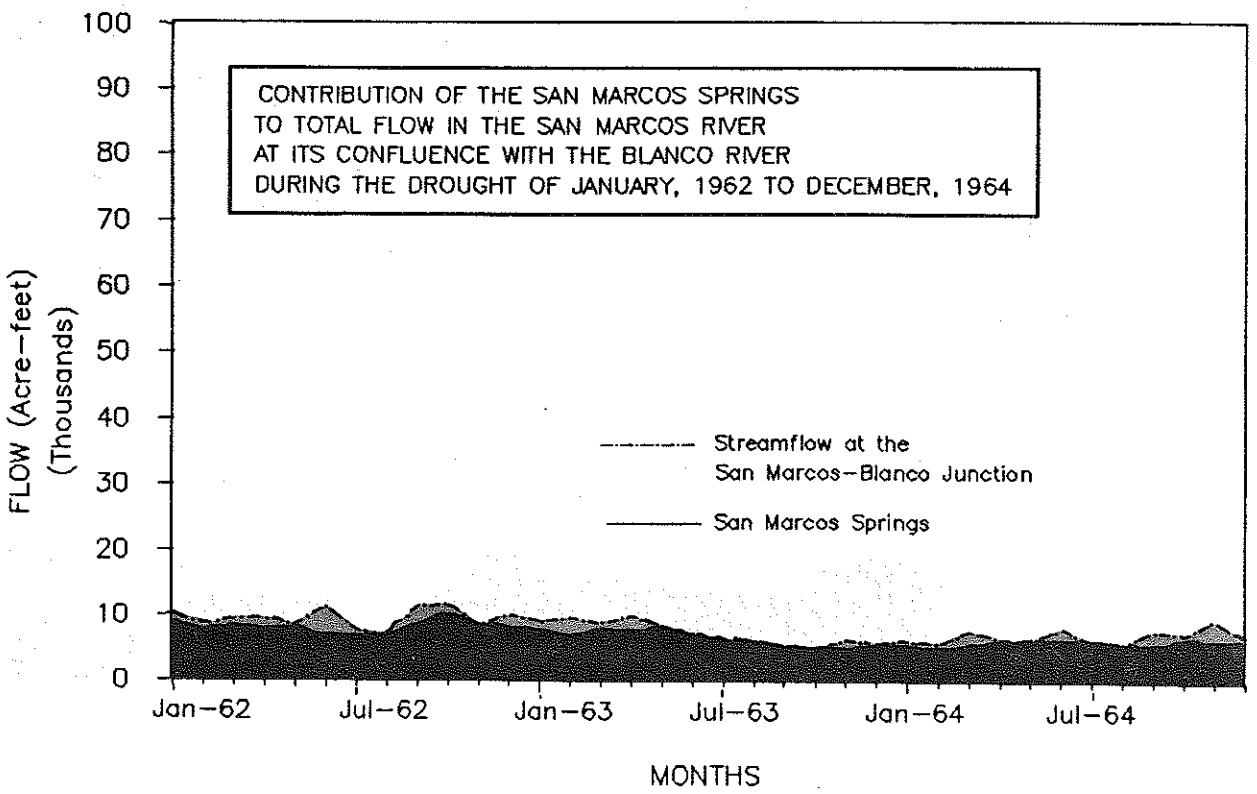




(FIGURE 3)

COMPARISON OF SPRINGFLOW TO STREAMFLOW





(FIGURE 4)

Tom Fox - Vice President, Raba-Kistner Consultants, Inc.

I am to talk about groundwater hydrology, but I approach it from the viewpoint of water quality.

Let us assume that we decide that we want to cease treating our waste water, because it's cheaper. Why don't we quit treating sewage and just dump it all in the river. Solution, that's number one. Two, we can do anything we want with respect to development, construction and activity on the recharge zone of the Edwards and any other aquifer, any other aquifer in the country. Let's make that decision. Let's see where it leads us. I'm supposed to be talking about groundwater hydrology, but, in reality, I'm talking about water quality and the relationship with our decision to cease treating wastewater. If we said we would discharge raw wastewater into the streams at our current populations, what would we have? Would we satisfy our goals, our objectives? Would we have a situation where we are producing cheap water? No question about it, it's the cheapest way to go. But does it satisfy our objectives with respect to environmental protection. I don't think so, I think people would argue that we're violating certain principles about environmental protection and water quality protection. So, we could safely say that discharging untreated wastewater, be it industrial or whatever, into the streams is an unacceptable alternative.

We in this region went through a process of examining the policies and issues relative to water quality protection and the Edwards Aquifer in 1987, and that process is still underway. There will be real changes that will be proposed. Part of Travis County will be coming under the Edwards Aquifer rules, or that is at least proposed. But, one of the key principals that the people from San Antonio and the Edwards Underground Water District endorsed is one of nondegradation. By nondegradation, we mean that we are not going to change the water quality in the Edwards Aquifer in a way that is measurable. We're not going to allow that change to occur by the activities of man in the recharge zone. I submit to you then that it would be inconsistent to suggest that we can continue to pump water from the Edwards Aquifer beyond a limit that would result in degradation of water quality.

We have data and evidence from wells that there was a change in salinity in 1956 in a number of wells as a result of drought and as a result of lowering of water levels. You could say that if there had been no pumping, the result would have been that of a natural phenomenon, and that water quality changed as a result of drought and discharge through the San Marcos Springs and the Comal Springs and that was a natural result. But, there was pumping. What we know is that there are more pumps and more water being extracted right now with not a lot of increased recharge.

The average recharge is now 640,000 acre feet. So, with pumping, we were making the rate of decline in the aquifer go faster. In the next drought, if we don't have a limitation on pumping, we are going to extract more and more water, thus causing the average water level to decline and causing water quality to be degraded, especially in the proximity of the saline or bad water line.

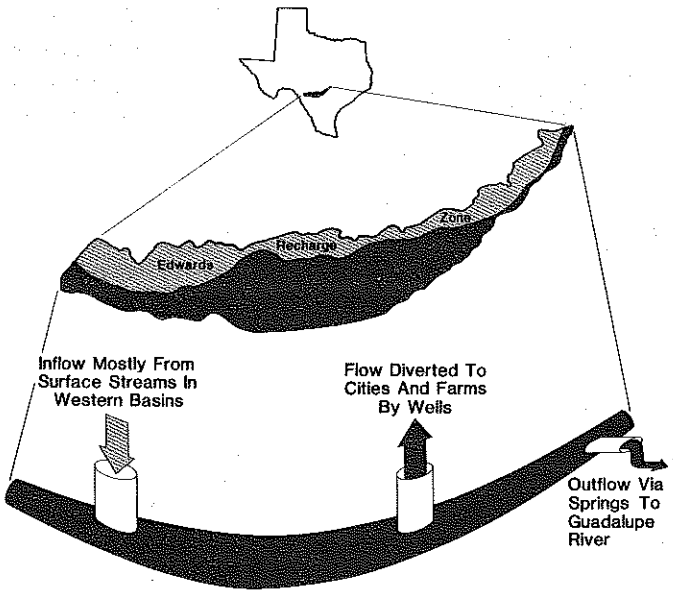
For some reason or other, December 2, and December 1, 1988 have been a real time for people to get together and talk about the Edward's Aquifer. I'm quoting from an article about yesterday's (December 1, 1988) meeting in San Antonio. "Enough water is available in the Edwards Aquifer, more than all the lakes in Texas, to pump into Comal and San Marcos Springs during times of drought and still leave San Antonio adequately supplied, a state water official claimed Thursday. These discussions agree with those of J. Lehr, Executive Director of the National Water Well Association who advocates setting up water lines and pumping water into the Comal and San Marcos Springs during the times of drought when the springs would otherwise go dry." Now that's fine if that's the policy people wish to choose and pursue and practice. They need to keep in mind that it's consistent with the policy of going back a hundred years and discharging untreated water into those streams, because that's in effect what may happen. You'll have a situation where you will be lowering water levels take-out further, during drought, when you start pumping to try to maintain flow in either the Comal or San Marcos Springs. This could cause discharge of salt water into those streams. Certainly that's a possibility, but what do we know? We know there was a change in quality in 1956. We know that we're in close proximity to the bad water line. We know that the pumping levels are greater. We know that we can pull it down faster, and not really have a lot of time to deal with it. We know people argue, stop trying to manage it, just let it go, and pump and solve these problems with structural solutions. Pump the water, discharge it into the river. This does not allow a lot of opportunity for correcting a mistake. In a short period of time if salinity is increasing in water that is discharged into the river, I'd raise the question of whether the Texas Water Commission would allow the discharge water that violates the stream's standards. The inconsistency is the notion that we are on one hand prepared to accept and endorse and encourage and insist upon a policy on what people do in the recharge zone, and at the same time, the same people will say, "Well, let's go ahead and pull it down even if it causes water quality degradation, because it may come back." Well, the same thing happens if I spill "trimethal-double-death" on the recharge zone. Fresh water will come back in that well some day. But there are serious consequences that will happen in the meantime.

Rollin Harden- Consulting Geologist, Harden and Associates

The Edwards Aquifer is a long, narrow conduit through which water moves underground across parts of south-central Texas (Figure 5). The conduit receives and dispenses major amounts of water, averaging about 600,000 acre-feet per year. *The Edwards Aquifer supports the two largest springs in Texas in addition to large municipal, industrial, and irrigation supplies, including the supply for the City of San Antonio. The underground water originates largely from surface sources which enter the Edwards in identified reaches of streams mostly west of San Antonio. This water then moves underground toward the east and northeast to be dispensed via springs in the Guadalupe River Basin or to be captured by wells before reaching the springs.

Well-Defined Boundaries

The Edwards Aquifer, relating directly to the Guadalupe River Basin, occurs in a band five to 30 miles wide and extends across portions of Kinney, Uvalde, Medina, Bexar, Comal, and Hays counties. It extends 175 miles from near Brackettville in Kinney County to just north of Kyle in Hays



(FIGURE 5)

County. The Edwards Aquifer has two adjacent sub-bands--a shallower outcrop area where recharge occurs and a deeper, artesian area through which most of the flow moves in route to the Guadalupe River Basin. The limits of the Edwards Aquifer are defined on the north by its recharge or intake area; on the west by a groundwater divide near Brackettville that separates flow toward Comal and San Marcos springs from flow to the Rio Grande Basin; on the northeast by a groundwater divide near Kyle that separates flow toward San Marcos Springs from flow to the Colorado River Basin; and on the south by the down dip limit of fresh water which is called the"bad-water" line. The lower boundary is the underlying Glen Rose Formation. The upper boundary in the artesian area is the Del Rio Clay.

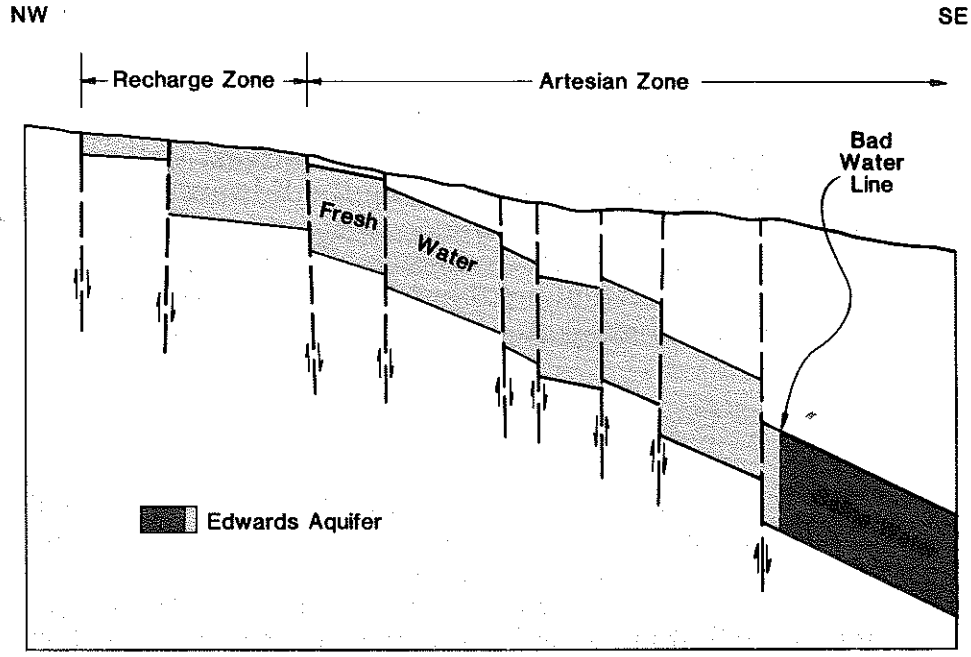
Association with Balcones Fault Zone

The Edwards Aquifer owes its existence to the Balcones Fault Zone and to its limestone and dolomite composition. The Balcones Fault Zone is a closely spaced series of steep-angled step faults which occur in a narrow belt along the Balcones Escarpment (Figure 6). The faulting becomes more intense from west to east. The faulting has created avenues along which significant limestone dissolution and channelling of flow occurs. There are many such avenues, some large and some small. The faults, in combination with the coastward dip of the rocks, place the Edwards beneath streambeds in its recharge area. The faulting also cuts across and connects the higher elevation western (recharge) basins with more easterly basins of progressively lower elevations. The faults form a frame work in which a network of openings in the rocks has developed. Springs, the natural spill points of the Edwards Aquifer, are all located along major faults.

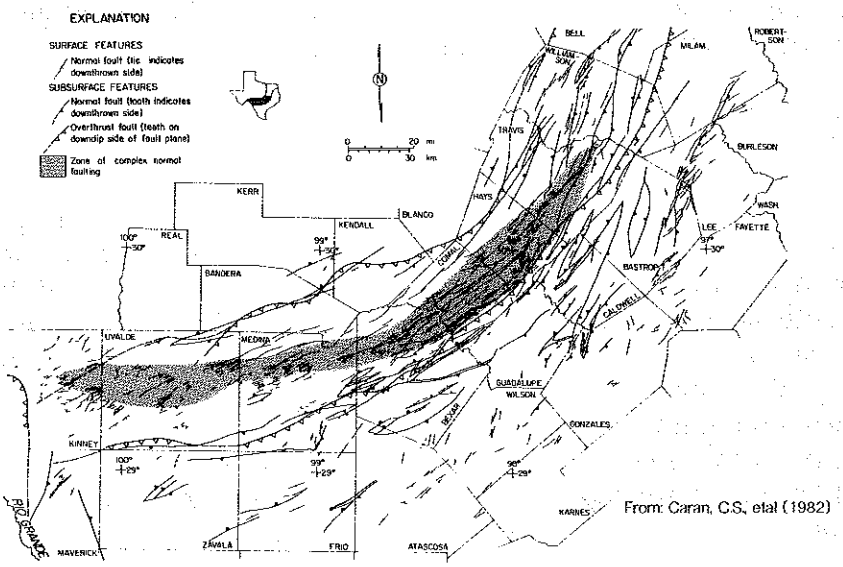
Large Openings

There is a large variability in the type and size of the openings in the Edwards Aquifer. The openings range in size from microscopic to large caverns. They include hairline cracks, open fractures, honeycombed zones, and a wide variety of cavities dissolved out by moving underground waters. Dissolution of the limestone and dolomite has created an extensive network of openings, especially along faults. Also, there are limestone beds within the Edwards Aquifer which have commonly undergone more dissolution than other beds, and so there are tubular zones, as well, in which large openings exist. Many large openings in the subsurface have been encountered while drilling wells. They range from less than a foot to nearly 100 feet; a 90-foot opening has been reported in one well drilled in San Antonio. The relatively large openings are one reason that the Edwards Aquifer is so important and so unique.

SCHEMATIC CROSS SECTION



FAULTS IN SOUTH-CENTRAL TEXAS



From: Caran, C.S. etal (1982)

(FIGURE 6)

Large Well Yields

The large and numerous openings in the Edwards give rise to uncommonly large well yields. Some of the largest well yields in Texas, and in the world, are from wells tapping the Edwards. Yields of 6,000 or 7,000 gallons per minute are common in some areas, and yields of as much as 19,000 gallons per minute are known. Where yields are large, they are more limited by well and pump diameters than by the actual water-yielding capabilities of the Edwards Aquifer.

Excellent Water Quality

The freshwater portion of the Edwards Aquifer (north of the "bad-water"line) contains excellent quality water. The quality reflects both the source of water and the rock through which it travels. The water quality changes very little from the areas at which it enters the Edwards until it exits, even though its flow path is quite long. The quality of the surface water entering the Edwards via recharging streams is similar to the quality exiting at springs and wells. Water along and south of the "bad-water" line changes abruptly in quality. That water contains much higher concentrations of minerals and is charged with hydrogen sulfide. Rocks comprising the Edwards are not nearly as porous south of the "bad-water" line, and consequently the water moves very slowly. Most of the water movement occurs in the freshwater portion of the Edwards.

Unique Fauna

A unique characteristic of the Edwards Aquifer is the presence of a large number of species of invertebrates as well as four vertebrates. The Edwards Aquifer is considered one of the most diverse subterranean aquatic ecosystems in the world. More than 40 species have been identified. Snails, worms, beetles, crustaceans (including shrimp, amphipods, copepods, isopods, and ostracods), salamanders, and catfish are included. Species have been found in wells ranging in depth from 190 feet to 2,000 feet and in numerous wells in the deep, artesian part of the aquifer in Bexar and Uvalde counties. Two species of blind catfish have been recovered from wells more than 1,000 feet deep in southern Bexar County.

Most groundwater units in Texas contain no animals. Only the Edwards is known to have such a diverse number of highly adapted, aquatic species. Thus far, species have been found in water from 18 wells and a few springs.

Recharge Mostly from Surface Streams

About 75 percent of the recharge to the Edwards Aquifer is from surface streams. Most recharge occurs in short stretches of the main stem of those streams crossing the Edwards outcrop (Figure 7). There are 13 more important recharging streams in all, 10 to the west of San Antonio and three to the east. The most important stream stretches are in the western basins, including the West Nueces, Nueces, Dry Frio, Frio, Sabinal, Seco, Hondo, Medina, Helotes, and Salado. In those 10 basins, about 78 percent of the recharge to the Edwards occurs. Next in importance are the Cibolo and Dry Comal basins which collectively contribute about 16 percent of the recharge. Basins further east, including the Guadalupe and Blanco basins, are relatively unimportant as sources of recharge, contributing only about 6 percent of the Edwards Aquifer recharge.

In many of the recharging stream reaches, all to nearly all of the base flow and large parts of the flood flow contribute to the flow in the Edwards Aquifer. Surface waters, in remarkably large amounts, go underground via joints, fractures, and solution openings in the Edwards. Stream losses of tens to hundreds of acre-feet per day are common over the recharging reaches of the streams. Losses from about a 15-mile stretch of the Frio River have amounted to more than 2,000 acre-feet per day.

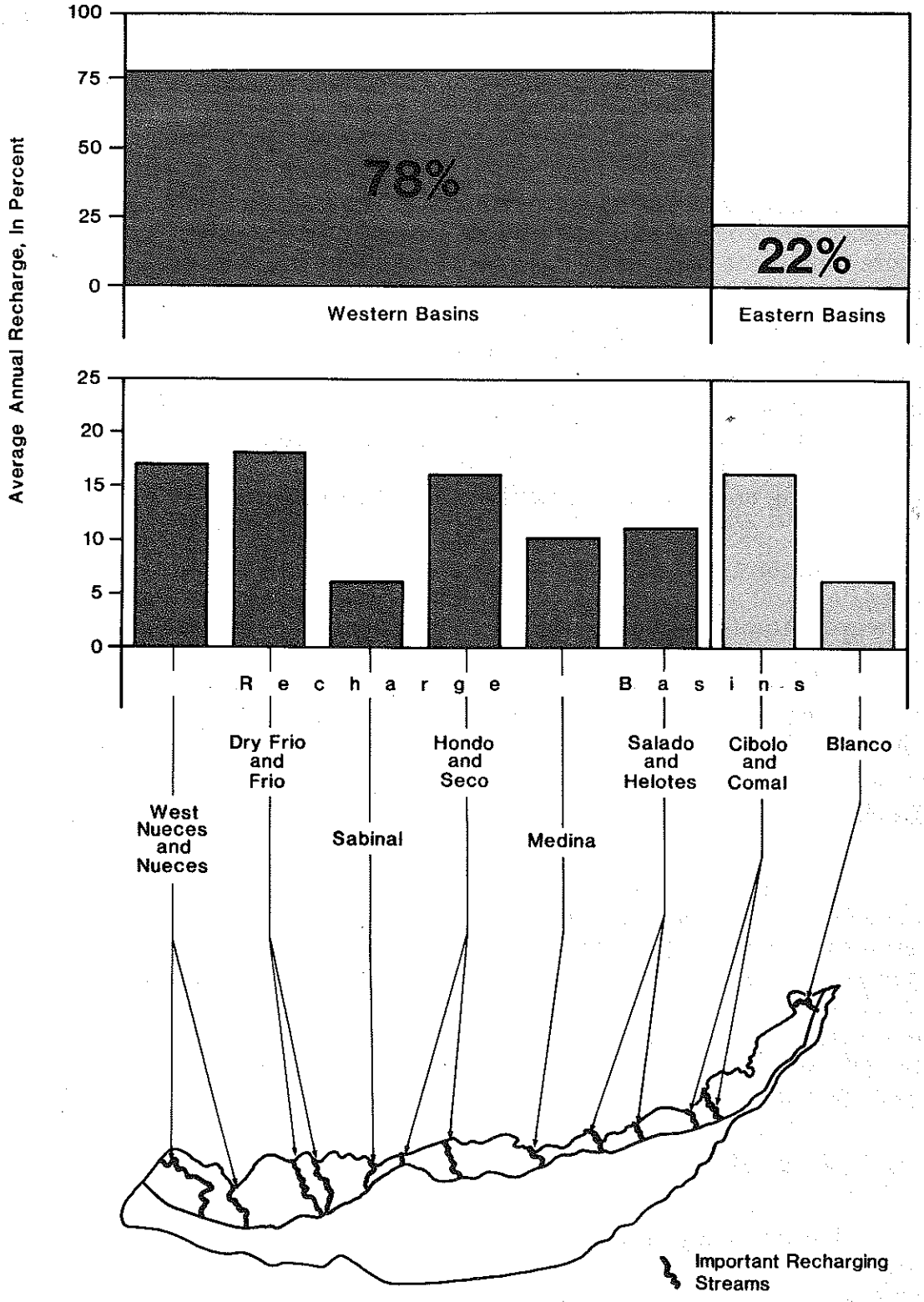
Recharge Quite Variable

Recharge over the last 50 years has averaged slightly more than 600,000 acre-feet per year (Table 1 and Figure 8). Recharge has ranged from as little as 44,000 acre-feet per year to as much as 1,700,000 acre-feet per year. The wide variation is due to the widely variable climatic conditions which occur in and adjacent to the recharge area. Recharge averaged only 169,000 acre-feet per year during the 1950-1956 drought period. In comparison, the abnormally wet period of 1970-1981 provided an average recharge of nearly 900,000 acre-feet per year.

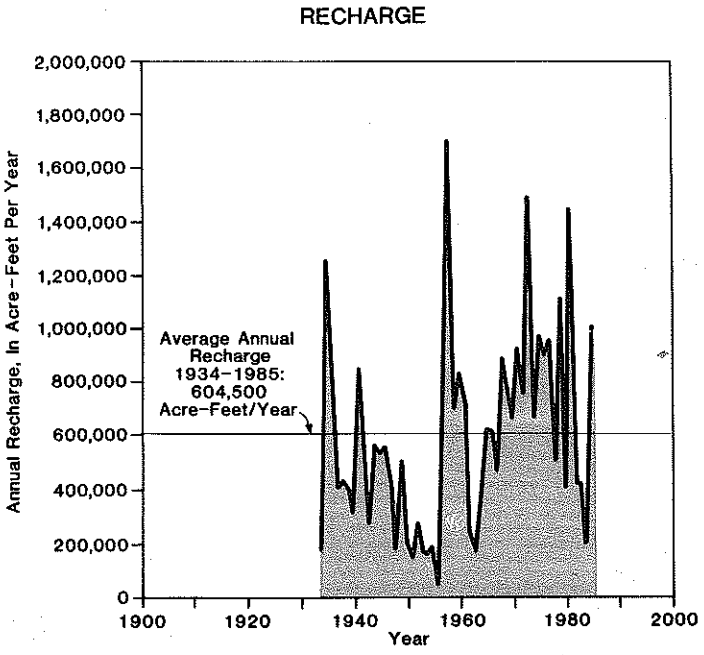
Rapid Water Movement

Once underground, the water flow in the Edwards Aquifer is toward progressively lower elevations, mostly to the south, then toward the east and northeast (Figure 9). The water moves south from the recharge areas into the artesian (confined) part of the aquifer and then from west to east and northeast. The water moves easily because the size and number of solution openings are large and connected with few restrictions. Such conditions are especially prevalent in the eastern half of the Edwards Aquifer's extent. The range in rate of movement is large, but the

RECHARGE COLLECTION SYSTEM



(FIGURE 7)

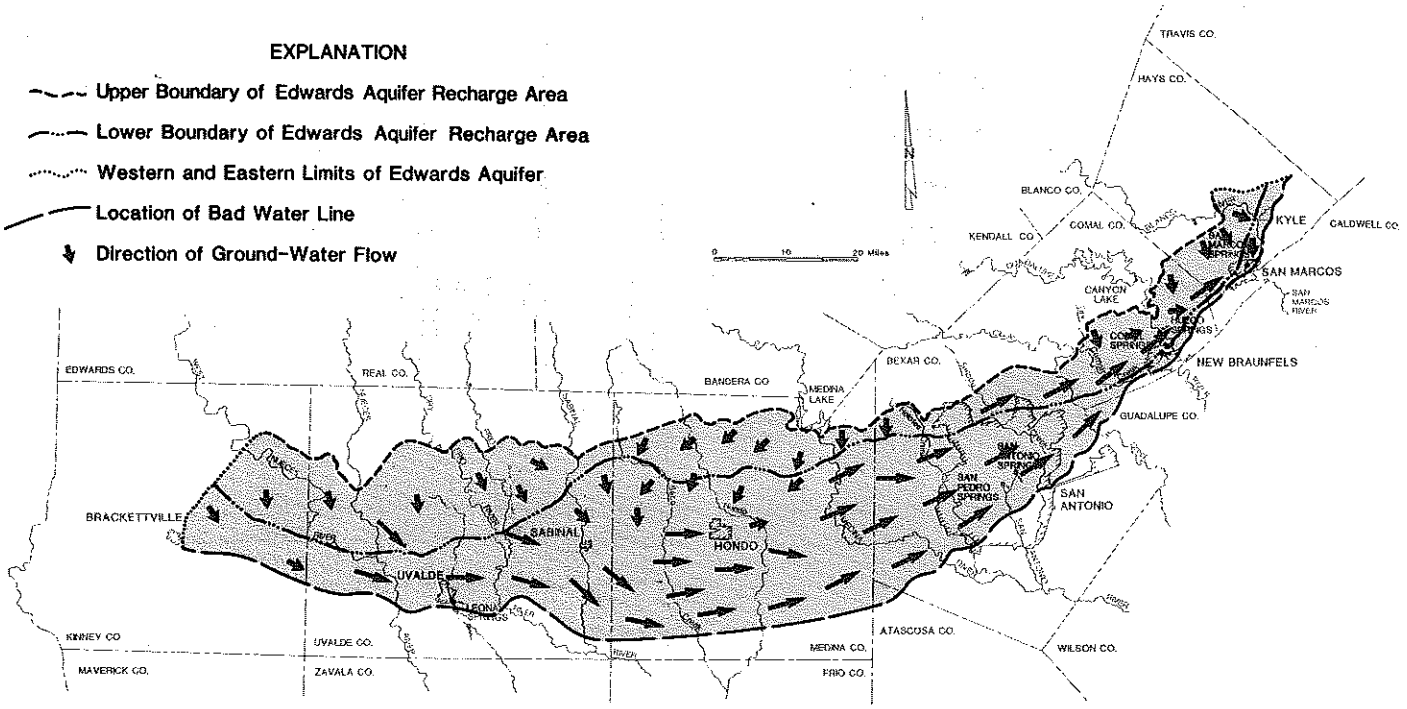


(FIGURE 8)

movement is nevertheless rapid relative to most underground waters. Movement rates of more than 2,100 feet per day have been measured over short distances. An average movement rate of more than one mile per year is indicated in the area between San Antonio and San Marcos.

The flow in the Edwards Aquifer is rapid enough to result in a suppressed geothermal gradient with relatively cool water temperatures which only vary over a narrow range. Thus, even deep wells have relatively cool water temperatures.

DIRECTION OF GROUND-WATER FLOW



(FIGURE 9)

Originally Most Flow was to Springs Feeding Guadalupe River

Before wells were drilled, the underground flow in the Edwards Aquifer was all toward springs, which were the only significant natural outlets. Then, as now, most of the spring flow exited the Edwards Aquifer in the Guadalupe River Basin and from the Comal and San Marcos springs. Comal Springs at New Braunfels are the largest group of springs in Texas, and San Marcos Springs at San Marcos are the second largest. Flow measurements for Comal Springs prior to 1927 indicate that flows were mostly between 220,000 and 290,000 acre-feet per year. At that time,

flows from San Marcos Springs averaged more than 100,000 acre-feet per year, which is the same as they currently do. Record daily high and low flows are:

	Record High Flow (Acre-Feet/Day)	Record Low Flow (Acre-Feet/Day)
Comal Springs	1,059	0
San Marcos Springs	627	91

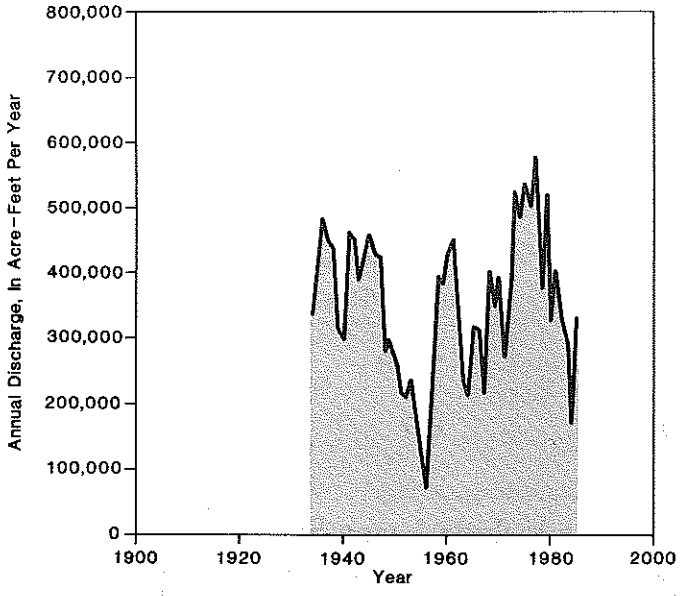
Other spring outlets include Leona Springs in Uvalde County, San Antonio and San Pedro springs in Bexar County, and Hueco Springs in Comal County. All of these springs occur at moderate to high elevations, and the outlets flow only during periods of moderate to high water levels in the Edwards. Leona Springs flows as much as 159 acre-feet per day when water levels are high at Uvalde, but averages only about 20 acre-feet per day. The flow of San Antonio Springs has been measured intermittently since 1958. The largest measured discharge was 295 acre-feet per day in 1977. The largest measured discharge from San Pedro Springs was 34 acre-feet per day in 1977. During 1983, San Antonio and San Pedro springs flowed only 25 percent of the time. Hueco Springs has had a maximum discharge of 260 acre-feet per day; Hueco has long periods of low or no flow, and has averaged about 70 acre-feet per day.

Total flow from all the springs has averaged more than 350,000 acre-feet per year (Figure 10). Comal and San Marcos springs account for 90 to 95 percent of the total. They are the lowest elevation, natural outlets for water in the Edwards Aquifer (Figure 11). They have flowed continually except for a time in 1956 when Comal Springs were dry. For five months in the summer of 1956, Comal Springs did not flow, and San Marcos Springs flowed at a much reduced rate.

Wells Intercept Springflow

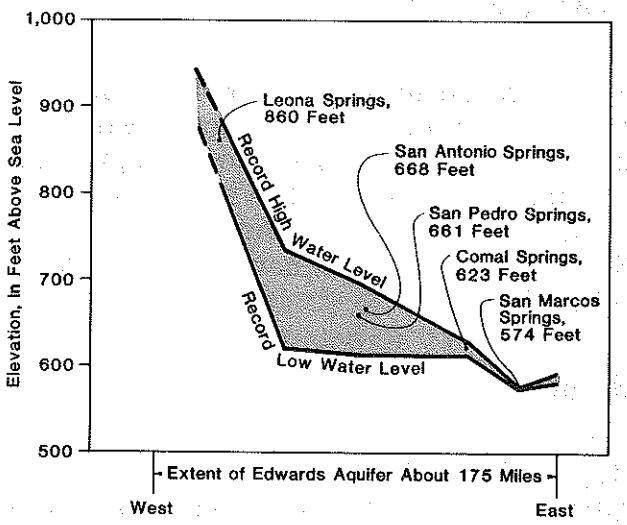
Before being tapped by wells, the spring flow from the Edwards Aquifer was much greater than it is today (Figure 12). Before wells, all of the recharge to the Edwards Aquifer eventually reappeared via springs largely in the Guadalupe Basin. Withdrawals by wells have had a large impact on spring flows and,consequently, have had a large impact on the related surface-water resources in the Guadalupe Basin. Amounts removed by wells are a direct, one-for-one depletion of flow that later would otherwise exit through springs to become apart of the surface-water resources.

DISCHARGE BY SPRINGS

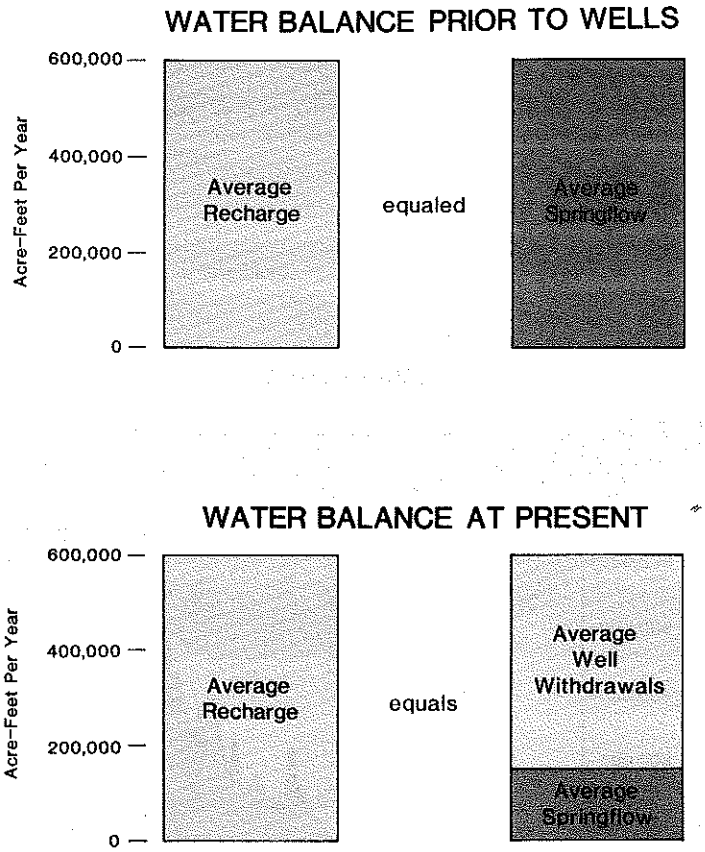


(FIGURE 10)

WATER LEVEL AND SPRING ELEVATIONS



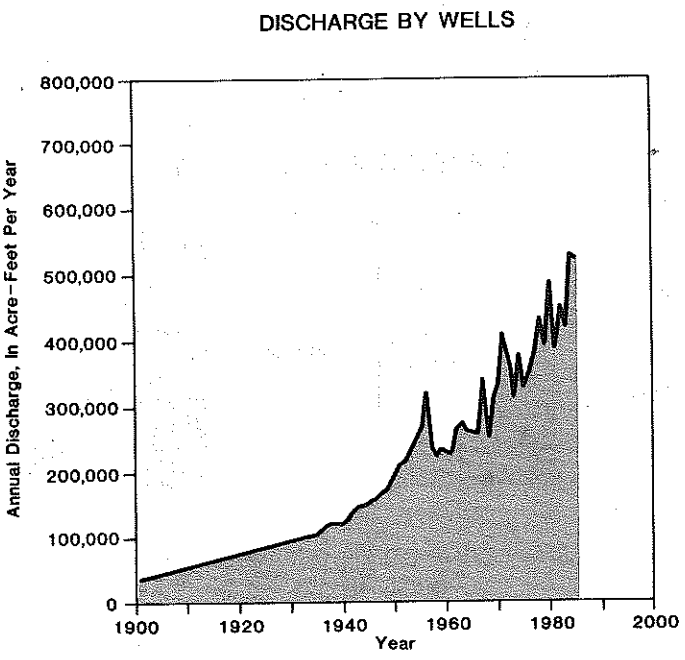
(FIGURE 11)



(FIGURE 12)

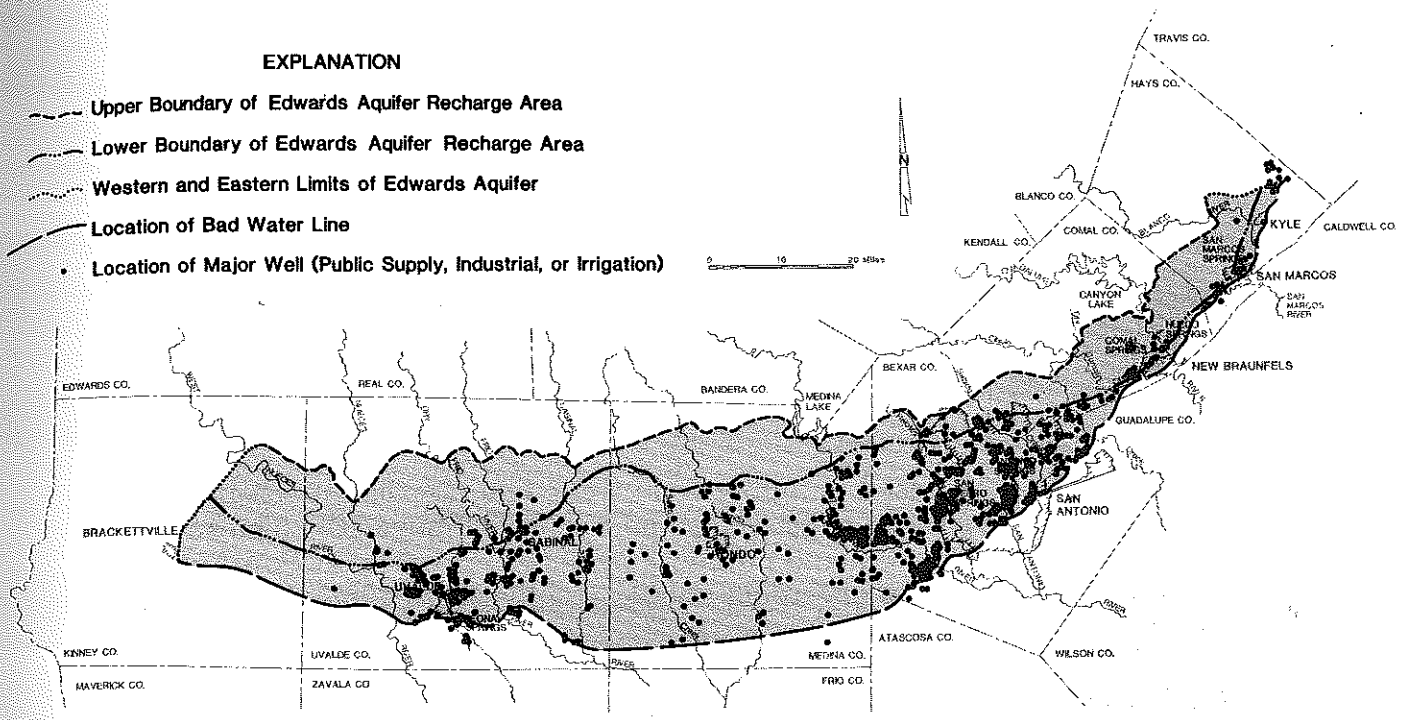
In about 1900, the total annual discharge by wells was a little over 30,000 acre-feet, nearly all in Bexar County (Figure 13). By 1934, the total annual withdrawal by wells had reached about 100,000 acre-feet. Well withdrawals have increased greatly in the past 25 yrs. Well withdrawals reached 530,000 acre feet during 1984. Most occurred in Bexar County where 310,000 acre-feet were withdrawn during 1984. Currently, there are about 800 major wells used for public supply, irrigation, and industrial purposes, and the number of wells is increasing (Figures 14 and 15).

The direct and immediate effect of well withdrawals on springflow was first observed for San Antonio Springs and San Pedro Springs in Bexar County. These springs supported the early Spanish settlements at San Antonio. Beginning in the late 1890's and early 1900's, numerous flowing wells were drilled. Thereafter, when the wells were allowed to flow, the


DISCHARGE BY WELLS
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Annual Discharge, In Acre-Feet Per Year
1900
1920
1940
1960
1980
2000
Year

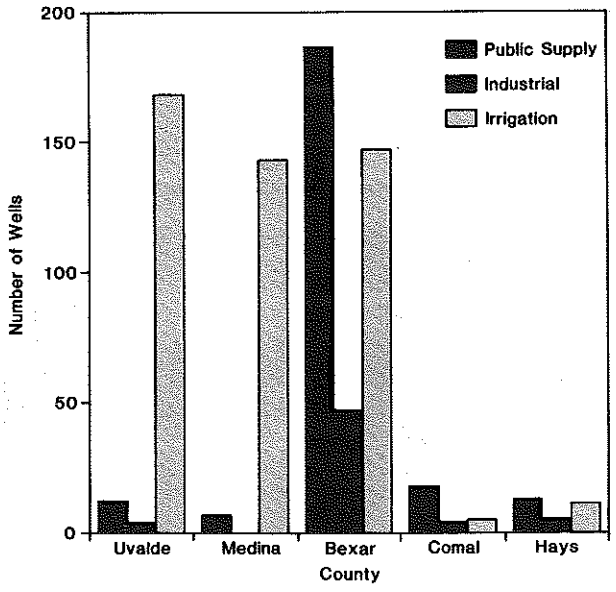
(FIGURE 13)

LOCATIONS OF MAJOR WELLS



(FIGURE 14)

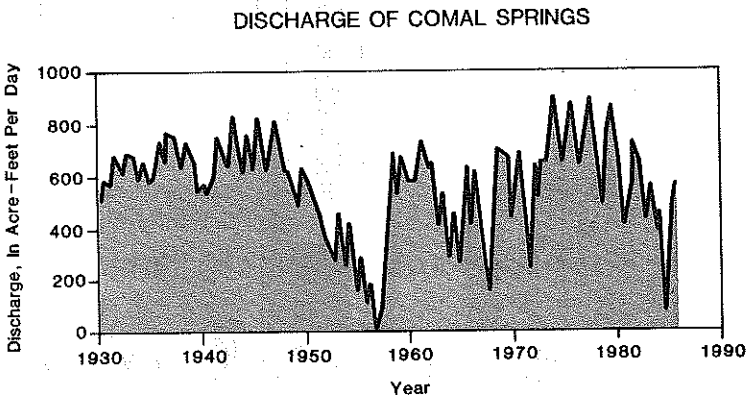
NUMBER AND USE OF MAJOR WELLS



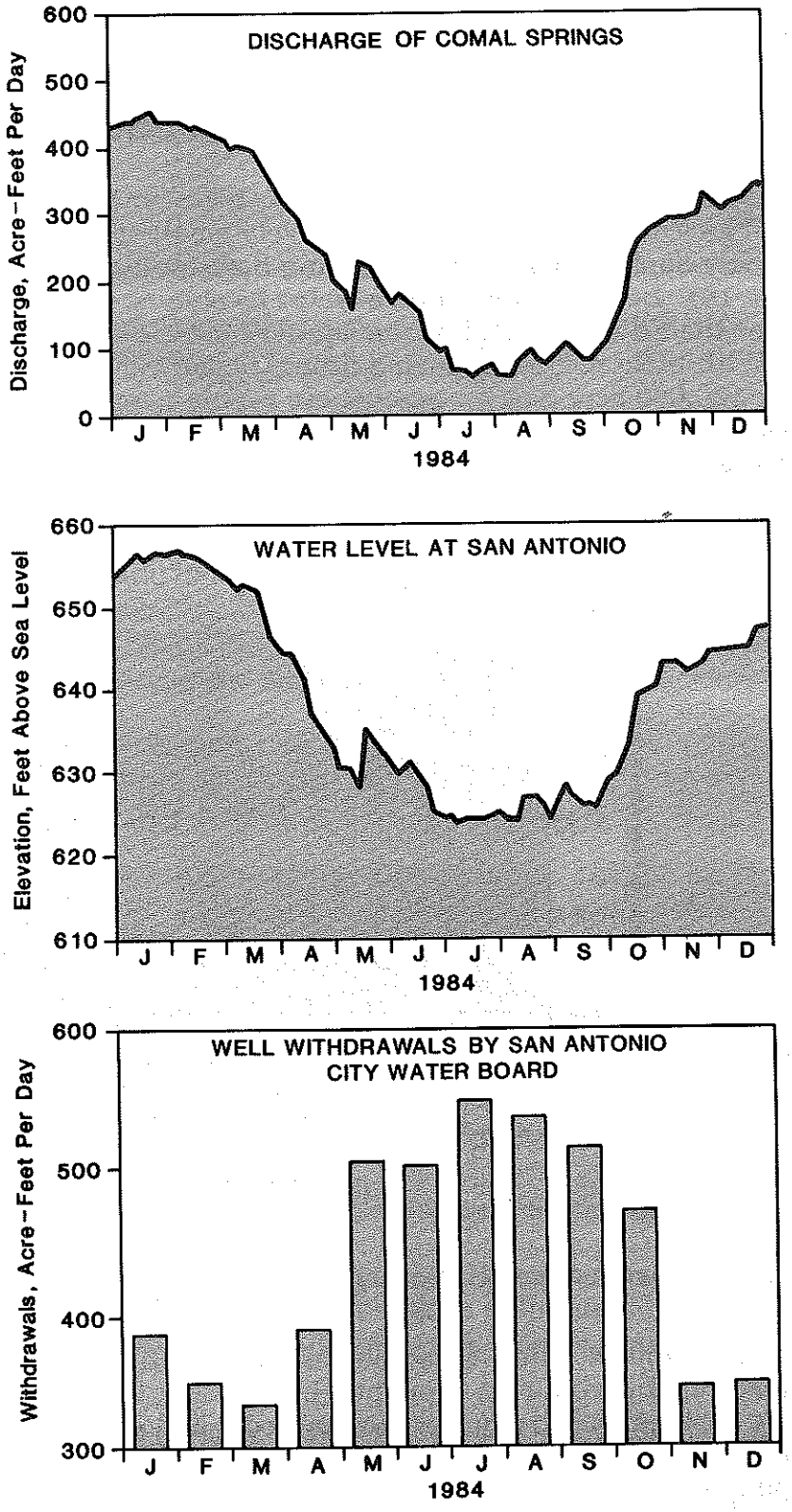
(FIGURE 15)

springs diminished and the resulting flow of the San Antonio River was greatly reduced, at times almost completely ceasing. On the other hand, when the wells were shut off by valves, the springs resumed their usual flow to the river. The well withdrawals at San Antonio have increased greatly over the years. At present, San Antonio and San Pedro springs flow only during wet times when the Edwards Aquifer has been recharged to high levels. These springs flowed continually until about 1945. Now they are dry for long periods due to increased withdrawals from wells which tend to keep local water levels lower than the outlets of these springs.

Over the years, increased pumping from wells has also had a significant and progressively greater effect on Comal Springs (Figure 16). The severe drought from 1950 to 1956 and pumping by wells, primarily at San Antonio, caused Comal Springs to dry up for about five months in 1956. Well discharge was 321,000 acre-feet in 1956. Since then, well withdrawals have increased, reaching 530,000 acre-feet in 1984. This has resulted in increased depletion of the flow from Comal Springs. Peak summer withdrawals by wells in Bexar County are now more than 1,000 acre-feet per day. The effects of the Bexar County withdrawals have become easily recognizable via the larger seasonal fluctuations both in water levels at San Antonio and in the flow of Comal Springs. The effects are especially pronounced in dry years like 1984, when the flow of Comal Springs decreased from 365 acre-feet per day on April 1 to 54 acre-feet per day by July 18 (Figure 17).



(FIGURE 16)

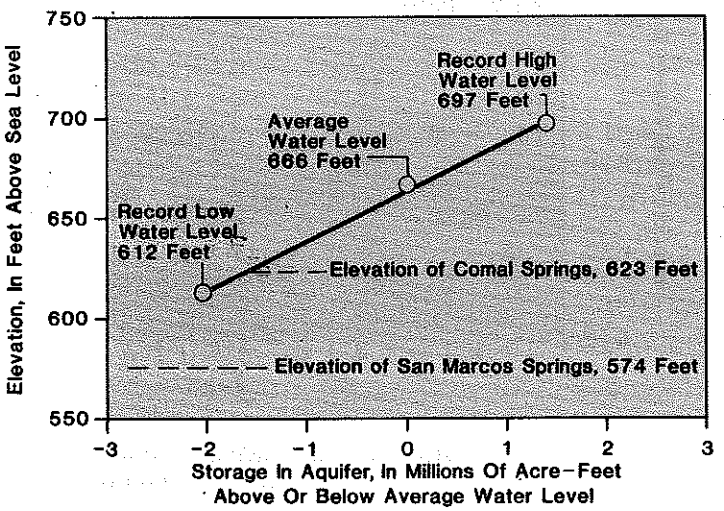

DISCHARGE OF COMAL SPRINGS
Discharge, Acre-Feet Per Day
600
500
400
300
200
100
0
J F M A M J J A S O N D
1984
WATER LEVEL AT SAN ANTONIO
Elevation, Feet Above Sea Level
660
650
640
630
620
610
J F M A M J J A S O N D
1984
WELL WITHDRAWALS BY SAN ANTONIO CITY WATER BOARD
Withdrawals, Acre-Feet Per Day
600
500
400
300
J F M A M J J A S O N D
1984

(FIGURE 17)

Small Storage Capacity

The Edwards Aquifer has relatively small storage capacity, and can be quickly depleted by wells and spring flows during multi-year droughts (Figure 18). Between the average water level and the lowest recorded water level for the Edwards Aquifer, the aquifer holds only about 2,000,000 acre-feet. With little recharge (during drought) and with withdrawals by wells of over 500,000 acre-feet per year, there is only a few years' supply available before water levels reach record lows and spring flows are severely impacted or stopped.

CORRELATION OF WATER LEVEL AT SAN ANTONIO
WITH CHANGE IN AQUIFER STORAGE

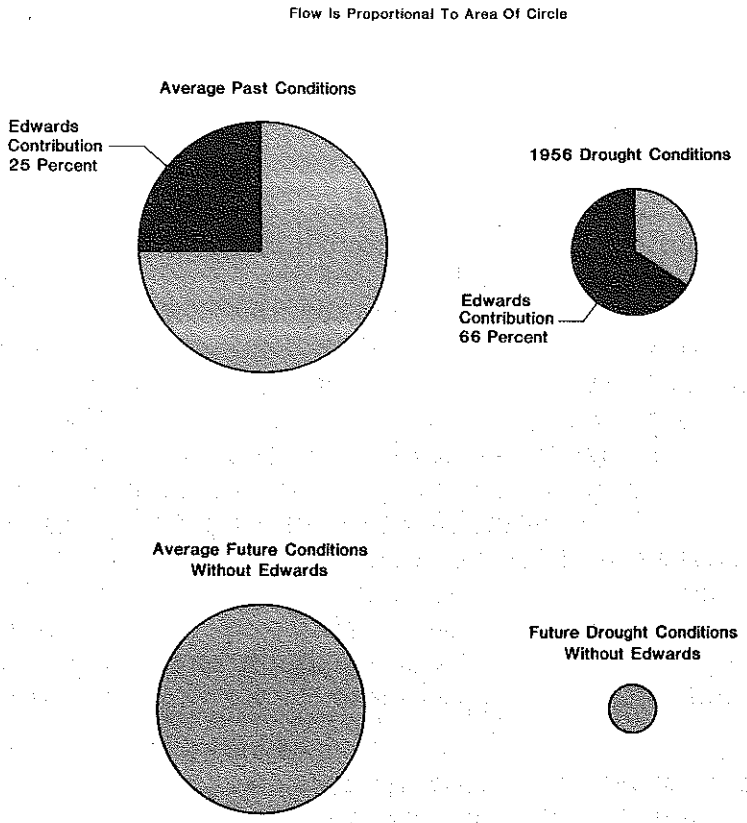


(FIGURE 18)

Well Withdrawals Affect Guadalupe River

Numerous studies, based on estimates of future pumping and assumed repetition of past droughts, project that both Comal and San Marcos springs will dry up for long periods, and even permanently, without the development of alternative water sources to eliminate excessive pumping and depletion of the Edwards Aquifer (Figure 19). If the Edwards Aquifer becomes depleted, the Guadalupe River will also be depleted, and the unique recreational and aquatic environments at and downstream of Texas' largest springs will be destroyed. Downstream water rights also suffer from excessive Edwards pumping, as do river water quality and the freshwater flows to coastal estuarine environments.

EDWARDS AQUIFER'S CONTRIBUTION TO
FLOW OF GUADALUPE RIVER AT VICTORIA



(FIGURE 19)

Roger Nevola -- Attorney, Vinson and Elkins
Legal/Regulatory Condsiderations and the Edwards Connection

In many respects, the occurrence, distribution and movement of water in the Edwards Aquifer are very similar to surface streams. These similarities and the important, direct relationship to the Guadalupe River lead to consideration of whether the Edwards is essentially an underground stream, making the water therein state water subject to appropriation. From legal and regulatory standpoints, the implications of the Edwards being an underground stream are very important. In jurisdictions outside Texas, various criteria have been utilized in legally defining underground streams. Common criteria have included:

1. Well-defined and known boundaries
2. Definite source of supply
3. Current of Water
4. Destination
5. Utility

The applicability of the above criteria to the Edwards Aquifer can be summarized as follows:

Well-Defined and Known Boundaries -- The boundaries of the Edwards Aquifer are presently known and well-defined. Earliest studies by geologists of the U.S. Geological Survey in the early 1900's recognized the outcrop of the Edwards, the related position of the Balcones Fault Zone, and the springs emanating from the system. The Balcones Escarpment, a distinct topographic feature, was recognized as trending along the recharge area of the Edwards. To the early geologists, surface indications of the southeastern most extent of the reservoir were the position of the springs. Since early times, more detailed mapping of the outcrop and recharge areas of the Edwards Aquifer has been completed, and many wells have been drilled in the deeper portions of the aquifer. This has allowed detailed water-level and water quality mapping. These mappings, together with well logs and well locations, now provide more accurate indications of the extent of the Edwards Aquifer.

Water in the Edwards Aquifer is confined at its lower boundary by relatively impermeable zones in the Glen Rose Formation. Its upper boundary in the artesian area is also a confining layer of quite impermeable strata, the Del Rio Clay. The lateral boundaries of the Edwards Aquifer are likewise well-defined. The northern boundary is its northern recharge limit, and its southern boundary is the "bad-water" line. Lateral boundaries occur at the groundwater divides forming the western and northeastern limits of the Edwards. Geologic, water-level and/or water quality mapping have defined these boundaries of the Edwards. Collectively, these physical boundaries represent the known physical limits within which the Edwards water is moving and where it is available to be tapped by wells. All of the water of importance moves within these limits. There are no overly significant additions to or escapes from the system as evidenced by water balance and other studies.

Source of Supply -- By far, the largest source of supply of water to the Edwards Aquifer is from surface streams. The Edwards Aquifer is supplied by a unique recharge collection system, with about 75 percent of the recharge occurring directly from surface water which flows into the Edwards Aquifer in streambeds crossing the Edwards outcrop. Recharge by stream losses has been established by actually measuring the losses in the streams via stream-gaging stations and seepage studies and by the mapping of geologic formations. Water

quality, water-level, and water balance studies also have aided in determining the source of supply to the Edwards.

Current of Water -- The movement of water in the Edwards Aquifer has been established by elevation surveys, flow observations, and tracer studies. Water in the Edwards moves continuously from higher to lower elevations and from recharge areas to discharge points.

Most of the movement in the Edwards is through large openings. Water in the Edwards Aquifer circulates freely along fractures and faults, and through honeycombed zones, channels and caverns. The water in the Edwards Aquifer flows at relatively rapid rates. The movement rate averages more than 5,000 feet per year between San Antonio and Hays County. This is 50 to 500 times faster than for most groundwater in Texas.

Other characteristics which attest to the large openings and the relatively rapid transfer of water are the unique occurrence of aquatic animals, the small storage capacity of the conduit over recorded stages, the turbidity of the water after rains in wells and springs close to recharge sources, and the similar water temperature and water quality throughout the system.

Destination -- The water in the Edwards Aquifer has a well-established and definable destination. Historically, and like surface-water reservoirs, the outlets were few. This has been established by studies of the flow of the springs, water levels, water quality, water balance, and the geologic formations. Prior to pumping by wells, Comal and San Marcos springs were the primary destination of the Edwards water. Since the advent of wells, the destination of the flow has been to both wells and springs, with the amount taken by wells being a direct capture of water that would otherwise later flow from springs. The springs, as the natural discharge points for the Edwards, will continue to flow until the amount of water taken from wells becomes so great that water levels drop below the level of the springs.

Utility -- The Edwards has sufficient magnitude and volume to be serviceable to the persons through whose land it flows. Indeed, it furnishes large amounts to large numbers of individuals in the cities, farms, and ranches overlying its extent. Use in 1985 included:

	Acre-Feet
Domestic, Stock and Miscellaneous	39,20
Industrial	16,50
Irrigation	203,100
Municipal and Military	263,700
Springs	334,000
Total	856,500

Uniqueness of Edwards Aquifer

The Edwards is quite unique in its observable, direct relationship with surface waters. The Edwards Aquifer captures much of the surface waters flowing across its outcrop in the western basins and furnishes much of the surface water resources in the Guadalupe River. Such a trans-basin diversion system is unknown among other underground waters in Texas both in amount and distance. Moreover, the pumping of wells quickly and observably diminishes spring flow and adversely impacts the flow of the Guadalupe River. With enough pumping by wells, the remaining Edwards-derived surface-water resources of the Guadalupe River could be totally expropriated. Nowhere else in Texas does the same situation exist, wherein such a major surface-water resource can be so directly and quickly affected by wells.

All water beneath the surface of the ground in Texas is presumed to be percolating groundwater, which is owned by the landowner, unless and until it is established that such water is in an underground stream or the underflow of a surface stream. Water in the Edwards Aquifer should no longer be presumed to be percolating groundwater. Based on the information set forth in Sections 1 and 2 of this report and relevant legal authority, it is clear that the Edwards is an underground stream, and that the water in the Edwards is owned by the State of Texas in trust for the benefit of the public.

Underground streams are subject to the same rules of law as any other Texas stream. When the State of Texas (or previous sovereign) granted lands that contain a watercourse within the boundaries of the grant, such as lands overlying an underground stream, it retained ownership of the waters in that stream. The sovereign thereafter maintained its ownership of such waters unless it subsequently conveyed title to such waters by clear, express and unequivocal terms.

In enacting certain legislation in the past relating to the Edwards, The Texas Legislature may have presumed, based on the information presented to it at the time, that water in the Edwards is percolating groundwater. As discussed above, such a presumption was entirely proper. However, the Legislature was careful never to convey title to such water. Water in the Edwards remains state water today.

It is well-established that the waters of the numerous rivers and creeks that feed the Edwards are owned by the State of Texas. The primary source of the water flowing through the Edwards is its tributary streams - about 75 percent of the water in the Edwards is from the flows of these streams. The major tributary streams include the West Nueces, Dry Frio, Sabinal, Seco, Hondo, Medina, Helotes, Salado, Cibolo, Dry Comal, and Blanco. Typically, all to nearly all of the base flows and large portions of the flood flows of these streams feed the Edwards, and through it, the Guadalupe River.

It is also well-established that the waters of the Guadalupe River and its tributaries are owned by the State of Texas. The Edwards is the major tributary of the Guadalupe River. Waters from the tributary streams of the Edwards flow freely through the Edwards to the Comal and San Marcos springs in the Guadalupe River Basin. The flow from the Edwards constitutes a significant portion of the flow of the Guadalupe River during normal weather conditions, and most of the flow of the Guadalupe River during dry conditions.

As discussed in Section 4 of this report, it is essential that uses of water from the Edwards and the Guadalupe River be regulated conjunctively, and that the regulation be implemented quickly, before the next major drought. Diversions from the Edwards reduce the flow from the Edwards to the Guadalupe, the same as diversions of water from any other tributary would reduce the flow of that tributary to the Guadalupe. Current diversions from the Edwards are very large (in excess of 500,000 acre-feet per year). Diversions are expected to increase even further if there is no regulation.

The State of Texas, under the jurisdiction of the Texas Water Commission, already has in place a well-developed system of regulation of its state owned waters. The tributaries of the Edwards are included in the existing system. The Guadalupe River and its surface tributaries are included in this existing system of regulation. The Edwards also is subject to this existing system of regulation because of the state's ownership of its waters.

The state would have the power to regulate the use of water from the Edwards even if such water were not owned by the state. However, an effective system of conjunctive regulation of the Edwards and connected surface streams can be implemented much more quickly and efficiently because all of the water is owned by the state.

It is unclear what rights exist today to use water from the Edwards. Rights to use water from the Edwards may have been explicitly granted by language in the grants of land overlying the Edwards. Additionally, under general law, owners of such land may have riparian rights to use water for domestic and livestock purposes and, perhaps, for other uses. Rights to use also may have been acquired under the appropriation statutes of the state.

In order to be certain of the nature and extent of any existing rights to use water from the Edwards, all claims of such rights would have to be adjudicated. Virtually all claims of rights to use state-owned surface water in Texas have already been adjudicated. About 25 years ago, claims of rights in the Lower Rio Grande Basin were adjudicated in a proceeding initiated in state district court. More recently, claims in other river and coastal basins have been adjudicated in proceedings initiated before the Texas Water Commission pursuant to the 1967 Texas Water Rights Adjudication Act, _11.301, et seq., Texas Water Code. The Legislature may have intended that the Adjudication Act apply only to surface streams, and not to underground streams.

Rights to use water from the Edwards may be acquired today for current or proposed uses by following the process required to obtain the right to use any state water. Under this process, permits may be obtained from the Texas Water Commission pursuant to Section 11.121 of the Texas Water Code. The Legislature may also be able to grant rights to use by direct legislative grant. Such a direct grant may be most efficient and equitable if it appears that many current users of water from the Edwards do not have any valid right to use such waters.

Analysis

A. Title to Waters in Underground Streams Was Not Conveyed to Landowners as Part of Lands Granted by the State of Texas or Previous Sovereigns

All water in Texas can be classified as either state water or private water. Private water is that water conveyed to the landowner by the sovereign as part of the property granted. Houston & T. C. Ry. Co. v. East, 98 Tex. 146, 81 S.W. 279,281 (1904). State water is that water owned by the State of Texas in trust for the benefit of the public. Motl v. Boyd, 116 Tex. 82, 286 S.W. 458, 468 (1926).

Whether an underground stream was conveyed to the landowner as part of the property granted or was retained by the sovereign in trust for the benefit of the public must be decided under the laws of the sovereign that existed at the time of the grant. State v. Valmont Plantations, 346 S.W. 2d 853,855 (Tex. Civ. App.- San Antonio 1961), aff'd, 355 S.W.2d 502 (Tex. 1962). Spanish and Mexican land grants are governed by the civil law of Spain and Mexico, id. Grants by the State of Texas are governed by the common law as interpreted by the state courts until the enactment of the statutes defining state water, from which point forward the terms of the statutes are controlling. Kraft v. Langford, 565 S.W.2d 223,228 (Tex. 1978); State v. Sun Oil Co., 114 S.W.2d 936,945 (Tex. Civ. App. - Austin 1938, writ ref'd).

As discussed below, regardless of the sovereign, grants of land overlying underground streams did not convey title to the waters in such streams.

1. Texas Grants

Under Texas law, percolating groundwater is private water. Houston & T.C.Ry. Co. v. East, 81 S.W. at 280-281. Percolating groundwater is defined as groundwater other than underground streams and the underflow of streams. Percolating groundwater is water percolating, oozing, or filtering through the earth. Bartley v. Sone, 527 S.W.2d 754,760 (Tex. Civ. App. - San Antonio 1974,writ ref'd n.r.e.); Cantwell v. Zinser, 280 S.W.2d 577,579 (Tex. Civ. App. -Austin 1948, no writ). Texas Water Code _52.001 (4) defines "underground water" for the purposes of underground water districts to mean "water percolating below the surface of the earth and that is suitable for agricultural, gardening,domestic or stock raising purposes, but does not include defined subterranean streams or the underflow of rivers." All underground waters are presumed to be

percolating water. Pecos County Water Control and Improvement District No. 1 v.Williams, 271 S.W.2d 503,506 (Tex. Civ. App. - El Paso 1954, writ ref'd n.r.e.); Texas Co. v. Burkett, 117 Tex. 16, 296 S.W. 273,278 (1927).

In Bartley v. Sone, the court recognized the general rule that the owner of land owns the percolating waters underneath the land, but then stated: "The rules referred to in the two preceding paragraphs are not applicable to water flowing in a subterranean stream or to the overflow of rivers." 527 S.W.2d at 760. See also Texas Co. v. Burkett, 296 S.W. at 278.

This statement is consistent with the General rule followed in other jurisdictions that underground streams are state water. In Howard v. Perrin, 8 Ariz. 347,76 P. 460 (1904), the court said:

> Throughout the Pacific Coast, where the doctrine of appropriation obtains, the decisions are uniform to the effect that waters percolating generally through the soil beneath the surface are the property of the owners of the soil, but that subterranean streams, flowing in natural channels, between well-defined banks, are subject to appropriation under the same rule as surface streams.

76 P. at 462; see also Wiel, Water Rights in the Western States, Vol. II, _1077(1911).

2. Spanish and Mexican Grants

According to the leading United States case discussing this issue, the ancient civil law, like the common law, distinguished between underground stream as public water and percolating water as private water. Maricopa County Municipal Water Conservation District No. 1 v. Southwest Cotton Co., 39 Ariz. 65,4 P.2d 369 (1931). In that case, the court stated:

> There are two great systems of law recognized in Western civilization: The common law, pertaining particularly to the English-speaking countries, and the civil law, which is found principally in those nations where the influence of the old Roman law from which it comes, and has been, the strongest. Both of these systems distinguish between well-defined natural streams on the one hand, and subterranean, percolating waters on the other. So far as the second is concerned, the principle governing them was, originally at least, the same under both systems. All rights to subterranean waters not flowing in definite, known channels belonged to the owners of the soil.

4 P.2d at 372. See also, Haldeman v. Bruckhart, 45 Pa. 514,520 (1863). Maricopa County notes that Spain and Mexico generally followed the principles of ancient civil law. Las Siete Partidas did state the springs and wells in Spain went with the land, and were not for common use. But according to Maricopa County, these rules applied only to percolating waters. 4 P.2d at 373.

Although no Texas case has yet dealt with this issue, the decision in a recent case dealing with the application of Spanish law to land grants in Texas is consistent with this position. In Re the Adjudication of the Water Rights in the Medina River Watershed of the San Antonio River Basin, 670 S.W.2d 250,252-253 (Tex. 1984), the Texas Supreme Court held that under the law of New Spain and Mexico, all watercourses were public. The court does not distinguish between water courses above or under the surface of the ground.

B. Definition of an Underground Stream

Texas case law has not yet defined the term "underground stream." However, the definition of an underground stream has been thoroughly discussed in other jurisdictions.

Other jurisdictions have agreed that an underground stream is a stream under the surface of the ground that has the same characteristics of a surface water course. Maricopa County, 4 P.2d at 376 (1931); City of Pasadena v. City of Alhambra, 180 P.2d 699,720 (Cal. App. 1947); Wheatley v. Baugh, 25 Pa. 528,531,64 Am. Dec. 721 (1855). In Huber v. Merkel, 117 Wis. 355,94 N.W. 354 (1903), the court stated:

> It is not meant by [underground stream] that there must be an open channel or fissure in the rock, through which water flows freely and rapidly, in order that there may be a defined subterranean stream (such channels are rare, if in fact they ever exist), but simply that the water, whether moving slowly or rapidly, and whether passing through sand or gravel or porous rock, must have the characteristics of a stream, in that it has a course, and a channel with definite bounds. Such subterranean streams doubtless exist ...

94 N.W. at 355-356.

Many characteristics may indicate the presence of a watercourse, either above or below the surface of the ground. These characteristics include a current of water. Hoefs v. Short, 273 S.W. 785,787 (Tex. 1925). They also include a source of supply. Pecos County Water Control and Improvement District No. 1 v. Williams, 271 S.W.2d at 506; Hoefs v. Short, id. A destination for the water may be a characteristic of a watercourse. Pecos County Water Control and Improvement District No. 1 v. Williams, id. Another characteristic of a water course is that it has utility, that is, that it "is of sufficient magnitude or volume to be serviceable to the persons through or along whose land it flows." Hoefs v. Short, 273 S.W. at 788.

An underground stream must also have defined and known boundaries. In this context, "defined" means a contracted and bounded channel, though the course of the stream may be undefined by human knowledge. City of Los Angeles v. Pomeroy, 124 Cal. 597,57 P. 585,598 (1899); N.S.V. Fallbrook Public Utility District, 347F.2d 48, 56 (9th Cir. 1965). "Known" refers to knowledge of the course of the stream by reasonable inference. City of Los Angeles v. Pomeroy, id.; Medano Ditch Co. v. Adams, 29 Colo. 317, 68 P. 431, 434 (1902).

Both surface and subsurface indications, as well as scientific opinion maybe used to demonstrate the existence and location of an underground stream. Maricopa County, 4 P.2d at 376. Courts have accepted many types of evidence to indicate that an underground stream has the characteristics of a watercourse.

For example, the presence of surface depressions or sinks has been used as an indication of an underground stream. Medano Ditch Co. v. Adams, 68 P. at 433;Tampa Waterworks Co. v. Cline, 37 Fla. 586, 20 So. 780 (1896). In Tampa Waterworks Co., the land at issue was underlaid by a rock of limestone formation. From a spring east and northeast, across the land of both parties, were surface depressions or sinks. The court held that "the depressions and surface indications in a direct line over the lands of the parties, and for some distance further east, indicate a subsurface stream as found in limestone formations," id.at 785.

The presence of a considerable amount of water may be an indication of an underground stream. This is especially true if the amount of water is considerable even in the dry season, and if this is evidence that the water originated from a considerable distance away. Hayes v. Adams, 109

Or. 51, 218 P.933,935 (1923); Cantwell v. Zinser, 208 S.W.2d at 579; Huelsmann v. Ohio, 56 Ohio App.2d 100, 381 N.W.2d 950,954 (1977).

The fact that pumping in one well has a direct and immediate impact on the flow of another well or of a spring is evidence of an underground stream. Nashville, C. & St. L. Ry. v. Rickert, 89 S.W.2d 889,896 (Tenn. Ct. App. 1936); Whitmore v. Utah Fuel Co., 73 P. 764,767 (Utah 1903); Burroughs v. Satterlee, 67 Iowa 396, 25 N.W. 808,810 (1885); Keeney v. Carillo, 2 N.M. 480, 495-496 (1883); Medano Ditch Co. v. Adams, 68 P. at 433. But this evidence alone is not sufficient to prove the existence and location of an underground stream. Pecos County Water Control and Improvement District No. 1 v. Williams, 271 S.W.2d at 507; Taylor v. Welch, 6 Or. 198, 201 (1876).

That the quality of the recharge water, the stored water, and the discharge water are similar is also an indication of an underground stream. Hayes v. Adams, 218 P. at 936; Maricopa County, 4 P.2d at 377; Medano Ditch Co. v. Adams,68 P. at 433; Washington County Water Co. v. Garver, 91 Md. 398, 46 A. 979, 981(1900). In Medano Ditch Co., the court was called upon to determine whether Medano Creek fed the Big and Little springs creeks through an underground stream. In reaching the conclusion that it did, the court considered testimony that when the Medano Creek was muddy, the flow of the Big and Little springs creeks would also show discoloration. Similarly, in Washington County Water Co., the issue was whether a stream which ran into a sinkhole fed some springs. The court stated:

> It may also be remarked that the fact that muddy water found its way from the stream to the spring affords an additional proof that it passed underground in a channel, and did not percolate through gravel and sand, as suggested by the defendant, for, if it had reached the spring by percolation, it would have been clarified and freed from mud.

46 A. at 981.

The fact that water sinks into the ground and reappears at a different place is also an indication of an underground stream. Whitmore v. Utah Fuel Co., 73 P.at 767; Keeney v. Canello, 2 N.M. at 495.

Further, the geologic history of the formation of an underground stream is acceptable evidence to prove the existence of an underground stream. Olson v. City of Wahoo, 124 Nebr. 802, 248 N.W. 304, 305; Maricopa County, 4 P.2d at 377;Medano Ditch Co. v. Adams, 68 P. at 433-434. In

Medano Ditch Co., in reaching the conclusion that an underground stream exists, the court discusses at length the history of the formation of the stream, and notes that "scientific writers on the geologic formations and conditions of the San Luis Valley tend to support this theory." 68P. at 433-434.

In addition, the presence of bedrock or impervious filling which forms the bottom or bed is evidence of an underground stream. Ryan v. Quinlan, 45 Mont.521, 124 P. 512, 515 (1912). Evidence from a series of wells or borings or tunnels is acceptable to demonstrate an underground stream. Maricopa County, 4P.2d at 377. The presence of fissures in the earth may indicate an underground stream. Deadwood Cent. R. Co. v. Barker, 86 N.W. 619, 622 (S.D. 1901).

The presence of vegetation in a certain area is an accepted indication of an underground stream. Hale v. McLea, 53 Cal. 578, 580-581 (1879); Hayes v. Adams, 218 P. at 936 (1923); Commonwealth of Kentucky v. Sebastian, 345 S.W.2d 46, 47(Ken. 1961). The sound of running water under the ground also may be evidence of the presence of an underground stream. Ryan v. Quinlan, 124 P. at 515; Maricopa County, 4 P.2d at 377. The presence of fish is also evidence of an underground stream. Tampa Waterworks Co. v. Cline, 37 Fla. 586 _ 2080.780 (1896).

It should be noted that there is a line of cases which holds that the existence and location of an underground stream may be demonstrated only by surface indications which would have, or should have, alerted a reasonable lay person to the existence and location of an underground stream; the existence and location of the underground stream may not be demonstrated by excavation or scientific opinion. See, e.g., Logan Gas Co. v. Glasgo, 122 Ohio St. 126, 170N.E. 874,876 (1930); Barclay v. Abraham, 121 Iowa 619,96 N.W. 1080, 1081-1082(1903); Board of Sup'rs of Clark County v. Mississippi Lumber Co., 80 Miss. 835,31 S. 905,906 (1902); Clinchfield Coal Corp. v. Compton, 148 Va. 437, 139 S.E.308,311 (1927).

The issue in this line of cases, however, was not whether an underground stream is public water, but whether a person is liable for interfering with the underground water supply of another. See, e.g., 29 A.L.R.2d 1354 et seq. In cases involving liability for damages, the courts reason that a person cannot be liable for damages to another which he could not reasonably foresee. Wheatley v.Baugh, 25 Pa. at 532; Collins v. Chartiers Val. Gas Co., 131 Pa. St. 143, 18 A.1012, 1013 (1890). This reasoning does not apply to whether an underground stream is public water, since reasonable foreseeability is not an issue in that inquiry.

Many cases have directly rejected the argument that underground streams maybe proved only by surface indications, even in cases involving

liability for damages. See, e.g., The Castalia Trout Club Co. v. The Castalia Sporting Club, 8 Ohio Cir. Ct. R. 194,203 (1893) aff'd, 56 Ohio St. 749, 49 N.E. 1108; Collins v.Chartiers Val. Gas Co. 18 A. at 1013-1014; cf. Maricopa County Municipal Water Conservation Dist. No. 1 v. Southwest Cotton Co., 4 P.2d at 377 (Surface indications are not an exclusive means of proof where issue was whether underground streams are subject to appropriation). The rationale of these cases is that the knowledge available to a reasonable person is expanding, and this fact should be taken into account. Thus, Kinney says in Irrigation and Water Rights, _ 1155:

> The first of these subterranean watercourses have all of the characteristics of surface water courses, that is to say, they have bed, banks forming a channel, and a current of water. The second class, while upon the one hand, may have all of these characteristics, upon the other hand these, as their names indicate, are still unknown and undefined. However, that they are there is well known as a scientific fact, and as the years go on, by exploitation of these streams many of the underground water courses in the latter class, which were formerly undefined and unknown, become defined and known, and thus pass from the second class to the first.

(Footnotes omitted)

See also, Collins v. Chartiers Val. Gas Co., 18 A. at 1013-1014. And many other cases have accepted scientific opinion without discussion. See, e.g., Olson v. City of Wahoo, 124 Nebr. 802,248 N.W. 304 (1933); Cantwell v. Zinser, 208 S.W.2d 577 (Tex. Civ. App. -- San Antonio 1974, writ ref'd n.r.e.); Yarwoodv. West Los Angeles Water Co., 132 Cal. 204,64 P. 275 (1901).

C. The Edwards is an Underground Stream

Considering the information set forth in Sections 1 and 2 of this report in light of the legal authorities discussed herein, it is clear that the San Antonio region of the Edwards Underground Reservoir is an underground stream. Some of the relevant factors are discussed below.

The source of supply of water to the Edwards is clearly established. About 75 percent of the water comes from the flows of the rivers and creeks that are tributary to the Edwards. The remainder is diffused surface water. These two sources of supply (flow from defined tributaries and diffused surface water) are the same for any significant surface stream in Texas.

The destination of the water in the San Antonio region of the Edwards Underground Reservoir also is clearly established. Virtually all of the flow not diverted by wells feeds the Guadalupe River through the Comal and San Marcos springs.

The current of water in the Edwards also is well-documented. Water flows freely through caverns, fractures, honeycombed zones, and other cavities dissolved out by the water moving to the Comal and San Marcos springs. The average rate of movement is 50-500 times faster than most groundwater in Texas. Rates of more than 2,100 feet per day have been measured over short distances.

The utility of the Edwards is clearly demonstrated by the large diversions and the various uses of diverted water. In 1985, over 500,000 acre-feet of water were diverted and beneficially used for municipal, industrial, irrigation, and other purposes. Diversions of water from the Edwards decrease the flows in the Guadalupe River significantly.

The boundaries of the Edwards are well-defined. The Edwards is a long, narrow conduit to the Comal and San Marcos springs. Water is confined at the lower boundary by the relatively impermeable zones in the Glen Rose Formation, and at the upper boundary in the artesian area by a confining layer of quite impermeable strata, the Del Rio Clay. The northern boundary is its northern recharge limit, and the southern boundary is the "bad water" line.

The Edwards is one of the most diverse subterranean aquatic ecosystems in the world. Over 40 species have been found, including shrimp, salamanders, and catfish, in wells ranging in depth from 190 feet to 2,000 feet.

D. Title to Water in the Edwards Has Never Been Conveyed Subsequent to the Grant of Lands Overlying the Edwards

1. Spain and Mexico

It was a fundamental principle of Spanish law that grants of property rights were not to be inferred. In Re Adjudiciation of the Water Rights in the Medina River Watershed of the San Antonio River Basin, 670 S.W.2d at 253. In New Spain,the government held title to all land and water and retained title to such unless specifically granted, and there was no grant of title or right by implication. In Re the Adjudication of the Water Rights In the Medina River Watershed of the San Antonio River Basin, 645 S.W.2d 596, 605-606 (Tex. Civ. App. - San Antonio 1982), rev'd on other

grounds, 670 S.W.2d 250 (Tex. 1984); see also, Harris v.O'Connor, 185 S.W.2d 993, 1009 (Tex. Civ. App. -- El Paso 1944, writ ref'dw.o.m.). No subsequent grant by Spain or Mexico of title to the water in the Edwards has been found.

2. Texas

Under Texas law, the general rule is that legislative grants of property must be construed strictly in favor of the state, and what is not unequivocally granted in clear and explicit terms is withheld. Empire Gas & Fuel Co. v. State, 47 S.W.2d 265,272 (Tex. 1932); United States v. 1,078.27 Acres of land, 446 F.2d1030, 1038-1039 (5th Cir. 1971).

For example, title to lands underlying navigable water is held in trust by the State of Texas for the public. Title to such land passes by grant or sale only when so expressly provided by the sovereign authority, and there is no presumption that there has been any act by the government which could have the effect of passing title. State v. Bradford, 50 S.W.2d 1065, 1069-1070 (Tex. 1932); City of Galveston v. Mann, 143 S.W.2d 1028, 1034 (Tex. 1940). Similarly, in this case, the waters of the Edwards are held in trust by the state for the public. Therefore, the title to these waters can pass only when expressly authorized by the Legislature, and there is no presumption that such title has passed.

No general Texas statute has conveyed title to state water. No act passed by the Texas Legislature specifically addressing the Edwards conveyed title to the waters in the Edwards.

Although the Texas Legislature has never conveyed title to water in the Edwards, it has enacted various acts that relate to the Edwards. Two that concern the Edwards directly are discussed below.

In 1959, the Texas Legislature passed an act creating the Edwards Underground Water District. 1959 Tex. Gen. Laws, ch. 99 at 173. Section 1 of the act provides that the District is created for the purpose of conserving, protecting, and recharging the underground water-bearing formations within the District, and for the prevention of waste and pollution of underground water, particularly the waters of the Edwards limestone and associated formations. Section 16 of the act recognized existing rights in underground water, but provided that no additional rights are granted:

> The ownership and rights of the owner of the land, his lessees and assigns, in the underground water are hereby recognized, and nothing in this Act shall be construed as depriving or devising such owner, his

> assigns or lessees, of such ownership or rights. This Act shall not be construed to be a grant of any rights of superior existing permits or water rights.

The term "underground water" was not defined in the act. However, at the time the act was passed, "underground water" was defined in Art. 7880-3C, V.T.C.S. (pursuant to which underground water conservation districts could be created), as follows:

> (3) "Underground water" is water suitable for agricultural, gardening, domestic or stock raising purposes, percolating below the earth's surface, and does not include defined subterranean streams or the underflow of rivers.

This definition is similar to the current definition of "underground water" in_ 52.001 of the Texas Water Code, which is quoted above. Although this definition applies only to the term as used in the general underground water conservation district statute, it is likely that "underground water" has the same meaning when used in the act creating the Edwards District.

The Edwards District act has been amended from time to time. In the most recent amendment, the District was given additional powers relating to the development, implementation and enforcement of a drought management plan. The act as it presently exists does not recognize the need for conjunctive regulation of the Edwards and connected surface streams.

Subsections (c) and (d) of _11.023 of the Texas Water Code also relate to the Edwards. These provisions, which were added by the Legislature in 1957, provide as follows:

> (c) Unappropriated storm water and floodwater may be appropriated to recharge underground freshwater bearing sands and aquifers in the portion of the Edwards underground reservoir located within Kinney, Uvalde, Medina, Bexar, Comal, and Hays counties if it can be established by expert testimony that an unreasonable loss of state water will not occur and that the water can be withdrawn at a later time for application to a beneficial use. The normal or ordinary flow of a stream or watercourse may never be appropriated, diverted, or used by a permittee for this recharge purpose.

(d) When it is put or allowed to sink into the ground, water appropriated under Subsection (c) of this section loses its character and classification as storm water or floodwater and is considered percolating groundwater.

It appears that the Legislature, at the time that it enacted the laws discussed above, may have presumed that water in the Edwards is percolating groundwater. As discussed above, such a presumption was entirely proper. However, the Legislature was careful never to convey title to any water in the Edwards and, therefore, such water remains state water today. The presumption that such water is percolating groundwater can be overcome at any time upon establishment that the Edwards is in fact an underground stream.

Session B - Judge Fred Clark presiding

Dr. James F. Garber - Dept. of Anthropology, SWTSU

Well, some of you are no doubt wondering what in the world is an archaeologist doing at a conference on water management? As it turns out, water is an extremely important issue to the human adaption to this region for the last 11,000 years and in fact the very unique quality of the water and of the aquifer as a whole has created a very unique response to it, a very special adaptation that spans 11,000 years. When I first got here, the thing that struck me was, of course, the river. So, one of the first things I started asking about were characteristics of the river and some of the earliest habitations in the region. I want to first get man over to the New World.

Man came across the Bering Straits land bridge. The dates are somewhat debatable but he came here through Alaska and down this ice free corridor into the United States and southward. When he came across, there were also animals that were going not only this direction but also some going that direction. Other animals that came this direction, we have several, ice age fauna, the mammoth and the mastodon. It's hard to imagine elephants roaming around in San Marcos, but they were here. The normal pattern for adaptation at that early time was to wander about constantly in search of food. The standard interpretation is that they were big game hunters going after these mammoths, mastodons, giant bison, sloths, these large ice age animals. My guess is that if a prehistoric man ever did or occasionally did kill an elephant he probably never stopped talking about it. The earliest, well documented culture in the New World, which we call Clovis, was present here in San Marcos. That dates to about 9200 B.C. There are other regions in the United States that also show evidence of that early culture. However, earlier occupations are not well documented. San Marcos shows evidence of this early occupation. What is unique in San Marcos is that when people found this area, they never left. And the reason is because of the water.

The major environmental zones in this immediate area are something very important to prehistoric man. If you go 100 yards in one direction, you're in the hill country. The hill country has its own unique set of plants and animals that could be exploited. You go 100 yards in the other direction, you're into the prairie environment, very flat. If you stay put you have the unique resources of the San Marcos River. So, prehistoric man, found some very special options open to him, different resource zones that he could explore. The major encampments, the ones that show repeated or continuous occupation are always located along the river or along some of these creeks; some of which do not flow today, but in prehistoric times had water year round in them. When you go up into the hill country here, you

get hunting camps, you get temporary encampments. The camps that are in this area are very, very temporary; a few artifacts show evidence of hunting. The base camps are always located here by the permanent water.

There are some of the projectile points (slides) that illustrate the prehistoric sequence. Here are the Clovis point, and through time they went through several changes winding up with the very small arrow points down there at the bottom of the slide. The arrow points came in very, very late in the sequence, probably about 900 A.D. When most of us think of Indians we think of feathers, drums, arrows. Well arrows were very, very late. People lived here for 10,000 years without the bow and arrow. These early inhabitants knew where the water was and when they found it they stayed there, occasionally roaming off, but they had a good deal along the springs; they knew it and therefore didn't have to move. They always went back to the river. We find in excavating those sites a more or less continuous occupation for 11,000 years. There are very few places on this continent that can make that claim. They were here in San Marcos because of the water. They would also have been at other sites along the escarpment where there is a spring. The whole headwater is basically surrounded with evidence of prehistoric occupation. It dates all the way from 9500 B.C. up to the present.

The important message that archaeology has to offer here is that man lived more or less non-stop for 11,000 years. That's a long time. Why were they here? Water. Why couldn't they live in other locations for 11,000 years more or less non-stop? They didn't have the water. So if we as a culture and custodian of that unique environment, if we manage our water resources effectively, then we can continue that rich tradition of continuous occupation. Earlier I heard people talking about what's going to happen with population growth? If we don't manage the water resources, there won't be any population growth. People will be moving away. They'll have to, why? No water. So, the key here, the message that archaeology has to offer is that through time there has been this association with water and in San Marcos it has worked because the springs would always flow. The next speaker you're going to hear will tell you about something that's not so pleasant. And that's what happens to people through time when the springs don't flow.

Dr. David Meltzer - Archaeology Department, Southern Methodist University

I'm going to be talking about springs. I'm going to be talking about springs that went dry. And, I'm going to be talking about what people do when springs go dry and what they do if they dig wells. But the kind of wells that I'm going to show you here today are 7000 year old wells from a

period from 7500 to 5000 years ago. This is not high tech. This barely even qualifies for low tech. It's an extremely hot and dry period. It's a period that literally laid the high plains of North America to waste because of drought conditions.

Let's talk about the 1930s. Everybody, of course, has burned into their mind the images of the dust bowl in the 1930s. They come out at us from the photographs, the mythology that we see that's developed around it, Steinbech's Grapes of Wrath, give us a fairly grim reminder of what a drought is like and how precarious human life is in the face of drought conditions. We know too that in certain hard hit areas of the High Plains, the drought led to widespread abandonment. It ruined farms. Banks failed. Homes were abandoned and we really get a clear sense of the human cost of the drought. The 1930s drought is tremendously important to American character and American history and yet the important thing to stress is that the 1930's drought for all intents and purposes was a trivial climatic event. We look at those old photographs and you see the black blizzard of the 1930s where hundreds of tons, 350 million tons in fact, blew eastward on one day, May 9, 1934 and they filled the sky. Yet if you look in the geological records, and I have, you don't see any evidence that that ever occurred.

Let's go back to the human cost. We look at what happens, we see the effects, the socioeconomic effects, the political effects of the dust bowl. We know what happened to people, they all packed up and they went to Bakersfield. What we don't know is that we had an episode in prehistory and the episode of prehistory is a quite different thing altogether because it was not an insignificant event. This was a prehistoric dust bowl, this thing lasted 2500 years instead of just 10 years. We don't know what the human cost was to that prehistoric dust bowl. We don't know how people responded to that drought episode. It used to be thought that folks simply packed up and left; that when it got hot and dry on the High Plains around 7500 B.C., people simply fled to the mountains of New Mexico where it was cooler, and wetter. It was suggested, however, back in the 1950s that the way they were able to survive during this extreme drought episode was that they dug wells. People were there. People came on to that very dry landscape, that landscape where there was a tremendous amount of blowing dust and dirt. And they dug wells. They dug wells in a variety of sediments, but predominantly down in the bottoms of the draws. They were heading for the low spots down in the bottom of the dry channels out in that area. And they were digging water holes. One of the things that we were expecting to find, knowing about Glen Evans' work at Black Water Draw, was that we would find probably one or two of these wells. We were more surprised to discover as we excavated that in fact, we were finding not just one or two, but thirteen or fourteen. Everything that you see here, are prehistoric water wells. This is the surface, this is that dry lake bed surface, as it was

exposed 7000 years ago. And people came on to that surface and dug wells. Ultimately what we found was that they dug over sixty of these wells in an area about the size of a small swimming pool. Just to give you a sense of the scale, it's about eighteen meters, top to bottom and about four meters side to side.

Allen Bienke - Executive Director, Texas Water Commission

It is likely that the issues related to the Edwards and the spring flow here will be viewed in great detail during the legislative session. I can't think of a better way for everyone to get informed about the issues. What I want to talk a little about today is the regulatory perspective. I guess from the standpoint of the Texas Water Commission, there are several aspects I want to mention to you today. I will give you the perspective, at least as I see it from the Texas Water Commission. I also want to talk about what regulatory tools we have at the Water Commission to deal with the issues that you are talking about today. And then I want to make a couple of observations, from the Water Commission's perspective, about what's happening.

You have already heard today from the previous speakers that the spring flow from the San Marcos and Comal Springs provides a great deal of the base flow into the San Marcos and the Guadalupe River Basins. Because we are the agency that issues the permits for the use of that river water, I want give you an idea of how many permits we've issued below the springs. We have 130 surface water users below the springs which account for about 800,000 acre feet of water on an annual basis. About 120,000 of that is municipal water, about 600,000 of that is industrial water, and about 79,000 of that is irrigation water. We also have water rights of about 2.1 million acre feet of water authorized for hydroelectric projects below the springs. And, that is accounted for by ten separate facilities downstream of the springs.

As you've already heard, the spring flow is very important to the users who have permits, for this water that is in the Guadalupe and San Marcos Rivers. Any reduction in that spring flow is certainly going to have an impact on these people who hold permits. It's going to have an impact on the ecosystem. It's going to have an impact on the recreational users and the industries that have grown up around the springs. And it's certainly going to have an impact on some of the instream uses that have been enjoyed over the years because of that spring flow.

Where too many wells have been drilled springs have been lost. Those springs have dried up and industry around that area has diminished

and in fact, dried up with the springs. So, it really is an important issue to the local community. It's an important issue to Central Texas to make some determinations and to come up with some solutions so that the spring flow is protected.

The regulatory activities that the Water Commission has to deal with this issue may be rather disappointing to you. The one primary program we have is we are the agency that allocates State water in Texas among people who make applications to use it. We have gone through the adjudication process throughout the State. That process has essentially determined all of the water rights in the State. We are now able to issue new permits to people when water is available. Computer models that model the historic flows of the rivers and streams allow us to make determinations when water is available and when it is not, and to issue permits to people who have a need for water when water is available.

We have a new program that I want to mention because it is associated with the Surface Water Rights Program. This is the Water Master Program. The Texas Water Commission, on November 30, 1988, approved the budget for what we call the South Texas Water Master Program. It is a Water Master that will encompass the Nueces, San Antonio and the Guadalupe River Basins. What this program is designed to do is provide an enforcement tool. It makes sure that only the people who have rights to surface water take that water in accordance with their permits. We will set up the system where we are able to monitor real-time data on river flows in the rivers and streams in the basin. Any person needing to divert water under a permit would call and get permission. We would find out if the water is available to allow them to divert. It is essentially a program that protects the water rights that currently exist. That could be a very important program if actions are not taken to protect the spring flow from the San Marcos and Comal Springs. That Water Master Program may become very significant if we have to cut back existing rights in these particular river basins.

One other program I want to mention has to do with groundwater regulation. You already know that in the State of Texas, the State does not regulate groundwater. It is the property of the land owner. The Water Commission role in groundwater regulation is to create the districts that have the power to regulate groundwater in Texas. Regulation, if it does occur, occurs at the local level under districts called Underground Water Conservation Districts. We are the agency empowered to create those districts. The legislature also has the authority to create those districts, but that is our only role in groundwater regulation from the supply side. Since we have a groundwater district in this area, the Water Commission probably can be of very little assistance as far as providing any solution by

providing a district that could indeed regulate groundwater. Your groundwater district does not have the powers of districts created under Chapter 52 of the Water Code.

The final area I want to mention is the area of water quality, where we do have a great deal of jurisdiction. We operate programs in Texas to protect groundwater quality, but in this area we have some particular rules and regulations that are unique. We have adopted what we call the Edwards Rules. They are a set of rules that control a variety of surface activities over the Edwards Recharge Zone. These rules prohibit waste water discharges over the Edwards, control the storage of hazardous and hydrocarbon substances, contain preventive measures for spills or accidents, contain regulations regarding septic tanks, and contain regulations about the design, engineering, and installation of waste water treatment plant collection systems.

Tom Fox mentioned some interesting issues in regard to water quality effects from overproduction. He's introduced some theories about whether or not the Water Commission may have authority to regulate to protect water quality if over-production in fact causes contamination or diminished quality in the aquifer. The Water Commission hasn't addressed that.

I would like to make a couple of observations. One is that I feel confident that the rules and regulations that have been adopted on a statewide basis by the Water Commission will be severely tested by the issues that are developing over the Edwards and related to the springs. We have some very unique situations here. They may indeed require some very unusual and unique solutions. State government and statewide rules and regulations don't always allow for those solutions or they're not always considered when those rules and regulations are put in place. As I've told you, one observation is the Water Commission really as very little control over regulating or controlling the spring flow that comes out of the San Marcos and Comal Springs. We cannot control production from wells that go into the Edwards.

The second thing I would like to mention is that if you don't have a conjunctive system, if you're unable to do that for whatever reason, then what you have is essentially two systems that are operating independently. You've got the system that we operate, the surface water system. We obviously have a great deal of interest in how that one is controlled. We also have the groundwater system that can be controlled at the local level. The interesting issue is the interface between those systems. If you've got two systems operating together and they're directly connected, it is indeed that interface that becomes there ally important question. The springs are one connection between the surface system and the underground system.

We have a great deal of interest in the regulation, control, and management of that interface. The problems that you're looking at today need to be addressed in a comprehensive and viable management plan. I think that plan needs to be initiated at the local level.

Tom Fox - Raba Kistner Consultants, Inc.

The Edwards Aquifer Rules dealing with protection of the recharge zone only apply in one place in Texas. Texas has a lot of groundwater that is affected by water quality regulation. But these rules of the Texas Water Commission only apply in the Edwards Aquifer. A precedent, I believe, is being established by that fact alone. So there can be some movement away from historical activities to some other kind of solution The fact that the Edwards Aquifer rules exist was a result of the failure, primarily of the local governments, to come together and find specific solutions for water quality threats back in 1968-1972.

In Texas we do have the fundamental policy that local units of government have authority, or can be given authority through groundwater management districts, to regulate groundwater among the various users. It is a total falsehood to say that there is no groundwater regulation in Texas. There is a policy that dates from 1949 that authorizes people to regulate uses among themselves. That's an extension of the American theory of groundwater management as opposed to the English theory which allowed people to regulate their own usage through being able to regulate production or being able to regulate well spacing. But there is a mechanism; it does exist. So districts can be created. It's a fundamental policy of the Texas Water Commission to say that districts should be created in the interest of the public good.

One of the other policies central to district creation is that whatever district is created should include an area coterminous to the aquifer or to hydrologic subunits to the aquifer. We've seen a lot of that not being done in the legislature. In the 1985 session and the 1987 session, groundwater districts were created. For example, a district was created in Anderson County of 25,000 or 30,000 acres. This groundwater district was created for a particular purpose. It did not cover an entire aquifer. The point is that people may begin to make the effort to swing the pendulum back; to begin to consider that districts should be created. If they're going to be created at all, they should be created around the basic hydrologic unit, the aquifer. There is plenty of precedent, plenty of validity to having different rules apply to different aquifers. We already do it in the Edward's Aquifer. It can be done and it should be done because of the diversity among aquifers.

There should be a wide range of rules and institutions that would be available to manage groundwater. Regulation is not the word. The issue is management. The Edwards Underground Water District was created by the legislature for the purpose of managing, but was not given any authority. It was to provide information, and try to persuade or convince; whatever it took to get people to understand the issues and begin to take action on their own initiative.

In 1975, a local committee in San Antonio and within the Edwards was created and some recommendations were made for development of alternative supplies, development of a regional management plan, and conservation. Those were policy recommendations. Things didn't happen. They didn't progress because a fundamental underpinning was not there -- the data and information that explained why these things needed to be done. That was recognized and addressed. Data are there, but it wasn't put together in a way that was acceptable.

There were a lot of other issues that needed to be addressed and resolved,but it was concluded that a comprehensive report and study needed to be made available to the public to make decisions. Who makes these decisions? Is it the legislature? The legislature does not on its own come down and say this is what we're going to do. The courts could, but the courts have to be given a case to try. They could make these decisions for us. That's another alternative. We can say, "Hey, let's give it to the courts and let the courts work it out". Remember, and there are people here who know more about this than I, how long it took to resolve the issues on the Rio Grande and what the end result might be of such a complicated case. Imagine having that tried in a federal district court in, say Tyler. That has been done for the Texas prison system and look at the results. Just imagine what the water system would look like. What we really need to do is try to resolve it among ourselves. That's what the intent of these studies were. They were to gather the information and make it available to people to cause decisions to be made, cause local people to say we've got to change these laws and have the authority to manage this aquifer system.

Everybody could agree on water quality protection, and, that management of the Edwards Aquifer is necessary, and a mechanism was outlined. Those are policy recommendations that were considered and accepted. But there was another issue in the winter of 1987 that had not been resolved. That was, who was going to do it? Who was going to be the management entity? It was proposed that it be the Edwards Underground Water District. The issue of representation was a factor in whether or not people were willing, and able, to go forward in making some of these decisions. People are not being represented by this system of representation. That issue prevented people from going forward.

Another one of the key recommendations was that in the absence of an immediate policy-regulatory plan, or management plan, the area must have a drought management plan. So, as a result of that, a side development proceeded. The Edwards District was given the authority to develop and implement a drought management plan. But, it had one key provision. If it could not do it by a certain date, then it was to be done by the Texas Water Commission. Again, precedent, for a different way of doing things. That was written into the law. It's got problems and could have problems in the future. An opportunity was provided for any county to withdraw from the District. That's one of the compromises that was struck to be able to go forward with a drought management plan. Indeed, it may be a problem to have an actual drought management plan if there is a split-up of the Edwards District.

Any plan must contain four elements. The four elements are serious conservation recommended for the entire region and is committed to by the City of San Antonio. A 17% ultimate conservation rate is a part of this plan. The recommendation here is to go for a 10% reduction in overall regional groundwater usage. That translates into a 17 percent reduction for municipal and industrial users throughout this area. A second component is reuse of wastewater where possible for new or existing facilities able to use it in a way that will reduce demands on the Edwards Aquifer. The third element is the development of surface water supplies starting first with the Applewhite Reservoir in San Antonio, and beginning the planning for the Cibolo and Cuero reservoirs. And, the fourth element is groundwater management, recognizing that there is a finite amount of water available in the form of groundwater. In November of 1986, it was recommended that an allocation plan be developed, but there is no longer an allocation plan. There is a plan that says that those users as of a date certain in perhaps a few months or years into the future will have a right to a fixed amount...to the water they are using right now, that's not allocation, that's grandfathering.

John Specht - General Manager, Guadalupe-Blanco River Authority

An important parcel of this whole program of planning that Tom has just described, was by the Guadalupe-Blanco River Authority, the San Antonio River Authority, the City of San Antonio, and the city working with funds provided by the Edwards Underground Water District in another major study of the two river basins. This study of the Guadalupe and the San Antonio really focused on what the resources are, what the hydrology is, and assembles the data and the information we need in order to feed into the planning processes. For example, it developed a model of both the Guadalupe and San Antonio River Basins. It studied the requirements of

the basin estuaries for fresh water inflows. It studied the potential reservoir sites that could be developed, if indeed any additional water resources were necessary. It tried to determine what the further factors are that will relate to the development of those resources, including impacts on the environment, and recreation resources. It tried to develop the cost data that are necessary to understand what kind of expenses will be entailed if we are to develop additional resources. All of that was fed into the studies that Tom described.

We have a finite resource, but it's adequate in the long run to provide for the needs for this region. Yet it's not located exactly where we might like it to be. It's not distributed exactly the way it might be most useful. So we are going to have to manage these resources in a manner that provides for our needs; and we will need to develop additional resources to move or put them in a place where they could be used within this overall management problem that we were facing.

I think it's interesting to realize that as we went through the planning process we began to run into trouble as we began to get specific and talk about the specific management plan that we would recommend. We began to talk about how much water was going to be used, particularly the water that is obviously available from the aquifer. As we moved into that, we began to identify the specific interest groups. Those interest groups are agricultural irrigation which had developed very significantly in the western part of the Edwards region, municipal and industrial uses, associated with the metropolitan area more or less in the center of this region and finally the concern about spring flow. We call it spring flow but it's a much broader issue than water issuing from the springs. Certainly it is that, but it's also the users downstream in the river basin composed of some of the same types of user groups that are active across the Edwards Aquifer -- irrigation, municipal uses, industrial uses, recreation uses, mining and many other uses. As the springs diminish, we're literally taking the water away from long term uses that have developed in the river basin, and I want to emphasize again the importance of inflows into the bays and estuaries. A significant industry is based upon freshwater inflows, periodic pulses of freshwater into those systems to sustain the productivity of the marine life.

Those of us that are working with the surface water, representing interests of spring flow and surface water uses downstream, have begun to argue that indeed our particular use needs a significant amount of that water from the Edwards to sustain our current uses and to have some potential for future growth. But, when you add it up, those categories needed more water than the average recharge of the aquifer -- substantially more. And when you consider the critical drought conditions, then you

could begin to envision some very severe shortages. And none of the interest groups wanted to accept a reduction during those periods of time.

If legislation is passed to regulate the aquifer, you're threatening to regulate all groundwater in the state, not just the Edwards Aquifer. How in the world would you expect to pass that through the legislature where there's reasonable concern for the long term right of capture of groundwater that probably all of us, including urban dwellers, have long held as being part of our basic property rights in the state. I don't think that we have a very good chance of reaching that point of compromise so that the legislature indeed would pass such legislation. We have established here, from various experts, that we have a serious problem. Demand on the aquifer is so great, particularly during periods of drought, that it can no longer sustain all uses. The easiest place to begin to see that is from the severe diminution of spring flow every time it begins to get dry. Mr. Gumbert, earlier today, identified the problem. We're not in a drought yet. It's rather dry, and if it gets a little drier and goes on a little longer, we're going to be in a very severe drought. But, right now the springflow is the major part, some 84 or 85 percent of the total flow, of the Guadalupe River. Think of the impact of that if we extend this dry period just a little bit further, such as in 1984 when the Comal Springs no longer were flowing at 280 cubic feet per second, but had dropped to less than 30 cubic feet per second within a very short period.

So here we are, having identified problems, having planned for them, but we can't come together, we can't reach a point of agreement to go forward. We have the potential. The water resources are there if we're willing to manage them and do some additional development in order to supplement the Edwards, and move the water sufficiently to make it available where it's needed. One factor in this whole process was drought management planning. That's very significant. Indeed it could force the entire issue. But, as we went through the process of actually developing a drought management plan for the Edwards, we weren't quite willing to make it strong enough to force the issue--to force, for example, the City of San Antonio to say, "My goodness, if we really have to cut back 60% in a severe drought, that's impossible, for a major metropolitan area." If we can't do that, and if the plan which is now adopted forces us to do that, we'd better find some alternative resources in order to supplement water supply from the Edwards.

Going back to some of the earlier discussion, what happens as springs dry up or as the area becomes more arid or as we go through a drought iteration. We have experienced drought before, and may be in the process of experiencing it again. Well, where do we go from here, if that doesn't look very rosy; if that doesn't paint a very pretty picture? What if

this is the one that is as bad as the drought of the 50's and we find ourselves at extremely low levels, and this is the one when the springs do indeed go dry for a period. There may be enough water in the Edwards Aquifer to pull the major metropolitan area through; enough to continue irrigation, for a seven or ten year drought period, such as we have experienced historically. But, there surely isn't going to be much flow in the river system, in fact very little, I would say under the present conditions of use. What would we do about that? What source would we use to take care of needs in the river basin, if we went long enough and pulled water levels down into poor quality water, or had some other problems and needed to supplement supplies to the metropolitan area for basic human need? How long does it take to develop a reservoir and put it in place, and have an initial reservoir fill so that it's a viable source of water? Do any of you have any idea how long that would take? If we do it on a local-state basis maybe ten to fifteen years from the day we start. During that period of time the drought will be happening and may even be over. We'll probably be back into more or less normal rainfall patterns. The damage will have been done. The impact will have been very, very significant and yet here we sit and can't agree on how much water should be allocated for irrigation, how much for spring flow and downstream water rights requirements, or how much San Antonio needs in the mid section of the area. We just can't quite get there. And, as long as we can't agree, the legislature's not going to be much inclined to help us.

Another question has been touched on by Mr. Nevola as well as Mr. Bienke; i.e., how is this question to be raised in a manner so as to force the issue--whether to go to the Water Commission to ask them to take an official look at managing the Edwards or to go to the courts directly to ask them to determine whether the state should take a role in managing the Edwards under present law.

That may be a necessary step when we can't seem to come together. None of us seem to be willing to give enough or willing to make the commitment of resources to go forward to develop water resources to supplement this aquifer system. Either way we're going to have to ask the legislature to give us the statutory direction or the processes necessary to regulate this aquifer. Ultimately I would expect to go through an adjudication process which recognizes the various uses, and tries, to the extent the resources are available, to honor those historic uses. This would move us into the processes that are necessary; the processes of conservation, reuse, and then finally some additional surface water development to supplement the aquifer, and indeed we have a great deal of potential there. But it takes a lot of time and it's most expensive.

Fred Pfieffer - General Manager, San Antonio River Authority

The Edwards Aquifer area planning process has been going on for many years. There have been recommendations made, but when we get to a decision point, recommendations fall by the way side time after time after time. This last effort sponsored by the City of San Antonio and the Edwards Underground Water District, and the studies by the Guadalupe-Blanco river Authority and San Antonio River Authority have gotten us to a point of having a lot of good information developed by people of good will who are trying to solve the problem for this area. These people are not greedy, money hungry, water hungry, reservoir building, environmental bashing people. They're people that do not have any other interest but to try to protect and develop the water resources for the people of this area.

There's a lot of disagreement. Maurice, I take my hat off to you. I take my hat off to John and I take my hat off to the citizens of San Antonio and our city government. Because, they all recognize our problems, our needs, and our desires. It's been tough, but there has been a lot of effort put into this planning. Conservation; I've had people say; "well, we're going to conserve our way to prosperity." That's impossible. I've had people say; "we use so much water if we divide by two, we don't have a problem." It doesn't work that way. A waterline has at least 10% loss. You have leaks. Go to your home today--is every one of your faucet washers in place and there's not a drop leaking? Turn on your hoses to water the garden. See if you don't have one of them squirting out the side somewhere, water going where it's not supposed to be going. We live in a society which is not perfect. But we've got to try to conserve as much as possible. We went through about 3 months talking about conservation. And we looked at all the things we could do and then we looked at the things that were politically feasible; that we could get a society to do and decided that we could squeeze out 17% with a long, sustained, effort. Now, in serious drought conditions you can save more than that, but you can't sustain it. Seventeen percent is a tremendous conservation effort. That was cranked into this plan using our sewage and maybe eventually drinking it, was also included. That's not very palatable to the general public. It's cranked into this plan. Developing surface water is in this plan. We have looked at it all. We have technical experts. But, I think now's the time to develop the political will to move forward and attempt to get a comprehensive management plan for the Edwards Aquifer area. If it is not done in the legislature, I can only project that it will be done in the courts. I would rather that we come together in compromise and get it done legislatively, in a deliberative process, than have to lose it in the courts, however it comes out.

Dr. Glenn Longley -- Director, Edwards Aquifer Research & Data Center

The topic that we were to address is, "what is being done?" As you can see at this point, there's been a great deal done. Each of the speakers has pointed out different aspects of studies, planning, and conservation. They're being done by the City of San Antonio, the Guadalupe-Blanco River Authority and various other entities including the Edwards District, and at this time a legislative package is being discussed.

If you accept the premise that you need to maintain some spring flows so that you can preserve historic water rights in the Guadalupe River Basin the problem is clear. In our Research Center, we have tried to address some of the concerns and issues. We have made dye tracing studies that show the movement of water to the springs in specific areas. We've looked at geochemical studies to get some idea of local versus regional contribution to the spring flow. We've found some very interesting results. Although, they are not going to solve the regional water problem, our research sheds light on some of the factors about which we are concerned. We found in the San Marcos Springs that springs at different ends of the lake have different amounts of certain chemical constituents, and the temperatures are different. Earlier studies had inferred a fault across the Spring Lake; some of the studies that we have done have indicated that that is the case.

We've carried out detailed studies on the statistical relationship of water levels in the San Antonio index well, with Comal spring flow. The correlation between these two variables is 95 percent. We've looked at the correlation between water levels in the San Antonio index well and flows at San Marcos Springs. It's not quite so good a relationship, but there is a relationship. Also, at our center we have done biological studies of the ecosystem. Ron Harden indicated to you something about the tremendous diversity of fauna in the aquifer. We know from the literature that this system is the most diverse groundwater ecosystem of any that have been described in the world. We feel that the diversity of organisms which inhabit the aquifer organisms is an indication that the water quality is high. It's an excellent water quality that we have today. We would not like to see the water quality diminish. So we try to keep an idea of the water quality at which the biological communities are being maintained. We feel that the biological community can be a good indication of changes in water quality.

To summarize, I want to say that speakers at this conference have shown that there is a tremendous effort being made by various entities throughout the region. I think that our conference participants have shown that the best solution is to try to solve the problem on a regional level

without having to go to the courts.

The Honorable William M. (Bill Sims)
Texas Senate District 25
Dinner Speaker

In his address, Senator Sims explained and emphasized the importance of water conservation as a part of the overall water management program in Texas. He focused attention upon the effects of brush infestation of nearly two-thirds of Texas's 95 million acres of open range land upon aquifer recharge, stream flow, and range productivity, since brush competes with forage grasses for both land and water. Senator Sims expressed his ideas that programs to reduce brush coverage, and particularly to reduce mesquite, would result in three types of benefits to the people of Texas.

The three major benefits from brush control efforts would be (1) increased aquifer recharge, (2) increased stream flows, and (3) increased forage production for livestock grazing. Increased aquifer recharge and increased stream flows could benefit urban dwellers through increased quantities of water for municipal, industrial, food production and other purposes. Increased forage production could benefit ranchers and farmers directly, since more livestock grazing could occur. Consumers would also benefit through larger quantities of meat and meat products at lower costs. To illustrate his points, Senator Sims showed slides of the 74 thousand acre Rocky Creek Watershed located to the northwest of San Angelo.

In the slide show, the history of vegetative changes on the Rocky Creek Watershed was given and was related to stream flows in the creek. Early explorers in the late 1600's observed grassland prairie with only about five percent of the area covered with woody species. Streams flowed and travelers cut the prairie grass for livestock feed at Ft. Concho in the 1870's. Livestock grazing was introduced to the area in the mid 1800's, and writings of the late 1800's began to record a dramatic change in the vegetation. Instead of open prairie with flowing streams and scattered trees, brush began to replace the grasses and forbes. Mesquite was dominant, with Juniper being recognized around 1900. The streams changed from steady flows to intermittent flows, and dry creek beds most of the time. The cause was brush infestation, since brush cover changes water infiltration rates, and brush extracts more water from the soil than grass does. As a result, grazing capacity of the land and stream flows were reduced. Until the drought of 1918, Rocky Creek flowed year-round. Thereafter, it flowed only during the winter, and in the 1930's it dried up completely.

In the 1960's, five landowners, whose holdings cover 33,000 acres or about half of the watershed, began range conservation, brush control work, and there seeding of grasses on the rangeland. However, brush strips were left for wildlife cover.

In 1964, springs began to flow again, and today it is estimated that Rocky Creek yields over 78 million gallons of water annually, which is worth more than $188 thousand annually to the people of San Angelo who use it.

The Rocky Creek experience supports the hypothesis that brush control and management could contribute significantly to aquifer recharge, spring flow, and stream flow. Thereby, a brush management program in Texas could contribute significantly to solving water supply problems in some areas of Texas, notably in the central and southern parts of the state where brush infestations of range land are the worst.

Saturday, December 3, 1988, Technical Panel Session
Dr. Herbert W. Grubb - Chairman, Technical Panel; HDR Engineering, Inc.

Let me explain just briefly what we're going to do this morning and then inform you about the Panel's role. We met yesterday and identified two major purposes for the Panel: (1) to prepare the concluding section of the proceedings in which the Panel will present the conclusions and recommendations coming from this conference and (2) to develop the conference proceedings. The Panel's work will be based on the presentations here, and the experience and information that is readily available to individual Panel members. As a part of that, this morning each panel member will be given an opportunity to make a presentation for about five minutes.

When you come forth, panel members, state for the record, your name and association. Following the presentation of the panel members, we will have an opportunity for you and the audience to enter into the discussions, ask questions and make your observations

Mayor Douglas Miller - New Braunfels

While you're thinking here today and as we recall the presentations of yesterday, we should identify the problems of the 1990's, if not the twenty-first century. And, now the hour is upon us. Where do we go from here?

As Dr. Grubb has said, we're going to compile this into some type of report. Do we let it sit on the shelf or do we move forward with it? If we move forward, then we proceed to come up with a solution for all of us. We're all in this together. It has got to be a working team effort. Judge Rains said yesterday, we have to take the "my and I" out of this problem and change it to "we and us," if we hope to come up with any comprehensive and long range solution. It's truly our problem.

New Braunfels will be using surface water by 1991 from Canyon, in conjunction with the water that's taken from the aquifer. Therefore we will be lessening the amount that we'll be taking from the aquifer. When the Edwards District held discussions on a regional plan, I brought up the point that New Braunfels already had instituted water rates to promote conservation. I would put this to those people from different political subdivisions that have an opportunity to do so, to go home and suggest to your councilmen and your commissioners or whatever it may be, that you institute water conservation rates and conservation programs and press hard on them.

In yesterday's paper, Mr. Harrington was talking about what are we going to do for the future and he was asked what are you going to do about Applewhite? His answer simply was, the story's not in yet. We're going to need surface water sometime in the next century. Well that's 110 years to me. 110 years doesn't cut it. We're going to have to move forward. We're going to have to take a look at solutions and not just look at them, but make decisions on them.

Now, being a former resident of the City of Uvalde, I understand from where they're coming. I think they know what our problems are, and what they're saying, in my estimation, is that until you in the cities decide to do something, we're not going to do anything. I'm saying that in New Braunfels we have begun to do something.

When you start looking at a realistic approach to this, we have to realize we have three choices and those choices are legislation, courts and ourselves. I don't believe anyone that spoke yesterday or will speak today believes the first two are viable alternatives. This water is a limited resource. It's something that we must protect. We must strive for a regional solution instead of individual solutions.

Dr. Larry McKinney - Texas Parks & Wildlife Department

The work that I do is in resource protection, I have made some study of how water issues have been resolved in Western states. These involve

legislative remedies and the courts, and, now public trust doctrines are beginning to be used.

The one thing I glean from the discussions yesterday is that it'll be much more desirable to try to resolve these problems with the people that know what's going on and the people that work with it every day rather than letting it go into court or even to the legislature.

Another area; the maintenance of environmental stream flows on the Guadalupe. It is my philosophy and my Department's philosophy, that the Texas river system is like an 80,000 mile network-- a blood supply system throughout the state. The streams, of course, are both intermittent and continual. It's very important when diverting stream waters, using these waters, building reservoirs, or whatever, that we do what we can to maintain the rivers and streams and not take so much water from them that we destroy the integrity of the network.

Stream flow is a very important subject with us; we strive to assure that when we develop these water resources that we leave something, that we will have something for the future. The situation that we have with respect to Comal and San Marcos Springs and the Guadalupe River is that we maintain the springs and the river not only for the flora and fauna that they contain but also for flows to the bays and estuaries. The Comal and San Marcos Springs and the Guadalupe River-- this area is a jewel in our crown. It's unique, it can't be replaced. What can be done to protect it is very important to us and important to the State of Texas as a whole.

Eddie Gumbert - Chairman of Board, Guadalupe Blanco River Authority

I would like to thank Glenn and Jean for giving me the opportunity to speak here today. What I would like to do is to relinquish my time to Harvey Banks, since he's come so far. I know that five minutes will not be sufficient for him to say what he has to say. So I will yield my time to you, Mr. Banks, sir.

Larry Gilley - City Manager, City of San Marcos

I want to say, first of all, as I observed the proceedings yesterday, I was impressed with the speakers and the range of the issues presented to this group. The issues were many, not only from the speakers, but from the audience. We don't always agree on the issues and the matters before us with regard to water and the life and the future of the aquifer. But even though we don't agree on those issues, I think we must recognize that the

Edwards Aquifer is critical to this area, and to this region of the state.

I would like to tell you how I view our role as municipal government water users. We're rather large users, not the largest in the area, but certainly we do consume a large amount of water from the aquifer. As municipal government officials, as users of water from the aquifer, our role must be one of accepting the responsibility to use that water as efficiently as possible; to encourage conservation among our users and also to observe those same conservation efforts ourselves.

Mr. Bishop spoke briefly yesterday of some of the measures that the city of San Marcos has in fact undertaken with regard to conservation efforts, and I'm very proud of those efforts. We have instituted a metering program for almost all of our municipal uses, which has allowed us to identify where, in fact, we were not being very conservation-minded. In wastewater treatment, for example, we have now modified our plant so that we can reuse some of the effluent on our sprinkling systems for our clarifiers. We have carefully evaluated our rate structures so that as we continue to modify those in the future, we will be able to encourage conservation through rates. We have enacted, over the past several years, a number of environmental ordinances that are designed to protect the aquifer. We've instituted a number of planning efforts. We have a very active planning commission. We have a very active planning staff that recognizes the precious nature of this resource. The question was raised yesterday, whether or not we should control population growth as a factor in preserving the aquifer. We encourage development away from the recharge zones.

I want to express our appreciation for the efforts being made by the City of New Braunfels and New Braunfels Utilities. We too, although we're not quite as far along in our efforts to develop surface water, recognize that is something in our future. We have recognized the need. We have begun planning efforts and we, like New Braunfels, think that we will be in the surface water business in the not too distant future. We obviously do not have all the answers, but we accept the responsibility for being a part of the solution.

Alex Fisch -Director, Guadalupe-Blanco River Authority

Protection of our water resources apparently is the big problem that we're dealing with here. This seminar has been very enlightening to me. I've only been on the Board about 18 months. In that time I have come to realize the complexity of the problem ahead of us. Who owns the water in the Edwards Aquifer seems to be the big question. And, until that answer

is found, we've got a problem in the regulation of the rate of use of that water. The regulation of Edwards Aquifer water use can be accomplished in a fair and equitable manner in the years to come, including use of aquifer water with the advent of surface water development.

Dr. Kenneth Ikels - Edwards Underground Water District, Comal County

As a board member on the Edwards Underground Water District we're going to be making some very difficult and important decisions in the months to come. I ask all of you for help with input. We need to know what you're thinking, how you're thinking and what your positions are. Our representatives in the legislature must understand the issue of the uniqueness of the aquifer, how we're going to treat it in the future, and just what the legislature might do about that. Until they are aware that it is a unique aquifer, I don't know what they're going to do.

An issue that is very important, particularly to New Braunfels and to San Marcos is the bad water line. There is a lot of controversy about the bad water line. We'll be drilling wells around Landa Park near the Lower Colorado River Authority (L.C.R.A.) plant. That's the vicinity where wells will be drilled in the fresh water zone, the transition zone, and in the bad water zone to help us determine and watch what this bad water line does. I'm a conservative individual, I'm not in favor of drawing down the aquifer below the lip of the springs for the simple reason that I have concerns that there may be considerable movement of this bad water line into the city wells.

The drought management plan is a management tool that we have in existence at the present time. It's on the board; everything is ready. But this plan could be in jeopardy because some of the western counties may elect to leave the Edwards District. We have to be ready as board members to attack this problem and go to the legislature to make the necessary arrangements, perhaps in a form such as the Edwards Rules exist at the present time, or some variation of that.

Harry Bishop - Edwards Underground Water District, Hays County

The City of San Antonio is really putting some money on the line, and they've passed ordinances just recently. They've increased water rates, they've increased sewerage rates and they've dedicated a lot of money and a lot of effort into moving ahead with our regional plan. In fact, there's a self-destruction clause in the regional plan as it's written saying that if the City of San Antonio doesn't proceed with the implementation, then the plan ends itself. So they have to show a good faith effort and it's important to the

rest of us that they show that leadership, because many voters in the district live in San Antonio and Bexar County.

The point I want to make pertains to regional planning and management of the aquifer -- management of the resource. Yesterday, I talked a little bit about comprehensive management, and then last night I became disturbed when Senator Sims started talking about single county districts. I talked to him about this, and ask that you all use whatever influence you have too. Single county districts, particularly in districts such as the Edwards, seem to me to be a blueprint for havoc, it just can't work. We have to have conjunctive management as well as comprehensive management. The Edwards Aquifer is an entity, it just has to be managed as an entity and we can't do it with five little separate political groupings.

Allen Bienke - Executive Director, Texas Water Commission

Because of the uniqueness of the Edwards and the problems associated with the springs and the Edwards aquifer, I think the situation defies traditional methods of dealing with groundwater and surface water problems. What that really means is that a unique solution to the problems is going to have to be fashioned.

The solution to the problem is going to require the development of a comprehensive and viable management plan. The key is how are you going to get that management plan put into place? Obviously there are three solutions; a local solution, a legislative solution and a legal solution. While I certainly encourage the local solution, I don't believe that you will have a final solution until you at least have the courts or the legislature get involved. Really the choice is there. Which one do you want to make your decision for you? I would encourage you to use the legislature rather than the courts. We have seen other areas in Texas where special masters have been appointed to regulate aspects of our governmental functions. Historically, we have seen the legislature deciding solutions to problems for the citizens of Texas when they are ripe and when it is timely. The key here is convincing the legislature that it is timely; that this requires a unique solution; and that the members of the legislature understand the uniqueness of the problem.

Harvey O. Banks - Consultant, California

The first conclusion that I have drawn is that there is a wide lack of understanding of the problems of the Edwards Aquifer. Those of you that listened to the papers yesterday now have a fairly comprehensive knowledge. There are probably many other people in this region that have

little or no understanding, knowledge, or appreciation of the problems of the Edwards Aquifer. The extreme complexity of that aquifer I'm sure is not understood. One of the characteristics of the system is that an action taken anywhere in the Aquifer impacts on a lot of other outputs of the system. There is not a wide understanding of the importance of the values of the Edwards; they're economic, they're environmental and they're social. Your solution must recognize that range of values.

I don't think there's a full appreciation of the horrendous consequences if you proceed to destroy the aquifer, as some advocated in San Antonio on November 30, 1988. Whether the advocate understands the Edwards, I'm not prepared to say, but his views were extreme and based on limited information. If you destroy the Edwards by continued over pumping, the consequences are going to be drastic, not the least of which will be a drastic reduction in property values. Public understanding has to encompass not just you people that now are dependent on the aquifer, but people throughout the state must be knowledgeable. There is little doubt that this will go before the legislature sooner or later. If you don't have understanding on the part of the state, you will not have the votes. The votes are what finally count in a decision.

I would say these are not engineering solutions. They involve a lot more than engineering. I listened yesterday to repeated references to your historic droughts. You're going to experience more severe droughts in the future than you have in the past. That's the history of hydrology. You haven't seen the worst yet, either drought or flood. So I'm going to call on you to provide for wise use of the Edwards. That's your problem. You have to first set up the objectives that you want to achieve. The objectives have to be based on beneficial uses including the social uses of the Edwards. You must develop a full range of alternatives and analyze them as to both their beneficial and detrimental impacts. That has been done to some extent. My impression is that it should be done more. You've got to find a way of equitably allocating the water resources that you now have and will have if you proceed wisely.

You've got to find a formula for the equitable allocation of costs, and all this will cost money. The equitable allocation of cost is a complex problem, as you're finding out. The third important conclusion that I drew is that you must find some way of maintaining the integrity of the Underground Edwards Water District -- as a district, as an organization. If the Edwards District is fragmented, you will have to start all over. Much of what's been done and the way of developing plans will no longer have validity, so you start over. I would hope, and this is sort of a conclusion, that the people to the west of you, in Uvalde, and the other areas, realize that if they separate themselves from a regional approach, ultimately they

may destroy themselves from the standpoint of water supply. It isn't as simple as protecting some abstract right. Unfortunately, all a water right is is a hunting license when you get down to it. If I understand the Edwards properly, the people to the west are going to be hurt severely over a long period of time by what you people to the east do. I would recommend that the farmers and others in Uvalde County and Medina County give careful consideration to their long range potential interests. Ultimately the decision has to rest with people. It doesn't rest with engineers like me, it doesn't rest with lawyers.

Finally, assuming that you reach some agreement where you can go ahead, the next problem you face is the organization that will carry this out. You have the organizations. You have the G.B.R.A., the San Antonio River Authority and the Edwards Underground Water District. But you need to carefully examine how all those existing agencies are going to function together and collectively do they have the full powers necessary to carry out what you finally decide you're going to do.

Anne Cooper - Representative, Texas Legislative District

There is a fundamental truth that carries over from finance to other resources. That truth is that you live on the interest and you don't mess around with the principal if you're going to survive. From time to time, generations come who add to the principal and I think of that possibly in terms of recharge facilities or reservoirs. But somebody has to come along, if the family is to survive, and say, it's the whole family we're talking about; it's just not yours to take. I really have great admiration for the leaders in San Antonio who are sitting on top of a great source of water. It would be easy for them to say it is just ours. We can pump it cheaply. Why should we care about the rest of the family? But if you look at this system, and the more you know about the system, the more overwhelmed you are by it; by the complexity of it; by the wonder of it. If we don't take care of it and if we do live on the principal, someday there won't be enough, and as Mr. Banks said, we will destroy ourselves. I listened to Allen (Bienke) talk about the legislation and to Mr. Banks. What the legislature needs is information, real information, hard information. If we don't have really hard information, we are forced to go on emotion. The people can say they're taking our water away. That is really a very emotional issue. It is absolutely essential that you continue to add to the information that you have.