DEEP TROUBLE: OPTIONS FOR MANAGING THE HIDDEN THREAT OF AQUIFER DEPLETION IN TEXAS

by Ronald Kaiser and Frank F. Skiller***

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* Professor, Texas A&M University, Institute of Renewable Natural Resources, Assoc. Director, Texas Water Resources Institute, B.S., Michigan State University, 1970; M.S. 1972; J.D. Thomas Cooley, 1976; LL.M University of California@Berkeley, 1988

Ronald Kaiser can be reached by mail at Campus 2261, College Station, Texas 77843-2261 or by e-mail at Rkaiser@tamu.edu.

Support for this research provided by the Texas A&M University System, Texas Agricultural Experiment Station, Texas Tech University System, and the Texas Tech University School of Law.

** George W. McCleskey Professor of Water Law, Texas Tech University School of Law. A.B., University of Chicago, 1964; J.D., University of Denver, 1966; LL.M., University of Michigan, 1969.

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I. INTRODUCTION

Groundwater is an important water source for Texas and its allocation and management is generating significant legal and political debate. Aquifers underlie most of Texas and provide about sixty percent of the state's total water supply.[1] Agricultural irrigation consumes about eighty percent of all the groundwater pumped annually in Texas.[2] The remaining twenty percent of groundwater pumped is consumed in municipal and manufacturing use. With the exceptions of San Antonio and El Paso, most major cities in Texas use a combination of surface and groundwater to meet their water needs.[3]

A combination of natural and man-made conditions, including Texas's recurring droughts, urban growth, aquifer overdrafting and mining, land subsidence, and endangered species have focused attention on the allocation and management of the state's groundwater supplies.[4] The legal and political

1. Water use figures are available in Texas water plans. For two recent iterations, see WATER FOR TEXAS 3-14 (Aug. 1997) thereinafter WATER FOR TEXAS 19971 and WATER FOR TEXAS: TODAY AND TOMORROW 3-1 to 3-6 (Tex. Water Dev. Bd. Dec. 1990) [hereinafter WATER FOR TEXAS 1990].

2. WATER FOR TEXAS 1997, *supra* note 1,at 3-16.

3. Groundwater supplies 100 percent of San Antonio's water and sixty-three percent of El Paso's water. *See* MARY SANGER & CYRUS REED, TEXAS ENVIRONMENTAL ALMANAC 10 (Tex. Ctr. for Policy Studies 2d ed. 2000) (citing SUMMARY HISTORICAL WATER USE 1995 (Tex. Water Dev. Bd. 1997)).

4. *See* WATER FOR TEXAS 1990, *supra* note 1, at 3-4; *see also* WATER FOR TEXAS 1997, *supra* note 1, at 3-3 (reporting current water supply conditions and predicting future water needs for Texas). Municipal water needs are projected to double in the next fitly years. WATER FOR TEXAS 1997, *supra* note 1, at 3-5. For a discussion on the role of droughts in stimulating legislative concerns see J. E. Buster Brown, *Senate Bill 1: We 've Never Changed Texas Water Law This Way Before*, 28 ST. B. TEX. ENVTL. L.J. 152 (1998). The Houston-Galveston Subsidence District was created to manage groundwater extractions to prevent land subsidence. The Edwards Aquifer Authority was created to manage groundwater in protection of threatened and endangered species that live in springs flowing from the aquifer. *See generally* Eric Albritton, *The Endangered Species Act: The Fountain Darter Teaches What the Snail Darter Failed to Teach*, 21 ECOLOGY L.Q. 1007, 1018 (1994) (illustrating the plight of five endangered species in the Edwards Aquifer); Ronald Kaiser & Laura Phillips, *Dividing the Waters: Water*

issues surrounding groundwater allocation and management intersect and clash with a long-held Texas tradition of treating groundwater as an unregulated private property right. The notion of private property rights in groundwater is so entrenched in both landowner and legislative psyche that any attempt to regulate the pumping of groundwater provokes significant political and legal opposition.[5] The management debate is being reopened by a combination of conditions including a scarcity of surface water supplies, aquifer overdrafting occurring simultaneously with increased urban population growth, and the thirst of cities for additional water supplies.

Providing an adequate water supply to growing cities and to an economy driven by high technology and tourism presents a daunting challenge to water planners and policy makers when supplies are limited.[6] In order to provide an adequate and reliable water supply, a number of cities are developing groundwater resources in rural areas. Agriculture and rural areas perceive this as a threat to growth.[7] The Texas Water Development Board predicts that, over the next fifty years, agricultural use of groundwater will experience a dramatic decline because of aquifer depletion and rising energy costs. At the same time, municipal share of groundwater use will double.[8]

Despite the importance of groundwater to the state's economy and the widespread mining and overdrafting of aquifers, state regulation of groundwater has been minimal, especially when compared to surface water management.[9] The laissez-faire capture rule adopted by the Texas Supreme Court and followed by the Texas Legislature minimized political conflicts over governmental management and control of groundwater pumping, but it left Texas aquifers subject to uncontrolled and harmful pumping.[10] The

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Marketing as a Conflict Resolution Strategy in the Edwards Aquifer Region, 38 NAT. RESOURCES J. 411, 423 (1998) (describing the creation of the Edwards Aquifer Authority in response to a federal lawsuit filed by the Sierra Club).

5. *See* Karen H. Norris, Comment, *The Stagnation of Texas Ground Water Law: A Political and Environmental Stalemate,* 22 ST. MARY'S L.J. 493,494(1990) ("Texas landowners. . . have successfully avoided any legislative or judicial action intended to limit ground water pumpage."); Stephen E. Snyder, Comment, *Ground Water Management: A Proposal for Texas,* 51 TEX. L. REV. 289,317(1973) ("Politica1 opposition from ground water users will probably remain the most formidable obstacle to adopting an effective ground water conservation program.").

6. According to data from the Texas Natural Resources Conservation Commission (TNRCC), twelve of the fifteen major river basins are fully appropriated. *See* TEXAS NATURAL RESOURCES CONSERVATION COMMISSION, A REGULATORY GUIDANCE DOCUMENT FOR APPLICATION TO DIVERT, STORE OR USE STATE WATER 26, tbl.8 *(1995); see generally* WATER FOR TEXAS 1997, *supra* note 1, at 3-2 (providing a general overall picture of current and anticipated future conditions associated with Texas's water resources).

7. *See* John Leidner et al., *Water Rights, Water Wars,* PROGRESSIVE FARMER, Aug. 2000, at 26-28.

8. WATER FOR TEXAS 1997, supra note 1, at 3-15.

9. Surface waters are owned and managed by the state. TEX. WATER CODE ANN. § 11.021 (Vernon 2000).

10. Under the capture rule, pumping is unregulated and landowners are allowed to withdraw as much groundwater from beneath their land as they can capture. In the exercise of this right there is no

capture rule is a limited private property protection rule, but more importantly, it directly contributes to increasing conflicts over well interference without offering protection for the small domestic well owner.[11] Although the rule has been widely criticized, the Texas Supreme Court has deferred to the legislature to develop rules for groundwater protection.[12]

In contrast to the unified regulatory system for surface water, the Texas Legislature has followed a decentralized approach to groundwater regulation and has deferred management to local groundwater management districts.[13] Generally, the local groundwater management districts are organized around political boundaries and do not encompass aquifer boundaries. Advocates of this approach suggest that regulatory tools are in place within districts to effectively manage groundwater resources.[14] The legislature has demonstrated its preference for this approach by authorizing the creation of a number of districts.[15] Critics suggest that problems of self interest, limited funding, local

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liability absent malice, waste, or subsidence. *See* Sipriano v. Great Springs Water of Am., Inc., 1 S.W.3d 75, 79 (Tex. 1999); City of Sherman v. Pub. Util. Comm'n, 643 S.W.2d 681, 686 (Tex. 1983); Friendswood Dev. Co. v. Smith-Southwest Indus., Inc., 576 S.W.2d 21, 25-30 (rex. 1978); City of Corpus Christi v. City of Pleasanton, 154 Tex. 289,294,276 S.W.2d 798, 801 (1955); Houston & Tex. Cent Ry. Co. v. East, 98 Tex. 146, 148, 81 S.W. 279, 280 (1904).

11. The often-unappreciated side effect of the capture rule is that current well owners are not protected from excessive pumping by other landowners. *See Sipriano,* I S.W.3d at 79; Pecos County Water Control and Improvement Dist. No. 1 v. Williams, 271 S.W.2d 503, 505 (Tex. Civ. App.—EI Paso 1954, writ ref'd n.r.c.).

12. *See Sipriano,* 1 S.W.3d at 80; Barshop v. Medina County Underground Water Conservation Dist., 925 S.W.2d 618, 619 (Tex. 1996); *see, e.g.,* Norris, *supra* note *5,* at 494; Lana Shadwick, Note, *Obsolescence, Environmental Endangerment, and Possible Federal Intervention Compel Reformation of Texas Groundwater Law,* 32 S. TEX. L. REV. 641, 665 (1991); *see also* Eric Behrens & Matthew Dore, *Rights of Landowners to Percolating Groundwater in Texas,* 32 5. TEX. L. REV. 185, 191 (1991) (commenting on the Texas Supreme Court's and Texas Legislature's refusal to change the rule); Joe Greenhill & Thomas Gee, *Ownership of Ground Water in Texas; The East Case Reconsidered,* 33 Tex. L. REV. 620, 629 (1955) (urging Texas courts and Texas Legislature to adopt rule prohibiting malicious waste of water); Corwin W. Johnson, *The Continuing Void, in Texas Groundwater Law: Are Concepts and Terminology to Blame?,* 17 ST. MARY'S L.J. 1281, 1293 (1986) (addressing the absence of a legislative declaration of state ownership of groundwater) [hereinafter Johnson, *The Continuing Voids in Texas Groundwater Law];* Corwin W. Johnson, *Texas Groundwater Law: A Survey and Some Proposals,* 22 NAT. RESOURCES. J. 1017, 1024 (1982) (discussing wastefulness of absolute ownership of percolating groundwater) [hereinafter Johnson, *Texas Groundwater Law];* Jana Kinkade, *Compromise and Groundwater Conservation,* 26 ST. B. Tex. ENVTL. L.J. 230, 233 (1996) ("Not only has the Texas Legislature been slow to act, but the Texas courts have impeded the progress of Texas groundwater law."); David Todd, *Common Resources, Private Rights and Liabilities: A Case Study on Texas Groundwater Law,* 32 NAT. RESOURCES. J. 233, 256(1992) (criticizing the law of Texas groundwater management).

13. In 1949, under authority of the conservation amendment of the Texas Constitution, Tex. CONST. art. XVI, § 59, the legislature provided for the creation of Underground Water Conservation Districts. Act of June 2, 1949, 51st Leg., R.S., ch. 306, § 1, 1949 Tex. Gen. Laws *559, repealed by* Act of June 16, 1995,74th Leg., ch. 933, § 6, 1995 Tex. Gen. Laws 4673, 4701.

14. A recent opinion limits the regulatory powers of groundwater conservation districts. S. Plains Lamesa R.R., Ltd. v. High Plains Underground Water Conservation Dist. No. l, No. 07-00-089-CV, 2001 WL 62272 (Tex. App—Amarillo Jan. 25, 2001, no pet. h.).

15. *See, e.g.,* 45 JEFF CIVINS ETAL., TEXAS PRACTICE: ENVIRONMENTAL LAW § 13.2(e) (2000) ("Regulatory authorities of an UWCD are extremely broad The UWCD's charge to prevent waste

politics, and the self-limiting nature of these districts prevent meaningful management and protection of groundwater resources.[16] Concerns have been raised regarding the number of districts needed, the motivations for creating additional districts, and whether district boundaries should more closely correspond with aquifer boundaries rather than political boundaries. Notwithstanding the fact that excessive groundwater withdrawals are a statewide problem, the legislative sentiment remains strong that groundwater should be managed locally, if at all.[17]

This article suggests that while much of the recent groundwater law debate has focused on protecting private property rights, creating additional local groundwater districts, or stopping cities from pumping groundwater from rural areas, these are not the core issues. While they are important and must be considered in any solution, they do not address the underlying problem or lead to sustainable solutions that will protect groundwater quantity and quality. The core groundwater management issues that must be addressed are: (1) how to resolve the conflicts over domestic well interference caused by high capacity wells; (2) how to prevent aquifer overdrafting and promote safe, sustainable aquifer yields; and (3) how to address aquifer mining. When examined in this context, the issues shift from protecting private property rights in groundwater to effectively managing aquifers and groundwater in

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gives it far-reaching authority under its rule making power.').

16. From the very beginning, criticisms over the localized control and limited authority of districts were well known to the Texas legislature. ***See*** Johnson, ***Texas Groundwater Law, supra*** note 12, at 1020 ("The Edwards Underground Water District... is broadly authorized to 'conserve, protect and increase the recharge of and prevent. . . waste and pollution of. . . underground water,' but regulatory powers needed to implement those goals have not been conferred.... The main function of this district appears to be data collection and dissemination."); Johnson, ***The Continuing Voids in Texas Groundwater Law, supra*** note 12, at 1282 ("[T]he legislature has passed the buck to local communities.... The response has been uneven and generally inadequate.*); Kaiser & Phillips, ***supra*** note 4, at 422-23 ("In one sense, underground water districts are planning giants and regulatory dwarfs. They have extensive power to study, report, disseminate and plan but they are limited in their ability to disturb the capture rule."); Norris, ***supra*** note 12, at 501 ("The Texas legislature purports to distribute considerable power and authority to local groundwater conservation districts; however, several factors combine to limit their effectiveness.'); Shadwick, ***supra*** note 12, at 677 ("In sum, funding and management of UWCDs illustrates how greed may manifest itself through the vehicle of local politics.... Admittedly, UWCDs truly epitomize the state's desire to defer regulation to local areas, but the result is perhaps not what the legislature intended.'); Steven E. Snyder, Comment, ***Ground Water Management: A Proposal for Texas,*** 51 TEX. L. REV. 289, 298 (1973) (explaining that "[d]espite the gaping holes in the UWCD's management powers, ... the most serious barrier to effective action is its dependence on local politics' because '[t]he district cannot be effective unless local residents, acting through popularly elected directors, are willing to impose management controls on their own pumping activities,' even though [n]one of the existing UWCDs have overcome this barrier and none have imposed production quotas.'); Edward Woodruff & James Williams, Comment, *The Texas Groundwater District Act of 1949: Analysis and Criticism,* 30 TEX. L. REV. 862, 866(1952) ('This act falls far short of being a complete independent groundwater code... . [I]t is merely a short appendage to the lengthy chapter on Water Control and Improvement Districts.").

17. Senate Bill 1 clarifies that it is the policy of the state that groundwater management is best accomplished through local groundwater districts, thus modifications on the rule of capture will be made by districts. TEX. WATER CODE ANN. § 36.0015 (Vernon 2000).

order to sustain an agricultural economy that is transitioning to an urban service economy.

Part II of the article introduces several hydrological concepts related to these issues. Part III summarizes state laws on groundwater allocation and management and their application in selected states. Part IV offers options for addressing Texas domestic well interference conflicts, and aquifer overdrafting and mining problems. This article does not advocate abolishing the rule of capture, nor does it suggest how groundwater districts should be organized and structured. It does, however, present options for managing groundwater resources within the capture rule and groundwater district arrangement.

II. GROUNDWATER CONCEPTS AND DATA

This section briefly outlines basic hydrological concepts applicable to well interference, aquifer overdrafting and mining problems, and it provides information on Texas surface water and groundwater uses.[18] This contextual information is an important predicate to examining options for groundwater management.

A. Basic Concepts

Groundwater is hydrologically divided into: (1) vadose water in the unsaturated zone, and (2) water in the zone of saturation.[19] in the unsaturated zone, the spaces in the soil or rock contain both air and water, creating high capillary forces. These capillary forces are so strong that water in the unsaturated zone is generally not available for pumping.[20] In contrast, the spaces in the saturated zone are completely filled with water and water will flow freely into wells and springs. The upper surface of the saturated zone is referred to as the top of the water table.[21]

Aquifers are geological formations that can store, transmit, and yield a quantity of water to a well or spring. There are two basic types of aquifers:

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18. Hydrology is concerned with the properties, occurrence, distribution and movement of water on and beneath the surface of the land. Groundwater hydrology is concerned with the movement of subsurface water caused by a difference in potential or head. RAPHAEL G. KAZMANN, MODERN HYDROLOGY I (Carey Croneis ed., 1965).

19. Hydrologist often use the term "vadose" to describe water in the unsaturated zone; however, the United States Geological Survey (USGS) no longer uses that term. The USGS classifies groundwater in either the unsaturated or the saturated zone. ***See*** U.S. GEOLOGICAL SURVEY CIRCULAR 1186, *Sustainability of Ground-Water Resources* 6-14(1999) [hereinafter USGS CIRCULAR 1186].

20. *Id.* at 7.

21. *Id.; see also* Mary P. Anderson, *Hydrogeologic Framework for Groundwater Protection, in* PlANNING FOR GROUNDWATER PROTECTION 1,3 (G. William Page ed., 1987) (describing the hydrologic cycle.

confined and unconfined.[22] These aquifers respond differently to pumping. Water in a well drilled into an unconfined aquifer will reach the top of the zone of saturation known as the water table. The water table will rise or fall in response to recharge and pumping. A confined aquifer, also called an artesian aquifer, is basically a pressured water strata. Water in a well drilled into a confined aquifer is under pressure and will reach the potentiometric surface.[23] These wells are often called artesian wells because water flows to the surface.

Pumping groundwater from a well always causes a decline in groundwater levels at or near the well. The draw down in water forms a conical-shaped depression in the water table which is referred to as a "cone of depression."[24] Pumping of a single high capacity well, or pumping of many wells, can have regionally significant effects on aquifers and groundwater systems and lower the water table[25] These pumping draw downs can adversely interfere with other wells in the area.

1. Well Interference

Well interference is a highly volatile policy issue in the allocation of groundwater in the West. Well interference is the result of the lowering of water levels in shallow or low-capacity wells near a high-capacity well during and shortly after the period when the high-capacity well is pumped.[26] It may be a temporary or permanent hydraulic phenomenon and may result from any of three circumstances. First, if the well interference is caused by a cone of depression created by the intermittent operation of the high-capacity well, the condition may be temporary.[27] Second, if the high-capacity well is operated more frequently, the cone of depression may be longer lasting. A third, and perhaps permanent, cause of well interference is the overall lowering of the water level in an aquifer caused by pumping which exceeds recharge. Most well interference problems arise when high-capacity commercial, irrigation, and municipal wells are located near lower-capacity domestic wells.[28]

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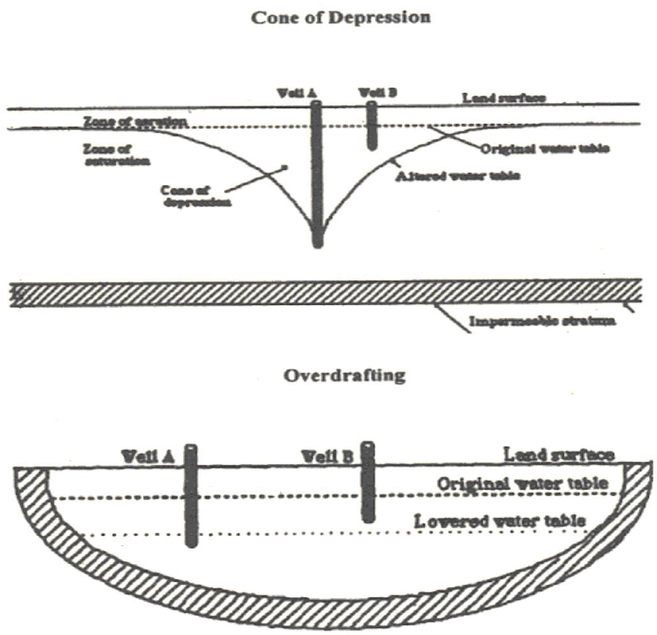
22. *See* MICHAEL BARCELONA ET AL., HANDBOOK OF GROUNDWATER PROTECTION 73(1988).
23. *Id.*
24. USGS CIRCULAR 1186, *supra* note 19, at 11-14; *see also Infra* fig. l (illustrating the schematics of well interference).
25. *See* USGS CIRCULAR 1186, *supra* note 19, at 11-14; *infra* fig.1.
26. USGS CIRCULAR *ll86, supra* note 19, at II.
27. *See Infra fig.1.*
28. USGS CIRCULAR 1186, *supra* note 19, at it.

Figure 1. Simplified Schematics of Well Interference Resulting from a Cone of Depression and Overdrafting.



Source: JOSEPH SAX, LEGAL CONTROL OF WATER RESOURCES (2d ed. West 1991)

As more and deeper wells are drilled into aquifers, the harmful impacts on existing shallower wells increase. An increase in wells probably would not be a major problem if all landowners were similarly situated with regard to wealth and power. However, any landowner with a bigger pump can wreak economic havoc on the small landowner without the same resources. The rule of capture, which encourages landowners to install bigger pumps and drill deeper wells to protect a source of water, exacerbates well interference. A landowner without access to a public water supply is left without any legal recourse or protection from the actions of a landowner with a bigger pump. Because of this, the rural Texas lifestyle is most at risk from the rule of capture.

It is tempting to treat domestic well interference cases dispassionately under the rubric of the maximum beneficial use of water or a private property right. To do so overlooks the social element and family hardship in well interference controversies, as was evident in the most recent Texas Supreme Court groundwater case.[29]

In *Sipriano,* Henderson County landowner Bart Sipriano and two others sued Great Spring Waters of America (also known as Ozarka Natural Spring Co.) for negligently draining their water wells.[30] Sipriano alleged that Ozarka caused the depletion of his wells by pumping 90,000 gallons of groundwater per day, every day, from land near his land.[31] Sipriano sought injunctive relief and actual and punitive damages for Ozarka's alleged negligence in causing the wells to go dry.[32] The trial court granted and the court of appeals affirmed Ozarka's motion for summary judgment, citing Texas's recognition of the rule of capture.[33] The Texas Supreme Court affirmed the decision.[34] The court declined to abandon the rule of capture and deferred to the Texas Legislature to regulate groundwater and address the problem of domestic well depletion.[35]

Adherence to the rule of capture continues to threaten a rural Texas lifestyle that is dependent on domestic wells as the sole source of water. This problem of dependence on domestic wells may not be as severe where the homeowner has access to a public water supply.

2. Aquifer Overdrafting and Safe Yield

Overdrafting of aquifers is a significant Texas problem.[36] This condition results from withdrawing water from an aquifer at a rate faster than its natural, or artificial, recharge rate.[37] If this practice continues for a long period of time, or if the aquifer has limited or little recharge, overdrafting is called mining.[38] The consequences of overdrafting are progressively higher water costs, and possible subsidence, or water quality degradation.[39]

In Texas, overdrafting occurs in portions of a number of aquifers.[40] In 1985, the Texas Legislature recognized that certain areas of the state were experiencing declining water tables and took action, authorizing the Texas Water Commission (TWC, the predecessor to the TNRCC) to institute a

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29. Sipriano v. Great Spring Waters of Am., Inc., 1 S.W.3d 75 (Tex. 1999).

30. *Id.*

31. ***Id.*** *at* 75-76. Sipriano's allegations were taken as true by the court for summary judgment purposes. ***Id.*** at 75.

32. ***Id*** **.**at 76.

33. ***Id.***

34. ***Id.*** at 81.

35. ***Id. at*** 80.

36. ***See*** sources cited ***supra*** note I (identifying this problem in a number of Texas water plans).

37. *See e.g.,* USGS CIRCULAR 1186, ***supra*** note 19, at 7 (explaining that "high ground-water use in areas of little recharge... causes widespread declines in ground-water levels and a significant decrease in storage").

38. ***See supra*** fig.1.

39. *Id.*

40. *See infra* tbl. 1.

groundwater management area designation and study process.[41] Senate Bill 1, introduced in the 75th Texas Legislature, reconfirmed the critical areas concept and added provisions for state-initiated groundwater conservation districts in critical areas that were renamed priority groundwater management areas (PGMAs).[42] At present, sixteen studies have been completed, and four study areas have been designated as PGMAs: (1) Hill County; (2) Upton, Midland, and Reagan Counties; (3) Hale, Swisher, and Briscoc Counties; and (4) Dallam County.

3. Aquifer Mining

In aquifers with little or no recharge, sustained withdrawals will eventually exhaust the supply or lower water tables below economic pump limits. In effect, the aquifer is being mined.[43] Groundwater mining results in numerous adverse consequences, including reduced flexibility to respond to dry spells and droughts in the future. Additionally, future economic development opportunities may be minimized because of a lack of water. Groundwater mining can also lead to land subsidence.

Several states have provided for depletion over a predictable number of years by controlling mining of aquifers.[44] The choice of time periods usually reflects a legislative policy judgment. A long depletion period preserves water for future uses but usually requires severe restrictions on present withdrawals. By contrast, a shorter period allows for larger withdrawals for the benefit of current users, but the depletion causes an economic crash in the irrigation economy in a local area.

B. Texas Groundwater Sources and Uses

1. Water Uses

Texans use nearly seventeen million acre-feet of water each year.[45] Groundwater accounts for about sixty percent of this demand for water with

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41. ***See*** TEX. WATERCODE ANN. §§ 35.002 -.019 (Vernon 2000).

42. Act of June 19, 1997, 75th Leg., R.5., ch. 1010, § 4.51, 1997 Tex. Gen. Laws 3610,3655.

43. ***See*** Fundingsland v. Colo. Groundwater Comm'n, 468 P.2d 835, 83940 (Cola. 1970) (discussing groundwater mining). In Texas, groundwater mining occurs in the Ogailala Aquifer, which is the largest source of groundwater used in the state. ***See*** *infra* notes 56-58 and accompanying text.

44. Colorado, New Mexico, and Oklahoma have adopted depletion timetables for some aquifers. In Colorado, the aquifer rate is forty percent over a twenty-five year period. ***See*** A. DAN TARLOCK, LAW OF WATER RIGHTS AND RESOURCES § 6.15 (2000). In Oklahoma, the depletion rate is calculated over twenty years, and in New Mexico the depletion rate is calculated over forty years. OKLA. STAT. ANN. tit. 82, § 1020.5 (West 1990); Mathers v. Texaco Inc., 421 P.2d 771, 774 (N.M. 1966).

45. A common nomenclature for measuring the volume, or amount of water used, is the acre-foot. This is the amount of water that covers one acre of land to a depth of one foot. An acre-foot of water is equal to 325,851 gallons of water.

surface water making up the other forty percent of water used by Texans.[46] Statewide, agriculture consumes the most water, with nearly two-thirds of all surface and groundwater used to irrigate crops, mostly in West Texas and the Lower Rio Grande Valley.[47] Municipal, manufacturing, mining, and power generation combined account for the remaining thirty-three percent.[48]

There are dramatic differences in consumption patterns between surface and groundwater.[49] Most of the water for irrigated agriculture in Texas is provided by groundwater.[50] Irrigation consumes about eighty percent of the groundwater, and municipalities and other uses account for the remaining twenty percent.[51] The opposite occurs with surface water use. About fifty-seven percent of Texas surface water is used for municipal and industrial purposes and forty-three percent is used for irrigation and livestock production.[52]

A change is occurring in the amount of surface and groundwater used for agricultural, municipal, and industrial purposes. Generally, the amount of surface and groundwater used for irrigation is declining while the use of these water sources for municipal and industrial use is increasing.[53] A further decline in irrigation water use is forecast by the Texas Water Development Board. At the same time, municipal, industrial, and other uses for water are likely to continue to increase.[54] In the next twenty-five years, the fastest growing use categories are projected to be in municipal and manufacturing use, and, by the 2040s, municipal and industrial uses of water are expected to exceed agricultural use of water.[55]

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46. WATER FOR TEXAS 1997, supra note 1, at 3-14.

47. ***See*** SANGER & REED, ***supra*** note ***3,*** at 11.

48. *Id.* at 3-4.

49. *See infra* fig.2.

50. Water is used to irrigate nearly seven million acres of land in Texas; however, most of this use is concentrated in the counties of the High Plains and lower Rio Grande valley. Water is used to irrigate at least twelve different types of crops in Texas. However, six crops comprised about three quarters of the irrigated acreage in Texas in 1994. They included: cotton (32%), wheat ***(15%),*** corn (15%), sorghum (9%), and rice (5%). These six crops use about 7.6 million acre-feet of water or about three quarters of all the surface and groundwater used for irrigation in Texas. ***See*** SANGER & REED, ***supra*** note 3, at 9-12.

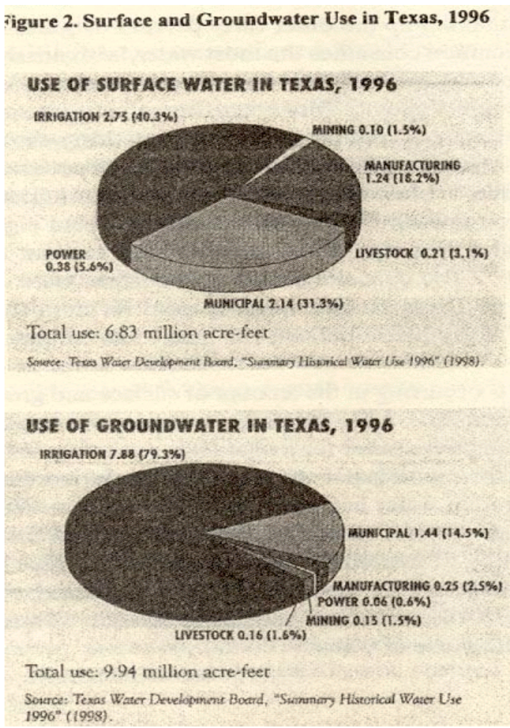
51. WATER FOR TEXAS 1997, ***supra*** note 1, at 3-15.

52. *See infra* fig.2.

53. Starting in the early 1970s groundwater use by agriculture began its decline from about thirteen million acre-feet to about ten million acre-feet by 1990, a decline of almost twenty percent. At the same time as irrigation water use has declined over the last twenty years, municipal and manufacturing water use has increased by more than sixty percent. Four reasons for this decline are: water affordability, water availability, a reduction in irrigated acreage, and an improvement in water conservation practices. Declining cheap water has resulted in the acreage reduction and adoption of water conservation. WATER FOR TEXAS 1997, supra note 1, at 3-3, 3-8.

54. Id. at 3-3.

55. Id. at 3-5.



Source: MARY SANGER & CYRUS REED, TEXAS ENVIRONMENTAL ALMANAC 9 (Tex. Ctr. for Policy Studies 2d ed. 2000)

2. Texas Aquafers

Texas aquifers are remarkably diverse in geologic structure, recharge potential and rates, storage, and transmissivity.[56] The Ogallala Aquifer, for example, is a huge aquifer underlying most of the Texas high plains. It receives little, if any, natural recharge from rain or snowfall.[57] More water is pumped from the Ogallala Aquifer than from all of the other Texas aquifers combined.[58] In contrast, the Edwards Aquifer is a highly rechargeable aquifer

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56. ***See infra*** Appendix (detailing the Ogallala, Seymour, Huesco-Mesilla Bolson, Cenozoic Pecos Alluvium, Edwards-Trinity (Plateau), Trinity, and Edwards (Balcones Fault Zone) aquifers).

57. WATER FOR TEXAS 1997, supra note I, at 3-205.

58. ***See infra*** tb1.1. The Ogallala Aquifer supplies two-thirds of all the groundwater used in Texas and provides thirty-eight percent of all the water used in Texas. Eighty percent of irrigated land in Texas

subject to rapid draw down from pumping, especially during drought. The Edwards Aquifer can be quickly replenished by rainfall.[59]

Nine aquifers supply about ninety-seven percent of the groundwater used in Texas.[60] The other three percent is drawn from twenty minor aquifers. Table I illustrates the annual pumping rates, recharge rates, and projected safe annual availability rates from the nine major aquifers. Information in this table illustrates that some aquifers are being mined; more water is pumped from the aquifer than will be replaced by the natural recharge process. The mining of aquifers has long term economic, environmental, and social implications for the regions served by the aquifers. These implications must be reflected in aquifer management practices.

Table 1. Water Extraction and Recharge Rates from Nine Major Aquifers in Texas*

	1990 Pump Rates (Million Acre-Feet)	1995 Pump Rates (Million Acre-Feet)	Annual Recharge (Million Acre-Feet)	Projected Safe Yield Yield
Ogallala	5.55	6.22	0.30	3.81
Edwards (Balcones)	0.53	0.47	0.44	0.44
Edwards-Trinity	0.19	0.25	0.78	0.78
Carrizo-Wilcox	0.45	0.49	0.64	0.85
Trinity	0.19	0.19	0.10	0.11
GulfCoast	1.23	1.15	1.23	1.23
Bolsum & Alluvium (Hueco, Cenozoic, Seymor)	0.32	0.39	0.43	0.97
TOTAL	8.46	9.16	3.92	8.19

Annual Recharge Rate – amount of precipitation and infiltration of surface water added to the aquifer.

Projected Annual Yield = annual recharge plus additional stored water that can be pumped without causing undue water quality and subsidence. Aquifers that have no storage can only provide annual recharge rate.

*This table is derived from MARY SAGER & CYRUS REED, TEXAS ENVIRONMENTAL ALMANAC 11 (Tex. Ctr. for Policy Studies 2d ed. 2000).

III. STATE GROUNDWATER LAWS

This section of the report will analyze the allocation rules and management approaches used by a number of states to develop a set of

is devoted to five crops: cotton, wheat, corn, grain sorghum, and pasture grasses and forage. SANGER & *REED, supra note3, at* 10-11.

59. WATER FOR TEXAS 1997, *supra* note 1, at 3-214.

60.Total groundwater use in 1994 was 9.4 million acre-feet and the nine major aquifers supplied 9.15 million acre-feet. *See supra* fig.2; *infra* tbl.1.

options for dealing with (1) well interference, (2) overdrafting, and (3) mining problems in Texas. This trilogy of problems is not unique to Texas; rather, it is ubiquitous.[61] The impact is not restricted to aquifers; groundwater pumping can also result in a number of changes to ecological resources which include reduced river flows, lower lake levels and reduced discharges to wetlands and springs. These ecological changes raise concerns about drinking water supplies, endangered species, riparian habitats, and migratory species.[62] Greater attention is now given to the sustainable management of groundwater.[63] The concept of groundwater sustainability has universal appeal, but it has proven to be an elusive concept to implement. Several states have struggled with sustainability issues and have adopted different management strategies for dealing with the problem.[64]

A. State Groundwater Allocation Rules[65]

When groundwater becomes scarce and insufficient to satisfy all users, states apply a single, or a combination, of four rules to resolve disputes that arise. The four rules relied on for resolving groundwater disputes are: (1) capture, (2) reasonable use, (3) correlative rights, and (4) prior appropriation.[66] The rules all have two prongs, a rights prong and a liability prong. The rights prong of each rule governs the withdrawal and consumption of groundwater; specifically, who may use ground water, in what quantity, for what purpose, and in what location. The liabilities prong of each of the four rules deals with resolution of disputes that occur when there is an insufficient supply of groundwater to satisfy the needs of all rights holders. Problems that arise are the result of well interference, overdrafting, mining, shortages, ecosystem impacts, and contamination.

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61. USGS CIRCULAR 1186, *supra* note 19, at 2, 7.

62. ***Id.***

63. ***Id.;*** Marios Sophocleus & Robert Sawin, *Safe Yield and Sustainable Development of Water Resources in Kansas,* Kansas Geological Survey, Circular 9 *at* http://crude2.kgs.ukans.edu/Publications/ pic9/pic9_l html (last visited Feb. 22, 2001).

64. *See* discussion *infra* Part III.D.

65. Research for this section was provided by Katarzyna Brozynski, Jason Byrd, Brian Croyle, and Russell Frost, Texas Tech University School of Law, Class of 2002.

66. For a treatise discussion of these rules, see A. DAN TARLOCK, LAW OF WATER RIGHTS AND RESOURCES (2000) [hereinafter TARLOCK, WATER RIGHTS AND RESOURCES] and 3 WATER AND WATER RIGHTS (Robert E. Beck ed., Michie 1991). For casebooks, see GEORGE GOULD & DOUGLAS GRANT, WATER LAW (5th ed. 1995); JOSEPH SAX ETAL., LEGAL CONTROL OF WATER RESOURCES (6th ed. 1991); and A. DAN TARLOCK ET AL., WATER RESOURCE MANAGEMENT (4th ed. 1993) [hereinafter TARLOCK, WATER RESOURCE MANAGEMENT].

1. Capture Rule

The rule of capture has its genesis in the doctrine of absolute ownership. The basis for absolute ownership has been traced to the 1843 English case of *Acton v. Blundell,* which established exclusive rights in a landowner to percolating groundwater beneath his land.[67] The English rule "is founded on the idea that a landowner should have dominion over the percolating ground water which underlies his land in much the same sense that he has dominion over the other elements in his subsoil.[68] It derives from the common law maxim of property, *"cujus est solum, ejus est usque ad coelum et ad infernos"* or "[t]o whomever the soil belongs, he owns also to the sky and to the depths."[69] Absolute ownership is a rule of property law and inherent in the ownership interests to land.

The rule of capture is an unqualified right of a landowner to withdraw unlimited amounts of water found beneath his land. No liability is imposed on a landowner for harm caused to a neighbor for interference with or drying up of a neighbor's well. Under this rule the water extracted may be put to any use without a limitation on location *(i.e.,* the groundwater does not have to be used on the overlying land). A landowner is neither required to reduce groundwater pumping during drought or shortage, nor restricted to pumping "reasonable" amounts.

Historically, many states followed the English common-law rule, but presently Texas is the only major state to adhere to it in its traditional form.[70] The English common-law rule was first applied in Texas by the supreme court in 1904 in *Houston & Texas Central Railway Co. v. East.*[71] In *East,* the Houston & Texas Central Railway Company withdrew water from land it owned and used it in nearby maintenance shops and for its locomotives. The company's pumping dried up the wells of neighboring landowners, including East.

East first argued that a landowner's right was "correlative" or limited by a "doctrine of reasonable use."[72] Second, East argued that the groundwater had to be used on the overlying lands. The Texas Supreme Court expressly rejected both of East's arguments. Instead, the court held that a landowner has the exclusive right to water beneath his soil and any harm resulting from an exercise of that right, such as harm to a neighbor, is *damnum abs que injuria,* "[a] loss which does not give rise to an action for damages."[73]

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67. 152 Eng. Rep. 1223 (1843).

68. JOSEPH L. SAX. WATER LAW PLANNING AND POLICY 460-6 1 (1968).

69. BLACK'S LAW DICTIONARY 341 (5th ed. 1979).

70. TARLOCK, WATER RIGHTS AND RESOURCES, *supra* note 66. § 4:6.

71. 98 Tex. 146, 81 SW. 279 (1904).

72. ***Id.*** at 148, 81 S.W. at 280.

73. *Id.* at 151,81 S.W. at 282 (adopting the rule of capture as established ***in Acton*** v. ***Blundell). But see*** Smith-Southwest Indus. v. Friendswood Dev. Co., 576 S.W.2d 21.30 (Tex 1978) (recognizing a

The Texas Supreme Court refused to impose any monetary liability on the railway company for causing East's wells to dry up. Additionally, no limit was placed on the amount of water the company could withdraw in order to avoid injury to East's wells. With the exception of wasting groundwater, or groundwater withdrawals made to maliciously injure another, the court suggested no restrictions regarding the use of withdrawn water.[74]

Texas courts have consistently applied the capture rule, absolving landowners of liability for interference with a neighbor's well, excessive loss of withdrawn water due to evaporation during transit to a distant point of use, or drying up springs.[75] In 1999, the Texas Supreme Court reiterated adherence to traditional application of the capture rule by unanimously reaffirming the rule in Sipriano v. Great Spring Waters of America, Inc.[76] In *Sipriano,* the company was using larger wells to pump groundwater that was bottled and distributed for sale nationwide. Although the company's larger industrial wells caused the plaintiff's smaller domestic wells to dry up, under the rule of capture, no liability was imposed.[77]

2. Reasonable Use

Most eastern and midwestern states modified the capture rule by adopting "reasonable use" criteria to resolve conflicts between competing well owners. The reasonable use rule developed out of a series of conflicts between cities that sunk high capacity wells in rural areas to extract groundwater for use in the city. To protect farmers and rural landowners from what the courts considered unfair competition and disparate economic power bases, courts modified the capture rule by imposing a reasonableness restriction on all pumpers.[78]

Two variations of the rule have evolved based on the location of the water's ultimate use. First, the American Rule creates a preference for using water exclusively on the overlying land or land within the basin. The second rule, the Restatement Rule, allows water, under limited circumstances, to be taken outside the confines of the basin.[79] Both rules grant rights to the overlying landowner, but they differ on criteria used to measure reasonableness for off-property uses.

As with the capture rule, overlying landowners have a legal right to pump water from beneath their land and use it for a beneficial purpose.[80]

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rarely applied exception for negligent pumping resulting in subsidence).

74. East, 98 Tex. at 149,81 SW. at 280.
75. ***See*** sources cited ***supra*** notes 10-12.
76. 1 S.W.3d 75, 80 (Tex. 1999).
77. Id.
78. TARLOCK, WATER RIGHTS AND RESOURCES, *supra* note 66. § 4:8.
79. RESTATEMENT (SECOND) OF TORTS § 858 cmt. a (1979).
80. J.W. Looney. *Modification of Arkansas Water Law: Issues and Alternatives,* 38 ARK. L. REV.

Under the reasonable use rule, an owner of overlying land can withdraw more than a reasonable amount of groundwater.[81] Both on-site and off-site rules resolve conflicts between overlying landowner pumpers involving well interference and aquifer overdrafting by comparing pumping rates and uses against reasonableness criteria. If landowner A's use of water is reasonable, even if it causes harm to landowner B, landowner A can still pump without liability to B. If the requirements of the rule are met, a landowner may withdraw groundwater even if doing so deprives another landowner of the reasonable use of groundwater.[82]

Reasonableness of use is determined by factors such as well location, amount of water, and the proposed use and placement of the water.[83] The rule deters waste to the extent that it prohibits unreasonable use.[84] Reasonable use does not create a right in a senior pumper to the maintenance of groundwater pressure necessary to support the least expensive means of withdrawal.[85] Reasonable use provides no basis for adjustment or apportionment of rights to common groundwater supply when the supply is insufficient to satisfy all the demands or requirements of overlying landowners.

a. *Reasonable Use-On-Site Limitation*

Groundwater use is a right incident to land ownership under the reasonable use rule provided that: (1) the use is reasonable, (2) the use is for the benefit of the overlying land, and (3) the use on non-overlying land is per se unreasonable.[86] Several states that have faced the issue of on-site use have not strictly adhered to the on-site rule but have allowed the transportation of groundwater off the land or outside the aquifer boundaries, so long as the use does not unreasonably interfere with neighboring landowners.[87] In some

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221, 245 (1984).

81. *See, e.g.,* Jarvis v, State Land Dep't, 479 P.2d 169, 172-73 (Ariz. 1970); Basset v. Salisbury Mfg. *Co.,* 43 N.H. *569, 574* (1862).

82. *See* TARLOCK, WATER RESOURCE MANAGEMENT, *supra* note 66, at 4-13.

83. T. Henderson, J. Trauberman, & T. Gallagaher, GROUNDWATER STRATEGIES FOR STATE ACTION 31(1984).

84. *See generally* Raphael J. Moses, *Basic* ***Groundwater Problems,*** 14 ROCKY MTN. MIN. L. INST. 501, 509(1969) (suggesting that a restriction against waste is inherent in the term "reasonable use," ***(i.e.,*** waste is unreasonable)).

85. See TARLOCK, WATER RESOURCE MANAGEMENT, ***supra*** note 66, at 6-14.

86. ***See*** FLA. STAT. ANN. § 373.016 (West 2000 & Supp. 2001); ***see, e.g.,*** Henderson v. Wade Sand & Gravel Co., 388 So.2d 900, 902 (Ala. 1980); Koch v. Wick, 87 So.2d 47,48 (Fla. 1956); Bridgman v.
Sanity Dist. of Decatur, 517 N.E.2d 309, 313-14 (Ill. App. Ct. 1987); United Fuel Gas Co. v. Sawyers, 259 S.W.2d 466, 468 (Ky. 1953); Finley v. Teeter Stone, Inc., 248 A.2d 106, 111-12 (Md. 1968); Forbell v. City of New York, 61 N.Y.S. 1005, 1007-08 (N.Y. App. Div.), ***aff'd,*** 58 N.E. 644 (N.Y. 1900); Rouse v. City of Kingston, 123 SE. 482,490 (N.C. 1924); Nashville, Chattanooga & St. Louis Ry. v. Rickert, 89 S.W.2d 889, 897 (Tenn. Ct. App. 1935).

87. Paloma Inv. Ltd. P'ship v. Jenkins, 978 P.2d 110, 115 (Ariz. Ct. App. 1999); ***see also*** Springer v. Kuhns, 571 N.W.2d 323, 327 (Neb. Ct. App. 1997) ("[T]he owner of land is entitled to appropriate

jurisdictions, landowners may withdraw water for reasonable use on the overlying land without incurring liability, even if the withdrawal causes subsidence of surrounding land.[88] Waste in a reasonable use state, in most instances, will only be enjoined if there is a concurrent injury associated with the waste.[89]

b. Reasonable Use-Off-Site Use Allowed

Section 858 of the *Restatement (Second) of Torts* reflects aspects of both reasonable use and correlative rights rules. However, it significantly differs from both. The *Restatement* seeks to provide specific criteria for comparing reasonableness of competing uses of groundwater. Accordingly, a landowner is not liable for withdrawal of groundwater and use outside overlying land unless:

> (1) the withdrawal unreasonably causes harm to a neighboring landowner by lowering the water table or reducing artesian pressure;
> (2) the withdrawal exceeds a reasonable share of the annual supply or total store of groundwater; or
> (3) the withdrawal has a direct and substantial effect upon watercourse or lake and unreasonably causes harm to a person entitled to the use of such water.[90]

While this rule protects against overdrafting, it does not prevent water from being used outside the confines of the aquifer. Commentators suggest that the Restatement rule functions like the rule of capture for large pumpers, but it gives a remedy to smaller pumpers who have been injured by the entry and actions of larger pumpers who are new to the basin.[91] For example, when an irrigation well becomes inadequate as new irrigation wells are drilled into the same aquifer, the harm to the original well is not unreasonable if the owner is merely forced to deepen his well to reach the level of the deeper wells and pay the same pumping costs. However, when a well is used only to supply a relatively small amount of water for domestic purposes—a use that does not ordinarily support the cost of deep wells and expensive pumps—the harm may be unreasonable when large withdrawals of water materially lower the water table. The reasonableness rule reflects the public policy decision

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subterranean waters found under his land, but he cannot extract and appropriate them in excess of a reasonable and beneficial use upon the land which he owns....")

88. Finley v. Teeter Stone, Inc., 248 A.2d 106, 111-12 (Md. 1968).

89. Prohosky v. Prudential Ins. Co.. 767 F.2d 387, 394 (7th Cir. 1985), ***rev***'g, Prohosky v. Prudential Ins. Co., 584 F. Supp. 1337 (N.D. ind. 1984).

90. RESTATEMENT (SECOND) OF TORTS § 858 (1979).

91. TARLOCK, WATER RESOURCE MANAGEMENT, *supra* note 66, at 4-30.

that large irrigators should not be allowed to impose excessive economic costs upon smaller water users.[92]

A number of states follow the reasonable use rule, or some variation of it. They include: Alabama, Arizona, Florida, Iowa, Kentucky, Maryland, Michigan, Nebraska, New Hampshire, New York, North Carolina, Ohio, Pennsylvania, Tennessee, West Virginia, and Wisconsin.[93] Notably, Illinois has, by statute, declared the rule of reasonable use applicable to groundwater withdrawals and defined reasonable use as "the use of water to meet natural wants and a fair share for artificial wants."[94]

3. Correlative Rights

The correlative rights rule was developed by California courts at the turn of the century, just before Texas adopted absolute ownership.[95] Correlative rights allocate the use of groundwater based on ownership of land above a basin or aquifer. Owners of land over an aquifer or basin are entitled to a reasonable share of the total supply. Each landowner has an equal right of use that is not subject to a temporal priority. Of course, when supplies are sufficient, each landowner's withdrawals are unlimited. Further, groundwater in excess of the overlying landowners' needs may be appropriated and taken outside the basin.[96]

During drought, or if the aquifer is overdrafted, each landowner is entitled to a fair and just proportion of the common pool. The share is generally determined by the ratio of land owned overlying the basin.[97] In times of shortage, pumping is restricted to overlying landowners.[98]

Initially, as California developed and honed the correlative rights doctrine, the system received attention from commentators. Minnesota has applied the correlative rights rule for years; Arkansas, Delaware, Missouri, Nebraska, and New Jersey have also adopted it.[99]

4. Prior Appropriation

A number of states have adopted appropriation or permit systems for groundwater that are similar, though not identical, to appropriation systems for surface water. Groundwater under this system is allocated based on a temporal principle called "first in time, first in right." A person develops a

92. *See* RESTATEMENT (SECOND) OF TORTS § 858A cmt. d (Tentative Draft No. 17, 1971).
93. *See* 3 WATERS AND WATER RIGHTS 291-391 (Robert E. Beck ed., Michie 1991).
94. 525 ILL. COMP. STAT. ANN. 45/4 (West 2000).
95. Katz v. Walkinshaw, 74 P. 766, 771-73 (Cal. 1903).
96. Wright v. Goleta Water Dist., 219 Cal. Rptr. 740, 746-47 (Ct. App. 1985).
97. Tehachapi-Cummings Water Dist v. Armstrong, 122 Cal. Rptr. 918, 924-25 (Ct. App. *1975).*
98. *Id.*
99. TARLOCK, WATER RIGHTS AND RESOURCES, *supra* note 66, § 4.15.

right to use groundwater by appropriating it from a basin and putting it to a beneficial use. Typically, a groundwater appropriator is protected to a "reasonable pumping level," not necessarily the historical level, in cases of shallower wells.

Excluding Arizona, California, and Texas, western states follow the appropriation or permit system for groundwater allocation. Thus, Colorado, Idaho, Kansas, Montana, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming allocate groundwater based on prior appropriation.[100]

B. Statutory Groundwater Management Approaches

In some areas of the country, an increase in demand for groundwater has resulted in aquifer overdrafting and mining. In response, most states have found the basic allocation rules lacking and have instead established critical basin study areas and experimented with administrative regulations addressing the specialized problems. The following tables illustrate this. Table 2 outlines how allocation rules function to address well interference, overdrafting, and mining problems. Table 3 lists the rules followed by western states and the extent to which they use state or local districts to deal with the problems.

100. COL. REV. STAT. § 37-90-103 (West 1999); IDAHO CODE § 42-226 (Michie 1996); KAN. STAT. ANN. §§ 82a-1020 to -1035 (1997); MONT. CODE ANN. §§ 85-2.501 to -520(1999); NEv. REV. STAT. § 534.020(1999); N.M. STAT. *Ann.* §§ 72-12-1 to -28 (Michie 1997); N.D. CENT. CODE § 61-01-01 (1995); Or. REV. STAT. § 537.505(1999); S.D. CODIFIED LAWS § 46-6-3 (Michie 1999); UTAH CODE ANN. §§ 73-1-1 to 4 (1989 & Supp. 1999); WASH. REV. CODE *ANN.* § 90.44.020 (West 1992); WYO. STAT. ANN. §§ 41-3-902 to -905 (Michie 1999).

TABLE 2 Features of Ground Water Allocation Systems

GW Systems	Rights Holders	Amount of Water	Liability for Well Interference	Off-tract Use	Water Transfer	Aquifer Mining	Conjunctive Management
Rule of Capture	Overlying Land-owner	Unlimited	NO, except for malice, waste	YES	YES	YES	NO
American Reasonable Use Rule (ARU)	SAME	*Reason-able* for beneficial use	YES, if unreasonable amount or off-tract use	NO	YES, within basin	NO	Possible
Restatement Reasonable Use Rule	SAME	Same as ARU	YES, if unreasonable amount and injurious	YES, if reason-able & no harm	YES	NO	Possible
Correlative Right	SAME	Proportional share based on ownership of overlying	YES, if exceed share and injurious	NO, unless surplus	YES, within basin and surplus	NO	NO
Prior Appropriation (PA)	SAME	Specific quantity for beneficial use	No, unless interfere with "reasonable pumping level" of other users	YES	YES, if no injury is caused to other users	YES, unless public policy or admini-strative ban	YES, if PA applies to surface water rights

Experiences from other states indicate that one or a combination of these four allocation rules cannot resolve all groundwater problems. Instead, states experiencing overdrafting, mining, or subsidence problems have adopted critical area legislation to supplement state allocation rules. Legislation of this type typically allows states to designate areas for study. When the amount of water available has been established and a determination is made that withdrawals exceed a numerical or conservation recharge rate, pumping can be controlled, limited, or suspended. New pumping can be prohibited in prior appropriation states. Arizona, California, Colorado, Idaho, Kansas, Nebraska, New Mexico, Nevada, Montana, Oregon, Texas, Washington, and Wyoming all have legislation allowing for critical area designation and regulation.[101] Designation, degree of control, and local input patterns vary extensively among the states.

Table 3. Groundwater Allocation Rules & Systems ror Selected States

STATE	Groundwater Rules				Critical Areas Programs Groundwater Districts	
	Capture	Reasonable Use	Correlative Rights	Prior Appropriation	State Control	Local Control
Arizona		x			x	
Califomia			x			x
Colorado				x	x	
Florida	x				x	x
Idaho				x	x	
Kansas				x	x	x
Nebraska		x		x		x
Nevada				x	x	
New Mexico				x	x	
North Dakota				x		
Montana				x	x	
Oregon				x	x	
South Dakota				x		
Texas	x					x
Utah				x		
Washington				x	x	
Wyoming				x	x	

States following the prior appropriation system vest most of the supervisory authority for critical groundwater areas in a state water official, usually a state engineer. Local input into district creation and a local

101. *See* discussion *infra* Part III.D.

governing board may be authorized, but these local boards generally act as an advisor to the state water official. Colorado, Florida, Idaho, Kansas, Montana, Nevada, Washington, and Wyoming exemplify this approach.[102] In states that do not follow the prior appropriation system (California, Nebraska, and Texas), local officials have greater autonomy in aquifer control, regulation, and management.[103] Typically, these districts address specific problems that are not adequately handled under the general allocation rules. Within a district, the rules adopted by the district's board apply to allocation and use of the groundwater. Texas generally applies the common law rule of capture to groundwater. Three exceptions to this general rule are areas located within the Edwards Aquifer Authority, a subsidence district, or a local groundwater conservation area.

Clearly, there is a varied approach among states in managing groundwater. A more detailed state-by-state description is provided in the next section. A review of approaches used in selected states reveals the following types of specialized rules:

1. Legislative "cap" on withdrawals (Texas-Edwards Aquifer Authority);
2. Conservation by waste reduction requirements and limitations on rights (Arizona);
3. Retiring existing rights to reach level of "safe yield" (Arizona);
4. Moratorium on new wells (Nebraska, Colorado);
5. "Pooling arrangement" with flexible application provisions (Nebraska);
6. "Critical township" districts' well spacing requirements limiting new wells (Nebraska);
7. Division into groundwater basins with different powers for management (Arizona, Florida);
8. Municipal preference during overdraft (Florida);
9. Aquifer management by State Engineer (New Mexico);
10. Conservancy districts based on artesian basins (New Mexico);
11. Critical groundwater districts based on overdraft conditions (Colorado, Kansas, Idaho, Nebraska).

Critical area legislation offers the advantage of faster response to problems. The legislature can set forth specific objectives to be attained and specific problems to be addressed by district management. This degree of specificity is not possible under the four allocation rules.

102. *See* discussion *infra* Part III.D.
103. *See* discussion *infra* Part III.D.

C. Water Uses and Groundwater Water Uses—A Snapshot of Selected States

The fifteen states, including Texas, reviewed in this section of the article provide a comparative snapshot of water use in the United States. These fifteen states consume about forty-five percent of total freshwater and seventy-five percent of fresh groundwater available for use in the country.[104] Fourteen western states and Florida are included in this review. Florida is included for comparison because of its extensive reliance on groundwater for irrigation and public water supply. Data used for this analysis are derived from the United States Geological Survey.[105]

1. Water Uses

Six of the states reviewed for this article rely on groundwater for about half of their water supply: Arkansas, Florida, Kansas, Nebraska, New Mexico, and Texas.[106] The other nine states rely primarily on surface water to supply their water needs. When compared with other states, California consumes the greatest amount of groundwater of any state even though California's consumption of groundwater is only forty percent of the state's total water consumption. California's groundwater use, by volume, is nearly twice that of Texas, the second largest user of groundwater in the United States.[107]

Irrigation is the predominate use for water in these fifteen states except North Dakota.[108] This is surprisingly true of Florida, a state often associated with the humid east. Irrigation and public supply represent the majority of water used in the fifteen states reviewed in this report and nationwide.

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104. W. SOLLEY ET AL.. *Estimated Use of Water in the United States in 1995:* U.S. GEOLOGICAL SURVEY CIRCULAR 1200, tbl.2 (1998) [hereinafter USGS CIRCULAR 1200].

105. USGS CIRCULAR 1200, *supra* note 104. tbls.2, 4, S (supplying data for this analysis).

106. *See infra* tbl.4.

107. *See infra* tbl.4 (illustrating that Texas uses 9.4 million acre-feet per year).

108. *See infra* tbl.5. The United States Geological Survey tracks eight different categories of extractive water use, including public supply, domestic, commercial, irrigation, livestock, industrial mining, and thermoelectric. For comparison purposes, these eight categories were aggregated into three: irrigation, public supply, and other.

Table 4. A comparison of surface and groundwater sources by state, 1995

	Groundwater Amount*	Percentage	Surface Water Amount*	Percentage	Amount in Acre-Feet
Arizona	3.1	41	4.5	59	7.6
California	16.2	40	24.4	60	40.6
Colorado	2.5	16	13.0	84	15.5
Florida	4.9	60	3.2	40	8.1
Idaho	3.1	18	13.8	82	16.9
Kansas	3.9	67	1.9	33	5.8
Nebraska	7.0	59	4.9	41	11.9
Nevada	1.0	38	1.6	62	2.6
New Mexico	1.9	49	2.0	51	3.9
North Dakota	.1	8	1.1	92	1.2
Oregon	1.1	13	7.7	87	8.8
South Dakota	.2	40	.3	60	.5
Texas	9.4	57	7.1	43	16.5
Utah	.9	18	4.0	82	4.9
Washington	2.0	20	7.9	80	9.9

* Converted to million acre-feet per year.

Table 5. Categorical use of surface and groundwater by state, 1995

STATE	Percent Irrigation	Percent Public Supply	Percent Other	Percent Total	Amount in Acre-Feet
Arizona	83	12	5	100	7.6
California	80	16	4	100	40.6
Colorado	92	5	3	100	15.5
Florida	48	29	23	100	8.1
Idaho	86	2	12	100	16.9
Kansas	65	7	28*	100	5.8
Nebraska	72	3	25*	100	11.9
Nevada	73	21	6	100	2.6
New Mexico	85	9	6	100	3.9
North Dakota	11	1	88*	100	1.2
Oregon	78	6	16	100	8.8
South Dakota	59	2	39	100	.5
Texas	67	22	11	100	16.5
Utah	82	12	6	100	4.9
Washington	73	13	14	100	9.9

* Thermoelectric is major use. Data for this table is dervied from USGS Circular 1200, tbl.4

2. Groundwater Uses

Groundwater is a significant source of water for irrigation purposes.[109] Except in Florida, North Dakota, and South Dakota, irrigation is the predominate use of groundwater in the fifteen sample states. Florida, a state with an estimated population of 14.1 million people in 1995, uses forty-three percent of its groundwater for public water supply purposes instead of irrigation.

Table 6. Percentage use of groundwater by category by State, 1995

STATE	Irrigation	Public Supply	Other	Percent Total
Arizona	75	15	10	100
California	75	19	6	100
Colorado	89	5	6	100
Florida	38	43	19	100
Idaho	89	6	5	100
Kansas	90	4	6	100
Nebraska	93	4	3	100
Nevada	75	14	11	100
New Mexico	75	16	9	100
North Dakota	48	25	27	100
Oregon	84	8	8	100
South Dakota	45	28	27	100
Texas	79	14	7	100
Utah	51	38	11	100
Washington	47	36	17	100

Data for this table is derived from USGS CIRCULAR 1200, tbl.8

D. Groundwater Management in Selected States

1. Arizona

Arizona's 4.2 million people use about 7.5 million acre-feet of water per year.[110] Surface water provides about sixty percent of the water used, and groundwater makes up about forty percent of this water. Eighty-three percent of all water in Arizona is used in irrigation, and groundwater is a significant source of that water. About seventy-five percent of all groundwater is used for irrigation.

109. *See infra* tbl.6.
110. *See infra* tbls.4-6.

Groundwater supplies are affected by overpumping and mining, contributing to problems in Arizona.[111] Overdrafting has lowered water levels in Arizona by as much as 400 feet. The result of this mismanagement is evident in worsening groundwater water quality, land subsidence, and the creation of earth fissures which cause damage to roads, buildings, and underground utility lines.

Groundwater in Arizona has historically been treated as a private resource and governed by the reasonable use doctrine.[112] This is the standard today, except for the exceptions created by the 1980 Groundwater Management Act.[113] The Act created three categories of groundwater use in land designated as non-regulated, non-irrigation expansion, and active management areas (AMAs). In the non-regulated areas, groundwater continues to be the traditional use and is considered the property of the overlying landowner.[114]

Two cases have defined "reasonable" in Arizona. In the first case, Bristor v. Cheatham, the Arizona Supreme Court found that although both landowners had a proprietary right to their groundwater, Cheatham's use was unreasonable because he transferred the water to fields three miles away.[115] Thus, Bristor was found to have a valid cause of action, and the court enjoined Cheatham's transfer of groundwater. The court, however, reiterated that groundwater could be diverted to make beneficial use on the land from which it was taken without incurring liability.[116] In the second and more recent case, Farmer's Investment. Co. V. Bettwy, the Arizona Supreme Court held that a pecan farmer's water use on overlying land was reasonable, while water use for non-overlying mines, one and a half miles away, was unreasonable.[117]

The Arizona Groundwater Management Act (GMA), passed by the Arizona Legislature in 1980, was designed to provide comprehensive guidelines for management of groundwater.[118] The greatest impact of the GMA was to prohibit new uses of groundwater (i.e., land not previously

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111. *See, e.g.,* ZACHARY A. SMITH, GROUNDWATER IN THE WEST 54 (1989); Groundwater Protection Council, Groundwater Report to Congress: Summary of State Water Conditions (2000), at http:Ilgwpc.site.net/gwreportlstates.htm (last visited Feb. 22, 2001).

112. *See* Bristor v. Cheatham, 255 P.2d. 173, 178 (Ariz. 1953); Howard v Perrin, 76 P.460,462 (Ariz. 1904), aff'd, 200 U.S. 71 (1906); see also Farmer's Inv. Co. v. Bettwy, 558 P.2d 14, 19 (Ariz. 1976) (explaining that in 1953 the Arizona Supreme Court "committed Arizona to the American doctrine of reasonable use").

113. *See* ARIZ. REV. STAT. ANN. §§ 45-401 to -637 (West 1994 & Supp. 2001); Philip R. Higdon & Terence W. Thompson, The 1980 Arizona Groundwater Management Code, 1980 ARIZ. ST. L.J. 621, 649 (1980).

114. Higdon & Thompson, *supra* note 113, at 649.

115. *Brastor*, 255 P.2d at 173-74.

116. *Id.*

117. *Bettwy*, 558 P.2d at 20-21.

118. ARIZ. REV. STAT. ANN. §§ 45401 to .637.

irrigated may not be irrigated in the future) and to restrict established uses to amounts previously used in certain areas now called active management areas (AMA).[119] The 1980 legislation dramatically changed the reasonable use doctrine, creating for the first time restrictions on the amount of groundwater that could be used.[120]

Concurrently, the GMA created the Department of Water Resources (DWR).[121] This department is responsible for the management of all water resources in Arizona, including that provided for in the GMA.[122] The DWR is headed by a director empowered with the final authority in all department decisions.[123] The director's powers include creating new AMAs, defining basins and sub-basins, limiting per capita consumption in urban areas, and enforcing the GMA through the use of civil and criminal penalties.[124] Ultimate authority rests in the Superior Court of Arizona, to which decisions made by the director may be appealed. The disputes are heard by judges selected for their expertise in water law.[125]

Five active groundwater management areas were created. Two are in Arizona's population centers of Phoenix and Tucson. The Phoenix AMA and the Tucson AMA were deemed critical because of existing overdraft situations and anticipated future population growth in both Phoenix and Tucson. The three other groundwater areas, Prescott, Pinal, and Santa Cruz AMAs, are in Arizona's major agricultural areas. These three areas were selected due to the continuous and significant overdraft status caused by crop irrigation. Other groundwater management areas can be designated as AMAs either by the director of the DWR (based upon specific criteria) or by the vote of the citizens living above an aquifer.[126]

Current users within an AMA were protected by grandfathered rights based on prior use in the five years before the enactment of the GMA.[127] Three types of grandfathered rights exist within an AMA.[128] The first, irrigation grandfathered rights, allows the user to pump the minimum amount necessary to irrigate his land. The second, Type 1 non-irrigation grandfathered rights, occurs when previously irrigated land is retired and put to another use. Type 1 landowners are limited to three acre-feet per acre. The third grandfathered right, Type 2 non-irrigation grandfathered rights, is based

119. Ellen K. Wheeler, *The Right to Use Groundwater in Arizona After Chino* Valley ll and Cherry v. Steiner, 25 *ARI Z.* L. REV. 473, 474 (1983).

120. *Id.*

121. Higdon & Thompson, *supra* note 113, at 635.

122. *Id.*

123. *Id.*

124. *Id.*

125. *Id*. at 636.

126. *See id.* at 632.

127. ARIZ. REV. STAT. ANN. § 45-465(A) (West 1994 & Supp. 2001).

128. Higdon & Thompson, *supra* note 113, at 650-51.

upon historical withdrawals for non-irrigation purposes.[129] The net result is that irrigators are now limited to the average amount of water used during the five-year period from 1975-79.

Each type of grandfathered right is fully transferable with the sale of the property. If, however, the new owner wishes to put the water to another use, he will be limited to three acre-feet per acre, as a Type 1 non-irrigation right.[130] The Type 2 non-irrigation rights apply to users of groundwater for non-irrigation purposes who held rights when the law was enacted in 1980.[131] The GMA limits Type 2 rights holders to the average amount used during the prior five-year period.

Additionally, the GMA also created two irrigation non-expansion areas, which are areas covered by the reasonable use doctrine, except that no new land within a non-expansion area may be irrigated.[132] There are two non-expansion areas in Arizona, the Douglas irrigation non-expansion area and the Joseph City irrigation non-expansion area.[133]

The GMA allows groundwater transportation within a sub-basin without liability or injunction, including sub-basins within the AMA's non-expansion and non-regulated areas.[134] A sub-basin is defined as "a relatively hydrologically distinct body or related bodies of groundwater within a groundwater basin."[135] A groundwater basin is defined by the director of the DWR as "a relatively hydrologically distinct body.., of groundwater."[136] Provision is made for the transportation of water away from the sub-basin in AMAs when done pursuant to a grandfathered irrigation right or a Type 1 non-irrigation right.[137] Qualified landowners are authorized to transport up to three acre-feet per acre per year.[138] If more than the allowable amount is transported and another landowner is harmed, the injured landowner may recover monetary damages.[139] A landowner may be harmed when a well goes dry, pumping costs increase, water quality is impaired, or land subsides.[140]

The GMA created a number of strategies to conserve water within each AMA, including limiting pumping to the minimum amount necessary for crops historically grown in the area.[141] In addition, no new irrigation within

129. *Id. at 65l.*
130. *Id.*
131. *Id.*
132. *Id*. a 1637.
133. *Id.*
134. Ariz. REV. STAT. ANN. §§ 45-541 to -544 (West 1994 & Supp. 2001).
135. *Id.* § 45402(31).
136. *Id.* § 45-402(12).
137. *Id.* § 45465.
138. *Id.* § 45-542(C).
139. *Id*.
140. Mary Doyle. *The Transportation Provisions of Arizona's 1980 Groundwater Management Act: A Proposed Definition of Compensable Injury,* 25 ARIZ. L. REV. 655, 663 (1983).
141. Ariz. REV. STAT. ANN. § 45-465(A).

an AMA will be permitted, and a program retiring current use was instituted.[142] Under the GMA, operators of mines and other industries are required to use the best available technology in extracting and using groundwater.[143] New developers must be able to assure a one-hundred-year water supply in order to develop within an AMA.[144] The director of the Department of Water Management can limit per capita consumption in urban areas.[145]

In non-irrigation expansion areas, the only conservation measures are prohibitions on the expansion of irrigated land and those measures imposed by the reasonable use doctrine. These provisions are a direct response to the serious groundwater overdraft situation that has existed in Arizona for decades. In 1977 the approximate overdraft from state aquifers was 2.5 million acre-feet.[146] In the last fifty years, eighty million acre-feet have been mined from Phoenix area aquifers alone and, although estimates vary, this rate of overdraft could lead to total depletion of the aquifer in as little as one hundred years.[147] All changes were made to reduce and eventually eliminate overdraft, particularly by retiring existing water rights.

2. California

Thirty-two million Californians use about forty million acre-feet of water each year.[148] In California, about forty percent of the water comes from aquifers and sixty percent from surface water sources. California is an agricultural state that uses a significant amount of water for irrigation. Eighty percent of the forty million acre-feet of water used each year is for irrigation. Groundwater is important for California agriculture as seventy-five percent of it is used for irrigation.

California is a big state with plenty of water, people, and problems.[149] The state is bipolar, with the water located in the north and the majority of the population located in the south. The entire state is susceptible to drought which affects every use, from irrigation to municipal and industrial water supply. There are some four hundred groundwater basins in the state. Groundwater overdrafting occurs in many basins. Statewide average annual groundwater extractions have exceeded average annual replenishment by two

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142. *Id.* §§ ***45452,*** -566(A)(6).

143. ***Id.*** § 45-564(A)(2).

144. ***Id.*** § 45-576.

145. ***Id.*** §§ ***45-564*** to -568.

146. Higdon & Thompson, ***supra*** note 113, at 632.34.

147. Robert Jerome Glennon, ***Because That's Where the Water Is: Retiring Current Water Uses to Achieve the Safe-yield Objective of the Arizona Groundwater Management Act,*** 33 ARIZ. L. REV. 89, 91(1991).

148. ***See supra*** tbls.4-6.

149. ZACHARY A. SMITH, GROUNDWATER IN THE WEST 54 (1989).

million acre-feet per year.[150] The overdrafting rate has been reduced by fifty percent from a 1960 rate of four million acre-feet per year.

California has identified eleven critically overdrafted basins.[151] In addition to these eleven basins, the state has identified at least forty-two basins where overdraft is occurring, but not at critical levels.[152] Many of these overdrafted aquifers are in the San Joaquin Valley portion of the Central Valley and in the Los Angeles Basin. A declining water table is causing increased pumping lifts and consequently higher energy costs. Water quality problems include sea water intrusion, increased salinity, and subsidence.

California has a confusing groundwater management program. Six methods of groundwater management have evolved in California. Two of the methods relate to allocating water under the correlative rights doctrine, and the other four methods are institutional forms of management.[153]

Overlying property rights allow anyone in California to drill a well and extract their correlative share of groundwater, which is not defined until a basin is adjudicated. The correlative rights doctrine was developed judicially and offers guidance in outlining the basic rights of landowners.[154] Owners of tracts that overlie a common supply of percolating water have correlative rights in the common supply.

Under California correlative rights, overlying landowners are entitled to a "fair and just portion" of the common groundwater, but they have no right to the maintenance of the natural water table.[155] A landowner was held liable when the amount of groundwater withdrawn caused damage to neighboring lands.[156] The correlative rights doctrine is also applied as a method of apportioning groundwater among competing users on the basis of a pro rata sharing of the available supply among all users.[157]

In basins where extensive overdrafting or mining is taking place, landowners have resorted to the courts to adjudicate the basin. As part of the adjudication, the court determines: (1) the eligible well owners (pumpers), (2) how much water well owners can pump, and (3) the water master to monitor and ensure that the basin is managed in accordance with the court's decree.[158]

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150. *Id.*

151. CALIFORNIA DEPARTMENT OF WATER RESOURCES, BULLETIN 118-80, GROUNDWATER BASINS IN CALIFORNIA 4(1980).

152. *Id.*

153. *Id.*

154. Katz v. Walkinshaw, 74 P. 766, 771-73 (Cal. 1903).

155. Hillside Water Co. v. City of Los Angeles, 76 P.2d 681,686-87 (Cal. 1938).

156. *See* O'Leary v. Herbert, 55 P.2d 834, 838 (Cal. 1936).

157. J. David Aiken & Raymond J. Suppalla, *Ground Water Mining and Western Water Rights Law: The Nebraska Experience,* 24 S.D. L. REV. 607, 614 (1979).

158. *See* CALIFORNIA DEPARTMENT OF WATER RESOURCES, GROUNDWATER MANAGEMENT IN CALIFORNIA: A REPORT TO THE LEGISLATURE 17-18(1999) [hereinafter GROUNDWATER MANAGEMENT IN CALIFORNIA].

Sixteen basins, all located in southern California, have been adjudicated.[159] In these basins, during water shortages, all overlying owners are entitled to a fair and just proportion of the available waters. Correlative rights to groundwater do not depend on use and such rights are not lost by nonuse.[160] When adjudicating competing claims to groundwater, a trial court cannot subordinate an unexercised overlying right to a present appropriative use.[161] All overlying landowners have correlative rights in the basin whether they are withdrawing groundwater or not.

In California, a person having a legal right to groundwater is limited to an amount that is reasonably necessary for beneficial purposes.[162] Public interest requires the greatest number of beneficial uses that the supply can yield, and water may be appropriated for beneficial uses subject to the rights of those who have a lawful priority. Any part of the safe yield of a basin that is not needed for the reasonable beneficial uses of the overlying landowners is excess or "surplus water." This water may rightfully be appropriated on privately owned land for non-overlying uses, such as devotion to a public use or exportation beyond the basin or watershed.[163]

If there is surplus water, non-overlying landowners may obtain appropriation rights to use it outside the basin. Surplus waters are the part of the safe annual yield that is not needed for use by overlying landowners.[164] If the basin is overdrawn by withdrawals exceeding the safe annual yield, use is restricted to overlying landowners.[165] Only surplus water may be transported for use on lands outside the basin.

An overlying landowner has no right to enjoin the appropriation of surplus waters.[166] Proper overlying use, however, is paramount, and the right of an appropriation, limited to the amount of the surplus, must yield to that of the overlying owner in the event of a shortage. Rights are correlative between overlying owners and are referred to as belonging to all in common.

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159. *Id.* These basins, in the order of the date of the court decision are: 1944 Raymond Basin; 1958 Cucamonga Basin; 1961 West Coast Basin; 1965 Central Basin; 1966 Santa Margarita River Watershed; 1969 San Bernadina Basin; 1972 Cummings Basin; 1973 Tehachapi Basin; 1973 Main San Gabriel Basin; 1977 Warren Valley Basin; 1978 Chino Basin; 1979 Upper Los Angles River Area; 1980 Scott River System; 1985 Puente; 1996 Santa Paula Basin; and 1996 Mojave Basin.

160. Wright v. Goleta Water Dist., 219 Cal. Rptr. 740,749 (Ct. App. 1985).

161. *Id.*

162. Peabody v. City of Vallejo, 40 P.2d 486,493 (Cal. 1935); Katz v. Walkinshaw, 74 P. 766, 772 (Cal. 1903); *see also* CAL. CONST. art. X, § 10 ("It is hereby declared that... the general welfare requires that the water resources of the State be put to beneficial use ... and that the conservation of such waters is to be exercised with a view to the reasonable and beneficial use thereof...

163. *Peabody,* 40 P.2d at 488; City of San Bernardino v. City of Riverside, 198 P. 784, 788 (Cal. 1921); Burr v. Maclay Rancho Water Co., 98 P. 260, 264 (Cal. 1908); *Katz,* 74 P. at 772.

164. *Wright,* 219 Cal. Rptr. at 752.53.

165. Tehachapi-Cummings County Water Dist. v. Armstrong, 122 Cal. Rptr. 918, 924-25 (Ct. App. 1975).

166. *Peabody,* 40 P.2d. at 492.

Each user may claim only his reasonable share when water is insufficient to meet the needs of all.[167]

In groundwater basins and aquifers with high use and overdrafting, California is experimenting with decentralized groundwater management to supplement the adjudication process. Groundwater may be managed by special legislation districts and by city and county ordinances.[168] Further, California has authorized local agencies to develop groundwater management plans.[169] Under the planning provision of the California Water Code, agencies with the powers of a water replenishment district may impose pumping fees to raise revenues to pay for facilities to manage the basin.[170] One hundred and forty-nine agencies in California have adopted groundwater management plans.[171]

Special legislation has been enacted to allow some parts of the state to form groundwater management districts. Twelve districts have been created to regulate the extraction of groundwater. These districts are located in the northern mountains and along the coast.[172] The legislation allows these districts to enact ordinances to limit or regulate pumping and exporting of water.

California's persistent refusal to institute state groundwater management has prompted local efforts to control and manage groundwater. A California intermediate court of appeals ruled that the state has not preempted groundwater management and, as a result of legislative silence, cities and counties can control and manage groundwater.[173] The California Supreme Court declined to review the lower court decision. As a result of this ruling, ten counties have now enacted groundwater management ordinances.[174] Some of the ordinances require a permit from the local Board of Supervisors before any groundwater can be exported.

167. *Katz,* 74 P. at 771. More recently, the California Supreme Court held that overlying correlative rights are not subject to "equitable apportionment" or sharing with appropriators as part of a"physical solution" for an overdrafted basin. City of Barstow v. Mojave Water Agency, 5 P.3d 853, 858 (Cal. 2000).

168. For a discussion of this approach, see Gregory Weber, *Twenty Years of Local Groundwater Export Legislation in California: Lessons Learned From a Patchwork Quilt,* 34 NAT. RESOURCES J. *656*, 661 (1994).

169. CAL. WATER CODE §§ 10750.56 (West 1992 & Supp. 2000).

170. *Id.* § 10754.3.

171. GROUNDWATER MANAGEMENT IN CALIFORNIA, *supra* note 158, at 7-13.

172. *Id.at6.*

173. Baldwin v. County of Tehama, 36 Cal. Rptr. 2d 886, 893 (Ct. App. 1994).

174. The following counties have adopted groundwater management ordinances: Butte, Imperial, lnyo, Kern, Lake, San Diego, San Joaquin, Shasta, Tehama, and Yolo. *See* GROUNDWATER MANAGEMENT in CALIFORNIA, *supra* note 158, at 21.

3. Colorado

Colorado has a population of 3.7 million and uses fifteen million acre-feet of water each year.[175] Most of this water, eighty-four percent, comes from surface sources. Ninety percent of all the water used in Colorado is consumed by irrigation.[176]

Colorado is rapidly approaching maximum utilization of its available water resources.[177] Rapid population growth in cities along the front range has led to increasing conflicts among urban, agricultural, recreational and environmental uses of water, especially during drought. Additionally, a number of downstream states claim rights to water originating in Colorado. Groundwater overdraft problems occur in the arid part of eastern Colorado.

Colorado classifies its groundwater as (1) tributary, (2) non-tributary, and (3) non-designated, non-tributary groundwater. This classification scheme determines the allocational rule of law and management program. Tributary groundwater is defined as that water in an unconsolidated alluvial aquifer which can influence the rate or direction of water in a natural stream.[178] A groundwater tributary to a natural stream is administered according to the state's surface water prior appropriation rules. The other two classes of groundwater are administered under a different set of rules.

In 1965, Colorado enacted the Ground Water Management Act, subjecting non-tributary groundwater to a modified doctrine of prior appropriation to prevent unreasonable aquifer depletion.[179] The Act created a statewide Groundwater Commission with authority to designate groundwater basins and subject them to state regulation.[180] Since most nontributary water is found in deep nonalluvial basins, the Act has been applied to eight basins in the eastern plains of Colorado. It affects mostly deep agricultural wells.

To allow full economic development of water resources in these basins, the Groundwater Commission allows up to forty percent mining of

175. Groundwater Protection Council, ***Groundwater Report to Congress: Summary of State Water Conditions*** (2000), *at* http://gwpc.site.netIgwreportIstates.htm (last visited Feb. 22. 2001).

176. ***See supra*** tbls.5, 6.

177. Groundwater Protection Council, ***Groundwater Report*** to ***Congress: Summary of State Water*** *Conditions* (2000), *at* http://gwpc.site.netIgwreport/states.htm (last visited Feb. 22, 2001).

178. COLO. REV. STAT. § 37-92-103(11) (1999).

179. ***Id.*** § 37-90.102. Nontributary groundwater is found in alluvial aquifers and is defined as "groundwater,.. . the withdrawal of which will not, within one hundred years, deplete the flow of a natural stream.., at an annual rate greater than one-tenth of one percent of the annual rate of withdrawal." ***Id.*** § 37-90-103(10.5); *see* ***also*** Colo. Ground Water Comm'n ***v.*** Dreiling, 606 P.2d 836, 839 (Colo. 1980) (explaining that the appropriation doctrine is modified when applied to designated ground waters to allow only "appropriation to the point of reasonable depletion").

180. COLO. REV. STAT. § 37-90-106. The Act allows the Commission to determine reasonable pumping levels in those aquifers. *Id.* § 37-90-111(b).

groundwater over a twenty-five year period.[181] In the northern basins, the depletion rule is forty percent over a one hundred year period.[182]

Local groundwater districts can be established within each basin, and thirteen districts have been created in the eight basins. These districts are subject to, and must operate under, the rules promulgated by the Groundwater Commission. Non-tributary groundwater within these basins is regulated by the Groundwater Commission using a modified appropriation doctrine.

The third class of groundwater is "non-designated, non-tributary groundwater," which is not tributary to a stream and is outside the boundaries of any designated basin.[183] This water is allocated on the basis of land own ership and not on the appropriation doctrine.[184] Colorado water courts have jurisdiction to determine the amount of water that can be withdrawn based on the amount of water underlying the land.[185]

4. Florida

Fourteen million Floridians use about eight million acre-feet of water annually. About sixty percent of all water used in the state comes from groundwater.[186] Nearly forty percent of the state's groundwater is used for irrigation with the remaining sixty percent used for public water supply and manufacturing uses. Groundwater supplies more than ninety percent of Florida's residents with drinking water.

Florida has a bifurcated permit and reasonable use system for allocating groundwater. In order to acquire a right to use groundwater, the governing board may require a potential user to apply for a permit.[187] All waters in the state are subject to regulation unless they are otherwise exempted, and one such exemption is water consumption by domestic users.[188] The state applies the reasonable use rule in awarding state permits to use groundwater under the guidance of the Florida Water Resources Act.[189]

A permit applicant must provide assurances that the proposed use is reasonable and beneficial, that the proposed use will not interfere with any previously existing right, and that the proposed use is consistent with the public interest.[190] The reasonable use requirement requires that the applicant

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181. ***Colorado Groundwater Law and Regulation,*** COLO. WATER 19 (1992).
182. ***Id.***
183. COLO. REV. STAT. § 37-90-103(10.5).
184. ***Id.*** § 37-90-137(4)(b)(I1***).***
185***.*** ***Id.*** § 37-92-203(1).
186. ***See supra*** tbls.4-6.
187. FLA. STAT. ANN. § 373.2 19 (West 2000).
188. ***Id.*** § 373.023(1)***.***
189. ***Id.*** § 373.219***.***
190. ***Id.*** § 373.219(1); ***see also*** Middlebrooks v. St. Johns River Water Mgmt. Dist., 529 So.2d 1167, 1168 (Fla. Dist. Ct. App. 1988) (applying the statute).

provide assurances that the use will not cause quality or quantity changes in the groundwater resource, that the use will not cause salt water intrusion, and that the use will not waste the groundwater resource.[191] The requirement that the proposed use must not interfere with any previously existing water right is a proactive step aimed at eliminating well interference problems. This requirement reduces the chance that a new well will interfere with existing legal water rights.

Once a permit is issued, it is conditioned on a permitee continuing to satisfy the statutory requirements.[192] Moreover, if these requirements are violated, a groundwater permit may be revoked.[193]

In 1972 the Florida Legislature passed the Florida Water Resources Act which divided the state into five different water management districts.[194] These water management districts, along with the Department of Environmental Protection, are responsible for regulating and controlling groundwater use in their respective regions.[195] Since these districts are divided geographically, each particular district can deal with specific groundwater issues in its region.

These water management districts control groundwater use through a permit system. Generally, permits are given for a specific number of years, and a water management district may require a compliance report every five years.[196] If there are competing applications for a groundwater right, preference should be given to the application which best serves the public interest.[197] When both applications serve the public interest, preference is given to a renewal application.[198]

Districts have the power to limit use in times of shortage and may apportion groundwater, rotate use, or even limit or prohibit use altogether.[199] This power allows water management districts to give preferences to cities or governmental agencies during overdraft periods.

Water management districts also take proactive measures to conserve groundwater resources. Each district is required to develop a "groundwater basin resource availability inventory."[200] The district uses this inventory to develop comprehensive plans dealing with groundwater conservation.[201]

191. FLA. ADMIN. CODE ANN. r. 40d-2.301 (1996).
192. *Id.* r. 40d-2.381.
193. *Id.* r. 40d.2.341.
194. FLA. STAT. ANN. § 373.219(1).
195. *See Id.* § 373.016(3).
196. *Id*. § 373.236.
197. *Id*. § 373.233(1).
198. *Id.* § 373 .233(2).
199. *Id*. § 373.175.
200. *Id*
201. *Id.*

Appropriators who wish to transfer groundwater must obtain a permit.[202] One permit requirement stipulates that the transfer must not interfere with the current or future population needs for groundwater in the area of the proposed extraction.[203] Cities in the area of the proposed extraction are allowed to present evidence on the future needs of the population, and if the proposed transfer will compromise these needs, the district may refuse to allow a permit for the transfer.[204]

S. Idaho

For a state with only one million people, Idaho uses a large amount of water. About eighty-six percent of Idaho's water is used for irrigation, two percent for public water supplies, and the remainder for electric power.[205] Most of Idaho's water comes from surface water supplies. Only eighteen percent of the water used comes from groundwater. However, about ninety percent of the groundwater is used for irrigation.

Groundwater in Idaho is a public resource allocated under prior appropriation rules.[206] All groundwater users must obtain a permit from the Idaho Department of Water Resources (IDWR).[207] "First in time—first in right" governs conflicts, provided the water is used for a beneficial purpose.[208]

Additionally, pumping levels of groundwater must also be reasonable. A prior appropriator may have a historic right to a certain amount of groundwater, but if this level is found to be unreasonable, the historic pumping level will not be protected.[209] Domestic wells are exempt from these groundwater permit requirements.[210]

The IDWR can establish groundwater management areas and critical groundwater areas.[211] Designation of a critical groundwater area gives the director of the agency enhanced power to regulate groundwater in the designated area. The agency may cease groundwater extraction or limit extraction on a prior appropriation basis.[212] This designation also allows the agency to refuse applications for new users.[213] In addition, the agency may

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202. *Id.* § 373.2295.
203. *Id.*
204. *Id.*
205. ***See supra*** tbls.4-6.
206. IDAHO CODE § 42.226 (Michie 1996).
207. ***Id. §*** 42.217.
208. ***Id.*** § 42-106.
209. Baker v. Ore-Ida Foods. Inc., 513 P.2d 627, 636 (Idaho 1973).
210. IDAHO CODE § 42-227.
211. ***Id.*** §§ 42-233a, -233b.
212. ***Id.*** § 42-233a.
213. ***Id.***

reduce withdrawals from a critical groundwater area as well as require groundwater users to report their withdrawal rates.[214]

The IDWR does not have the same power to stop withdrawals of ground water in a groundwater management area.[215] Any curtailments or reductions in a management area are based on priority, a junior/senior basis, with older appropriators having their groundwater needs met first. These conservation districts are generally created on an ad hoc basis for individual groundwater basins in the state. Although they are created for specific locales, the districts are not managed locally. The IDWR, a statewide agency, is responsible for district creation and management.[216]

6. Kansas

Kansas has a population of 2.5 million people and uses nearly six million acre-feet of water each year. Nearly seventy percent of the water comes from aquifers and thirty percent from surface water sources.[217] Kansas is an agricultural state that uses a significant amount of water for irrigation. Sixty-five percent of all the state's water is used for irrigation. Groundwater is important for Kansas agriculture as ninety percent of it is used for irrigation, nearly all in the western part of the state.

Water is unevenly distributed throughout the state. Surface water resources are found mostly in the east and groundwater in the west. Groundwater overdraft has occurred and many areas are closed to further appropriation.[218] Adverse water-quality impacts due to irrigation, petroleum production, agrochemicals, waste sites, and agricultural droughts are fairly routine.

In 1978, Kansas converted to a prior appropriation permit system to allocate and manage groundwater.[219] Pre-existing rights were vested and permits granted based on that vesting.[220] Rights to pump groundwater after 1978 require a permit from the state?[221] The right to use water is based on the first in time—first in right seniority system.[222]

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214. ***Id.*** § 42-223b.

215. ***Id.***

216. The IDWR recently announced plans to develop "conjunctive management" rules for the East Snake Plain Aquifer. *Idaho: State Tackles Administration of Groundwater and Surface Water,* 5 W. WATER L. & POL'Y REP. 106, 107 (Feb. 2001).

217. ***See supra*** tbls.4-6.

218. Groundwater Protection Council, ***Groundwater Report to Congress: Summary of State Water Conditions*** (2000), ***at*** http:Ilgwpc.site.net/gwreport/states.btm (last visited Feb. 22,2001).

219. ***See*** KAN. STAT. ANN. §§ 82a-702 to .710 (1997).

220. ***Id.*** § 82a-703.

221. ***Id.*** §§ 82a-708, -709.

222. ***Id.*** § 82a-707.

Groundwater is managed at the state level with advisory input from local groundwater management districts.[223] The Kansas Department of Agriculture administers and enforces the permit system.[224]

Special groundwater management districts, with limited management and regulatory responsibilities, can be established by a local vote.[225] Districts can prepare a management plan, acquire and own property, conduct research, monitor well pumping, develop demonstration projects, recommend designation of intensive groundwater use control areas, and levy water user charges.[226] All significant regulatory responsibilities, however, must be submitted to and approved by the state water engineer.[227]

Five local districts have been established in Kansas.[228] Three of the five are in the western portion of the state and are closed to new appropriations.[229]

7. Nebraska

As in Texas, sixty percent of Nebraska's water comes from aquifers. Irrigation is a major consumer of water as seventy-two percent of the nearly twelve million acre-feet of water is allocated to this use.[230] Ninety-three percent of all groundwater is used for irrigation.

Nebraska generally has an abundant water supply for its 1.6 million residents, although quantity varies seasonally and annually. There is localized groundwater overdraft, especially in the western portion of the state.[231] Drought has a significant impact on agriculture, on small communities, and on older water supplies. Salinity problems exist in the South Platte River and in the canal systems originating in Colorado.

Prior to 1975, Nebraska groundwater law was governed almost exclusively by piecemeal judicial and legislative adjustments to the reasonable use doctrine.[232] Reasonable use has been replaced in special groundwater management areas by a permit system.[233] In other parts of the state the reasonable use rule remains.

Under the reasonable use rule, a landowner is entitled to appropriate waters found under his land. He cannot, however, extract and appropriate

223. *Id.* § 82a.1028(o).

224. *Id.* §§ 82a-612,-706.

225. *Id*. §§ 82a-1020,-1025.

226. *Id.* § 82a-102S(o).

227. *Id.* § 82a-1028.

228. Telephone Interview with Jim Bagley, Kansas State Engineer. Division of Water Resources, Kansas Department of Agriculture (Sept. 12, 2000).

229. *Id.*

230. *See supra* tbls.4.6.

231. Groundwater Protection Council, *Groundwater Report* to *Congress: Summary of State Water Conditions* (2000), *at* http://gwpc.site.net/gwreport/states.htm (last visited Feb. 22. 2001).

232. *See* Aiken & Supalla, *supra* note 157, at 618.

233. NEB. REV. STAT. ANN. §§ 46-656 to -674 (Michie 1995 & Supp. 2000).

subterranean water in excess of "a reasonable and beneficial use upon the land which he owns, especially if such use is injurious to others who have substantial rights to the waters. If the natural underground supply is insufficient for all owners, each is entitled to a reasonable proportion of the whole..."[234] In Nebraska, water rights are appurtenant to the land, and a change in land ownership automatically results in a transfer of the water rights to the new landowner. Only limited transfers of water rights are permitted apart from the sale of land.[235]

In 1975 Nebraska passed the Ground Water Management Act (NGMA).[236] The NGMA requires that (1) all wells (except domestic wells) be registered with the state, (2) well-spacing rules be followed, and (3) groundwater control areas be established in regions with aquifer overdrafting and mining.[237] Except in control areas, a landowner need only check that no well-spacing laws are being violated and that a well registration form is filed with the state Department of Water Resources.[238] Well registration, but no water right, is required. Permits for water withdrawals are required only for certain industrial and geothermal wells, and for wells in groundwater control areas.

In areas of declining water tables, groundwater use can be significantly restricted by the NGMA.[239]About fifty percent of the state is included within a special groundwater management area.[240] Primary responsibility for regulating groundwater in these areas is given to the local Natural Resource Districts (NRDs). Twenty-three NRDs blanket the state.[241]

Unlike groundwater districts in other states, Nebraska's NRDs are multi-purpose resource districts that have a wide range of natural resource management responsibilities including soil and water conservation, flood and soil erosion control, drainage, rural water supply, recreation, forestry and range management, and wildlife habitat management.[242] The districts are governed by a locally elected board of directors and day-to-day operations are run by a manager and a full-time professional staff.

Subject to approval of the state board, NRDs establish groundwater "control areas" and have authority to limit access to the aquifer and, as a last

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234. See Olson v. City of Wahoo, 248 N.W. 304, 308 (Neb. 1933).

235. NEB. REV. STAT. ANN. §§ 46-122, 46-290 to -294.

236. *Id.* §§ 46-656 to -674.

237. *Id.*

238. Kurt Stephenson, Governing the Commons: History and Evaluation of Local Democratic Groundwater Management in the Nebraska Upper Republican Natural Resource District 109-111 (1994) (unpublished Ph.D. dissertation, University of Nebraska) (on file with the Texas Tech Law Review).

239. NEB. REV. STAT. ANN. §§ 46-656 to -674.

240. Telephone Interview with Steve Gall, Water Engineer, Nebraska Department of Water Resources (Sept. 12, 2000).

241. *Id.*

242. NEB. REV. STAT. ANN. § 2-3229.

resort, declare a well-drilling moratorium.[243] They may impose more restrictive well-spacing requirements than those required by state law, may require systems of rotational pumping, may limit withdrawals by different groundwater users, and may require installation of water meters on wells to measure total withdrawals.[244] The drilling of new wells has also been curtailed by some NRDs in areas experiencing an annual decline in the aquifer water table, designated as "critical townships." The state spacing requirement of 1000 feet was increased to 3300 feet in 1978 and to one mile in 1992.[245] This approach ensures that groundwater depletion will not accelerate in the most critical areas.

8. Nevada

Nevada's 1.5 million people use about 2.6 million acre-feet of water per year. About forty percent of this water comes from groundwater sources. As in other western states, Nevada uses a significant portion of its water for irrigation. About three quarters of all the state's surface and groundwater is used for irrigation. The remaining portion is used for municipal and[246] manufacturing purposes.

Municipal water supplies are insufficient in some cities, such as Las Vegas, Reno-Sparks, Lovelock, Wendover, Dayton. and Incline Village.[247] There is intense competition among urban, agricultural, municipal, tribal, and environmental users for the state's limited surface and groundwater supplies. Widespread groundwater overdraft exists due to municipal and agricultural use and some localized aquifer contamination.

Rights to groundwater use can only be acquired through a statutory permit appropriation process administered by a state engineer.[248] In approving or rejecting a groundwater permit application, the state engineer must determine if: (1) there is unappropriated water in the proposed source, (2) the proposed use will impair existing rights, (3) the proposed use is not detrimental to the public interest, and (4) the project is feasible and not filed for speculative purposes.[249] All groundwater rights are considered real property and can be bought, sold, traded, and leased. Like all prior appropriation states, first in time—first in right guides the use of groundwater.[250]

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243. *Id.* § 46-666(5).

244. ***Id.*** § 46-666(1)(a)-(d).

245. ***See Id.*** §§ 46-651 to -655.

246. *See supra* tbls.4-6.

247. Groundwater Protection Council, ***Groundwater Report to Congress: Summary*** *of State Water Conditions* (2000). *at* http:llgwpc.site.net/gwreport/states.htm (last visited Feb. 22, 2001).

248. NEV. REV. STAT. § 534.050 (1999).

249. ***Id.*** §§ 534.110-120.

250. ***Id.*** § 534.100.

There are 256 groundwater basins in Nevada, and the state engineer, on his own motion or by petition of well owners in a basin, may designate any one of them for added protection and control.[251] Whether or not a basin is designated dictates the procedure to be followed in obtaining a groundwater permit. In undesignated basins, a person, at their own risk, can drill a well prior to filing an application for a permit. A permit must be sought before drilling a well in a designated basin.

Local advisory boards can be established in designated basins to advise the state engineer in managing the designated basin[252] Legislative intent suggests that the state engineer and local board be in agreement whenever possible, but if there is any disagreement the views of the state engineer prevail.[253] Since a written report of such disagreement must be made to the governor, the power of the local board is probably more political than legal.[254] In designated basins, the state engineer may limit pumping to prevent the unreasonable lowering of the water table.[255]

Groundwater mining is not statutorily defined, but the state engineer has the authority to restrict use in order of priority when the average annual recharge is not adequate to satisfy all rights.[256] The engineer may restrict drilling and pumping to prevent depletion, and in some basins irrigation use has been denied altogether.[257]

9. New Mexico

With about 1.6 million people, New Mexico uses nearly four million acre-feet of water annually, about half coming from groundwater. Like most of the West, New Mexico uses its water largely for irrigation.[258] Groundwater provides about three quarters of all the irrigation water used in the state.

Water is scarce in this arid state. Surface water is completely appropriated and any supply reduction brings shortages. Groundwater overdrafting is occurring, and the problem is particularly acute in the urbanized portions of the state.[259] Agriculture is particularly vulnerable to drought. Other problems include water quality degradation by

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251. *Id.* § 534.030.

252. *Id.* § ***534.030(5).***

253. *Id.* § 534.035(8).

254. *Id.*

255. *Id.* § 534.l20.

256. *Id.*

257. NEVADA DEPARTMENT OF CONSERVATION & NATURE. RESOURCES, STATE WATER PLAN 3.15 (2000).

258. Approximately eighty-five percent of the state's water is used for irrigation. *See supra* tbls.4--6.

259. Groundwater Protection Council, *Groundwater Report to Congress: Summary of State Water Conditions* (2000), *at* http://gwpc.site.net/gwreport/states.htm (Last visited Feb. 22, 2001).

municipal/industrial discharge into the Rio Grande River, saline, contaminated agricultural runoff, and urban contamination of some ground water.

Groundwater is property of the state and is allocated by prior appropriation.[260] First in time—first in right governs, provided water is put to beneficial use.[261] A water right, although a vested property interest, is only a privilege of use of the resource.[262]

Groundwater and prior appropriation systems are managed by the state engineer. All permits, transfers, or changes in location or purpose of use must be approved by the engineer.[263]

IV. LESSONS LEARNED FROM OTHER STATES: GROUNDWATER MANAGEMENT OPTIONS FOR TEXAS

This tour through Texas groundwater laws and problems, and the sojourn through the maze of approaches used by other states, leads to three conclusions about options for Texas groundwater issues. First, like other western states, groundwater has been and will continue to be an important water source for Texas farms and cities. The locations, sources, uses, and users of groundwater are generally well known but the trends are less certain. The future is difficult to predict, but assessing long term impact is essential. What is known is that Texas cannot sustain its current approach to groundwater management without some fundamental changes. What is not well known are the long term positive and negative impacts on farms and cities as aquifers are mined or overpumped.

Second, the increasingly balkanized conflict over urban uses of groundwater drawn from rural areas, and the entanglement of local groundwater management districts in this conflict, creates strong arguments for greater state legislative guidance over important water allocation issues with statewide import. The issue is not whether Texas will continue to defer to local groundwater districts to solve regional or state problems, because it is a foregone conclusion that the state has started down that slippery slope and will not change. The issue is whether the state will provide aquifer-sustainable use standards for local groundwater management districts to follow. Overdrafting and mining of groundwater are aquifer-wide issues that must be addressed accordingly.

Third, the rule of capture has contributed to and exacerbated well interference, aquifer overdrafting, and mining problems. If left untreated, these problems will lead to short and long-range negative economic,

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260. *See* N.M. CONST. art. XVI, § 2.

261. *Id.*

262. N.M. Prods. Co. v. N.M. Power Co., 77 P.2d 634, 640-41 (N.M. 1937).

263. N.M. STAT. ANN. § 72-2-1 (Michie 1999).

hydrologic, and social consequences. The Texas Supreme Court will not, in the near future, change the rule of capture. The court believes that the legislature has the constitutional authority to abolish, modify, or change the rule and replace it with state or local regulations in order to conserve, develop, and preserve groundwater resources.[264]

Several legislative alternatives are available that would protect and conserve groundwater resources by easing the negative consequences of the capture rule. The alternatives discussed below focus on (1) well interference, (2) aquifer overdrafting, and (3) aquifer mining problems. The alternatives are not listed in any order of priority or preference.

A. Well Interference

Well interference is caused by the pumping of high-capacity wells near shallower low-capacity wells. This pumping generally lowers the water level in the smaller well. The interference may be a temporary or permanent hydraulic phenomenon. If the well interference is caused by a cone of depression created by the intermittent operation of the high-capacity well, the condition may be temporary.[265] However, if the high-capacity well is operated more frequently, the cone of depression may be longer lasting. The overall lowering of the water table in an aquifer by pumping which exceeds recharge is a third and perhaps permanent cause of well interference.

Most of the well interference problems arise when high-capacity commercial, irrigation, or municipal wells are located near small-capacity domestic wells. The interference is more often a result of the cone of depression rather than an overall lowering of the water table. However, in smaller aquifers, well interference may be a result of the cone of depression and a lowering of the water table.

In Texas, the capture rule imposes a particular hardship on small domestic well owners. These well interference conflicts are usually imposed on rural landowners who have limited access to public water systems. They bear the economic brunt and familial hardship of having their wells go dry.

1. Protection of Domestic Wells

The private property rights of pre-existing domestic well owners could be protected, alleviating the economic hardship and inequity to smaller domestic well users. Protection from unreasonable interference by higher capacity wells could extend to pre-existing domestic wells capable of producing up to 10,000 gallons per day.

264. *See* Sipriano v. Great Spring Waters of Am., Inc., 1 S.W.3d 75, 77-80 (rex. 1999); Barshop v. Medina County Underground Water Conservation Dist. 925 5.W.2d 618, 633 (Tex. 1996).

265. *See supra fig* 1.

This domestic well protection rule could apply to well interference caused by any high capacity non-domestic well capable of producing more than 25,000 gallons per day. The protection rule could provide the domestic well owner with a cause of action for damages or injunctive relief against non-domestic well owners. This protection could apply in one of several ways: to all aquifers and areas of Texas, only to aquifer areas not included within the boundaries of a local groundwater district, or only to selected aquifers or portions of aquifers.

a. Options

In order to protect pre-existing small domestic wells from unreasonable interference, the legislature could adopt any one, or a combination of options.

> Option 1) Adopt statutorily defined criteria of reasonable use to assess whether the domestic well interference is caused by the unreasonable use of the non-domestic higher capacity well. If the high-capacity well unreasonably interferes with the domestic well, the high-capacity well owner would have to compensate the domestic well owner or provide him with a source of water;
>
> Option 2) Adopt well spacing standards to insure that high-capacity well sites are not located near pre-existing domestic wells;
>
> Option 3) Adopt a preference schedule for the use of groundwater similar to the schedule found in Texas Water Code § 11.024 that could be used as a ranking order for preferred uses in resolving well interference disputes.[266]

b. Rationale

From a legal perspective, protecting pre-existing domestic wells from unreasonable interference protects private property rights and home ownership values. Domestic well owners are protected from competition with high-capacity well owners, while reasonable water use is allowed.

This approach encourages a low cost, negotiation-based framework for resolving conflicts and disputes between domestic well owners and other users. By providing the parties with the criteria to measure reasonableness, disputes are transformed from rights and techno-economic power-based frameworks to fact and interest-based frameworks. The approach provides

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266. Reasonable use criteria could be taken from the *Restatement (Second) of Torts*. *See supra* note 79 and accompanying text. Other reasonable use criteria could include: (1) purpose of use, (2) economic and social value of each use, (3) the extent and amount of harm caused, (4) the practicality of adjusting the quantity of water used by each well owner, and (5) the protection of existing uses and investment backed expectations of the parties.

strong incentives for the parties to work out negotiated solutions that will provide domestic users with water for their homes while allowing for other economic uses of water.

This approach promotes economic efficiency and equity by requiring the offending parties to internalize the external cost of well interference. Under the present system, when the pumping of a high-capacity well causes interference with a smaller domestic well, the homeowner incurs all of the cost of well interference and the offending party incurs none of the costs. These options require high-capacity pumpers to internalize some of the external costs that are now imposed on the domestic well owner. These options still allow the high-capacity well to operate, but only after the pumper mitigates the economic harm to the domestic well user.

2. Non-Domestic Well Interference Issues

If well interference occurs between high capacity non-domestic wells, such as between irrigators or industrial users, at least four options exist to address such problems.

Option 1) Retain the capture "no liability" rule for these disputes because these pumpers are generally equal in economic and bargaining power;

Option 2) Adopt another allocational rule such as correlative rights or

reasonable use;

Option 3) Adopt well-spacing requirements for high-capacity wells; or

Option 4) In areas covered by local groundwater districts, grant the districts

powers necessary to resolve disputes under their rules.[267]

B. Aquifer Overdraft and Safe Yield-Options

Two interrelated concepts—aquifer overdraft and safe yield—are at the core of regulatory schemes for managing water use when aquifer pumping levels exceed natural or artificial recharge. "Overdrafting" is generally defined as a temporary condition in an aquifer, or segment of an aquifer, where the amount of water withdrawn by pumping exceeds the rate of natural and/or artificial recharge overtime. "Safe yield" refers to the optimal quantity of water that can be continuously withdrawn from the aquifer without adverse

267. The regulatory power of groundwater conservation districts may be limited under current laws. *See* 5. Plains Lamesa R.R., Ltd. v. High Plains Underground Water Conservation Dist. No. 1, No. 07-00-0089-CV, 2001 WL 62272 (Tex. App—Amarillo Jan. 25, 2001, no pet. h.)

economic, environmental, and aquifer impacts.[268] These two concepts connote a public policy choice between treating an aquifer as a renewable or a nonrenewable resource.

Aquifer overdrafting has been long recognized as a problem in Texas.[269] The legislature empowered local groundwater districts to respond to the problem. With the passage of Senate Bill 1, the Texas Legislature expressly recognized groundwater conservation districts as the preferred method of groundwater management.[270] As of January 1, 2000, Texas had fifty confirmed districts plus thirteen provisional districts created by Senate Bill 1911.[271] Generally, the districts are organized around political boundaries and do not encompass aquifer boundaries. The four tools that districts have to manage groundwater include the power to (1) prevent waste, (2) issue permits for wells, (3) control well spacing, and (4) prepare, adopt, and implement a management plan.

In 1985, the Texas Legislature recognized that certain parts of the state were experiencing declining water tables and authorized the Texas Water Commission, predecessor to the TNRCC, to institute a designation and study process. Accordingly, in 1986, the Texas Water Commission and the Texas Water Development Board identified possible critical areas and conducted further studies to determine the severity of overdraft and contamination problems.[272]

In 1997, Senate Bill I reconfirmed the critical areas concept and added provisions for state initiated groundwater conservation districts in critical areas that were renamed priority groundwater management areas (PGMA).[273] The process requires a detailed study before an area is designated as a PGMA. To date, sixteen studies have been completed. Four areas have been designated as PGMAs. The PGMAs include: (1) Hill County; (2) Upton, Midland, and Reagan Counties; (3) Hale, Swisher, and Briscoe Counties; and (4) Dallam County.

A local approach to groundwater management can be criticized as an inadequate response to a state-wide problem. Aquifers that have either statewide or regional economic, environmental, and social significance may not be effectively managed by locally controlled districts. This concern becomes particularly acute where multiple districts are located over a single regional aquifer and these districts are operated under competing and conflicting

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268. *See* CALIFORNIA DEPARTMENT OF WATER RESOURCES, BULLETIN 118-75, CALIFORNIA'S GROUNDWATER 31(1975); R ALLAN FREEZE & JOHN A. CHERRY, GROUNDWATER 364 (1975).

269. See *supra* tbl.1.

270. TEX. WATER CODE ANN. § 36.0015 (Vernon 2000).

271. Act of June 18, 1999,76thLeg.,R.S.,ch. 1331,§ 1, 1999 Tex. Gen. Laws 4536, 4536.

272. Texas Natural Resource Conservation Commission, *Overview of the Texas Natural Resource Conservation Commission*, *at* http://tnrcc.state.tx.us/permitting/waterperm/wwperm/c2fnl.pdf (last visited Feb. 22, 2001).

273. TEX. WATER CODE ANN. §§ 35.00l-.013.

philosophies and strategies. Stated otherwise, how can locally controlled districts effectively manage aquifers, which usually are regional water resources, when the aquifers have statewide impacts and significance? Another practical issue is whether the critical area legislation, known today as the PGMA process, has been effective in dealing with the problem. Concerns have been raised regarding the number of districts Texas might need, the motivations for creating additional districts, and determination of districts along political rather than aquifer boundaries.

A fundamental policy requiring legislative consideration is whether the state should manage its aquifers as a renewable or a nonrenewable resource. If the choice is to manage an aquifer as a renewable resource, the legislature should provide local groundwater districts specific guidance on methods and goals. Several options for guidance that will accomplish this goal are discussed below. Any option selected should be consistent with the overall goal of aquifer sustainability. The following discussion presents some different options addressing sustainability.

> Option 1) Establish statutory descriptive standards for aquifer sustainability based on optimal safe yield criteria.

The safe yield criteria could later be numerically defined by groundwater availability models as tempered by economic, environmental, and social factors. These safe yield standards could be applied: (1) to all rechargeable aquifers in the state, (2) on an aquifer by aquifer basis, (3) on segments of aquifers, or (4) in PGMA study areas.

The standards would bring predictability and consistency to the management of aquifers by local groundwater districts while giving them flexibility in local means of implementation. Monitoring and reporting requirements could be established to insure that local districts conform to the state goal of aquifer sustainability.

> Option 2) Grant authority to the TNRCC to set descriptive standards for aquifer sustainability based on statutory optimal safe yield criteria.

Again, as with Option 1, safe yield criteria could later be numerically defined by groundwater availability models and tempered by other economic, environmental, and social factors. As with Option 1, these safe yield standards could be applied: (1) to all rechargeable aquifers in the state, (2) on an aquifer by aquifer basis, (3) on segments of aquifers, or (4) in PGMA study areas.

The standards would bring consistency to the management of aquifers by local groundwater districts while still giving them flexibility in local means of implementation. Monitoring and reporting requirements could be established to insure that local districts conform to the state goal of aquifer sustainability.

> Option 3) Establish aquifer-wide, regional, or sub-basin districts to coordinate planning and management and integrate the efforts of local groundwater management districts into the regional management district's planning authority for the aquifer.

These districts could have (1) coordinating, or (2) supervisory authority. The model for this approach is the Edwards Aquifer Authority.

> Option 4) Allow for the continued legislative establishment of local groundwater districts.

Presently, this approach does not address sustainability and would continue non-uniform aquifer rules.

> Option 5) Place a moratorium on the establishment of additional local groundwater districts until groundwater availability models can be run on the major aquifers.

This option would allow for the establishment of districts based on integration into an aquifer-wide plan.

None of the above five options would preclude the creation of local groundwater districts, but they would require that all districts operate under uniform sustainability standards for aquifers. Districts would have the ability and authority to apply local insight and knowledge in aquifer management, but they could not operate under different or inconsistent sustainability standards.

C. Aquifer Mining-Options

Groundwater mining occurs when withdrawals are made from an aquifer at rates in excess of net recharge over a sustained period of time. In aquifers with little or no recharge, sustained withdrawals will in due course exhaust the supply or lower water tables below economic pumping limits. When groundwater is pumped faster than this rate over long periods of time, it is in effect being mined and depleted without recharge. To the degree that groundwater is mined, flexibility to respond to future dry spells and droughts is lost.

Several states have provided for controlled mining of aquifers so that depletion occurs over a predictable number of years. The choice of time periods usually reflects a legislative policy judgment. A long depletion period preserves water for future uses but usually requires severe restrictions on present withdrawals. By contrast, a shorter period allows for larger withdrawals for the benefit of current users, but the depletion causes an economic crash in the irrigation economy for a local area.

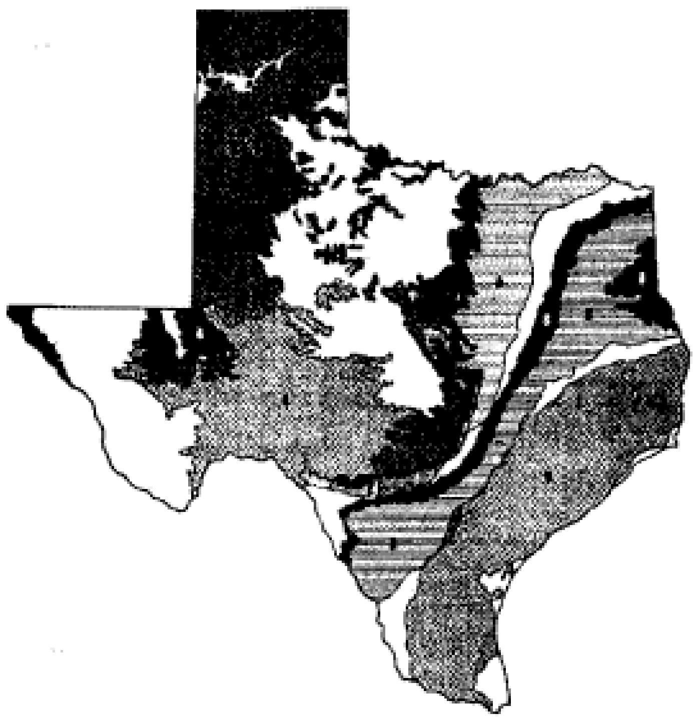
Mining occurs in limited recharge aquifers. Considering existing pumping practices, mining of limited recharge aquifers is occurring in the Ogallala and in the Hueco-Mesilla Bolson aquifers.[274] From a public policy perspective, two options for structuring management approaches are possible. These tend to be mutually exclusive propositions.

> Option 1) Retain capture rule and allow unlimited pumping which will allow private economic decision making and market-place forces to determine hydrologic and economic life of aquifer; or
>
> Option 2) Establish aquifer depletion rates over a period of time that are socially and politically acceptable.

The life span *(e.g.,* twenty, forty, seventy-five years) of an aquifer may be legislatively set or may be determined administratively pursuant to legislative criteria. A longer time period would limit current pumping to preserve the resources for future generations and provide a transition time to other resources or to another economic base. A shorter time period would allow greater pumping by present users. If the time period is short, an established irrigation economy may crash and impose short-term hardships on the region and limit the opportunity to diversify the local economy.

274. *See supra* tbl.1.

APPENDIX



Major Aquifers of Texas:
1. Ogallala 2. Seymour 3. Hueco-Mesilla Bolson 4. Cenozoic Pecos Alluvium 5. Edwards-Trinity (Plateau) 6. Trinity 7. Edwards (BFZ) 8. Carrizo-Wilcox 9. Gulf Coast.
Shaded Areas: Outcrop (That part of a water-bearing rock layer which appears at the land surface).
Ruled Areas: Downdip (That part of a water-bearing rock layer which dips below other rock layers).

The following discussion highlights information on each aquifer.[275]

High Plains (Ogallala) Aquifer

The Ogallala Formation of Pliocene age occurs at or near the surface over much of the High Plains area of northwest Texas. The formation

275. The Appendix is modified from the description of aquifers in Texas found at TEXAS DEPARTMENT OF WATER RESOURCES, WATER FOR TEXAS: A COMPREHENSIVE PLAN (1984) and WATER FOR TEXAS 1997, *supra* note 1, at 3-205 to 3-23 7.

consists of alternating beds of silt, clay, sand, gravel, and caliche, reaching a maximum known thickness of more than 900 feet in southwestern Ochiltree County. The High Plains aquifer consists primarily of the Ogallala Formation, and includes all water-bearing units, mainly Cretaceous and Triassic sediments, with which it is in hydraulic continuity. However, the Canadian River has cut through the formation dividing it into two parts, the North Plains and the South Plains.

The zone of saturation in the aquifer ranges in thickness from only a few feet to more than 500 feet. The thickest saturated sections occur in the northeastern part of the South Plains. In the large irrigation area north and west of Lubbock, the saturated interval generally ranges between 100 and 300 feet. South of Lubbock, the saturated zone is generally between fifty and 150 feet thick.

Water depth in the aquifer ranges between 100 and 200 feet throughout much of the South Plains, but depths commonly exceed 300 feet in parts of the North Plains. Yields of wells range from less than 100 gpm (gallons per minute) to more than 2,000 gpm, averaging about 500 gpm.

Small quantities of natural recharge to the High Plains (Ogallala) Aquifer result from precipitation on the land surface and underflow from that part of the aquifer in New Mexico. Water moves slowly through the formation in a general southwesterly direction toward the eastern escarpment of the High Plains.

Alluvium and Bolson Deposits

Deposits of alluvium occur in many parts of Texas and generally consist of alternating and discontinuous beds of silt, clay, sand, and gravel of recent geologic age. In some areas, these deposits contain comparatively large volumes of water, and the five largest and most productive of these local aquifers collectively make up a major aquifer in the Trans-Pecos area.

In the El Paso area and the El Paso Valley, alluvium and bolson deposits ranging to more than 9,000 feet thick contain fresh water to depths of about 1,200 feet. Large-capacity wells completed in this aquifer commonly yield between 1,000 and 1,500 gpm, supplying water for irrigation and municipal use.

Alluvium and bolson deposits extending from northeastern Hudspeth County to northern Presidio County supply large volumes of water for irrigation. Large-capacity wells completed in the aquifer yield up to 2,500 gpm. At the present rate of pumpage, however, it is projected that these supplies will be largely depleted before the year 2020.

In the upper part of the Pecos River drainage system in Texas, deposits of alluvium ranging up to 1,500 feet or more in thickness yield large volumes of water used principally for irrigation. This aquifer also supplies municipal and industrial water needs in this region, including supplies for the cities of

Monahans and Pecos. Legal rights to the water in a large volume of the aquifer in northwestern Winkler and northeastern Loving Counties have been acquired by the City of Midland as a potential source of future supply for that city; however, these supplies can furnish only a part of Midland's projected future water needs.

Isolated areas of alluvium (principally erosional remnants of the Seymour Formation) furnish domestic, municipal, and irrigation supplies to areas of North and West Central Texas. These local aquifers in the upper Red and Brazos River Basins vary greatly in thickness, but in most areas the saturated interval is less than 100 feet. Pumpage at times and in local areas has exceeded the rate of recharge. Yields of large-capacity wells range from less than 100 gpm to 1,300 gpm, with the average being about 300 gpm.

Along the Brazos River, between northern McLennan County and central Fort Bend County, stream-deposited alluvial material ranging from less than one mile to about seven miles wide supplies water for irrigation and other purposes. Thickness of the saturated interval in the aquifer ranges to eighty-five feet or more, with the maximum thickness of saturation occurring in the central and southeastern part of the aquifer.

Edwards-Trinity (Plateau) Aquifer

The Edwards-Trinity (Plateau) Aquifer underlies the Edwards Plateau and extends westward into the Trans-Pecos region of Texas. The aquifer consists of water-saturated sand and sandstone of the Trinity Group and limestone of the overlying Fredericksburg and Washita Groups of Cretaceous age. These water-bearing units range to more than 800 feet in thickness. Large-capacity wells completed in fractured and cavernous limestone locally yield as much as 3,000 gpm.

The Edwards-Trinity (Plateau) Aquifer supplies small cities and communities of the area with water. Industrial supplies are also obtained from the aquifer locally, principally for petroleum recovery. Natural discharge of water from the aquifer constitutes a substantial part of the base flow of several streams, including the Pecos, Devils, Nueces, Frio, and Llano Rivers.

Water supplies of the Edwards-Trinity (Plateau) Aquifer have proven difficult to develop, however, because of the irregular distribution of permeability in the limestone beds and the variable thickness of the lowermost sand and sandstone beds. In heavily pumped areas, water levels have declined significantly. Sustained heavy pumpage over long periods would result in substantial depletion of the base flows of streams draining the plateau, thus reducing somewhat the surface-water supplies of these river basins and recharge to the Balcones Fault Zone Aquifer.

Edwards (Balcones Fault Zone) Aquifer

The Edwards (Balcones Fault Zone) Aquifer extends east from central Kinney County and northeast into southern Bell County. It includes the Edwards Limestone and stratigraphically associated limestone beds of Cretaceous age. Conditions favorable for the development of extensive solution channels and cavities and the consequent accumulation of large volumes of water in these formations have resulted from faulting along the Balcones Fault Zone.

This aquifer supplies municipal and industrial water to numerous cities and towns, including the total municipal supply of the City of San Antonio. Capacities of wells operated by the city are among the largest in the world, with some wells yielding over 16 thousand gallons per minute each. Industrial and irrigation water supplies are also pumped from the aquifer.

Some of the largest springs in the state result from the discharge of water from the aquifer. These include Leona Springs at Uvalde, San Pedro and San Antonio Springs at San Antonio, Comal Springs at New Braunfels, San Marcos, Barton Spring at Austin, and Salado Springs at Salado.

The aquifer is partly recharged by precipitation on the recharge zone, storm runoff which enters the recharge zone, and streams which head in the Edwards Plateau. The West Neuces, Nueces, Frio, Sabinal, Medina, and Blanco Rivers and Seco, Hondo, and Cibolo Creeks flow across the Balcones Fault Zone, losing water into the extensive fracture system of the aquifer. Water moves rapidly through the aquifer, and the volume of water in storage and the rate of springflow change rapidly in response to rainfall. For example, the depletion of water in storage resulting from continuous heavy pumpage during the drought years 1948-1956 was almost completely restored during the wet years 1957 and 1958.

Highly saline water, containing hydrogen sulfide gas, occurs in the Edwards and associated limestone beds south of the heavily pumped areas. The possibility of saline water intrusion and the need to maintain springflow at adequate levels for environmental and recreational purposes are constraints upon increased pumping from the aquifer, particularly during drought periods, as water needs increase.

Trinity Group Aquifer

The Trinity Group Aquifer extends over a large area of North and Central Texas. The thickness of the aquifer ranges from a few feet along its western edge to more than 1,200 feet in the eastern part. Yields of large-capacity wells range up to several thousand gpm. In thin sections of the aquifer, where water is withdrawn principally for irrigation and domestic use, most wells yield less than 100 gpm.

The Trinity Group Aquifer has been intensively developed for municipal and industrial water supply in the Dallas-Fort Worth area and formerly provided much of the municipal water supply for the City of Waco. In these heavily pumped areas, significant reduction in artesian head has occurred, thus lowering pumping levels and increasing pumping costs.

Carrizo- Wilcox Aquifer

The Carrizo-Wilcox Aquifer, one of the most extensive in Texas geographically, furnishes water to wells in a wide belt extending from the Rio Grande northeastward into Arkansas and Louisiana. The aquifer consists of hydrologically connected sand, sandstone, and gravel of the Wilcox Group and overlying Carrizo Formation.

The Carrizo-Wilcox Aquifer is recharged by precipitation and storm runoff on the outcrop areas and by streams which cross the outcrop area. The water-bearing beds dip beneath the land surface toward the Gulf, except in the East Texas structural basin, where the formations form a trough and are exposed at the surface on both sides of the trough's axis. The net thickness of the aquifer ranges from a few feet in the outcrop to more than 3,000 feet downdip.

Water in the Carrizo-Wilcox Aquifer is generally under artesian pressure, and flowing wells are common in areas of low elevation. However, in heavily pumped irrigation areas, such as the Winter Garden area, and in municipal and industrial well fields, such as those north of Lufkin, water levels have declined and pumping costs have increased significantly.

Yields of wells vary widely, but yields of more than 1,000 gpm from large-capacity wells are common, and some wells yield as much as 3,000 gpm. Usable quality water occurs at greater depths (up to about 5,300 feet) than in any other aquifer in the state.

Water from the Carrizo-Wilcox Aquifer is used for irrigation in the Winter Garden area and for municipal and industrial use in Angelina and Nacogdoches Counties. The municipal and industrial use in these two counties has exceeded 20 million gallons of water per day.

Gulf Coast Aquifer

The Gulf Coast Aquifer underlies most of the Coastal Plain from the Lower Rio Grande Valley northeastward into Louisiana, extending about 100 miles inland from the Gulf. The aquifer consists of alternating clay, silt, sand, and gravel beds belonging to the Catahoula, Oakville, Lagarto, Goliad, Willis, Lissie, and Beaumont Formations, which collectively form a regional, hydrologically connected unit.

Fresh water occurs in the aquifer to depths of more than 3,000 feet,. and large quantities of water are pumped for municipal, industrial, and irrigation use. In the Houston metropolitan area, from 300 to 350 million gallons are pumped daily for municipal and industrial use. Large-capacity wells yield as much as 4,500 gpm in this area. In the central and southern parts of the coast, the net thickness of water-bearing zones in the aquifer decreases, and yields of wells are somewhat less, although locally wells may yield as much as 3,000 gpm.

The aquifer is recharged by precipitation on the surface and seepage from streams crossing the outcrop area. The rate of natural recharge is estimated to be sufficient to sustain present levels of pumpage from the aquifer; however, in heavily developed areas withdrawals must be limited to quantities equal to local area recharge, otherwise the water table will be lowered further and additional subsidence will occur. In some areas where the aquifer is essentially undeveloped, substantial volumes of potential recharge are rejected. Problems related to withdrawal of water from the Gulf Coast Aquifer are: (a) land-surface subsidence, (b) increased chloride content in the water of the southwest portion of the aquifer, and (c) salt-water encroachment along the coast.