Reevaluation of State's Ground-Water Resources Completed

By R. D. Price, D. A. Muller
and W. B. Klemt
Geologists,
TWDB Water Availability Division

Comprehensive water planning in the State of Texas provides a means for meeting future ground-water needs through sound management. The Texas Water Plan, released in November, 1968, states, "the objective of such management is the operation of underground resources by carefully calculated procedures: to produce water at minimum cost; to protect the useability of the aquifer; to extend the life of a ground-water basin or to maintain water quality at a desirable level." Effective ground-water management is dependent upon up-to-date quantitative information such as sustainable yields and recharge potentials of the aquifers. Texas is fortunate in that more than 50 percent of its total surface area is underlain by either major or minor ground-water aquifers.

The development of ground water from these aquifers has progressed rapidly during the past half century, with the drought of the 1950's causing a tremendous increase in ground-water use. Although more than 1,000 municipalities and numerous industries use large quantities of ground water, the greatest use in Texas has been in agriculture for irrigating important crops such as grain sorghum, cotton, wheat, forage crops, rice, hay and pasture acreage, vegetables, corn oil crops other than cotton, orchards, and nut crops. With such demands placed upon ground-water use, it is imperative that the best data available be periodically gathered and properly employed.

As additional data from new investigations become available, it is necessary to incorporate this information into the ground-water availability estimates. To accomplish this, a re-evaluation of the ground-water availability data as presented in the Texas Water Plan has been recently completed by the Board's Water Availability Division. This work is fundamental to successful comprehensive long-range planning. The study revealed that approximately 4,295,700 acre-feet of ground water is available annually from the major and minor aquifers of the State as sustainable annual yield. The results of this evaluation in terms of ground-water availability are summarized by aquifer and river basin in Tables 1 and 2. Figures 1 and 2 show the location of the aquifers evaluated.

Because all aquifers in the State are heterogeneous and anisotropic to varying degrees, the quality of water in these aquifers commonly varies locally as well as on a regional basis. In many cases, water quality constitutes a major constraint on development and utilization of the ground water. Even though water within a particular aquifer, or portion thereof, may have a relatively low total dissolved solids content, it may contain certain chemical constituents which render it unsuitable for a specific use or uses (municipal, industrial, agricultural, etc.). Water having a favorable total dissolved solids content could have a high iron content or high silica content and therefore could be unsuitable for domestic and/or industrial use without extensive and costly pretreatment. Water having a favorable total dissolved solids content could have a high sulfate content, thus limiting its use for municipal and domestic use and possibly also for livestock-watering purposes. Likewise, water having a favorable total dissolved solids content could have a high boron content and thus be harmful to certain irrigated crops. Generally, only ground water containing less than 3,000 milligrams per liter (mg/l) total dissolved solids was included in the current re-evaluation. Exceptions to this were made for the Blaine, Santa Rosa, and Rustler aquifers, where moderately saline waters containing 3,000 to 10,000 mg/l

TABLE 1.—SUMMARY OF ESTIMATES OF AVAILABILITY OF GROUND WATER IN TEXAS BY AQUIFER

Aquifer	Figures Used in Development of 1968 Texas Water Plan Estimated Ground-Water Annual Yield, ac.-ft.	Revised Ground-Water Availability Estimated Annual Yield, ac.-ft.
MAJOR		
Ogallala	—	298,000
Carrizo-Wilcox	576,500	602,400
Edwards (Balcones Fault Zone)	413,700	399,700[1]
Trinity Group	70,200	96,200
Alluvium and Bolson Deposits	312,800	398,200
Gulf Coast	2,361,000	1,143,400[2]
Edwards-Trinity (Plateau)	658,000	784,100
MINOR		
Woodbine	25,100	25,100
Queen City	28,000	51,500
Sparta	92,000	152,000
Edwards-Trinity (High Plains)[3]	—	—
Santa Rosa	33,400	23,500
Hickory Sandstone	45,000	52,600
Ellenburger-San Saba	25,000	29,400
Marble Falls Limestone	—	26,400
Blaine Gypsum	40,000	142,600
Igneous Rocks	8,000	10,700
Marathon Limestone	30,000	18,300
Bone Spring and Victorio Peak Limestones	50,000	17,000
Capitan Limestone	—	5,000
Rustler	5,000	14,000
Nacatoch Sand	—[4]	900
Blossom Sand	—[4]	1,300
Purgatoire-Dakota[3]	—	—
Other Undifferentiated	5,600	3,400
GRAND TOTALS	4,779,300	4,295,700

[1] The 1974 estimate provides for spring flow at Comal and San Marcos Springs.
[2] The 1974 estimate provides for minimum subsidence.
[3] Included with Ogallala aquifer.
[4] 1968 data included this aquifer under the heading of Other Undifferentiated.

were included because these waters are currently being used locally for irrigation and livestock-watering purposes.

Sustainable annual yield, for the purpose of this re-evaluation, is defined as the amount of ground water which can be safely withdrawn perennially throughout the extent of the aquifer without reducing the amount of water in storage. The sustainable annual yield, in effect, equals the effective recharge of the aquifer. A single well, or a well field, cannot recover the total sustainable annual yield of any particular aquifer. As previously stated, all aquifers in the State are to varying degrees heterogeneous and anisotropic. Therefore, the productivity of wells can range widely within localized areas as well as on a regional basis.

The procedural steps used to appraise the available ground water from an aquifer included a review of pertinent publications and then selection of an evaluation method, or combination of methods, for each aquifer. Methods selected for determining sustainable annual yield included: (a) surface

TABLE 2.—SUMMARY OF ESTIMATES OF AVAILABILITY OF GROUND WATER IN TEXAS BY BASIN

Basin	Figures Used in Development of 1968 Texas Water Plan Estimated Ground-Water Annual Yield, ac.-ft.	Revised Ground-Water Availability Estimated Annual Yield, ac.-ft.
Canadian	–	91,000
Red	123,600	348,000
Sulphur	5,700	5,700
Cypress	15,000	15,000
Sabine	319,000	98,000
Neches	560,000	311,000
Trinity	326,600	238,000
San Jacinto	500,000	295,000
Brazos	425,200	476,000
Colorado	538,700	562,000
Lavaca	200,000	86,000
Guadalupe	160,300	144,000
San Antonio	343,500	322,000
Nueces	167,700	208,000
Rio Grande	604,000	695,000
Neches-Trinity	1,000	14,000
Trinity-San Jacinto	50,000	36,000
San Jacinto-Brazos	80,000	82,000
Brazos-Colorado	125,000	68,000
Colorado-Lavaca	75,000	8,000
Lavaca-Guadalupe	75,000	48,000
San Antonio-Nueces	30,000	30,000
Nueces-Rio Grande	54,000	115,000
GRAND TOTALS ALL BASINS	4,779,300	4,295,700

water-budget studies to determine inflows and outflows, by which recharge is computed on the basis of historical streamflow records; (b) low-flow studies to determine aquifer recharge and evapotranspiration losses; (c) flow-net analyses to determine recharge rates; (d) base-flow and spring-flow measurements to determine rejected recharge, by which rejected recharge is approximately equal to effective recharge; (e) the U.S. Study Commission or "trough" method, which uses theoretical lines of recharge and discharge with maximum pumping lifts of 400 feet to determine the yield of artesian aquifers by increasing natural recharge at the outcrop as a result of increased hydraulic gradients; (f) water-budget studies of losses from surface reservoirs in order to estimate seepage losses; (g) computer model methods; (h) determination of the amount of water moving through the aquifer under existing hydraulic gradients; (i) use of a percentage of annual precipitation on aquifer outcrop areas as recharge; and (j) comparison of pumpage records and water-level trends.

The above-described ground-water availability analyses *also* included the assumption that the water developer will use proper methods and procedures to locate, space, construct, and complete his well or wells to minimize potential ground-water quality degradation, borehole leakage, and maximize the life of the well. In addition, constraints were included in certain evaluations in order that hazards, such as saline water encroachment into aquifers and land-surface subsidence, would be minimized.

Water recoverable from storage is that part of the underground reservoir storage capacity estimated to be capable of being dewatered during periods of insufficient recharge. It is impossible to completely dewater an aquifer because of physical and economic limits inherent in large-capacity well operations; that is, as water levels decline, well yields will decrease resulting in a lowering of well efficiency and less water being taken from storage. Ultimately, if still within the realm of economic reality, yields will decrease until they are in equilibrium with recharge.

With all of the above-cited factors considered, the current statewide re-evaluation resulted in a net decrease in

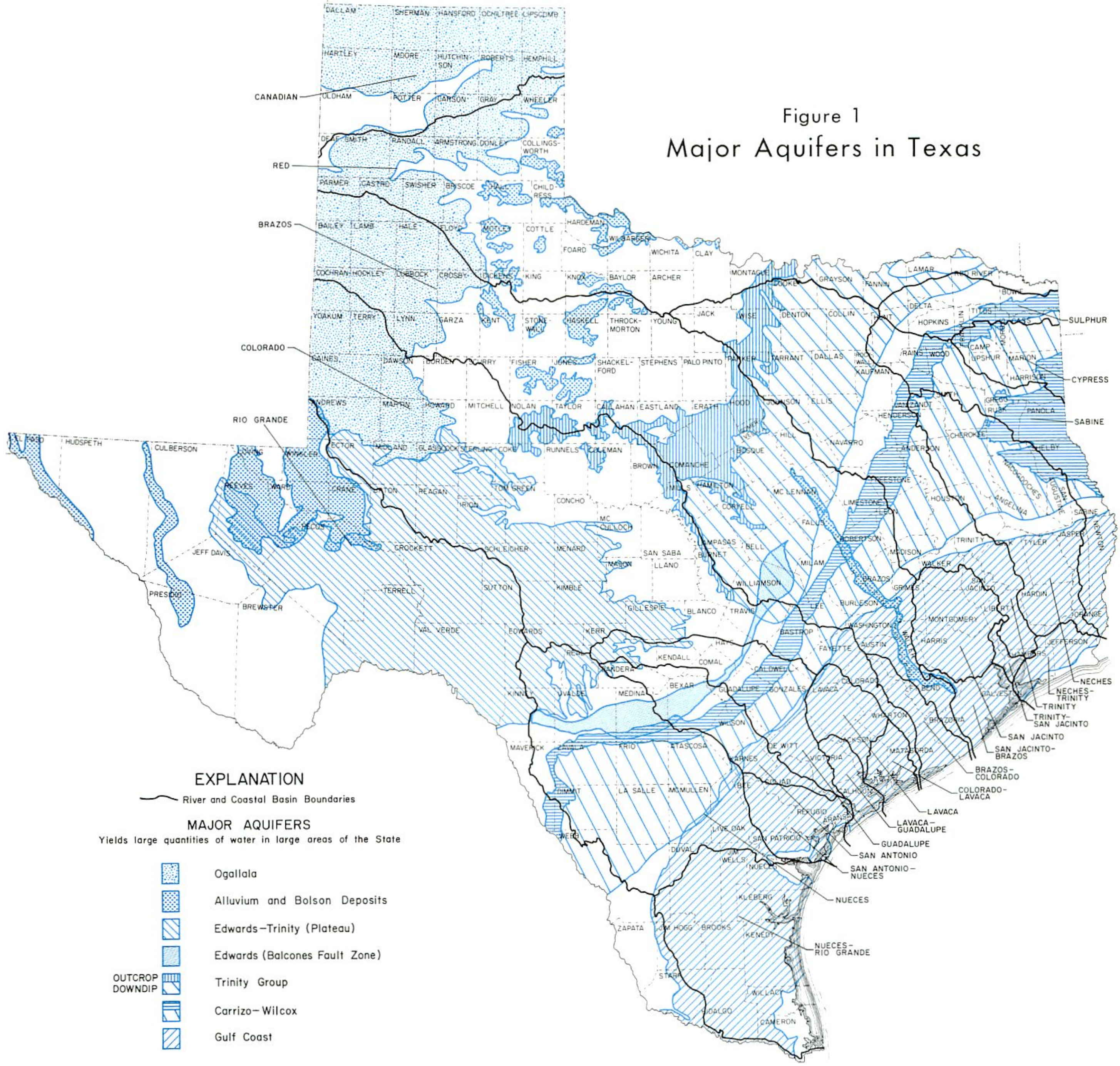

Figure 1
Major Aquifers in Texas

perennial yield of 483,600 acre-feet (10 percent) from the estimates used in development of the Texas Water Plan. This decrease results primarily from re-analysis of the Gulf Coast aquifer where approximately 1,217,600 acre-feet less ground water is now estimated to be perennially available than is indicated in the Texas Water Plan. Allowance for minimum land-surface subsidence, by assuming less drawdown of the potentiometric surface (water table), and the control of pumpage to alleviate saline water encroachment within the Gulf Coast aquifer reduced previous estimates. Conversely, the Ogallala aquifer shows the largest increase in estimated annual yield of 298,000 acre-feet annually. In previous estimates, effective recharge had not been determined and therefore was not included in data presented in the Texas Water Plan. Any additional ground water developed from the Ogallala must come from the recoverable storage.

As part of a continuing program for refinement of ground-water availability data, the Board has a number of investigations in progress. Among those being done by the Water Availability Division are: (1) Evaluation of the sustained annual yield of the Gulf Coast aquifer continues through analyses of alternative methods of computing hydrostatic head decline, (2) Individual "well field" computer models are being

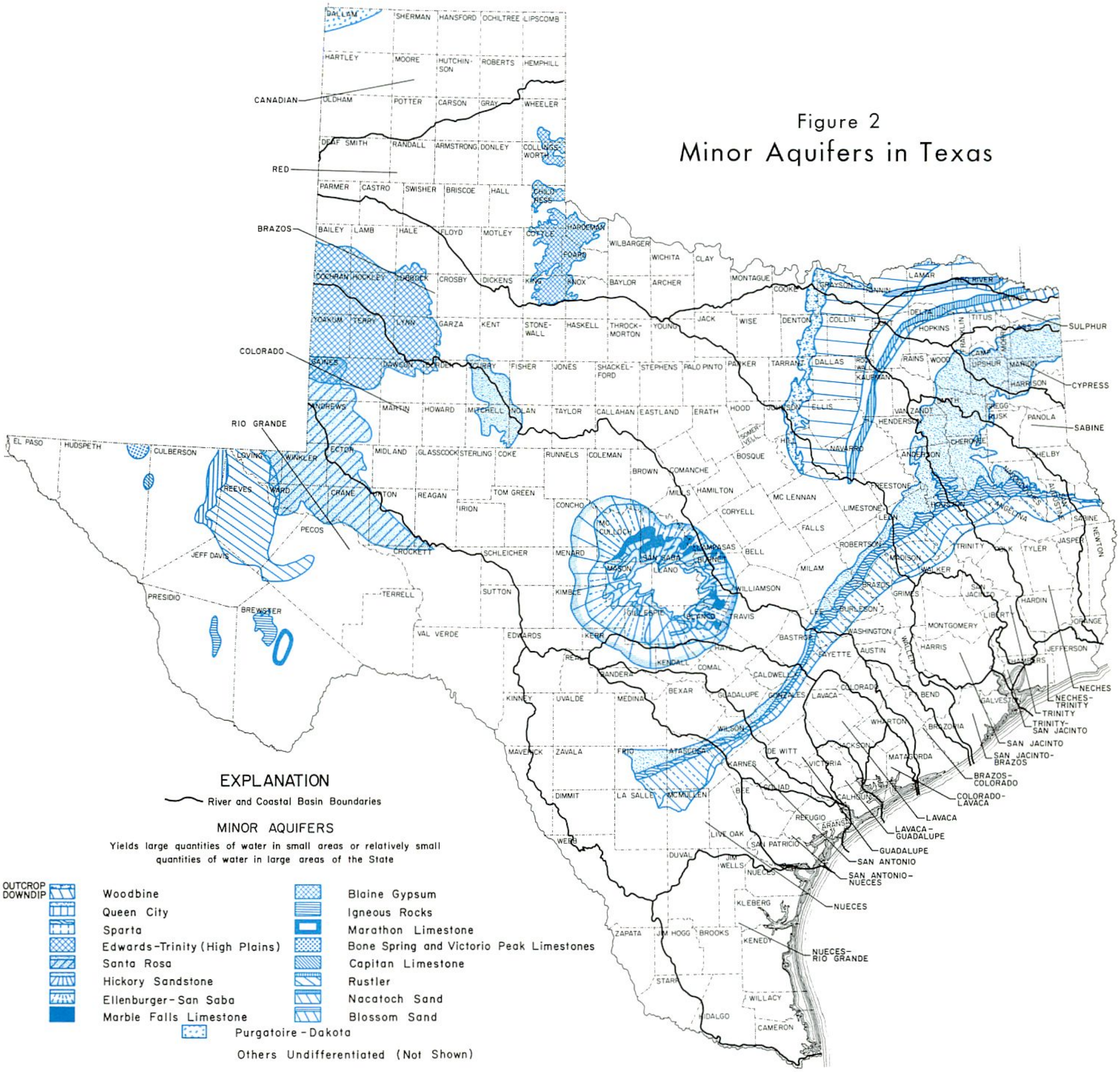

Figure 2
Minor Aquifers in Texas

utilized to evaluate the ground-water supplies of various municipalities and industries throughout the State, and (3) The "West Central Texas Municipal and Industrial Water Demands Project." The principal objectives of this study are the delineation and description of all ground-water resources within this area of Texas in terms of quantity, quality, and yield characteristics of the various aquifers.

Refinement of the estimates of the dependable yields of Texas aquifers is a continuing process. As additional data become available and appropriate modeling techniques are applied to these aquifers, new and more accurate and complete estimates result.