TEXAS BOARD OF WATER ENGINEERS
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ESTIMATED USE OF GROUND WATER IN WATERSHEDS OF TEXAS

Prepared by the Board of Water Engineers
and the U. S. Geological Survey

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C O N T E N T S

ILLUSTRATION

TABLE

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GENERAL STATEMENT

Several factors have caused increased ground-water use in Texas, especially in the past five years. The most important are expanding agricultural and industrial economies and the existence of the most severe drought of climatic record. These two factors, either singularly or in combination affected most areas of the State and the demand for ground-water information far exceeds the file of available data. From all available sources it is estimated that about 7,498,400 acre feet of ground water was used from wells in 1955 throughout Texas. Ground water issuing as springs and later appropriated as surface water is not included in this estimated. Of the total quantity of ground water used, about 83 percent was for irrigation, 7 percent for industry, 6 percent for municipal supply and 4 percent for rural (domestic and livestock) supply.

The included map shows the principal ground-water reservoirs and the watersheds of the State. The figures for ground-water use given in Table 1 are computed for the watersheds. The map and table include the High Plains which strictly speaking is a non-contributing area. The area has no well developed drainage and the ground-water reservoir is neither geologically nor hydrologically connected to any major drainage system. However, more ground-water is pumped from the water-bearing formations of the High Plains than from all other ground-water reservoirs of the state combined. The northern part of the High Plains is incised below the Ogallala formation (which is the principal water-bearing formation) by the Canadian River in a northeast trending valley which ranges in width from six to thirty-two miles. There is very little ground-water development from the relatively impermeable "red beds" which underlie the Ogallala. They form the surface of most of the Canadian River Valley and no separate tabulation is made for that drainage system.

SOURCES FOR INFORMATION

In past five years several state and federal agencies have obtained information that reflects the amount of ground water used in Texas and the purposes for which it is used. The Board of Water Engineers with its principal cooperator, the U. S. Geological Survey, makes scientific studies of the occurrence, availability and chemical quality of ground-water in the State. In general the use of ground water in a given area is determined with the completion of the study. Except for continuing cooperative studies with the Cities of Houston, San Antonio and El Paso, the scope of ground-water investigations up until now has not included continuous studies of fluctuations in ground-water development for any given area, or for the state as a whole.

The Extension Service of A & M College has maintained close estimates of irrigated acreage by counties in the State through about 250 county agents. By applying duty-of-water figures for various areas using ground water the amount used annually can be estimated with reasonable accuracy.

The Bureau of Business Research of the University of Texas has made estimates of ground-water used by industry in the Gulf Coastal Region and in the High Plains. Their efforts were concentrated largely in the more industralized parts of these regions and their data is up to date as of 1954.

The State Health Department obtained information about public water supplies and thus their records reflect the quantity of ground-water used by about 300 municipalities in the state.

Estimates of the quantity of ground water used for rural purposes (stock and domestic) is based upon figures from the Bureau of Census of the United States Department of Commerce.

RELATION BETWEEEN SURFACE AND GROUND WATER

Relation between surface water and ground water may be explained by describing their roles in the hydrologic cycle a term which pertains to the circulation of water in its different environments. Water falling on the land surface either enters the ground or runs off into streams. A part of the water that enters the ground is evaporated or transpired by plants. Water in excess of these soil requirements percolates downward to zones of saturated rocks and thus reaches ground-water reservoirs or aquifers, as they are sometimes called.

Water in the saturated zone is called ground water which moves from areas of high head to areas of low head. It may be returned to the surface artifically by wells or naturally by seeps and springs.

The surface and ground water relationship in upper drainage basins of the Nueces, San Antonio and Guadalupe Rivers where ground water is stored largely in confined and unconfined limestone reservoirs, is known in substantial detail through scientific hydrologic studies. Headwater reaches of streams comprising these drainage systems rise on the southern and southeastern Edwards plateau in Edwards, Real, Bandera and Kerr Counties and traverse the Balcones fault zone in Uvalde, Medina, Bexar, Hays and Comal Counties. The source of base flows of most of these streams is ground-water discharge at the edge of the Plateau. Prior to cessation of flows of many large springs along the Balcones fault zone a substantial part of stream flow below the fault zone was ground-water discharge. Conflicts have developed between surface and ground-water users in the region of the ground-water reservoirs during the present drought, which in this region of the state began in 1947.

Substantial basic data have been compiled in parts of the Gulf Coastal Plain of East Texas which indicate that ground-water reservoirs are rejecting recharge from streams that flow over their surface exposures. This condition, apparently, is little affected by drouth.

Studies made by the Surface Water Branch of the U. S. Geological Survey in 1952 suggest that an average of about 15 percent of the flow of Texas streams was from ground water. It was noted that the amount varied from 8 percent for the Neches River at Rockland to 88 percent for the Devils River near Del Rio. More information is needed about ground water and its relation to stream flow in most of Texas.

GENERAL ASPECTS OF GROUND WATER OCCURRENCE IN TEXAS

There are eight principal ground-water reservoirs in Texas (see map). These reservoirs are extensive beds of largely stratified sedimentary rocks consisting of sand, sandstone and fractured and cavernous limestone. Two of the reservoirs are unconsolidated deposits of clay, silt, sand and gravel. The eight reservoirs include water-bearing formations of regional extent and importance. There are numerous other water-bearing formations of local extent and importance which are not included on the map.

With the exception of the extensive Ogallala formation, which underlies the surface of the High Plains, these ground-water reservoirs span two or more watersheds, along the trend of their surface outcrop and in their subsurface extent. For example, the Carrizo-Wilcox ground-water reservoir forms an irregular narrow band from the Rio Grande River in Webb County northeastward to the Texas-Arkansas-Louisiana line in Cass, Harrison, Panola and Shelby Counties. The surface exposure of the formations and the downdip extent of usable quality water determine the width of the band. The reservoir is traceable across nine major watersheds of the state.

Red-Sulphur-Cypress Watershed

The principal aquifers in the Red-Sulphur-Cypress watershed consists of the sands of the Trinity group. The Trinity furnishes small to moderate quantities of good quality of water to several municipalities in the watershed. Practically no water is used for industrial or irrigation purposes in this area. In the lower part of the watershed beds of sand and sandstone of the Carrizo-Wilcox furnish water to wells.

Sabine Watershed

The principal water-bearing formations in the Sabine watershed are the sands of the Carrizo-Wilcox group, and the important Gulf Coast aquifers which are the sands of the Lagarto clay, Willis sand and the Lissie formation and the Beaumont clay. The sands of the Carrizo-Wilcox are the principal water producers in the upper part of the watershed and large supplies remain undeveloped in this area. In the lower watershed the sands of the Lissie, Willis and Beaumont are potentially large producers. Comparatively large quantities of water are now being used in Jasper, Newton and Orange Counties, principally for industrial use. The quality of practically all the ground water in the Sabine watershed is good and large supplies remain virtually untapped.

Neches-Angelina Watershed

The principal water-bearing formations in the Neches-Angelina watershed are the sands of the Carrizo-Wilcox group, the sands of the Lagarto clay, the sands of the Goliad-Willis-Lissie group and the sands of the Beaumont clay. Large withdrawals for industrial purposes have been made in northern Angelina County from the Carrizo sand and water levels have been affected in municipal wells at Lufkin and Nacogdoches. There has been very little ground-water development in the lower Neches-Angelina watershed. However, here as in the Sabine watershed large quantities of water could be withdrawn from the Goliad-Lissie-Willis group and the sands of the Beaumont clay. The quality of the water from all of the aquifers in this watershed is good except in the sands in the Beaumont clay in the lower part of the watershed.

Trinity Watershed

The important water-bearing formations in the Trinity watershed are the Trinity and Woodbine sands, the sands of the Carrizo-Wilcox group, the sands in the Lagarto clay and Oakville sandstone, the sands of the Goliad-Willis-Lissie group. Large water supplies have been developed from the Trinity and Woodbine sands in the Dallas and Fort Worth area in Tarrant and Dallas Counties. Here local overdevelopment has occurred. This has resulted in lowering of water levels at least locally in the Dallas and Fort Worth areas and which is a matter of concern to the industry and municipalities in that area. The Carrizo-Wilcox group remains largely undeveloped in the Trinity watershed but large quantities of water could be developed. Comparatively large quantities are being pumped in the lower Trinity basin principally for rice irrigation in Liberty County. However, the supplies have not been depleted and large reserves remain, particularly in the sands of the Goliad-Willis Lissie group.

San Jacinto Watershed

The principal water-producing sands in the San Jacinto watershed are those of the Lagarto clay, Goliad-Willis-Lissie group, and the Beaumont clay. Large quantities of water are being withdrawn in the Houston-Pasadena area principally from the Lagarto clay and the Goliad-Willis-Lissie group. Sands of the Beaumont clay produce large quantities of water for industrial use in the Houston ship channel Baytown-LaPorte area and in Galveston County. The tremendous concentration of industry in the Houston area and the consequant large withdrawals of ground water have caused large declines in water levels in the vicinity of Houston in Harris, Fort Bend and Waller Counties. However, the declines do not represent a depletion of supply but merely a depressuring the aquifers. As a result there has been some land subsidence and local salt-water encroachment. Relatively large quantities of water remain to be developed from the Goliad-Willis-Lissie group in the northern part of the watershed.

Brazos Watershed

The principal water-producing sands in the Brazos watershed are those of the Trinity group, the Carrizo-Wilcox group, Oakville sandstone and Lagarto clay, the Goliad-Willis-Lissie group and the Beaumont clay. The sands of the Trinity group have not been developed extensively in the Brazos watershed and moderate to large quantities of water could be obtained from them in the area roughly between Waco and Palo Pinto County. The sands of the Carrizo-Wilcox are largely untapped in the Brazos watershed and moderate to large quantities of water are available. Large quantities of water are pumped from the Goliad-Willis-Lissie group principally for rice irrigation. However, here again the supplies have not been depleted and large quantites are available for development. Shallow sands of the Beaumont clay produce relatively large quantities of water for industrial use principally in

Brazoria County.

Colorado Watershed

The principal water-bearing formations in the Colorado watershed are the sands of the Trinity group, Edwards limestone, the Carrizo-Wilcox group, the Oakville sandstone and Lagarto clay and sands of the Goliad-Willis-Lissie group. The sands of the Trinity group and the Edwards limestone do not have the potential in the Brazos watershed that they have elsewhere in Texas. However, in the Colorado watershed they are largely untapped and small to moderate quantities of water are available from them. The sands of the Carrizo-Wilcox are here again virtually untapped and are capable of producing large quantities of water. Large supplies of water are being withdrawn from the Goliad-Willis-Lissie group and are being use principally for rice irrigation. However, the supplies have not been depleted and tremendous quantities of water remain untapped in these formations.

Guadalupe-San Antonio Watershed

The principal water-bearing formations in the Guadalupe-San Antonio watershed are the sands of the Trinity group, Edwards and associated limestones, Carrizo-Wilcox group and Catahpula, Oakville-Lagarto group and the Goliad-Willis-Lissie group. The Edwards and associated limestone produces large quantities of good quality water for industrial, municipal and irrigation uses in the heavily pumped San Antonio area. The Carrizo-Wilcox group is virtually untapped in this watershed and here as in adjacent watersheds is capable of producing large quantities of water. The sands of Goliad-Willis-Lissie group produce large quantities of water for rice irrigation and industrial use in the southeastern part of the watershed. However, additional moderate to large quantities of water are available from these sands throughout the watershed.

Nueces Watershed

The principal aquifer of the Nueces watershed consists of the sands of the Trinity group, the Edwards and associated limestone, the Carrizo-Wilcox group, the Oakville sandstone and Lagarto clay, the Goliad-Willis-Lissie group. The Edwards limestone produces large quantities of good quality water for municipal and irrigation uses principally in Medina and Uvalde Counties. The Carrizo-Wilcox has produced large quantities of water for many years for irrigation in the Winter Garden District in Zavala and Dimmit Counties. The concentration of wells and consequent large withdrawals of water have caused excessive declines of water levels and local overdevelopment of the Carrizo-Wilcox. The sands of the Oakville sandstone and Lagarto clay are largely undeveloped in the Nueces watershed. Samll yields can be expected from wells tapping them. The greatest potential for ground-water development in the lower Nueces watershed lies in the sands of the Goliad-Willis-Lissie group. However, these sands are not nearly as prolific in this part of Texas as they are in the upper Gulf Coast area and only moderate supplies of water should be expected from them.

Coastal Watersheds

The principal water-producing formations in the Coastal watersheds are the sands of Goliad-Willis-Lissie group and of the Beaumont clay. The sands of the Goliad-Willis-Lissie group produce large quantities of water for rice irrigation principally in Wharton and Jackson Counties. However, the supplies have not been depleted and large quantities of water still remains to be used in the southern part of the watershed. Sands of the Goliad-Willis-Lissie group are not as productive and much smaller quantities of water are developed. Large quantities of water from the basal sands of the Beaumont are used for municipal and industrial purposes in Galveston and Brazoria Counties. However, large declines in water levels have resulted in land subsidence and salt-water encroachment in the Texas City area in the southern part of the watershed. The sands are less productive and only small quantities of water should be expected from a single formation such as the Beaumont clay.

Rio Grande Watershed

The principal aquifer of the Rio Grande watershed consists of sands and gravel in alluvial and bolson deposits in the lower Rio Grande Valley. Large quantities of water are contained in the sands and gravels in the alluvial deposits. The water is in many places of poor chemical quality and is unsuitable for long time irrigation of some soil types and crops. Only small to moderate quantities of water of good quality are available from the alluvial deposits in the El Paso area. Large quantities of water of good chemical quality are being pumped from sands and gravels of the bolson deposits for municipal and military uses. Large quantities of water are pumped for irrigation from the alluvial deposits in the Rio Grande Valley itself in the El Paso area. However, most of the water in the alluvium is of poor chemical quality.

Pecos-Devils Watershed

The principal aquifer in the Pecos-Devils watershed consists of sands and gravels in the Recent river and Older alluvium, derived mountain outwash and the Edwards limestone. Much of the water from the alluvium is highly mineralized. However, under favorable soil conditions the water has been used with varying degrees of success for many years for irrigation. The water in the Edwards limestone is of good chemical quality. However, only locally should large yields be expected from wells.

Non-Contributing Watershed

The principal water-producing formations in the Non-Contributing watershed are the sands and gravels of the Bolson deposits and the Bone Spring limestone of Permian age. The Bolson deposits produce large quantities of good quality water in the Lobo Flats and Wild Horse Draw areas. The amount of ground water pumped in this closed basin of Hudspeth, Culberson, Jeff Davis and Presidio Counties cannot be estimated from available data. It is known that irrigated agriculture is the principal user and the area of heaviest withdrawal is near Dell City in northeast Hudspeth County.

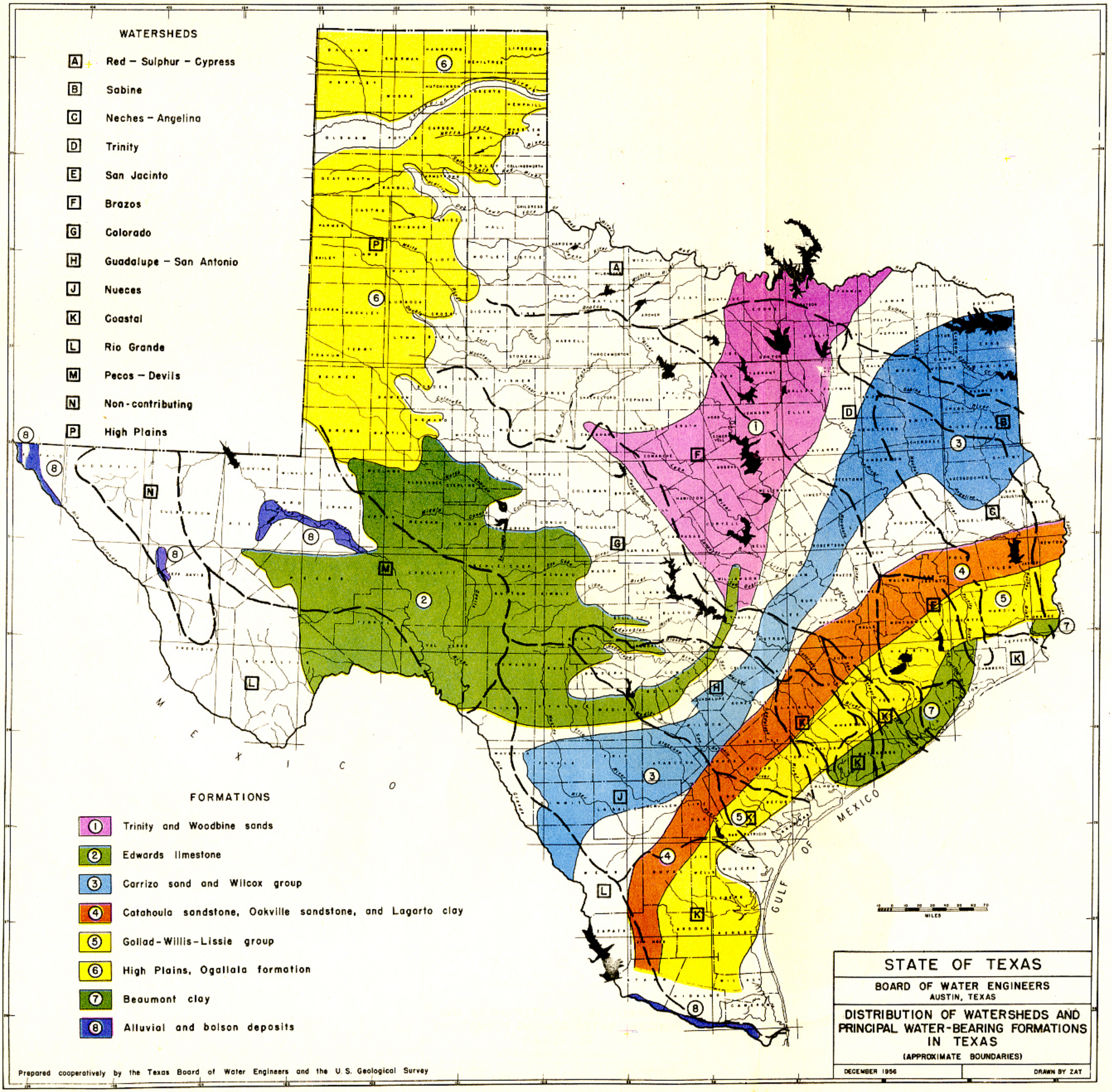
The High Plains

Most of the usable ground water in the High Plains watershed is found in the sands and gravels of the Ogallala formation. The Ogallala formation produces large quantities of good quality water for irrigation throughout much of the High Plains. The heavy pumpage of ground water in the High Plains is largely a mining operation as much more water is being pumped than is being recharged by precipitation on the Plains. As a result of the large withdrawals of water for irrigation in the High Plains water levels have decelined generally and in some places the declines have been great enough so that the yields of wells have been substantially decreased.

Table 1.- Estimated Ground Water Use in Watersheds of Texas in 1955

Watersheds				Annual Ground Water Use					
River Basins	Area Considered (sq. mi.-approx.)	Number of Towns Considered	Population Considered	Rural (Domestic and stock) (acre feet)	Irrigation (acre feet)	Industry (acre feet)	Muncipal (acre feet)	Total use exclusive of Rural	Percent of total use exclusive of Rural
Red-Sulfur Cypress	24,400	62	222,000		91,400	11,200	27,800	130,400	1.80
Sabine	2,500	24	110,200		4,900	22,400	14,800	42,100	0.58
Neches-Angelina	9,200	28	140,300		13,100	67,200	12,800	93,100	1.29
Trinity	17,700	78	847,200		31,000	78,400	42,200	151,600	2.10
San Jacinto	2,900	19	866,000		120,300	134,400 a/	106,000	360,700	4.99
Brazos	35,400	100	237,600		121,300	22,400	28,600	172,300	2.39
Colorado	29,900	39	85,200		124,900	22,400	11,400	158,700	2.20
Guadalupe-San Antonio	10,300	32	613,300	280,000	39,600	39,200 b/	82,600	161,400	2.23
Nueces	16,900	25	238,600		297,300	11,200	16,600	325,100	4.50
Coastal	10,500	54	288,000		124,500	11,200	38,700	174,400	2.41
Pecos-Devils	19,900	15	54,700		645,900	16,800	7,400	670,100	9.28
High Plains c/	35,000	77	569,900		4,325,300	78,400	74,800	4,478,500	62.08
Rio Grande	20,700	12	722,700		269,900	5,600	24,500	300,000	4.15
Total	235,300	565	4,995,700	280,000	6,209,400	520,800	488,200	7,218,400	100.00
							Rural	280,000	
							Grand Total	7,498,400	

a/ Principally Houston industrial area
b/ Principally San Antonio industrial area
c/ Includes Canadian River Valley in Texas


WATERSHEDS
A Red – Sulphur – Cypress
B Sabine
C Neches – Angelina
D Trinity
E San Jacinto
F Brazos
G Colorado
H Guadalupe – San Antonio
J Nueces
K Coastal
L Rio Grande
M Pecos – Devils
N Non-contributing
P High Plains
FORMATIONS
1 Trinity and Woodbine sands
2 Edwards limestone
3 Carrizo sand and Wilcox group
4 Catahoula sandstone, Oakville sandstone, and Lagarto clay
5 Goliad-Willis-Lissie group
6 High Plains, Ogallala formation
7 Beaumont clay
8 Alluvial and bolson deposits
MEXICO
GULF OF MEXICO
MILES
STATE OF TEXAS
BOARD OF WATER ENGINEERS
AUSTIN, TEXAS
DISTRIBUTION OF WATERSHEDS AND PRINCIPAL WATER-BEARING FORMATIONS IN TEXAS
(APPROXIMATE BOUNDARIES)
DECEMBER 1956
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